Lower Balonne Distributary System

Lower Balonne Distributary Model Results to Support Basin Plan Requirements

Water Planning and Coastal Sciences

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1 Introduction

The Lower Balonne Distributary System Model was developed using the SOURCE Model as a platform. A detailed background to the data used, methodology, calibration and validation of the model development is documented in *Condamine–Balonne River Basin Model, Volume 3 – Calibration of Hydrological Models – Lower Balonne Distributary System (DSITI, 2017).*

1.1 Current model

In preparing a water resource plan (WRP) and a resource operations plan (ROP) under the *Water Act 2000* (Qld), Queensland develops a hydrologic model to test management scenarios. The current plans, viz. the Water Resource (Condamine–Balonne) Plan 2004 (current WRP) and the Condamine and Balonne resource operations plan July 2015 (current ROP), uses the Integrated Quantity Quality Model (IQQM) for the catchment models.

The current ROP model for the Condamine–Balonne also forms the basis for the audited Cap model which supports Cap Reporting requirements under the Murray–Darling Basin Agreement and in the transition to the Basin Plan Section 71 reporting. Note that the current ROP and Cap models use different simulation periods but are otherwise the same.

In the ROP and Cap models, the Lower Balonne Distributary System was represented as a separate IQQM.

1.2 Proposed Model

Queensland has developed a new model for the Lower Balonne Distributary System as part of the review of the current WRP and ROP and for the proposed Water Plan (WP) package being developed to comply with Basin Plan requirements. This new Draft WP model differs from the current model on the following points:

- A more detailed representation of the system, especially the Narran Lakes system.
- Updated Methodology – Queensland has updated the model methodology based on the learnings from previous model builds to improve the robustness of the model. This update has come from model application, internal and external audits and developments external to technology. This is addressed in Appendix A. A key driver for this update was so that the model could be used to determine the sustainable diversion limit (SDL) and the baseline diversion limit (BDL) consistent with the Basin Plan requirements i.e. Chapter 10 and Position Statement 3 C Method for Determining Take.
- Better Data – With every review more data becomes available. This is particularly significant in the case of the Distributary system where a long-term flow was used to improve the representation of antecedent conditions in the loss nodes and a record flood was used to improve the representation of breakouts in the system. This is addressed in Appendix A.

It needs to be noted that there have been changes to water allocations between the current and new Draft WP models because of the recovery of water for the Basin Plan.

1.3 Basin Plan Requirements

The Basin Plan prescribes requirements that Queensland needs to address to meet accreditation.

The key requirements that need to be addressed by the model are:

1. BDL – Baseline diversion limit of an SDL resource unit. The Baseline diversion limits are determined based on development conditions as specified in Schedule 3 of the Basin Plan. In general, the BDL is a sum of:
   - take from water courses
   - take from regulated river
   - take by floodplain harvesting
   - take by commercial plantation
   - take from basic rights

   The model provides a component of the take identified in Schedule 3 as the long-term annual average limit on the quantity of water that can be taken from the watercourse and from regulated rivers. The other forms of take are considered in the Water Accounting Methods Report (NRM, 2016).

2. SDL – Sustainable diversion limit of the Water Resource Plan area. The SDL is the long-term average sustainable diversion limit from an SDL resource unit as defined in Schedule 2 and 4 of the Basin Plan. Clause 10.10 of the Basin Plan specifies that the Water Resource Plan must set out the method for determining the maximum quantity of water that the plan permits to be taken for consumptive use during a water accounting period. This method may include the modelling. For the Condamine–Balonne SDL resource unit, Queensland prepared the IQQM Model to meet this requirement. As there are no SDL adjustment measures proposed for the Condamine–Balonne, the difference between BDL and SDL is achieved by Commonwealth water recovery. To simulate SDL in the model, the Commonwealth's water entitlements would have to be treated as inactive (i.e. not used for consumptive take).

3. Annual Actual Take – Determination of annual actual take must be specified. As per clause 10.15 of the Basin Plan, the determination of the quantity of water, actually or estimated, taken for the consumptive use by each form of take from each SDL resource unit will be determined after the end of a water accounting period. The method used to estimate the quantities should be same as used to determine BDL and SDL.

4. Environmental Water – Determination of the environmental water requirements of environmental assets and ecosystem functions. Clause 8.51, sub-sections (1) and (2) of the Basin Plan list a number of measures to determine the environmental water requirements of an environmental asset and states that a method to estimate them may include a conceptual model.

5. SDL Adjustment Proposals – Models are an important tool for evaluating the SDL adjustment proposals. Chapter 7 of the Basin Plan states that the Authority can propose adjustments to the surface water SDLs if certain additional changes in infrastructure are proposed through the implementation of 'supply measures' and 'efficiency measures'.

Sections 10.22, 10.49 and 10.50 of the Basin Plan specify requirements that the WRP Package meet:

a) Section 10.22 states that a water resource plan must describe what was done to comply with the requirements mentioned in Part 4, Chapter 10 of the Basin Plan.

b) Section 10.49 states that:
   - A water resource plan must be based on the best available information
   - The water resource plan must identify and describe the significant sources of information on which the water resources plan is based.

c) Section 10.50 states that:
   "A water resource plan must identify any significant method, model or tool that has been used to develop the water resource plan."

This report covers the requirements outlined above.

2 Lower Balonne Distributary System SOURCE Model

The Lower Balonne Distributary System Model was developed by using the SOURCE Modelling platform. A detailed background to the data used, methodology, calibration and validation of the model development is documented in Section 6.25 of *Condamine–Balonne River Basin Model, Volume 3 – Calibration of Hydrological Models – Lower Balonne Distributary System (DSITI, 2017).*

Figure 1 shows the extent of the model.

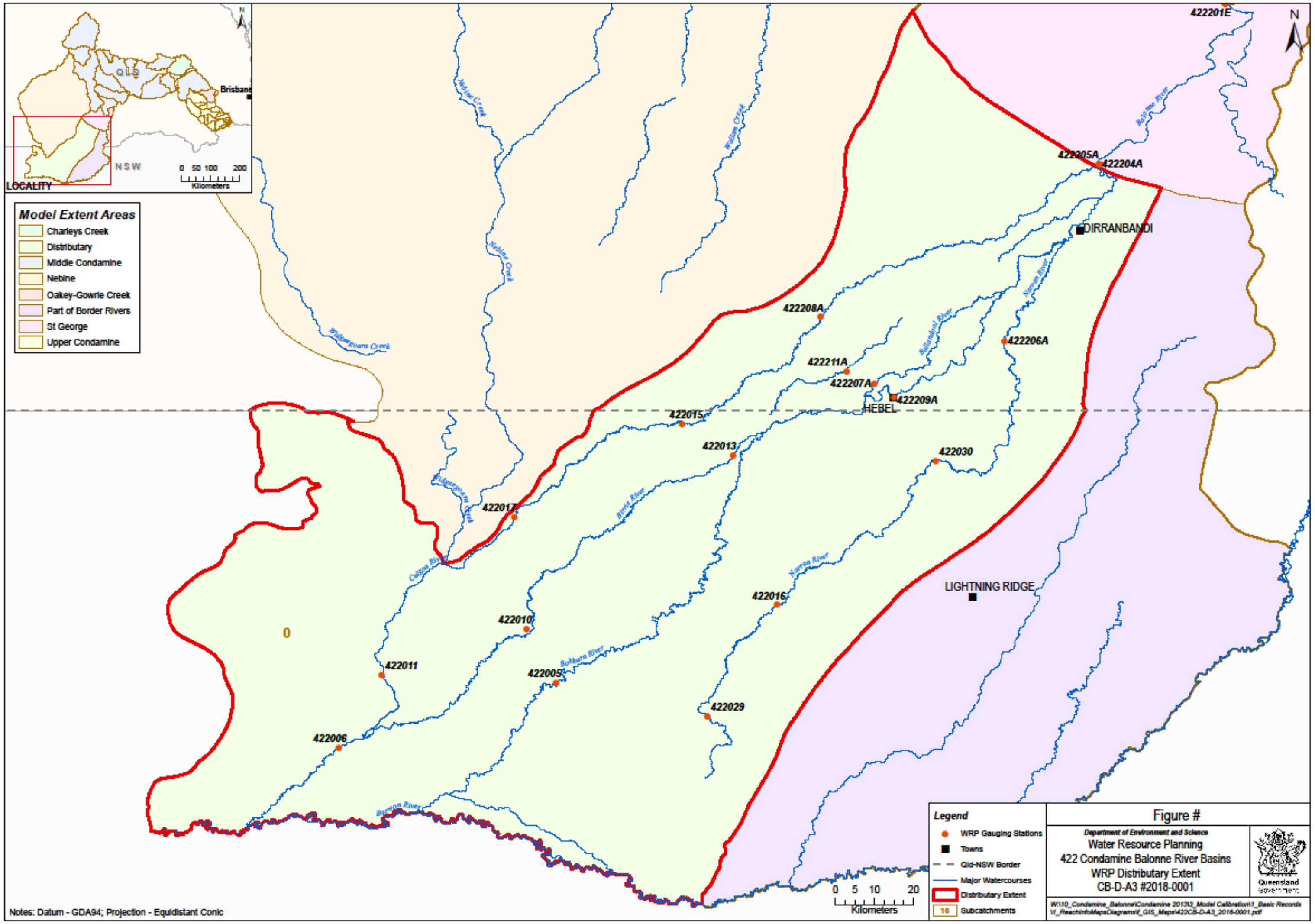

Figure 1 Model Extent

3 Model Scenarios

In this section, the model scenarios are described. The details of the model scenarios are described in Table 1.

Table 1 Detail of the Model Scenarios

Case Number	Model Name	Description	Simulation Period
1710D	Current Cap IQQM	This IQQM model was developed to underpin the first generation Water Resource Plan (WRP, 2004) and Resource Operation Plan (ROP,2008) and was later extended to cover the Basin Plan Period.	1895–2017
1811E	Current Cap IQQM Adjusted for Trades	This IQQM model was the Current Cap Model modified to reflect the trades up to June 2017.	1895–2017
1902H	New Lower Balonne Distributary Draft WP SOURCE Model	This SOURCE model was developed to underpin the second generation Water Resource Plan representing all of the Water Allocations and licences in the basin reflecting trade up to November 2018.	1889–2013
1808J	New Lower Balonne Distributary Draft WP IQQM	This IQQM model was developed to assist identify the cause of difference between the SOURCE model and the Gen 1 IQQM.	1889–2013

All of the model scenarios cover a period greater than the Basin Plan (1895–2009) so they are able to fulfil the Plan's requirements. All results in this report are provided for the Basin Plan period.

These scenarios were used to simulate the extractions (BDL) under the Resource Operation Plan for the Lower Balonne Distributary System.

The model simulated the flows and extractions by water allocations.

3.1 Current Cap IQQM (Case 1710A)

A current Cap IQQM case (case 1710D) was simulated using the current Lower Balonne Distributary ROP IQQM. The inflows to the model were estimated using the St George Current Cap model and the Nebine Cap IQQM.

3.1.1 Storage Details and Assumptions

There are no major on-stream storages in the Lower Balonne Distributary system. Details of the weirs in the system are given below. Details of the on-farm storages were determined during the Gen 1 ROP certification process.

Table 2 Lower Balonne Distributary System On-stream Storages

IQQM node no and description	Full Supply Volume (ML)	Dead Storage Volume (ML)
5 B1 Bifurcation Weir	1,000	100
12 B2 Bifurcation Weir and Dirranbandi Weir	1,800	180
41 B3 Bifurcation Weir and Stevenson Water Harvesting Storage	850	85
15 Weirs B2 to GS422206A	400	40
16 Narran R – Upstream 422206A WH On-stream Storage	800	80
22 Narran R – Downstream 422206A WH On-stream Storage	900	90
284 New Angledool Weir	200	20
194 Bokhara R – Weirs B3 to GS 422209A	260	26
196 Bokhara R – WH Storages B3 to 422209A	100	10
185 Bokhara R – Weirs downstream of 422209A	160	16
192 Ballandool R – B3 to 422207A	741	50
188 Ballandool R – WH Storages downstream of 422207A	150	15
69 Briarie Ck – Weirs upstream of 422211A	300	30
11 Briarie Ck – Weirs downstream 422211A	1,500	50
57 Culgoa R – WH Storages from 422204A to 422208A	1,500	150
289 Goodooga Weir	90	0
286 Weilmoringle Weir	600	60

3.1.2 Management System

The Lower Balonne Distributary system does not have a water management system for supplemented users. However, there is an announcement system that controls access to water harvesting. This is implemented in the IQQM using a file controlling the water harvesting.

The environmental management rules specified in the current WRP were implemented in the IQQM using a water harvesting control file created by the St George Current Cap model.

3.1.3 High Priority Demand

The town water supplies in the model are described below.

Table 3 Lower Balonne Distributary Town Water Supplies

IQQM node no and description	Nominal Volume (ML/a)	Water Allocation Group
13 Dirranbandi TWS WA 1614	205	LB4
187 Hebel TWS WA 1615	10	LB7
285 New Angledool TWS	20	NSW
80 Goodooga TWS	100	NSW
287 Weilmoringle	20	NSW

3.1.4 Medium Priority Demand

There is no medium priority demand supplied from the Lower Balonne Distributary System.

3.1.5 Unsupplemented Demand

The unsupplemented demands in the Lower Balonne Distributary System can be found in Attachment 10C of the ROP (2008) along with the overland flow licences in Attachment 12. The water harvesting thresholds used in the model have been adjusted to reproduce the announcement system which is based on the inflows to Beardmore Dam when the dam is overflowing. The model thresholds are given in Appendix B.

3.2 Current Cap IQQM Adjusted for Trades (Case 1811E)

The model is the same as the Current Cap IQQM, except that the allocations that have had a change in conditions have been adjusted to reflect the change in conditions. The allocations are the same as in the new Draft WP Model described below. The main difference is the inflows are from Case 1811A for the Current Cap St George model adjusted for trades and the rainfall, evaporation and crop demand from the current Cap model have been used. The event management rules from the current Cap model were also used.

3.3 New Lower Balonne Distributary System Draft WP SOURCE Model (Case 1902H)

The new Lower Balonne Distributary System Draft WP SOURCE model used the flows estimated using the St George Model (Case 1808J). The recovered water in this section has been separated from the original allocations and have been represented as individual allocations.

3.3.1 Storage Details and Assumptions

The storages in the Lower Balonne Distributary system SOURCE model are given in

Table 2.

3.3.2 Management System

The Lower Balonne Distributary system does not have a water management system for supplemented users. However, there is an announcement system that controls access to water harvesting. This is implemented in the SOURCE model using a file controlling the water harvesting in a similar manner to the Current Cap IQQM.

3.3.3 High Priority Demand

The town water supplies are described in Table 3.

3.3.4 Medium Priority Demand

There is no medium priority demand supplied from the Lower Balonne Distributary System.

3.3.5 Unsupplemented Licensed Data

Details of the allocations in the model can be found in the spreadsheet called ‘Lower Balonne WMA - from RCS-QA.xlsx’. The water harvesting allocations with a Multi-Year Volumetric Limit (YVL) were represented with large demand, while the allocations with an Instantaneous Volumetric Limit (IVL) were presented by the storages supplied during the certification process with the capacity restricted to the IVL.

3.4 New Lower Balonne Distributary Draft IQQM (Case 1808J)

The new Lower Balonne Distributary Draft WP IQQM is a copy of the new Lower Balonne Distributary Draft WP SOURCE model converted to the IQQM platform. Because the IQQM model used the same flow and model network as the SOURCE model, it was used to identify the differences caused by the change in the modelling platform.

4 Reconciliation with Murray–Darling Basin Plan Schedule 3

The Basin Plan places limits on water extractions within the SDL resource units. The model 1808J is proposed to estimate the available water, specifically the take from watercourses for water allocations and licences. This will support the Water Accounting Methods proposed in the Water Accounting Methods Report (NRM, 2016) for the other forms of take and classes of water access right. For the details on these proposed methods, see the report cited above.

The following section provides the comparison and of the long-term diversions between the various model scenarios, using the Basin Plan simulation period 1895–2009. Table 4 provides a comparison between the long-term diversions of the water allocations in the model scenarios while Table 5 presents the mean annual flow at the Border, while Table 9 presents the mean annual flow at the end of system gauges. The flows for the Without Development Cases are presented in Table 7 and Table 8.

Table 4 Long-Term Diversions for the Various Models (1895–2009)

Demand	Current Cap IQQM (1710D) (GL)	Current Cap IQQM Adjusted for Trades (1811E) (GL)	New Lower Balonne Distributary Draft WP SOURCE Model (1902H) (GL)	New Lower Balonne Distributary Draft WP IQQM (1808J) (GL)
Unsupplemented Demand	202	201	205	205
Overland Flow	77	80	81	83
Total	279	281	286	288

Table 5 Long-Term Flows at Border for Development Cases (1895–2009)

Location	Current Cap IQQM (1710D) (GL)	Current Cap IQQM Adjusted for Trades (1811E) (GL	New Lower Balonne Distributary Draft WP SOURCE Model (1902H) (GL)	New Lower Balonne Distributary Draft WP IQQM (1808J) (ML)
Culgoa at Brenda Gauge (422015)	226	216	238	234
Briarie at Woolerbilla-Hebel Rd (422211A)	38	48	57	56
Ballandool at Hebel-Bolon Rd (422207A)	32	33	37	32
Bokhara at Hebel (422209A)	38	39	41	41
Narran at Border	87	87	93	91
Total	421	423	466	454

Table 6 Long-Term Flows at the End of System Gauges for Development Cases (1895–2009)

Location	Current Cap IQQM (1710D) (GL)	Current Cap IQQM Adjusted for Trades (1811E) (GL	New Lower Balonne Distributary Draft WP SOURCE Model (1902H) (GL)	New Lower Balonne Distributary Draft WP IQQM (1808J) (ML)
Culgoa at Downstream Collerina (422006)	202	200	216	213
Bokhara at Goodwins (422005)	26	31	34	34
Narran at Narran Park (422029)	63	64	68	66
Total	291	295	318	313

Table 7 Long-Term Flows at Border for Without Development Cases (1895–2009)

Location	Current Cap IQQM (1710D) (GL)	New Lower Balonne Distributary Draft WP SOURCE Model (1811F) (GL)
Culgoa at Brenda Gauge (422015)	620	590
Briarie at Woolerbilla-Hebel Rd (422211A)	81	88
Ballandool at Hebel-Bolon Rd (422207A)	57	49
Bokhara at Hebel (422209A)	54	50
Narran at Border	179	171
Total	991	948

Table 8 Long-Term Flows at the End of System Gauges for Without Development Cases (1895–2009)

Location	Current Cap IQQM (1710D) (GL)	New Lower Balonne Distributary Draft WP SOURCE Model (1811F) (GL)
Culgoa at Downstream Collerina (422006)	478	481
Bokhara at Goodwins (422005)	50	53
Narran at Narran Park (422029)	133	120
Total	661	654

It should be noted that the new Lower Balonne Distributary models now includes the water harvesting allocations that were previously in the St George model. The mean annual diversions of these allocations have been included in comparison above.

The main reason for the increase in the diversions was the increase in the flow into the Distributary system from upstream. The increased flow from breakout flows from the Middle Condamine model that bypassed the St George gauge and came back into the Lower Balonne did not increase the flow during the 1895 to 2009 period of simulation as they only occurred during the record floods in 2011 and 2012.

The total mean annual diversions of the Lower Balonne Distributary system were increased by 3.6 per cent compared to an increase of 7.8 per cent in the inflows at St George. The flow at the Border was increased by 9.7 per cent for the with development situation. For the without development situation, there was a slight 1 per cent decrease in the predicted cross-border flow in the SOURCE model compared to the IQQM, caused by the recalibration of the losses within the Distributary system. The new losses were recalibrated using data that included the recent Millennium drought and included an allowance for dry antecedent conditions.

A comparison between the new SOURCE model and the new IQQM shows there were some differences between the two modelling platforms. The IQQM predicted slightly higher diversions and lower end-of-system flows. The differences were the result of a number of small differences between the modelling platforms. The SOURCE crop model does not exactly reproduce the crop demand of the IQQM and was about 1 per cent less than the IQQM. The method of calculating the evaporation from storages is also different between the two platforms. A discussion of the reasons for the difference between the results of the models is given in Appendix A. A more general discussion of the differences between the IQQM and SOURCE model platforms can be found in DES (2018).

5 Conclusion

The new model for the Lower Balonne Distributary System has benefited from additional information that has become available to update the legislative models that support the Queensland Water Resource Planning process and Murray–Darling Basin Plan requirements. The models have benefited from:

- new climatic and streamflow data
- updated methodology
- longer simulation period and better representation of climatic variability.

The Basin Plan has a simulation period from 1895 to 2009 which differs from both the current Resource Operation Plan (2008) and the new Resource Operation Plan (2017), causing some of the variation in the diversion figures between Basin Plan and State Plan. When a consistent period is applied, it is possible to compare take from watercourses by allocations for the two plans, as shown in Table 4Table 9. The CEWH entitlements in the Lower Balonne Distributary system have been modelled separately. As these allocations are same as the other allocations in the system, they have been modelled as extracting their full entitlement.

Table 9 Long-term mean annual diversions from watercourses under water allocations and licences: comparison of model 1710A and 301A

Mean annual diversions (1895–2009)	Current Cap IQQM (1710D)	Draft WP SOURCE Model (1902H)
Total	279 GL	286 GL
CEWH entitlements only	65 GL	68 GL

As can be seen in Table 9, the ROP 2019 (1812A) estimates of mean annual diversions are slightly higher than the estimates provided by the ROP 2008 (1710D) model. The main difference between the two models is the higher stream flows in the model from upstream resulting from improved methods of estimating flows from rainfall using Sacramento rainfall-runoff models that have been calibrated using calibration techniques. There were also some slight differences caused by the different modelling platforms that have been discussed in more detail in Appendix A.

A summary of the diversions from the various models simulating the Current Cap case is presented in Table 10. This case is the same as the current BDL case. The summary of the diversions from the new Draft WP models are presented in Table 11 for comparison.

The total long-term diversions for the Condamine Balonne system estimated using the Draft WP models were 5 per cent higher than the total estimated using the Current Cap model. Most of the increase was caused by an increase in the overland flow diversion, which was caused by the increased flows in the Draft WP SOURCE model. There was also an increase in the long-term diversion estimated for the unconverted licences in Oaky Gowrie Creek after conversion to allocations using a more refined model. The new Draft WP model predicted an increase in the long-term diversions in the catchment because of an increase in the long-term flows throughout the system and at the end of the system.

The new model demonstrates Queensland’s commitment to improve on the previous model’s robustness and defensibility. All future models will build on the new model and use the latest information, methodologies and technology available at the time when the next new model is developed.

Table 10 Long-Term Diversions for the Whole Condamine-Balonne System from Current Cap IQQM 1710A (1895–2009)

Type of Take	Upper Condamine (GL)	Middle Condamine (GL)	St George (GL)	Distributary (GL)	Total (GL)
Supplemented water allocations	25	3	76	0	104
Unsupplemented water allocations	54	116	124	147	441
Overland flow licences (floodplain harvesting)	0	0	18	59	77
Overland flow licences (local catchment runoff)	17	43	0	0	60
Town water supply	6	3	3	0	12
Unconverted licences	0	15	0	0	15
Total	102	180	221	206	709

Table 11 Long-Term Diversions for the Whole Condamine-Balonne System from Draft WP SOURCE Model 310A and 1811F (1895–2009)

Type of Take	Upper Condamine (GL)	Middle Condamine (GL)	St George (GL)	Distributary (GL)	Total (GL)
Supplemented water allocations	24	3	72	0	99
Unsupplemented water allocations	60	119	124	150	453
Overland flow licences (floodplain harvesting)	0	0	20	61	81
Overland flow licences (local catchment runoff)	12	54	0	0	66
Town water supply	5	3	3	0	11
Unconverted licences	0	23	0	0	23
Total	101	202	219	211	733

6 References

DES (2018), *Differences Between the Source and IQQM Modelling Platforms*. Department of Environment and Science.

Department of Natural Resources and Mines (2016), *Water Accounting Methods Paper for Warrego-Paroo-Nebine Water Resource Plan, State of Queensland, February 2016.*

Department of Science, Information Technology and Innovation (2017), *Condamine-Balonne River Basin Model, Volume 1 – Calibration of Hydroloical Models – to St George (GS422201F).*

ROP (2008), Condamine and Balonne Resource Operations Plan December 2008 Amended July 2017 (Revision 5). Department of Natural Resources and Mines, State of Queensland.

WRP (2004), Water Resource (Condamine and Balonne) Plan 2004. State of Queensland.

Appendix A – Methodology and Data Differences

Methodology and Data Differences 1995 to 2013

The IQQM developed for the first Water Resource Plan was completed in 1998 with a simulation period from 1922 to 1995. The period of simulation was extended from 1895 to 2006 for the CSIRO Sustainable Yield Study and was then extended to 2009 for the Murray–Darling Basin Plan modelling. The Sacramento models developed in the 1990s were used to extend the period of simulation back to 1895.

In 2013, a new set of models were developed for the Condamine–Balonne using the SOURCE platform. These models used an extended data set, which included new gauging stations, as well as new methods for model calibration. Consequently, the flows in the SOURCE models are different from the flows in the original models.

There are also differences between how the SOURCE and IQQM models perform certain processes, which can give different simulated diversions and flows especially in complex systems.

An attempt was made to isolate the differences between the two modelling platforms by setting up an IQQM mode with the same flows and routing and loss parameters as the SOURCE model. It was found that most of the differences could be attributed to the differences in the flows.

A general discussion of the main points of difference between the two models is given below.

Rainfall and Evaporation

Different rainfall and evaporation data were used. Some of the rainfall stations used in the original model have been closed, so it was necessary to use another near-by station in the SOURCE model. SILO patched point data, which is recorded station rainfall infilled with SILO data drill (grid) data at that location, was used.

In the Sacramento modelling, new techniques were used to select rainfall stations in the calibration. Stations were chosen that gave the best agreement between the modelled and measured streamflow.

In the SOURCE modes, evaporation data from the Warwick site were used for all of the catchment even though it is located in the northern section. This site had the best metrological data for the estimation of the lake and potential evaporation in the catchment. It was best to use this data rather than data extrapolated from this site. The evaporation at Warwick would be fairly similar to evaporation in these catchments and any errors are unlikely to have a large effect on the model.

Flow Data

Recorded flow data used to develop the original IQQM and the SOURCE models has varied in a number of ways:

- Different and additional gauges used.
- Longer records with flows associated with more extreme weather conditions.
- Rating changes. This will change earlier flow records if the rating curves change.
- Data may have been extracted differently. Variations include use of different time offsets and different conversion calculations used to generate flow data from levels.

In the original IQQM, stream gauges on the main stream were mainly used for estimating flows. In the SOURCE model, more tributary gauges and new gauges were used to improve the estimation of the flows.

Sacramento Calibrations

The latest Sacramento models are different to the original ones. They use different catchment areas, rainfall, evaporation and flow data (residuals were developed on numerous different modelling assumptions and for different time periods and, in some cases, flow data were extracted differently).

The main difference was the use of the FORS method to determine both catchment parameters and the rainfall stations. This methodology resulted in better agreement between the modelled and measured flows. The Sacramento models were calibrated over a longer calibration period that included a major drought and record floods, which should improve the ability of the model to predict these events.

Use of Historical Diversions in Flow Calculations

There are very few measured diversions in this catchment. The derived inflows can only be accurately adjusted if daily diversion data is available. As this data was not available, it was considered better to not include them in the estimation of inflows.

Flow Adjustment Explained (using DMM)

Once the full length inflow sequences for the whole model were included, further adjustments were made to the Sacramento parts of them to obtain a better match between the model and the long-term recorded flow data in the catchment. The program DMM was used to make the adjustments.

DMM is an adjustment process applied across multiple reaches. It is used to adjust Sacramento data in multiple reaches upstream of a long term gauge, to bring the modelled and recorded flows into alignment. Recorded head water inflows and calculated residual inflows are not adjusted.

DMM first calculates the difference between modelled and recorded flows at the downstream gauge being adjusted to. The differences are caused by inaccuracies in Sacramento inflows due to inaccurate spatial and temporal rainfall and evaporation representation, and also by the averaging of lag and routing, and losses. DMM adjusts the Sacramento parts of the inflow sequences to produce sequences which together with the calibrated model's assumptions, will result in better alignment of the modelled and gauge flows at the long-term gauges. It does multiple iterations to converge towards a best set of adjusted inflows and then the user decides which iteration's inflows give the best result overall. The program usually modifies Sacramento data by scaling in proportion to the differences between the modelled and measured flow at a downstream gauge. If there is gauged flow but no modelled flow, the program distributes the measured flow over the upstream sub-catchments using a scaling factor based on the catchment area of the sub-catchments weighted by the mean annual rainfall on the sub-catchment.

DMM can be applied to align the model to multiple long term gauges. In this case the adjustment is done to the next long-term downstream gauge and the adjusted inflow data is then excluded from adjustments to gauges further downstream.

The final residual reach inflows are used in the model validation and model simulation runs.

Appendix B – Distributary Model Water Harvesting Thresholds

ROP Threshold (ML/day)	St George Model Threshold (ML/day)
1,200	1,910
1,500	2,010
2,000	3,374
2,500	3,415
3,000	5,098
3,500	5,132
4,000	5,554
5,000	6,299
6,000	7,189
7,000	8,546
8,000	14,832
10,000	17,020
12,000	18,196
14,000	19,906
16,000	21,403
18,000	23,523
20,000	25,669
22,000	27,749
24,000	29,797
26,000	31,837
28,000	33,877
30,000	35,917
32,000	37,947
34,000	39,946
36,000	41,947
38,000	43,947
40,000	45,947
42,000	47,947
44,000	49,946
46,000	51,946
48,000	53,947
52,000	57,947
56,000	61,947
60,000	65,947