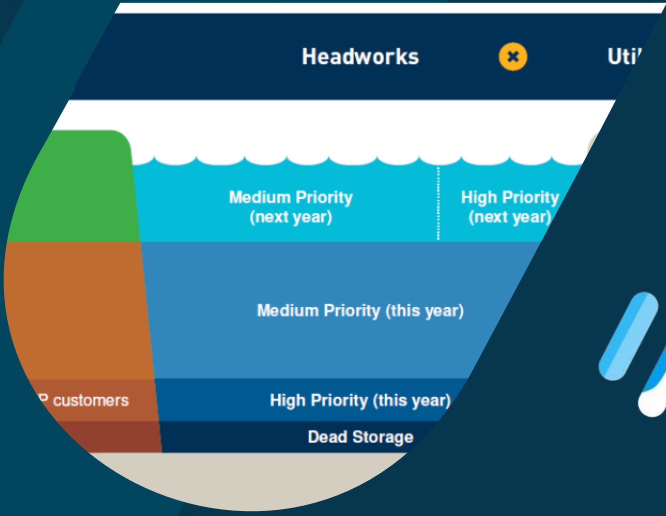

Water Solutions
Certainty in Water

Report to

QUEENSLAND COMPETITION AUTHORITY

on

RURAL IRRIGATION PRICE REVIEW 2020-24

ASSESSMENT OF HYDROLOGIC FACTORS

Job Number	WS0895.1901.001
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Water Solutions
Certainty in Water

Queensland Competition Authority
Rural Irrigation Price Review 2020-24
Assessment of Hydrologic Factors

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Executive Summary

This report summarises the hydrologic advice and guidance provided to assist the Queensland Competition Authority in the conduct of the Rural Irrigation Price Review 2020-24. Three key tasks were undertaken: quality assurance of Headworks Utilisation Factor (HUF) calculations for six specified schemes, a hydrologic review of submissions associated with pricing for the Central Brisbane River scheme Medium Priority (MP) irrigators, and a hydrologic review of submissions associated with pricing for the Giru Benefited Area (GBA) MP irrigators. The key conclusions for each of these three tasks are summarised below.

HUF Methodology Quality Assurance

Relative hydrologic benefit is estimated by calculating the percentage of the scheme's storage volume primarily responsible for delivering the security of supply for each user group

This study carried out a quality assurance review of the data and calculations of SunWater's estimation of the MP HUF for the following schemes; Barker Barambah, Callide Valley, Lower Mary, Nogoa-Mackenzie, Pioneer Valley, and Upper Burnett. The review has checked the data and calculations used for each of the six schemes against the documented procedure provided in SunWater's submission.

In summary, this review has determined that the data and calculations applied by SunWater have generally been in keeping with the procedure documented in SunWater's submission for the six reviewed schemes. A number of small calculation errors and issues have been identified, but these issues only had a modest effect on the calculated MP HUF, with differences less than about 1% to the values quoted in SunWater's submission.

Central Brisbane River Scheme Hydrologic Benefits Review

Dams and weirs do not create water, they create security

The first question in this task is whether the two scenarios presented in the Central Brisbane Benefits Study, the Existing Case and the Without Dams Case, provide an appropriate basis for assessing the relative benefits of the Central Brisbane River scheme to medium priority irrigators.

The review has determined that comparison of the two cases is not an appropriate method to assess relative benefit, because:

- The two cases do not present results against the Environmental Flow Objectives (EFOs) in the Water Plan. It is expected that the Existing Case would meet EFOs, while the configuration of the Without Dams Case makes it likely it would not meet the EFOs, with the Without Dams case allowing irrigators to take water required to meet environmental flow objectives. If one case meets the EFOs while the other does not, then evaluating benefits by comparing these two cases is not a fair comparison.

- The two cases do not present results against the Water Allocation Security Objectives (WASOs) in the Water Plan. It is expected that the Existing Case would meet WASOs, while the configuration of the Without Dams Case makes it likely it would not meet the WASOs for other scheme users, as other users have been removed from the model, and no restrictions are placed on the extraction of irrigators. If one case meets the WASOs while the other does not, then evaluating benefits by comparing these two cases is not a fair comparison.

Further, even if evaluation of the two cases were considered an appropriate method to assess relative benefit, evaluation of the results presented in the report indicates that the dams do provide substantial benefit to MP irrigators.

The second question in this task relates to the comprehensiveness of the presented statistics with regard to evaluating the benefit provided by the scheme to MP users. The key conclusions made regarding the statistics presented in the Central Brisbane Benefits Study are as follows:

- The discussion in the report focuses on the volume of diversion rather than the security of supply. Dams and weirs do not create water, they create security. The focus in evaluating the benefit from a regulated system should be on supply security.
- Based on the presented results, the dams reduce the annual probability of failure to deliver the full MP allocation from 1 in 2 (50%) to 1 in 10 (10%), a five times improvement.
- In addition to this substantial improvement in annual reliability, the dams also provide an effectively guaranteed volume of water for MP users, through the announced allocation procedure, that may be taken at any time of the year. This guaranteed supply is a significant benefit over the vagaries of relying on the occasional fall of rain during a drought period with no dams.
- Other benefits MP users received from the scheme include the predictability and steadiness of the flow, which simplifies the management of the irrigator pumping infrastructure required to access water, and the flood mitigation benefits provided by the dams.

The third part of this task involved estimating the appropriate HUF for Central Brisbane irrigators. A modification to the standard HUF methodology, that addresses the characteristics of the Central Brisbane announced allocation procedure, was developed and applied. This improved procedure provided a MP HUF of 1.12%.

This MP HUF equates to a HP:MP Unit Cost Ratio of 2.27:1, which appears reasonable given the relativity of the WASOs for High Priority (HP) and Medium Priority (MP) specified in the Water Plan.

It is thus recommended that Seqwater re-evaluate the apportionment of costs to MP entitlements in the Central Brisbane scheme based on a modified HUF approach similar to that presented in this report.

Giru Benefited Area Hydrologic Study Review

To be able to compare scheme performance in one area, the cases compared must provide the same level of performance in other areas

This task involved the assessment of the appropriateness of the underlying inputs, assumptions, calculations and models used in the Giru Benefited Area hydrologic study, and the evaluation of whether the modelled cases provide an appropriate basis for costing.

This review has identified a number of issues with the modelling behind the report, issues that raise significant concern with using the results of the modelling for the purpose of pricing. In addition to the issues identified with the model's configuration, it is critical that the model output is examined with regard to the two key objectives associated with the scheme, water supply reliability and environmental flow performance. In the report water supply reliability is generally maintained, but environmental performance, both of the aquifer levels and passflow requirements, are either not met or not assessed.

It is concluded that there is significant uncertainty associated with using the reported results and thus use of the model, in its current form, to provide a basis for pricing is not recommended.

This study has analysed supplemented release and extraction data presented in the submitted Kavanagh 2017 report. Review of this data indicates that GBA irrigators are receiving little contribution from natural Haughton River flows in dry periods. The OD Hydrology model, even with all its issues, also indicates that the contribution of natural flows is very small.

While the OD Hydrology model could be updated to address the issues raised in this report, the supplemented release data tends to indicate that it is unlikely that an improved model will identify that natural flows provide a large contribution to the water security of GBA irrigators.

This study thus concludes that there does not appear to be a strong basis for differential pricing of GBA MP users (that is, increasing unit prices for other Burdekin distribution system MP users to be able to provide a discount for GBA MP users) based on the contribution of natural flows in the Haughton River.

It is thus recommended that Haughton Zone A (including the GBA) is considered as fully part of the Burdekin Haughton Channel Distribution System, with all MP allocations in this distribution system paying the same price.

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Nomenclature

Term	Description
AA	Announced Allocation
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
Att	Attachment
ARI	Average Recurrence Interval
ARR2016	Australian Rainfall and Runoff, 2016 Edition
AWSP	Annual Water Security Performance
BHWSS	Burdekin Haughton Water Supply Scheme
BPEQ	Board of Professional Engineers of Queensland
CBBS	Central Brisbane Benefits Study
CPUVS	Combined Percentage of Useable Volume
CUFSV	Combined Useable Full Supply Volume
CV	Current Volume
CWSA	Critical Water Sharing Arrangements
DD	Diversion Days
DERM	Department of Environment and Resource Management
DNRM	Department of Natural Resources and Mines
DNRME	Department of Natural Resources, Mines and Energy
DLWC	Department of Land and Water Conservation
DSL	Dead Storage Level
DSV	Dead Storage Volume
DSV Hwks	Dead Storage Volume Headworks
EA	Engineers Australia
EC	Existing Case
EFO	Environmental Flow Objective
FSL	Full Supply Level
FSV	Full Supply Volume
FSV Hwks	Full Supply Volume Headworks
GBA	Giru Benefited Area
Govt	Government
GS	Gauging Station
HMC	Haughton Main Channel
HP	High Priority
HPA	High Priority Allocations
HPAmax	High Priority Allocations, maximum
HP1	High Priority Zone 1
HP1util	Effective Utilisation of the HP1 Zone
HP2	High Priority Zone 2

HP2util	Effective Utilisation of the HP2 Zone
HUF	Headworks Utilisation Factor
IQQM	Integrated Quantity Quality Model
MAD	Mean Annual Diversion
MBRI	mid Brisbane River Irrigators
MP	Medium Priority
MPA	Medium Priority Allocations
MPAmin	Medium Priority Allocations, minimum
MP0	Storage volume associated with 0% AA for MP, 100% AA for HP
MP100	Storage volume associated with 100% AA for MP, 100% AA for HP
MP1	Medium Priority Zone 1
MP1F	For the Central Brisbane, a factor to estimate MP1_MP from MPAmin. The factor allows for operational losses, etc., involved in delivering to MP users during the year.
MP1_HP	For the Central Brisbane, a subdivision of MP1 to more closely reflect the storage that is primarily ensuring water security for users other than MP.
MP1_MP	For the Central Brisbane, a subdivision of MP1 to more closely reflect the storage required to supply MP users in the current year.
MP1util	Effective Utilisation of the MP1 Zone
MP1util_HP	For the Central Brisbane, a subdivision of MP1util to more closely reflect the effective utilisation of volume in Zone MP1_HP for HP WAE
MP1util_MP	For the Central Brisbane, a subdivision of MP1util to more closely reflect the effective utilisation of volume in in Zone MP1_MP for MP WAE
MP2	Medium Priority Zone 2
MP2util	Effective Utilisation of the MP2 Zone
MOV	Minimum Operating Volume (usually same as DSV)
NOL	Nominal Operating Level
NV	Nominal Volume
OM	Operations Manual
PB	Parsons Brinckerhoff
P1, P2, P3	Probability of Utilisation for zones in the headworks storages
QA	Quality Assurance
QCA	Queensland Competition Authority
Qld	Queensland
RFQ	Request For Quote
ROL	Resource Operations Licence
ROP	Resource Operations Plan
RPEQ	Registered Professional Engineer of Queensland
S or s	Section
SEQ	South-East Queensland
SILO	Scientific Information for Land Owners

SL	Storage Loss
TOL	Transmission and Operational Loss
TOR	Terms of Reference
UV	Useable Volume
WAE	Water Allocation Entitlements
WASO	Water Allocation Security Objective
WOD	WithOut Dams Case
WMP	Water Management Protocol
WP	Water Plan
WRP	Water Resource Plan
WS	Water Solutions Pty Ltd
WSS	Water Supply System

1 Introduction

1.1 Background

The Queensland State Government referred the monopoly business activities of SunWater and Seqwater to the QCA for an investigation about pricing practices via a referral notice to the QCA dated 29 October 2018. The monopoly business activities to be investigated are those associated with the bulk water supply and distribution of water for irrigation in a specified set of water supply schemes and distribution systems. The key objective of the investigation is to recommend irrigation prices for the period 1 July 2020 to 30 June 2024.

SunWater and Seqwater have subsequently provided submissions to the investigation, as have a range of stakeholders, with the submissions available on the QCA website.

In April 2019 the QCA issued a Terms of Reference (TOR) for a project to undertake an assessment of hydrological factors as a basis for cost allocation in specific water supply schemes, and in May 2019 Water Solutions was engaged to provide this assessment.

This report presents the methodology, results and recommendations of this assessment.

1.2 Key Objective and Tasks

The key objective of the project is as follows:

To provide expert hydrologic advice and guidance to assist the QCA to determine the appropriate apportionment of costs between different customer groups in specified schemes/systems.

The TOR requested three key tasks to be performed in this assessment:

- To conduct an independent quality assurance of SunWater's proposed headworks utilisation factors (HUF) in specified Water Supply Systems (WSSs), to assess whether the underlying data, assumptions and calculations result in appropriate calculations for HUF factors.
- To provide expert advice in relation to the Central Brisbane River Benefits Study submitted by Seqwater. Advice was requested on whether or not the conclusions from this study provide an appropriate means of comparing benefit of the water storage assets between high and medium priority water allocation entitlements (WAE) in this scheme and, if not, recommendations for an alternative suitable methodology.
- To provide an independent peer review of the hydrologic study of the Giru Benefited Area submitted by SunWater, including advice regarding the proportion of water used by customers in this area that can be delivered by natural recharge of the aquifers compared to that from supplemented releases to the Haughton River.

It is highlighted that this review is focused on hydrologic factors associated with the above three tasks. There may be a range of other factors that have influence on the appropriate apportionment of costs between users groups in the assessed schemes. Assessment of non-hydrologic factors is beyond the scope of this review.

1.3 Structure of this Report

The remainder of this report is structured as follows:

- Section 2 presents the methodology and results of the quality assurance review conducted on the calculation of the MP HUF for six nominated schemes.
- Section 3 provides the review and recommendations associated with the assessment of the Central Brisbane River Benefits Study, including recommendations on appropriate methods to calculate the MP HUF for Central Brisbane River WSS Irrigators.
- Section 4 provides the review and recommendations associated with the assessment of the hydrologic study of the Giru Benefitted Area, including recommendations on appropriate methods to calculate the MP HUF for Giru Benefitted Area Irrigators.
- Section 5 provides a summary of the various recommendations made throughout this report.
- Section 6 summarises the conclusions of this report.
- Section 7 lists the key references used in this assessment.

2 HUF Methodology Quality Assurance

2.1 Introduction

The first of the three tasks in this project is to undertake an independent quality assurance of the derivation of the Headworks Utilisation Factors (HUF) by SunWater for six specified schemes:

- Barker Barambah
- Callide Valley
- Lower Mary
- Nogoa-Mackenzie
- Pioneer Valley
- Upper Burnett

The purpose of the HUF calculation methodology is to provide an estimate of the relative share of the storage assets in each Water Supply Scheme (WSS) required to supply the different priority groups in the scheme. The determined shares are used as a basis for apportioning costs between the different priority groups.

Section 2.2 and 2.3 below provide an introduction to the use of supplemented water for irrigation and how this relates to the concept of Priority Groups. Section 2.4 then provides an overview of the HUF methodology, and Section 2.5 a summary of the application of the methodology in SunWater's 2018 submission. Section 2.6 then provides details of the Quality Assurance procedure applied to the six schemes, including a summary of the key outcomes.

2.2 Irrigation and Priority Groups

Water Supply Schemes around the state may deliver to one or more Priority Groups of users. The Water Plan provides a performance objective for each Priority Group, called the Water Allocation Security Objective (WASO). A set of water sharing and operational rules are defined for each Priority Group that provides the required performance. Catchment water balance modelling, typically using the IQQM model, is undertaken to verify that the required performance is provided by the defined rules. The water sharing and operational rules pertaining to the scheme are documented in a range of documents, such as the Water Plan (WP), Resource Operations Plan (ROP), Resource Operations Licence (ROL), Water Management Protocol (WMP), and/or Operations Manual (OM).

The authority to use water from a WSS is provided through the issue of Water Allocation Entitlements (WAE). Each WAE will state the priority group to which it belongs.

A range of labels are applied to the different Priority Groups in a scheme, including groups such as High, High A, High B, Medium, Low, Risk, etc. However the typical scheme has two priority groups, Medium Priority (MP) and High Priority (HP). As the name implies, HP typically has a higher security of supply, that is, HP water will usually continue to be delivered through more severe dry spells than occurs for MP allocations. The higher security is reflected in the higher WASO specified for HP users in the Water Plan, and the defined water sharing and operational rules are structured to provide this higher level of security.

Traditionally MP WAE has been used for the purposes of rural irrigation, while HP WAE was typically used for urban and industrial purposes. However this is generally no longer a legal requirement. A person holding a MP or HP WAE may use water under that entitlement for any purpose, drinking, irrigation, recreation, industrial etc, etc. There are a number of reasons why individual users may wish to hold allocation of a certain security, for example users with orchards typically desire higher reliability that users with annual crops, as the consequences of a period without water are more severe.

It is noted that the current pricing review being undertaken by the QCA is entitled the Rural Irrigation Price Review, however as explained above, those using the WAE for irrigation might hold a WAE in the High, High A, High B, Medium, Low, Risk, etc., priority group. The focus of this review is thus on the appropriate share of the storage assets to assign to the priority group historically associated with irrigation in each scheme (which is High B in the Pioneer scheme, and Medium in the other 5 schemes considered in this review).

2.3 Pricing for Irrigation

SunWater (2018i) provides background on principles and process for setting prices for irrigation customers. Section 1.1 of SunWater (2018i) describes that SunWater's irrigation prices generally take the form of a two part tariff:

1. Fixed tariffs: Charges paid per megalitre of water allocation entitlement held by the irrigator.
2. Volumetric tariffs: Charges paid per megalitre of actual water used by the irrigator, measured at the meter or 'offtake'.

Section 2.2 of SunWater (2018i) indicates that fixed costs need to be divided between high and medium priority allocations, and that most irrigation users hold medium priority water allocation entitlements. SunWater indicates that the division of fixed costs between high and medium priority customers is undertaken through two distinct methodologies:

- The Headworks Utilisation Factor (HUF) methodology is used to allocate a portion of the fixed costs between high and medium priority allocations.
- The remaining portion of the fixed costs is allocated based on the volume of the water access entitlement.

This review is focused on application of the HUF methodology, i.e. the results of this review may influence the allocation of costs in the first dot point above, but will have no influence on the allocation of costs in the second dot point. Thus, even if it is determined that the priority group HUF is zero, this does not necessarily mean that the priority group will pay no fee for their water.

2.4 The HUF Methodology

The purpose of the HUF calculation methodology is to provide an estimate of the relative share of the storage assets in each Water Supply Scheme (WSS) that supply the different priority groups in the scheme. The determined shares are used as a basis for apportioning costs between the different priority groups.

Page A-3 of SunWater (2018j) provides a formal definition for Headworks Utilisation Factors, as follows:

> "Headworks Utilisation Factors are defined as "the percentages of a scheme's storage headworks volumetric capacity able to be utilised by each priority group of water entitlements in that scheme, taking into consideration:

- the application of operational requirements, water sharing rules and Critical Water Supply Arrangements associated with the relevant Resource Operations Plan (ROP) or interim resource operations plan[1] (IROL); and
- the probability of utilisation of the scheme storages under conditions of relative supply shortage".”

The HUF methodology simplifies the various priority groups in a scheme into two buckets, called High and Medium. In most schemes these two categories directly map to their similarly named priority groups, but in some schemes there are exceptions, e.g. in the Pioneer the Medium bucket contains High B WAE (the high bucket contains High A WAE), while in the Callide scheme both High A and High B are in the High bucket, while Medium and Risk are in the Medium bucket.

Section 2.2.1 of SunWater (2018i) outlines the HUF methodology as follows:

- Headworks – the total storage in a water supply scheme is determined and partitioned as shown in Figure 2-1. The partitioning depends on the size of the storage and the operational rules (including water sharing rules).
- Utilisation – the driest 15-year period is found in the hydrological model for the corresponding water plan and probabilities are calculated for the storage being in each of these partitions.
- Headworks x Utilisation = HUF. The final medium priority HUF is calculated by taking both the headworks partition volumes and their utilisation into account.

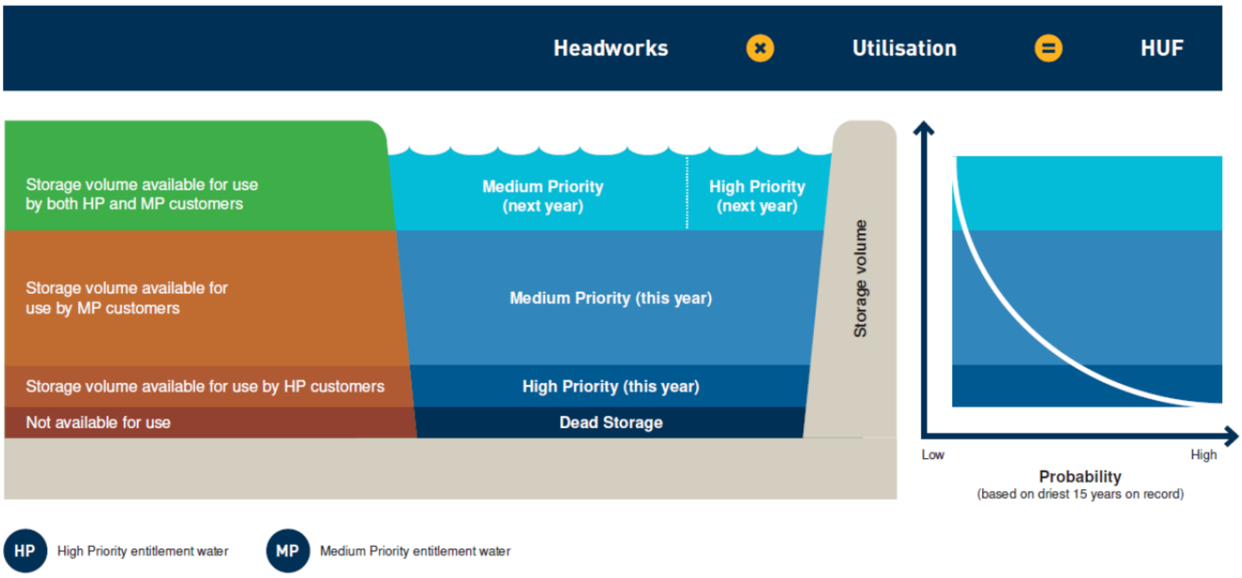

Figure 2-1 – How is the HUF Calculated? (SunWater 2018i)

A more detailed figure illustrating the key parameters in the HUF calculation procedure is presented in Section A.3 of SunWater 2018j, reproduced below.

[1] Plan is used in the source, but it is likely the author meant licence.

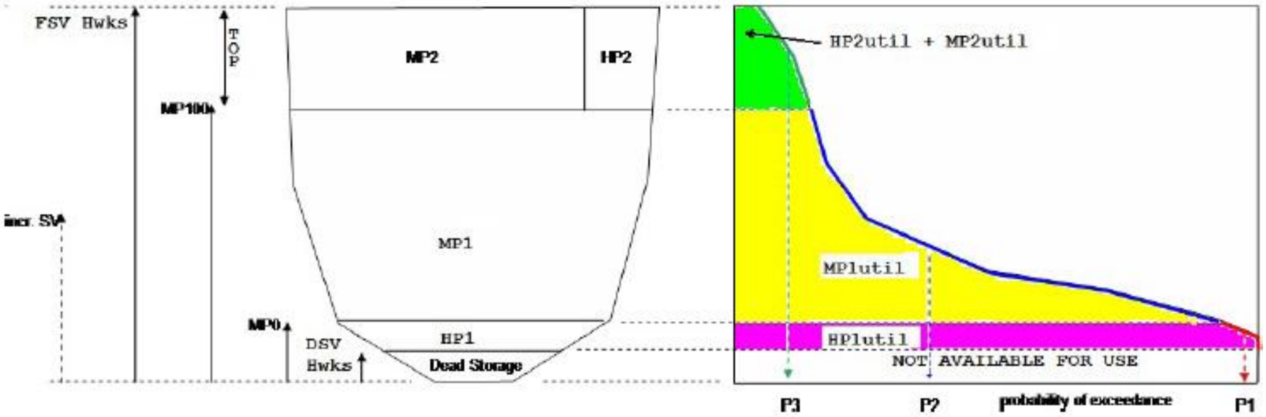

Figure 2-2 – HUF Parameters (SunWater 2018j)

The key steps in the calculation of the HUF are outlined below, drawn from Section A.2 and A.3 of SunWater (2018j):

1. Identify the water entitlement groupings
2. Determine the volumes of the identified water entitlement groupings
3. Determine the extent to which water sharing rules, critical water sharing rules and other operational requirements give the different water entitlement priority groups exclusive or shared access to components of storage capacity
4. Assess the hydrologic performance of each component of headworks storage
5. Determine the Headworks Utilisation Factors

It is highlighted that the scope of this task is constrained to reviewing the application of the HUF methodology, and not the appropriateness of the steps included in the HUF calculation procedure. The HUF procedure itself has been reviewed in the 2012/3-17 Price Review, and has been accepted by the QCA as being fit for purpose. This section thus focuses on whether the HUFs have been determined using the procedure documented in SunWater 2018j.

2.5 Application of the HUF Methodology in SunWater's 2018 Submission

SunWater (2018j) presents the technical methodology of the HUF approach, consolidating material presented in a number of reports associated with the previous price path review. Section 2.2.1 of SunWater (2018i) indicates that the HUF methodology applied in the 2018 submission is consistent with the approach approved by QCA in the previous price review in 2012.

Table 1.1 of SunWater (2018j) outlines the reasons why the HUF has changed for a number of schemes. Some additional changes since the last price review are also discussed in Section 2.2.2 of SunWater 2018i.

SunWater presents the key parameters in the calculation of the HUFs in Section 2 of SunWater 2018j. SunWater's estimates of the resultant HUFs for each priority group for the nominated schemes are presented in the table below (drawn from Table 1 in SunWater (2018j))

Table 2.1 – Revised HUFs for Selected Schemes

Scheme	Original MP HUF	Revised MP HUF	Other Priority Group HUFs
Barker Barambah	76%	72%	High – 28%
Callide Valley	10%	27%	Risk – 1% High A – 58% High B – 14%
Lower Mary River	42%	48%	High – 52%
Nogoa Mackenzie	45%	28%	High – 72%
Pioneer Valley	44%	38%	High A – 62%
Upper Burnett	18%	64%	High – 36%

As the first QA check in this review, the revised HUFs presented in the table above do, as expected, add up to 100%.

2.6 2019 Quality Assurance Review

The data and calculations of SunWater's estimation of the MP HUF were checked in this study. Notes on the Quality Assurance process applied for each of the six schemes of interest to this review are provided in tables in Appendix A. Each table contains notes against the key steps of the HUF calculation procedure outlined in Section 2.4.

In summary, the quality assurance audit presented in Appendix A has determined that the data and calculations applied by SunWater have generally been in keeping with the procedure documented in SunWater's submission for the six reviewed schemes. A number of small calculation errors and issues have been identified, but these issues only had a modest effect on the calculated MP HUF, with differences less than about 1% to the values quoted in SunWater's submission.

A summary of the key outcomes and recommendations for each reviewed scheme is provided in Section 2.6.1 below, while Section 2.6.2 contains a preliminary re-estimation of the MP HUFs for the 6 schemes with the identified issued addressed.

2.6.1 HUF QA Recommendations Summary

A summary of the key outcomes and recommendations related to the identified issues for each scheme is provided below:

Barker Barambah

- The HUF calculations for this scheme have generally been undertaken in accordance with the documented procedure. One small issue was identified (see below), but the net effect of this issue on the MP HUF was insignificant.
  - A small typo in the storage level used for Joe Sippel Weir (294.4m instead of 294.5m) was identified in the calculation of MP 0 using the AA spreadsheet.
- Update the Departmental website listing of total MP allocation in the Barker Barambah scheme to remove the erroneous double listing for Barambah Zone HZ.

Callide

- The HUF calculations for this scheme have generally been undertaken in accordance with the documented procedure. Two issues were identified (see below), but the net effect of these issues on the MP HUF was insignificant.
  - Convert the maximum amount of MP to HP using the rules in the Fitzroy Water Management Protocol, and then update the HUF calculation to reflect this change. (This action has been completed by SunWater in the addendum to Appendix J provided during this review.)
  - Update the minor typo in the documentation for the FSV of Callide Dam (ROL value is 136,300 ML).
- Consider, perhaps in a future price path, the appropriate adjustment to make to the calculation of the MP HUF to reflect the benefit provided to those users storing Awoonga Dam water in the air space of Callide Dam.
- Consider, perhaps in a future price path, the issues raised in Appendix A with regard estimation of MP100 in the Callide Valley WSS HUF Investigation for this scheme. It is recommended that a report is prepared presenting the data, methodology and results of the Callide Valley WSS HUF Investigation. The report should include a professional opinion on the recommended methodology to calculate the HUF for this non-standard scheme, both for current HP/ MP allocation volumes and for possible future traded HP / MP allocation volumes.
- Consider, perhaps in a future price path, an update to the Callide HUF to subdivide the HP zone into the parts of that zone associated with High A and High B, as the difference in the security of High A and High B appears to be around the same as the difference between the security of High B and Medium Priority.
- At the appropriate time, update the Callide ROL to correct:
  - The name of Kroombit Dam
  - The accepted DSV of Callide Dam

Lower Mary

- The HUF calculations for this scheme have generally been undertaken in accordance with the documented procedure. Two issues were identified (see below), but the net effect of these issues changed the MP HUF by less than 1%. If time permits, it would be of benefit to update the calculations to address these minor issues:
  - In the calculation of MP0, Tinana Barrage was set to its full supply level while Mary Barrage was set to a low level. It is recommended consideration is given to the range of potential level combinations that might apply to this situation. (A preliminary re-estimation of MP0 gave 11,609ML, slightly lower than the value adopted by SunWater.)
  - The MPAmin value applied in the HUF calculation spreadsheet was slightly different to that documented in s2.6 of SunWater 2018j.
- It is noted that the scheme allocations have changed slightly owing to water trading since SunWater undertook their calculations. If the HUF calculations for this scheme are updated, it would be of benefit to use the latest available allocations.
- At the appropriate time, review and potentially delete Att 4 Part 3 Table 8 of the Mary ROP.

Nogoa Mackenzie

- The HUF calculations for this scheme have generally been undertaken in accordance with the documented procedure. Two issues were identified (see below), but the net effect of these issues changed the MP HUF by less than 1%. If time permits, it would be of benefit to update the calculations to address these minor issues:
  - Update the HUF calculation spreadsheet to apply the correct values of MPAmin and HPAmax.
  - Check that the time series of storage volumes from the IQQM model in the HUF calculation spreadsheet are being incorporated into the calculation in chronological order.
- Ensure the AA spreadsheets (used to calculate MP0 and MP100) and the HUF calculation spreadsheet are appropriately archived in the working for the price review.
- At the appropriate time, update the base IQQM model to reflect the deflated Bedford Weir fabridam, and reconfirm that the Water Plan objectives are still met. Use the revised time series of headworks volumes in future calculations of the HUF.
- At the appropriate time, update the Operations Manual to reflect the deflation of the Bedford Weir fabridam.

Pioneer

- The HUF calculations for this scheme have generally been undertaken in accordance with the documented procedure. One issue was identified (see below), but the net effect of this issue changed the MP HUF by less than 1%. If time permits, it would be of benefit to update the calculations to address this minor issue:
  - Review the reason why the Pioneer AA spreadsheet appeared unable to solve the equations in the level range 284.78 to 284.84, and update the HUF calculation if required.
- At the appropriate time, update the base IQQM model to reflect the deflated Dumbleton Rocks Weir and Mirani Weir fabridams, and reconfirm that the Water Plan objectives are still met. Use the revised time series of headworks volumes in future calculations of the HUF.
- At the appropriate time, update the Resource Operations Plan to reflect the deflation of the two fabridams.

Upper Burnett

- The HUF calculations for this scheme have generally been undertaken in accordance with the documented procedure.
- It is noted that the scheme allocations have changed slightly owing to water trading since SunWater undertook their calculations. If the HUF calculations for this scheme are updated for any reason, it would be of benefit to use the latest available allocations in the update.
- At the appropriate time, update the base IQQM model to reflect the deflated Claude Wharton Weir fabridam, and reconfirm that the Water Plan objectives are still met. Use the revised time series of headworks volumes in future calculations of the HUF.
- At the appropriate time, update the Resource Operations Plan to reflect the deflation of the fabridam.
- Ensure that separate costs are appropriately determined for the John Goleby Weir sub-scheme, as the weir and its allocations have been removed from the calculation of the

Upper Burnett MP HUF. With this sub-scheme only supplying MP users, a MP HUF of 100% applies for this sub-scheme.

- In this scheme 10,469ML of MP allocation was assumed to be converted to Low Priority allocation and ignored in the calculation of the HUF. The documented HUF methodology does not appear to allow existing MP allocation to be ignored in the calculation of the HUF, and also does not appear to allow conversion of MP allocation to priority groups other than HP as part of the HUF calculation. However this scheme is a special case, and the reasoning provided for converting and ignoring these allocations in the calculation of the HUF for this scheme appears to be reasonable. It is thus recommended that the HUF methodology is updated to explicitly allow the steps that were taken in this scheme, by, for example, allowing unsaleable allocation to be ignored in the calculation of the HUF. (In the future, if this allocation becomes saleable, as either medium or low priority, it is recommended that it is accounted for in the calculation of the HUF.)

In addition to the recommendations above, some more general recommendations were developed during this review, summarised below:

General HUF Procedure

- Update the procedure to reflect the way MP1util, etc. are actually calculated (steps 1 to 7 on page A-10 of SunWater 2018j). The definitions of P1, P2 and P3 should either be updated, or deleted from the procedure as they are not a necessary step to calculate the HUF.
- Ensure that an appropriate number of significant figures are quoted on the determined HUFs when the HUFs are being used to calculate prices, particularly for small percentage HUF values.

It is noted that some of the recommendations above may require investigation beyond the time available in this Price Review. If the scope of the task prevents it being assessed for the current Price Review, it is recommended that the issue is assessed in time to provide advice to the next Price Review.

2.6.2 Preliminary Re-estimated HUFs

In the process of undertaking this review the MP HUF's were re-estimated with the various typos, revised allocations etc., identified in Section 2.6.1 addressed, with the results provided in Table 2.2. Please note that this table is provided for information only. SunWater may wish to use the values presented in this table as a guide to any re-estimation of the HUFs for these schemes.

Table 2.2 – Preliminary Estimation of Scheme HUFs

Parameter	Barker Barambah	Callide Valley	Lower Mary River	Nogoa Mackenzie	Pioneer Valley	Upper Burnett
MPAmin (ML)	32,079	13,370	32,630	156,113	47,357	35,291
HPAmax (ML)	2,236	5,611	1,819	56,000	30,753	1,380
FSV Hwks (ML)	136,190	136,300	16,750	1,339,033	160,318	186,740
DSV Hwks (ML)	1,122	2,880	7,065	19,520	8,950	2,581
MP0 (ML)	12,942	20,000	11,609	267,493	55,196	8,409
MP100 (ML)	67,773	81,852[1]	16,750	474,574	107,038	65,929
HP1 (ML)	11,820	17,120	4,544	247,973	46,246	5,828
MP1 (ML)	54,831	61,852	5,141	207,081	51,842	57,520
HP2 (ML)	4,458	16,095	0	228,226	20,977	4,546
MP2 (ML)	63,959	38,353	0	636,233	32,303	116,265
HP1util (ML)	10,381	15,914	4,379	199,552	41,534	5,111
MP1util (ML)	20,763	6,049	4,155	64,539	22,174	13,168
HP2util (ML)	549	0	0	4,930	3,033	0
MP2util (ML)	7,878	0	0	13,743	4,670	1
MP HUF (%)	72.4%	27.5%[2]	48.7%	27.7%	37.6%	72.0%[3]
MP HUF in SunWater 2018j	72%	28%[2]	48%	28%	38%	71%[3]

1 Based on Callide Valley WSS HUF Investigation, and assumes does not change if the MPA drops through trading (See Appendix A).

2 Value for combined Medium and Risk Priority allocations. The disaggregated HUF for Medium Priority is 26.2%, compared to 27% in SunWater 2018j. The disaggregated HUF for Risk Priority is 1.0%, compared to 1% in SunWater 2018j.

3 Total scheme value that includes Burnett Water's allocations. The MP HUF for the non-Burnett Water allocations is 65.2% compared to 64% in SunWater 2018j.

The preliminary recalculated values estimated by this study are provided in the orange row in Table 2.2. The grey row in Table 2.2 shows the MP HUF documented in SunWater 2018j. It can be seen that the preliminary revised values determined in this study are similar to those stated in the SunWater submission.

3 Central Brisbane River WSS Hydrologic Benefits Review

3.1 Introduction

The second of the three tasks in this project is to provide advice related to the appropriate HUF to apply to irrigators (medium priority WAE) in the Central Brisbane River WSS.

The Central Brisbane River WSS Scheme serves 126 MP users and two HP users (Table 2, Seqwater 2018). 123 of the MP users are for irrigation, while the other three consist of two Councils and a golf club. The two HP users are the Glamorgan Vale Water Board and Seqwater itself (Both the Glamorgan Vale Water Board and Seqwater use their allocation to provide water to a range of water users).

S4.5 of QCA's April 2013 Report on the Central Brisbane River WSS provides a brief summary of the history of prices charged to irrigators in this scheme. The report indicates that no charges were applied to these irrigators in the 2006-2011 price path, but that tariffs were applied in the 2013-17 price path.

As part of the development of the 2013-17 price path Seqwater commissioned Parsons Brinkerhoff to apply the HUF methodology to assist in determining the appropriate price for these users. However application of the methodology in a strict manner by PB resulted in a MP HUF of 69%, even though HP urban accounts for 97.5% of the WAE. Parsons Brinkerhoff thus suggested an alternative method that resulted in MP HUF of 2.1%. After a number of submissions and further calculations, the QCA adopted a value of 1.6% for the 2013-17 Irrigation Price Review.

Section 2.1 of Seqwater (Nov 2018) discusses interaction with the Mid-Brisbane River Irrigators (MBRI) as part of preparation for the pricing review. Seqwater advised of the MBRI's submissions to the last QCA review, in which they submitted that they did not receive any service from the scheme, as water had been available for irrigation before the dams, and because the dams were not constructed for irrigation supply. Seqwater further advises that, following the last pricing review, MBRI still considers that their questions regarding the level of service provided by the scheme have not been sufficiently addressed.

Seqwater has thus funded an independent study to assist in resolving the MBRI's questions regarding the level of service provided. SLR Consulting undertook the study and provided a report on the matter dated Oct 2018. Based on this study, Seqwater stated in its submission that "there is no hydrologic benefit for the MP irrigation customers from the scheme, therefore on this basis Seqwater submits that these customers should have no share of scheme costs" (Seqwater Nov 2018). That is, Seqwater's submission is that the MP HUF for this scheme is effectively 0%.

In this study the QCA requires the provision of expert advice and guidance in relation to the benefit the scheme assets provide to MP WAE irrigators in this scheme. This advice includes advice on the Central Brisbane Benefits Study (SLR 2018), in particular:

- the appropriateness of comparing the two modelled scenarios as a basis for assessing the relative benefit of the scheme's bulk water assets that is attributable to each WAE priority group, or whether the assessment should be based solely on the existing case reflecting existing regulatory arrangements,
- the comprehensiveness and relevance of output statistics presented, in terms of assessing the relative benefit of the scheme's bulk water assets that is attributable to each WAE priority group,

- whether the results from this study provide an improved approach to assigning benefits attributable to each WAE priority group in the Central Brisbane River WSS, as compared to the adjusted nominal WAE used by the QCA in the 2013 review.

Advice on these three specific areas of inquiry are summarised in the following sections.

3.2 Appropriateness of the Scenarios as a Basis for Assessing Relative Benefits

Assessing the relative benefits of a water supply scheme to the different priority groups it serves is not a simple task. The natural flow regime is complex with a huge range of climatic conditions leadings to wet and dry periods with many different characteristics. Users are distributed spatially, having different access to structures and tributary flows and incurring different levels of transmission losses. Priority groups may have significantly different levels of security and scheme operation rules may be complex. The amount of water able to be accessed by the various priority groups over time varies significantly depending on all of these factors.

In the previous price path, the HUF methodology was applied in most schemes for the purpose of defining the relative benefit to each priority group of users from the scheme assets. The HUF methodology has been accepted as providing a reasonably fair approach to defining relative benefit for most schemes. For the Brisbane scheme the standard approach did not provide an appropriate result, and thus the method was further modified, with the QCA adopting a MP HUF of 1.6% for the 2013-17 Irrigation Price Review.

In the current price path, the Central Brisbane Benefits Study presents an alternative methodology where the benefit to irrigators is assessed by running a modified Brisbane River IQQM model. The base Moreton Water Plan full use of entitlements IQQM scenario is modified in the Central Brisbane Benefits Study as follows:

- Somerset Dam and Wivenhoe Dam are (effectively) removed from the model
- All high priority WAE is removed from the model.
- The regulated irrigator nodes representing the Central Brisbane medium priority Irrigators are converted to unregulated irrigator nodes, with no restrictions on what water they can access. If water flows past their location, they will take the water, up to the volume required to satisfy their defined monthly pattern. No local rainfall is included on the unregulated irrigator nodes (and the soil moisture depletion is set to a small number) so that the irrigators will try to extract the same monthly pattern of water regardless of local rainfall.

The Central Brisbane Benefits Study assesses benefit by comparing the extractions made by the irrigators in this alternative case to the amount extracted in the base IQQM scenario. The base IQQM scenario is the State Government's full use of entitlements case that was developed as part of the Moreton Water Plan, extended by the Department to cover the millennium drought (Period of Simulation Jan 1889- June 2011).

Based on a number of statistics the Central Brisbane Benefits Study concludes that less water is available to irrigators in dry periods in the base IQQM scenario compared to the modified scenario, and thus that:

> "Wivenhoe and Somerset Dams (and the associated operational and entitlements) provide Central Brisbane Irrigators with no significant change to modelled hydrologic benefit, when compared to the predicted access under a hypothetical scenario where

> irrigators were able to take water from natural river flows and where there were no dams and system regulation for urban purposes."

The first question QCA requires to be answered in this task is whether the two scenarios presented in the Central Brisbane Benefits Study provide an appropriate basis for assessing the relative benefits of the Central Brisbane River WSS to medium priority irrigators.

It is the opinion of this review that the answer to this question is No.

The key reasons for this determination are discussed in the following sub-sections.

3.2.1 Historical Conditions

One of the reasons submitted for why the irrigators should not contribute to expenses of the scheme is that the irrigators do not receive any service from the dam because the water had been available for irrigation before the dams, and because the dams were not constructed for irrigation supply (s2.1, Seqwater Nov 2018). Seqwater advises that this concern was raised in MBRI's submissions to the last QCA review, and that MBRI still considers that these questions have not been sufficiently addressed, and that the Central Brisbane Benefits Study was commissioned to address these concerns.

Further, the original cases to be assessed in the Central Brisbane Benefits Study, as requested in the RFQ for that task, are defined in s6.2 of SLR (2018). Three cases were originally requested:

1. *Current development (Moreton Water Plan) case under full utilisation of existing entitlements, existing instream water infrastructure and current storage operational strategies (the "Existing Case")*
2. *Pre-Wivenhoe dam development case under full utilisation of pre-Wivenhoe dam water entitlements, water infrastructure and conditions of water access (the "Pre-Wivenhoe Dam Case").*
3. *Pre-Wivenhoe Dam Case to further removing Somerset Dam and associated water entitlements (the "Pre-Wivenhoe and Somerset Dam Case").* (s6.2 SLR 2018)

It appears from the above that there was some desire to model pre-dam water entitlements, infrastructure and conditions as part of the methodology to estimate the benefit of the scheme to irrigators.

The authority to divert water for irrigation in the Central Brisbane has undergone a series of significant changes over the decades (some detail is provided in s4.5 of SLR 2018). The MP WAE currently held by irrigators and other users in the Central Brisbane are dramatically different to the authority to divert water that existed before Somerset and Wivenhoe Dams. As a few examples, the WAE are now volume based, separated from land, and able to be traded to other users under the rules presented in the Moreton Water Management Protocol.

However, the Central Brisbane Benefits Study has not modelled these cases as historical, pre-dam construction, conditions. For example, a year has not been stated for the pre-dams case, i.e. the date at which historical extraction conditions are to be modelled. Construction commenced at Somerset Dam in 1935 (Seqwater website)[2]. If the study had sought to model pre-dam

[2] The RFQ requested cases pre Wivenhoe Dam and pre Somerset Dam, but the pre-Wivenhoe case was not modelled in the SLR report owing to the reasons provided in s8.3 of the SLR report. This review thus focuses on the two key cases modelled, the Existing Case and the Without Dams Case.

conditions, it might have selected a year in the 1920s as the 'pre-dams' date, and then researched the actual infrastructure, system operation rules, and issued authorities to divert water for irrigation and for other purposes at the stated year.

It is noted that water storage infrastructure did exist in the Brisbane catchment prior to 1935, for example Mt Crosby Weir, Gold Creek Dam and Enoggera Dam, and also that water was extracted for urban uses in SEQ before 1935. The Central Brisbane Benefits Study does not summarise historical conditions at a particular 'pre-dams' date, nor attempt to model such.

Rather than attempting to model historical conditions accurately, the Central Brisbane Benefits Study takes the current Moreton Water Plan full use of entitlements case and removes selected elements to create a case it calls the "Without Wivenhoe and Somerset Dams Case" (shortened to 'Without Dams' (WOD) in this review). There are a large number of differences between the modelled Without Dams case and accurate historical conditions, but without detailed research it is difficult to be definitive about this. However a few of the likely key differences are summarised below:

- All urban demand has been removed in the Without Dams case, whereas urban areas have used water from the Brisbane River for over 100 years. If an accurate historical case is to be created, historical extractions from historical storages and locations (such as Mount Crosby Weir, Gold Creek Dam and Enoggera Dam) should be included in the model, along with the system operational rules of the day.
- The full current volume of MP WAE has been included in the Without Dams case, whereas historical authorities to divert irrigation water were likely to have different conditions (and may have been different in number). For example, s4.5 of SLR 2018 indicates that irrigation licences used to be based on the area permitted to be irrigated rather than the volume permitted to be diverted.

So it is clear that the case in the Central Brisbane Benefits Study is not an accurate representation of historical conditions. If a 1920's historically accurate case was considered the appropriate scenario to assess the relative benefits of the scheme to MP irrigators[3], then the answer to the question at issue in this review (Do the two scenarios presented in the Central Brisbane Benefits Study provide an appropriate basis for assessing the relative benefits of the Central Brisbane River WSS to MP irrigators.) is No.

However the focus in this review is on evaluating the benefit currently provided by the scheme to irrigators, relative to other user groups. The following sections thus considers if the two modelled cases in the Central Brisbane Benefits Study present a reasonable basis on which to assess current relative benefits to MP irrigators.

3.2.2 Environmental Release Rules to Meet EFOs

The Water Plan (Moreton) 2007 details the Environmental Flow Objectives (EFOs) for the plan area. Part 4 introduces the various statistics used for the EFO's, and Schedule 7 provides the numerical targets that the system is required to meet for each of these statistics.

The required EFOs are not trivial. For example, low flow objectives include seasonal flow requirement for the 50% and 90% daily flows and for the percentage of days of no flow.

[3] Answering this question would likely require an opinion on the legal status of the 1920's era authorisations held by the irrigators to divert water from the Brisbane River, and whether such status still had validity today.

The Central Brisbane Benefits Study has not presented statistics indicating compliance with these EFOs for the two cases.

With the Existing Case being the case associated with the Moreton Water Plan, it is expected that the Existing Case would meet all EFOs.

The Without Dams case does not appear to include any rules to protect environmental flow water, for example, minimum thresholds for extraction or rules to protect events important for the environment. Section 8.4 of SLR 2018 indicates the irrigators are included using unregulated irrigation nodes, and as such will take any water that flows past their diversion point even if that water was necessary to meet an EFO. The Without Dams case may thus not meet the EFOs required in the Water Plan.

If one case meets the EFOs while the other does not, then evaluating benefits by comparing these two cases is not a fair comparison.

3.2.3 Water for Other Users and Their Performance (WASOs)

The Water Plan (Moreton) 2007 details the Water Allocation Security Objectives (WASOs) for the plan area. Part 4 introduces the statistic used for the WASOs, and Schedule 8 provides the numerical targets that the system is required to meet for each priority group.

MP WASOs for the Central Brisbane are for the monthly water sharing index to be at least 90%, with the extent to which it is less than 95% to be minimised. For HP, the WASO is at least 95%, with the extent to which it is less than 100% to be minimised.

The Central Brisbane Benefits Study has not presented statistics indicating compliance with these WASOs for the two cases.

With the Existing Case being the case associated with the Moreton Water Plan, it is expected that the Existing Case would meet all WASOs.

The Without Dams case does not appear to include any rules to protect water required for other users. Additionally, the Without Dams case has removed all of the high priority demand from the scheme (including the Glamorgan Vale WAE and the WAE for South-East Queensland urban users). The modelling of the irrigators as unregulated irrigators means they will take any water that flows past their diversion point even if that water was necessary to meet the WASO for another user. Without including the other users in the model, or protecting the water required to deliver to these users, the Without Dams case is unlikely to meet the WASOs required in the Water Plan.

If one case meets the WASOs for other users in the system, while the other case does not, then evaluating benefits by comparing these two cases is not a fair comparison.

3.2.4 Use of Ponds

In a number of places in the Central Brisbane Benefits Study (e.g. s5.5) mention is made that IQQM does not model river pools, and that this would mean that extraction in the Without Dams case would be underestimated.

If irrigators go to the extent of extracting from the standing river pools in times of drought, this may further decrease the performance again the EFOs. For example, Table 5 and 6 in Schedule 7 of the Moreton Water Plan provide a number of objectives associated with the duration of no flow periods. Extraction from standing ponds will tend to increase the periods of zero flow.

In addition, clause 23 of the Moreton Water Plan provides conditions associated with the restriction on taking water from waterholes and lakes in the plan area. In brief, the taking of water from waterholes and lakes is only permitted if authorised by the chief executive.

In summary, use of ponds should be treated equally in both cases. The lack of detailed modelling of river ponds in the IQQM model is thus unlikely to lead to a potential to underestimate extraction in the Without Dams Case.

3.2.5 Rain on Irrigated Areas

On page 18 of SLR (2018) it is advised that the Without Dams case assumed that the rain on the crop used to drive the required extraction was assumed to be zero. This assumption means that there will be no reduction in demand with local rainfall. That is, even if it buckets down on the area licenced to be irrigated, the node will still divert water on that day from the passing flood.

This is a significant assumption for unregulated run of river irrigators drawing water from an unregulated watercourse. The typical unregulated irrigator draws water from the river to irrigate their land, and if there is significant local rain this reduces the need to irrigate. River flow in unregulated streams is also, as you would expect, highly dependent on rainfall. That is – the biggest flows often occur when there is the least need to irrigate. In the Without Dams case, assuming that irrigators continue to take water through significant rainfall events may exaggerate the volume of water that is diverted.

In the Existing Case the full use of entitlements philosophy is applied, which involves setting up the irrigation node to draw its full nominal allocation each year (capped by the announced allocation). In reality irrigators may not draw much water during significant rainfall events, but will then draw that volume a week or a month later based on flow released from the dam. The large volume in storage allows this to occur, and the water balance over the year is reasonably reflected in the model. However in the unregulated case the lack of large dam storage means that there are no extended periods of flow from the dam in dry periods, from which the irrigation node can make up for the error in taking flow during high rainfall periods.

3.2.6 Flexibility of Extractions

Further to the discussion in the previous section, in the Existing Case the MP users have significant flexibility in when they extract their water during the year. They might choose to extract all their water early in the water year, all their water late in the water year, or any pattern in between. The large size of the dam allows this significant flexibility, and MP users do not suffer from, for example, additional evaporative losses from leaving their water in the dam until later in the year, or additional transmission losses if they choose to draw their water in the driest part of year, etc.

This flexibility is a significant benefit that is much reduced in the Without Dams case. If users choose to draw more water in the drier part of the year in the Without Dams case, then the water able to be diverted on average will decrease significantly.

To gain an appreciation of the level of benefit of the dams for different patterns of use it would be necessary to run a series of paired EC and WOD scenarios, with each pair testing a different monthly pattern of extraction.

It is thus evident that the comparison of a single fixed pattern Existing Case and Without Dams case pair would not be sufficient to paint a holistic picture of actual benefits of the Existing Case.

3.3 Comprehensiveness of Presented Output Statistics

A number of issues have been identified with the statistics presented in the Central Brisbane Benefits Study. Details are provided in the following sections.

3.3.1 EFOs

As discussed in Section 3.2.2, the Central Brisbane Benefits Study does not provide any statistics associated with the EFOs. Without these statistics it is impossible to see if both cases are meeting these requirements. If one case meets the EFOs while the other does not, then evaluating benefits by comparing these two cases is not a fair comparison.

Presentation of compliance with the EFOs for both cases would be required before a valid comparison of benefit could be undertaken.

It is noted that Att2, s3 of the ROL indicates daily flows are required past Mt Crosby Weir if the combined percentage of useable volume in storage of Wivenhoe and Somerset dams is >=15%, although it does not specify how large these flows are required to be.

In addition, it is important to recognise that the EFOs, while serving a critical purpose, do not provide the whole story on the environmental benefits or consequences of a particular set of operating rules, infrastructure and users. It would thus be of value to provide plots and analysis of daily flows, weir levels, daily flow exceedance plots, etc, at selected locations in order to provide a more comprehensive analysis of the relative performance of different cases in meeting the generic goal of protecting the environment.

3.3.2 WASOs, Mean Annual Diversions and Diversion Days

As discussed in Section 3.2.3, the Central Brisbane Benefits Study does not provide the monthly supplemented water sharing index (the WASO statistic) for any user groups. If one case meets the WASOs for other users in the scheme area while the other does not, then evaluating benefits by comparing these two cases is not a fair comparison.

However it is noted that the report does provide two statistics that are somewhat similar to the monthly supplemented water sharing index, being the Mean Annual Diversion (MAD) results and the Diversion Days (DD) results.

Owing to the method typically applied in the full use of entitlement modelling, the mean annual diversion divided by the nominal allocation (MAD/NA), monthly supplemented water sharing index (WASO) and diversion days (DD) are all similar quantities in the Existing Case.

This is because full use of entitlement modelling involves the following methodology:

- WAE holders in the model divert at their full rate from day 1 of the water year (applying the standard monthly pattern of demand).
- The diversion only stops (usually) if the cumulative diversion in the water years reaches the AA limit at that time. As long as the AA keeps ahead of the cumulative extraction, there will be no restriction and the WAE holder will thus divert their full nominal allocation over the water year, consistent with the full use of entitlements approach.
- If the cumulative diversion catches up to the AA, no diversion will take place in that water year until the AA increases again.

The net effect of the above modelling methodology is that the model tends to take all or nothing (of its standard daily demand) on each day of the water year. The mean annual diversion expressed as a percentage of the nominal allocation, will thus be almost identical to the diversion days percentage. The two statistics are only different because of:

- the odd day when the cumulative diversion hits a sub-100% AA, and takes less than the usual daily demand on that single day because of the AA cap, or
- The effects of a variable monthly pattern. This is best illustrated by taking an extreme example: if the monthly pattern has its demand concentrated in a couple of months, with all other months having very low demand, it is possible to achieve a very high diversion days percentage while achieving a low MAD/NA %.

Table 8-7 of SLR 2018 illustrates the similarity of the two statistics for the Existing Case, with the MAD/NV being 95.3%, while the DD is 96.1%.

The WASO statistic, the monthly supplemented water sharing index, is the % of months that the full monthly demand is satisfied. It is thus (almost) a monthly version of diversion days statistic. It follows then that the monthly supplemented water sharing index will also tend to be similar to the MAD/NA %.

However, there is a significant difference between the monthly supplemented water sharing index and the diversion days statistic:

- The monthly supplemented water sharing index is defined in the Water Plan as the % of months that the full monthly demand is satisfied.
- The diversion days statistic is defined in SLR 2018 as the % of days that any water is taken by the irrigation node.

The definition of the diversion days statistic and the implications of the full use of entitlements modelling methodology mean that it tends to be a misleading statistic, as follows:

- In the Existing Case, if the AA in particular year is 50%, the diversion days statistic for that year will be around 50%. This might be taken to mean that the irrigator is only able to divert water on 50% of the days in the year. However this is not true, water is accounted for on an annual basis, and users may extract water as they choose. Many irrigators may, when a low announced allocation is announced, choose to plant a smaller area of crop, and draw a smaller amount of water each day to produce a viable, but smaller, yield. The % of days that some water is available to divert in this year is 100%. The implication of the diversion days statistic, that no water is available on some proportion of the days, may thus be misleading to some readers of the report.
- In the Without Dams case, the unregulated irrigator nodes have been set up to take even the smallest dribble of flow, and the diversion days statistic counts diversion of any flow on a day as a success. The diversion day statistic for the Without Dams case may thus be unrealistically elevated by a number of days of very low diversion counting as successes in this statistic.

Table 8-7 of SLR 2018 illustrates this effect – the MAD/NV has decreased from 95.3% to 93.6% from the EC to the WOD case, while the DD statistic has increased from 96.1% to 97.6%.

In summary, to enable compliance with the Water Plan to be evaluated, the monthly supplemented water sharing index (WASO) statistics must be presented for both cases. Mean Annual Diversion is also a useful statistic, its presentation is encouraged. However the diversion days statistic is misleading, and its use is therefore discouraged.

3.3.3 Annual Diversion Exceedance Plot

Figure 8-3 and 8-4 in the Central Brisbane Benefits Study are presented and annotated to illustrate the assessed benefit drawn from the two cases. (These figures are reproduced in Figure 3-1). The report appears to present some misunderstandings in the interpretation of this plot, which may mislead some readers. This is explained below.

The graph is developed by extracting the 122 year timeseries of annual MP diversions from the model, ranking the diversion volumes from smallest to largest, and then plotting the diversion volume against the % of years that volume is equalled or exceeded.

The % of years in which the full allocation is available is a key measure of performance. This statistic is the point at which the plotted line drops below the maximum diversion. The green line on the plots in Figure 3-1 indicates that MP users get 100% of the nominal allocation in ~90% of years.

The Water Plan requires that in the Central Brisbane the monthly water sharing index for MP users to be at least 90%, with the extent to which it is less than 95% to be minimised. This is the definition of the WASO for MP WAE.

It is not a coincidence that the green line indicates that the Existing Case provides MP users with full nominal allocation in 90% of years while the required MP WASO is 90%. The % of years that full allocation is provided (referred to in this report as the Annual Water Security Performance (AWSP)) is effectively an annual version of the monthly water sharing index adopted for the WASO. And, owing to the full use of entitlements methodology described in Section 3.3.2, the monthly water sharing index will usually be close to, but slightly higher, than the AWSP.

In the absence of WASO statistics in the report, this review assesses performance based on the AWSP[4] statistic.

On the yellow line, for the Without Dams case, the diversion falls below the full nominal allocation early. With the yellow line only gradually moving away from full diversion, a decision needs to be made on how much deviation will be adopted for this statistic, a deviation of ~1% is adopted here. The AWSP of the MP WAE in the Without Dams case is thus about 50%.

So the Existing Case improved the AWSP of the MP WAE from ~50% to ~90%, a substantial margin.

[4] Note that the AWSP statistic has some advantages and so is beneficial to examine anyway. The AWSP statistic tends to be a more stable statistic than the monthly water sharing index, owing to the application of the full use of entitlements methodology.

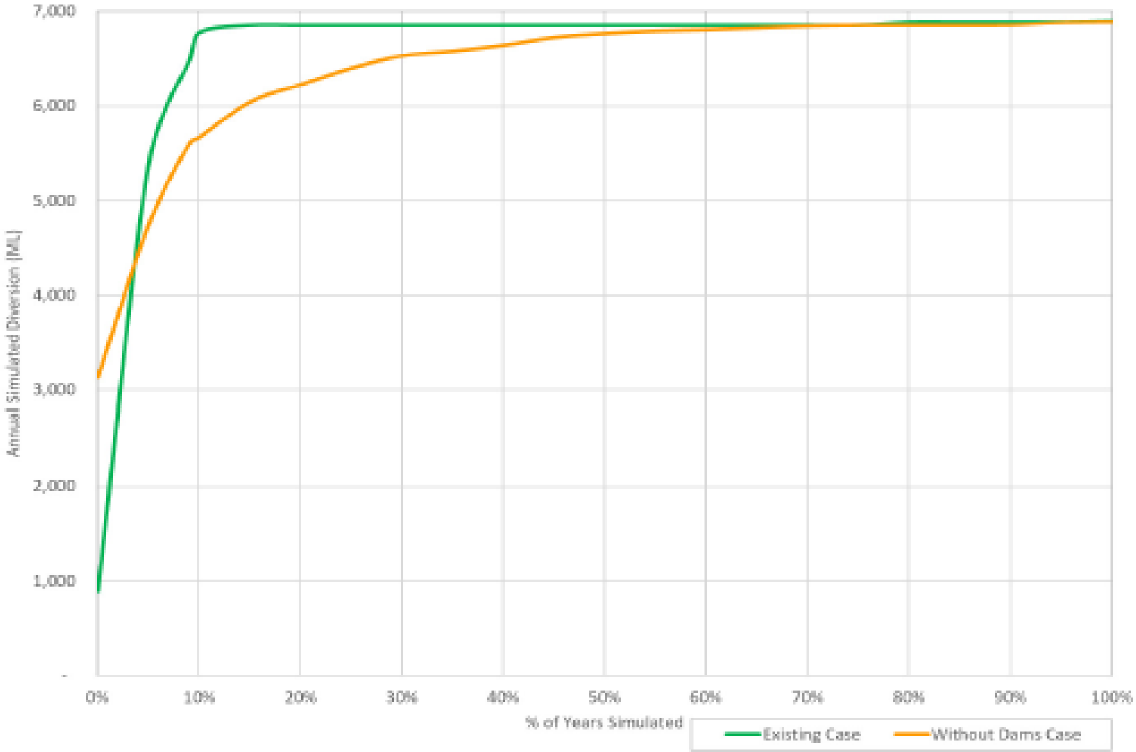

Figure 8-3 Annual Simulated Volume % of Year Simulated

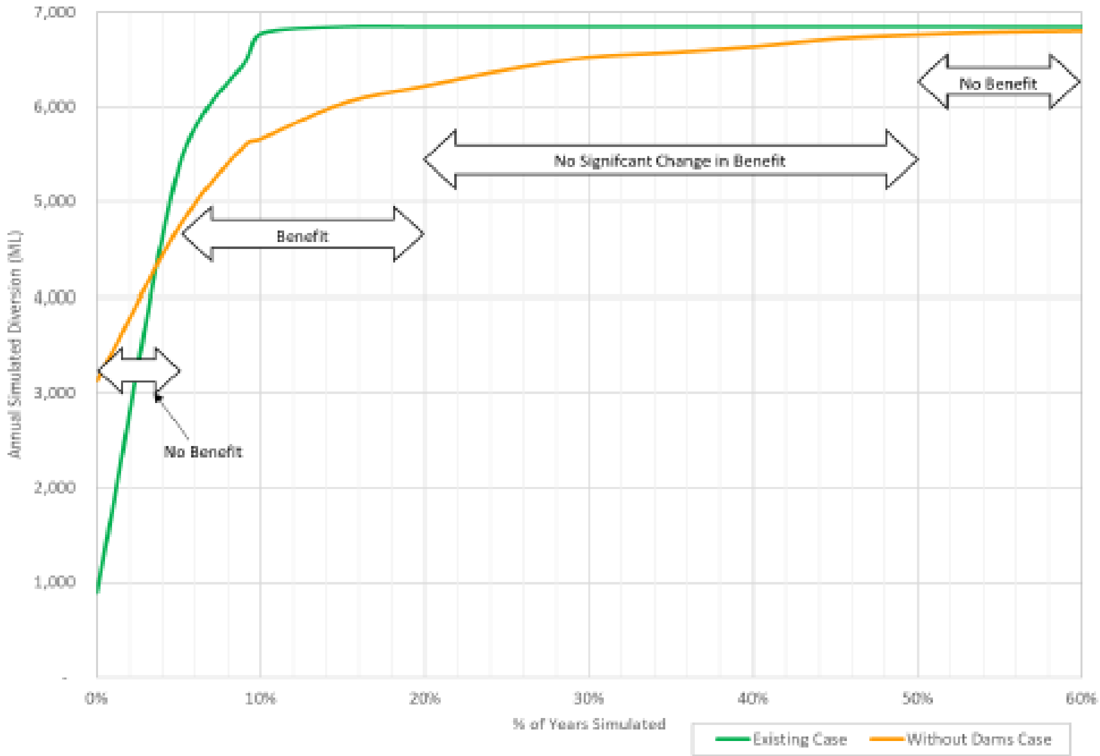

Figure 8-4 Annual Simulated Volume % of Year Simulated – Zoomed

Figure 3-1 –Annual Diversion Exceedance Plots (SLR 2018)

Another way to consider the performance is to evaluate the AEP of a 'failure' year, defined as a year in which the full nominal allocation is not provided. This is simply calculated as 100% - the AWSP. That is, the AEP of failing to deliver the full allocation in the Without Dams Case is 50% (1 in 2 years) while for the Existing Case it is 10% (1 in 10 years). On this measure, the Existing Case provides five times better performance than the Without Dams Case.

Performance may also be evaluated at other levels of delivery, e.g. you could compare the % of time that at least 90% of the nominal allocation (~6200 ML) fails to be delivered (~16% EC to 7% WOD, or 1 in 6 EC to 1 in 17 WOD, roughly a 3x improvement). To cut to the chase, benefit should largely be assessed by changes in the x-axis direction, rather than the y-axis direction as the labels on Figure 8-4 seem to imply.

It is noted that, at diversion volumes below about 4300 ML (62% of nominal allocation), the WOD case appears to perform better than the EC case. This is not unexpected – the EC case is attempting to meet EFOs in dry conditions, while the WOD case allows the irrigators to take the last drop of flow in dry conditions.

However, irrigators are not necessarily better off in the WOD case even under these severe drought conditions. If a low AA of, say, 15% is announced at the start of the water year, irrigators have the ability to plan ahead for that low availability of water, something that is not available if no handy dam guaranteeing the water is present. And they can take that water at the time that suits their intended crop, without suffering any evaporation or losses (such as would occur in an on-farm storage operated by an unregulated irrigator) [5]. Users in the WOD case are at the mercy of the climate – perhaps they theoretically could divert more water in fits and starts during the year, but if it cannot be diverted at the right time of the year to keep their crop alive, then the extra water does not provide much benefit.

Dams and weirs do not create water, they create security. If you just sum the average annual amount of water that passes a point on an unregulated river, this will almost inevitably be larger than the annual diversion that you can extract from a regulated system at a defined level of performance. Thus great care should be taken in comparing average diversion rates, it is usually much more appropriate to compare water supply security.

In conclusion, it is considered that, even if the two cases were considered reasonable to indicate the relative benefits from the scheme to MP and HP WAE, that Figure 8-3 and 8-4 in SLR 2018 indicate that the MP WAE are significantly better off in the EC case compared to the WOD case.

3.3.4 MAD/NV

Another reported measure of benefit is the mean annual diversion divided by the nominal allocation (MAD/NV) percentages in Table 8-7, 8-8 and 8-9 of the report, reproduced below. The report provides MAD/NV for three periods, the full 1889-2011 period, and for two 15 year periods, 1902-16 and 1997-2011.

Note the diversion days statistic is misleading as discussed in Section 3.3.2, and thus has been greyed out.

[5] As discussed in Section 3.2.6 statistics on the benefits of the flexibility of extraction available in the Existing Case could be calculated based on a series of runs with different extraction patterns. Producing statistics on the planning benefits of the announced allocation process would be more difficult, but perhaps could be developed by including farm level go/no go decisions at the start of the planting season in the model, calculating the economic loss associated with failed crops, etc.

Water Solutions

Table 3.1 – SLR 2018 MAD/NV Statistics – Long Term Average

Table 8-7 Comparison Mean Annual Diversion and Diversion Days – Long Term Average

IQQM Node	Description	Existing	Without Dams	[redacted]	[redacted]
		MAD/NV (%)	MAD/NV (%)	[redacted]	[redacted]
145	Reg LB1	95.3	97.7	[redacted]	[redacted]
163	Reg LB3	95.3	93.9	[redacted]	[redacted]
175	Reg LB5	95.2	90.6	[redacted]	[redacted]
194	Reg LB9	95.2	89.3	[redacted]	[redacted]
TOTAL		95.3	93.6	[redacted]	[redacted]

Table 3.2 – SLR 2018 MAD/NV Statistics – 1902-16

Table 8-8 Comparison Lowest Diversion Period Diversion and Diversion Days – 1902 - 1916

IQQM Node	Description	Existing	Without Dams	[redacted]	[redacted]
		LDPD*/NV (%)	LDPD*/NV (%)	[redacted]	[redacted]
145	Reg LB1	89.8	96.6	[redacted]	[redacted]
163	Reg LB3	89.5	85.3	[redacted]	[redacted]
175	Reg LB5	89.0	78.7	[redacted]	[redacted]
194	Reg LB9	89.4	76.8	[redacted]	[redacted]
TOTAL		89.5	85.9	[redacted]	[redacted]

* Lowest Diversion Period Diversion Volume

Table 3.3 – SLR 2018 MAD/NV Statistics – 1997-2011

Table 8-9 Comparison Lowest Diversion Period Diversion and Diversion Days – Lowest Diversion Period – 1997 – 2011

IQQM Node	Description	Existing	Without Dams	[redacted]	[redacted]
		LDPD*/NV (%)	LDPD*/NV (%)	[redacted]	[redacted]
145	Reg LB1	74.4	96.4	[redacted]	[redacted]
163	Reg LB3	74.2	90.8	[redacted]	[redacted]
175	Reg LB5	73.8	87.0	[redacted]	[redacted]
194	Reg LB9	74.1	85.9	[redacted]	[redacted]
TOTAL		74.2	90.0	[redacted]	[redacted]

* Lowest Diversion Period Diversion Volume

SLR indicate they have presented statistics for the two periods 1902-1916 and 1997-2011 because one of them is the lowest diversion period for the EC case while the other is the lowest for the WOD case.

The two periods are useful, especially because they are the only two periods in which there are supply shortfalls to MP WAE users in the EC case. This is best illustrated through a time series plot of annual diversions for MP users (i.e. the same data used in the plots in Figure 3-1), see Figure 3-2. Note the annual diversion is expressed as a percentage of nominal allocation, and that the annual volumes are accumulated over the water year (July-June). The two periods of shortfall can clearly be seen, during the 1900s and 2000s droughts.

In summary, the above statistics show:

- Over the full period of simulation, the EC case performs better than the WOD case. The average size of the shortfall in delivery is 36% larger in the WOD case.
- Over the 1902-16 period, the EC case performs better than the WOD case. The average size of the shortfall in delivery is 34% larger in the WOD case.
- Over the 1997-2011 period, the WOD case performs better than the EC case. The average size of the shortfall in delivery is 61% smaller in the WOD case.

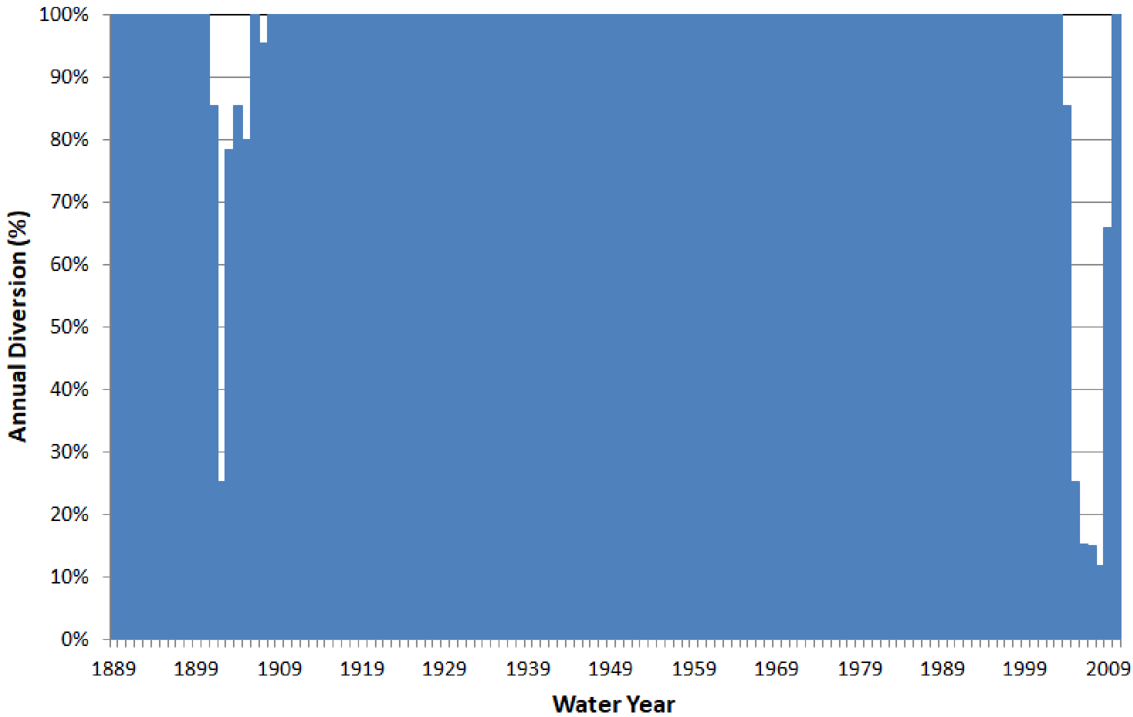

Figure 3-2 – Existing Case – Annual Diversion by MP WAE as a % of NA

Note again the issue of the security and flexibility of the regulated supply. While the WOD case produces a larger MAD in the worst drought period (1997-2011), this diversion is at the mercy of rainfall patterns, while Figure 3-2 shows that in most years the EC case makes a substantial amount of water available to be extracted at any time of the year. This security of supply is a significant benefit, even if the average diversion is lower.

In conclusion, it is considered that, even if the two cases were considered reasonable to indicate the relative benefits from the scheme to MP and HP WAE, and even if mean diversion is considered to be more important than water security, that the presented MAD/NV figures illustrate that MP WAE are significantly better off in the EC case compared to the WOD case under all conditions up to and including the second worst drought period on record. It is only in the extremely severe millennium drought where the scheme restrictions on MP WAE diversions (in order to meet HP WASO and EFO objectives) lead to the EC case showing lower diversions than are able to be drawn under unconstrained conditions in the WOD case.

3.3.5 Timeseries of Diversions

Figure 8-3 and 8-4 in SLR 2018 are useful plots, if you ignore the somewhat misleading annotations (as discussed in Section 3.3.2). However to provide a better appreciation of the relative performance of the two cases plotting this data as a time series is illuminating. Figure 3-2 provides an example of this type of plot, which should be presented for MP WAE and for HP WAE (and for all other water user groups in the model) for both cases.

Plotting diversions as a daily timeseries may also be considered, particularly for unregulated users, however the full use of entitlements methodology (described in Section 3.3.2) means that care must be taken in interpreting results for regulated systems in models at the sub-annual scale.

3.3.6 HUF Comparison

Section 8.4.4 of SLR 2018 presents a comparison of simulated diversions over the 15 year dry period from 1997 to 2011, and states that the HUF methodology is based on the lowest diversion period. However the HUF methodology is not directly based on diversions to WAE holders, rather it is based on calculating the average amount of water stored in zones of the headworks storage volume that have been assessed as being the most important for delivering to either MP or HP WAE.

Some care should thus be applied making conclusions related to the HUF based on diversion results.

3.3.7 Predictability and Rate of Change

SLR 2018 indicates in a number of locations, e.g. s5.4, that irrigators are unable to access water in high flow events owing to infrastructure conditions. High flows and rapidly changing flows, particularly without notice, cause difficulties for irrigators, potentially damaging equipment, requiring equipment to be moved, etc.

The scheme provides two key benefits to irrigators in this regard. Firstly, flows tend to not vary as dramatically (compared to the WOD case), with steady low flows occurring most of the year to meet urban demands. Secondly, it is understood that Seqwater provide significant notice and warnings of likely changes in releases, which is of benefit to irrigators in the operation of their infrastructure.

Statistics could be developed to provide a partial measure of this benefit from the results of the model, but there would be some judgment required to assess the benefit of the advance warning times, etc.

3.3.8 Flood Mitigation

The dams also provide a level of flood mitigation to irrigators, both through the reduction of flood frequency and level and through the better warnings available (Better instrumentation, more predictable, longer lead time, etc).

Statistics could be developed to provide a measure of the flood mitigation benefits to irrigators, but it is highlighted that these benefits apply to wide range of people and are not well correlated with the volume of nominal allocation that might be held by an individual. For example there may be landholders along the Brisbane River who have their own water supply and do not draw on the Central Brisbane system, but nevertheless benefit from the flood mitigation provided by the dams. And conversely, a reticulated urban user high on the slopes of Mount Coot-tha will be paying for water supply but getting little direct benefit from the flood mitigation provided by the dams.

It is noted that in the previous pricing review a further reduction of 56% for irrigators was recommended by the QCA to account for the flood mitigation benefits provided to the dam (s4.6 QCA 2013), essentially assigning all of the costs associated with the flood mitigation benefit to high priority users.

This issue is not constrained to the Brisbane system, nearly all dams provide a measure of flood mitigation to downstream areas (through the passive flood routing provided by their storage and spillway), and procedures to assign a proportion of the dam costs to those who benefit from this are not well developed. It is noted that increased development on floodplains is tending to increase the population who are benefiting from such services, and also that the increasing development downstream of dams is leading to increased dam safety costs at some dams (requiring higher capacity spillways, etc). This is an area that may benefit from reform, and is recommended for further consideration for the next round of price reviews.

3.4 An Improved Approach

Firstly, based on the considerations outlines in Section 3.2 and 3.3, the results from the Central Brisbane Benefits Study are not considered to provide an improved approach to assigning benefits attributable to each WAE priority group in the Central Brisbane River WSS, as compared to the adjusted nominal WAE used by the QCA in the 2013 review.

While the method used in the 2013 QCA review is considered better than that presented in the Central Brisbane Benefits Study, it has some limitations, and thus consideration was given to an improved method to assign benefits to each WAE priority group in the Central Brisbane River WSS.

Firstly, Section 3.4.1 below provides a brief summary of the previous methods use to assess relative benefit in this scheme. Then Section 3.4.2 outlines a few options for an improved approach, and recommends the method considered most appropriate for the 2020-24 Price Review.

3.4.1 Previous Approaches

In the previous price path Parsons Brinckerhoff applied the HUF methodology to a range of schemes including the Central Brisbane Scheme.

The standard HUF methodology was developed based on the announced allocation procedure applied by SunWater in the majority of their schemes, see Section 2. A key step in the procedure is to identify the volume in storage when the announced allocation for MP is 0% and for HP is

100%, and then the volume in storage when the announced allocation for MP is 100%.The lower volume is then assumed to be for the benefit of HP customers, and the middle volume for MP customers. Any remaining volume in storage is then assumed to split by the nominal allocation volumes for MP and HP, and assume to relate to supply for future years. See the conceptual HUF partitioning of the storage illustrated on Figure 2-1.

The HUF methodology has been accepted by the QCA as being fit for purpose for most schemes in the 2012/3-17 Price Review. However Parsons Brinckerhoff identified that the HUF method is not applicable to the Central Brisbane because of it water sharing structure and the extremely high reliability provided by the storage to the HP priority group.

PB thus made an alternate suggestion, to base the HUF on the ratio of MPA to HPA, factored by the cutoff percentage (7041 / 279000 * (100 - 14.9)). The QCA modified this approach, instead adopting the middle level of restrictions. At 35% useable storage the announced allocation drops from 55% to 40%, and hence the 2013 price review recommended (7041 / 279000 * (100 - 35)) = 1.6%.

3.4.2 Modified HUF Approach

The QCA have accepted that the HUF approach is an appropriate method to inform the price review, and it has been used in the other schemes examined in this review. It is thus considered that an approach that essentially applies the same “storage volume apportionment to priority groups” is appropriate for the Central Brisbane[6].

To do this effectively it is necessary to analyse why the standard HUF approach did not work for the Brisbane Scheme.

It was identified that the middle zone of storage in the Central Brisbane, between the storage volume required to supply 0 and 100% of MP AA (Zone MP1 on Figure 2-2) is clearly far in excess of the actual volume required to supply MP users this year. This occurs because the Central Brisbane AA method is simply a lookup table based on useable volume in storage, i.e. there is no attempt to work out how much can be supplied to MP users given the storage volume, estimated tributary inflows, transmission losses, etc, as done in most other schemes. In the Central Brisbane, the MP1 zone illustrated on Figure 2-2 is actually supplying water both for MP this year and security for HP allocations for the following years. The basic HUF methodology does not account for this, and thus does not work effectively for this scheme.

Thus it was determined to further subdivide Zone MP1 into two parts, the part associated with delivery of MP WAE water this year, and the rest associated with maintaining the security of HP allocations.

To undertake this revised approach the following methodology was performed.

[6] Alternatives do exist, such as determining conversion rates based on trading conversion rates etc. One way to approach this would be to run the model with all demands at the MP WASO performance level, and then again with all users at the HP WASO performance level. Alternatively this approach could be undertaken for a fixed proportion of the demand traded, e.g. 50%. (The response to trading MP to HP and visa versa may be non-linear, so the conversion rate may depend on the volume converted.)

MP and HP WAE

Table 2 of Seqwater 2018 provides a total MP WAE is 7,194 ML and HP WAE of 278,867 ML. However an email from Seqwater (4 July 2019) provided a slight correction to this, reducing the HP allocation to 278,847 ML.

No conversion rate to HP is specified for this scheme, and hence:

- MPAmin = 7,194 ML
- HPAmax = 278,847 ML

It is noted that Somerset Dam and Wivenhoe Dam, although they work together to deliver water to the same groups of users, have been included in different defined schemes. Wivenhoe Dam is in the Central Brisbane WSS, while Somerset Dam is in the Stanley River WSS. Seqwater confirmed by email 4 July 2019 that there are no additional allocations in the Stanley River WSS. With the two dams working together to deliver water to the same amount of WAE, the two schemes are assumed to effectively be a single scheme for HUF calculation purposes.

Unlike the other schemes examined in this report, the volumes of HP and MP WAE are not listed on the state government website (link below). To be consistent with other schemes, it is recommended that the current allocations for the Central Brisbane (and Stanley River) are listed on this site in the same manner as other schemes.

https://www.business.qld.gov.au/industries/mining-energy-water/water/water-markets/current-locations

Additionally, there seems to be significant duplication between the documentation for the Central Brisbane and Stanley River schemes. As the two dams work together to deliver water to the same groups of users, it is recommended that consideration be given to simplifying the water planning documentation by officially including both structures in the same scheme.

Dam FSV and DSV

The FSV and DSV for Wivenhoe Dam were extracted from the Central Brisbane River WSS ROL. The FSV and DSV for Somerset Dam were extracted from the Stanley River WSS ROL.

Table 3.4 – Central Brisbane – Dam Characteristics

Dam	FSV (ML)	DSV (ML)
Wivenhoe Dam	1,165,200	4,886
Somerset Dam	379,850	4,000

Determination of MP0 and MP100

The AA table is based on the Combined Percentage of Useable Volume in Storage of Wivenhoe and Somerset Dams (CPUVS, as defined in the Operations Manual). Storage evaporation is accounted for in the determination of useable volume. There are thus many combinations of levels in each dam which would result in the same combined useable volume percentage. Rather than examining a wide range of cases, this study has simplified the approach to use indicative typical volumes in the two storages in such dry times, as follows:

- A time series of the modelled volumes in storage in Somerset and Wivenhoe Dams was obtained from the base Moreton WP full use of entitlements case. This is plotted in Figure 3-3.
- An exceedance plot of these storage volumes was created, see Figure 3-4. (Note this plot is based on all data in the simulated period, an alternate approach might adopt correlated volumes on the first day of the water year, etc.)
- Storage volumes pairs were extracted from the exceedance plot for the same probability.
- The UV for each storage is the current volume (CV) less the dead storage volume (DSV) and the storage loss (SL) allowance. The SL allowance is based on the current surface area of the storage multiplied by the evaporation depths in Table 4 of the Operations Manual.
- The storage-area curve for the two dams was extracted from the base IQQM model system file.
- The CPUVS was then determined from the formulae given in the Operations Manual, which equates to: $CPUVS = [(CV – DSV – SL)_{Wiv} + (CV – DSV – SL)_{Som}] / [(CV – DSV)_{Wiv} + (CV – DSV)_{Som}]$. The resultant storage volumes associated with a CPUVS of 15% and 50% were then determined, see Table 3.5. For convenience, lines are included on Figure 3-4 illustrating the storage volume pairs that produced the required CPUVS values of 15% and 50%.
- It is noted that this equation accounts for storage loss in the nominator but not in the denominator. This appears somewhat odd, as it means it is impossible for this equation to give 100%, with the maximum possible value about 83%[7].

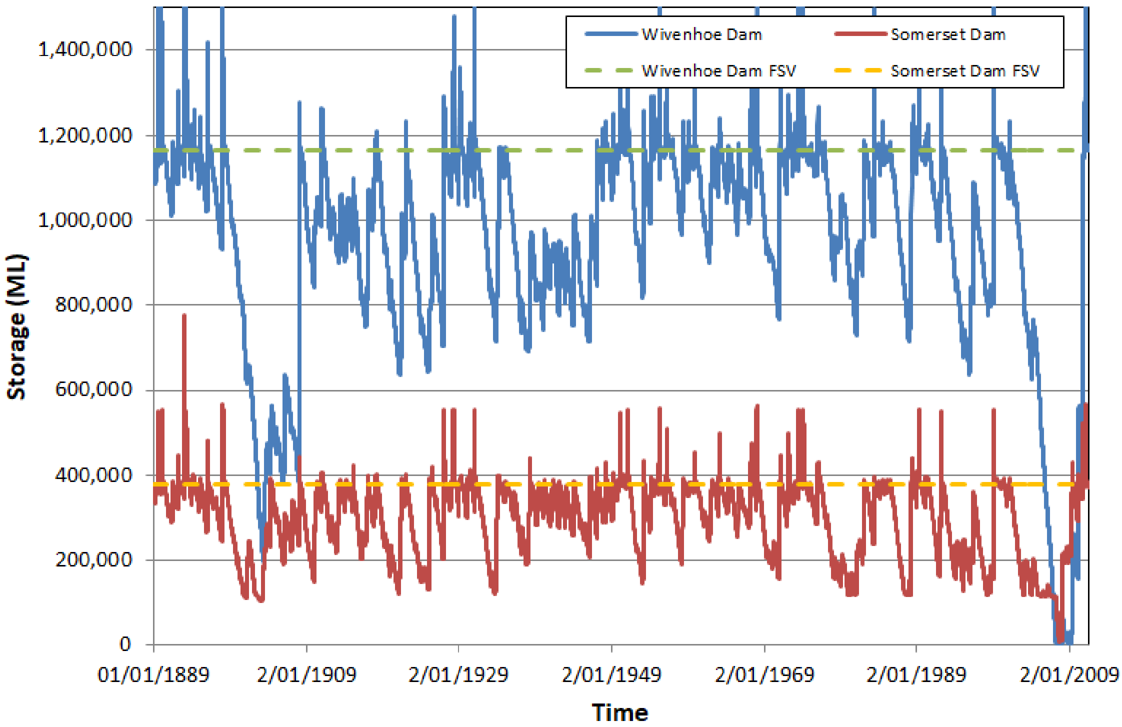

Figure 3-3 – Base Case – Volumes in Wivenhoe and Somerset Dams

[7] If this is not the intent of the procedures documented in the Operations Manual, then it is recommended that the Operations Manual is updated.

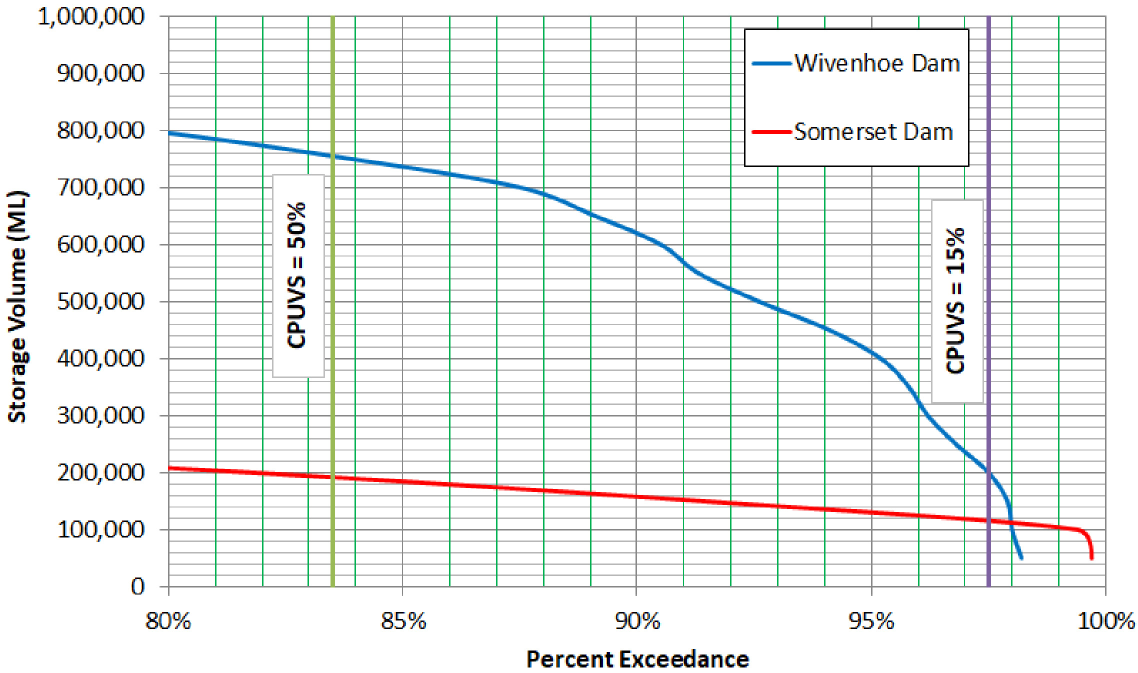

Figure 3-4 – Base Case – Probability of Exceeding Stored Volume

Table 3.5 – Central Brisbane – Storage Volumes to Provide 0% and 100% MP AA

Wivenhoe Dam Volume (ML)	Somerset Dam Volume (ML)	CPUVS	MP0 and MP100 (ML)
755,000	192,500	50%	MP100 = 947,500
200,000	117,500	15%	MP0 = 317,500

It is noted that the determined MP0 and MP100 are substantially larger than those estimated by PB in their 2012 report. It appears that PB may not have accounted for storage evaporation as required by the current Operations Manual.

<u>Estimation of Storage Zones</u>

The zones of the storage applicable to each priority group were estimated as follows:

- Zone HP1 was set equal to MP0 – the DSV, 308,614 ML. (While HP is not at 100% AA at this level, the volume of stored water for HP WAE above this level will be accounted for later.)
- Zone MP1 was set to MP100 – MP0, 630,000 ML.
- Zone MP1 has to be subdivided into the portion that is really for the delivery to MP WAE, and the rest which provides additional security for HP users.
- Following the conceptual approach applied for other WSS's, it is necessary to estimate what stored volume is required to deliver 100% of the 7,194 ML of MP WAE. For the purposes of this study a MP1F factor of 1.2 is adopted, and it is thus estimated that 8,633 ML of storage is required to deliver 100% of the MP WAE. 8,633 ML was assigned to

Zone MP1_MP for MP users, with the remaining 621,367 ML assigned to Zone MP1_HP for HP users. (See Section 3.4.4 for discussion on why MP1F=1.2 was adopted for this calculation.)

- Zone MP2 + HP2 is thus the final zone of the combined storage, FSV Hwks – MP100, 597,500. It is subdivided into MP2 and HP2 based on the nominal allocations.

The modified zones for the Central Brisbane are illustrated on Figure 3-5, with the changes from the base figure (Figure 2.14 in SunWater 2018j) shown in red[8].

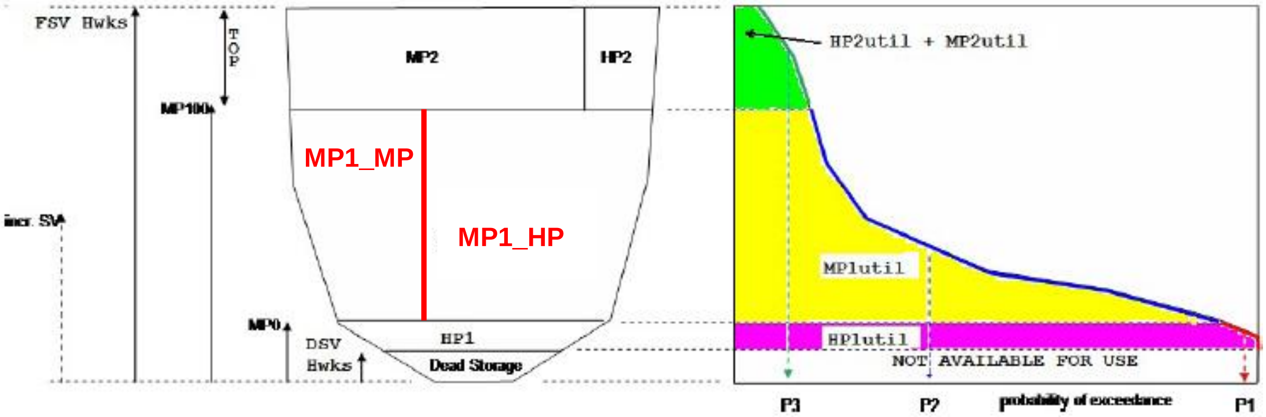

Figure 3-5 – Modified HUF Parameters for Central Brisbane

<u>Estimation of Effective Utilisation of the Zones</u>

SunWater's HUF calculation spreadsheet tool was adapted for the Central Brisbane. The 1889-2011 time series of volumes in Wivenhoe and Somerset Dams, each capped by their FSV's, were totalled and inserted into the tool. MPAmin, HPAmax, DSV Hwks, FSV Hwks, MP0, MP100, as calculated above were inserted into the tool. The tool then determined the effective utilisation volume for each zone, that is, the mean volume of water present in each zone in 15 year periods stepping through the 1889-2011 period of data.

<u>Calculation of the MP HUF</u>

The MP HUF was calculated for each 15 year period based on a modification of the formulae on pg A-10 of SunWater 2010j, as follows:

MP HUF = (MP1util_MP + MP2util) / (MP1util_MP + MP2util + HP1util + MP1util_HP + HP2util)

The 15 period with the lowest HUF was selected, which unsurprisingly contains the 2000s drought, the 15 years ending June 2010. The determined MP HUF was 1.12%.

A summary of the values used in the calculation of the Central Brisbane MP HUF is provided in the table below.

[8] Note this figure is illustrative only. In the Central Brisbane the MP WAE is only a small proportion of the total WAE, and hence the zones associated with MP WAE are relatively small.

Table 3.6 – Preliminary Estimation of Central Brisbane MP HUF

Parameter	Central Brisbane
MPAmin (ML)	7,194
HPAmax (ML)	278,847
FSV Hwks (ML)	1,545,050
DSV Hwks (ML)	8,886
MP0 (ML)	317,500
MP100 (ML)	947,500
HP1 (ML)	308,614
MP1 (ML)	630,000
HP2 (ML)	582,521
MP2 (ML)	15,029
MP1F	1.2
MP1_MP (ML)	8,633
MP1_HP (ML)	621,367
HP1util (ML)	282,929
MP1util (ML)	431,046
MP1util_MP (ML)	5,907
MP1util_HP (ML)	425,140
HP2util (ML)	147,208
MP2util (ML)	3,798
MP HUF (%)	1.12%
MP HUF in QCA 2013	1.6%

3.4.3 Benchmarking of the Central Brisbane HUF

The calculation in the previous section has resulted in an estimated HUF for MP users in the Central Brisbane scheme, but it is important to review the final result to ensure it is fit for intended purpose, that is, that it is reasonable to use the determined MP HUF to calculate the relative cost paid by MP and HP users in the scheme. The HUF methodology is an approximate method that may not provide an appropriate answer in all basins, given the differences in topography, climate, infrastructure, operation rules, usage and water security, and thus benchmarking the resultant HUF is prudent.

One issue with the HUF procedure is that it uses the worst 15 year period in the IQQM modelled period, and the actual probability of the selected period may vary wildly. The typical IQQM model may have around 120 years of historical climate included in its simulation. While there is reasonable confidence that a drought that occurs, say, twelve times over a 120 year simulation period is about the AEP 1 in 10 event, the probability of the worst drought in the 120 year simulated period is more difficult to define. For example the worst drought in the period might be the AEP 1 in 50 event, the AEP 1 in 120 event or even the AEP 1 in 1,000,000 event. Hydrologists often address this issue by fitting some sort of distribution to the data, and using that to estimate the probability of events near or beyond return intervals equal to the period of record, but that process is not simple when multi-year events are considered, particularly in a system with significant constructed infrastructure and management rules.

To take an extreme example, scheme AA rules usually assign all the water in storage to HP in the worst years. It is possible that the worst 15 year period in a simulated period might involve only supplying water to HP WAE in the whole 15 year period. Applying the HUF process to this situation would result in a MP HUF of 0%. If the probability of that 15 year drought was actually, say, 1 in 1,000,000, and in any vaguely normal set of years MP WAE received significant water, then assigning zero cost to MP users would not appear to be reasonable.

This review thus sought to understand what a reasonable HUF for the Central Brisbane scheme would look like. The first issue to address is that, while the HUF does achieve its goal of providing a mechanism to distribute costs over the priority groups in a scheme, it is not easy to discern the relative unit price for various priority groups from the HUF. The unit cost ratio between HP and MP allocations, determined from the HUF and the calculated MPAmin and HPAmax, has thus been determined for the Central Brisbane scheme. This factor, the HP:MP Unit Cost Ratio, represents how much more cost is applied to a HP WAE holder per ML of nominal allocation, compared to a MP WAE holder[9].

In order to provide a guide on the appropriate size of this ratio for the Central Brisbane, the HP:MP Unit Cost Ratio for the six schemes examined in Section 2 has also been determined for comparative purposes. The results for all seven schemes are provided in Table 3.7.

It can be seen that there is quite some variation in the HP:MP Unit Cost Ratio for the seven analysed schemes. The appropriate size of this ratio from a hydrologic viewpoint is not simple to define, but to gain some appreciation of whether the ratio for particular scheme should be higher or lower than for another scheme two simple methods were applied:

- Comparison to HP:MP trading rates, and
- Comparison to Water Plan WASOs.

The HP:MP trading conversion rates specified in water planning documents were typically determined by modelling runs looking at converting various amounts of HP to MP and visa versa, and seeing how much allocation could be delivered while still meeting the Water Plan WASOs and EFOs. These values are by no means definitive, the response of schemes is often non-linear and thus the determined rates are highly based on the volume converted. Nevertheless, they may provide an order-of indication of relative hydrologic value. Unfortunately these rates have only been defined for a few schemes. The available values are tabulated in Table 3.7. (It is noted that a conversion rate of 1 for conversion from HP to MP is provided in s14 of the Central Brisbane Water Management Protocol. This factor would be conservative for trading in this direction, but unfortunately does not provide much guidance on the relative value of HP and MP allocations.)

The second method is to compare the defined WASOs for each priority group. The aim of water supply schemes is to provide water security, and the WASO is the defined measure of that security. By comparing the probability of failure associated with the WASO for each priority group, an order-of appreciation of their hydrologic benefit may be obtained.

The resultant HP:MP ratios from comparing the WASOs is given in Table 3.7. For the purposes of this study, if a range of WASO's is given in the WP, the average value was used in this calculation[10].

[9] Note the presented HP:MP Unit Cost Ratios are based on the HUF only. Any further adjustments (such as the adjustment for flood mitigation benefits discussed in Section 3.3.8) are not reflected in the tabulated values.

[10] Note some caution should be applied owing to this assumption, as it is the actual performance of the two user groups under the defined operational rules that is the key factor in comparing current hydrologic benefit.

It is noted that this method, using the probability of failure associated with the WASO, does tend to break down at very high WASO percentages. To take an extreme, the upper end of the defined WASO for High A in the Pioneer is 100%. The probability of failure cannot be easily determined from very high WASOs. That is, the very worst year in a ~100 year sequence might have a probability anyway from (say) 1 in 30 to 1 in 1,000,000 AEP. Caution is recommended in interpreting results for those schemes with WASO's above, say, 98%.

Table 3.7 – Benchmarking of the Central Brisbane HUF

Parameter	Barker Barambah	Callide Valley	Lower Mary River	Nogoa Mackenzie	Pioneer Valley	Upper Burnett	Brisbane
MP HUF (%)	72.4%	27.5%	48.7%	27.7%	37.6%	72.0%	1.12%
HP:MP Unit Cost Ratio from the HUF	**5.5**	**6.3**	**18.9**	**7.3**	**2.6**	**9.9**	**2.3**
HP:MP Ratio Based on Trading Rate	n/a	3	n/a	3	n/a	n/a	n/a
Mean HP WASO	99.0%	96.5% (High A) 90.0% (High B)	97.0%	96.5%	97.5% (High A)	99.0%	97.5%
Mean MP WASO	75.0%	65.0%	90.5%	82.0%	96.0% (High B)	85.0%	92.5%
HP:MP Ratio Based on Probability of Failure	25.0	10.0 (High A) 3.5 (High B)	3.2	5.1	1.6	15.0	3.0

It can be seen that the Central Brisbane HP:MP Unit Cost Ratio from the HUF is lower than for the other six schemes. However it is apparent that MP users in the Brisbane enjoy a higher level of security than in most other schemes, and thus it would be expected that the Central Brisbane HP:MP Unit Cost Ratio would be lower. The determined ratio of 2.3:1 for the Central Brisbane thus appears to be of the right order.

3.4.4 MP1F Factor

As described in Section 3.4.2, it is necessary to determine the appropriate size of the portion of the MP1 zone that is really delivering water security for MP users.

The factor needs to be sufficient to cover the operational losses associated in storing and delivering water for MP users. It is noted that the operational losses that apply to this situation are not those in the normal year. Rather, AA formulae usually adopt conservative estimates of transmission and operational losses, i.e. those that would occur under drought conditions.

There is a large volume of HP water being released down the river most of the year, and a large volume of water stored for HP users in the dams, and hence it is considered that there would be a relatively small incremental increase in operational losses associated with delivering this extra water.

To assist in evaluating the appropriate MP1F factor the ratio of MP1 to MPAmin was calculated for the six schemes examined in Section 2, tabulated below.

Table 3.8 – Ratio of MP1 to MPAmin

Parameter	Barker Barambah	Callide Valley	Lower Mary River	Nogoa Mackenzie	Pioneer Valley	Upper Burnett
Ratio MP1 / MPAmin	1.71	4.63	0.16	1.33	1.09	1.63

The results in Table 3.8 show two outliers:

- The Mary scheme shows an extremely small ratio of 0.16, which seems at first glance to indicate an unearthly level of efficiency. However the Lower Mary is different to the other five schemes, in that it is the only scheme in which the determined MP100 volume is not sufficient to deliver 100% of the MP WAE. Rather, as discussed in Appendix A, the HUF procedure caps MP100 at the full supply volume of the headworks storages, and at this volume the application of the standard scheme AA rules (varied to remove the inflow allowance as required by the documented HUF methodology) is only able to deliver 11% AA. If the ratio is recomputed based on 11% of MPAmin, a ratio of 1.45 is determined, which is more in keeping with the other schemes.
- The Callide Valley scheme shows a high value. It takes 4.6 ML of storage to deliver 1 ML of MP allocation in this scheme, some ~3 times less efficient that the nearest other scheme examined. However the Callide Valley scheme is significantly different to the other five schemes, in that it delivers to many customers through groundwater recharge, and the AA's in this scheme are determined from groundwater levels rather than directly from storage volumes[11]. With these significant differences, Callide is not a good guide for the appropriate ratio in the Central Brisbane.

Removing the two outliers provides a range of 1.09 to 1.71 from the other four schemes.

Additionally, modelling of the Giru scheme (described in OD Hydrology 2018) adopted an average transmission loss of 20%, while the analysis of releases and diversions for Giru in Kavanagh (2017) identified that about 140ML needed to be released from the Haughton Channel for each 100ML delivered to the GBA in a dry period.

All of these other schemes have, of course, different topography, climate and different levels of MP and HP WAE. Owing to a range of reasons, most notably that MP releases in the Brisbane are relatively small and are being made on top of substantial releases for HP, it is considered that the appropriate MP1F for the Central Brisbane should be towards the lower end of the indicative range. A MP1F of 1.2 was thus adopted for the purposes of this study.

The resultant MP HUF is quite sensitive to the adopted MP1F. Thus a sensitivity analysis on the assumed MP1F is presented in the table below.

[11] See Appendix A for a discussion on method used to estimate the storage volumes that equate to MP0 and MP100 for this scheme.

Table 3.9 – Central Brisbane – Sensitivity of the MP1F Assumption

MP1F	MP HUF	HP:MP Cost Ratio
1.0	1.01%	2.53
1.2	1.12%	2.27
1.5	1.29%	1.97
2.0	1.58%	1.61

It is recommended that Seqwater gives consideration to an appropriate scaling factor to apply to the MP WAE nominal volumes to estimate the part of the MP1 zone that is actually required to deliver water to MP users. Estimated transmission and operational losses during droughts are likely the main driver behind this factor. Ideally Seqwater would analyse release and diversion data during significant droughts in order to estimate this factor. However it is noted that the small size of the MP WAE in the Central Brisbane, and the short period of metered extraction data, may make computation of this factor difficult. In the absence of adequate data, a value based on professional judgement would need to be applied.

3.4.5 Recommendation

It is recommended that Seqwater re-evaluate the apportionment of costs to MP WAE in the Central Brisbane WSS based on a modified HUF approach, subdividing the central MP1 zone to its primary purposes of supply to MP users and to HP users. The preliminary estimated MP HUF given above, 1.12%, may provide a guide for this revised procedure.

4 Giru Benefited Area Hydrologic Study Review

4.1 Introduction

The third of the three tasks in this project is to provide advice related to the hydrologic study of the Giru Benefited Area submitted by SunWater, including advice regarding the proportion of water used by customers in this area that can be delivered by natural recharge of the aquifers compared to that from supplemented releases to the Haughton River.

Section 3.8 of the QCA's April 2012 report on the Burdekin Haughton Distribution System indicates that the Giru Benefited Groundwater Area is supplied through the Haughton Main Channel and Balancing Storage and consists of natural channels, relift pump stations and lagoons. The Haughton River is regulated by the Val Bird and Giru Weirs, both of which are managed to maximise recharge to the groundwater area.

Figure 4-1 provides a schematic of the Burdekin Haughton Water Supply Scheme. Releases from Burdekin Falls Dam travel down the Burdekin River and then though a number of channel systems to the Haughton Balancing Storage, and from there through more channels to the Haughton River, where they are stored in Val Bird Weir and Giru Weir. The elevated levels along the Haughton River and in these two weirs increased infiltration into the groundwater aquifer. Irrigators in the GBA then take their water from the aquifer through their groundwater bore/s and/or directly from the surface watercourses.

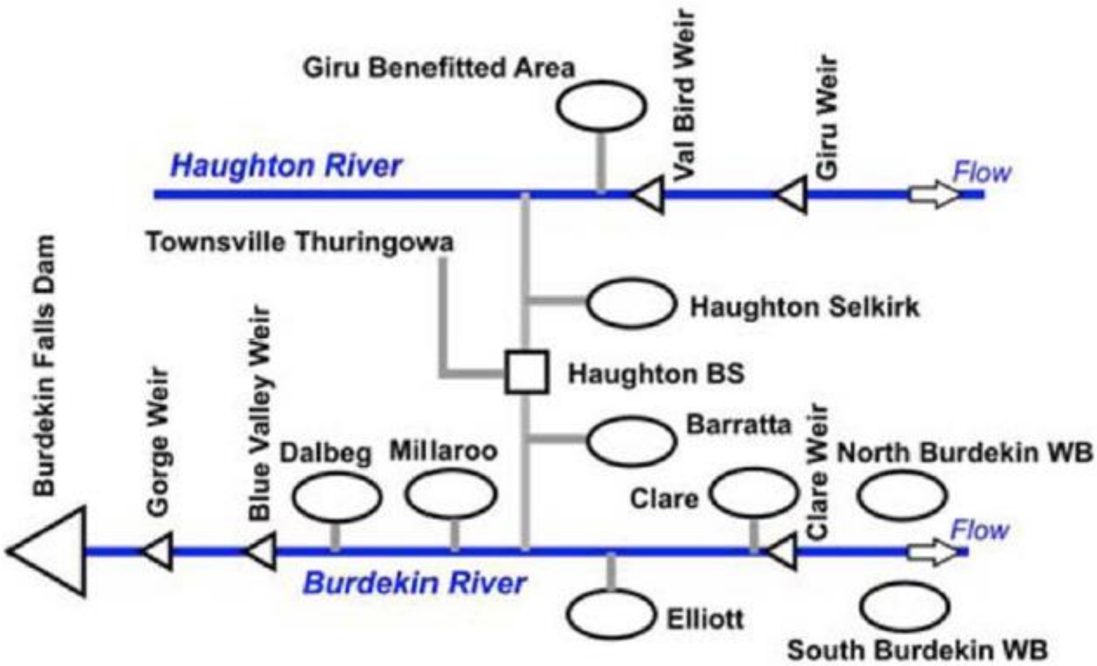

Figure 4-1 – Schematic of the BHWSS (OD Hydrology 2018)

The GBA groundwater aquifer is intimately connected to the surface water system. This is recognized in the Water Plan for the Burdekin Basin (2007), which states:

> *"7. Declaration about watercourse—Act, s 1006(2)*
>
> *(1) Water in an aquifer under a watercourse or under land adjacent to a watercourse, in the Giru Benefited Groundwater Area, is declared to be water in the watercourse.*
>
> *(2) Subsection (1) does not apply to water the chief executive is satisfied is not hydraulically connected to the water in the watercourse." (*Part 2 Section 7)

SunWater has advised that[12], to their knowledge, no declaration has been under subsection 2 above, i.e. water in the entirety of the GBA groundwater aquifer is considered to be effectively water in the watercourse.

In the 2012 review the QCA recognised that there was a hydrological basis for a lower price charged to customers in the Giru Benefited Area in the Burdekin-Haughton distribution system. Specifically, natural groundwater yields were recognised as contributing a proportion of available supplies. Based on evidence available at the time, the QCA said that only a proportion of WAE was provided by SunWater infrastructure (51%), with the remaining volumes deemed to be natural groundwater yields (49%). For the 2012 review, the QCA recommended discounted charges in the Giru Benefited Area to reflect that only ~51% of the water supplied was provided by SunWater's infrastructure. In 2012 the QCA also recommended that SunWater further investigate the hydrologic circumstances in the GBA.

In Appendix I of SunWater's submission SunWater advised that they have funded an independent review of the Giru Benefitted Area, and provided that report as Appendix K of their submission. In Table 3.1 of Appendix I SunWater advises that it may be appropriate for the QCA to review the 49% discount current provided to GBA customers.

Appendix K of SunWater's submission contains a report by OD Hydrology presenting the development and application of a conceptual aquifer mode for the Giru Benefitted Area (OD Hydrology 2018).

The objective of this part of this study is to conduct an independent peer review of the hydrologic study of the Giru Benefited Area (Appendix K of SunWater's submission, containing OD Hydrology 2018). This review is to include:

- assessing the appropriateness of underlying inputs, assumptions and models and whether calculations have been undertaken as outlined in the study report; and
- whether the interpretation of results in this report provide an appropriate basis for assessing the proportion of water used by Giru Benefited Area customers that can be sourced from natural recharge of the aquifers (rather than supplemented releases to the Haughton River).

The first point above is reviewed in Section 4.2 below, while Section 4.3 addresses the second dot point above.

[12] In the response to QCA Information Request 56.

4.2 Model and Report Review

The first part of this task is to assess the appropriateness of underlying inputs, assumptions, calculations and models used in the report.

Notes on the review of the model and report are provided in the table in Appendix B.

A summary of the key issues identified with the data, assumptions, calculations and modelling behind the report from the review presented in Appendix B is provided below:

- The report only gives a very brief introduction to the data, assumptions and calculations used in the model. The sources of many of the parameters, such as the transmission and operational loss allowance, the aquifer porosity, and the aquifer-weir interchange flow rates, are not described. The adjustment of model parameters during the calibration process is not well described. A more rigorous documentation of the data, assumptions and calculations used in the model is required to provide a robust foundation for the conclusions made on the model results.
- The report raises the issue of a shift in GBA irrigators to access their water direct from surface streams rather than through bores, indicates this will be examined, but then does not go on to analyse this issue.
- Evaporation data has been applied to the surface of the weirs without any pan factors, and no evapotranspiration has been applied direct to the aquifer/ ground surface.
- The origin of the demand pattern used in the model is not described, and the demand pattern appears to be quite 'lumpy', which may be a result of the pattern being based on a limited period of data. Confirmation that this demand pattern reasonably represents expected long term average extraction rates would be of benefit.
- The fixed monthly demand pattern extracts the same volume of water regardless of local rainfall, which may result in an over-estimation of extraction in the unsupplemented cases.
- The surface of the weirs has been modelled with a fixed area that appears to be an overestimate of the actual ponded surface area, particularly at low storage levels. This overestimation of area affects the direct rain and evaporation computed for the weirs.
- The weir operating levels maintained in the model appear to be higher than the nominal operating levels specified in the Operations Manual. Additionally, it appears that the actual levels maintained in the weirs in recent years are also significantly above the specified nominal operating levels. See Section 4.2.1 for further discussion on this issue.
- No outlet rating curve has been included in the model for the outlet from Val Bird Weir (or for Giru Weir). SunWater have advised that they need to fill and spill Val Bird Weir when demands are larger than the outlet capacity, and this behaviour is not reflected in the model. The levels in the weirs are key drivers of groundwater recharge – this inaccuracy may significantly affect model results.
- The aquifer – weir interchange is modelled with a simplified procedure that only considers the level in the weir. Groundwater – surface interchange would be better modelled if relative water levels were considered.
- The ROL requires natural flows up to 40ML/d to be passed through the weirs. This rule has not been included in the model, and the report presents no statistics evaluating the performance against this rule (or the full set of Water Plan EFOs) for the modelled cases.
- The unsupplemented cases are modelled with the same spreadsheet as the supplemented case, with the only change being the removal of releases from the Haughton Balancing Storage and the modification of the demand. The unsupplemented

cases thus still included supplementation of the aquifer from the elevated storage levels created by the two weirs.

- The model has not included modelling of other, non-GBA, Haughton River users. While the Haughton Balancing Storage releases have been modified to remove releases for other users, not modelling these users complicates interpretation of the model results, particularly with regard meeting the passflow requirement.
- The calibration against bore levels is reasonable at some sites, but at others it appears the model has not captured the amplitude of the groundwater level changes. Only limited calibration results are provided for the unsupplemented case, and there is thus more uncertainty associated with this case, which also often has much larger groundwater level variations.
- Recorded levels for the two weirs are available, and the presentation of calibration results against recorded weir levels would strengthen confidence in the model results. Preliminary plots in the model appear to show some significant differences in modelled weir levels.
- Additionally, it would be beneficial to see comparisons of the model results against those produced by the IQQM model. While there are some differences between the two modelling approaches, most notably that this model adopts an ‘average’ demand level that is less that the full use of GBA allocations, the models should be able to be usefully compared for such factors as weir levels, EFO performance, etc. Benchmarking the models results against IQQM would assist in providing confidence in the model’s results.

4.2.1 Nominal Operating Levels

As discussed in Section 4.2 the model has used operating levels above the specified nominal operating levels in the Operations Manual, and plots of historical weir levels appear to show that nominal operating levels have not been well maintained in recent years.

The OD Hydrology Report notes the poor performance of the scheme in meeting the passflow requirements of the ROL, however it does not pick up the observed poor performance of the scheme in maintaining the nominal operating levels in Val Bird and Giru Weirs.

Figure 3, 4 and 5 of OD Hydrology 2018 are reproduced in Figure 4-2. The three plots are for the same time period, so the timing of the releases can be roughly lined up with the water levels they produce. It can be seen that the water level in Val Bird Weir (the middle plot) is typically close to the solid flat line that represents the full supply level, occasionally dropping down to near the large dashed line, the nominal operating level. The upper plot is showing that natural flows in the Haughton River only occur rarely – maintenance of Val Bird Weir water level near its FSL appears to be largely a consequence of the releases made by the operator.

Figure 4-3 shows recorded water levels for Val Bird Weir for a longer time period, from Kavanagh 2017, and appears to show that the maintenance of levels near the FSL appears to be a more recent behaviour.

Figure 4-2 also appears to show that Giru Weir has often been maintained at a level above its nominal operating level.

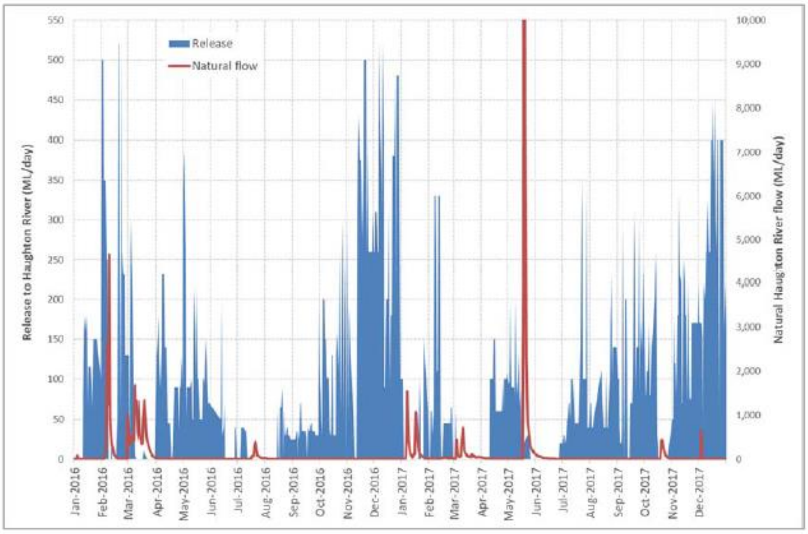

Figure 3 –Daily GBA supplemented release

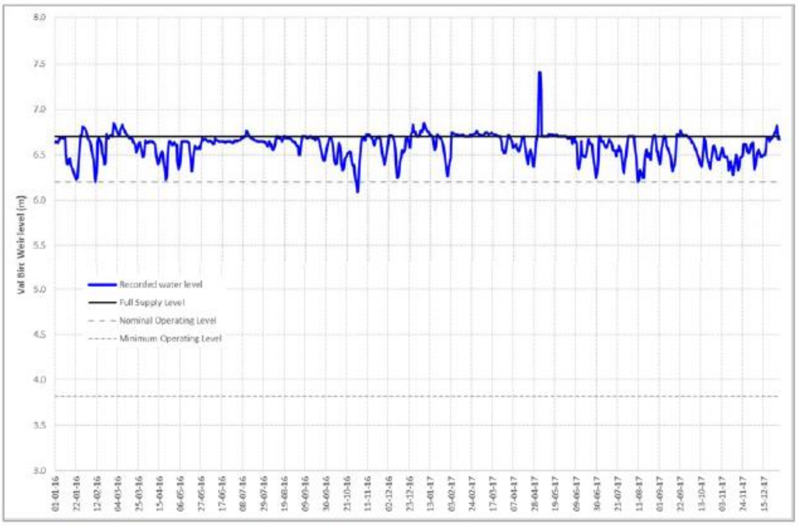

Figure 4 –Val Bird Weir water level behaviour

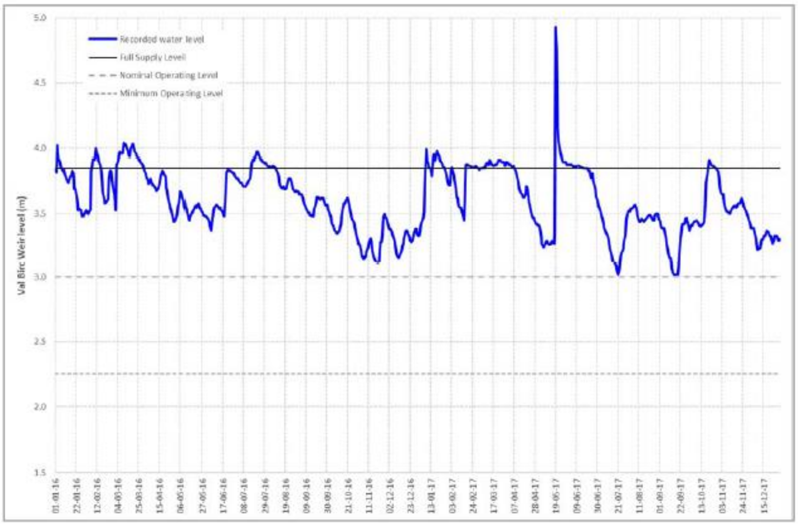

Figure 5 –Giru Weir water level behaviour

Figure 4-2 – Releases to the GBA and Weir Water Levels (OD Hydrology 2018)

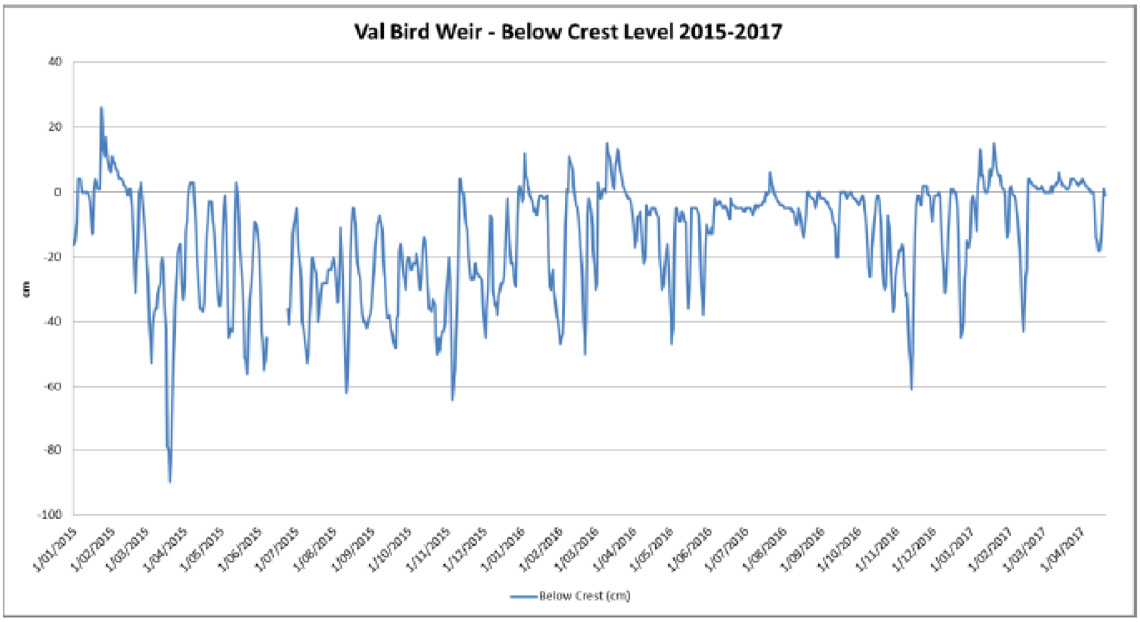

Figure 4-3 – Val Bird Weir Water Levels (Kavanagh 2017)

Maintaining weir levels above the specified nominal operating levels appears to be contrary to the requirements of the BHWSS Operation Manual extract shown in Table 1 of OD Hydrology 2018. Section 4(2) states that the ROL holder must not release except to meet minimum stream flow requirements, to supply water to a user, or to maintain a downstream storage at its Nominal Operation Level. The plot for Val Bird Weir would thus be expected to show levels to be generally around the Nominal Operating Level, only going higher if there is a natural inflow.

It is important from a water allocation entitlements performance / system yield point of view to maintain air space in downstream storages. This allows natural downstream flows to be captured, contributing to the performance/yield of the scheme. The topping up of downstream storages to nominal operating levels is usually implemented in the system IQQM models, and this operational process is part of the rule set that is required to meet the Water Plan WASOs. If in reality operators are topping up to the FSL, this may compromise the performance/reliability of the water allocation entitlements.

However there are operational reasons why levels in downstream weirs might not fall exactly along the nominal operating level at all times, for example, uncertainties in transmission losses, rain rejection (rain causing users to not take water they had earlier ordered), etc. However such reasons would typically only result in the occasional rise above the nominal operating level - Figure 4-2 appears to show a more systematic exceedance.

On enquiry, SunWater advised[13] that:

- They typically do run the weirs at levels higher than the nominal operating levels, but lower than the full supply levels, for the purposes of making releases to supply downstream customers.

[13] In the response to QCA Information Request 56.

- The outlet at Giru Weir is a 40ML/d outlet[14]. This outlet is only used to release environmental flows.
- The outlet on Val Bird Weir is rated to 55 ML/d (at FSL, with lower capacity at lower weir levels) but that the demand downstream could be 100 ML/d. SunWater advised that Val Bird Weir was sometimes run at levels above FSL in order that flow occurs over the spillway to meet these high levels of demand downstream.

Regarding Giru Weir, SunWater have indicated they do typically run Giru Weir above its NOL, but none of the three reasons allowed by Section 4 of the Operational Manual appears to apply to this weir. As this operational strategy appears to be contrary to the requirements of the Operations Manual (and the operation rules behind the scheme's MP allocation performance in the basin IQQM model), it is recommended that the operating level for Giru Weir in the OD Hydrology model is set equal to the NOL. Additionally it is recommended that the actual operation of Giru Weir aims to maintain the NOL in accordance with the rules documented in the Operations Manual.

Regarding Val Bird Weir, Figure 4-3 shows that Val Bird Weir has been run near or above its FSL since around 2016. Based on the response above this may have occurred owing to large river demands occurring downstream in this period. Prior to 2016 Val Bird Weir was generally run below its FSL – it is presumed that river demand prior to 2016 was below the capacity of the outlet. Section 1 of OD Hydrology notes that there has reportedly been a transition of GBA irrigators to take water directly from surface water rather than from groundwater bores. This may be the reason for the apparent dramatic increase in demand rates direct from the river channel downstream of Val Bird Weir in recent years.

As the level in Val Bird Weir is a key parameter for modelling, it is recommended that operational practices associated with any requirement to fill and spill to meet downstream demands is included in the model.

Further, this strategy has the potential to impact on the performance of allocations in the Burdekin Haughton scheme. If the shift of GBA users to take water direct from surface water is decreasing performance for other allocation holders, this would not be ideal. Further investigation of this issue is recommended.

It is noted that there may be benefits for a range of parties in maintaining higher weir levels, for example, providing access to surface water for a wider number of users, increasing infiltration to the groundwater aquifer, increasing pond recreational use, etc. If there is good reason to maintain these weirs at higher operating levels, this should be tested in the basin IQQM model, the implications for water supply security assessed, and the provisions of the relevant plans updated to reflect the preferred operational strategy.

4.3 An Appropriate Basis for Pricing

The second part of this task is to assess whether the interpretation of results in this report provide an appropriate basis for assessing the proportion of water used by Giru Benefited Area customers that can be sourced from natural recharge of the aquifers, rather than from supplemented releases to the Haughton River.

[14] S4.2.2 of OD Hydrology notes that the environmental flow requirements were not met over the period assessed by that report (2016-17), and that SunWater had commissioned the addition of a controlled outlet valve on Giru Weir to meet the minimum streamflow condition.

Section 4.3.1 outlines a possible method to assess the proportion of demand that can be sourced from natural flows for the purposes of pricing using the model presenting in OD Hydrology 2018. Section 4.3.2 then discusses the preferred method to undertake this task, using supplemented release data. Section 4.3.3 then provides the final recommendation from this review of the contribution of natural flows to the supply of GBA irrigators.

4.3.1 Using the OD Hydrology 2018 Model

As discussed in Section 4.2 a large number of issues have been identified with the modelling behind the report, issues that raise significant concern with using the results of the modelling for the purpose of pricing. The calibration of the model to bore records provides some reassurance that the results are not completely inappropriate, and the use of the model in a comparative manner reduces the impact of uncertainties present in both cases, but significant uncertainty is still associated with using the reported results.

Nevertheless, an assessment of the presented results has been undertaken, and the following comments are made:

- Table 1 in OD Hydrology summarises the results for four cases, the 100% use, supplemented base case, and three unsupplemented cases, with 100%, 50% and 30% of current use respectively.
- The unsupplemented, 100% use case clearly fails to deliver the water required by irrigators, with the aquifer going to empty (-8.0m). In addition to not delivering the required water, this case is very likely to lead to severe saltwater intrusion, thus failing the key environmental goal of managing the aquifer levels. It is thus not considered further in the report.
- There are a number of measures of environmental performance that could be used for this system, but for the GBA the two key environmental performance measures are considered to be:
    - the level in the aquifer over time, which directly relates to the key GBA aquifer management goal of preventing saltwater intrusion, and
    - the EFOs presented in Schedule 5 of the Water Plan.
- The Water Plan presents a complex set of low, medium and high flow objectives that should be assessed when evaluating whether two cases are providing the same performance. However it is likely that performance against the EFOs can be evaluated through a simplification in the Haughton River. That is, the Haughton River does not have a large impoundment or a significant volume of flood harvesters, and thus high flows are unlikely to be significantly impacted. For low flows, the ROL specifies a passflow requirement, flow up to 40ML/d at the upstream gauges must be passed through both weirs. While results should be presented against the full set of EFOs, it is likely that assessment of EFO performance may be demonstrated by showing that this passflow requirement is met in all cases.

For an unsupplemented case to be a valid measure of unsupplemented yield, it must provide the same allocation performance and the same environmental performance as the base case. Assessment of the supplemented case and the 50% and 30% unsupplemented cases with regard allocation performance and the two key environmental performance objectives, the provision of the passflow and maintaining aquifer levels, are thus discussed below.

Allocation Performance

The supplemented case and the 50% and 30% unsupplemented cases all deliver 100% of the required volume of water in every year, and thus it is considered that they all effectively meet their water allocation security objectives.

However the model includes an important difference in the access to water between the supplemented and unsupplemented cases. In the supplemented case some users are permitted to take water direct from surface water, while the unsupplemented cases require all users to take all water direct from groundwater.

While the security of the allocation is the same in all three cases, the ability to take some water direct from surface water is a benefit that does not exist in the unsupplemented cases examined.

Passflow Performance

As mentioned in Section 4.2 the model does not include any rules to provide the required passflow, and it is thus expected that performance against the passflow requirement will be poor for all three cases. There is no release from Giru Weir in the model, and hence the spillway flow for Giru Weir was checked to see if it met the requirement to pass the first 40ML/d combined flow at the two upstream gauges. The results are provided in the table below.

Table 4.1 – Giru Model Cases – Passflow Performance

Case	% of Days the Passflow Requirements are Met
Supplemented Case	59.4%
Unsupplemented, 50% Demand	60.4%
Unsupplemented, 30% Demand	60.4%

All three cases are thus equally bad at meeting the passflow requirement, failing on about 40% of the days in the simulation period.

However it is difficult to be definitive that, if a rule was included to pass the required flow, all three cases would react equally. That is, in the supplemented case the huge Burdekin Falls Dam provides extensive storage to meet the additional demand requirements owing to not taking this flow, whereas in the unsupplemented cases leaving this flow in the river will mean an even harder drain on stored aquifer levels, further reducing the groundwater performance, and potentially meaning the defined demand cannot be met.

Aquifer Level Performance

Aquifer performance may be assessed through a graph of aquifer levels for the three cases over the modelled simulation period. Figure 21 in OD Hydrology provides such a graph. From this graph it can be seen that the 30% and 50% unsupplemented cases have significantly reduced performance compared to the base case. Even in the 30% case aquifer levels are below 0m for extensive periods of time, with a minimum aquifer level of around -1m.

It appears in the base case that the operator has effectively been operating the system to keep the aquifer above 0m. If this is the performance level of the base case, the other cases should produce a similar performance to be validly compared.

To assist in assessing the % of demand likely to provide a similar performance to be base case on this graph, a number of cases were modelled using the spreadsheet for lower levels of demand (These cases were created by changing Cell H8 to be equal to the demand % modelled.)

The first plot below is a repeat of OD Hydrology's Figure 21, with an additional case at 15% of demand.

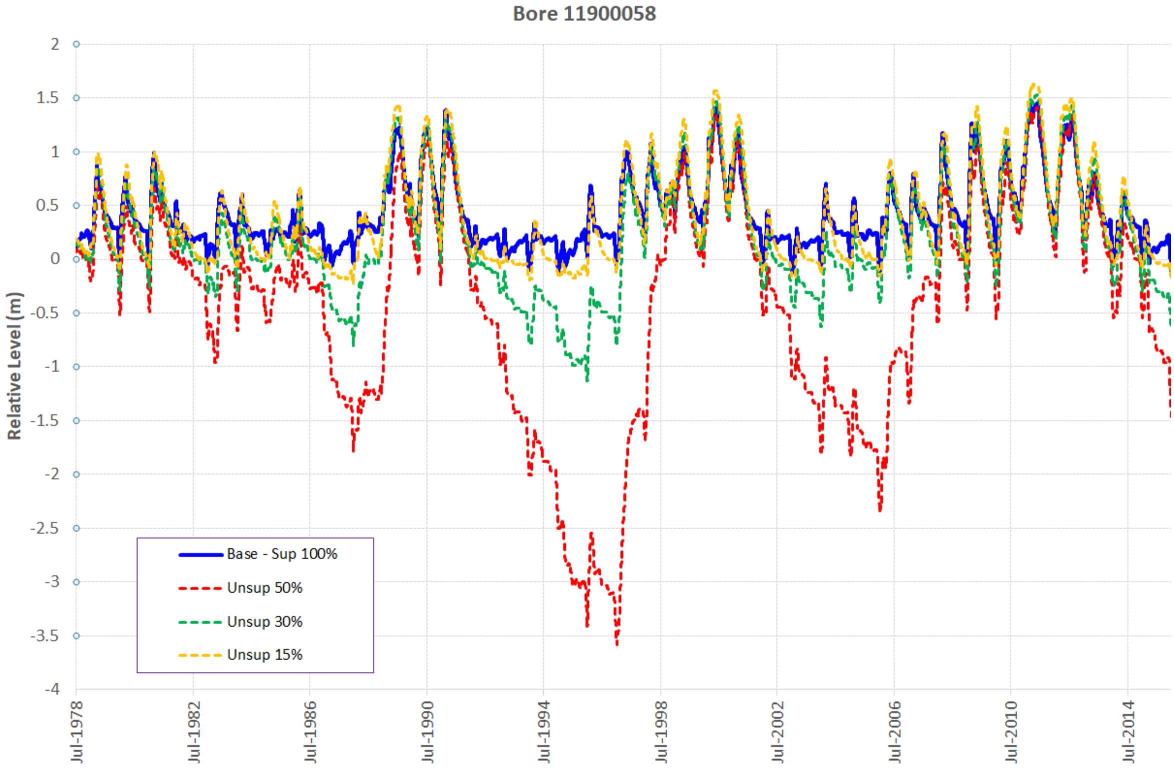

Figure 4-4 – Modelled Aquifer Levels

From the above it appears even a 15% unsupplemented demand leads to lower aquifer levels, and an increased risk of seawater intrusion, than in the base case.

To enable a more detailed comparison of the likelihood of low aquifer levels, a level exceedance plot is provided below. This plot shows the % of time that the indicated level is equalled or exceeded in each case, with the plot focused on the lower level part of the graph. Additional cases are included on this graph, results for the unsupplemented case with demands every 5% from 0% to 15%, with the intent of enabling a close examination of the case that provides similar performance to the base case.

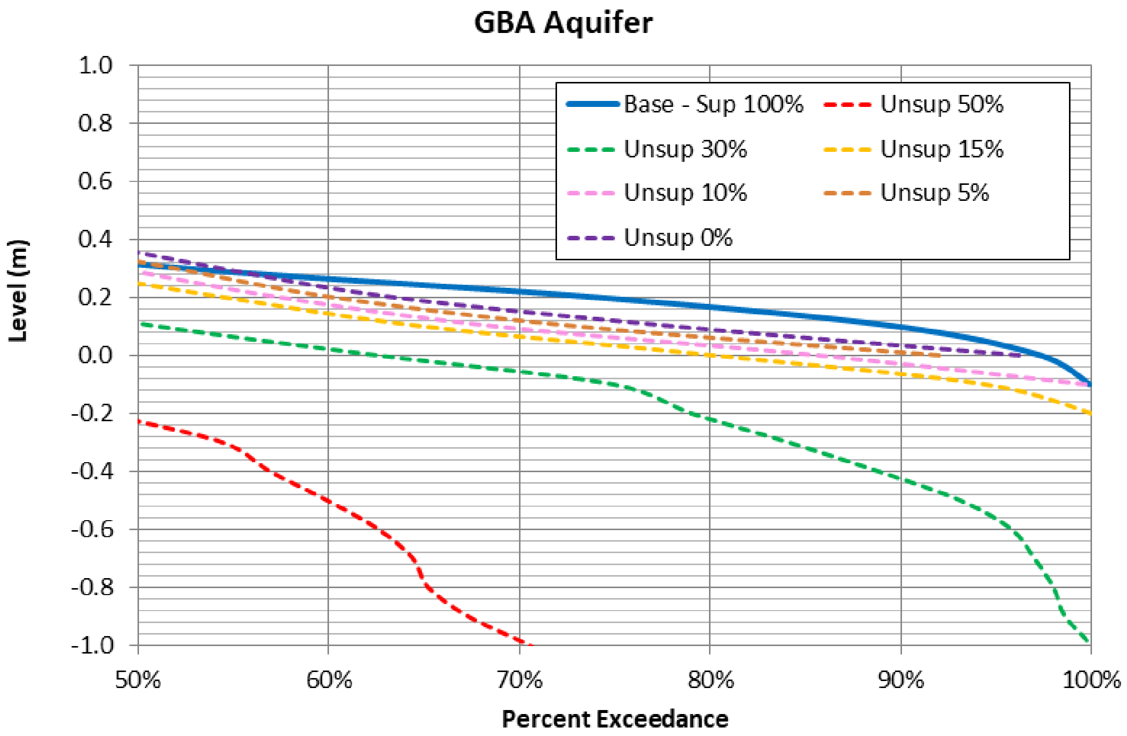

Figure 4-5 – Aquifer Level Exceedance Plot

The different nature of the curves on this plot does not make it simple to assess which unsupplemented case provides the same aquifer level performance as the base case. If the lowest modelled level is used as a benchmark, the 10% unsupplemented case would be chosen as being compatible, but it can be seen that this case gives aquifer levels ~0.12m lower than the base case on about 40% of the days in the simulation period. If the performance at the, say, 90% exceedance percentage was chosen, not even the 0% demand case provides the same level of performance as the base case.

As an additional comment, maintenance of aquifer levels in the GBA aquifer is clearly of critical importance both for the sustainability of irrigation in the area and for the environment. However the Water Plan currently only has objectives related to surface flows for the Burdekin Haughton WSS. Explicitly adding a groundwater level objective to the Water Plan would thus appear to have value. It is thus recommended that consideration be given to this area in the next review of the Burdekin Basin Water Plan.

4.3.2 Using Supplemented Release Data

Some of the other information presented in OD Hydrology 2018 and Kavanagh 2017 enables an estimate to be made of the likely relative contribution of the supplemented releases and natural flows to meeting the required performance of the MP WAE users in the GBA. This is discussed in the points following:

- Figure 3 in OD Hydrology (reproduced in Figure 4-2) provides a comparative plot of natural flows and supplemented releases. Based on this plot it appears that supplemented flows are made most of the time, with natural flows only occurring rarely.

- Section 4.1 in OD Hydrology 2018 states that 68,000 ML was released from Haughton balancing storage into the Haughton River for supplementation of the GBA over the 2 year period. Section 5.1.2 in OD Hydrology 2018 states that the modelled long term average demand is 34,500. This appears to equate to about a 1:1 supplemented volume to extraction volume.
- Table 1, Table 2 and Table 9 in Kavanagh 2017 appear to back this up, showing that water use is, on average, around equal to supplemented diversions from the balancing storage.
- It is noted that the Kavanagh 2017 data is for all Haughton Zone A users, but, as explained earlier, it is likely more robust to evaluate the data for all users in this zone. (It is noted that the non-GBA Haughton A allocations are small, 40,148 - 39,634 = 514 ML of MP).
- It is highlighted that great care must be taken in using average diversion as the measure of performance in a water supply system. The primary role of dams is to provide security of supply. Dams do not create water, they merely store it so it can be used when required. This is recognized in the HUF methodology which examines the worst 15 year period, and also in the WASO performance objectives specified in Water Plans. As is indicated by the annual performance graphs for the Brisbane scheme presented in Figure 3-1 and Figure 3-2, performance in a supplemented system in driven by the climatic pattern in a handful of low flow years. Using average delivery over a period of average years will generally not be an appropriate way to assess the benefit of a supplemented scheme.
- The worst year in Table 2 of Kavanagh 2017 show shows efficiencies down to 66%, with 2011/12 to 2013/14 averaging around 70%. These figures mean that ~140ML needs to be released from the balancing storage for every 100 ML supplied to irrigators.[15]

If natural flows were significantly contributing to the security of water extracted by GBA irrigators in dry periods, then the releases required from the Haughton Channel would be less than the extracted volumes in dry periods. The release data included in Kavanagh 2017 actually indicates the reverse. That is, there appears to be approximately 40% extra operational losses involved in delivering water to GBA irrigators in dry periods, over and above that required to deliver water to Haughton Main Channel users.

It is noted that this is not an unusual situation. In droughts natural inflows are typically small, and virtually all water in droughts is typically sourced from the big storage/s that provide the hydrologic foundation for a scheme. In droughts, when there is little tributary inflow and groundwater levels are low, it is typical that more losses are involved in delivering water to a user

[15] It is noted that the data in Kavanagh 2017 is for a small period (11 years), from which a small 3 year dry period has been selected as representative of the 'worst' dry period. Also, being recorded historic data, this data is subject to a host of real world issues (measurement errors to global economic crises) that may change the measured values for reasons beyond hydrology. The tried and tested way to address this sort of issue is to develop a hydrologic model and model a fixed set of conditions over a climatic sequence. While the Kavanagh 2017 data does not present a strong case for the contribution of natural Haughton River flows, it would be possible to develop a robust model of the system to analyse this further if desired. Such a model should, at a minimum, cover the same 100+ years climatic sequence used in the Burdekin Basin IQQM model. (In fact a good method to develop this model might be to extend the basin IQQM model to better reflect groundwater processes associated with the GBA.) With such a model the contribution of natural flows in the worst '15 year' drought could be extracted, so as to provide some compatibility with the drought period selected for pricing purposes generally.

at the end of the system as opposed to someone who is directly below the main dam. Those at the end of the system also benefit directly from all the dams, weirs, channels and pumps between the main dam and their location, while someone directly below the main dam only directly benefits from the main dam. However it is a key underlying principle of the adopted pricing methodology (including the HUF methodology) that all scheme allocations of the same priority pay the same contribution to headworks costs, and that all allocations of the same priority on distribution systems pay the same contribution to distribution system costs. While users further from the main dam do generally incur greater transmission losses in dry times, subdivision of medium priority users into sub-groups in any scheme in order to apply differential pricing is not keeping with this key underlying pricing principle.

4.3.3 Recommendation

In summary, this review has identified a number of issues with the model used in the OD Hydrology report, issues that raise significant concern with using the results of the modelling for the purpose of pricing. However, review of recorded supplemented releases and extractions, presented in Kavanagh 2017, indicates that GBA irrigators are receiving little contribution from natural Haughton River flows in dry periods.

The OD Hydrology model, even with all its issues, also indicates that the contribution of natural flows is very small. While the OD Hydrology model could be updated to address the issues raised in this report, the supplemented release data tends to indicate that it is unlikely that an improved model will identify that natural flows provide a large contribution to the water security of GBA irrigators.

This study concludes that there does not appear to be a strong basis for differential pricing of GBA MP users (that is, increasing unit prices for other Burdekin distribution system MP users to be able to provide a discount for GBA MP users) based on the contribution of natural flows in the Haughton River. It is thus recommended that Haughton Zone A (including the GBA) is considered as fully part of the Burdekin Haughton Channel Distribution System, with all MP allocations in this distribution system paying the same price.

5 Recommendations

A summary of the recommendations made throughout this report is provided below, listed under headings for the three key tasks this review has involved.

5.1 HUF Methodology Quality Assurance

The recommendations associated with this task were summarised in Section 2.6. These recommendations are repeated below for convenience.

Barker Barambah

- The HUF calculations for this scheme have generally been undertaken in accordance with the documented procedure. One small issue was identified (see below), but the net effect of this issue on the MP HUF was insignificant.
  - A small typo in the storage level used for Joe Sippel Weir (294.4m instead of 294.5m) was identified in the calculation of MP 0 using the AA spreadsheet.
- Update the Departmental website listing of total MP allocation in the Barker Barambah scheme to remove the erroneous double listing for Barambah Zone HZ.

Callide

- The HUF calculations for this scheme have generally been undertaken in accordance with the documented procedure. Two issues were identified (see below), but the net effect of these issues on the MP HUF was insignificant.
  - Convert the maximum amount of MP to HP using the rules in the Fitzroy Water Management Protocol, and then update the HUF calculation to reflect this change. (This action has been completed by SunWater in the addendum to Appendix J provided during this review.)
  - Update the minor typo in the documentation for the FSV of Callide Dam (ROL value is 136,300 ML).
- Consider, perhaps in a future price path, the appropriate adjustment to make to the calculation of the MP HUF to reflect the benefit provided to those users storing Awoonga Dam water in the air space of Callide Dam.
- Consider, perhaps in a future price path, the issues raised in Appendix A with regard estimation of MP100 in the Callide Valley WSS HUF Investigation for this scheme. It is recommended that a report is prepared presenting the data, methodology and results of the Callide Valley WSS HUF Investigation. The report should include a professional opinion on the recommended methodology to calculate the HUF for this non-standard scheme, both for current HP/ MP allocation volumes and for possible future traded HP / MP allocation volumes.
- Consider, perhaps in a future price path, an update to the Callide HUF to subdivide the HP zone into the parts of that zone associated with High A and High B, as the difference in the security of High A and High B appears to be around the same as the difference between the security of High B and Medium Priority.
- At the appropriate time, update the Callide ROL to correct:
  - The name of Kroombit Dam
  - The accepted DSV of Callide Dam

Lower Mary

- The HUF calculations for this scheme have generally been undertaken in accordance with the documented procedure. Two issues were identified (see below), but the net effect of these issues changed the MP HUF by less than 1%. If time permits, it would be of benefit to update the calculations to address these minor issues:
  - In the calculation of MP0, Tinana Barrage was set to its full supply level while Mary Barrage was set to a low level. It is recommended consideration is given to the range of potential level combinations that might apply to this situation. (A preliminary re-estimation of MP0 gave 11,609ML, slightly lower than the value adopted by SunWater.)
  - The MPAmin value applied in the HUF calculation spreadsheet was slightly different to that documented in s2.6 of SunWater 2018j.
- It is noted that the scheme allocations have changed slightly owing to water trading since SunWater undertook their calculations. If the HUF calculations for this scheme are updated, it would be of benefit to use the latest available allocations.
- At the appropriate time, review and potentially delete Att 4 Part 3 Table 8 of the Mary ROP.

Nogoa Mackenzie

- The HUF calculations for this scheme have generally been undertaken in accordance with the documented procedure. Two issues were identified (see below), but the net effect of these issues changed the MP HUF by less than 1%. If time permits, it would be of benefit to update the calculations to address these minor issues:
  - Update the HUF calculation spreadsheet to apply the correct values of MPAmin and HPAmax.
  - Check that the time series of storage volumes from the IQQM model in the HUF calculation spreadsheet are being incorporated into the calculation in chronological order.
- Ensure the AA spreadsheets (used to calculate MP0 and MP100) and the HUF calculation spreadsheet are appropriately archived in the working for the price review.
- At the appropriate time, update the base IQQM model to reflect the deflated Bedford Weir fabridam, and reconfirm that the Water Plan objectives are still met. Use the revised time series of headworks volumes in future calculations of the HUF.
- At the appropriate time, update the Operations Manual to reflect the deflation of the Bedford Weir fabridam.

Pioneer

- The HUF calculations for this scheme have generally been undertaken in accordance with the documented procedure. One issue was identified (see below), but the net effect of this issue changed the MP HUF by less than 1%. If time permits, it would be of benefit to update the calculations to address this minor issue:
  - Review the reason why the Pioneer AA spreadsheet appeared unable to solve the equations in the level range 284.78 to 284.84, and update the HUF calculation if required.
- At the appropriate time, update the base IQQM model to reflect the deflated Dumbleton Rocks Weir and Mirani Weir fabridams, and reconfirm that the Water Plan objectives are

still met. Use the revised time series of headworks volumes in future calculations of the HUF.

- At the appropriate time, update the Resource Operations Plan to reflect the deflation of the two fabridams.

Upper Burnett

- The HUF calculations for this scheme have generally been undertaken in accordance with the documented procedure.
- It is noted that the scheme allocations have changed slightly owing to water trading since SunWater undertook their calculations. If the HUF calculations for this scheme are updated for any reason, it would be of benefit to use the latest available allocations in the update.
- At the appropriate time, update the base IQQM model to reflect the deflated Claude Wharton Weir fabridam, and reconfirm that the Water Plan objectives are still met. Use the revised time series of headworks volumes in future calculations of the HUF.
- At the appropriate time, update the Resource Operations Plan to reflect the deflation of the fabridam.
- Ensure that separate costs are appropriately determined for the John Goleby Weir sub-scheme, as the weir and its allocations have been removed from the calculation of the Upper Burnett MP HUF. With this sub-scheme only supplying MP users, a MP HUF of 100% applies for this sub-scheme.
- In this scheme 10,469ML of MP allocation was assumed to be converted to Low Priority allocation and ignored in the calculation of the HUF. The documented HUF methodology does not appear to allow existing MP allocation to be ignored in the calculation of the HUF, and also does not appear to allow conversion of MP allocation to priority groups other than HP as part of the HUF calculation. However this scheme is a special case, and the reasoning provided for converting and ignoring these allocations in the calculation of the HUF for this scheme appears to be reasonable. It is thus recommended that the HUF methodology is updated to explicitly allow the steps that were taken in this scheme, by, for example, allowing unsaleable allocation to be ignored in the calculation of the HUF. (In the future, if this allocation becomes saleable, as either medium or low priority, it is recommended that it is accounted for in the calculation of the HUF.)

In addition to the recommendations above, some more general recommendations were developed during this review, summarised below:

General HUF Procedure

- Update the procedure to reflect the way MP1util, etc. are actually calculated (steps 1 to 7 on page A-10 of SunWater 2018j). The definitions of P1, P2 and P3 should either be updated, or deleted from the procedure as they are not a necessary step to calculate the HUF.

- Ensure that an appropriate number of significant figures are quoted on the determined HUFs when the HUFs are being used to calculate prices, particularly for small percentage HUF values.

It is noted that some of the recommendations above may require investigation beyond the time available in this Price Review. If the scope of the task prevents it being assessed for the current

Price Review, it is recommended that the issue is assessed in time to provide advice to the next Price Review.

5.2 Central Brisbane River WSS Hydrologic Benefits Review

Key recommendations resulting from this task are summarised below:

- It is recommended that Seqwater re-evaluate the apportionment of costs to MP WAE in the Central Brisbane WSS based on a modified HUF approach, subdividing the central MP1 zone to its primary purposes of supply to MP and HP users. As part of this, Seqwater will likely need to estimate an appropriate MP1F factor to apply to this scheme. The preliminary MP HUF given in this study, 1.12% (based on an estimated MP1F of 1.2), may provide a guide for this revised procedure.
- The recommendation above does not require an update of the Central Brisbane Benefits Study. However, if this study is updated, it is recommended that:
  - Results are presented against the Water Plan's required EFOs or WASOs.
  - The presented statistic, Diversion Days, is considered to be potentially misleading, and its use is therefore not recommended.
  - While volumes of diversion are of interest, the evaluation of benefit in the report should focus on the security of supply. Dams and weirs do not create water, they create security.
  - The flexibility of supply is also a significant benefit. Statistics should be presented to provide an appreciation of this benefit, perhaps through the modelling of a range of diversion patterns, crop types, etc.
  - To provide a full appreciation of benefits, further statistics could be included to provide an indication of the benefits associated with the predictability and steadiness of the flow and the flood mitigation provided by the dams.
- The Central Brisbane WSS provides substantial flood mitigation benefits to downstream properties. However this issue is not constrained to the Brisbane system, nearly all dams provide a measure of flood mitigation to downstream areas (through the passive flood routing provided by their storage and spillway), and procedures to assign a proportion of the dam costs to those who benefit from this are not well developed. It is noted that increased development on floodplains is tending to increase the population who are benefiting from such services, and also that the increasing development downstream of dams is leading to increased dam safety costs at some dams (requiring higher capacity spillways, etc). This is an area that may benefit from reform, and is recommended for further consideration for the next round of price reviews.
- Unlike the other schemes examined in this report, the current volumes of HP and MP WAE for Central Brisbane (and Stanley River) schemes are not listed on the state government website. To be consistent with other schemes, it is recommended that the current allocations for the Central Brisbane River / Stanley River schemes are listed on the website in the same manner as other schemes.
- There appears to be significant duplication between the documentation for the Central Brisbane and Stanley River schemes. As the two dams work together to deliver water to the same groups of users, it is recommended that consideration be given to simplifying the water planning documentation by officially including both structures in the same scheme.
- The Central Brisbane WSS AA procedure is based on a table of useable volume versus AA in the Operations Manual. The useable volume used in the first column of this table is

determined from the formulae given in the Operations Manual, which equates to: CPUVS = [(CV – DSV – SL)$_{Wiv}$ + (CV – DSV – SL)$_{Som}$] / [(CV – DSV)$_{Wiv}$ + (CV – DSV)$_{Som}$]. It is noted that this equation accounts for storage loss in the nominator but not in the denominator. This appears somewhat odd, as it means it is impossible for this equation to give 100%, with the maximum possible value about 83%. If this is not the intent of the procedures documented in the Operations Manual, then it is recommended that the Operations Manual is updated.

5.3 Giru Benefited Area Hydrologic Study Review

Key recommendations resulting from this task are summarised below:

- This study concludes that there does not appear to be a strong basis for differential pricing of GBA MP users (that is, increasing unit prices for other Burdekin distribution system MP users to be able to provide a discount for GBA MP users) based on the contribution of natural flows in the Haughton River. It is thus recommended that Haughton Zone A (including the GBA) is considered as fully part of the Burdekin Haughton Channel Distribution System, with all MP allocations in this distribution system paying the same price.
- This review has identified a number of issues with the model used in the OD Hydrology report, issues that raise significant concern with using the results of the modelling for the purpose of pricing. While the review of supplemented release data tends to indicate that it is unlikely that an improved model will identify that natural flows provide a large contribution to the water security of GBA irrigators, if the model is updated it is recommended that the revised model address the issues raised in Appendix B and Section 4.2 of this report. Alternatively, development of a new model of the GBA, building on the basin IQQM mode as described in Section 4.3.2, would provide a better basis for evaluation of the 15 year dry period, which would be more compatible with the standard pricing approach. Whatever modelling approach is applied, careful documentation of the data, assumptions and calculations used in the model is required, to provide a robust foundation for the conclusions made on the model results.
- It appears that Val Bird Weir and Giru Weir have been maintained at levels higher than the nominal operating levels specified in the Operations Manual. The spreadsheet model also maintains levels above the specified nominal operating levels. This practice may be contrary to the requirements of the BHWSS Operation Manual and may have impacts on the scheme performance. Further investigation of this practice is recommended, in particular, whether the movement of GBA irrigators from groundwater use to direct use of surface water is creating a new requirement to maintain Val Bird Weir over its FSL for much of the year. Once this investigation is complete, it is recommended that operational practices are altered to improve compliance or, if there is good reason to maintain these weirs at higher operating levels, this should be tested in the basin IQQM model, the implications for water supply security assessed, and the provisions of the relevant plans updated to reflect the revised operational strategy. And, of course, any future modelling of the GBA, to evaluate the contribution of natural flows or other matters, should reasonably reflect the documented operational strategy applied.
- As identified in OD Hydrology 2018, recent operational practice has not been very successful in releasing the environmental passflow required by the ROL, and this requirement has also not been included in the OD Hydrology model. OD Hydrology 2018 indicates that SunWater was commissioning a controlled outlet valve to assist in this

required release. The valve should be installed in a timely manner, and then releases made in compliance with the passflow requirement. And, of course, any future modelling of the GBA, to evaluate the contribution of natural flows or other matters, should reasonably reflect the documented operational strategy applied.

- Maintenance of aquifer levels in the GBA aquifer is of critical importance both for the sustainability of irrigation in this area and for the environment. However the Water Plan currently only has objectives related to surface flows for the Burdekin Haughton WSS. Explicitly adding a groundwater level objective to the Water Plan would thus appear to have value. It is thus recommended that consideration be given to this area in the next review of the Burdekin Basin Water Plan.

6 Conclusions

This report summarises the hydrologic advice and guidance provided to assist the Queensland Competition Authority in the conduct of the Rural Irrigation Price Review 2020-24. Three key tasks were undertaken: quality assurance of Headworks Utilisation Factor (HUF) calculations for six specified schemes, a hydrologic review of submissions associated with pricing for the Central Brisbane River scheme Medium Priority (MP) irrigators, and a hydrologic review of submissions associated with pricing for the Giru Benefited Area (GBA) MP irrigators. The key conclusions for each of these three tasks are summarised below.

6.1 HUF Methodology Quality Assurance

Relative hydrologic benefit is estimated by calculating the percentage of the scheme's storage volume primarily responsible for delivering the security of supply for each user group

This study carried out a quality assurance review of the data and calculations of SunWater's estimation of the MP HUF for the following schemes; Barker Barambah, Callide Valley, Lower Mary, Nogoa-Mackenzie, Pioneer Valley, and Upper Burnett. The review has checked the data and calculations used for each of the six schemes against the documented procedure provided in SunWater's submission.

In summary, this review has determined that the data and calculations applied by SunWater have generally been in keeping with the procedure documented in SunWater's submission for the six reviewed schemes. A number of small calculation errors and issues have been identified, but these issues only had a modest effect on the calculated MP HUF, with differences less than about 1% to the values quoted in SunWater's submission.

6.2 Central Brisbane River Scheme Hydrologic Benefits Review

Dams and weirs do not create water, they create security

The first question in this task is whether the two scenarios presented in the Central Brisbane Benefits Study, the Existing Case and the Without Dams Case, provide an appropriate basis for assessing the relative benefits of the Central Brisbane River scheme to medium priority irrigators.

The review has determined that comparison of the two cases is not an appropriate method to assess relative benefit, because:

- The two cases do not present results against the Environmental Flow Objectives (EFOs) in the Water Plan. It is expected that the Existing Case would meet EFOs, while the configuration of the Without Dams Case makes it likely it would not meet the EFOs, with the Without Dams case allowing irrigators to take water required to meet environmental flow objectives. If one case meets the EFOs while the other does not, then evaluating benefits by comparing these two cases is not a fair comparison.

- The two cases do not present results against the Water Allocation Security Objectives (WASOs) in the Water Plan. It is expected that the Existing Case would meet WASOs, while the configuration of the Without Dams Case makes it likely it would not meet the WASOs for other scheme users, as other users have been removed from the model, and no restrictions are placed on the extraction of irrigators. If one case meets the WASOs while the other does not, then evaluating benefits by comparing these two cases is not a fair comparison.

Further, even if evaluation of the two cases were considered an appropriate method to assess relative benefit, evaluation of the results presented in the report indicates that the dams do provide substantial benefit to MP irrigators.

The second question in this task relates to the comprehensiveness of the presented statistics with regard to evaluating the benefit provided by the scheme to MP users. The key conclusions made regarding the statistics presented in the Central Brisbane Benefits Study are as follows:

- The discussion in the report focuses on the volume of diversion rather than the security of supply. Dams and weirs do not create water, they create security. The focus in evaluating the benefit from a regulated system should be on supply security.
- Based on the presented results, the dams reduce the annual probability of failure to deliver the full MP allocation from 1 in 2 (50%) to 1 in 10 (10%), a five times improvement.
- In addition to this substantial improvement in annual reliability, the dams also provide an effectively guaranteed volume of water for MP users, through the announced allocation procedure, that may be taken at any time of the year. This guaranteed supply is a significant benefit over the vagaries of relying on the occasional fall of rain during a drought period with no dams.
- Other benefits MP users received from the scheme include the predictability and steadiness of the flow, which simplifies the management of the irrigator pumping infrastructure required to access water, and the flood mitigation benefits provided by the dams.

The third part of this task involved estimating the appropriate HUF for Central Brisbane irrigators. A modification to the standard HUF methodology, that addresses the characteristics of the Central Brisbane announced allocation procedure, was developed and applied. This improved procedure provided a MP HUF of 1.12%.

This MP HUF equates to a HP:MP Unit Cost Ratio of 2.27:1, which appears reasonable given the relativity of the WASOs for High Priority (HP) and Medium Priority (MP) specified in the Water Plan.

It is thus recommended that Seqwater re-evaluate the apportionment of costs to MP entitlements in the Central Brisbane scheme based on a modified HUF approach similar to that presented in this report.

6.3 Giru Benefited Area Hydrologic Study Review

To be able to compare scheme performance in one area, the cases compared must provide the same level of performance in other areas

This task involved the assessment of the appropriateness of the underlying inputs, assumptions, calculations and models used in the Giru Benefited Area hydrologic study, and the evaluation of whether the modelled cases provide an appropriate basis for costing.

This review has identified a number of issues with the modelling behind the report, issues that raise significant concern with using the results of the modelling for the purpose of pricing. In addition to the issues identified with the model's configuration, it is critical that the model output is examined with regard to the two key objectives associated with the scheme, water supply reliability and environmental flow performance. In the report water supply reliability is generally maintained, but environmental performance, both of the aquifer levels and passflow requirements, are either not met or not assessed.

It is concluded that there is significant uncertainty associated with using the reported results and thus use of the model, in its current form, to provide a basis for pricing is not recommended.

This study has analysed supplemented release and extraction data presented in the submitted Kavanagh 2017 report. Review of this data indicates that GBA irrigators are receiving little contribution from natural Haughton River flows in dry periods. The OD Hydrology model, even with all its issues, also indicates that the contribution of natural flows is very small.

While the OD Hydrology model could be updated to address the issues raised in this report, the supplemented release data tends to indicate that it is unlikely that an improved model will identify that natural flows provide a large contribution to the water security of GBA irrigators.

This study thus concludes that there does not appear to be a strong basis for differential pricing of GBA MP users (that is, increasing unit prices for other Burdekin distribution system MP users to be able to provide a discount for GBA MP users) based on the contribution of natural flows in the Haughton River.

It is thus recommended that Haughton Zone A (including the GBA) is considered as fully part of the Burdekin Haughton Channel Distribution System, with all MP allocations in this distribution system paying the same price.

Should additional clarification on any aspect of this work be required, please do not hesitate to contact Water Solutions.

7 References

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Appendix A – Scheme HUF Review Notes

Table A.1 – Barker Barambah HUF Review

<table>
<tr><th>Step</th><th>Review Notes</th></tr>
<tr><td>1. Identify the water entitlement groupings</td><td>Two priority groupings in this scheme, MP and HP, according to the WP.</td></tr>
<tr><td>2. Determine the volumes of the identified water entitlement groupings</td><td>SunWater obtained current allocation volumes from the Qld Govt website on 14/3/2018. Check on 12/6/2019 confirms the allocations have not changed. HP 2,236 ML. MP 37,793 ML.
No change in total HP allocation is permitted by the trading rules in this scheme, so no volume of MP was converted to HP.
However SunWater actually used a value of 32,079 ML for the MP allocation in this price review, and also in the previous price review. On enquiry, SunWater identified that the Dept website was in error, with the MP allocation for Barambah Zone HZ erroneously listed twice on the website. Correcting for this error provides a MP allocation of 32079ML.
So the values quoted in s2.4 of SunWater 2018j are correct:
MPAmin = 32,079 ML
HPAmax = 2,236 ML</td></tr>
<tr><td>3. Determine the extent to which water sharing rules, critical water sharing rules and other operational requirements give the different water entitlement priority groups exclusive or shared access to components of storage capacity</td><td>The HUF calculations have used:
FSV Hwks = 136,190 ML
DSV Hwks = 1,122ML
The ROP Att4.3D provides the following, which confirms the above figures. (However note the original figures have been rounded, which affects the precision of the total numbers.)
<table>
<tr><th>Storage</th><th>FSV (ML)</th><th>DSV (ML)</th></tr>
<tr><td>Bjelke Petersen Dam</td><td>134,900</td><td>1,000</td></tr>
<tr><td>Sippel Weir</td><td>710</td><td>96</td></tr>
<tr><td>Silverleaf Weir</td><td>580</td><td>26</td></tr>
<tr><td>TOTAL</td><td>136,190</td><td>1,122</td></tr>
</table>
The HUF calculations have used:
MP0 = 12,952 ML
MP100 = 67,510 ML
These numbers have been determined using the schemes AA Spreadsheet, which implements the AA rules given in Schedule 9 of the Water Plan (Burnett Basin). A review of the spreadsheets identified:
The nominated level for Joe Sippel Weir is 294.4m AHD in the 0%MP AA Spreadsheet, while the nominal operating level for this weir in Schedule 9 clause 5 of the WP is 294.5m AHD. Small difference which is unlikely to significantly affect the result. (Note the nominated level in the 100% MP AA spreadsheet is correct at 294.5m AHD.)
Correcting for the level in Joe Sippel Weir and recalculation MP0 and MP 100 from the AA spreadsheet gives the following preliminary values, which are close to the values SunWater used:
MP0 = 12,942 ML</td></tr>
</table>

	◦ MP100 = 67,773 ML • Based on these revised values preliminary estimates of the storage components are as follows: ◦ HP1 = 11,820 ML ◦ MP1 = 54,831 ML ◦ HP2 = 4,458 ML ◦ MP2 = 63,959 ML • These values are close to the values SunWater determined. • Note the effect of CWSA rules in place at the time of the previous price path review was considered in the previous price path HUF. However these rules have since been deleted, and hence no CWSA adjustment is made this time.
4. Assess the hydrologic performance of each component of headworks storage	• The storage volume time series used for this calculation varies from 1,905 to 136,190, which appears consistent with it being for the combination of the three storages making up the FSV Hwks. • The identified driest 15 year period for this scheme is the 15 years to June 1915. • With the above numbers changed, the average volume in each of the 4 storage zones is estimated as follows ◦ HP1util = 10,381 ML ◦ MP1util = 20,763 ML ◦ HP2util = 549 ML ◦ MP2util = 7,878 ML • It is noted that P1, P2 and P3 are not required to be estimated to determine the HUF. Also. The definitions of P1, P2 and P3 do not appear to well match the way they have been determined in the spreadsheet. As P1,P2 and P3 are redundant, it is suggested that that the steps in the procedure related to calculating these parameters are removed.
5. Determine the Headworks Utilisation Factors	• The HUF has been computed using the formulae in Step 1 on the bottom half of pg A-10 of SunWater (2018j) • With the revised values above, a preliminary estimation of the MP HUF using the formulae in Step 1 on the bottom half of pg A-10 of SunWater (2018j) provides a value of 72.4%.

Table A.2 – Callide Valley HUF Review

Step	Review Notes
1. Identify the water entitlement groupings	• Four priority groupings in this scheme, High A, High B, Risk and Medium, according to the WP.

2. Determine the volumes of the identified water entitlement groupings	• SunWater obtained current allocation volumes from the Qld Govt website on 15/3/2018. Check on 13/6/2019 confirms the allocations have not changed. High A 4,311ML, High B 1,066 ML, MP 13,558 ML, Risk 514 ML.
	• S2.4 of SunWater 2018j advises that Risk priority water is generally available from Callide Dam releases and was therefore considered comparable to MP. This seems reasonable given the provision in S6 and S11 of the Callide Operations Manual, and that the WASO for both groups are similar in Schedule 7 of the WP (60 and 65%).
	• S2.4 of SunWater 2018j shows that High A and High B were both included in the HP grouping. Schedule 7 of the WP indicates the WASO for High A is 95%-98%, while for High B it is 90%. This is a significant difference in performance, i.e. at the indicated performance levels High B will suffer from supply shortages ~two to five times as often as High A, which is similar to the difference in performance between High B and MP (that is, Medium will suffer from supply shortages ~ four times as often as High B). There thus may be an argument to subdivide the high priority tariff group into two parts. However currently there is only one High grouping, and on that basis it is reasonable to include High A and High B in the High grouping.
	• Trading rules in the Fitzroy Water Management Protocol allow MP to be converted to High B at a rate of 3 MP = 1 High B, with High B capped at a maximum of 1,300 ML. Page A-7 of SunWater 2018j indicates that in this circumstance the method requires the assumption that HP allocations are maximised through trading. On enquiry, SunWater has confirmed that this was an oversight.
	• If MP was converted to HP, High B would increase by 1300-1066= 234 ML, and MP would decrease by 3x234=702 ML.
	• S2.4 of SunWater 2018j indicates the following total allocations were used:
	  ○ MPAmin = 14,072 ML (sum of Risk and MP)
	  ○ HPAmax = 5,377 ML (sum of High A and High B)
	• However if the conversion of MP to HP was included, the values would be:
	  ○ MPAmin = 13,370 ML
	  ○ HPAmax = 5,611 ML

3. Determine the extent to which water sharing rules, critical water sharing rules and other operational requirements give the different water entitlement priority groups exclusive or shared access to components of storage capacity	• The HUF calculations have used:
	  ○ FSV Hwks = 136,300 ML (136,370 is stated in s2.4 of SunWater 2018j, but this appears to be a typo, as 136,300 was used in the actual calculation).
	  ○ DSV Hwks = 2,880 ML
	• The ROL for this scheme gives details of Callide Dam, Callide Weir and Kroombit Dam (Table 3 in the ROL, labelled Kroombit Weir, is actually for Kroombit Dam), but it is only the Callide Dam volume that is included in the scheme release rules (Table 2 in the Operations Manual). Thus only the Callide Dam storage volume should be considered for this scheme.

	• The ROL Table 1 provides the following data for Callide Dam. It appears that the DSV used in the calculation is not the same as that stated in the ROL.

Storage	FSV (ML)	DSV (ML)
Callide Dam	136,300	85
TOTAL	**136,300**	**85**

- SunWater have provided an extract of the earlier Callide Dam infrastructure schedule from the IROL, which states the DSV is 2,880 ML, as adopted in hydrologic modelling. The IROL also indicates that the volume below the level of the outlet works is 3,350 ML, which means that a temporary pump will need to be installed in order to deliver the last bit of HP water to the power station. 2,880 ML was used in the previous price path, and SunWater decided to use 2,880 ML again as there has been no change to the delivery infrastructure in the last five years.
- The HUF calculations have used:
  - MP0 = 20,000 ML
  - MP100 = 81,852 ML
- This scheme does not apply a standard AA spreadsheet, rather:
  - the MP0 volume is drawn from Table 2 in the Operations Manual, i.e. the level where releases for groundwater (medium priority) cease.
  - The MP100 value was drawn from a previous study (Callide Valley WSS HUF Investigation) which assessed a best fit volume to provide 100% announced allocations as per Table 3 in the Operations Manual.
- On enquiry, SunWater provided further detail regarding the Callide Valley WSS HUF Investigation, which was briefly reviewed.
  - In this study SunWater compiled historical data over the period 1989-2016 of Callide Dam levels and the AA's that were announced in the various groundwater zones in the scheme. The AA's in the seven zones varied, but as expected were generally higher when there was more water in the dam. In Jan 1991 the level in Callide Dam reached approximately EL 211m, and the AA's for three of the zones reached 100% soon after. For the other zones, two do not have data in 1991, and one appears to need less water in storage to reach 100% AA, while the other appears to need more. Based on this SunWater decided to adopt the storage volume at EL 211m (81,852ML) as MP100.
  - It is noted that the EL211m 1991 event was enough to produce 100% AA in the three zones (3B, 3A, and 8A), while in 1996 and 2003 EL 207.4m produced 75% to 95% in these three zones. The actual minimum volume to provide 100%, based on the historical data, may thus be between these two levels (~55,000 to 81,852ML, based on the storage curve in SunWater 2018a).
  - The results of this investigation were provided in a spreadsheet – it appears no formal report documenting the data, methodology and results of this study has been

		prepared. ◦ A full review of the Callide Valley WSS HUF Investigation is beyond the scope of this project, but it is noted that this approach is different to the AA spreadsheet approach used at other schemes, that is, it is based on historical levels and AA's rather than a direct estimate of the current storage volume required to deliver 100% AA to current total MP WAE. This means, for example, that the result relies on allocations, AA rules and extraction rules all being consistent over the historical period analysed. Ideally this sort of issue would be discussed and resolved in the report on the study, but in this instance it appears no report has been produced. ◦ However, it is acknowledged that the nature of the Callide Scheme is such that the standard AA spreadsheet approach cannot be applied, and it is thus necessary to develop an alternate approach. Assuming that allocation and extraction conditions did remain constant over the 1989 to 2016 period, the approach would appear to have reasonable merit. ◦ However, the HUF methodology breaks the above assumption (even if historical conditions have been constant). That is, the HUF methodology requires that the maximum amount of MP is converted to HP. The MPAmin used in the HUF methodology is thus not the same as the MP WAE that existed in 1991. With MPAmin being less that MPA, it follows that MP100 should be less that the volume determined from historical data. A scenario modelling approach may be required in order to estimate appropriate values for cases which do not have sufficient historical record available. ◦ As an order of estimate, MPA / MPAmin = 1.05, so perhaps the (MP100-MP0) volume should be ~5% lower, giving an estimated MP100 of 78,766ML. ◦ But, review of the IQQM results used in the HUF calculation identifies that the maximum stored volume over the 1992-2007 15 year period is ~58,500 ML. Thus, small changes in the estimated MP100 are unlikely to change the calculated HUF. ◦ It is noted that, based on MP100=81,852ML, approximately 4.6 ML of stored volume is required to deliver each MP ML of water, see Section 3.4.4. The Callide scheme has a number of significant differences to other schemes reviewed in this study, but it is noted that this ratio is more than double the ratio for the other analysed schemes, which may indicate the estimated MP100 is overly conservative. That is, it may be the case that the AA rules in this scheme have a similar effect to those in the Central Brisbane (see Section 3.4.2), where the volume between MP0 and MP100 is not just being used to provide security to MP users. ◦ In conclusion, as the Callide Valley WSS HUF Investigation is a key element in the determination of costs for customers, it is recommended that the issues raised above are considered, and then a report on the investigation is prepared by the RPEQ engineer undertaking the study. The report should document a rigorous professional opinion to assist in the calculation of the HUF for this non-standard scheme.

<table>
<tr><td></td><td>

The MP2 and HP2 values in s2.4.3 of SunWater 2018j appear to be in error. This error has occurred because the MPAmin value inserted into the calculation spreadsheet was in error. However, because MP2util and HP2util were determined to be 0 ML, this error does not affect the result.
If the updated values of MPAmin = 13,370 ML and HPAmax = 5,611 ML are applied, and it is assumed that these changed allocations do not affect the estimation of the MP100 volume, then the revised preliminary estimates of the storage components are as follows:

HP1 = 17,120 ML
MP1 = 61,852 ML
HP2 = 16,095 ML
MP2 = 38,353 ML

CS Energy and Callide Power Management Re-lift Licences

It is noted that this scheme includes a set of rules that allows CS Energy and Callide Power Management to store water transferred from Awoonga Dam in the air space of Callide Dam. It is understood that the rules for this practice have been developed to effectively eliminate any negative impact on the water available in the base Callide scheme, e.g. the additional water bears the increase in losses, spills first, etc. As this use is not contained within the HP allocations applied in the HUF methodology, the portion of the Callide Dam FSV assigned to HP users do not include these users, and the HP HUF does not result in any Callide dam costs being assigned to these two users.
On enquiry, SunWater has advised that it considers it reasonable to exclude these users from the Callide Dam HUF calculations, as they do not have allocations from the Callide WSS, and their water is only temporarily stored in Callide Dam, being the first to spill.
However, there is no doubt that these two users are receiving a hydrologic benefit from the Callide scheme headworks. While some (non-WAE) groups who gain benefit from scheme headworks (e.g recreational fishers) are not explicitly assigned costs in the pricing process, the QCA has previously recommended assignation of costs for other non-WAE benefits (eg flood mitigation in the Central Brisbane). In fact it could be considered that the benefit to these two users in the Callide is very similar to the flood mitigation benefits in the Central Brisbane, in that both are receiving benefits based on the air space in their respective scheme’s headworks.
It is recommended that the QCA give consideration as to whether these two industrial users should be accounted for in the calculation of the MP HUF for the Callide scheme.

</td></tr>
<tr><td>4. Assess the hydrologic performance of each component of headworks storage</td><td>

The storage volume time series used for this calculation varies from 2,647 to 136,885, which appears consistent with it being for Callide Dam. It is noted the sequence goes a little above the nominated FSV (i.e. Callide Dam is above FSL and spilling on some days in the run). For the purposes of the HUF calculation it would be preferable to cap this sequence at the FSV. For this scheme not capping the volumes makes no difference, but for schemes with multiple storages not capping the volumes might affect the calculations).

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</table>

	• The identified 15 year dry period is the 15 years to June 2007. • With the above numbers changed, the average volume in each of the 4 storage zones is estimated as follows o HP1util = 15,914 ML o MP1util = 6,049 ML o HP2util = 0 ML o MP2util = 0 ML • Note these values are the same as those presented in s2.4.3 of SunWater 2018j, i.e. the identified errors in the input data do not affect the result in this case.
5. Determine the Headworks Utilisation Factors	• The HUF has been computed using the formulae in Step 1 on the bottom half of pg A-10 of SunWater (2018j) • With the revised values above, a preliminary estimation of the MP HUF using the formulae in Step 1 on the bottom half of pg A-10 of SunWater (2018j) provides a value of 27.5%. • S2.4.4 of SunWater 2018j then disaggregates these values to the four priority groups. If the updated values of MPAmin and HPAmax are used, the disaggregated values recompute to: o MP HUF = 26.2% o Risk HUF = 1.0% o High A HUF = 55.9 % o High B HUF = 16.9 % • Note some care should be taken with rounding HUF values at small percentages, e.g. if 0.6 -1.4 is rounded to 1% this could mean up to a 66% increase in costs would apply to that group. It is thus recommended that the HUFs are applied with an appropriate number of decimal places retained.

Table A.3 – Lower Mary HUF Review

<table>
<tr><th>Step</th><th>Review Notes</th></tr>
<tr><td>1. Identify the water entitlement groupings</td><td>• Two priority groupings in this scheme, High and Medium, based on the WP.
• Noted the Teddington Weir WSS is partially connected this scheme, and so some of its allocations are counted in the determination of the Lower Mary HUF.</td></tr>
<tr><td>2. Determine the volumes of the identified water entitlement groupings</td><td>• SunWater obtained current allocation volumes from the Qld Govt website. Check on 14/6/2019 confirms the Teddington Weir allocations are the same, but the Lower Mary has changed slightly (HP= 459 ML, MP= 29,940ML).
• Rules in s113 of the ROP require bulk water transfer between the Lower Mary and Teddington Weir WSS's. The maximum amount transferred is equal to the sum of the Teddington Weir MP allocations (s113(2)) plus the Teddington Weir HP allocations – 6,819 (s113(5)). SunWater has thus added the Teddington Weir MP allocations and 1,360ML (8,179-6,819) of the Teddington Weir HP allocations.
• No conversion factor is provided in the ROP to convert between priority groups, and hence MPAmin and HPAmax are the same as MPA and HPA.
• If the allocations current on 14/6/2019 were adopted, the following values would apply.
o MPAmin = 32,630 ML
o HPAmax = 1,819 ML</td></tr>
<tr><td>3. Determine the extent to which water sharing rules, critical water sharing rules and other operational requirements give the different water entitlement priority groups exclusive or shared access to components of storage capacity</td><td>• The HUF calculations have used:
o FSV Hwks = 16,750 ML
o DSV Hwks = 7,065 ML
• For this scheme the following storages are included in the announced allocation calculations in the ROP (Att 4 Part 3 Table 5). The FSV and DSV from the ROP is provided for each structure. The total FSV and DSV both match the total in s2.7 of SunWater 2018j.
<table><tr><th>Storage</th><th>FSV (ML)</th><th>DSV (ML)</th></tr><tr><td>Mary Barrage</td><td>12,000</td><td>5,050</td></tr><tr><td>Tinana Barrage</td><td>4,750</td><td>2,015</td></tr><tr><td>**TOTAL**</td><td>**16,750**</td><td>**7,065**</td></tr></table>
• The HUF calculations have used:
o MP0 = 11,705 ML
o MP100 = 16,750 ML
• These numbers have been determined using the schemes AA Spreadsheet, which implements the AA rules given in the ROP. A review of the spreadsheets identified:
o Att 4 Part 3 Table 6 of the ROP provides a list of inflows to be assumed in the AA calculation, however the AA spreadsheets have used zero inflows. At first glance this appeared odd - the various allowances in the AA procedure are a package, and in general removal of one element from</td></tr>
</table>

	such a package should be done with caution. ◦ Further review of the HUF procedure identified that deletion of the inflows is part of the procedure, step 3b on page A-8 of SunWater 2018j. This step may have been added to the HUF methodology owing to a comment in PB 2012, which concluded that the HUFs for the Logan, Warrill and Mary Valley WSS's only appeared to be reasonable if the minimum historic inflows are removed from the analysis. With removal of inflows being part of the documented procedure, SunWater has followed the documented procedure. ◦ With the inflows in the AA spreadsheet set to zero, SunWater adjusted the levels in each weir to determine MP0 and MP100. ◦ SunWater found that Mary Barrage at 1.0m, and Tinana Barrage at 2.5m, combined volume 11,705ML, gave 100% for HP and 0% for MP, and thus set MP0=11,705ML. It is noted that these two storage levels are somewhat unbalanced – Tinana Weir is at its FSL, but Mary Barrage is 1.9m lower than its FSL, only being 0.85m above its DSV. With the two weirs having different storage characteristics there are a number of combinations of levels which would result in 0% AA for MP. For example, Mary Barrage at 2.01m, and Tinana Barrage at its DSL of -0.5m also gives 100% for HP and 0% for MP. If this combination of volumes was adopted, MP0 would be set to 11,513ML. ◦ S108 of the ROP prohibits the taking of water for irrigation use under medium priority water allocations from the scheme when Mary Barrage is lower than 1.0m, with the prohibition continuing until the weir rises above 1.2m. This rule effectively provides a cutoff at which medium priority diversion ceases. It was thought that SunWater may have adopted the 1.0m level in Mary Barrage owing to this rule, but on enquiry SunWater has advised that this is not the case. ◦ Using the MP0 value when Tinana Barrage is full, or when Tinana Barrage is at its DSL, both appear somewhat unbalanced. It is considered preferable to use a combination of levels more likely to occur in a particular drought. For the purposes of this review the two extreme values are averaged, providing a MP0 of 11,609ML. ◦ For MP100, SunWater attempted to adjust the levels in both weirs to provide 100% to MP, but found that even setting both weirs to the FSL did not result in 100% AA to MP. With both weirs set to their FSL, a MP AA of only 11% was achieved. (The Lower Mary scheme consists of relatively small weirs on a reliable river – the performance of the scheme is highly dependent on inflows during the year. In the normal AA procedure, 100% MP is achieved with about a 14,700 ML combined storage volume, but the removal of the inflow allowance means that the full headworks volume of 16,750 ML only is sufficient to provide 11% AA to MP users.) ◦ According to step 3c on page A-8 of SunWater 2018j, MP100 is not permitted to exceed the scheme full supply volume. MP100 was thus set to the scheme full supply volume, 16,750 ML. • The resultant MP0 andMP100 volumes with the above changes are

	thus: ◦ MP0 = 11,609 ML ◦ MP100 = 16,750 ML • Recalculating preliminary values of the storage components based on the values estimated in this review provides: ◦ HP1 = 4,544 ML ◦ MP1 = 5,141 ML ◦ HP2 = 0 ML ◦ MP2 = 0 ML • It is noted that Att 4 Part 3 Table 8 of the ROP provides Transmission and Operational Losses for the Lower Mary Scheme, in a form suitable for use in the AA calculation, however the AA formulae in s110 does not use a TOL allowance
4. Assess the hydrologic performance of each component of headworks storage	• The storage volume time series used for this calculation varies from 7,097 to 16,750, which appears consistent with it being for the combination of the two storages making up the FSV Hwks. • The MPAmin value used in the spreadsheet (32,688ML) differs slighted from the documented value. • SunWater used the period ending June 1947 as the driest 15 year period. • With the various values adjusted as above, three periods were almost tied as the driest periods, the periods ending June 1923, June 1946 and June 1947. Extending the decimal places to three identified that the period ending June 1923 gave the lowest MP HUF. • With the various values adjusted as above, the average volume in each of the 4 storage zones is estimated as follows: ◦ HP1util = 4,379 ML ◦ MP1util = 4,155 ML ◦ HP2util = 0 ML ◦ MP2util = 0 ML
5. Determine the Headworks Utilisation Factors	• The HUF has been computed using the formulae in Step 1 on the bottom half of pg A-10 of SunWater (2018j) • With the various values adjusted as above, a preliminary estimation of the MP HUF using the formulae in Step 1 on the bottom half of pg A-10 of SunWater (2018j) provides a value of 48.7%.

Table A.4 – Nogoa Mackenzie HUF Review

<table>
<tr><th>Step</th><th>Review Notes</th></tr>
<tr><td>1. Identify the water entitlement groupings</td><td>Two priority groupings in this scheme, High and Medium, based on the WP.</td></tr>
<tr><td>2. Determine the volumes of the identified water entitlement groupings</td><td>SunWater obtained current allocation volumes from the Qld Govt website on 15/3/2018. Check on 13/6/2019 confirms the allocations have not changed. HP 46,127 ML. MP 185,732 ML.
Trading rules in the Fitzroy Water Management Protocol allow MP to be converted to HPB at a rate of 3 MP = 1 HP, with HP capped at a maximum of 56,000 ML. Page A-7 of SunWater 2018j indicates that in this circumstance the method requires the assumption that HP allocations are maximised through trading.
If MP was converted to HP, HP would increase by 56,000-46,127= 9,873 ML, and MP would decrease by 3x9,873=29,619 ML, giving the total below (which match the values in s2.7.1 SunWater 2018j.)
MPAmin = 156,113 ML
HPAmax = 56,000 ML</td></tr>
<tr><td>3. Determine the extent to which water sharing rules, critical water sharing rules and other operational requirements give the different water entitlement priority groups exclusive or shared access to components of storage capacity</td><td>The HUF calculations have used:
FSV Hwks = 1,339,033 ML
DSV Hwks = 19,520 ML
For this scheme the following storages are included in the announced allocation calculations in the Operations Manual. The FSV and DSV from the ROL is provided for each structure. The DSV matches the total in s2.7 of SunWater 2018j, but the FSV is different.
<table>
<tr><th>Storage</th><th>FSV (ML)</th><th>DSV (ML)</th></tr>
<tr><td>Fairbairn Dam</td><td>1,301,000</td><td>12,300</td></tr>
<tr><td>Bedford Weir</td><td>22,900</td><td>3,290</td></tr>
<tr><td>Bingegang Weir</td><td>8,060</td><td>1,400</td></tr>
<tr><td>Tartrus Weir</td><td>12,000</td><td>2,530</td></tr>
<tr><td>TOTAL</td><td>1,343,960</td><td>19,520</td></tr>
</table>
A note in s2.7.2 indicates the FSV Hwks has been reduced because of the deflation of the Bedford Weir fabridam. The fabridam was 1.2m high according to the ROL, with a fixed crest level of 122.80m AHD. Based on the storage curve in the AA spreadsheet, the revised storage volumes in the scheme are as follows, which matches the values indicated by SunWater.
<table>
<tr><th>Storage</th><th>FSV (ML)</th><th>DSV (ML)</th></tr>
<tr><td>Fairbairn Dam</td><td>1,301,000</td><td>12,300</td></tr>
<tr><td>Bedford Weir</td><td>17,973</td><td>3,290</td></tr>
<tr><td>Bingegang Weir</td><td>8,060</td><td>1,400</td></tr>
<tr><td>Tartrus Weir</td><td>12,000</td><td>2,530</td></tr>
<tr><td>TOTAL</td><td>1,339,033</td><td>19,520</td></tr>
</table></td></tr>
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The HUF calculations have used:
MP0 = 268,115 ML
MP100 = 475,429 ML
These numbers have been determined using the scheme's AA Spreadsheet, which implements the AA rules given in the Operations Manual. A review of the spreadsheets identified:
The spreadsheets provided did not seem to match the values provided in SunWater 2018j. The date of the AA calculation, the MP and HP allocations used and the results did not match.
The spreadsheets were updated to match the start of the water year (1 July) and the MPAmin and HPAmax values were included. The level in Fairbairn Dam was iterated until the desired AA was achieved, providing the following preliminary results:
MP0 = 267,493 ML
MP100 = 474,574 ML
These numbers are within the margin of accuracy of the values used by SunWater.
Using SunWater's values, the storage components were calculated, HP1 and MP1 were matched, but different values were computed for HP2 and MP2. It appears SunWater has used the nominal volumes to partition MP2 and HP2, rather than the MPAmin and HPAmax values.
Recalculating preliminary values of the storage components based on the values estimated in this review provides:
HP1 = 247,973 ML
MP1 = 207,081 ML
HP2 = 228,226 ML
MP2 = 636,233 ML

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<tr><td>4. Assess the hydrologic performance of each component of headworks storage</td><td>

In the original HUF calculation spreadsheet provided by SunWater, the storage volume time series used for this calculation varies from 109,322 to 1,343,960, which appears consistent with it being for the combination of the four storages making up the FSV Hwks but without the adjustment for the deflation of the fabridam. 9Review of the IQQM sys file shows that the fabridam is assumed to be inflated in the IQQM scenario.)
However the original HUF calculation spreadsheet only included end of water year values. On enquiry SunWater provided an updated spreadsheet including daily storage values. The revised storage volume time series in the spreadsheet varied from 23,526 to 1,339,033, which is now consistent with being for the total of the four storages with the fabridam deflated.
The IQQM sys file shows that the fabridam is assumed to be inflated in the IQQM scenario used to source the storage volume timeseries. SunWater has capped the volume in the weir at its reduced FSV in an attempt to remove the influence of the additional volume stored behind the fabridam. This is likely to give a fair result, if you assume you cannot change the IQQM scenario. However it is highlighted that, if the inflated fabridam was removed from the IQQM scenario, it would cause a reduction in stored volume even when the weir was below the fixed sill. It would be more robust to update the IQQM scenario to reflect the change in the headworks infrastructure, re-extract the storage volume timeseries, cap at each storages' FSV,

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	and then re-calculate the HUF.
	• The identified driest 15 year period for this scheme in the original HUF calculation spreadsheet was the 15 years to June 1949, with a MP HUF of 28.2%, and a graph for this period is provided in s2.7.4 of SunWater 2018j. In the revised spreadsheet provided the driest 15 year period appears to be the period ending June 1972, which also provides a MP HUF of 28.2%. However the date order of the storage volume time series appears to have been scrambled in this spreadsheet. When the time series storage volume data is put back in chronological order, the 15 years to June 1950 becomes the driest, with a MP HUF of 28.0%
	• The HUF calculation spreadsheet was updated with the parameters as described above, and the storage volume timeseries placed in chronological order. With these changes the identified driest 15 year period for this scheme is the 15 years to June 1950.
	• With the above numbers changed, the average volume in each of the 4 storage zones is estimated as follows
	  ○ HP1util = 199,552 ML
	  ○ MP1util = 64,539 ML
	  ○ HP2util = 4,930 ML
	  ○ MP2util = 13,743 ML

5. Determine the Headworks Utilisation Factors	• The HUF has been computed using the formulae in Step 1 on the bottom half of pg A-10 of SunWater (2018j) • With the revised values above, a preliminary estimation of the MP HUF using the formulae in Step 1 on the bottom half of pg A-10 of SunWater (2018j) provides a value of 27.7%.

Table A.5 – Pioneer HUF Review

<table>
<tr><th>Step</th><th>Review Notes</th></tr>
<tr><td>1. Identify the water entitlement groupings</td><td>Two priority groupings in this scheme, High Class A and High Class B.
The Pioneer Water Plan also has WASOs for Medium and Risk priority groups, but there are no WAE in the Medium or Risk groups in the Pioneer scheme..</td></tr>
<tr><td>2. Determine the volumes of the identified water entitlement groupings</td><td>SunWater obtained current allocation volumes from the Qld Govt website on 14/3/2018. Check on 15/6/2019 confirms the allocations have not changed.
No conversion factor is provided in the ROP to convert between priority groups, and hence MPAmin and HPAmax are the same as MPA and HPA.
In this scheme the High Class B allocations are placed in the MPA bucket, while the High Class A allocations are placed in the HPA bucket.
The values in s2.8.1 SunWater 2018j are thus correct, i.e.
MPAmin = 47,357 ML
HPAmax = 30,753 ML</td></tr>
<tr><td>3. Determine the extent to which water sharing rules, critical water sharing rules and other operational requirements give the different water entitlement priority groups exclusive or shared access to components of storage capacity</td><td>The HUF calculations have used:
FSV Hwks = 160,310 ML
DSV Hwks = 8,950 ML
For this scheme the following storages are included in the announced allocation calculations in the ROP (s99-101). The FSV and DSV from Att 3(a) of the ROP are provided for each structure. The total DSV matches the value in s2.8 of SunWater 2018j but the FSV is different.
<table>
<tr><th>Storage</th><th>FSV (ML)</th><th>DSV (ML)</th></tr>
<tr><td>Teemburra Dam</td><td>147,500</td><td>8,300</td></tr>
<tr><td>Mirani Weir</td><td>4,660</td><td>410</td></tr>
<tr><td>Marian Weir</td><td>3,980</td><td>110</td></tr>
<tr><td>Dumbleton Rocks Weir</td><td>8,840</td><td>130</td></tr>
<tr><td>TOTAL</td><td>164,980</td><td>8,950</td></tr>
</table>
A note in s2.8.2 of SunWater 2018j indicates the FSV Hwks takes into account the deflation of the fabridams at Dumbleton Rocks Weir and Mirani Weir. The fixed crest at Dumbleton Rocks Weir is at 14.00m AHD according to the ROP, and for Mirani Weir the fixed crest is 45.20 m AHD. Revised volumes for the two weirs at these reduced levels were obtained from the storage curves in the AA spreadsheets, providing the revised volumes below. This matches the value used by SunWater, given rounding.</td></tr>
</table>

<table>
<tr><td></td><td>

Storage	FSV (ML)	DSV (ML)
Teemburra Dam	147,500	8,300
Mirani Weir	2,730	410
Marian Weir	3,980	110
Dumbleton Rocks Weir	6,108	130
TOTAL	**160,318**	**8,950**

- The HUF calculations have used:
  - MP0 = 55,196 ML
  - MP100 = 106,453 ML
- These numbers have been determined using the schemes AA Spreadsheet, which implements the AA rules given in the ROP. A review of the spreadsheets identified:
  - The calculation of the storage volumes associated with two AA level cases (High A 80% and High B 0%, and High A 100% and High B 10%) were checked using the AA spreadsheet and appear correct. The calculation of MP0 from these two values, using the adjustment provided ins2.8.2 of SunWater 2018j, appears reasonable.
  - When the MP100 case was rerun, the AA spreadsheet indicated that a solution could not be obtained. The AA in this case was 100%, but the TOA allowance appears to be low for this result. The Teemburra Dam Level was 284.78m in this case. A run with 284.77m got to a solution, with the AA=87%. The AA spreadsheet appeared unable to solve the equations in the level range 284.78 to 284.84. At a level of 284.85m the spreadsheet successfully found a solution with AA=100%, and the TOA appears to be the correct value (6,360ML). If this level is adopted the MP100 is then 107,038 ML.
- If the revised MP100 case is adopted, the resultant MP0 andMP100 volumes are as follows:
  - MP0 = 55,196 ML
  - MP100 = 107,038 ML
- Recalculating preliminary values of the storage components based on the values estimated in this review provides:
  - HP1 = 46,246 ML
  - MP1 = 51,842 ML
  - HP2 = 20,977 ML
  - MP2 = 32,303 ML

</td></tr>
<tr><td>4. Assess the hydrologic performance of each component of headworks storage</td><td>

- The storage volume time series used for this calculation varies from 16,476 to 160,379. On enquiry, SunWater advised that they have capped the storage volume timeseries for each storage at their FSVs, but that a greater number of significant figures were used in this task, providing a total headworks FSV of 160,379 ML.
- The FSV Hwks value in the spreadsheet differs slighted from the documented value. The value, 160,379ML, matches the total

</td></tr>
</table>

	headworks value described in the previous dot point. • SunWater used the period ending June 1988 as the driest 15 year period. • With the various values corrected as indicated above, the average volume in each of the 4 storage zones is estimated as follows: ○ HP1util = 41,534 ML ○ MP1util = 22,174 ML ○ HP2util = 3,033 ML ○ MP2util = 4,670 ML
5. Determine the Headworks Utilisation Factors	• The HUF has been computed using the formulae in Step 1 on the bottom half of pg A-10 of SunWater (2018j) • With the revised values above, a preliminary estimation of the MP HUF using the formulae in Step 1 on the bottom half of pg A-10 of SunWater (2018j) provides a value of 37.6%.

Table A.6 – Upper Burnett HUF Review

<table>
<tr><th>Step</th><th>Review Notes</th></tr>
<tr><td>1. Identify the water entitlement groupings</td><td>Three priority groupings in this scheme, High, Medium and Low, based on the WP.</td></tr>
<tr><td>2. Determine the volumes of the identified water entitlement groupings</td><td>SunWater obtained current allocation volumes from the Qld Govt website on 14/3/2018. Check on 15/6/2019 indicates there has been some changes. The website now indicates HP 1,380 ML. MP 47,320 ML (a decrease of 150 ML HP, and an increase of 300 ML MP).
John Goleby Weir is on a side stream, and cannot access water released from Wuruma Dam. Water sharing in the John Goleby is essentially independent of the rest of the scheme. The allocation in the John Goleby sub-scheme are thus excluded from the HUF calculation for the majority of the scheme.
The John Goleby subscheme consists of ROP Zones OD and PA – HP 0 ML and MP 1,560 ML. With all of the allocations in this sub-scheme being medium, a MP HUF of 100% effectively applies. The costs for this subscheme should thus be separately determined, and all costs for the subscheme are apportioned to MP users.
Low Priority User Group:
S2.10 of SunWater 2018j has assigned 10,469 ML to the Low Priority user group in the scheme, while the Qld Govt website indicates no Low priority WAE currently exist. S63 of the Burnett Water Plan provides provision for conversion of MP allocations to low priority at a 1:1 ratio if Claude Wharton Weir is lower than 94.4m AHD (i.e. if the volume lost through the deflation of the fabridam has not been restored) at the time that water sharing rules for the Upper Burnett are included in the ROP. Review of the ROP indicates that water sharing rules have not yet been included in the ROP, and so clause 63 has yet to be triggered.
SunWater has advised that there is 5,469 ML of MP allocation under clause 63(2), and a further 5000 ML is specified under clause 63(3), providing the total of 10,469ML. SunWater, through Burnett Water, owns all of this allocation.
The announced allocation formulae in Schedule 9 of the water Plan effectively ignore these allocations, with the formulae explicitly removing 10,469 ML from the denominator of the equations. That is, no water is allocated to these allocations, effectively increasing the reliability of other allocations in the scheme.
The allocation assigned to Low Priority water has not been considered in the HUF calcs. SunWater has advised that these allocations are effectively unsaleable[16]. With no customer owning these allocations, there is no one to pay any costs if such were assigned to this user group.
However it is noted that there is no step in the documented HUF methodology that allows MP water to be converted to Low Priority water.
There is also no step in the documented procedure to selectivity exclude allocations held by a particular party, even if those allocations are unsaleable.</td></tr>
</table>

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	◦ It is noted that the Ministerial referral notice for the QCA's pricing review excludes water services provided by Burnett Water in relation to Paradise Dam and Kirar Weir. In s2.10 of SunWater 2018j 20,000 ML of MP allocation is identified as being Burnett Water allocation, with 9,531 ML of the Burnett Water allocation included in the Upper Burnett HUF calculation methodology, while 10,469 ML is ignored. Table 2.4 in SunWater 2018i indicates that 20,000 ML of Upper Burnett Water associated with Kirar Weir was excluded by the QCA in the 2012 price decision, and that SunWater has applied these adjustments again. ◦ Even though the QCA's task is just to review the non-Burnett Water part of the Upper Burnett scheme, it is necessary for the Burnett Water allocations to be included in the HUF calculation. As shown in s2.10.4 of SunWater 2018j, the HUF for Burnett Water allocation is a necessary product of the methodology, even though the Burnett Water HUFs are not within the scope of this review. ◦ In summary, if these allocations are essentially unsaleable, and they are effectively assigned zero allocation in the announced allocation procedure, it would appear to be appropriate to vary the standard HUF procedure for this scheme to exclude them from the HUF calculation at this time. ◦ In the future: ▪ If the lost storage volume at Claude Wharton Weir is recovered, the 10,469 ML of MP water will remain as MP water, the AA formulae would be updated to cover the AA's to these allocations, and SunWater would be able to make the water available for sale. In this circumstance it would be appropriate to include this water in the MP allocation considered in the HUF calculation. ▪ If the lost storage volume at Claude Wharton Weir is not recovered, water sharing rules for low priority are included in the ROP, and s63 of the Water Plan is triggered, the 10,469 ML will be converted to Low Priority, and then potentially might be sold to users. The Water Plan provides a WASO of 25% for Low Priority. With Low Priority having a low, but appreciable, performance, it may be appropriate to refine the HUF methodology to apportion part of the scheme storage to this priority group at that time. • No conversion factor is provided in the ROP to convert between priority groups, and hence MPAmin and HPAmax are the same as MPA and HPA. • The total MP (assuming that the 10,469ML of MP assigned to potential future conversion to low priority may be ignored) is thus 47,320 – 1,560 – 10,469 ML. ◦ MPAmin = 35,291 ML (including the LP, 45,760 ML) ◦ HPAmax = 1,380 ML • These values are slightly different to the values in s2.10.1 SunWater 2018j, however it appears SunWater's values were correct at the time they did the calculation.

	• Note the total MP allocation including the MP water potentially to be converted to low priority is also provided above, as this number is required in the AA spreadsheets, see below.
3. Determine the extent to which water sharing rules, critical water sharing rules and other operational requirements give the different water entitlement priority groups exclusive or shared access to components of storage capacity	• The HUF calculations have used: ○ FSV Hwks = 186,740 ML ○ DSV Hwks = 2,581 ML • For this scheme the following storages are included in the announced allocation calculations in the Water Plan (s40-53). The FSV and DSV from Att 4.2D of the ROP is provided for each structure. The total DSV matches the value in s2.8 of SunWater 2018j but the FSV is different. (table 1 below) • A note in s2.8.2 of SunWater 2018j indicates that the deflation of the Claude Wharton Weir fabridam has affected the storage volume. The fixed crest at this weir is 92.9m AHD, volume 8,080 ML according to storage curve A3-213616. Revised storage volumes are tabulated below. These values match the values included in s2.10 of SunWater 2018j. (table 2 below) • The HUF calculations have used: ○ MP0 = 8,611 ML ○ MP100 = 65,929 ML • The allocations used in SunWater's AA spreadsheets are tabulated below.

Storage	FSV (ML)	DSV (ML)
Wuruma Dam	165,400	2,430
Jones Weir	3,720	10
Claude Wharton Weir	12,800	120
Kirar Weir	9,540	21
TOTAL	**191,460**	**2,581**

Storage	FSV (ML)	DSV (ML)
Wuruma Dam	165,400	2,430
Jones Weir	3,720	10
Claude Wharton Weir	8,080	120
Kirar Weir	9,540	21
TOTAL	**186,740**	**2,581**

Storage	MP (ML)	HP (ML)
Wuruma Dam	2,050	10
Jones Weir	20,780	320
Claude Wharton Weir	14,597	1,000
Kirar Weir	8,033	200
TOTAL	**45,460**	**1,530**

- It is noted that these allocations include all MP allocations, including the MP allocations that might be converted to LP in the future. The AA formulae included in Schedule 9 of the Water Plan have adjustments for the 10,469ML in the denominator of the AA formulae, i.e. the 10,469 ML is removed within the formulae, and thus it is necessary to include this water in the total MPA used in the AA spreadsheets.
- The reduction of 150ML HP, and increase of 300 ML MP, is located in zones NA and NB, in the Claude Wharton sub-scheme.
- These numbers have been determined using the schemes AA Spreadsheet, which implements the AA rules given in the ROP. A review of the spreadsheets identified:
  - Like the Lower Mary, the water sharing rules for the upper Burnett include an allowance for minimum inflows. This allowance is included on the Kirar. Jones and Claude Wharton sub-schemes but not the Wuruma subscheme, i.e. it is included on the small weirs which rely more heavily on flow during the year in order to deliver to WAE holders. As per the procedure, the inflow allowance on the Kirar. Jones and Claude Wharton sub-schemes has been set to zero for the purposes of calculating the HUF.
  - For MP0, the storages are at low levels, and the AA is calculated with the scheme split into subschemes. The calculations for MP0 appear reasonable with the WAE volumes SunWater has used. (and the additional 300ML of MP allocation in the Claude Wharton sub-scheme does not, by definition, affect MP0).
  - For 100% the AA is calculated for the scheme as a whole. The calculations for MP100 appear reasonable. If the additional 300ML of MP allocation in the Claude Wharton sub-scheme is included, it does not change the result.
- The MP0 andMP100 volumes computed by SunWater are confirmed, based on the allocations obtained by SunWater in 2018. However if the updated allocations are used MP0 and MP100 are as follows:
  - MP0 = 8,409 ML
  - MP100 = 65,929 ML
- Recalculating preliminary values of the storage components based on the values estimated in this review provides:
  - HP1 = 5,828 ML
  - MP1 = 57,520 ML
  - HP2 = 4,546 ML
  - MP2 = 116,265 ML

4. Assess the hydrologic performance of each component of headworks storage	• The storage volume time series used for this calculation varies from 2,499 to 186,740, which is consistent with the DSV and FSV used in this scheme.
	• As with the other schemes with deflated fabridams, the IQQM sys file shows that Claude Wharton was modelled assuming the fabridam is operational. While the additional stored volume above the fixed sill has been removed from the storage volume timeseries, the inclusion of the fabridam in the IQQM model will affect stored volumes even below the fixed sill.
	• SunWater used the period ending June 2008 as the driest 15 year period.
	• With the various values corrected as indicated above, the average volume in each of the 4 storage zones is estimated as follows:
	  ○ HP1util = 5,111 ML
	  ○ MP1util = 13,168 ML
	  ○ HP2util = 0 ML
	  ○ MP2util = 1 ML

5. Determine the Headworks Utilisation Factors	• The HUF has been computed using the formulae in Step 1 on the bottom half of pg A-10 of SunWater (2018j) • With the revised values above, a preliminary estimation of the MP HUF using the formulae in Step 1 on the bottom half of pg A-10 of SunWater (2018j) provides a value of 72.0%. • S2.10.4 of SunWater 2018j then goes on to subdivide the HUF into values for the SunWater and Burnett Water parts of the scheme. The values indicated in SunWater 2018j appear to be correct for the allocation totals available at the time SunWater did their calculations. (If the more recent allocations are used, the SunWater MP HUF becomes 65.2%[17].)

[17] Assumes that the water traded was within SunWater's pool of allocations, which is must be as it involved conversion of HP to MP, and there is no HP in Burnett Water's pool.

Appendix B – Giru Model and Report Review Notes

Table B.1 – Giru Model and Report Review

<table>
<tr><th>Component</th><th>Review Notes</th></tr>
<tr><td>Objectives</td><td>The objectives of the work presented in the OD Hydrology report are presented in Section 1 of that report. The indicated objectives are to:
provide an improved understanding of the interaction between ground and surface water in the GBA,
ensure operation of the GBA is equitable and in compliance with the ROP and SunWater's operating rules, and
consider if an alternative operating regime for the GBA could generate additional capacity or reliability in the Haughton Main Channel (HMC) while retaining the agreed level of service to the GBA
It is noted that the documented objectives of the study does not include the determination of a hydrological basis for the lower price charged to customers in the Giru Benefited Area, the key issue of concern for this review. However this purpose is mentioned later in the report, Section 3 of the OD Hydrology report indicates that the study was conducted to “allow initial assessment of natural versus supplemented ‘yield’ and irrigation supply reliability.”
The introduction also highlights that operation of the GBA has two key objectives:
Supplementation of groundwater supply to users
Management of groundwater levels, preventing excessive water level rise or fall, and reducing the risk of saltwater intrusion</td></tr>
<tr><td>Overall Model Configuration</td><td>The sheet ‘watbal’ in the provided Excel Workbook contained the core calculations of the model
Timestep: Daily
Period of Analysis: 5/5/1978 to 21/1/2018.
Models the system with three conceptual buckets, Val Bird Weir, Giru Weir and the Groundwater Aquifer
Each bucket has inflows and outflows and tracks storage volume daily. (Further details on the inflows and outflows are described further below.)
A number of parameters are included in bold blue at the top of the sheet. Some of these appear to be fixed data (such as weir capacity) while others appear to be calibration parameters (such as the transmission loss percentage).
Two of these parameters are the key variables used in the three scenarios plotted in the key output graph (Figure 21) in OD Hydrology 2018. These are:
Cell F8 holds a percentage which is applied to the supplemented releases from the Haughton Channel for GBA users. A note on the cell indicates this parameter is set to 85% for the supplemented case, with the 85% determined by matching simulated releases to the 2 year (2016-2017) recorded releases. For the unsupplemented cases, this cell is set to 0%.
Cell H8 hold a percentage which is applied to the total demand of the GBA users. It is set to 100% for the supplemented case, 50% for the 50% demand unsupplemented case, and 30% for the 30% demand unsupplemented case.
The review below first focuses on the modelling of the supplemented case, followed by the changes for the two unsupplemented cases.</td></tr>
</table>

Input Data	• Rain data (mm) in the model is labelled as being from "119006A - Major Creek at Rocky Waterhole Lat:-19.66886667 Long:147.02481667 Elev:34m"
	  ○ The average monthly rainfall in the data set used was checked against average monthly rainfall for the same period in the Giru PPD dataset (independently downloaded from the SILO site), and found to be a good match
	• Evap data (mm) in the model is labelled as being Patched Point data from "33028 GIRU POST OFFICE, Lat: -19.5114 Long: 147.1064"
	  ○ The average monthly evaporation in the data set used was checked against average monthly American Class A Pan data for the same period in the Giru PPD dataset (independently downloaded from the SILO site), and found to be a good match.
	  ○ However this evaporation data is used in the model to estimate evaporation from the ponded area of the two Weirs. No pan factor appears to have been applied. Pan factors may be estimated from the Morton evap estimates in the PPD file (or the Morton Lake estimates could be used directly). Preliminary estimates of appropriate pan factors indicate an average pan to lake factor of 0.87. Lake evaporation in the model thus appears to be overestimated by about 15%. (Also, see below)
	• Flow data (ML/d) is included in the model from two GS, GS119005A - Haughton River at Mount Piccaninny and GS119006A - Major Creek at Rocky Waterhole
	  ○ The data used was checked against GS data independently downloaded from the Qld Govt Water Monitoring Information Portal and found to be a good match
	• The model uses a series of bore level records for comparison. Bore data for one bore (11900063) was checked against data for this bore reported in Narayan et al (2004) and was found to be a good match.
	• Level – Volume data is used in the model for Val Brid and Giru Weir. The FLS and FSV in the data matches that for these weirs specified in the ROL. It is noted that no level vs surface area data is provided for the weirs.
	• The weirs are assumed to start full (first day of the simulation period is 5/5/1978). The aquifer is assumed to start at 1000 ML. The report does not document the reasons for why these initial values were chosen. However it would be expected that these initial conditions are unlikely to significantly affect the model results after the first year of simulation.

Demand	• A set of monthly demand values are provided in the model. The monthly values appear to be derived from a set of average daily extraction data(?) in each month, which vary from 0 to 450 ML/d. The pattern is quite variable, with, for example, zero demand in July and August, a significant demand in September, and then no demand in October and November. No information is included in the report on the derivation of this pattern. • The total annual demand is derived from the pattern in the spreadsheet, providing a value of 43,250ML. The total MP WAE in Haughton Zone A , according to the State Govt Website, is 40,184 ML. In the response to information request 56 SunWater have advised that the total MP WAE in the GBA is 39,634 ML. Usually such a pattern is based on historical usage data. With no documentation on the source of this data, and with the demand pattern values appearing to be high, there is some concern regarding the validity of the demand pattern used. • The ML/d demand values are divided by a factor of 10. A further factor of 0.78 is noted next to the monthly demand table, and the monthly values are divided by this factor and then multiplied by the recorded pan evaporation.

	The documentation does not explain the reasoning for either factor. • Noted that no pan to evapotranspiration factor appears to be included in this calculation. Based on the Morton Wet estimates in the SILO PPD data a pan to PET factor of ~0.85 may apply. • A further factor is applied to the demands in Cell F8. As described above, this factor appears to be the adjustment to the demand for the three modelled cases, 100% for the 100% demand supplemented demand case, and 50% and 30% for the 50% demand and 30% demand unsupplemented cases. • The resultant demands (with the 100% demand factor) vary from 0 to 900 ML/d. Average annual demand is 34,583 ML/a. With the total allocation in the GBA being 39,634 ML, this equates to an average use of ~87% of full allocation. • Three columns are included in the spreadsheet to apply this demand, one on Val Bird Weir, one on Giru Weir, and one on the Aquifer. In the unsupplemented case all demand is placed direct on the aquifer. In the supplemented case a portion of the demand is assumed to be extracted direct from Val Bird and Giru Weirs. The portion diverted from the Val Bird is assumed to be the value in Cell F8 x 15%, (0.85*15=13% for the 100% demand supplemented case), and for Giru the value in Cell F8 x 40%, (0.85*40=34% for the 100% demand supplemented case). No information is provided in the report on why the demand is distributed in this manner. • It is noted that the demand is applied as a fixed monthly pattern that does not vary with rainfall. That is, the model demands the same volume in January even if it buckets down every day in the month. In the unsupplemented cases the model is counting extraction in these periods as part of the assessed yield, whereas in reality irrigators are unlikely to want to divert any water. In the supplemented case this error is of less import, as irrigators can makeup for it by ordering water later when it is dry.

The Weirs	• Inflow to Val Brid Weir calculated from:
	  ○ Inflows from the Haughton River (GS 119005A)
	  ○ Inflows from Major Creek (GS119006A)
	  ○ Supplemented Releases from the Haughton Balancing Storage
	  ○ Less transmission loss estimate (20% of the above flows assumed lost)
	• The supplemented releases is determined by estimating the amount of water required to keep Val Bird Weir at its operational level. This estimate on each day is determined by adding up the day before's storage, Haughton R and Major Creek GS flow and transmission loss estimate and todays demand. The release is multiplied by 85%, which appears to be a calibration parameter. The release is capped at a maximum release of 520 ML/d, and if the necessary release is below 130 ML/d the release is set to 0 ML/d.
	  ○ It is noted that the day before's Haughton R and Major Creek GS flow and transmission loss estimate have already been counted in the determination of yesterday's storage, so these quantities are effectively double counted. Perhaps the modeller is using yesterdays' value as an estimate for today's value? If, so, it is an approach that has not been applied in the similar calculations to determine the release from Val Bird Weir to Giru Weir.
	  ○ Also note the other key quantities that affect storage volume, rainfall and evap, are not used in the modelled equation.
	• Inflow to Giru Weir is the total release and spill from Val Bird Weir.
	• Net Evap from the weirs is determined by Evap – Rain (in mm), and then converted to a volume using a fixed nominal surface area of 100 ha.

	o Choosing 100 ha makes the math easy, but is this an accurate measure of each weir's surface area? Based on aerial photography of the weirs a preliminary estimate of the surface area of Giru Weir is 75 ha, and at Val Bird Weir 45 ha (noted it was difficult to determine the upstream end of the ponded area at Val Bird Weir) . It thus appears that evaporation, and direct rainfall may be overestimated by a factor of up to ~2.2. o In addition, using a fixed area means that a unit of rainfall or evaporation always leads to the same volume regardless of how small the weir ponded are might be at the time. If the weirs are low this error will get larger, and thus this approximation will have a larger effect on cases with more variable storage volumes, such as occurs in the unsupplemented cases. • Release from Val Bird Weir is estimated from the volume necessary to top Giru Weir up to the stated operational volume of 600 ML, as long as that release is not expected to drop Val Bird Weir below its stated operational volume of 500ML o The nominal operating levels for the weirs are, according to the Operations Manual, are ▪ Val Bird 6.20m (380ML based on the storage curve in the model ▪ Giru Weir 3.00 m (515 ML based on the storage curve in the model) o Both operational volumes used in the model thus appear to be higher than the actual figures. o It is noted that Clause 4(2) in the Operations Manual generally only allows releases up to that required to maintain the nominal operating level. Inclusion of rules to top up weirs to higher levels in the model may be contrary to the documented scheme operation rules. o Additionally, it appears that the actual levels maintained in the weirs over recent years is also significantly above the nominal operating levels specified in the Operations Manual. Maintaining weir levels at too high a level has the potential to reduce scheme performance. See Section 4.2.1 for further detail. o No outlet rating curve has been included in the model for the outlet from Val Bird Weir (or for Giru Weir). SunWater has advised that the outlet on Val Bird Weir releases a maximum of 55 ML/d at FSL, and less at lower levels. Releases from Val Bird Weir range up to around 200 ML/d in the model, and the model allows these releases to occur at low weir levels. SunWater have advised that they need to fill and spill the weir when demands are larger than the outlet capacity, and this behaviour is not reflected in the model. The levels in the weirs are key drivers of groundwater recharge – this inaccuracy may significantly affect model results. • Aquifer recharge o Aquifer recharge is determined via a complicated formula for both weirs, which appears to apply the following rules: ▪ If the weir is above half its FSV, recharge is assumed to flow from the weir to the Aquifer. The rate of flow is 100MLd at the weir's FSV, and 0 L/d at ½ the weir's FSV, and linearly interpolated with the weir's stored volume in between. However the recharge flow is capped by the available volume in the weir, i.e recharge can't be bigger than the source volume.

	▪ If the weir is below half its FSV, recharge is assumed to flow from the Aquifer to the weir. The rate of flow is 100ML/d when the weir is empty, and 0 L/d at ½ the weir's FSV, and linearly interpolated with the weir's stored volume in between. However the recharge flow is capped by the available volume in Aquifer, i.e recharge can't be bigger than the source volume. ○ Aquifer recharge is not a simple quantity to estimate, but the above only appears to use one side of head differential that drives recharge. That is, when the weir is higher that the aquifer, it will tend to flow into the aquifer, and when the aquifer is higher, it will flow the other way. This approach simplifies the direction of flow to only be based on the level in each weir, that is, it effectively assumes that the aquifer level is always at a level equivalent to the level associated with the ½ FSV volume in both weirs (According to the storage curve this is about 2.9m in Giru Weir and 6.0m at Val Bird Weir). However the report shows aquifer levels varying over many metres in the modelled runs, so this assumption appears to be problematic. • Spill is any excess volume above the FSV from the previous days storage plus inflow and minus take, net evap, release, aquifer recharge. The model does not apply any spillway routing, e.g. all water above the FSL is assumed to be able to flow out in the day, and the weir volume never gets above FSV. ○ This assumption is likely to be reasonable, given the most of the time the weirs will be below FSL. However it is noted that on occasion the weirs may be above FSL for some days in flow events, and that modelling the additional driving head provided by elevated levels may provide an improved estimate of flow into groundwater aquifers. Figure 4 and Figure 5 in OD Hydrology 2018 show a few occasions in the plotted two year period when levels are ~0.2m above FSL for some days, and one more major event with levels ~1m above FSL. • The volume in storage in the weirs is the previous days storage plus inflow and minus take, net evap, release, aquifer recharge and spill.
Aquifer	• Rainfall recharge is estimated by multiplying the rainfall depth in mm by an aquifer area of 50km2 and a factor of 13%. ○ A rough check of the area of the GBA, based on mapping in the Water Plan, provided an area of 60km2, so the adoption of 50km2 for the area of the aquifer appears reasonable. • Recharge from irrigation is estimated at 10% of the total amount of water drawn from the aquifer and the two weirs. • Recharge from/to Val Bird and Giru Weirs is estimated as described above. • Extraction from the aquifer is equal to the total demand (less any demand taken at Val Bird and Giru Weirs), as long as the aquifer is not lower than -8m. It appears -8m is the level at which the aquifer is assumed empty. • Discharge from the aquifer is estimated at 1% of the volume in the aquifer. ○ Discharge thus reduces as the aquifer gets lower, which seem reasonable. ○ This discharge presumably accounts for discharge to the ocean (and perhaps to neighbouring aquifer areas, although a two way transfer might be more appropriate if there is significant interaction with neighbouring aquifers.) ○ Other than the interchange with the weirs and the extraction by irrigators, this is the only mechanism to remove water from the aquifer.

	• The volume in storage in the aquifer is the previous day's storage plus the recharge from rainfall, irrigation and the two weirs, less extraction and the discharge. • There does not appear to be any direct modelling of evapotranspiration effects from the aquifer, i.e. the evaporation data is not directly used in the aquifer water balance. The volumes extracted for irrigation, or perhaps in the 1% discharge estimate, might cover for the lack of evapotranspiration? However it is noted that the applied irrigation pattern is lumpy, with zero demand in four months of the year, and this cannot cover for evapotranspiration effects in those months. • The level of the groundwater table is estimated by the volume in storage divided by the defined aquifer area of 50 km2 and a defined porosity of 25%.
Environmental Flows	• As highlighted in Table 2 of OD Hydrology 2018, the ROL requires the maintenance of minimum stream flows downstream of Giru Weir . The required discharge is the recorded flow at GS119005A and 119006A, up to a maximum total flow rate of 40 ML/day. • No release has been included in the model at Giru Weir, or at Val Bird Weir, to reflect this passflow requirement. • Section 4.2.2 of OD Hydrology notes that the passflow requirements have not always been met historically, and that SunWater is commissioning the addition of a controlled outlet valve on Giru Weir to address this deficiency.
Unsupplemented Cases	• The unsupplemented cases are modelled with the same spreadsheet as for the supplemented cases, with the only change being to set Cell F8 set to zero, which reduced the volume released from the Haughton Main Channel into the Haughton River • This means that the unsupplemented cases still include a level of supplementation, as the two constructed weirs are still in the model. These weirs raise the ponded level and thus supplement the natural infiltration into the aquifer.
Other Haughton River Users	• Section 4.1 of the report notes that report is focused only on usage by GBA users. There are other users along the Haughton River upstream of the GBA who take water from the Haughton River, and releases from the Haughton Balancing Storage also deliver water to these WAE holders. Section 4.1 indicates that releases for non-GBA users are accounted for separately, and thus the model appears to only include modelling of the releases for and extractions by GBA users. • The decision to not model other users along the Haughton River complicates the modelling of the river. For example, some proportion of the flow at the upstream gauging station presumably is used by these other users, but in this model all of this flow is assumed available for GBA users. Modelling of the meeting of the ROL passflow requirements would also be easier if all users were included in the model. • Also, based on Kavanagh 2017 it is understood that the GBA users and other users on the Haughton are collectively known as Haughton Zone A users. The extent of Haughton Zone A pictured in Schedule 2A of the Water Plan appears to be very similar to the extent of the GBA area pictured in Schedule 3 of the Water Plan. • The Haughton River and the Aquifer and completely linked. So much so that the Water Plan has declared that the water in the Aquifer is water in the Watercourse (Part 2 Section 7) • There thus appears to be little reason not to include all Haughton Zone A WAE holders in the model and assessment.

Transition to Surface Flow	• Section 1 of the OD Hydrology report indicates that recently GBA irrigators have reportedly been transitioning from accessing their water through groundwater bores to direct access to surface water, and that this issue will be explored in the report. • However there does not appear to be further discussion of this issue in the report. (Although it is noted that the supplemented model did assume a default proportion of water was extracted direct from the weirs.)
Calibration	• The model was calibrated against bore levels, with calibration plots for bore 11900058 and 11900054 provided in Figure 9 and 10 of the OD Hydrology Report. The bore levels were adjusted by a fixed offset to line the bore trace up with the average modelled levels, which is reasonable. The calibration result on these plots appears reasonable, although there are some periods where the model appears to under-represent the recorded variability for small periods of several years. This is odd because the recorded levels in these periods don’t seem much different to the periods that are matched well – it is the modelled trace that seems to flatten out in these periods? This area would benefit from further investigation. • Additional calibration plots for the supplemented case are contained in Attachment A. The results appear to bear a fair resemblance to the recorded values, but on several plots it appears the amplitude of the variation in groundwater levels has been under-represented. • Figure 11 and 12 provide a small sample of results for the unsupplemented conditions. The calibration for these conditions is not as well supported in the report, with only these two plots presented. Examination of the pre-supplementation performance at other bores appears to show the model does not appear to well match the amplitude of the recorded groundwater levels. • The model produces levels in Val Bird Weir and Giru Weir, and recorded levels for these two weirs exist as demonstrated by Figure 4 and Figure 5 in OD Hydrology 2018. (The model also appears to contain some plots against records of weir levels, which do not show a great match.) Levels at the weirs should be available back to at least 2009, when the ROL requirement to record weir levels commenced. The simulation of levels in these two weirs is important as it is the vehicle for supplemented flows to enter the aquifer. It is recommended that weir levels should be considered in the calibration of the model, and graphs and statistics illustrating the match to recorded weir levels should be provided. • Additionally, it would be beneficial to see comparisons of the model results against those produced by the IQQM model. While there are some differences between the two modelling approaches, most notably that this model adopts an ‘average’ demand level that is reportedly less that the full use of GBA allocations, the models should be able to be usefully compared for such factors as weir levels, EFO performance, etc. Benchmarking the models results against IQQM would assist in providing confidence in the model’s results.