

INDEPENDENT REVIEW OF NSW FLOODPLAIN HARVESTING POLICY IMPLEMENTATION

FINAL REPORT

by the

INDEPENDENT REVIEWERS

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and

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JULY 2019

EXECUTIVE SUMMARY

As part of the development and implementation of the Floodplain Harvesting Policy (the Policy) in New South Wales (NSW), the Department of Industry requested that the modelling and implementation of the Policy be independently reviewed. The Terms of Reference for the Review are in Attachment 1.

This is the Final Report of that independent review.

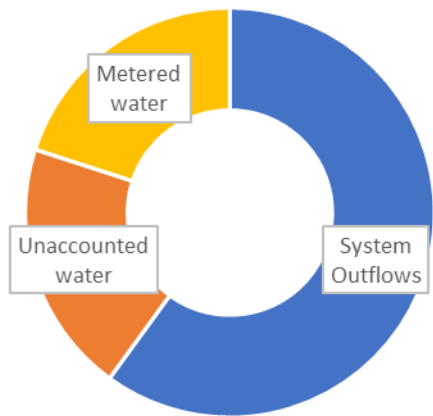
The process for the review provided for the independent reviewers to develop a “scope of review” (Attachment 2) into matters identified through presentations by the Department, discussions with stakeholders and formal submissions made to the independent reviewers. This Final Report follows the questions posed by the independent reviewers in the “scope of review” and builds on an earlier draft Report and further formal submissions to it.

There has been considerable investment and policy development into improving the management of floodplains in the Northern NSW areas of the Murray Darling Basin, with policy settings for floodplain harvesting set by successive governments since 1995. The overall water reforms in the Basin have meant that governments need to continue to investigate and implement policy reforms in order to meet Basin Plan obligations.

This review will ultimately inform the floodplain harvesting licensing and other parts of the process for implementation of the Floodplain Harvesting Policy by the Department and will also be considered by the Murray Darling Basin Authority. The implementation of this Policy is based on technical modelling and assessment of supporting data and is being completed across a number of basins.

The specification of floodplain harvesting as a licensed form of take is primarily around identifying water volumes that were formerly assumed as part of “floodplain system losses” in the Department’s water resource numerical models, that is, water that was not otherwise able to be accounted for in those models. It is accepted that these volumes were not purely “losses” in a physical sense, but comprised elements of both Planned Environmental Water (i.e. water committed under a water sharing plan for fundamental ecosystem health or other specified environmental purposes and that cannot be taken or used for any other purpose) and floodplain harvesting volumes not previously separately quantified in the models. The intent is to now formally quantify floodplain harvesting, as illustrated in the figures below, by accounting for them out of what was previously unaccounted for water.

River Basin Water Balance
(prior to accounting for FPH)



River Basin Water Balance
(accounting for FPH)

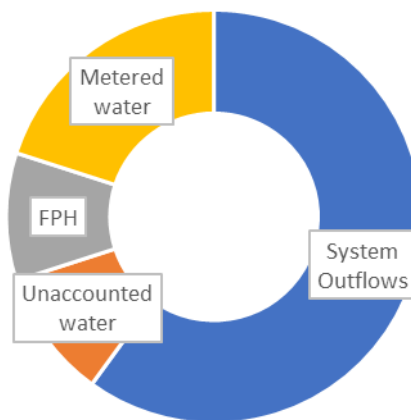


Figure 1. Defining Floodplain Harvesting Volumes in the Numerical Models for Floodplain Harvesting Policy Implementation

It is also intended that this process also provides technical rigour to inform the implementation of management levers that can be used to improve outcomes for downstream water users (including the environment) and to appropriately manage the investment in water recovery by Governments, including through Basin Plan implementation. This is further illustrated in Figure 2, which shows that since the period of the Cap (or Basin Development at the year 2000, whichever is smaller), there has been growth in both the number of shares and the total diversion volume in some basins, as measured at the year 2008. Implementation of the Basin Plan means to reduce the total diversion volume to the Cap or development at the year 2000, not reduce the number of water shares.

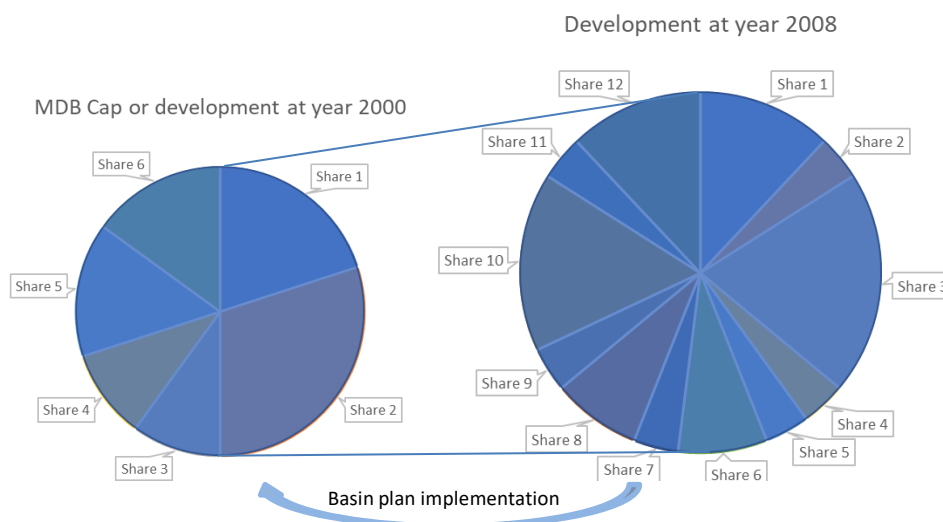


Figure 2. Managing water shares and growth as part of Basin Plan Implementation

This Policy therefore does not allow for increased floodplain harvesting, it brings this component of take into the licensing framework and provides the management levers for

adjusting this in order to allow for recovery of water from this form of take in the future, should it be found to have grown beyond planned limits.

The primary objective of this review is to therefore provide transparency around that technical information and to also provide stakeholders with the confidence that the technical rigour and supporting processes are suitable to support policy implementation. The review does not focus on individual concerns or property scale concerns. Rather, it provides a process by which stakeholder concerns with the process, information, data and models can be assessed and any issues or limitations noted. Associated with this are recommendations around how these issues may be dealt with prior to establishing draft licenses for floodplain harvesting. It therefore focuses on the elements of importance to the implementation of the Policy, rather than focusing on fine scale detail or the Policy itself.

Ultimately, the implementation of the Floodplain Harvesting Policy and the numerical modelling which informs the implementation will impact people's lives and livelihoods in the Murray Darling Basin in NSW and further downstream. The reviewers, through the formal submissions and the interviews, meetings and discussions held with Basin stakeholders during this review process are acutely aware of this and have approached this review with the objective of ensuring that the NSW Floodplain Harvesting Policy is implemented through the application of best possible approaches to numerical modelling and volumetric assessment.

Key Findings

The process of implementing the NSW Floodplain Harvesting Policy is likely to have significant ramifications for stakeholders across the Murray Darling Basin in NSW, both those in the Northern Basin and those downstream. There are a number of findings identified through the review process that relate directly to the determination of licensed entitlements for floodplain harvesting through the use of numerical modelling, but also to the actual or perceived impacts of floodplain harvesting on downstream users. These findings include:

Modelling Approaches

- The NSW Department of Industry modellers are to be generally congratulated for their efforts, diligence and application of numerical water resource models in the Border Rivers and Gwydir basins where the detailed application of floodplain harvesting modelling has been largely completed, though yet to be fully documented and made publicly available. These models represent a significant advancement in the determination of consumptive water use and the understanding of the various sources, extractions and uses of water taken in these valleys.
- The determination of floodplain harvesting volumes is, in effect, a determination by difference. That is, there are a number of "points of truth" that indicate volumetric flows and consumption in a particular river reach, but floodplain volumes, including floodplain harvesting volumes, in themselves have not been directly measured. The points of truth are therefore combined within the numerical model to evaluate the likely difference needed to ensure that an overall water balance in the model is

achieved in comparison to measured data and this is then ascribed to floodplain harvesting. The reviewers note that from the documentation reviewed, there is no cross-verification of the volumes required to satisfy this floodplain harvesting volume other than that needed to satisfy the water balance in the model.

- The justification and evidence provided around the use of the adopted parameters and model for rainfall-runoff is very limited, though an assessment of literature and likely runoff coefficients has been completed. It is therefore difficult to determine how the current approach is calibrated or validated and without further evidence it is a challenge to support the inclusion of rainfall-runoff volumes within the FPH take as currently modelled. We also reviewed further submissions from stakeholder groups and subsequent analysis by the department on this issue and have provided additional clarification and advice based on our assessments as part of this review. We note the contentious nature of the rainfall-runoff inclusion as part of the policy though we are unwilling to agree to the current method of accounting for rainfall-runoff until further considerations are undertaken. We therefore recommend that a 3rd party complete analysis on the quantum and significance of this issue and identify the best methods of accounting for this form of take.
- Reference is made in documentation that the modelling complies with good modelling practice (e.g. Black et al 2011), however no formal assessment of compliance with that has been sighted by the reviewers. In addition, the results of calibrations of the models are stated to be within acceptable limits, however those acceptable limits are not explicitly stated within the documents reviewed.

Documentation

- Overall, we find that there is a lack of transparency in the steps undertaken to develop the numerical models used in the implementation process, largely because of a lack of coherent, complete and up to date documentation outlining the methodologies, calibration, verification and assessment of scenarios. We do note that considerable efforts are currently being expended in addressing this and we strongly commend the completion of this documentation and its release into the public domain as soon as practicable. We also note that, due to this lack of documentation, or the ability of the reviewers to identify if documentation existed to address a particular element of review, the reviewers may not have correctly evaluated that element and this may not properly represent the actual position or status of the issue. Consequently, additional evidence relevant to the scope of the review may still come forward at a future date and it will be important for any such evidence to be properly and transparently considered.
- There is a significant lack of public information about floodplain harvesting volumes, either those volumes estimated to have been taken in the past, the capacity and capability for floodplain harvesting water to be taken in the present, and what those volumes may be in the future following implementation of the Policy, how they compare and an explanation of any differences. As part of the Policy implementation process, it will be important to communicate a strong narrative

around what the differences before and after implementation will mean, especially in respect to differences in reported floodplain harvesting volumes from previous reporting, and also how recovered water may improve downstream outcomes.

Stakeholder Engagement and Communication

- There is, by necessity, a simplification of the complexity of on-farm processes in developing the numerical models. In this process of simplification, the modellers have relied on multiple lines of evidence, including information provided by land holders, remote sensing, information from other agencies and on-line data sources to develop a reasonable representation of enterprises in the relevant river basins. In doing so, this information leads to the model providing an estimate of individual volumetric entitlement to a particular farm or enterprise. Given the likely impact of these individual entitlements on the operations of a farm or enterprise, there needs to be a process by which the actual information used to represent that farm or enterprise, including the assumptions around water use and management, in addition to infrastructure information already covered by Water Infrastructure Plans, is communicated back to the land holder for transparency, procedural fairness, confirmation, verification where appropriate, and building of trust.

Water Planning and Management

- Modelling and other work done to date as part of implementation of the Policy has been an important step in bringing the management of floodplain harvesting diversions into a more transparent, responsive and responsible regulatory regime. This is necessary for community, industry, other stakeholder and Government confidence. There is still a substantial amount of work to be done as this important step sets the levers for future adaptive management through monitoring, evaluation and reporting and sets the basis for compliance and enforcement activities, as necessary.
- The existing floodplain harvesting models do not explicitly represent flood water returns to the river, and the representation of floodplain flows, per se, can be especially challenging. Consequently, the models are not suitable to assess the benefits/impacts of the floodplain harvesting licensing framework, including the entitlement and account management rule framework, on specific downstream flows, either in the rivers or on the downstream floodplains themselves. Within the models, flows downstream of any flood outbreak are highly insensitive to variation of the amount of floodplain harvesting diversions allowed, including timings and volumes. The main potential unknown risk as a result of this is the impact of floodplain diversions on downstream floodplain flows and the downstream floodplain environment.
- What the current models can do is to estimate relative differences between two or more scenarios of floodplain harvesting diversions. For example, the long-term average annual floodplain harvesting volumes taken under current levels of

development can be compared with respective volumes that would be taken under levels of development in 2008 or in 1999-2000 or 1993-1994. If floodplain harvesting volumes permitted to be taken are reduced, then it is highly likely that more water is available downstream compared to the case where floodplain harvesting volumes are not reduced.

- Proposed account management rules, per se, do not mitigate event based environmental risks but do provide for broader environmental benefits compared with not having an entitlements and account management rules framework.
- Collaborative work has been underway for some time to better enable the “shepherding” of held environmental water down the mainstreams of the northern NSW valleys (Commonwealth Environmental Water Holder, MDBA, the Department pers comm, February 2019). Similar considerations may need to be given for possible future instances where held environmental water is contributing to floodplain flows such that that water is “shepherded” down floodplain and/or down river to achieve the intended environmental and other benefits.

Based on these key findings, further work is needed to place implementation of the Policy on a firmer foundation and to achieve and demonstrate the overall success factors for implementation of the Policy. This further work will require substantial resources and effort from the Department and others.

Key Recommendations

Modelling Approaches

- Significant further documentation and justification of the rainfall-runoff model used, and the parameters chosen in each valley, soil type, and farm enterprise is required before the inclusion of the rainfall-runoff component within the models can be considered suitable or not. This should not be seen as a decision as to whether rainfall-runoff should be included as part of licensed take, but that without documentation and justification, the current approach cannot be properly evaluated for suitability in estimating this component and further analysis is required to establish a way forward.
- Where possible, undertake a comparison of floodplain breakout volumes assumed in the model against other evidence. A number of “response curves” are used to estimate the likely overbank flows at particular breakout points in the models. Cross-verification of these likely volumes against other lines of evidence would be highly desirable to ensure that the assumed volumes are within the bounds of realistic estimates. Where this is not possible, modellers should identify uncertainty so that some policy measures may be included in water sharing plans to take corrective action should future work show that the assumptions and likely volumes need revision.

- As a future improvement to the models, undertake data collection and model re-configuration to represent return flows and down floodplain flows so that downstream impacts can be better determined.

Documentation

- Complete documentation required as outlined in this Final Report, make it publicly available and hold workshops with industry, community and other stakeholders to explain it. For clarity and transparency and improved understanding, this should be done as a matter of utmost priority and before the issuing of floodplain harvesting water access licences to individuals.
- Prepare a comprehensive guideline outlining in detail the process steps used, or to be used, for implementing the Policy – in particular the process for floodplain harvesting licensing, including matters for decision making, and for defining and calculating floodplain harvesting volumes and share components.
- As a matter of priority, complete the Model Build and Scenario reports for each valley, with the reports to be explicit about how the matters raised in this review have been handled. Subject to review and consideration of the final reports, appropriate sections of the draft reports for the Border Rivers and the Gwydir valley could be used as templates for the other valleys.
- Document compliance with good modelling practice in the Model Build and Scenarios Reports.
- Document an assessment of model uncertainty and suitability for application, including where future improvements should be made to reduce that uncertainty, in the Model Build and Scenarios Reports.
- As a matter of priority, the Department should communicate a stronger narrative around what the differences before and after implementation of the Policy will mean, especially in respect to differences in progressively updated floodplain harvesting volumes from any previous communications. A simple fact sheet outlining the best available information about volumes of water and take, including floodplain harvesting take, for each valley, with provisions for updating as new or improved information becomes available, would be helpful for transparency and clarity and placing the importance of the Policy implementation in context.
- As a matter of priority, the Department and the MDBA should publish an updated summary document to succinctly describe what BDLs and SDLs are and how BDLs and SDLs have changed or may change with updated information, including updated floodplain harvesting volumes determined in accordance with the Policy.

Stakeholder Engagement and Communication

- On-farm information used in the model should be communicated and confirmed with landholders to provide greater transparency around how the entitlement has actually been calculated and evaluated. This should also include estimates from the model of the volumes of different consumptive use sources that have been determined for each farm.
- The Department should hold workshops with industry, community and other stakeholders in each of the respective valleys to further explain the Policy implementation guideline and the valley specific Model Build and Scenario reports after they have been prepared.

Water Planning and Management

- Acquisition of robust floodplain flow and floodplain harvesting monitoring data is essential to verify volumes and water balances into the future, and to confirm the meeting of the Policy objectives and compliance. Consequently, the reviewers recommend that monitoring and auditing proceed as matters of priority.
- As the final FPH volumetric entitlements are determined and quantified, an assessment of 3rd party (downstream users) impact, including cumulative impact, needs to be completed to clearly show stakeholders that downstream outcomes will be improved and/or accounted for in the implementation of the Policy.
- Water sharing plan amendment rules, consisting of flow management rules / access rules for floodplain harvesting licences in addition to account management rules, be considered, especially to minimise impacts of floodplain harvesting on down floodplain environments and to protect held environmental water.
- The Department and the MBDA should, as a matter of priority, develop agreed next steps for implementation of the Policy and the preparation and accreditation of water resource plans under the Basin Plan, taking account of the findings and recommendations from this independent review. These next steps should include independent assessment and verification of responses to the recommendations in this Final Report to determine and transparently demonstrate whether the responses meet all aspects of the recommendations.

1.0 BACKGROUND

The NSW Floodplain Harvesting Policy (the Policy) was first published in May 2013 and amended and updated in September 2018. (See industry.nsw.gov.au for more information.)

Among other things, the purpose of the Policy is to manage floodplain water extractions more effectively in order to protect the environment and the reliability of water supply for downstream water users. The Policy also describes a licensing framework for floodplain water extractions within limits and objectives set by water sharing plans.

The Policy is progressively being implemented, starting with the NSW Border Rivers, Barwon-Darling, Namoi, Gwydir and Macquarie valleys in northern NSW.

To improve stakeholder confidence, the NSW Department of Industry (the Department), together with the Murray Darling Basin Authority (MDBA), have commissioned an independent review of implementation of the Policy, including independent peer review of revised floodplain harvesting modelling in northern NSW. The Terms of Reference for the independent review are in Attachment 1.

Key Policy objectives relevant to the modelling include:

- a) Estimation of the long-term average volume of floodplain harvesting allowed;
- b) The application of accounting rules to ensure that this volume is not exceeded;
- c) That the method used to estimate individual entitlements results in fair and equitable outcomes for individuals, within the constraints of the Policy; and
- d) That the implementation and outcomes of the Policy are consistent with commitments to water reform.

The focus of the independent review is to ensure that the modelling is technically robust, based on the best available information and that implementation of the NSW Floodplain Harvesting Policy is consistent with relevant legislation and other related policies.

The scope of the independent review contains both technical and policy implementation related matters.

2.0 PROCESS FOR THE REVIEW

The independent reviewers (Tony Weber of Alluvium Consulting Australia and Greg Claydon, a sub-consultant to Alluvium) have used the following for detailed review of the implementation of the Policy and the preparation of this Final Report:

1. Reading of relevant published materials on the Department's website;
2. Attendance at stakeholder workshops in Dubbo, Sydney and Tamworth during early October 2018, during which staff from the Department and the MDBA made

presentations about their approach to implementation of the Policy and workshop attendees made comments and sought clarifications;

3. Face to face, telephone and email discussions with stakeholders as requested by them following the above workshops;

4. Consideration of written submissions requested by the independent reviewers directly from stakeholders by 16 November (subsequently extended to early December 2018 as requested by some stakeholders);

5. Further discussions with the Department and the MDBA about, and further review of, draft documents prepared by the Department, recognising that very substantial documentation was still being undertaken throughout the review timelines;

6. The sending of the “scope of review” document (Attachment 2 to this Final Report) to the Department, the MDBA and stakeholders on 21 December 2018;

7. Follow-up face to face, telephone and email discussions with the Department, the MDBA and stakeholders during February, 2019 as either requested by them or required by the reviewers, and detailed analyses of progressively available and amended documentation (amounting to more than one hundred documents and thousands of pages of data and information), to seek evidence and/or clarify matters to enable the independent reviewers to develop draft findings and recommendations relevant to the “scope of review”;

8. The provision of a preliminary draft report to the Department and the MDBA for fact checking only, and feedback to the independent reviewers where there may have been clear though inadvertent errors in facts e.g. the availability of documents, data or other evidence;

9. The preparation of a draft Report by the independent reviewers and its simultaneous distribution to the Department, the MDBA and stakeholders who had made submissions to or otherwise sought information about the review, and publication of the draft Report on the Department’s website on 08 May 2019;

10. Receipt of written submissions about the draft Report by the independent reviewers directly from stakeholders by 22 May (subsequently extended to early June 2019 as requested by some stakeholders);

11. Follow-up face to face, telephone and email discussions with the Department, the MDBA and specific submitters and stakeholders during late June / early July, 2019, as either requested by them or required by the reviewers, to discuss and clarify certain matters raised in submissions to enable the independent reviewers to finalise the review;

12. The preparation of this Final Report by the independent reviewers and its distribution to the Department and the MDBA and notification of same to

stakeholders who had made submissions to or otherwise sought information about the review, and publication of this Final Report on the Department's website.

The independent reviewers do note that the discussions and submissions covered a wide range of issues associated with floodplain harvesting, with some being beyond the scope of this review, highlighted by the following examples:

- Some submissions highlighted that floodplain harvesting should be made illegal due to adverse downstream impacts and lack of equity;
- Others questioned whether the components of take, including rainfall runoff and floodplain harvesting, are equitably shared across all users in a basin;
- Specific details regarding individual works and draft licensing amounts.

The independent reviewers' task was not to assess these as they relate back to original policy decisions or individual circumstances, but rather to confirm whether the modelling has been undertaken consistent with the Policy objectives and assess whether the Policy is being implemented consistent with legislation and policy. The above examples and other policy comments were forwarded to the Department for their consideration and subsequent direct response.

3.0 OVERVIEW OF SUCCESS FACTORS FOR IMPLEMENTATION

The independent reviewers have evaluated whether, based on the information provided to them, and their assessments, the approaches to implementation of the Policy:

- are based on the best available data and information, and, where assumptions have had to be made about that data and information, those assumptions are reasonable, robust, defensible, transparent and auditable based on the available evidence;
- are based on sound numerical modelling concepts, inputs and results and the numerical modelling is "fit-for-purpose" and appropriately documented;
- consider and treat on-farm and downstream water users and uses equitably and consistently, in line with the Policy objectives;
- can be applied in a repeatable and consistent way across the northern NSW valleys;
- can accommodate further updates should new data or information provide justifiable evidence to overcome any previously identified limitations;
- are supported by provisions in the NSW Water Management Act 2000, the Commonwealth Water Act 2007 and the Murray-Darling Basin Plan 2012;
- are appropriate for granting floodplain harvesting water access licences and being incorporated into water sharing plans; and

- have been sufficiently explained to and understood by stakeholders.

4.0 CONSIDERATION OF MATTERS FOR DETAILED REVIEW

In considering the information below, it is important to keep in mind that the terms of reference for the review required the independent reviewers to consider implementation of the Policy, not the Policy itself, though some interpretation was invariably required.

Each section below contains a brief description of the issue, the focus questions considered by the independent reviewers and their findings and recommendations.

4.1 Appropriate Conceptualisation of Policy Implementation

Many irrigator and non-irrigator stakeholders asserted that the implementation of the Policy would involve specification, at least initially, of a volume of floodplain harvesting take that is “no more and no less” than would be permitted to be taken lawfully at the time of negotiations around the Policy development. This is in recognition that, under the Policy and its licensing framework, floodplain harvesting does not involve the take of “new water”, but rather water already taken in some way through otherwise authorised works, within the limits set by instruments such as the Murray-Darling Basin cap on diversions and applicable water sharing plans. On the other hand, some stakeholders asserted that implementation of the Policy includes making decisions about granting floodplain harvesting licences, regulatory instruments under the NSW *Water Management Act 2000*, and such decisions need to be in full accordance with all of the provisions of the legislation, including consideration of its objectives and impacts.

There has been some confusion and doubt amongst some stakeholders as to the interpretation of the amended and updated 2018 Policy, including the definitions and legal underpinnings of floodplain harvesting, including “overland flow harvesting” and “rainfall runoff harvesting”, and how they have been or may be accounted for in the Baseline Diversion Limits (BDLs) and Sustainable Diversion Limits (SDLs) and other relevant matters under the Murray-Darling Basin Plan 2012.

There has also been some confusion among some stakeholders as to the dates that are relevant to quantifying floodplain harvesting entitlements and how data and information about on-farm infrastructure and irrigator behaviour at those dates have been collected and used.

4.1.1 Do the guidelines and process steps for implementation of the Policy adequately cover the determination of eligible floodplain harvesting works and the identification of irrigator behaviour at the appropriate time?

Evidence Reviewed

Guidelines for implementation of the Policy have yet to be comprehensively drafted, collated into the one document and made available to the reviewers or the public.

However, the process for implementation of the Policy is set out in broad terms in documents such as the publicly available *NSW Floodplain Harvesting Policy* (version published September 2018).

How the process is being implemented in a practical and modelling sense is set out in various levels of detail in the report titled *Modelling and data collection for implementing floodplain harvesting*, available on the Department's website, and draft Departmental reports such as the *NSW Border Rivers Source Model Build Report (incomplete draft version of 21 February 2019)* and the report titled *Model Scenarios and Floodplain Harvesting Entitlements for NSW Border Rivers Regulated River System* (draft version of 29 January 2019), made available to the reviewers. Among other things, the latter draft report describes how the Border Rivers model has been developed to represent works eligible for a floodplain harvesting entitlement and summarises data and results.

A similar draft report is available for the Gwydir valley and the reviewers were informed that reports for the Barwon- Darling, Namoi, and Macquarie valleys will be drafted in due course and final reports for all five valleys will be published and publicly available at some time in the future prior to the release of draft floodplain harvesting entitlements in each valley.

The Department has also received independent probity advice which considered whether the registration of interest (ROI), irrigator behaviour questionnaire (IBQ) and water infrastructure plan (WIP) processes for the Floodplain Harvesting Project were:

1. lawful;
2. properly documented;
3. followed and the criteria applied consistently; and
4. fair, in that the processes afforded natural justice to people who had submitted an ROI.

A letter to the Department from the independent probity advisor and containing a summary of the advice was made available to the reviewers.

Findings

To place the findings for this and other questions in this review process in context, it is instructive to read down some important definitions under the *NSW Floodplain Harvesting Policy* as follows:

'Floodplain' means any area of land designated as a floodplain under the *NSW Water Management Act 2000* (WM Act) or the *Water Act 1912*. The Policy applies to floodplain harvesting activities on properties where all or part of that property lies within the designated floodplain.

'Floodplain harvesting' is the collection, extraction or impoundment of water flowing across floodplains, including rainfall runoff and overbank flow, but excluding the taking of:

- water under a water access licence that is not a floodplain harvesting access licence
- water under a basic landholder right, including water taken under a harvestable right
- water under an applicable water access licence exemption under the WM Act
- used irrigation water.

‘Floodplain harvesting works’ are generally works built:

- specifically to facilitate floodplain harvesting, including pumps, structures or other works that divert water into or from storages, supply channels, depressions or otherwise impound flows
- for multiple purposes that have the effect of facilitating floodplain harvesting, such as:
 - levees, conveying works and off-river storages constructed in billabongs or depressions
 - below-ground level channels from which the water is delivered into storages
 - works that collect rainfall runoff and which deliver that water into storage.

Floodplain works that do not facilitate the collection, extraction or impoundment of water flowing across floodplains are not considered to be floodplain harvesting works, and as such do not require approval under the Policy additional to an approval already required for other purposes under the WM Act.

‘Works considered eligible’ for detailed assessments, to be undertaken for the purposes of issuing work approvals and authorising floodplain harvesting access licences, are works capable of floodplain harvesting that, on or before 3 July 2008, were:

1. constructed on a floodplain in accordance with an approval granted pursuant to Part 2 or Part 8 of the *Water Act 1912* or the WM Act
2. subject to a pending application for an approval to construct the work on a floodplain under Part 2 or Part 8 of the *Water Act 1912* or WM Act
3. constructed on a floodplain and for which it can be established, to the satisfaction of the Minister for Water, that the Department did not require an approval under Part 2 or Part 8 of the *Water Act 1912*. In submitting an ROI relating to this category, the person submitting the ROI should provide evidence that the Department did not require an approval for the works in question.

Existing works for which an application under the *Water Act 1912* or the WM Act was required and not made on or before the 3 July 2008 cut-off date will not be authorised for floodplain harvesting.

Implementation of the policy is taking place in five stages:-

1. Registrations of interest—The Department has requested water users to submit registrations of interest to obtain the necessary authorisations to undertake floodplain harvesting activities.
2. Determining eligibility—The registrations of interest have been examined against eligibility criteria to determine which works used or proposed for floodplain harvesting qualified for further assessment.
3. Issuing work approvals—Eligible works, and applications for such works, are being assessed to determine their capability to harvest floodplain water, and, where such works are proposed to be operated outside the terms of an existing approval, their impacts on the environment. Based on these assessments, the department will issue work approvals to individuals.
4. Incorporating floodplain harvesting in water sharing plans—Existing water sharing plans will be amended to establish rules for the management of floodplain harvesting and provide that floodplain harvesting access licences be exercised in accordance with those rules.
5. Issuing floodplain harvesting access licences—The Department will notify licence holders of the terms and conditions of floodplain harvesting access licences that are to be issued. Water accounts for individual licences will be credited with initial allocations.

As part of the stage for issuing works approvals, capability assessments require the applicants to certify a water infrastructure plan (WIP) and to complete an irrigator behaviour questionnaire (IBQ). The WIP identifies and detail all works capable of undertaking floodplain harvesting. The IBQ requests information such as crop history, crop water use, on-farm water balance, climatic information, stored volumes and other information relating to the irrigation activity's on-farm water balance.

Both the WIP and the IBQ have been assessed by the Department against other sources of data including licensing records, satellite imagery and remote sensing to independently verify the information supplied by the applicant. The draft Departmental reports, *NSW Border Rivers Source Model Build Report (incomplete draft version of 21 February 2019)* and the report titled *Model Scenarios and Floodplain Harvesting Entitlements for NSW Border Rivers Regulated River System (draft version of 29 January 2019)*, for example, explain how IBQ information, historical satellite imagery, LIDAR methods and on-farm visits by Departmental staff have been used during the eligible works verification process. The process included opportunities for applicants to request an external review of the Department's assessments for works eligibility and preparation of a WIP.

Based on the information provided in the independent probity advice letter and the process steps for implementation of the Policy that were outlined, the probity advisor considered that:

- the ROI, IBQ and WIP processes were properly documented and followed;
- the ROI criteria were consistently applied; and
- the ROI, IBQ and WIP processes afforded natural justice to people who had submitted an ROI.

We conclude that, from the documents reviewed, the process steps for implementation of the Policy do adequately cover the determination of eligible floodplain harvesting works and the identification of irrigation behaviour at the appropriate time, with 3 July 2008 being a key date.

Recommendations

A comprehensive guideline outlining in detail the process steps for implementing the Policy, including matters for decision making, should be prepared by the Department and made publicly available to demonstrate transparency and raise confidence.

As a matter of priority, the Model Build and Scenario reports for each valley should be completed by the Department and made publicly available. Each of the reports should be explicit about how eligible floodplain harvesting works have been determined, including how IBQ information has been used. Subject to review and consideration of the final reports, appropriate sections of the draft reports for the Border Rivers and the Gwydir could be used as templates for the other valleys.

The Department should hold workshops with industry, community and other stakeholders in each of the respective valleys to further explain the guideline and the reports after they have been prepared.

As part of the implementation process, it will be important to communicate a strong narrative around what the differences before and after implementation will mean, especially in respect to differences in reported floodplain harvesting volumes from previous reporting, and also how recovered water may improve downstream outcomes.

4.1.2 Do the guidelines and process steps for implementation of the Policy adequately cover and explain if, when and how, water sharing plans, BDLs and SDLs are to be amended, including any legal provisions that apply, consistent with the NSW Water Management Act 2000, the Commonwealth Water Act 2007 and the Murray-Darling Basin Plan 2012?

Evidence Reviewed

Guidelines for implementation of the Policy have yet to be comprehensively drafted, collated into the one document and made available to the reviewers or the public.

However, the process for implementation of the Policy is set out in broad terms in documents such as the publicly available *NSW Floodplain Harvesting Policy* (version published September 2018).

How the process is being implemented in a practical and modelling sense is set out in various levels of detail in the report titled *Modelling and data collection for implementing floodplain harvesting*, available on the Department's website, and draft Departmental reports such as the *NSW Border Rivers Source Model Build Report (incomplete draft version of 21 February 2019)* and the report titled *Model Scenarios and Floodplain Harvesting Entitlements for NSW Border Rivers Regulated River System* (draft version of 29 January 2019), made available to the reviewers.

The *Diversion Formula Register for the Murray-Darling Basin*, a protocol established under paragraph 4(1) (b) to Schedule E (former Schedule F) of the Murray-Darling Basin Agreement (a Schedule to the Commonwealth *Water Act 2007*) for the recording of water diversions from the river system of the Murray-Darling Basin, version 6 available on the Murray-Darling Basin Authority's (MDBA's) website, has important definitions of relevance to implementing the Policy. The MDBA has the delegated authority to approve amendments to the Register.

The *Murray-Darling Basin Plan 2012*, available on the MDBA's website, among other things, contains Schedule 2, outlining matters relating to surface water Sustainable Diversion Limit (SDL) resource units (including formulae for SDLs), and Schedule 3, outlining formulae for Baseline Diversion Limits (BDLs) for each surface water SDL resource unit.

Water sharing plans have been approved for each of the five valleys under the WM Act to establish long term extraction limits among other things. The water sharing plans for the Gwydir, Namoi and Macquarie, but not the NSW Border Rivers and the Barwon-Darling, also contain floodplain harvesting principles, and are available on the NSW Government website. The water sharing plans contain provisions to enable them to be amended.

). The Department has prepared a *Floodplain harvesting Fact Sheet -Floodplain harvesting in regulated rivers* (October 2018) outlining some of these matters, including accounting for floodplain harvesting in water sharing plans, under the cap and in the Basin Plan, and how plan limits are calculated.

Findings

NSW water sharing plans (WSPs) made under the WMA Act set the level of overall extractions within water sources in NSW. In regulated river water sources and the Barwon-Darling, the plan limit is generally defined as the lesser of the:

1. Murray–Darling Basin Ministerial Council Cap (the cap) baseline conditions: extraction levels under development conditions, water management rules and irrigator behaviour as they were in 1993–1994 for most valleys (with the Border Rivers date being set at 30/11/1999 to recognise the enlargement of Pindari Dam); or
2. long-term average annual extractions under development conditions and irrigator behaviour at a specified date (1999–2000 for most plans and 2001–2002 for the Border Rivers) and water management rules, as specified in the respective water sharing plan (from July 2004 onwards for regulated river plans and the Barwon-Darling plan).

These two scenarios provide snapshots in time for infrastructure and behaviour (generally at 1993–1994 and 1999–2000), but with the latter also adjusted for the introduction of the July 2004 management rules. For most regulated river plans, the lesser of these represents the ‘plan limit’. The reviewers have been informed that, although there are additional analyses to be done, in all cases to date for the northern NSW valleys, scenario 2 has been shown to produce a lower number than scenario 1. That is, the rules in the WSPs facilitate lower average extractions than the cap, even with the infrastructure growth that may have occurred since 1993–1994 (the Department pers comm October 2018). The evidence and process used to derive these numbers will need to be made explicit in the documentation.

The cap was agreed by the Murray–Darling Basin Ministerial Council. As a signatory to the Murray–Darling Basin Agreement (a schedule to the Commonwealth *Water Act 2007*), NSW is required to limit surface water extractions in the Murray–Darling Basin to within the cap.

The Council formalised the cap in August 2000 by adopting Schedule F to the Murray–Darling Basin Agreement. Subsequently Schedule E (former Schedule F1) was amended by the Council in 2008. At the time of adopting Schedule F, the Council agreed, among other things, that:-

- all forms of water use are to be incorporated in cap management arrangements as they are recognised and can be quantified;
- diversions from floodplain and overland flows are to be included in cap accounting arrangements as a matter of priority;
- farm dam water use should be included in cap accounting arrangements as soon as practicable and all future administrative arrangements should support this outcome;
- water use by tree plantations eventually be considered for inclusion in the cap where it is found to be significant.

The *Diversion Formula Register for the Murray–Darling Basin*, version 6 (18 June 2018) available on the MDBA’s website (the Register), was developed in response to the above decisions. As mentioned previously, the MDBA now has the authority to amend the Register.

The Register provides the formulae for calculating diversions for each of the designated river valleys throughout the Murray–Darling Basin defined under Schedule 1 of Schedule E of the Murray–Darling Basin Agreement.

The quantitative formulae given in the Register are the formulae to be used:

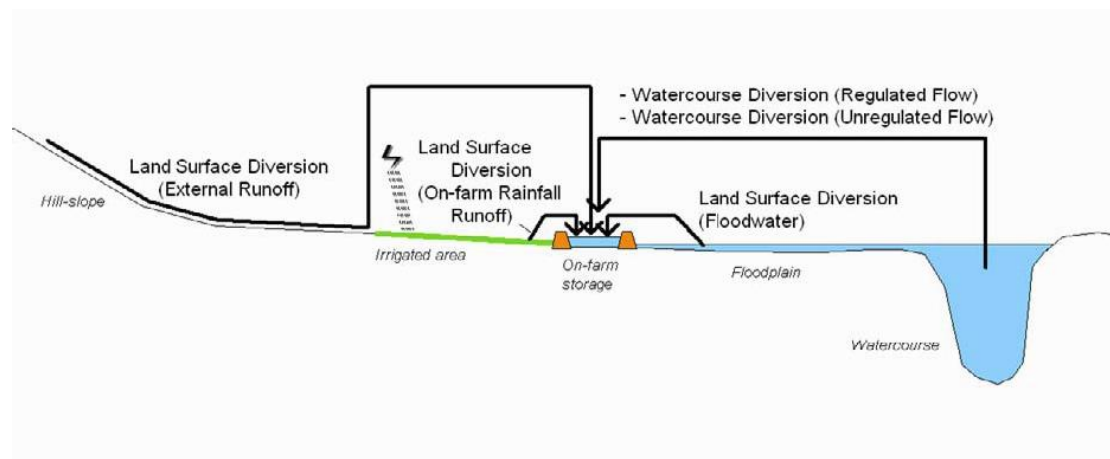
- in determining the volume of water diverted in the relevant valley in any given water year (for current, future and for historical diversion records); and
- in the estimation of diversions in analytical models of river systems that have been developed to determine cap compliance.

It is envisaged that the MDBA will change the diversion formulae from time to time as it becomes practical or important to monitor certain items in more detail. An example of a change is when new diversion accounting approaches become possible, such as for implementation of the Policy.

The term “diversions” includes all forms of consumptive water use which may affect surface water flows. Diversions may be grouped into two broad categories:

- watercourse diversions; and
- land-surface diversions.

These two categories of diversions are illustrated in the figure below. The total diversion in any valley is the sum of the watercourse diversions and land-surface diversions.



Watercourse diversions are diversions directly from within the beds and banks of surface water sources e.g. rivers, streams, creeks, lakes and billabongs either through gravity or pumping. Diversions of this type, both on regulated and unregulated systems in all States, are usually covered by licenses. With some exceptions in the terminology used for different types of rights to surface water diversions, there is little ambiguity on what constitute watercourse diversions. The total watercourse diversion in any valley is the sum of all consumptive diversions which occur directly from the watercourses minus any water returned directly to the watercourses.

Land-surface diversions are all forms of surface water diversions for the purpose of consumptive use, that occur from beyond those which occur by the more traditional licensed extractions from within the beds and banks of surface water courses, (e.g. rivers, lakes, billabongs). In essence “land-surface diversions” are all surface water diversions other than the watercourse diversions.

The total of land-surface diversions in any valley is the sum of individual components of land-surface diversions, as and when they are recognised and quantified including the following:

- floodplains irrespective of whether such water originated as floodwater; overtopping the banks of a watercourse or as runoff on its way to a watercourse;
- local runoff, irrespective of whether such runoff originated inside or outside a farm, or the bunded areas of a farm;
- interception by hillside farm dams in upland catchments;

but excluding these diversions:

- direct rainfall onto storages or roofs for rainwater tanks;
- infiltration to groundwater; and
- tail-water (the excess irrigation water that may be collected and returned to the on-farm storages).

The Register outlines the components of land-surface diversions as they are currently understood and are illustrated in the following table. As land-surface diversions form a very significant component of diversions in northern NSW and southern Queensland (the northern part of the Basin), the table is illustrated with reference to these two States. However, the concept may apply to all States.

Component name	Equivalent term (NSW)	Equivalent term (Qld)
Land-surface diversion (floodwater)	Floodplain harvesting	Overland flow take
Land-surface diversion (on-farm rainfall runoff)	Rainfall runoff harvesting	Overland flow take
Land-surface diversion (external rainfall runoff)	Overland flow harvesting	Overland flow take

(Application of the Floodplain Harvesting Policy in NSW covers all three components of floodplain harvesting, rainfall runoff harvesting, and overland flow harvesting listed in the table above.)

The formulae in the Register at the present time, prior to the implementation of the Policy, for land surface diversion components of the Gwydir and NSW Border Rivers, as examples, are shown in the table below:

Land-surface Diversion Components	
Land-surface (Floodwater) Diversion by Licensed Pumpers =	The sum of all the estimated floodplain water harvesting diversions occurring in the Gwydir River Valley.
Land-surface (Floodwater) Diversion by Licensed Pumpers =	The sum of all the estimated floodplain water harvesting diversions occurring in the NSW portion of the Dumaresq, Macintyre and Boomi River Valleys.

By way of comparison, the formula in the Diversion Register at the present time for the land surface diversion component of the Qld Border Rivers, is shown in the table below:

Land-surface Diversion Components	
Overland Flow Diversion =	The sum of the estimated overland flow take of floodwater and rainfall runoff for irrigation purposes in the Queensland section of the Border Rivers catchment. <i>Note - Estimates are based on the capacity of notified works and rainfall data.</i>

It should be noted that because NSW rainfall runoff is not in the current formulae in the current Register doesn't mean that rainfall runoff is not subject to the cap as the definitions clearly include it. It does mean that NSW is not currently required to report on it.

The reviewers have been informed that once there is increased confidence in the estimate of rainfall runoff and improved monitoring is in place (i.e. after implementation of the Policy is well underway), the Register would be updated to include rainfall runoff reporting, in addition to other necessary changes (Department pers comm January, 2019, MDBA pers comm February, 2019).

Under the provisions of the Basin Plan, the cap is intended to be replaced by sustainable diversion limits (SDLs) in 2019. It is intended that in due course these SDLs will include floodplain harvesting extractions in accordance with the Policy. The SDLs under the Basin Plan are defined as a BDL minus a reduction volume to be returned to the environment. Advice to the reviewers is that, if a BDL is increased in its quantum as a result of new or better information, as enabled under the Basin Plan, for example, through the work in implementing the Policy, the SDL is increased by the same amount.

However, in addition to evident differences in legal opinions about the setting and changing of SDLs (beyond the scope and capacity of this review), as outlined in the *South Australian Murray Darling Basin Royal Commission Report*, (29 January) 2019 (available on www.mdbrc.sa.gov.au) and the MDBA's response of 20 February, 2019 to that report (available on the MDBA's website), there remains considerable conjecture and confusion among various stakeholders about SDLs, what they are, how they are set and changed. This was clear from submission's made to the reviewers' draft Report about this floodplain harvesting Policy implementation review. Consequently, while the MDBA has recently updated its website to describe how BDLs and SDLs may change with updated information (MDBA pers comm April, 2019), further communications with stakeholders are required as a matter of priority for transparency and, hopefully, clarity and understanding.

Under the Basin Plan, the BDL means the baseline limit of take from an SDL resource unit (essentially the surface water sharing plan area for each of the five valleys) and is the quantity of water calculated in accordance with column 2 of the table in Schedule 3 for that SDL resource unit.

As an example, in Schedule 3 of the Basin Plan, the BDL for the Gwydir or the Border Rivers, respectively, is the sum in each of:-

- (a) the long-term annual average limit on the quantity of water that can be taken from regulated rivers and by floodplain harvesting (excluding take under basic rights) calculated by:
 - (i) summing the quantity of water that would have been taken by those forms of take for each year of the historical climate conditions under State water management law as at 30 June 2009; and
 - (ii) dividing that quantity by all of the years of the historical climate conditions; and

(b) the long-term annual average take of water, averaged over the period from July 1993 to June 1999, for take from watercourses other than from regulated rivers (excluding take under basic rights); and

(c) the long-term annual average take of water from watercourses under basic rights calculated on the basis of the take under the level of development that existed on 30 June 2009; and

(d) the long-term annual average limit on the quantity of water that can be taken by runoff dams (excluding take under basic rights) calculated on the basis of the quantity of water that could be taken under State water management law as at 30 June 2009; and

(e) the long-term annual average take of water by runoff dams under basic rights calculated on the basis of the take under the level of development that existed on 30 June 2009; and

(f) the long-term annual average net take of water by commercial plantations calculated on the basis of the take under the level of development that existed on 30 June 2009.

The Department has been using the same river basin modelling approach to calculate extraction limits for water sharing plans approved under the WM Act as for calculating extractions under the cap, the 3 July, 2008 date for eligible floodplain harvesting works in accordance with the Policy, and for current conditions. This is explained in some detail in the draft model reports made available to the reviewers and mentioned previously. For example, the draft Border Rivers and Gwydir modelling scenarios reports, made available to the reviewers, summarise the development of a revised plan limit estimate for the two respective valleys. The reports also outline how floodplain harvesting entitlements have been defined and that, in conjunction with the accounting rules, demonstrate how respective total diversions would be returned to those allowed under the respective plan limits.

To calculate baseline extractions for the water sharing plan reference dates, the Department sets the models to have the development conditions and irrigator behaviours that were occurring in 1999–2000 (or 2001–2002 for the Border Rivers), inputting the water management rules of the relevant water sharing plans. The model is run for the entire period of climatic record of measured/simulated daily climate and streamflow, with the long-term average annual extractions calculated from results generated by the model. For example, the models, that estimate the BDL, run from 1895 to 2009.

The Department does the same exercise for the cap baseline conditions (using 1993–1994 generally, or 1999–2000 for the Border Rivers, development conditions, irrigator behaviour and water management rules as inputs) to arrive at a long-term average annual extraction number for the cap. As outlined previously, the lower of the two numbers is the long-term average annual extraction limit under a water sharing plan, and known as the plan limit.

At the end of every water year, climate information from that water year is added to the period of record and the model is re-run to incorporate the new information and provide an updated calculation of the plan limit. Just as additional data can influence plan limits, so too can additional information on development conditions and irrigator behaviour in 1993–1994

and 1999–2000, or as the case may be. Upgrades to the modelling software and improved model configuration can also result in an updated calculation of the plan limit.

Nevertheless, while the approved *Water Sharing Plan for the Gwydir Regulated River Water Source 2016*, (current version for 27 June 2018 available on the NSW Government website), establishes a long-term extraction limit for this water source being the lesser of:-

(a) the long-term average annual extraction from this water source that would occur with:-

(i) the water storages and water use development that existed in 1999 - 2000, and

(ii) the share components in this water source that existed on 1 July 2004, and

(iii) the rules defined in this Plan as at 1 July 2004, excluding the rules in clause 38, and

(iv) the application of a limit on supplementary water access licence available water determinations of 1 megalitre per unit share, or

(b) the long-term average annual extraction from this water source that would occur under cap baseline conditions,

it also specifies that, for the purposes of establishing the long-term extraction limit and auditing compliance with it, the following shall be included:

(a) all water extractions by all categories of access licences in accordance with the rules used for accounting of cap diversions for Schedule E of the Murray-Darling Basin Agreement,

(b) domestic and stock and native title rights extractions,

(c) volumes of water delivered as adaptive environmental water,

(d) floodplain harvesting extractions estimated to be taken for use in conjunction with extractions authorised from this water source, and

(e) water allocations assigned from access licence water allocation accounts in this water source to access licence water allocation accounts in another water source.

These and other clauses within the Gwydir and other relevant water sharing plans will have to be amended to fully incorporate the Policy and its implementation. The WM Act and the water sharing plans currently permit changes to be made to effectively facilitate the issue and commencement of floodplain harvesting licences. These amendments will also have to be incorporated into applicable water resource plans to be accredited by the MDBA under the provisions of the Basin Plan.

Requirements for and details of these amendments of water sharing plans are known and have been outlined in the Policy document, available on the Department's website. However, they have yet to be discussed fully with stakeholders but are scheduled as the Policy implementation process proceeds (the Department pers comm January 2019).

We conclude that, from the documents reviewed and the verbal information provided, the clear intent is that the process steps for implementation of the Policy do adequately cover if, when and how, water sharing plans, BDLs and SDLs are to be amended to reflect floodplain harvesting volumes and licensing, including any legal provisions that apply, consistent with the NSW Water Management Act 2000, the Commonwealth Water Act 2007 and the Murray-Darling Basin Plan 2012.

However, we also conclude that there are benefits in additional explanation of this to enable stakeholders to adequately understand the process and the requirements.

Recommendations

As a matter of priority, the Department and the MDBA should publish an updated summary document to succinctly describe what BDLs and SDLs are, how BDLs and SDLs may change with updated information, as it becomes available, including floodplain harvesting volumes determined in accordance with the Policy.

A comprehensive guideline outlining in detail the process steps for implementing the Policy should be prepared by the Department and made publicly available to demonstrate transparency and raise confidence.

As a matter of priority, the Model Build and Scenario reports for each valley should be completed by the Department and made publicly available. Each of the reports should be explicit about how water sharing plans, BDLs and SDLs are to be amended based on the modelling work. Subject to review and consideration of the final reports, appropriate sections of the draft reports for the Border Rivers and the Gwydir could be used as templates for the other valleys.

The Department should hold workshops with stakeholders in each of the respective valleys to further explain the guideline and the reports after they have been prepared.

4.1.3 Do the guidelines and process steps for implementation of the Policy adequately cover the issuing of individual farm floodplain harvesting water access licences and explain how any share components will be determined, including processes for a review of any individual anomalies?

Evidence Reviewed

Guidelines for implementation of the Policy have yet to be comprehensively drafted, collated into the one document and made available to the reviewers or the public.

However, the process for implementation of the Policy, including issuing individual floodplain harvesting access licences with applicable share components, is set out in broad

terms in documents such as the publicly available *NSW Floodplain Harvesting Policy* (version published September, 2018).

How the process is being implemented in a practical and modelling sense is set out in various levels of detail in draft Departmental reports such as the *NSW Border Rivers Source Model Build Report (incomplete draft version of 21 February 2019)* and the report titled *Model Scenarios and Floodplain Harvesting Entitlements for NSW Border Rivers Regulated River System* (draft version of 29 January 2019), made available to the reviewers. Among other things, the latter draft report describes how a model post-processing utility has been developed to define individual floodplain harvesting entitlements and summarises data and results.

A similar draft report is available for the Gwydir valley and the reviewers were informed that reports for the Barwon- Darling, Namoi, and Macquarie valleys will be drafted in due course and final reports for all five valleys will be published and publicly available at some time in the future prior to the release of draft floodplain harvesting entitlements in each valley.

On 04 March 2109, The Department also provided the reviewers with a draft report titled *Defining and calculating floodplain harvesting entitlements V7* (undated).

Findings

Under the Policy, the process for determining individual share components will vary depending on whether a regulated river or an unregulated river access licence applies.

As explained elsewhere in this review, the long term average annual extraction limits for regulated rivers (and the Barwon–Darling) are being determined using computer models that simulate river basin behaviour based on more than one hundred years of climate data, the amount of irrigation development in the water source and the applicable plan rules. The entitlement determination process uses multiple lines of evidence in data review and modelling. Accordingly, this approach includes data from hydraulic models, gauged streamflow, remote sensing, flood and licensing records, as well as survey and on-ground inspection data.

In the Barwon–Darling, floodplain harvesting activities were not typically accounted for when *Water Act 1912* unregulated licences were volumetrically converted. As a result, the Barwon–Darling is being treated like a regulated river in terms of its extraction limits and floodplain harvesting licensing.

Under the Policy, properties with eligible floodplain harvesting works that had regulated licences (prior to 03 July 2008, with or without groundwater access licences) and did not hold an unregulated licence during 1993-1999, unless for conveyance only, will have their floodplain harvesting entitlements determined by modelling and will have a floodplain harvesting (regulated river) access licence. All other properties with eligible floodplain harvesting works will have their floodplain harvesting entitlement calculated, and, on the basis of the calculation, may have a floodplain harvesting (unregulated river) access licence.

Share components for individual floodplain harvesting (regulated river) access licences will be determined in two steps:

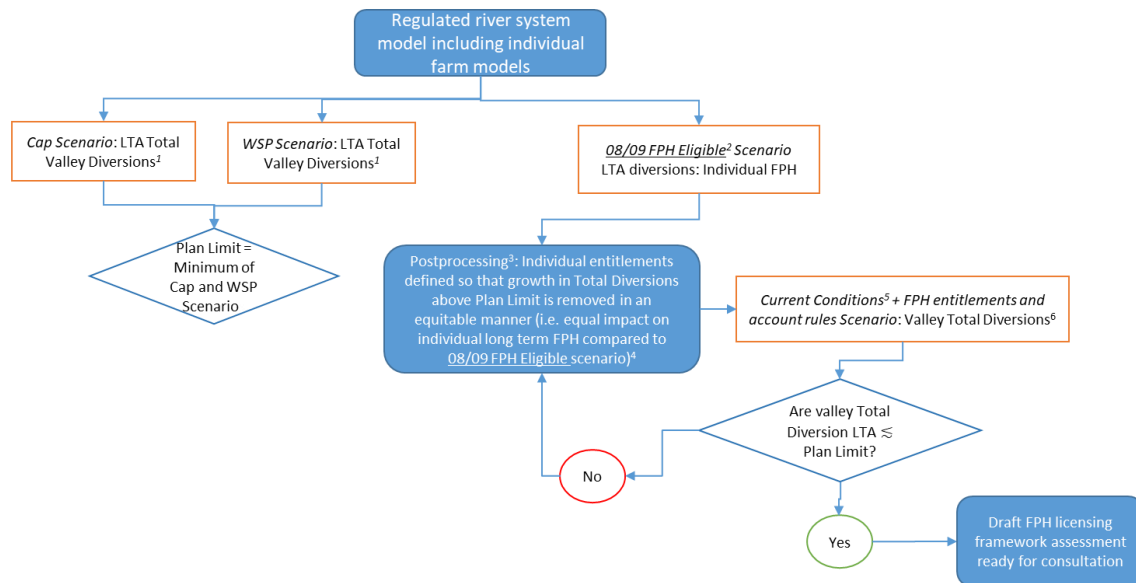
1. The long-term volume of water that all eligible works are capable of taking will be determined—this process will determine both individual and total floodplain harvesting volumes from eligible development;
2. Scaling of individual floodplain harvesting volumes based on eligible development will be used in conjunction with account management rules to ensure that total diversions do not exceed the total extraction limit. Any impacts required to remove growth in use above the plan limit will be distributed equally across individuals—this will determine a total share component for each individual.

The draft Model Scenario reports, made available to the reviewers, describe the use of a modelling post-processing utility which has been developed to define individual floodplain harvesting entitlements in regulated river water sources. This process has been developed to ensure that the requirements of the respective water sharing plan limits are met.

The key steps are outlined below:-

- Plan limit update: this sets the limit to long term average diversions for the whole valley;
- 2008-2009 floodplain harvesting (FPH) Eligible Infrastructure: floodplain harvesting assessed using eligible infrastructure - this may result in total floodplain harvesting being more than the plan limit by a certain percentage;
- Entitlement determination: The unconstrained simulated floodplain harvesting results from the 2008-2009 FPH Eligible Infrastructure scenario are analysed outside of the model. This utility determines the entitlements required to achieve a reduction in floodplain harvesting of around the same percentage for each property. The proposed accounting rules are also applied during this assessment. This step means that the required overall reduction in floodplain harvesting, required to meet plan limit requirements, is achieved;
- Modelling impact of the rules: The entitlements are defined in the model, along with the accounting rules, to confirm the impact of the FPH accounting rules.

The process is shown diagrammatically below:-



1 Cap and WSP scenarios include all infrastructure at the relevant dates as defined in the Plan Limit definition (typically 93/94 and 99/2000). The scenarios also differ in management rules, as defined in each water sharing plan. Long term average (LTA) total diversions includes all modelled diversions for that valley (eg. includes general security, supplementary)

2 The long term unconstrained FPH results are used during the next step ("post-processing") to determine the distribution of FPH entitlements. Two 08/09 FPH Eligible Scenarios are created: one has only existing eligible development. For properties that have eligible but not yet constructed development, a separate version of the model is used at this step. This approach avoids impacts on the assessment of current eligible infrastructure.

3 This analysis is basically a sensitivity testing process. It is not practical to do the required number of sensitivity tests using the river system model so a separate "post-processing" utility is used. This utility simulates the floodplain harvesting accounting rules and determines the entitlement which results in the required % impact on FPH, compared to 08/09 FPH Eligible Scenario results. The entitlements and account management rules are then checked in the river system model.

4 If current condition total diversions are already equal to or less than Plan Limit, then individual entitlements defined so that there is no impact on individual long term FPH compared to 08/09 FPH Eligible scenario

5 Growth assessment is based on total diversions hence needs to also account for ineligible infrastructure where these are able to be used for other water take purposes

6 This scenario tests all the entitlements including those for future development, but using only existing infrastructure

In some cases, individual share components will not equal the capability of the works currently in place. Individuals, whose existing works have the capability to harvest more than provided for by the share components and account management rules, will be required to take less water and/or modify their works to reduce their take. Non-compliance will be enforced by the NSW regulator.

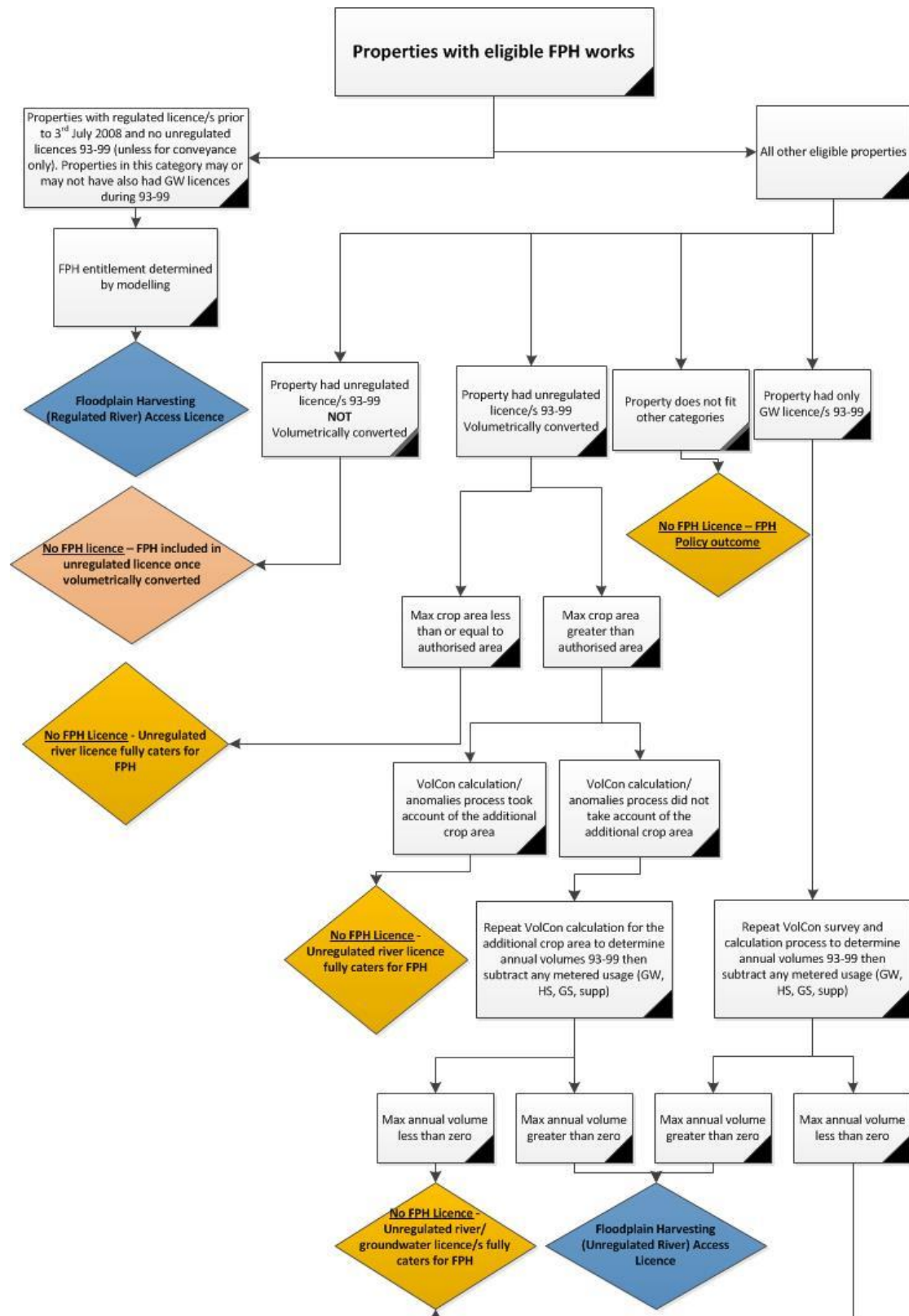
It is also possible that once individual licences have been issued, estimates of the total long-term average annual take associated with floodplain harvesting could be recalculated due to better information or further improvements in model accuracy. In recognition of this possibility, water sharing plans will permit available water determinations for floodplain harvesting access licences to be adjusted.

As mentioned previously, under the Policy, the process for determining share components for floodplain harvesting (regulated river) access licences (and for the Barwon–Darling) will be different from that used for floodplain harvesting (unregulated river) licences.

It is recognised that there may be instances in unregulated river water sources where existing floodplain harvesting works meet the eligibility criteria for assessment under the Policy, but the floodplain harvesting extractions associated with the works are not currently included within issued share components and unregulated river extraction limits. Where this is the case, other than in the Barwon–Darling, the extraction limit will be recalculated to include an amount that equals the annual extraction averaged over the period from 1 July 1993 to 30 June 1999 by floodplain harvesting activities that were not included in unregulated river access licence share components during the volumetric conversion process of 2000.

The Policy also states that where existing floodplain harvesting works in unregulated river water sources meet the eligibility criteria for assessment and it can be demonstrated that the area irrigated using water taken by those works is in addition to the area assessed during the volumetric conversion process of 2000, a new floodplain harvesting (unregulated river) access licence may be issued. The share component of the issued access licence will be determined using the volumetric conversion process that was used for unregulated river access licences in the same water source.

To calculate floodplain harvesting entitlements for properties with eligible floodplain harvesting works, the following steps are being taken:



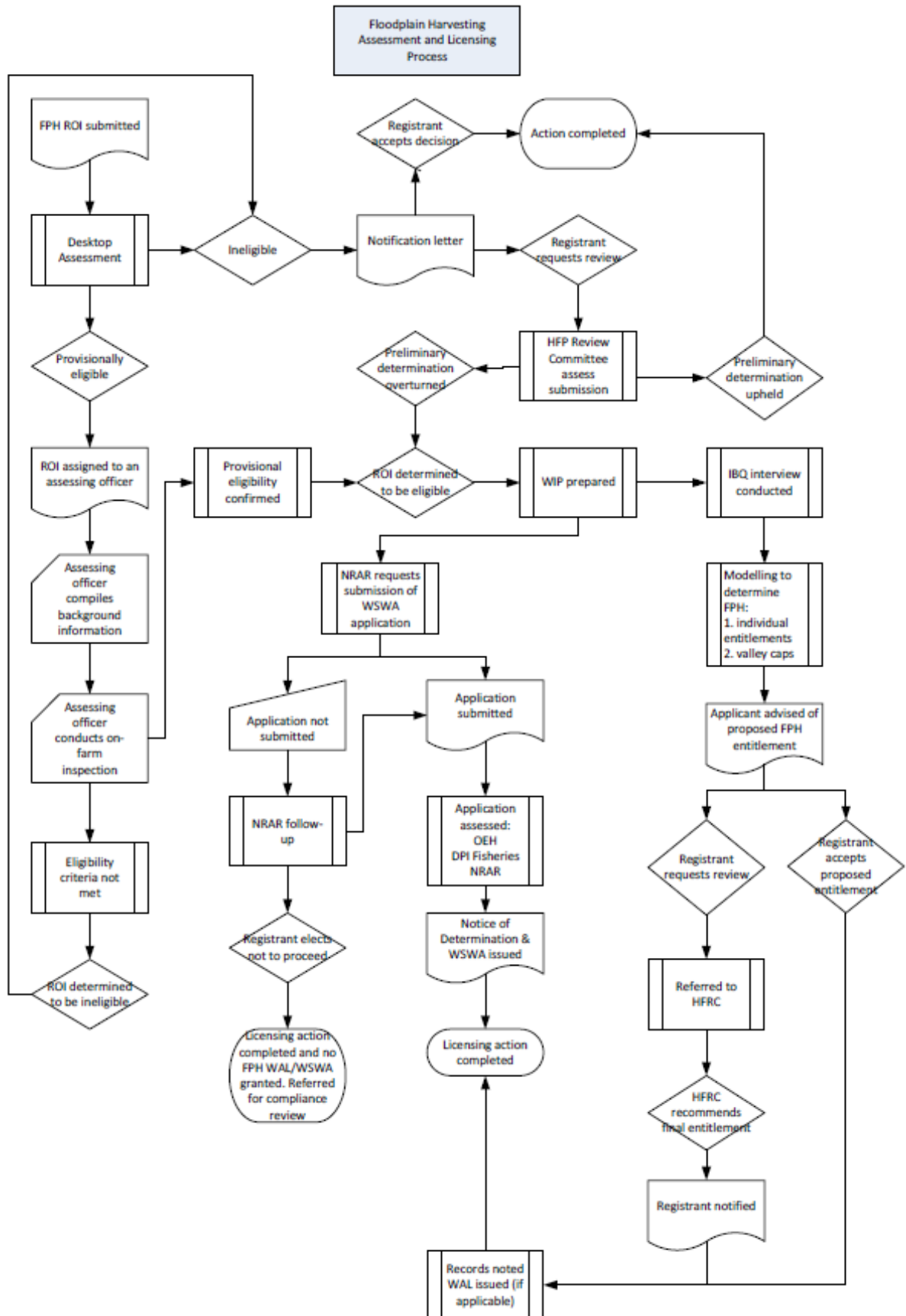
In both regulated and unregulated water sources where floodplain harvesting access licences are issued, the Department will make preliminary determinations of individual share components for all applications within that water source and notify the applicants. If an applicant disagrees with a preliminary determination of their individual share component, the applicant may make a submission to have the preliminary determination reviewed.

Because a change in an individual's entitlement volume may impact on others' share components across a plan area (noting that the entitlement determination step outlined above ensures that the required overall reduction in floodplain harvesting, required to meet plan limit requirements, is achieved), it will be important to get the timing of advice of preliminary determinations right. It would seem highly desirable that on-farm information used should be communicated and confirmed with landholders sooner rather than later to provide greater transparency around how the entitlement has actually been evaluated. This should also include estimates of the volumes of different consumptive use sources that have been determined for each farm

The review process itself will be similar to the anomalies committees that were used in the volumetric conversion process for licences in unregulated rivers carried out by the Department in 2000. It is intended that proceedings will be informal, with an opportunity to make both written and oral submissions. The Department will inform persons requesting review of the details regarding the proceedings, such as the time for review and any requirements regarding submissions, at the time it provides notification of preliminary determinations. Submissions may be made only by persons in relation to their own ROIs.

After all submissions have been reviewed, the Department will make a final determination of individual share components and licences will be issued.

The overall assessment and licensing process is shown in the following diagram, made available to the reviewers by the Department.



We conclude that, from the information available to us, the process steps for implementation of the Policy adequately cover the issuing of individual farm floodplain harvesting water access licences and explain how any share components will be determined, including processes for a review of any individual anomalies. The timing of these process steps is important for stakeholder confidence and understanding.

Recommendations

A comprehensive guideline outlining in detail the process steps for implementing the Policy should be prepared by the Department and made publicly available to demonstrate transparency and raise confidence.

As a matter of priority, the Model Build and Scenario reports for each valley should be completed by the Department and made publicly available. Each of the reports should be explicit about the issuing of individual farm floodplain harvesting water access licences and explain how any share components will be determined based on the modelling work. Appropriate sections of the draft reports for the Border Rivers and the Gwydir can be used as templates for the other valleys.

The Department should hold workshops with stakeholders in each of the respective valleys to further explain the guideline and the reports after they have been prepared and before the issuing of floodplain harvesting water access licences to individuals.

4.1.4 What is the basis for the proposed and/or designated floodplain boundaries and what is classed as floodplain flows?

Evidence Reviewed

The document *Rural floodplain management plans Technical manual for plans developed under the Water Management Act 2000 Version 2* (June 2018), available on the Department's website, outlines how floodplain boundaries are defined and floodplain management planning is undertaken.

How floodplain management plans, including any relevant infrastructure information, flows information and/or results from hydraulic models, are used in a practical and hydrological modelling sense is set out in various levels of detail in draft Departmental reports such as *the NSW Border Rivers Source Model Build Report (incomplete draft version of 21 February 2019)*, made available to the reviewers.

A similar draft report is available for the Gwydir valley and the reviewers were informed that reports for the Barwon- Darling, Namoi, and Macquarie valleys will be drafted in due course and final reports for all five valleys will be published and publicly available at some time in the future.

Findings

Part 8 of the *Water Act 1912* (WA 1912) was introduced in 1984 to require the licensing of any work that could affect flood-flow distribution and to allow floodplains to be designated. Part 8 of the WA 1912 was amended in 1999 to allow for more strategic coordination of

controlled works through the preparation of statutory rural floodplain management plans (FMPs). These FMPs were developed to overcome difficulties with assessing works on an ad-hoc basis.

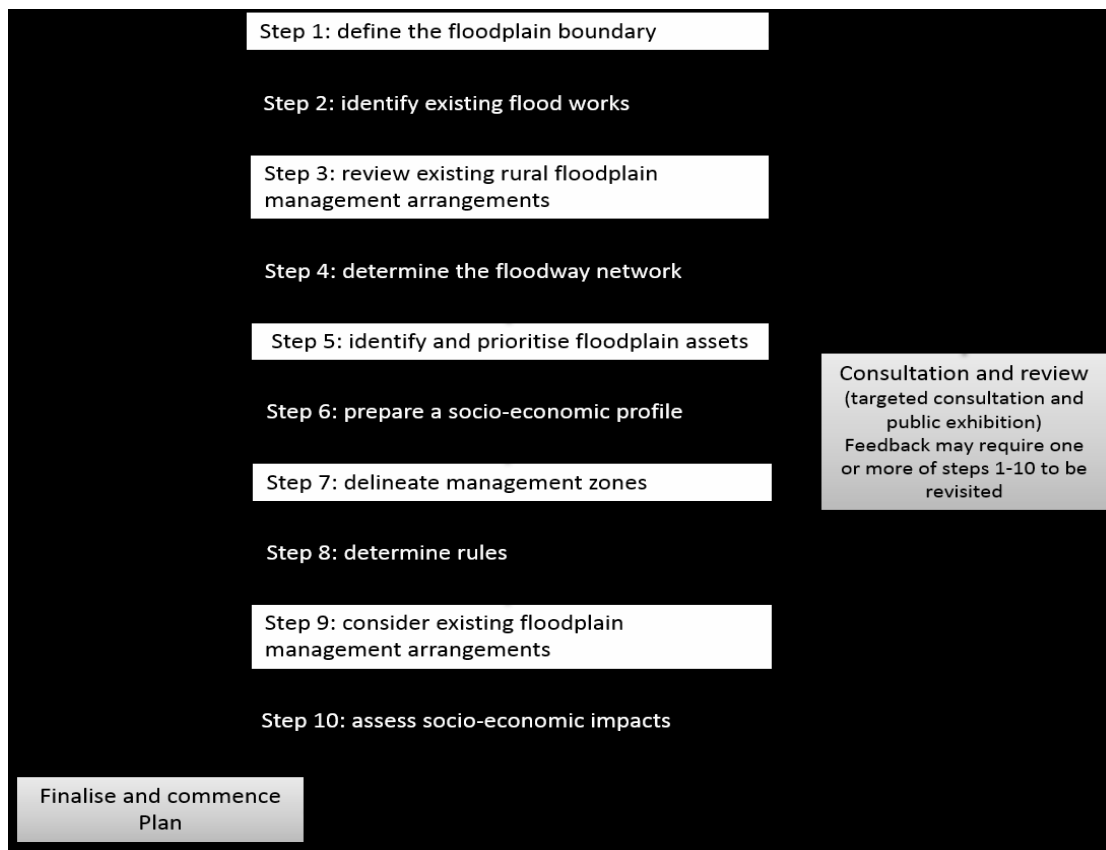
Part 8 of the WA 1912 was repealed in 2016 and replaced by the relevant provisions of the WM Act. WM Act rural FMPs are currently being developed in accordance with the floodplain planning and environmental protection provisions of the WM Act.

For purposes of the Policy, 'floodplain' means any area of land designated as a floodplain under the WM Act or the WA 1912. The Policy applies to floodplain harvesting activities on properties where all or part of that property lies within the designated floodplain. The Policy applies to all areas of all properties, where all or part of the property lies within the designated floodplain. To remove any doubt, the Policy applies to all areas of the property, irrespective of whether parts of the property are developed for irrigation or not.

There are existing floodplain designations in each of the northern Murray-Darling Basin valleys in NSW where there is significant floodplain harvesting. In some cases these designations may be adequate to implement the Policy; in others they may need to be tailored to include the location of existing floodplain harvesting works. The Department will assess whether changes to existing designations are needed having regard to registrations of interest in obtaining a water supply work approval and access licence for floodplain harvesting.

WM Act rural FMPs are currently being prepared for the northern MDB floodplains of the Macintyre (Border Rivers), Macquarie, and Lower and Upper Namoi valleys. The WM Act rural FMP for the Gwydir Valley Floodplain commenced in August 2016, and the WM Act rural FMP for the Barwon–Darling Valley Floodplain commenced in June 2017.

The floodplain management planning approach for FMPs developed under the WM Act involves 10 steps as shown in the following diagram:-



Steps 1-5 are especially relevant for coherence with floodplain harvesting licensing in accordance with the Policy, while step 5 may be especially relevant for specific works approvals. Perusal of the draft hydrological modelling reports made available to the reviewers indicate that processes are in place to achieve coherence. For example, the Office of Environment and Heritage (OEH) has developed hydrodynamic models for each of the valleys and this information has been used to inform the river system models. Hydraulic models inform the location of floodplain breakouts, the relationship between river flow and breakout flow, and the order of access to floodplain harvesting.

In addition, the Policy includes a review process to consider submissions on:-

- determinations about whether the work is located on a property where all or part of that property lies within the designated floodplain
- cases in which existing floodplain designations do not adequately incorporate existing floodplain harvesting works.

While the floodplain management planning process includes the determination of design floods, the relevant factors for implementation of the Policy are land surface diversions, which, as previously mentioned, are described in the MDBA Register as:

‘The total of land-surface diversions in any valley is the sum of individual components of land-surface diversions, as and when they are recognised and quantified including the following:

- floodplains irrespective of whether such water originated as floodwater; overtopping the banks of a watercourse or was runoff on its way to a watercourse;
- local runoff, irrespective of whether such runoff originated inside or outside a farm, or the bunded areas of a farm;
- interception by hillside farm dams in upland catchments;

but excluding these diversions:

- direct rainfall onto storages or roofs for rainwater tanks;
- infiltration to groundwater; and
- tail-water (the excess irrigation water that may be collected and returned to the on-farm storages).’

We conclude that, from the information available to us, appropriate and adequate processes are underway to designate floodplain boundaries and to consider diversions from flows across floodplains under the Policy in a coherent way to floodplain management planning under the WM Act.

Recommendations

The Model Build reports for each valley should be completed by the Department and made publicly available. Each of the reports should be explicit about how information from floodplain management planning under the WM Act is coherently being considered in the hydrological modelling and the implementation of the Policy. Appropriate sections of the draft reports for the Border Rivers and the Gwydir can be used as templates for the other valleys.

4.1.5 Have the pros and cons of alternative approaches to determining individual farm floodplain harvesting water access licenses and share components been considered and compared with the currently adopted approach for Policy implementation?

Evidence Reviewed

A number of issues were discussed in the *Implementing the NSW Floodplain Harvesting Policy Consultation Paper* (March 2018), available on the Department’s website. For clarity, the issue of including rainfall runoff in the definition of floodplain harvesting has been a policy decision, beyond the terms of reference of this review of implementation of the Policy, whereas the methods used to quantify and account for rainfall runoff are within the terms of reference of this review and are considered further later in this Final Report.

The Policy document (version published September, 2018) contains some commentary about a history of use approach.

Some discussions about different and/or simpler and/or faster ways of determining floodplain harvesting licence volumes and volume shares have been held in the past

(Department pers comm December 2018 and Northern Valleys Irrigators Alliance pers comm February 2019). In addition, a number of documents exist that explain how water entitlement licences have been issued or amended, including having their applicable entitlement volumes determined or changed/reduced, for example for area-based conversions in unregulated river systems and for over-allocated groundwater systems and the like.

Findings

The reviewers note that the 2018 Policy was “in the making” for more than a decade, with multiple formal and informal periods of consultation with and submissions from stakeholders. Regulatory arrangements for the taking of “non-watercourse” (floodplain harvesting) water are relatively recent compared with the century or more of legal controls on the take of water from within riverbanks or underground aquifers. Nevertheless, while different approaches to licensing and water sharing have been considered in certain types of circumstances, for example for groundwater or unregulated river systems, no comprehensive analyses and comparisons for floodplain harvesting have been formally documented and made available to the reviewers.

For example, the 2018 Consultation Paper had appendices that included alternative approaches to using account management rules with entitlements modelled over a shorter rather than longer time period to reduce variations across individuals and improve equity considerations. The applicability and implications of these alternatives are discussed in more detail later in this Final Report

Consideration of any approach to determining individual farm floodplain harvesting water access entitlements and share components would involve evaluations and comparisons of a number of factors such as:-

- Compliance with the Policy and legislation
- Ability to meet requirements of water sharing plans and the Basin Plan
- Availability of verifiable data and information
- Extent and complexity of inputs and resources
- Timelines and timeliness
- Robustness and thoroughness
- Repeatability and consistency
- Accuracy/uncertainty of results

- Equity of water sharing
- Transparency and defendability
- Stakeholder understanding and support
- Risks to the Department, to the licensees and to other water users and parties.

The Policy document stated that the determination of share components will not be based on any history-of-use information. History-of-use information was considered by the Department to have several disadvantages for disaggregating the total floodplain harvesting volume, including:

- the lack of verifiable records for all existing users and therefore the potential for inequitable sharing of the available volume
- the inadequate coverage of existing measuring and monitoring systems
- the high climatic variability associated with floodplain harvesting events
- previous severe and prolonged droughts, which meant that opportunities for floodplain harvesting activities were limited, distorting historical use patterns.

On the other hand, the current detailed hydrological modelling approach for the regulated systems is also potentially subject to these limitations, in addition to other factors which are discussed in more detail later in this Final Report.

One option discussed in the past and again mentioned to the reviewers was using an approach based only on on-farm storage volumes and areas developed for irrigation, perhaps with appropriate scaling factors specific to each valley. The method proposed could be very similar to the more familiar conversion process for unregulated entitlements. While this option is relatively simpler and faster, with significantly fewer data and verification requirements, it apparently has not been discussed widely and there were concerns about inequities, especially within valleys, and the relative lack of rigour and thoroughness (Department pers comm, December, 2018, Northern Valleys Irrigators Alliance pers comm, February, 2019).

It is instructive with the benefit of hindsight, that had agreement been reached to take action to measure and monitor floodplain diversions, even when the Policy was first published in May, 2013, we could now have up to five years of extremely helpful data and information to assist model calibration and verification and the determination of volumetric licences. Such approaches to undertaking volumetric conversions are not uncommon. In light of events in recent years, such an approach may also have supported the irrigation industry's social licence to operate in the Murray-Darling Basin and the Department's standing as a trusted and respected water resources planner, manager and regulator.

Further delays in having responsible measuring, monitoring, regulatory, compliance, enforcement and management systems in place may exacerbate the situation, both for water users and the downstream environment, especially if there are also not adequate works and other controls in place.

The reviewers have also noted that there were a range of views about certain alternative policy implementation approaches expressed by stakeholders in their submissions to the reviewers' draft Report. While some submissions suggested proceeding with the current floodplain harvesting licensing approach as soon as possible; some submissions suggested a "hold" on implementation until the evidence and other issues raised in the draft Report were adequately resolved; other submissions suggested that there should be a further "calibration" period (or perhaps more transparently a "verification and validation" period) with further data collection over a number of years to further inform floodplain harvesting volumes for subsequent entitlement calculations; while still other submissions suggested issuing licences as currently proposed and using a "calibration" period to inform a "review" under water sharing plan provisions in the future. A number of stakeholders commented that any alternative approaches need to recognise that a floodplain harvesting water access licence is a compensable "property right". Again, it is instructive that, as far as the reviewers have been made aware, the relative pros and cons of these alternative approaches have not been evaluated, documented and widely discussed between the Department and among stakeholders.

We conclude that, from the information available to us, relatively rudimentary evaluations have been undertaken of the pros and cons of only some overall alternative approaches to determining individual farm floodplain harvesting water access licenses and share components compared with the currently adopted approach for Policy implementation.

Recommendations

As part of good policy practice, the Department, in consultation with stakeholders, should review and evaluate the successes and opportunities for improvement in the development and implementation of the Policy after the current implementation work in the northern NSW valleys has been completed.

4.2 Appropriate Conceptualisation of the Numerical Modelling at Appropriate Scales

Traditionally, numerical hydrologic models have been used to assess and consider impacts of different water infrastructure and water management approaches at basin, valley and sub-valley scales.

Using numerical hydrologic models, combined in some cases with hydraulic models, to determine individual farm based water entitlements and volumetric shares is an extension of this traditional approach.

Some stakeholders have questioned whether there are too many complexities, uncertainties or plain unknowns associated with the modelling of on-farm floodplain harvesting take to enable a consistent, reliable and defensible determination of farm based volumetric floodplain harvesting entitlements. A particular difficulty encountered when trying to

develop numerical model estimates of floodplain harvesting is the lack of measured data to use for validation. In the absence of measured data, multiple lines of evidence may be used to try to build some additional confidence in the estimate of floodplain harvesting and its uncertainty.

4.2.1 Do the models properly represent regulated and unregulated systems (including the Barwon-Darling) in accordance with the Policy intent?

Evidence Reviewed

Departmental reports such as *Volumetric floodplain harvesting entitlement determination - Gwydir River Valley (September 2016)* and the *NSW Border Rivers Source Model Build Report (incomplete draft version of 21 February 2019)* have been made available to the reviewers. Among other things, these reports describe how the respective models represented regulated and unregulated systems and summarise data and results.

The reviewers were informed that reports for the Barwon- Darling, Namoi, and Macquarie valleys will be drafted in due course and final reports for all five valleys will be published and publicly available at some time in the future prior to the release of draft floodplain harvesting entitlements in each valley.

On 04 March 2019, the Department also made available the draft report *Defining and calculating floodplain harvesting entitlements (undated)* which provided additional details for the unregulated systems process, including an overall flowchart of the approach and some farm level information.

Findings

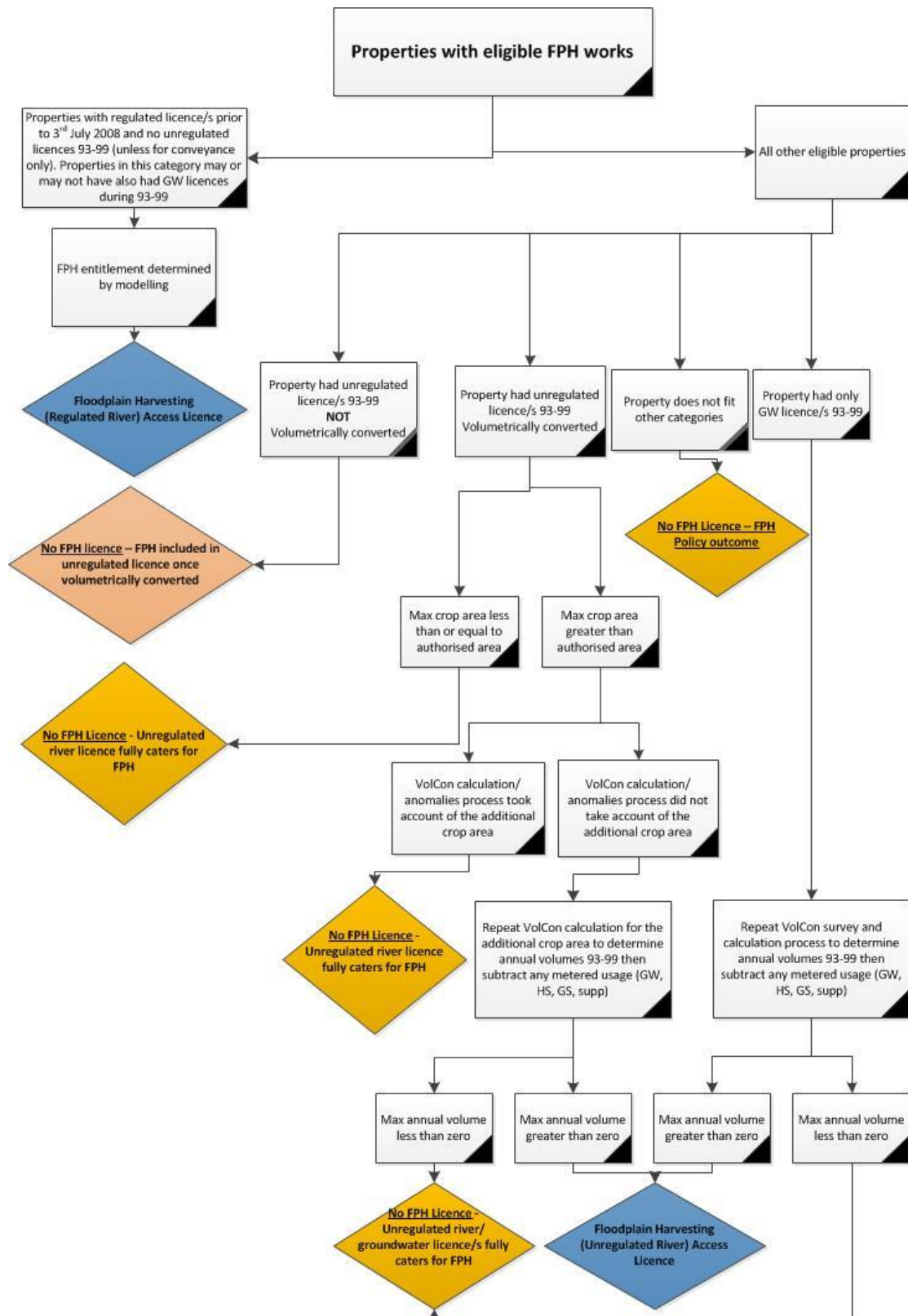
Information covered in 4.1.3 is also relevant to this matter.

The Policy provides that eligibility for floodplain harvesting is largely constrained to extractions associated with regulated rivers and the Barwon-Darling, with the five valleys mentioned previously being the priority locations for assessments and for consideration under this review. (Regulated rivers are defined under the WM Act.)

As mentioned previously in this Final Report, numerical models are being used to determine floodplain harvesting entitlements associated with eligible properties with regulated licences prior to 03 July, 2008 in the regulated rivers and the Barwon-Darling valleys, whilst a volumetric calculation is required to determine floodplain harvesting entitlements associated with all other properties with eligible floodplain harvesting works.

It is projected that modelling will account for in excess of 90% of eligible floodplain harvesting properties in the Northern Basin.

After consideration of ROIs and determining eligibility, all eligible works for floodplain harvesting entitlements have been split into two groups and entitlements are being determined according to the process defined below:-



In unregulated river water sources (other than the Barwon–Darling), the total volume of water available for floodplain harvesting is, in most cases, already accounted for within the existing access licence share components and the long term average annual extraction limits.

As mentioned previously, in the year 2000, licences for unregulated users changed from area-based (authorised area for irrigation) to volume based (a limit on the volume of water that can be extracted). This was known as volumetric conversion and landholders were given a volume of water that could be used each year (annual volumetric conversion).

At the time of volumetric conversion, unregulated licensees provided information about their irrigated areas, the types of crops planted and methods of water extraction. The survey required the licensee to provide up to six years of information on the area of crops grown (1993 - 1994 to 1998 - 1999). The method of calculating the volumetric conversion is given below:

- a) If the reported total area irrigated exceeded the area authorised by the licence, the crop areas reported for that year were adjusted back to the authorised area. Volumetric conversion was only applied to the authorised area.
- b) The areas for each crop type reported in the survey were multiplied by the appropriate crop water use conversion rate for the climate zone to give a volume in megalitres. The perennial rate was applied where crops were over-sown on the same area.
- c) If the total reported area in a year was less than the authorised area, the remaining area was multiplied by the inactive crop water use rate for the climate zone to give a volume in megalitres.
- d) The total of the volumes for each crop and area, plus the volume for the inactive area (if any) were added to give an annual volume.
- e) The volumes from each of the years were compared. The highest of these volumes was selected as the irrigation entitlement, in megalitres per year.

Where landholders did not return the survey, their authorised area was converted at an 'inactive' rate. This rate varied, depending on which zone they were in, from 1.0 to 6.0 ML/ha.

In some cases, licensees believed that their entitlement was inappropriate or an anomaly and could request a review through the *Independent anomalies review committee*. Landholders provided evidence to assist the committee make an informed decision. The criteria for anomalies were:

- Demonstrated water usage different to the conversion rate through usage data, pump hours/calibration data, crop yield information;
- Evidence that the individual user, despite being inactive has made significant investment in irrigation infrastructure;
- Evidence of usage history prior to the 6-year survey period.

Some of the properties with eligible floodplain harvesting works were dealt with through this process.

Water users were given the opportunity to report if they were taking additional water (e.g. through overland flow) or had unapproved works. Water use, dam sizes and so on, were verified by the Department and additional access licences/volumes and approvals issued in most cases. Eligible properties with floodplain harvesting works have been checked against these amnesty enquiries.

Determinations about such matters are also subject to the review process outlined in the Policy.

Within the models themselves being used for regulated river systems, industry standard practices are being used to estimate inflows from ungauged catchments.

The Policy states that, in updating the modelled estimate for floodplain harvesting in a regulated water source, the Department will establish a committee with irrigation stakeholders from each valley to consult on ways to maximise the robustness of the modelling and ensure that parameters relating to farm operations accurately reflect actual behaviour to the greatest degree feasible.

The Department informed the reviewers that a Modelling Consultative Committee was established comprising irrigation industry representatives from the Northern Basin valleys. Only two meetings of this committee were held in 2014 and the dominant discussions were around policy settings and not modelling conceptualisation nor parameterisation. This is unfortunate, given the central position of modelling to determining floodplain harvesting licence volumes.

The reviewers are aware that the modellers have had a number of larger and smaller stakeholder discussions in individual valleys over a number of years in attempts to explain the modelling approaches and to maximise the representativeness and the robustness of the modelling. The reviewers also attended the workshops run by the Department with stakeholders in October 2018 and are aware of the proposed additional workshops in coming months, including to present the results of this independent review. Even so, stakeholders indicated to the reviewers their desire to have additional dialogue and understanding about modelling frameworks, inputs and results (Northern Valleys Irrigators Alliance, Australian Floodplain Association, Commonwealth Environmental Water Holder, MDBA pers comm February 2019) To improve transparency and trust, it is important that such discussions be documented, including documentation as to stakeholder advice given and what has been the Departmental response to that advice.

We conclude that, based on the information available to us, the models and processes properly represent high level approaches to be taken for eligible properties in regulated and unregulated systems (including the Barwon-Darling) in accordance with the Policy intent, but greater transparency about that would be beneficial to raise stakeholder understanding and trust, and potentially to improve the robustness and applicability of the models themselves.

Recommendations

As a matter of priority, the Model Build reports for each valley should be completed by the Department and made publicly available. Each of the reports should be explicit about how

floodplain harvesting eligible properties with regulated licences prior to 03 July 2008 have been represented in the models and how all other eligible properties have been handled.

The reports should also be explicit about stakeholder advice given and what has been the Departmental response to that advice, including from the numerous modelling discussions that have been held with stakeholders and industry representatives. If there is conflicting advice, the Department and stakeholders should engage in additional dialogue about the available evidence and approaches to improving or handling it, recognising the risks and uncertainties involved.

4.2.2 Do the models and determination of allowable take have due regard to downstream impacts such as Matters of National Environmental Significance?

Evidence Reviewed

The respective water sharing plans, available on the NSW Government website, and floodplain management plans approved or to be approved under the WM Act have regard to downstream impacts and environmental outcomes, including consideration of key ecological assets and Matters of Environmental Significance. The water sharing plans importantly include extraction limits and the Basin Plan, available on the MDBA’s website, sets sustainable diversion limits for each SDL resource unit and explains how they have been derived.

Draft Departmental reports such as the *NSW Border Rivers Source Model Build Report (incomplete draft version of 21 February 2019)* and the report titled *Model Scenarios and Floodplain Harvesting Entitlements for NSW Border Rivers Regulated River System* (draft version of 29 January 2019), were made available to the reviewers. Among other things, these reports outline how water sharing plan extraction limits and Basin Plan SDLs are considered, including arrangements to check and demonstrate compliance with those limits.

The Policy (version published September 2018), available on the Department’s website, outlines the environmental assessments required to grant a water supply work approval or a flood work approval under the WM Act.

The Commonwealth Environmental Water Holder provided further advice on environmental water requirements (pers comm, February 2019).

Findings

How the implementation of the Policy, including the modelling aspects, handles extraction limits and SDLs, is outlined in previous parts of this Final Report. In that respect, through water sharing plans and the Basin Plan, and the accreditation of the applicable BDL models by the MDBA, downstream impacts, including on Matters of National Environmental Significance, are considered.

However, the models for the floodplain flows and the determination of floodplain harvesting volumes do not adequately represent return flows to the rivers and cannot be used to specifically assess the impact of floodplain harvesting per se on specific downstream flows.

Further research is required to support this type of analysis (the Department pers comm February 2019).

What the current models can do is to estimate relative differences between two or more scenarios of floodplain harvesting diversions. For example, the long-term average annual floodplain harvesting volumes taken under current levels of development can be compared with respective volumes that would be taken under levels of development in 2008 or in 1999-2000 or 1993-1994. If floodplain harvesting volumes permitted to be taken are reduced, then more water is available downstream compared to the case where floodplain harvesting volumes are not reduced.

In essence, within the models, a proportion of the formerly assumed floodplain system flows and “losses” in the models (which actually include elements of floodplain flows) are reconfigured to simulate flows onto the floodplain, some of which are then accessed by the individual farm enterprises. There is no reduction of the floodplain flows through implementation of the Policy, as the intent is that this formerly unaccounted form of take (which already existed) is now accounted for in a water entitlements framework. However, significant limitations still exist regarding the current understanding of how directly harvesting of water on the floodplain affects downstream floodplain flows, return flows and corresponding downstream river flows. Most of these simulated floodplain flow paths that have been incorporated into the models do not re-join the main river, and any water not harvested is “lost” to the river system in the models. (It is recognised that in reality the floodplain water not harvested may be very beneficial for other water users and uses, including the environment.) The effect of this model configuration is that the simulation of downstream flows is insensitive to the volume of floodplain harvesting take.

The configuration of floodplain harvesting using effluent flow paths is unlikely to affect the veracity of the licence volume and take estimates, given that implementation of the Policy is largely attempting to reproduce historic diversions from authorised floodplain works and then limit the volumes so that plan limits are complied with. However, this approach makes it very difficult to assess any impacts on downstream flows that might arise from changes to the floodplain harvesting framework (volumetric licences and account management rules).

Within particular locations, approaches in the hydrologic modelling may have been informed by relevant and available hydraulic modelling performed as part of floodplain management planning. For example, there are two areas of National Environmental Significance in the Gwydir catchment: Gwydir-Gingham and Mallowa wetlands. The Gwydir hydrologic model includes detailed representation of the Gwydir-Gingham wetlands based on the 2010 hydraulic modelling, together with the latest modelling of the Environmental Water Allowance, EWA (previously known as the Environmental Contingency Allowance, ECA) (the Department pers comm February 2019).

With respect to works, the Policy outlines that, in order to grant a water supply work approval or a flood work approval under the WM Act, or grant a controlled work approval under the WA 1912, an assessment of the environmental impacts of the work must be carried out. Works proposed to be authorised for floodplain harvesting will undergo this environmental assessment, except for works which are already covered by an approval

issued under Part 2 or Part 8 of the WA 1912 or the WM Act. No additional assessment will be required for such works as long as the works will be operated within the terms of the approval.

The assessment required in order to grant an approval for a given work or set of works will depend on the extent to which existing approvals are sufficient to authorise the works for floodplain harvesting. Works with a valid approval that will be operated for floodplain harvesting purposes in ways that do not fall within the terms of the existing approval will require assessment of those operations that are not covered by the existing approval. Any works that do not have a valid approval will be assessed according to normal procedure.

Works will be assessed in relation to considerations including, but not limited to, the potential impact of floodplain extractions and changed flood flow distribution on threatened species, fish passage and breeding, groundwater connectivity, floodplain connectivity, wetlands and flood-dependent ecosystems, and other water users. Environmental assessments will consider the contribution of all existing works, whether authorised or not authorised, to the cumulative impact of water management activities. Environmental assessments will also draw on information relating to floodplain flow paths and environmental assets contained in floodplain management plans, where available.

In cases where existing approvals or applications do not include information sufficient to enable assessment of environmental impacts, the Department may request additional information.

We conclude that, based on the information available to us, there are specific limitations in the models with respect to the consideration of the impacts of allowable floodplain harvesting take, per se, on downstream flows, including in specific locations, but broader flow impacts are within system extraction limits and SDLs. Some of those limitations can be assessed and possibly mitigated in specific locations with additional floodplain flow information, including from hydraulic models and investigations for floodplain management plans.

Recommendations

Include in a comprehensive guideline, outlining in detail the process steps for implementing the Policy to be prepared by the Department and made publicly available, clear information about how decisions about the determination of allowable take have due regard to downstream impacts such as Matters of National Environmental Significance.

As a matter of priority, the Model Build and Scenario reports for each valley should be completed by the Department and made publicly available. Each of the reports should be explicit about model limitations with respect to determining downstream impacts, what are the associated risks of that in specific locations, and how those risks might be mitigated, including with additional data and information collection and potentially additional investigations.

4.2.3 Is the conceptualisation of the modelling at appropriate spatial and temporal scales to evaluate individual farm take and behaviours and represent these adequately in a draft entitlement?

Evidence Reviewed

Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016 and discussion with modellers conducted on 20 February 2019.

Findings

The conceptualisation of farm behaviour is illustrated in Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016 Figure 2-2 as shown below.

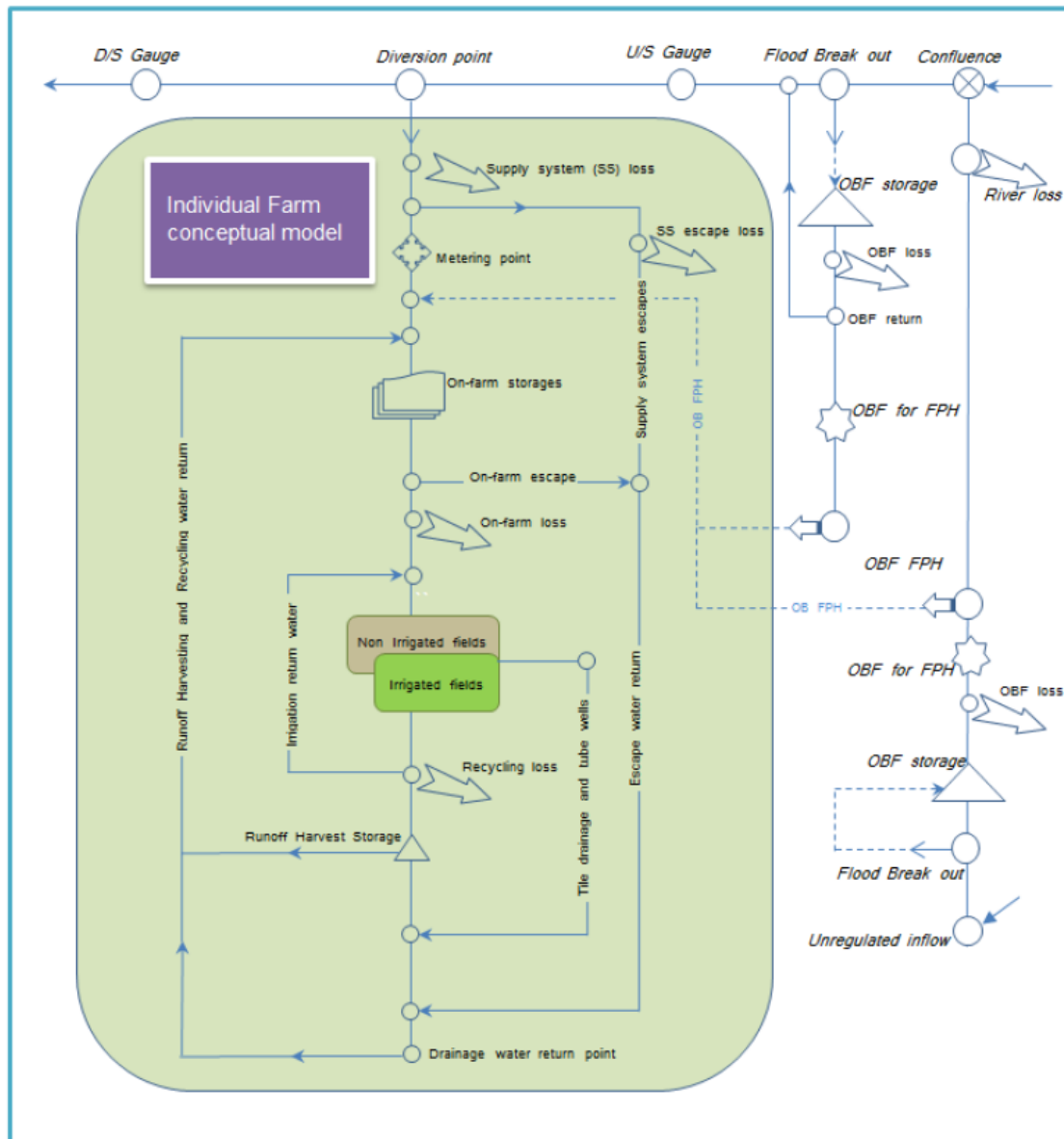


Figure 3. Figure 2-2 from Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016

This model identifies that there are number of on-farm infrastructure and behavioural components that can be included within the model, but it was also noted that some of these components (e.g. on farm storage) are lumped to simplify the operation of the model. The use of a conceptual overbank flow (OBF) storage that represents the total breakout volume from a reach to be accessed by floodplain harvesting (FPH) is a useful method of allowing the FPH volumes to be calibrated to achieve water balance in a reach, but there doesn't appear to be any validation or verification of those volumes other than that needed to satisfy the crop demand, losses and variation in on-farm storage (OFS). The IQQM and Source models, observed for the Gwydir and Border Rivers respectively, allow for complex farm behaviours to be accounted for, and these behaviours are populated from the lines of evidence, but where the lines of evidence are inconclusive, variations to the behaviour parameters are made to best fit with calibration. This approach is supported, but there needs to be cross verification of the final parameters adopted within the individual enterprises simulated to

ensure they are an adequate simulation of what is actually occurring, based on best available evidence. Obviously, this information should have been contained in the Irrigator Behaviour Questionnaire (IBQ) documents, but this was not always the case or the data was found to be erroneous or inaccurate and adjustments were needed to correctly represent the information found in other lines of evidence.

Overall, the conceptualisation of the modelling appears to be adequate to represent individual farm/enterprise operations, noting that in cases where data was not conclusive, valley wide averages from other lines of evidence have been applied.

Recommendations

Communication of the adopted farm behaviour parameters for individual farms (or groups of farms) needs to be made back to the relevant landholders to demonstrate that the parameters are an appropriate representation of infrastructure and behaviours of individual farms and reasons for their selection outlined. It is not intended that this be a process of debate and change about specific values, just that the final parameters chosen, especially around key aspects such as crop water use, cropping area available, permanent and temporary storage volumes used, be communicated back to landholders to demonstrate what was used to determine the volumetric entitlement.

4.2.4 What are the multiple lines of evidence and have they been used in a transparent way to provide for the conceptualisation of the numerical models and the inputs to those models.

Evidence Reviewed

A summary of data and modelling to determine the licencing framework for managing floodplain harvesting, Fact Sheet, NSW Department of Industry, 2018; Healthy Floodplains Modelling for water users, PowerPoint presentation, 08/11/18; Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016; discussions with modellers.

Findings

The multiple lines of evidence that have been quoted in the documentation reviewed include (but not limited to):

- Irrigator Behaviour Questionnaires (IBQs)
- Remote sensing information (including Landsat, Irrisat, WoFS, LiDAR)
- Information from Department of Industry staff, especially hydrographers and field staff
- Industry guidelines
- Australian Bureau of Statistics data

- Published literature.

The diagram outlined in the Healthy Floodplains presentation of 8th November 2018 shows that an evidence hierarchy is followed to assess the suitability and use of particular lines of evidence as shown below.

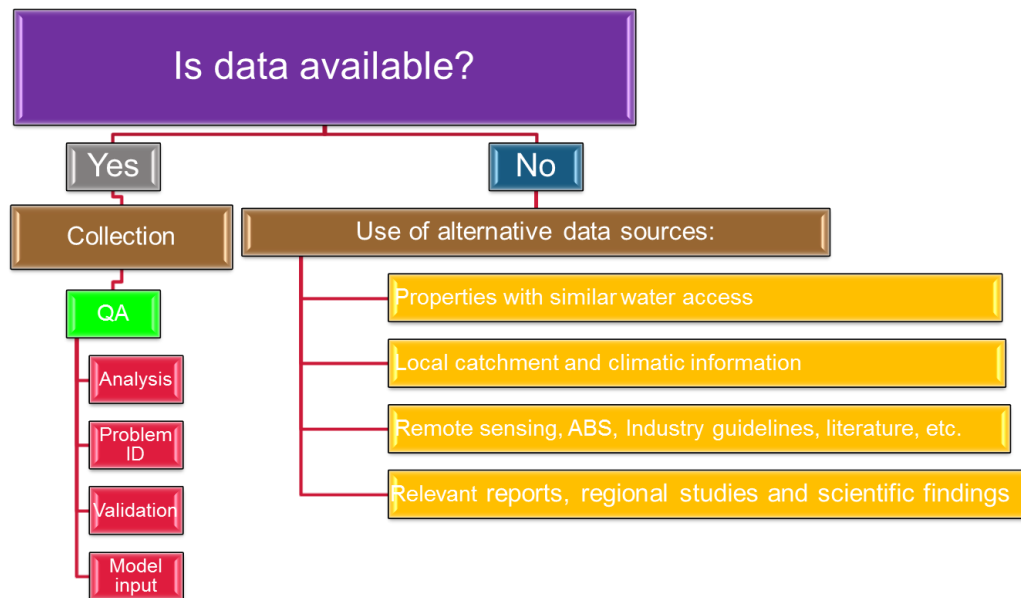


Figure 4 Line of evidence selection hierarchy

From discussions with the modellers, two broad methods of applying evidence to individual farms have been used. In the Gwydir, individual farm parameters were used as far as practicable (and supported by the available evidence), whereas in the Border Rivers, average industry values were typically used for a number of parameters, with individual farm parameters informing infrastructure and access points for example. It was the opinion of the modellers that there was little difference in the modelled behaviour between the two.

What was also observed was that there was a general unreliability in most of the information in the IBQs, with the possible exception of crop area, so in most cases the information in them was used as a guide to refer to in addition to other lines of evidence. Largely, the information regarding on-farm infrastructure such as OFS was informed by remote sensing, especially Landsat imagery during and post large flood events for temporary storage.

As noted in the previous review element 4.2.3, the communication to landholders of the values used, and the results obtained has not occurred. This would allow for better transparency, discussion and cross verification.

Recommendations

Communication of the adopted farm behaviour parameters for individual farms (or groups of farms) needs to be made back to the relevant landholders to demonstrate that the

parameters are an appropriate representation of infrastructure and behaviours of individual farms. The timing of this communication should be at a time before draft entitlements are issued, in order to provide transparency to the entitlement holder as to what parameters were used to determine the entitlement volumes and allow for modifications to be made where supported by evidence.

4.2.5 Is there evidence in the documentation as to what data, information and assumptions (including from Irrigator Behaviour Questionnaires - IBQs) have been used or not used and why?

Evidence Reviewed

Floodplain harvesting conceptual design Case study, Draft, DoI Water (undated); FPH Modelling Review, PowerPoint Presentation by Northern Irrigators Association, 29 October 2018; Healthy Floodplains Modelling for water users, PowerPoint presentation, 08/11/18; discussions with modellers on 20 February 2019.

Findings

The process by which particular lines of evidence are used is discussed above, and appears sound, but it is of concern that the IBQs are treated as indicative only, mostly due to the inconsistency in data quality, completeness and consistency for similar farms in the same basin or even within the same reach. No other documentation was viewed that indicated when and why the IBQ information is disregarded, even though the process to do so as discussed with the modellers appears sound. Further documentation is therefore sorely needed.

Recommendations

As a matter of priority, the Model Build and Scenario reports for each valley should be completed by the Department and made publicly available. In particular, the decision rules around when and why different data inputs are considered and used or rejected.

4.2.6 With respect to the influence of the IBQs on model parameterisation, when was on-farm information reported from the IBQs used or not used and how were inconsistencies between other data sources and the IBQs reconciled?

Evidence Reviewed

Floodplain harvesting conceptual design Case study, Draft, DoI Water (undated); FPH Modelling Review, PowerPoint Presentation by Northern Irrigators Association, 29 October 2018; Healthy Floodplains Modelling for water users, PowerPoint presentation, 08/11/18; discussions with modellers on 20 February 2019.

Findings

Generally, the IBQs have been used as the primary source of information for input into the models until it has been determined that the data was inconsistent with other lines of evidence, or simply wasn't completed within the questionnaire. Indications within the

Healthy Floodplains Modelling for water users PowerPoint presentation are that other than crop area, most of the other data needed for modelling was missing and needed to be addressed or estimated through other lines of evidence. This is shown in the following figures from the presentation.

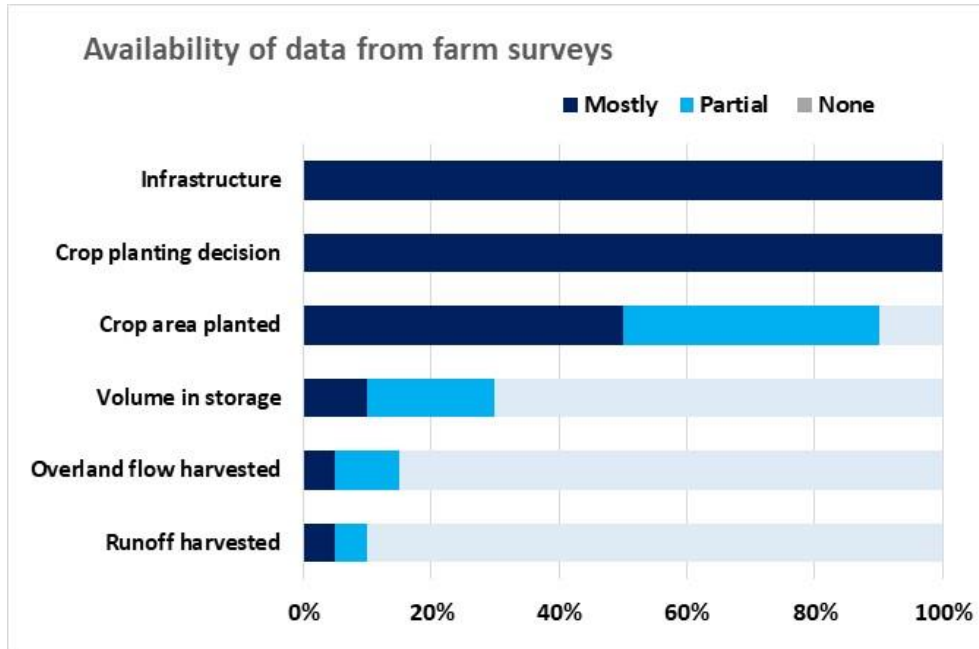


Figure 5. Overall availability of information from IBQs (Healthy Floodplains Modelling for water users, PowerPoint presentation, 08/11/18)

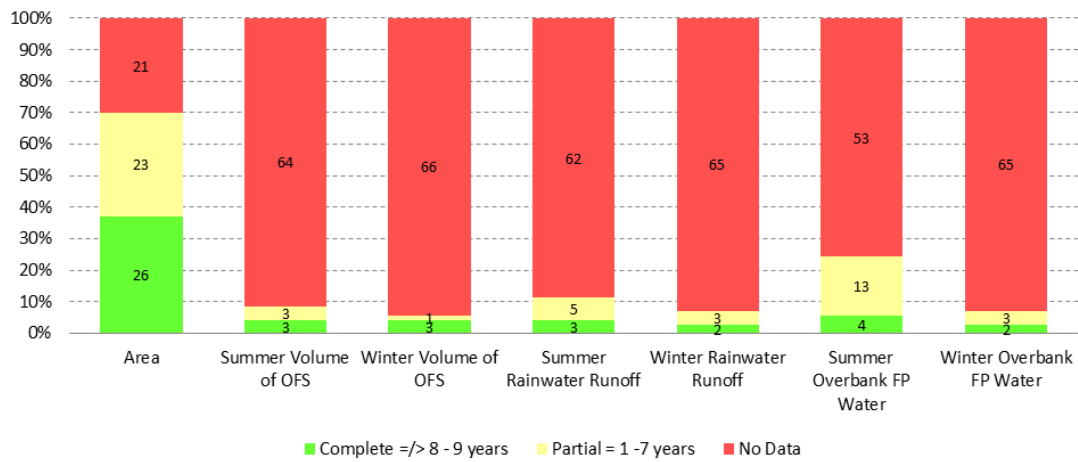


Figure 6. Availability of information in IBQs from the Macquarie basin

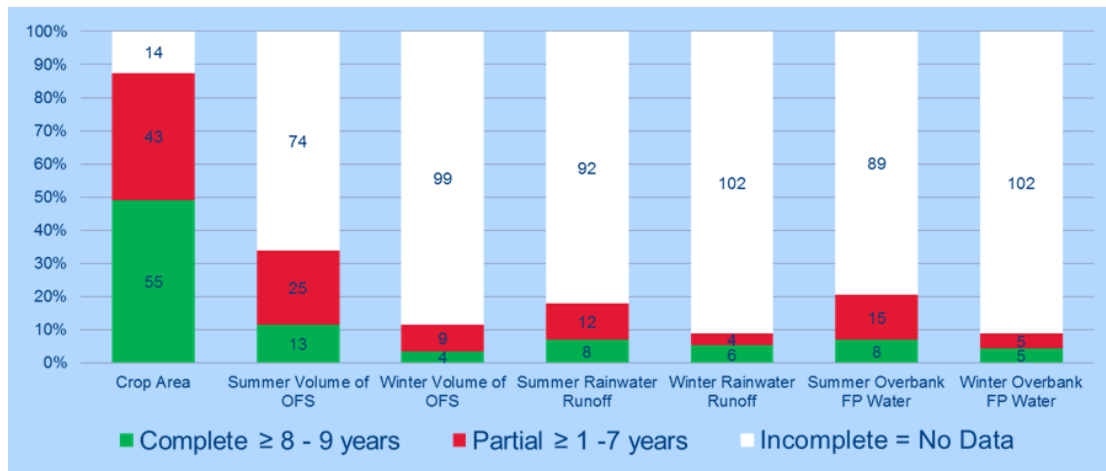


Figure 7. Availability of information in IBQs from the Gwydir basin.

Recommendations

As a matter of priority, the Model Build and Scenario reports for each valley should be completed by the Department and made publicly available. In particular, the decision rules around when and why different data inputs are considered and used or rejected. It would also be useful to plot or otherwise represent the variability in information received within the IBQs and comparisons made to other lines of evidence to demonstrate that the selected model parameters or data inputs are consistent with that variability.

4.2.7 What is the verification process at the farm scale?

Evidence Reviewed

Border Rivers Floodplain Harvesting Modelling - Rationale for Data Choices, memo to reviewers (undated); Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016; discussions with modellers on 20 February 2019.

Findings

The verification of data inputs and model parameters is based on ensuring that the selected information is consistent with basin wide information. The IBQs provide initial estimates for on farm behaviour, but adjustments to take and other parameters are then largely rationalised to achieve consistency with other lines of evidence (such as crop areas from remote sensing). From the documentation reviewed, there doesn't appear to be any discussion with landholders of the information used for verification purposes though through the pilot farm assessments undertaken in the Gwydir, this process was completed for a small number of farms.

In general, there appears to be a reluctance to collaborate with landholders and it was noted in stakeholder discussions that the former collaborative approaches (e.g. Modelling Consultative Committee) used in developing the models is no longer undertaken. This may be to ensure that there is no perception of favouring one water user group over another after recent media scrutiny, but the general lack of communication with all water users by

the modellers in recent times was raised a number of times by stakeholders and reduces the transparency of the process.

Recommendations

There is a need to ensure that the chosen parameters relating to particular farms or enterprises are realistic in relation to farm activity and are discussed with landholders. It appears that currently, the parameters are chosen to maximise calibration performance and consistency against multiple lines of evidence but no real verification against farm scale operations (other than crop area from IBQs) are made. We therefore recommend that when the final volumetric entitlement is made, it will be essential to provide the landholder with the farm parameters used to determine that entitlement to ensure that they adequately represent the way the farm is operated and how it may need to change under a different amount of volumetric use. For basins where modelling is yet to be completed, further consultation with landholders around the information being used in the models would help to demonstrate transparency, and we note that previous efforts through the Modelling Consultative Committee in the Gwydir may provide better collaboration opportunities to refine the modelling.

4.2.8 Are the lines of evidence used repeatable and auditable?

Evidence Reviewed

Border Rivers Floodplain Harvesting Modelling - Rationale for Data Choices, memo to reviewers (undated); FPH Modelling Review, PowerPoint Presentation by Northern Irrigators Association, 29 October 2018; discussion with modellers on 20 February 2019.

Findings

On balance, the process and hierarchies used for the multiple lines of evidence appear sound and repeatable but lacking in documentation around when choices of particular evidence is used in preference to another and hence they are unlikely to be auditable.

We note that there are perceived and actual uncertainties with many of the datasets relied on by nature of the methods of collection and collation of those datasets, and it is a basic element of any modelling activity to review the uncertainties to determine if they are likely to significantly affect the model outputs. While there are limitations in specific datasets (e.g. remote sensing data) as noted in our discussions with key stakeholders, we do not believe that these are materially different to any other datasets that may also be available to modellers to inform particular model inputs or parameters. Overall, it appears that the consideration of which datasets to use is based around a sound choice of using the best available datasets that inform the modelling. The process of using multiple lines of evidence in this manner to reduce model uncertainty is consistent with modelling best practice.

Recommendations

As a matter of priority, the Model Build and Scenario reports for each valley should be completed by the Department and made publicly available. In particular, the decision rules

around when and why different data inputs are considered and used or rejected. It would also be useful to plot or otherwise represent the variability in information received within the IBQs and comparisons made to other lines of evidence to demonstrate that the selected model parameters or data inputs are consistent with that variability.

4.2.9 Is the representation of flow paths, on-farm infrastructure including temporary and permanent storages, irrigated areas and their operational arrangements in the models appropriate and supported by the best available evidence?

Evidence Reviewed

Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016; discussions with modellers on 20 February 2019; Gwydir IQQM model; Border Rivers Source model.

Findings

The representation of the flow paths, on-farm infrastructure including On Farm Storage (OFS), irrigated areas and operational behaviours within the models is largely simplified to lump up control infrastructure such as OFS, temporary storage etc into specific parameters within an individual farm node. An example is individual OFS being considered as a series of cells within a lumped OFS representing the total volume available. This does assume that a certain behavioural pattern is undertaken consistently that may not reflect actual farm operations (e.g. sequential filling and draining of OFS in the same sequence each time). Conceptually this representation is appropriate considering a number of farms that can access OBF, but it does considerably simplify the complexity of individual enterprise operation that may not properly reflect the variability in that operation which then may also affect the amount of FPH possible for a given event. It is expected that over long-term analysis, this variability would not significantly alter the likely take, but if specific time-periods are used for analysis then this may result in differences between actual and modelled FPH take.

The extent to which the simplification of farm complexity affects the determination of individual farm entitlements is not known as there is no real sensitivity analysis of the likely variability of individual property operation undertaken, though broader scale sensitivity testing across whole basins are done.

Recommendations

Undertake sensitivity testing of a number of case study farms to examine the changes in entitlement estimates with variations in farm infrastructure operations to examine if this variability is significant (or not).

4.2.10 Are the uncertainties in the numerical modelling approach sufficiently known and understood at the farm scale to enable individual farm-based water entitlements and volumetric shares to be confidently and equitably determined?

Evidence Reviewed

Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016, specifically Section 8.

Findings

There are no quantitative estimates of model uncertainty though the calibration results are completed for successive flow gauges downstream. The current modelling process and complexity makes quantifying such uncertainties challenging and the impacts of combined uncertainties are not well understood. We believe that a more qualitative assessment of uncertainty is still required, combined with an analysis of parameter sensitivity, in order to document where the major uncertainties may lie and how they can be addressed through further model improvements. Without this uncertainty estimate, it is not possible to understand if individual or combined parameter and data uncertainties are significant enough to impact on the ability to adequately estimate individual entitlements. The document, Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016 states that uncertainty levels are within accepted limits, but no documentation of what the uncertainties that were assessed were, what their limits may be or whether this was an adequate analysis or not. We don't see this is a failure of the modelling, but as not assisting in providing the necessary degree of confidence needed and asked for by a range of stakeholders.

Recommendations

Verification of model uncertainty against agreed model uncertainty criteria is required, especially to support the statement in Section 8.1.2 on p38 of Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016.

4.2.11 Is the numerical modelling approach “fit-for-purpose”, including model structure, appropriate calibration, validation and documentation to provide confidence in same?

Evidence Reviewed

Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016, Gwydir Valley Independent Audit of Cap Model by Bewsher Consulting March 2009; Quality Assurance Review of IQQM Modelling of the Healthy Floodplains Gwydir IQQM by Barma Water Resource Consulting Pty Ltd (undated).

Findings

The overall approach to the numerical modelling appears sound and has been previously independently assessed in some basins as being appropriate, but the documentation of the current round of modelling is severely lacking and inconsistent, with numerous unpublished reports, memos and documents sent through for assessment that are either not current, disjointed, inconsistent or incomplete that has made the review process very challenging.

We do note that the current updates to the model build and model scenario documentation are being completed but as yet, modelling in some basins is not completed or presented for review and as such, we have largely based our assessment and review on the Gwydir and Border Rivers basins modelling.

Recommendations

As a matter of priority, the Model Build and Scenario reports for each valley should be completed by the Department and made publicly available.

4.2.12 What mitigations have been used to offset unacceptable outcomes due to the existence of various uncertainties, and are they adequate?

Evidence Reviewed

The Policy document, available on the Department’s website, and the draft Model Build and Scenario reports for the Gwydir and the Border Rivers, mentioned previously in this Final Report and made available to the reviewers, are relevant to this matter.

Findings

Detailed discussions about uncertainties, especially modelling related uncertainties, appear in other sections of this Final Report.

The key procedural mitigation under the Policy is the establishment of the review process outlined previously. The role of the independent committee, established under that process, is to analyse issues raised by ROI submitters in respect of the draft entitlements, and provide advice and recommendations to the Department regarding resolution of such issues.

Mitigations can also result from undertaking independent reviews such as this one, the subject of this Final Report, and the independent probity advice mentioned previously, in addition to the stakeholder engagement processes that are integral to water resource planning and management.

The adequacy of the mitigations from the above types of processes does depend on what actions are taken, and the transparency, reasonableness and defensibility of those actions, in response to any recommendations from the reviews to address uncertainties and to manage and mitigate any risks involved. These are still matters for future consideration.

There is a fundamental risk if implementation of the Policy allows floodplain harvesting diversions to increase or does not reverse past growth in diversions above plan limits / the SDL. The consequence of this fundamental risk depends on the degree to which it may be realised, if at all. Updated water sharing plans will likely need to enable the use of available water determinations, in concert with the volumetric licences and account management rules, drawing on the results of the modelling work as outlined in the draft modelling reports.

It has been noted that, under the account management settings, there may be extended wet periods of time when diversions are legitimately in excess of the annual average SDL estimates. The 20% trigger for exceedance of the SDL set out in the Basin Plan, which provides a scheme to track growth in diversions, together with the reasonable excuse guidelines under the Basin Plan, are intended to ensure compliance with the SDL, subject to the content of these guidelines. The compliance framework will focus on diversion trends over time, as well as any individual water year. The SDL compliance method for most modelled forms of take does try to account for wet and dry conditions (MDBA pers comm April 2019). It is expected that this would also be an important issue for the Department, as a framework that was likely to lead to breaches of the SDL would require the NSW Government to undertake growth in use management actions (Commonwealth Environmental Water Holder pers comm, February 2019). This is primarily a matter for the MDBA as a regulator of the Basin Plan and more information is available in the SDL Reporting and Compliance Framework available on the MDBA’s website.

From an environmental perspective, some patterns of use may be more detrimental than others, despite having the same long-term average. The sequence of wet and dry years is important when considering the potential effects of management regimes. The current modelling approach uses the observed long-term climate record, which is assumed to be one possible future sequence. However, it seems unlikely that climatic conditions will repeat in this way as climate is highly variable and changing. There are modelling approaches that generate “replicates” of climate data that have the same statistical properties, and it is possible to use these to better understand the different sequences of potential future climates. However, there are practical and logistic issues in this approach for models with such a large number of input variables. It is recognised that the Department is proposing a 500% account limit, which is intended to address a number of potential issues and impacts.

Notwithstanding the lack of sensitivity in the modelling for various floodplain harvesting diversions on downstream flows mentioned previously in this Final Report, a review of time series of modelled diversions under potential future climates could assist in better understanding the potential for these issues to occur, and impact on the environmental outcomes sought by environmental water managers (Commonwealth Environmental Water Holder pers comm February, 2019). Again the MDBA will have a regulatory responsibility for these matters as it seeks to accredit models and new water resource plans, noting that the focus of the MDBA’s accreditation of water resource plan models is to ensure they are an appropriate method of estimating annual permitted take, and represent best available knowledge; rather than an assessment of their capacity to test a range of environmental outcomes (MDBA pers comm April 2019).

As mentioned previously in this Final Report, the current models’ insensitivity between simulated river flows and the volume of floodplain harvesting (drawn from previously assumed floodplain “losses” in the models) constrain the ability to assess the downstream impacts of the proposed volumes of floodplain harvesting to be used for the licences. Further model development would be necessary to improve this situation, but the issues involved in understanding how diversions at particular points on the floodplain affect flows

and environments downstream on the floodplain in particular may be difficult to resolve without considerably additional data and information.

We conclude that, based on the information available to us, there is a good understanding of the existence of various uncertainties and a number of important mitigations have been put in place to handle potential impacts. Further modelling work could be done to evaluate the impacts of potential future climate sequences.

However, as we outlined previously in this Final Report, we also conclude that, based on the information available to us, there are specific limitations in the models with respect to the consideration of the impacts of allowable floodplain harvesting take, per se, on downstream flows, including in specific locations on the floodplain. Some of those limitations can be mitigated in specific locations with additional floodplain flow and environmental information, including from hydraulic models and investigations for floodplain management plans.

Recommendations

As a matter of priority, the Model Build and Scenario reports for each valley should be completed by the Department and made publicly available. Each of the reports should be explicit about model uncertainties and how any associated potential adverse impacts have been mitigated.

The Department should publish all independent reviews relevant to implementation of the Policy and its responses to and actions taken following the reviews. This should include independent assessment and verification of responses to the recommendations in this Final Report to determine and transparently demonstrate whether the responses meet all aspects of the recommendations. Stakeholders should be engaged in these processes.

4.3 Appropriate Climatic Considerations

A number of stakeholders made comments about past and future climate change, and the variability of climate across the valleys where the Policy is to be implemented. They questioned the understanding of the representativeness of the climate series in terms of understanding present day conditions.

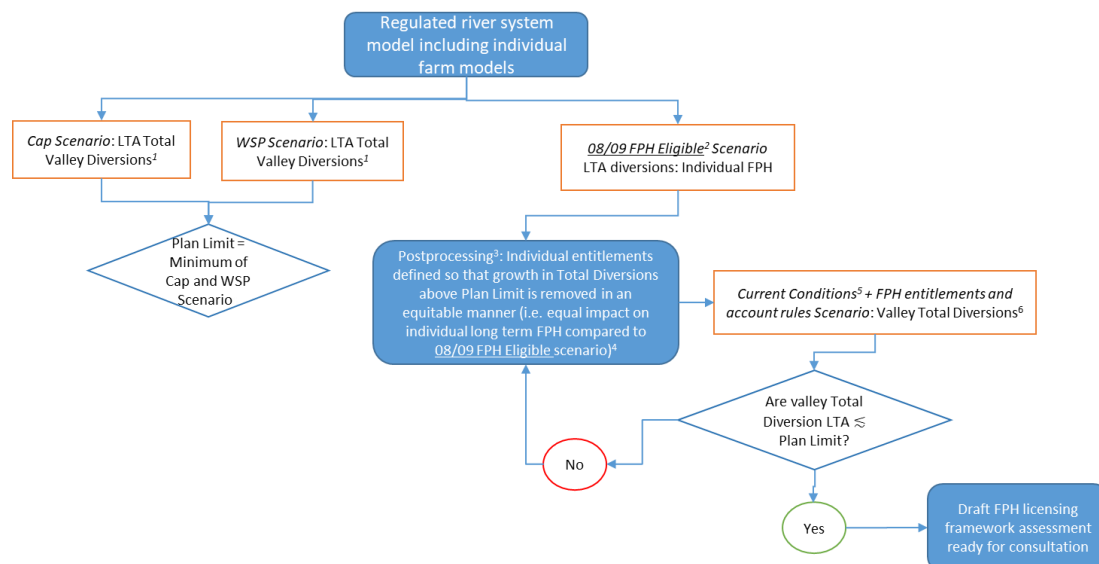
4.3.1 With respect to understanding the representativeness of the climate series in terms of understanding present day conditions, does a long-term climate sequence reduce any recent climatic shifts such as step changes and has this been examined at all?

Evidence Reviewed

Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016; Entitlement derivation flow chart provided by NSW DoI on 14 March 2019 discussion with modellers on 20 February 2019.

Findings

The process of determining volumetric entitlement is highly dependent on the period of analysis. Previous work has been completed to understand the nature of this and how changes in take may be affected by the use of different analysis years. Ultimately, any measure of take is required to use long-term climatic sequences to determine the FPH component robustly and consistently. The current process to determine volumetric entitlement uses long-term climate sequences consistent with cap modelling and across both the Border Rivers and Gwydir River basins. This process is set out diagrammatically below:



For each of the scenarios, the same climatic sequence is used. The assumption is made that this climatic sequence is sufficiently long-term to be representative of the variability of climate in the respective valley, however no evidence was viewed where an assessment of the variability in climate in the adopted climate sequence or whether this is an adequate representation of past or current climate has been made. We see that as being required in future works, in that some consideration as to whether the adopted climate sequence is likely to be indicative of future climate conditions and how this may impact on basin management. This is not a trivial exercise and is probably not within current modelling scope, but with indications of climate change for specific regions in NSW, and improvements in climate modelling and data products representing climate change, it is important that studies be undertaken to evaluate the impact of climate change on basin water management.

Recommendations

Consideration of the impacts of future climate change should be undertaken in future modelling exercises. Some analysis as to the representativeness of the existing long-term climate sequence to simulate recent climate conditions and the likely impact of this on FPH take needs to be completed.

4.3.2 To better understand the resolution of the climate data (both rainfall and evapotranspiration), what are the implications of broadscale climate inputs when assessing farm scale conditions?

Evidence Reviewed

Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016.

Findings

Point scale rainfall data is used within the models with only evapotranspiration data being obtained from broader scale (SILO) data. There will always be differences between actual rainfall events measured at the gauges used in the modelling and that which has fallen on a particular farm or farms. Using a long-term climatic sequence, these differences will largely disappear, but if short-term climate periods are used for any analyses, this may cause differences between individual farm FPH volumes and that assumed from point scale rainfall. The challenge is that there are unlikely to be better datasets of rainfall that do not also have issues in rainfall heterogeneity and hence the use of current climate data is considered appropriate for the modelling undertaken.

Recommendations

None required.

4.3.3 Has a potential future drying climate been considered in the implementation of the Policy?

Evidence Reviewed

The draft Model Build and Scenario reports for the Gwydir and the Border Rivers, mentioned previously in this Final Report and made available to the reviewers, are relevant to this matter.

Findings

No climate change scenarios have been considered in the modelling work and are not proposed at this stage (the Department pers comm January 2019).

Climate change issues were also discussed extensively in both the *South Australian Murray Darling Basin Royal Commission Report 2019* and the MDBA's response to that report referred to earlier in this Final Report. The MDBA has advised that, to specifically address climate change, regular 10 yearly reviews of the Basin Plan are required, which allow for emerging climate change patterns to be considered. These reviews could result in changing water limits or other water management arrangements, which could require consideration in State water resource plans. The MDBA further advised that the suite of measures to respond to climate change fall into four broad categories:- those that refine existing water management arrangements, those that buffer the system from the additional stress of climate change, those that enhance responses to climate change, and those that facilitate adaptation to climate change at a range of timescales (MDBA pers comm February, 2019).

As we have noted previously in this Final Report, we conclude that further modelling work could be done to evaluate the impacts of potential future climate sequences.

Recommendations

As a matter of priority, the Model Build and Scenario reports for each valley should be completed by the Department and made publicly available. Each of the reports should be explicit about how potential future climates have been considered, including potential impacts and mitigations. The approach should be coherent with any requirements under the Basin Plan.

4.4 Appropriate Identification of Floodplain Flows and Rainfall Runoff Volumes Available for Taking

Several stakeholders have expressed views as to whether the taking and use of rainfall runoff from irrigated lands should or should not be included in the floodplain harvesting definition as it is in the amended and updated 2018 Policy. In any event, implementation of the Policy by way of a whole of on-farm water balance requires explicit consideration of and accounting for volumes of water from both “overbank” on-farm floodplain flows and flows on the floodplain that may emanate from rainfall runoff from dryland and irrigated areas “up floodplain”.

4.4.1 Are the data, information and assumptions used to generate/estimate “overbank” on-farm floodplain locations, flow rates, volumes, timings, frequencies and durations appropriate and supported by the best available evidence, including local floodplain knowledge from within government and external stakeholders?

Evidence Reviewed

Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016

Gwydir IQQM model

Discussions with modellers on 20 February 2019

Findings

The primary data sources used are the local river information in the IBQs that were supplied by the local hydrographers, supplemented by information provided by landholders and cross checked with river reach flow differences between upstream and downstream gauges. The volumes determined are then verified against storage behaviour, remote sensing data and cropping behaviour. Ultimately, without direct measurements, this is likely to be the best that could be undertaken, but even so, the process is a “result by difference” rather than one that can be directly estimated. In other words, the process of actual volumetric determination is ensuring that enough overbank flow occurs to supply the users that fits within the flow differences (losses) that are measured between upstream and downstream river reach gauges.

Recommendations

The process followed is satisfactory in the absence of any other measurement methods, though some further verification of actual volumes, perhaps by comparison with estimated volumes for specific events as derived through other methods, is warranted. Given that the entire process of volumetric entitlement, measurement of growth and determination of FPH take is determined based on this volume, a method of validation that has some direct link to actual OBF volumes rather than a result by difference would provide further confidence that the numbers being derived are in the realms of realism. This does not indicate that the current process has inadequacies, just that a separate validation process would provide greater confidence in the results obtained.

We note that there are some efforts in other states to commence measurement of actual overbank and overland flows and that this may be worth consideration in future iterations of OBF volumes.

4.4.2 Specifically, how is calibration/verification of floodplain volumes undertaken and is this appropriate and supported by the best available evidence?

Please see 4.4.1 above.

4.4.3 With respect to consistency between different lines of evidence regarding overland/floodplain flows, what is the variability in each of the data sources and between them and how has this been reconciled?

Evidence Reviewed

No specific evidence was provided, though discussions with the modellers on 20 February 2019 provided some background and the findings were inferred from this and from the understandings obtained by reading other evidence

Findings

Currently it appears that if a line of evidence is not consistent with other evidence then it is disregarded or considered an outlier but appears that no assessment in the variability of information is directly undertaken. Crop water use variability has been assessed to some extent in some valleys, to show the final parameters used in the modelling are within the range of data, but no statistical assessment of variability appears to have been conducted nor sensitivity testing of using alternate parameterisation based on this variability.

Recommendations

Consideration of sensitivity testing with key model parameters such as OBF volumes, crop watering volumes, FPH storage, temporary storage operation etc should be conducted with at least one valley/basin model to show the likely variations in FPH take and which of these parameters is the most sensitive to determining that value. Without a formal sensitivity assessment there is no method available to identify which model parameters are most influential in determining volumetric take. This would assist the modellers in evaluating which parameters require additional focus to improve the confidence in the results obtained.

4.4.4 Is the data, information and assumptions used to generate/estimate on-farm rainfall runoff rates, volumes, timings, frequencies and durations from both dryland and irrigated areas appropriate, supported by the best available evidence and consistent with the Floodplain Harvesting Policy intent?

Evidence Reviewed

DOI Water - Crop Modelling Assumptions and Literature Review - FPH program August 2018, NSW Department of Industry, 2018; Appendix 5 – Rainfall runoff literature and data review, Border Rivers Model Build Report (incomplete) (provided via email 18 March 2019).

Findings

The justification and evidence provided around the use of the adopted parameters and model for rainfall-runoff is very limited, though an assessment of literature and likely runoff coefficients has been completed. It is therefore difficult to determine how the current approach is calibrated or validated and without further evidence it is a challenge to support the inclusion of rainfall-runoff volumes within the FPH take as currently modelled.

We note that there are a range of issues from stakeholders on this topic that do not appear to have been addressed in the documentation reviewed and, given this focus, more evidence is needed to justify the use of the model chosen and its parameterisation.

Further discussions with the Healthy Floodplains team have been held between the draft and final versions of this review regarding the application of rainfall-runoff as a form of take and a number of submissions from irrigator groups also raised concerns around this issue. The following advice was passed on to the Department after consideration of all of these.

- 1) As reviewers, we are agreed that rainfall runoff is to be accounted for as part of the farm water balance, and it is not reasonable to argue that the additional runoff created simply through developing an irrigation field should be seen as part of a water right. The additional runoff difference between a natural condition and a developed farm (whether dryland or set up as an irrigated enterprise prior to irrigation) is not “free”. This runoff difference is highly dependent on the starting point prior to development of a cropping enterprise. In most cases, this is likely to be an area of cleared land, typically grazing, which would have had additional runoff compared to the natural condition. To then argue that there would have been additional runoff created is highly dependent on what was there before. We therefore do not believe it is correct to argue that the difference between natural condition and current state is a reasonable position on which to access to that runoff without being accounted for.
- 2) We also reviewed submissions from the irrigator groups and subsequent analysis by the department and we conclude that a) the runoff rates reported in the submissions by the irrigator groups are excessively high and not consistent with literature, and b) the modelling used in the irrigators’ submission is considerably dated in approach and many better methods are available to assess this issue. A review by the Department on this modelling and the literature was comprehensive and should form the basis of any additional analysis. We note the contentious nature of this and recommend that a 3rd party complete this analysis.

- 3) Runoff from irrigated fields is highly likely to be additional to that which would have occurred without irrigation, but given the rainfall volumes and frequency in different areas of the northern basin, the amount and significance of this additional runoff, especially over long time frames used in modelling assessments, is uncertain and needs further analysis.
- 4) Understanding this additional volume is therefore essential to understand how much further consideration is needed in terms of implementation, however given the irrigation stakeholder focus, analysis of this via defensible methods is required to resolve it properly.
- 5) Runoff from irrigated fields is highly likely to result from a mix of general allocation, supplemented water and/or floodplain harvesting water, in addition to rainfall runoff. A method by which allowance is made for this is required.

Recommendations

Significant further documentation and justification of the rainfall-runoff model used, and the parameters chosen in each valley, soil type, and farm enterprise is required before the inclusion of the rainfall-runoff component within the models can be considered suitable or not.

More comprehensive, defensible analysis of the sensitivity and quantum of this rainfall-runoff should be undertaken, preferably by a 3rd party. This should then form part of model development documentation in addition to how this is incorporated within the models and how it will be accounted for in a volumetric entitlement.

4.4.5 Why was a particular rainfall-runoff model chosen, how was it calibrated and how is it downscaled to paddock conditions at the farm?

Please see 4.4.4

4.4.6 How does the rainfall-runoff model account for different irrigation behaviours (e.g. watering prior to rainfall events) and how does this relate to other water uses?

Please see 4.4.4. From discussions with the modellers and the limited information available for review, it is stated that the model accounts for soil moisture changes as a result of irrigation, but no evidence was provided to verify this. It is assumed that over the long-term, this balances out, though no assessment of this appears to have been undertaken.

4.5 Appropriate Identification of On-Farm Infrastructure to Temporarily or Permanently Take and Store Floodplain Flows

Several stakeholders have expressed views as to whether the use of temporary storage facilities should or should not be included in the floodplain harvesting licensing arrangements. In any event, implementation of the Policy by way of a whole of on-farm water balance does require consideration of and accounting for volumes of water from both temporary and permanent storage facilities.

On-farm water take and storage can be very complex, involving multiple facilities that may be operated differently depending on the real-time circumstances. Approaches to operations may also change over the years as experience is gained, efficiencies are improved, works are modified, and an adaptive approach to management is adopted. Identifying levels of on-farm development that existed in the past (e.g. in 1993-1994 for which the Murray-Darling Basin cap on diversions is defined, in 1999-2000 for which most water sharing plans define limits, or on 3 July 2008 which is a key date for eligible floodplain harvesting works), and the water management behaviours that may have existed then, are especially challenging.

4.5.1 Does the modelling reflect the impacts of eligible works only and are other structures (illegal, changed as a result of trading of entitlements, or otherwise) assumed to be included or excluded from the models and do they allow for disaggregation of the Plan limit into volumetric shares?

Evidence Reviewed

Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016, Gwydir IQQM model and Border Rivers Source model.

Findings

The process steps for determining eligible floodplain harvesting works have been discussed in section 4.1.1 of this Final Report. Removal or the non-use of ineligible works will be an important implementation, compliance and enforcement matter.

From the evidence reviewed, dependant on the scenario, works are considered as appropriate and included or excluded from the relevant model run. A full list of the works included or excluded were not observed, though many examples within the model were sighted.

Recommendations

It would be useful within the model appendices to include an indication of the amount of infrastructure that was assessed as eligible or ineligible works accounted for in the relevant model scenarios to demonstrate what has been considered in each scenario. It is realised that this information at the fine scale is very sensitive, but at least broader indications of what has been included or excluded would provide further transparency.

The guideline for implementing the Policy should outline how existing ineligible works are to be managed through compliance and enforcement.

4.5.2 Is the adopted base case scenario clear within the model in terms of the timeframe it is intended to represent and is this supported by the best available evidence?

Evidence Reviewed

Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016

Modelling and data collection for implementing floodplain harvesting, NSW Department of Industry, 2018

Gwydir IQQM and Border Rivers Source models

Findings

The base case scenario is clearly that which represents the Baseline Diversion Limit and the PBP. While no direct evidence of the scenario inclusions was observed in the models (due to both complexity and the time needed to examine a specific scenario in detail), that described in the evidence reviewed appears that the base scenario is adequate and representative of the situation being assessed.

Recommendations

None required.

4.5.3 Is the data, information and assumptions used to identify on-farm diversion and take works, permanent storages, irrigated areas, and modelling of how they have been/are used, appropriate, supported by the best available evidence, and consistent with the Floodplain Harvesting Policy intent?

Evidence Reviewed

Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016, IBQ examples provided by the department, IBQ example provided by NSW Department of Industry, IBQ example B provided by NSW Department of Industry, Healthy Floodplains Modelling for water users, PowerPoint presentation, 08/11/18.

Findings

Generally, the data used appears to be consistent with the best available evidence following the line of evidence hierarchy on p8 of Healthy Floodplains Modelling for water users, PowerPoint presentation, 08/11/18. It is highly likely that there are gaps, omissions and errors in any of the lines of evidence used, however they generally support an overall assessment of farm behaviour, albeit simplified and lumped within the model. Overall, the evidence does assist in developing the volumes of FPH take and the need to limit that to the BDL for the basin/valley. The approach does not, intentionally, seek to allow or cater for an increase in FPH take, but imposes an assessment of allowable take based on estimates of existing FPH and the need to reduce that by some amount to limit growth back to the volumes required to achieve the BDL.

We believe that the approach is sound, though there is an underlying concern that the simplification and averaging of farm behaviour does not allow for the actual variability

between different irrigator/enterprise operations and may therefore unduly affect some users more than others.

Recommendations

While the process of data collection, verification, validation and data use is sound, some assessment of farm by farm variability, supported by the sensitivity testing recommended in responses to other questions in this Final Report needs to be completed to confirm that the responses and data uses are appropriate and that the simplification and lumping processes do not unduly cause inequity in required reductions in FPH take.

4.5.4 Is the data, information and assumptions used to identify on-farm temporary storages, and model representation of how they have been/are used, appropriate, supported by the best available evidence, and consistent with the Floodplain Harvesting Policy intent?

Evidence Reviewed

On Farm Storage Remote Sensing Verification (draft), NSW Department of Industry, (undated), Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016.

Findings

The data processing and assessment of the lines of evidence (IBQs and remote sensing) appears sound. While there will be uncertainties in some of the data sets, these appear to be relatively minor over the long-term periods assessed. The differences between the temporary storage volumes reported in the IBQs and remote sensing is concerning and there does appear to be a delay between the event occurrence and the next possible Landsat run used. We are unsure of the significance of this and it also is associated with an understanding of what is actual “usable” temporary storage.

Recommendations

Further explanation of the differences between IBQs and remote sensing temporary storage volumes would be useful to improve transparency, but the significance of these differences as they relate to FPH take doesn’t appear to be great from the evidence reviewed.

4.5.5 What has been/is the relative significance of the volumes taken into temporary storages and is the management of any risks associated with that significance appropriate?

Evidence Reviewed

On Farm Storage Remote Sensing Verification (draft), NSW Department of Industry, (undated)

Findings

See above, but also noting that only a small number of events were able to be assessed.

Recommendations

As per 4.5.4.

4.6 Appropriate On-Farm Water Use Considerations

On-farm water use is influenced by location, crop and soil type, watering system, irrigator behaviour, among other things. On-farm water use can come from several sources, including direct irrigation and irrigation from storages that hold supplementary water access entitlements, floodplain harvesting water, rainfall runoff, used and contaminated water.

4.6.1 Is the data, information and assumptions used to generate/estimate crop (and any pre-water) irrigation demand volumes, timings, frequencies and durations appropriate and supported by the best available evidence? Do they represent the different cropping conditions in the relevant basins?

Evidence Reviewed

The report *Modelling and data collection for implementing floodplain harvesting* (October 2018), available on the Department's website, contains substantial information about crop modelling assumptions and irrigation application rates (pp 32-40).

The draft Model Build reports for the Gwydir and the Border Rivers, mentioned previously in this Final Report and made available to the reviewers, are also especially relevant to this matter.

Findings

The volumes of water to irrigate crops are a key component of the water balance, along with climatically determined water availability. Getting this volume correct is important to get realistic, long-term average estimates of floodplain harvesting.

Crop modelling forms part of the overall river system modelling that is being used to determine floodplain harvesting entitlements. The crop models, that are being used by the Department, estimate demands on a daily basis, and divert water to meet these demands. The irrigation water use in any one year can be influenced by a large range of factors apart from climate. Some of these factors can be simulated and others are outside the feasibility of long-term simulation modelling.

The models have been developed to represent historic cropping behaviour, including how much is planted in response to conditions of water availability. Future changes in cropping behaviour such as changes in area planted, crop type or more wide-spread under-irrigation may be examined in future modelling.

The models are able to represent inter-annual variability in crop water use due to the use of long-term climate data. Limitations in water availability are also simulated, and this can account for some of the historic under-irrigation of crops.

The models are not able to explicitly predict the influence of hail, crop disease or market variation, however. It may be possible to undertake some refinement of the methodology (for example, to account for heat stress). However, this can only be included if there is long-term data available to support the simulation.

The crop water balance for each crop is represented using the method outlined in the industry standard FAO Irrigation and Drainage Paper 56, *Crop Evapotranspiration—Guidelines for computing crop water requirements*.

This method uses crop factors (Kc) to convert potential evapotranspiration to crop evapotranspiration. These factors change as the crop develops over time from planting to harvest or between seasons for perennial crops. There are many different ways of estimating this factor: energy balance, soil water balance studies, lysimeters or remote sensing. However, in many cases the factors are taken from published data such as FAO56. The FAO56 method divides the crop growth into four distinct stages: (i) initial, (ii) crop development, (iii) mid-season, and (iv) late season.

The FAO56 method provides a range of values. Specific values were derived in consultation with agronomists from the NSW Department of Agriculture for different climatic zones in NSW in 2000. Cotton crop factors are based on more recent advice from NSW DPI Agriculture. This data set has been used for Border Rivers, Macquarie and Namoi. Modelling for the Gwydir and Barwon Darling are based more on model calibration processes, where crop factors were estimated within a known range to calibrate irrigation demand to regulated diversions. The planting dates used in the crop models are informed by the IBQs.

The IBQs included questions about water use rates, including pre-watering and tail-water returns. A large range in values was reported. For example, responses in the Border Rivers range from 3.6 ML/ha to 11.5 ML/ha after subtracting for tail-water returns. There is no geographical relationship to the responses and the accuracy and comparability of the data are not known, especially whether a similar period was used when responding to what is 'average'. This information was referred to when assessing results, but was not used directly in the model.

It is concerning that such a large range of water use rates have been reported.

It is not clear to the reviewers as to the extent of further consultation that has been undertaken by the Department with irrigator groups to attempt to reconcile and agree appropriate crop water use rates. Such engagement would greatly assist transparency and robustness in the data and information. Industry organisations such as Cotton Australia and cotton researchers could also beneficially be involved in the discussions. For transparency, the advice from those discussions could be documented, together with the Department's response to that advice.

Alternative methods for estimating crop water use rates, especially for cotton, have been well described in the draft Model Build reports and the publicly available modelling report. The approaches appear to be sound and the comparisons have been used to expose

potential uncertainties or explain some variances. Given the range of crop water use figures quoted previously, some further sensitivity testing could be done with the crop water use rates in the modelling.

The Department has informed the reviewers that some sensitivity testing has been done for a case where an irrigator may be set up to use more water (either through a greater area planted or less efficiency). This may increase airspace in on-farm storages and provide for greater floodplain harvesting diversions. For example, if an additional 10% application loss is assumed, floodplain harvesting total volumes are increased by 1.4% and 3% in the NSW Border Rivers and the Gwydir valleys respectively (the Department pers comm March 2019).

We conclude that, based on the information available to us, the data, information and assumptions used to generate/estimate crop (and any pre-water) irrigation demand volumes, timings, frequencies and durations are appropriate and supported by the best available published evidence and they do represent the different cropping conditions in the relevant basins. However, further engagement with industry on the results would be beneficial and instructive given the wide range of numbers expressed in the IBQs.

Recommendations

As a matter of priority, the Model Build reports for each valley should be completed by the Department and made publicly available. Each of the reports should be explicit about how crop irrigation demands have been determined, including how IBQ information has been used. Appropriate sections of the draft reports for the Border Rivers and the Gwydir can be used as templates for the other valleys.

The Department should engage further with irrigator groups, industry and cotton researchers in each of the respective valleys to further discuss crop irrigation demands and variations observed with a view to mutually increasing understanding and transparency.

4.6.2 Where floodplain harvesting in unregulated systems is to be assessed, is the process available for determining rate of water use, groundwater use, unregulated water an appropriate method for determining floodplain harvesting entitlements?

Evidence Reviewed

The document *Volumetric Conversion - the next stage - A booklet for landholders with licences on unregulated rivers in NSW* (undated) was made available to the reviewers by the Department.

On 04 March 2019, the Department also made available the draft report *Defining and calculating floodplain harvesting entitlements* (undated) which provided additional details for the unregulated systems process, including an overall flowchart of the approach and some farm level information.

Findings

Further discussion about determining floodplain harvesting volumes and issuing licences in unregulated systems appears earlier in this Final Report in 4.1.3 and 4.2.1.

Determining floodplain harvesting volumes and issuing licences in unregulated systems (excluding the Barwon Darling) is to happen through a process similar to the volumetric conversion of area-based licences in unregulated systems and undertaken several years ago.

The crop conversion methodology appears to be well established and understood. Crop conversion rates are based on levels of average water use for particular regions and take account of climatic conditions, irrigation practice and crop types. Rates have been jointly developed by the Department and NSW Agriculture, with input from rural industry associations and regional communities.

Floodplain harvesting entitlements for unregulated systems are to be issued only to cover for an additional water use, which is not covered by any existing water access licence (surface water and groundwater) at a property. Licence information is available on Departmental registers and databases. Implementation of the Policy provides for an independent review process for ROI submitters, as outlined previously in this Final Report.

An updated publicly available fact sheet and more targeted information for landholders involved in or impacted by the issuing of licences in unregulated systems would be helpful.

We conclude that, based on the information available to us, where floodplain harvesting in unregulated systems is to be assessed, the process available for determining rate of water use, groundwater use, and unregulated surface water licence volumes is an appropriate method for determining floodplain harvesting entitlements.

Recommendations

An updated fact sheet about the process for floodplain harvesting licensing in unregulated systems, possibly building on the documents made available to the reviewers, could be published and more targeted information could be provided to landholders involved in or impacted by the issuing of licences in unregulated systems.

4.6.3 Is the data, information and assumptions used to generate/estimate on-farm irrigation supply system and in-field efficiencies appropriate and supported by the best available evidence?

Evidence Reviewed

The draft Model Build reports for the Gwydir and the Border Rivers, mentioned previously in this Final Report, were made available to the reviewers for this matter.

Findings

The documentation indicates that a 30% water loss due to channel and irrigation application losses has been assumed. This is reported to be based on industry expert advice, supported by available literature for local conditions. Tailwater returns are not explicitly modelled – the efficiency and hence application rates are net of tailwater returns. This is an important factor for irrigators to understand if they are comparing assumptions.

On-farm storage losses have been modelled separately using evaporation from the simulated storage area and assumed 2mm/day seepage based on results reported in the literature for local conditions.

As discussed in 4.6.1, some sensitivity testing of some of these assumptions in the models has been undertaken, but more could be undertaken to explore uncertainties and implications, noting that surface water irrigation efficiency and storage seepage rates can vary widely.

Subject to that caveat, we conclude that, based on the information available to us, the data, information and assumptions used to generate/estimate on-farm irrigation supply system and in-field efficiencies are appropriate and supported by the best available evidence.

Recommendations

As a matter of priority, the Model Build reports for each valley should be completed by the Department and made publicly available. Each of the reports should be explicit about how farm irrigation supply system and in-field efficiencies have been determined. Appropriate sections of the draft reports for the Border Rivers and the Gwydir can be used as templates for the other valleys.

4.6.4 Is the data, information and assumptions used to validate on-farm cropped areas appropriate and supported by the best available evidence?

Evidence Reviewed

The draft Model Build and Scenario reports for the Gwydir and the Border Rivers, mentioned previously in this Final Report, were made available to the reviewers for this matter.

Findings

The draft Border Rivers Model Build Report outlines how Landsat and MODIS data have both been used to review IBQ summer crop area data with no significant anomalies identified. Remote sensing for winter crop areas is known to be less reliable and hence has not been used to review IBQ data. Winter crop areas are relatively insignificant in the Border Rivers both in terms of area and water use.

The above draft report explains that the remote sensing data was obtained from 2009-2010 to 2013-2014 for one tile in the Border Rivers. This covers approximately 55% of the total developed area for floodplain harvesting properties and approximately 65% of the floodplain harvesting entitlement. MODIS analysis uses a time series analysis to look for spectral response which approximates the expected crop behaviour. Landsat offers higher spatial resolution however the time series analysis is more difficult using this dataset as Landsat has a slower orbit.

Both data sets compare well to the reported IBQ survey data. MODIS is 5% higher than survey data and Landsat is 2% less than survey data. The annual totals for the Landsat data compare very well to the IBQ survey data.

Additional MODIS data is available; for all floodplain harvesting properties and for additional years. This data is presented in the draft Border Rivers Floodplain Harvesting Scenarios Report.

On the other hand, no remote sensing of the irrigated areas for the entire valley was conducted for the Gwydir. Generally, the reported IBQ areas were adopted for model calibration unless clear mistakes were identified (for example planted areas in excess of areas developed for irrigation). IBQ reported areas were verified by remote sensing only for the subset of eligible floodplain harvesting properties. (See answer to Question 4.2.7 above for information on validation of the cropped areas.)

It is not clear to the reviewers the extent to which these results have been reported back to the IBQ submitters, nor how cropped areas have been verified for other years of interest outside those mentioned above.

Nevertheless, we conclude that, based on the information available to us, the data, information and assumptions used to validate on-farm cropped areas are appropriate and supported by the best available evidence.

Recommendations

As a matter of priority, the Model Build and Scenario reports for each valley should be completed by the Department and made publicly available. Each of the reports should be explicit about how cropped areas have been determined and verified. Appropriate sections of the draft reports for the Border Rivers and the Gwydir can be used as templates for the other valleys.

4.7 Appropriate On-Farm Water Balance Considerations

There are a range of water sources measured, estimated or exempt from licensing (with allowances such as the harvestable right from dryland areas) that are managed (taken, interfered with, used or recycled) on-farm at any given time – daily, weekly, monthly, seasonally, annually, multi-yearly.

4.7.1 Is the data, information and assumptions used to validate on-farm water balances appropriate, supported by the best available evidence and consistent with regulation and policy, including allowances for contaminated runoff and used irrigation water?

Evidence Reviewed

The draft Model Build report for the Border Rivers, mentioned previously in this Final Report, was made available to the reviewers for this matter.

Findings

Information in the Border Rivers draft Model Build report stated that individual farm water balances were used as a key check to ensure that all sources of water have been reasonably represented. This means that this was also a key check to ensure that floodplain harvesting

is 'realistic'. In this test, the model is configured with historic crop areas and crop types. In early stages of the calibration other parts of the model were also forced (e.g. off allocation diversions) however in the final water balance test, all other aspects of the model are fully simulated. The following results were checked using the water balance test.

The simulated on and off allocation diversions were compared to recorded data for the extraction location/s associated with each property. The overall result, ignoring properties with incomplete records, was -3% (i.e. simulated on and off diversions are 3% less than recorded). If the model under-simulates on and off allocation diversions, it may mean that rainfall and floodplain harvesting have been over-estimated. However, the final simulation model does not take into account temporary trading of water which means that some properties run out of water in their account. If temporary trading were taken into account, these properties would divert more on allocation water and the bias would be closer to zero (the Department pers comm February 2019). In addition to the average or overall results, it will also be important to report Information about the annual variations as they may be important to farm business transactions.

The premise of the farm water balance test is that the model simulates a realistic crop irrigation demand and that all sources of water should be reasonably represented to ensure that the crop is viable. This means that the model was checked to ensure that there was not extensive crop water stress.

Individual results were interpreted as being good if the water balance was within 10% bias. Values outside of this range were assessed to see if there was a reasonable explanation. Other checks included comparisons to IBQ reported harvesting frequency and volume estimates where these were provided.

The approach does not explicitly model what is contaminated. All rainfall runoff harvesting is classified as floodplain harvesting to be managed under the entitlement. Provisions to allow for management of contaminated runoff are currently being reviewed with further information to be provided to stakeholders following the consultation on the *Draft Floodplain Harvesting Monitoring and Auditing Strategy – November 2018* (the Department pers comm March 2019).

As outlined in a previous part of this Final Report, crop water use rates are modelled exclusive of tailwater returns, i.e. exclusive of used irrigation water, and the on-farm water balance reflects this.

We conclude that, based on the information available to us, the data, information and assumptions used to validate on-farm water balances are appropriate, supported by the best available evidence and consistent with regulation and policy, recognising contaminated runoff and used irrigation water management at the farm level.

Recommendations

As a matter of priority, the Model Build reports for each valley should be completed by the Department and made publicly available. Each of the reports should be explicit about how

on-farm water balances have been verified. Appropriate sections of the draft report for the Border Rivers can be used as templates for the other valleys.

4.7.2 In reconciling the water balance, what other losses are included or implicit in the on-farm modelling and how are these handled in terms of rainfall-runoff assessments, for example?

Evidence Reviewed

Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016; On Farm Storage Remote Sensing Verification (draft), NSW Department of Industry, (undated); Modelling and data collection for implementing floodplain harvesting, NSW Department of Industry, 2018

Findings

A number of additional losses are accounted for that are either explicitly modelled (e.g. OFS seepage, interception), or implicitly accounted for. The process of their inclusion (noting limitations of the evidence supplied for justification of rainfall-runoff modelling) appears to be satisfactory.

Recommendations

None specific to this question, but noting issues regarding the justification of the rainfall-runoff modelling.

4.7.3 Are the uncertainties in the water balance calculations known and understood to the extent that any residual unknowns in the water balance calculations can be meaningfully and reliably determined?

Evidence Reviewed

Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016; though there was only limited information in this document to evaluate this question. Discussions with the modellers on 20 February 2019 provided further clarification.

Findings

From what we have observed, uncertainties are attempted to be minimised through the calibration process such that the parameters and volumes determined are those which provide the least variation between observed data and model results. The difficulty is that this is still a result by difference in order to determine the final OBF volume and FPH take for each farm and these values are not otherwise validated against an independent data source as one does not appear to be currently available or has not been identified.

Recommendations

Some verification or validation of the final OBF and FPH values needs to occur, ideally in collaboration with water users. Currently, the process is to use all of the information available to determine these values, but there is no process by which these numbers are then independently validated. We recommend that a method of validation is adopted if possible, using an alternate data source (e.g. the OEH hydraulic models of specific events) to examine whether the OBF volumes are appropriate (i.e. that sufficient OBF has occurred for the volumes determined in the model). This may be as simple as comparisons of a number of key OBF events in a valley or basin.

Note that the terms verification and validation are used deliberately, verification being a process by which the results are checked against other data used in the models to evaluate consistency, validation being a process by which the results of the models are checked against an independent data source.

4.8 Appropriate Application of Water Accounting Rules

Some stakeholders were of the view that there is insufficient information currently available to determine the potential impact of floodplain harvesting volumetric limits and account management rules on downstream flows, recognising their importance to downstream landholders' livelihoods, Matters of National Environmental Significance and the ecological character of floodplain and instream environmental assets.

4.8.1 Are the account management rules effectively represented in the model and is that representation consistent with the Floodplain Harvesting Policy intent.

Evidence Reviewed

The Policy document, available on the Department's website, and the draft Model Build and Scenario reports for the Gwydir and the Border Rivers, mentioned previously in this Final Report and made available to the reviewers, are relevant to this matter.

The reviewers also sighted two draft information sheets: *Floodplain Harvesting Gwydir Valley Regulated River System Results (June 2018)* and *Floodplain Harvesting Border Rivers Regulated River System Results (June 2018)* and the background documents that preceded them - *Border Rivers: Regulated Floodplain Harvesting Entitlement Revisions Using Short Term Average and Account Limits (Draft 30/11/2017)* and *Gwydir: Regulated floodplain harvesting entitlement revision using short-term average take* (undated). Some relevant information and discussion are also in the *Implementing the NSW Floodplain Harvesting Policy Consultation Paper (March 2018)*, available on the Department's website.

Findings

The Policy states that account management rules will be developed on a valley-by-valley basis in conjunction with the proposed entitlements that recognise floodplain harvesting variability. The two primary considerations that will be used to set these account management rules are:

- achieving the updated long-term extraction limits (plan limits); and

- distributing impacts as equitably as possible across individuals.

The Policy states that account management rules that are established for each valley may include rules for:

- initial account balances
- limits on account balances
- allocation announcements to be made at the commencement of each water year
- carryover of unused allocations from one year to the next
- limits on annual use, both in the short- and long-terms.

The reviewers found some confusion with the documentation about what approaches to setting entitlements and account management were being used, as these have evolved over time. Entitlement volume and account management rules are two tools to manage growth in floodplain harvesting. All regulated river floodplain harvesting entitlements will be determined by modelling.

The plan limits for the Gwydir Valley and NSW Border Rivers are based on infrastructure at 1999-2000 and 2001-2002 respectively and management rules defined in the corresponding water sharing plans. The plans already include estimates of floodplain harvesting based on the specified level of infrastructure. Improved data and modelling methods provide more accurate estimates. The Basin Plan 2012 allows for these estimates to be revised whenever it can be demonstrated that better estimates are available. The plan limits are referred to as the Baseline Diversion Limits (BDLs) in water resource plans under the Basin Plan. The revised BDL models will be submitted by the Department to the MDBA for review as part of the accreditation of water resource plans.

In both the Gwydir Valley and the NSW Border Rivers, the total eligible level of development under the Policy is greater than that for the plan limits. This has led to growth in floodplain harvesting. This means that the licensing framework will by necessity have some impact on individuals to remove this growth. The stated intent of the entitlements and account management rules is to distribute these impacts as equitably as possible.

The following accounting rules are now proposed for both the Gwydir Valley and NSW Border Rivers:

- 100% of the entitlement to be credited to the account each year;
- The account is debited annually for all floodplain harvesting (including rainfall runoff) in that year;

- The account balance cannot exceed 500% of the entitlement. Any unused allocation can be carried over into the next water year subject to the 500% account limit;
- Annual usage will be limited to 500% of the entitlement;
- Annual usage is also limited to the balance left in the user's account except where an overdraw is required to retain contaminated rainfall runoff from developed areas. Further conditions on this activity may also apply.

In the first 5 years, some allowance has been made to initialise the accounts. The following additional conditions are to apply during this time:

- 500% of the entitlement to be credited to the account in the first year; and
- In the first 5 years, total usage is limited to 500% of the entitlement.

The floodplain harvesting accounting rules have been designed to manage highly variable harvesting within the BDL (the Department pers comm January 2019). For example, some properties may only be able to harvest overland flow approximately once every five years on average. This means that the floodplain harvesting diversions in that one year are much higher than the long-term average (e.g. they could be 5 times the average). If the annual usage limit for that one year in this example was defined at 100% of the entitlement, this would have a very large impact on harvesting (e.g. long-term average harvesting reduced to one fifth).

Specific software capabilities were developed so that alternative floodplain harvesting accounting rules could be modelled and simulation results analysed. Over the period of model development diverse options for accounting rules have been tested.

Extensive analyses of various entitlement and account management rule framework combinations have been undertaken, with the aim that the framework returns diversions to the BDL, and relative impacts on individual floodplain harvesting landholders have been considered. It is also necessary that the overall management rules prevent growth in harvesting to occur if additional on farm development was to be implemented.

Existing model capabilities, however, do not allow for modelling of 'negative' account balances, which is needed to represent the Policy's provision allowing water users to temporary 'overdraw' the account to ensure capture of contaminated runoff on farm. Some preliminary testing on how much the accounts would need to be 'overdrawn' has been done. For example, some initial modelling for the Border Rivers has been undertaken to test whether the accounting provision may result in growth in use. This draft assessment assumed current infrastructure levels. The long-term diversions after the accounting rules are applied have been compared to the Baseline Diversion Limit (BDL). Assuming no account debit is allowed, long term diversions are slightly higher than the BDL. Total diversions are 0.35% higher and floodplain harvesting is 0.99% higher. The extra provision to allow up to 100% debit of the account produces very similar results, i.e. there is no increased risk of growth. This assumes that rainfall harvesting only is reported against the provision. The

final assessment will need to demonstrate compliance with the BDL (the Department pers comm April 2019).

Analyses that have been made available to the reviewers show that application of different forms of the accounting framework significantly impacts on overland flow harvesting but is required to control growth in use. The application of accounting rules, such as annual diversion limits and account balance limits, plus scaling of entitlements based on achieving the plan limits, can be used to control growth in use.

The most effective measure to control growth in use is reduction in entitlements. However, this measure on its own results in the biggest individual impacts on current levels of overland flow take, so a combination of entitlement and accounting rule measures has been adopted. For example, a larger entitlement with a lower account balance limit and annual extraction limit result in smaller individual impacts.

It has also been shown that harsher restrictions are required to manage BDL compliance for overland flow diversions than restrictions required to achieve the same for total diversions. For example, managing growth in overland flow diversions within two to three percent results in total diversions under the BDL of between one and two percent in the Gwydir.

We conclude that, based on the information available to us, the latest account management rules are represented in the models, and that representation is consistent with the Policy intent with respect to achieving updated plan limits, potentially managing growth in diversions, and considering impacts on individual floodplain harvesting landholders.

Recommendations

As a matter of priority, the Model Build and Scenario reports for each valley should be completed by the Department and made publicly available. Each of the reports should be explicit about how the latest account management rules have been represented in the models and fully explain the results and implications of applying the entitlements and account management rules framework.

4.8.2 Does the numerical model configuration allow for appropriate simulation of downstream flows and is it sufficiently sensitive for assessing impacts that may arise from floodplain harvesting licences, changes in floodplain harvesting volumes and account rules, including impacts on Matters of National Environmental Significance, and the efficient and effective use of environmental water holdings?

Evidence Reviewed

Volumetric floodplain harvesting entitlement determination - Gwydir River Valley, DPI Water Surface Modelling, September 2016; discussions with modellers on 20 February 2019

Findings

The models currently represent any residual OBF as a “loss” and residual return flows are not simulated. These models therefore cannot assist in determining downstream impact as

this was not the intent in the modelling. The models were developed to assess volumetric take, not downstream impact.

Our concern therefore is that that if the implementation of the Policy results in changes to FPH take (i.e. a reduction in overall volume, but changes in take of certain events due to accounting rules and carryover), surely the downstream impacts, including cumulative impacts, of this need to be determined, otherwise how will it be determined whether this is an improvement or detriment for downstream users? While the implementation of the FPH Policy is certainly about the introduction of measures to limit growth and reducing existing FPH take to that required to achieve the BDL, there needs to also be an assessment of whether this results in changes to downstream users and leads to beneficial outcomes, otherwise it is difficult to understand the reasoning for undertaking it. Transparency and clarity about these matters, and the factors for making licensing and/or water sharing plan decisions about them, are primary concerns of many stakeholders. Currently, the assumption is that implementation of the Policy will lead to improvements for downstream users, but no assessment of this has been observed in the evidence provided. The independent reviewers note that this issue was not specifically a requirement of this review, but it is certainly a major stakeholder issue that needs to be addressed, otherwise the current implementation process would not be considered to have evaluated the likely impacts of its application.

Recommendations

As the final FPH volumetric entitlements are determined and quantified, an assessment of 3rd party (downstream users) impact, including cumulative impact, needs to be completed to clearly show stakeholders that downstream outcomes will be improved and/or accounted for in the implementation of the Policy. In the absence of a water sharing plan, typically, this would form part of a Regulatory Impact Assessment or similar process, but the inter-relationship between the individual floodplain harvesting licensing decisions and water sharing plan decisions needs to be well explained and understood. We have not sighted evidence of this.

These matters may best be addressed by preparing a comprehensive guideline outlining in detail the process steps used, or to be used, for implementing the Policy – in particular the process for floodplain harvesting licensing, including matters for decision making, and for defining and calculating floodplain harvesting volumes and share components.

4.8.3 What is the effectiveness of the account management rules to mitigate event based environmental risks, and the evidence used to determine residual risk?

Evidence Reviewed

The draft Model Build and Scenario reports for the Gwydir and the Border Rivers, mentioned previously in this Final Report and made available to the reviewers, are relevant to this matter.

The reviewers also sighted two draft information sheets: *Floodplain Harvesting Gwydir Valley Regulated River System Results (June 2018)* and *Floodplain Harvesting Border Rivers*

Regulated River System Results (June 2018) and the background documents that preceded them - *Border Rivers: Regulated Floodplain Harvesting Entitlement Revisions Using Short Term Average and Account Limits (Draft 30/11/2017)* and *Gwydir: Regulated floodplain harvesting entitlement revision using short-term average take* (undated).

Findings

The existing floodplain harvesting models do not explicitly represent flood water returns to the river, and the representation of floodplain flows, per se, can be especially challenging. Consequently, the models are not suitable to assess the benefits/impacts of the floodplain harvesting licensing framework, including the entitlement and account management rule framework, on downstream flows, either in the rivers or on the downstream floodplains themselves. Within the models, flows downstream of any flood outbreak are highly insensitive to variation of the amount of floodplain harvesting diversions allowed (the Department pers comm February 2019).

The episodic nature of water access, and the significant difference between the average floodplain harvesting volume (as allocated each year) and the peak volume of floodplain harvesting that can occur, can lead to a relatively high level of access being permitted in any one year, which could pose a risk for downstream water users and the environment (Commonwealth Environmental Water Holder pers comm, February, 2019). In this context, the proposal to retain the 500% account limit indefinitely is an important control, as it will prevent a very large account balance from building up during extended dry periods.

An approach to this issue would be to inspect the modelled output from the proposed framework of licence volumes and account management rules to understand if and when there were periods of higher environmental stress, and consider what rules could be changed within the framework that could materially reduce that stress (Commonwealth Environmental Water Holder pers comm, February, 2019). Unfortunately, as mentioned previously, the configuration of floodplain harvesting within the models has made the simulation of downstream flows insensitive to changes in floodplain harvesting.

In addition, if the irrigation development in place is significantly larger than that modelled as part of the plan limit, and consequently larger than otherwise account balances are able to build, diversions can exceed those modelled under the plan limit for some periods of time, which may have environmental impacts (Commonwealth Environmental Water Holder pers comm, February, 2019). Mitigations against this have been considered in the entitlement and account management rule framework combinations outlined in 4.8.1 above.

Under the Policy, water sharing plan amendment rules may also allow the establishment of new access rules for floodplain harvesting licences to minimise impacts on the environment and other water users, provided these rules do not result in additional water being recovered for the environment. In the northern valleys, the first area where the Policy is being implemented, access rules will not be included in the initial amendments. Instead, provision will be made for including these rules as a future amendment, to the extent that this can be achieved without reducing the overall extraction. Within this context, it will be important to be transparent and clear about the statutory decisions required for floodplain

harvesting licences and those for water sharing plan amendments and any inter-relationships.

More broadly, the Department advises that implementation of the Policy will restrict the current take of floodplain harvesting across the northern valleys - not increase it, and this will have broader environmental benefits compared to the case of not implementing the Policy. This restriction is also necessary because there has been growth in floodplain harvesting diversions across the northern valleys above the limits set by the cap, NSW water sharing plans and the Basin Plan (the Department pers comm February 2019). Again, this is supported by the results from the entitlement and account management rule framework combinations outlined in 4.8.1 above.

We conclude that, based on the information available to us, the account management rules, per se, do not mitigate event based environmental risks but do provide for broader environmental benefits compared with not having an entitlements and account management rules framework.

Recommendations

Water sharing plan amendment rules, consisting of flow management rules / access rules for floodplain harvesting licences in addition to account management rules, be considered, especially to minimise impacts of floodplain harvesting on down floodplain environments.

In preparing a comprehensive guideline outlining in detail the process steps used, or to be used, for implementing the Policy, be transparent and clear about the statutory decisions required for floodplain harvesting licences and those for water sharing plan amendments and any inter-relationships.

4.8.4 What is the effectiveness of the account management rules, or other event-based mechanisms, to protect held environmental water from floodplain harvesting, including under a future scenario within constraints relaxed operating conditions?

Evidence Reviewed

The draft Model Build and Scenario reports for the Gwydir and the Border Rivers, mentioned previously in this draft Report and made available to the reviewers, are relevant to this matter.

The reviewers also sighted two draft information sheets: *Floodplain Harvesting Gwydir Valley Regulated River System Results (June 2018)* and *Floodplain Harvesting Border Rivers Regulated River System Results (June 2018)* and the background documents that preceded them - *Border Rivers: Regulated Floodplain Harvesting Entitlement Revisions Using Short Term Average and Account Limits (Draft 30/11/2017)* and *Gwydir: Regulated floodplain harvesting entitlement revision using short-term average take* (undated).

Findings

The findings in 4.8.1-3 above are also relevant to this matter.

Together with provisions for Planned Environmental Water, environmental water holdings are generally managed to achieve in-channel outcomes (except for the Gwydir wetlands and Macquarie Marshes) within the regulated system, and floodplain harvesting would not normally be expected to have a significant impact on these outcomes. The proposed relaxation of flow constraints in the Gwydir Valley is mainly about flow paths through the wetlands, and the last regulated sections below Tyreel regulator. Actions to build capacity for these higher releases from Tyreel regulator should also address the potential for increased floodplain harvesting, including through construction of additional works, or licence conditions, where appropriate (Commonwealth Environmental Water Holder pers comm, February 2019).

It is highly likely that, once introduced, the floodplain harvesting licensing framework alone won't be able to protect held environmental water from floodplain harvesting, particularly in the lower Gwydir, where a number of properties have very low floodplain harvesting access thresholds. Additional measures/rules would need to be introduced to ensure that held environmental water does not end up in the on-farm storages of water users (the Department pers comm, February 2019).

Collaborative work has been underway for some time to better enable the “shepherding” of held environmental water down the mainstems of the northern NSW valleys (Commonwealth Environmental Water Holder, MDBA, the Department pers comm, February 2019). Similar considerations may need to be given for possible future instances where held environmental water is contributing to floodplain flows such that that water is “shepherded” down floodplain and/or down river. This matter also has implications for monitoring, evaluation, auditing, compliance, enforcement and reporting systems.

We conclude that, based on the information available to us, the account management rules, per se, nor any other existing event-based mechanisms, do not protect held environmental water from floodplain harvesting.

Recommendations

Water sharing plan amendment rules, consisting of flow management rules / access rules for floodplain harvesting licences in addition to account management rules, be considered, especially to protect held environmental water from floodplain harvesting, including under a future scenario within constraints relaxed operating conditions.

Attachment 1 – Terms of Reference

Statement of Contractor requirements

Terms of Reference – Independent Review of NSW Floodplain Harvesting Policy Implementation

Background

1. The *NSW Floodplain Harvesting Policy 2013* (the Policy) was developed to bring on-farm rainfall runoff harvesting and overland flow harvesting into NSW's water licensing framework, and consistent with diversion limits under NSW and Commonwealth law.
2. The Policy is being progressively implemented in NSW's five northern inland managed river systems. This implementation has required a significant investment in collecting additional detailed information and upgrading river system models.
3. The implementation is well advanced overall, with two river system models nearly complete, two river systems at an advanced stage, and the remaining system scheduled for completion by March 2019.
4. The results from the modelling will inform the subsequent issuing of licences and accordingly is of great interest to a range of stakeholders, and an independent process is necessary to provide confidence that the results are adequate for the purpose.
5. This scope of works is aimed at contracting a review of modelling based technical components of NSW floodplain harvesting work, and its interaction with other NSW and Commonwealth legislation and policy, in a way that engages key stakeholders and improves transparency and public confidence in the outcomes.

Contractor Requirements:

6. NSW together with the MDBA requires the services of a contractor to undertake an independent review of the implementation of the Policy. The contractor may undertake this individually, or engage other contractors to work as a panel.
7. The contractor(s) will have:
 - a) Extensive knowledge and experience in water resource management and policy at a river system and basin scale.
 - b) Extensive knowledge of hydrological modelling processes, and their representation within managed river system planning models.
 - c) Well-developed stakeholder consultation and communication skills.
8. It is expected that the review will span a period of 7 months (Oct 2018 – April 2019) on a part-time basis and will include:
 - a) Attendance and involvement in stakeholder consultation workshops (Oct 2018 and April-May 2019).
 - b) Bilateral consultation with key stakeholder groups (Oct 2018 – Jan 2019).
 - c) Meetings with relevant Department of Industry and MDBA staff, including modellers (Oct 2018 – April 2019).
 - d) Model technical review (Oct 2018 – April 2019).
 - e) Reporting (April 2019).

Aims of this independent review

9. Develop through structured discussions with stakeholders and DoI Water staff at the outset of this review a framework to assess confidence in meeting the key Policy and broader water management objectives relating to modelling, and apply this framework in the course of this review.
10. Confirm the Policy objectives, and that the modelling has been undertaken consistent with the Policy objectives. Key Policy objectives relevant to the modelling include:
 - a) Estimation of the long term average volume of floodplain harvesting allowed.
 - b) The application of accounting rules to ensure that this is not exceeded.
 - c) That the method to estimate individual entitlements results in fair and equitable outcomes for individuals, within the constraints of the Policy.
 - d) That the implementation and outcomes of the Policy are consistent with commitments to water reform, e.g., as a result of the Matthew's review and the Basin Plan.
11. Develop an understanding of the modelling undertaken to implement the Policy objectives and assess its fitness for this purpose, including, but not limited to considerations of:
 - a) The appropriateness of the conceptual model enhancements to the underlying water planning modelling framework, and associated assumptions.
 - b) The adequacy of the additional information collected for use in this conceptual model, and the quality control applied to this additional information.
 - c) The usage of this information within the modelling framework, and the methods and assumptions used to fully resolve the water balance.
 - d) Other information that might be accessible within the overall scope and timeframes of the project.
12. Determine whether there are any limitations in the information collected for modelling and its treatment in the modelling that critically compromises the meeting of the key objectives of the Policy, and make recommendations as to how these can be resolved; including consideration of whether this should occur within the timeframes of the project or at a later date.
13. Determine the sufficiency of information provided to stakeholders, and make recommendations as to improvements in this information if required.

Deliverables and proposed timeframe

14. Attend a project inception meeting with NSW and MDBA – before 28 September 2018.
15. Attend the initial consultation workshops and address stakeholders in relation to the peer review process and scope – week of 8 October 2018.
16. Develop a draft framework for assessing whether the revised modelling provides confidence in meeting key Policy objectives drawing on stakeholder feedback from the initial workshop, any written submissions as well as bilateral discussions with key stakeholders – by 30 November 2018.

17. Consult with key stakeholders on the draft framework and refine as necessary to create a final – by 31 January 2019.
18. Review and if necessary seek to resolve any critical issues with modelling information, quality control, conceptual model, water balance estimates and application of accounting rules in close consultation with NSW and MDBA modelling staff in order to meet the following timetable:
 - a) Border Rivers, Gwydir, Barwon-Darling and Macquarie Valleys - by 15 February 2019.
 - b) Namoi Valley - by 12 April 2019.
19. Apply the framework referred to in (17) to develop an assessment report for the Border Rivers, Gwydir, Barwon-Darling and Macquarie Valleys by 15 February 2019, that includes:
 - a) Background to NSW floodplain harvesting licensing policy
 - b) A summary of consultation used to develop the report, and issues raised
 - c) A discussion about the key assumptions made in modelling, and information used to support updates to floodplain harvesting baseline diversion limit (BDL) estimates.
 - d) A discussion of the outputs of the model and proposed licensing and management rules in the context of water management; NSW commitments to water reform via the Matthew's review, Northern Basin toolkit and the compliance compact; and the Basin Plan.
 - e) Consideration of the level of uncertainty and the associated risks (including to third parties), and any measures in place to mitigate any risks identified.
20. Amend the assessment report described in (19) to include the Namoi Valley - by 12 April 2019.
21. Attend the second round of consultation workshops (valley based) and present on the key findings of the peer review process - during April-May 2019.

Attachment 2 – Scope of Review

INDEPENDENT REVIEW OF NSW FLOODPLAIN HARVESTING POLICY IMPLEMENTATION PROPOSED MATTERS FOR DETAILED REVIEW

EXECUTIVE SUMMARY

As part of the development and implementation of the Floodplain Harvesting Policy in NSW, the Department of Industry has requested that the modelling and implementation of the policy be independently reviewed. This process is currently underway and the matters in this document provide for a “scope of review” into matters identified through presentations by the Department, discussions with stakeholders and formal submissions made to the independent reviewers.

There has been considerable investment and policy development into improving the management of floodplains in the Northern NSW areas of the Murray Darling Basin, with policy settings for floodplain harvesting set by successive governments since 1995. The overall water reforms in the Basin have meant that governments need to continue to investigate and implement policy reforms in order to meeting Basin Plan obligations.

This review is part of that process and will ultimately form part of the justification process for the Floodplain Harvesting Policy implementation to the Murray Darling Basin Authority. The implementation of this policy is based in technical modelling and assessment of supporting data and is being completed across a number of basins.

The primary objective of this review is to therefore provide transparency around that technical information and to also provide stakeholders with the confidence that the technical rigour and supporting processes are suitable to support policy implementation. It is not intended that the review focus on individual concerns or property scale concerns. Rather, it will provide a process by which stakeholder concerns with the process, information, data and models can be assessed and any issues or limitations noted. Associated with this will be recommendations around how these issues may be dealt with prior to establishing draft licenses for floodplain harvesting. It will therefore focus on the elements of importance to the implementation of the policy, rather than focusing on fine scale detail.

The review is to be conducted based on the Matters for Detailed Review presented here, using a collaborative and consultative process with the Department, MDBA, other state agencies and concerned stakeholders. It is intended that the review progress through until April/May 2019 with the final results presented to interested parties in that timeframe.

1.0 BACKGROUND

The NSW Floodplain Harvesting Policy (The Policy) was first published in May 2013 and amended and updated in September 2018. (See industry.nsw.gov.au for more information.)

The Policy is progressively being implemented, starting with the NSW Border Rivers, Barwon-Darling, Namoi, Gwydir and Macquarie valleys in northern NSW.

To improve stakeholder confidence, the NSW Department of Industry (the Department), together with the Murray Darling Basin Authority (MDBA), have commissioned an independent review of implementation of the Policy, including independent peer review of revised floodplain harvesting modelling in northern NSW.

The focus of the independent review is to ensure that the modelling is technically robust, based on the best available information and that implementation of the NSW Floodplain Harvesting Policy is consistent with relevant legislation and other related policies.

The scope of the independent review contains both technical and policy implementation related matters.

2.0 PROCESS TO IDENTIFY MATTERS FOR DETAILED REVIEW

The independent reviewers (Tony Weber of Alluvium Consulting Australia and Greg Claydon, a sub-consultant to Alluvium) have used the following to propose matters for detailed review of the implementation of the Policy:

1. Reading of relevant published materials on the Department's website;
2. Attendance at stakeholder workshops in Dubbo, Sydney and Tamworth during early October, 2018, during which staff from the Department and the MDBA made presentations about their approach to implementation of the Policy and workshop attendees made comments and sought clarifications;
3. Face to face, telephone and email discussions with stakeholders as requested by them following the above workshops;
4. Consideration of written submissions requested from stakeholders by 16 November (subsequently extended to early December 2018 as requested by some stakeholders);
5. Further discussions with the Department and the MDBA about, and further review of, draft documents prepared by the Department, recognising that there is still very substantial documentation to be undertaken.

In keeping with the focus of the review, the independent reviewers now propose to investigate, analyse and make comments in their draft Review Report about the matters outlined below. Feedback about this proposal is welcomed, recognising that additional matters may also be identified as the review further progresses.

The independent reviewers do note that the submissions covered a wide range of issues associated with floodplain harvesting, with some being beyond the scope of this review, highlighted by the following examples:

- Some submissions highlighted that floodplain harvesting should be made illegal due to adverse downstream impacts and lack of equity;
- Others questioned whether the components of take, including rainfall runoff and floodplain harvesting, are equitably shared across all users in a basin;

- Specific details regarding individual works and draft licensing amounts.

The independent reviewers' task is not to assess these as they relate back to original policy decisions or individual circumstances, but rather to assess whether the policy is being implemented consistent with legislation and policy and that this is appropriately represented in the models. The above examples and other policy comments have been forwarded to the Department for their consideration and subsequent direct response.

3.0 OVERVIEW OF SUCCESS FACTORS FOR IMPLEMENTATION

The independent reviewers propose that their Review Report will outline whether, based on the information provided to them, and their assessments, the approaches to implementation of the Policy:

- are based on the best available data and information, and, where assumptions have had to be made about that data and information, those assumptions are reasonable, robust, defensible, transparent and auditable based on the available evidence;
- are based on sound numerical modelling concepts, inputs and results and the numerical modelling is “fit-for-purpose” and appropriately documented;
- consider and treat on-farm and downstream water users and uses equitably and consistently, in line with the Policy objectives;
- can be applied in a repeatable and consistent way across the northern NSW valleys;
- can accommodate further updates should new data or information provide justifiable evidence to overcome any previously identified limitations;
- are supported by provisions in the NSW Water Management Act 2000, the Commonwealth Water Act 2007 and the Murray-Darling Basin Plan 2012;
- are appropriate for granting floodplain harvesting water access licences and being incorporated into water sharing plans; and
- have been sufficiently explained to and understood by stakeholders.

4.0 OVERVIEW OF MATTERS FOR DETAILED REVIEW

In considering the information below, it is important to keep in mind that the terms of reference for the review require the independent reviewers to consider implementation of the Policy, not the Policy itself, though some interpretation is invariably required.

Each section below contains a brief description of the issue and proposes focus questions to be considered by the independent reviewers.

4.1 Appropriate Conceptualisation of Policy Implementation

Many irrigator and non-irrigator stakeholders asserted that the implementation of the Policy would involve specification, at least initially, of a volume of floodplain harvesting take that is “no more and no less” than would be permitted to be taken lawfully at the time of negotiations around the policy development.

There has been some confusion and doubt amongst some stakeholders as to the interpretation of the amended and updated 2018 Policy, including the definitions and legal underpinnings of floodplain harvesting and rainfall runoff, and how they have been or may be accounted for in the Baseline Diversion Limits (BDLs) and Sustainable Diversion Limits (SDLs) and other relevant matters under the Murray-Darling Basin Plan 2012.

There has also been some confusion among some stakeholders as to the dates that are relevant to quantifying floodplain harvesting entitlements and how data and information about on-farm infrastructure and irrigator behaviour at those dates have been collected and used.

4.1.1 Do the guidelines and process steps for implementation of the Policy adequately cover the determination of eligible floodplain harvesting works and the identification of irrigator behaviour at the appropriate time?

4.1.2 Do the guidelines and process steps for implementation of the Policy adequately cover and explain if, when and how, water sharing plans, BDLs and SDLs are to be amended, including any legal provisions that apply, consistent with the NSW Water Management Act 2000, the Commonwealth Water Act 2007 and the Murray-Darling Basin Plan 2012?

4.1.3 Do the guidelines and process steps for implementation of the Policy adequately cover the issuing of individual farm floodplain harvesting water access licences and explain how any share components will be determined, including processes for a review of any individual anomalies?

4.1.4 What is the basis for the proposed and/or designated floodplain boundaries and what is classed as floodplain flows?

4.1.5 Have the pros and cons of alternative approaches to determining individual farm floodplain harvesting water access licenses and share components been considered and compared with the currently adopted approach for Policy implementation?

4.2 Appropriate Conceptualisation of the Numerical Modelling at Appropriate Scales

Traditionally, numerical hydrologic models have been used to assess and consider impacts of different water infrastructure and water management approaches at basin, valley and sub-valley scales.

Using numerical hydrologic models, combined in some cases with hydraulic models, to determine individual farm based water entitlements and volumetric shares is an extension of this traditional approach.

Some stakeholders have questioned whether there are too many complexities, uncertainties or plain unknowns associated with the modelling of on-farm floodplain harvesting take to enable a consistent, reliable and defensible determination of farm based volumetric floodplain harvesting entitlements. A particular difficulty encountered when trying to develop numerical model estimates of floodplain harvesting is the lack of measured data to use for validation. In the absence of measured data, multiple lines of evidence may be used to try to build some additional confidence in the estimate of floodplain harvesting and its uncertainty.

4.2.1 Do the models properly represent regulated and unregulated systems (including the Barwon-Darling) in accordance with the Policy intent?

4.2.2 Do the models and determination of allowable take have due regard to downstream impacts such as Matters of National Environmental Significance?

4.2.3 *Is the conceptualisation of the modelling at appropriate spatial and temporal scales to evaluate individual farm take and behaviours and represent these adequately in a draft entitlement?*

4.2.4 *What are the multiple lines of evidence and have they been used in a transparent way to provide for the conceptualisation of the numerical models and the inputs to those models.*

4.2.5 *Is there evidence in the documentation as to what data, information and assumptions (including from Irrigator Behaviour Questionnaires - IBQs) have been used or not used and why?*

4.2.6 *With respect to the influence of the IBQs on model parameterisation, when was on-farm information reported from the IBQs used or not used and how were inconsistencies between other data sources and the IBQs reconciled?*

4.2.7 *What is the verification process at the farm scale?*

4.2.8 *Are the lines of evidence used repeatable and auditable?*

4.2.9 *Is the representation of flow paths, on-farm infrastructure including temporary and permanent storages, irrigated areas and their operational arrangements in the models appropriate and supported by the best available evidence?*

4.2.10 *Are the uncertainties in the numerical modelling approach sufficiently known and understood at the farm scale to enable individual farm based water entitlements and volumetric shares to be confidently and equitably determined?*

4.2.11 *Is the numerical modelling approach “fit-for-purpose”, including model structure, appropriate calibration, validation and documentation to provide confidence in same?*

4.2.12 *What mitigations have been used to offset unacceptable outcomes due to the existence of various uncertainties, and are they adequate?*

4.3 Appropriate Climatic Considerations

A number of stakeholders made comments about past and future climate change, and the variability of climate across the valleys where the Policy is to be implemented. They questioned the understanding of the representativeness of the climate series in terms of understanding present day conditions.

4.3.1 *With respect to understanding the representativeness of the climate series in terms of understanding present day conditions, does a long term climate sequence reduce any recent climatic shifts such as step changes and has this been examined at all?*

4.3.2 *To better understand the resolution of the climate data (both rainfall and evapotranspiration), what are the implications of broadscale climate inputs when assessing farm scale conditions?*

4.3.3 *Has a potential future drying climate been considered in the implementation of the Policy?*

4.4 Appropriate Identification of Floodplain Flows and Rainfall Runoff Volumes Available for Taking

Several stakeholders have expressed views as to whether the taking and use of rainfall runoff from irrigated lands should or should not be included in the floodplain harvesting definition as it is in the amended and updated 2018 Policy. In any event, implementation of the Policy by way of a whole of on-farm water balance requires explicit consideration of and accounting for volumes of water from both “overbank” on-farm floodplain flows and flows on the floodplain that may emanate from rainfall runoff from dryland and irrigated areas “up floodplain”.

4.4.1 Are the data, information and assumptions used to generate/estimate “overbank” on-farm floodplain locations, flow rates, volumes, timings, frequencies and durations appropriate and supported by the best available evidence, including local floodplain knowledge from within government and external stakeholders?

4.4.2 Specifically, how is calibration/verification of floodplain volumes undertaken and is this appropriate and supported by the best available evidence?

4.4.3 With respect to consistency between different lines of evidence regarding overland/floodplain flows, what is the variability in each of the data sources and between them and how has this been reconciled?

4.4.4 Is the data, information and assumptions used to generate/estimate on-farm rainfall runoff rates, volumes, timings, frequencies and durations from both dryland and irrigated areas appropriate, supported by the best available evidence and consistent with the Floodplain Harvesting Policy intent?

4.4.5 Why was a particular rainfall-runoff model chosen, how was it calibrated and how is it downscaled to paddock conditions at the farm?

4.4.6 How does the rainfall-runoff model account for different irrigation behaviours (e.g. watering prior to rainfall events) and how does this relate to other water uses?

4.5 Appropriate Identification of On-Farm Infrastructure to Temporarily or Permanently Take and Store Floodplain Flows

Several stakeholders have expressed views as to whether the use of temporary storage facilities should or should not be included in the floodplain harvesting licensing arrangements. In any event, implementation of the Policy by way of a whole of on-farm water balance does require consideration of and accounting for volumes of water from both temporary and permanent storage facilities.

On-farm water take and storage can be very complex, involving multiple facilities that may be operated differently depending on the real-time circumstances. Approaches to operations may also change over the years as experience is gained, efficiencies are improved, works are modified, and an adaptive approach to management is adopted. Identifying levels of on-farm development that existed in the past (eg in 1993/94 for which the Murray-Darling Basin cap on diversions is defined, in 1999/2000 for which most water sharing plans define limits, or on 3 July 2008 which is a key date for eligible floodplain

harvesting works), and the water management behaviours that may have existed then, are especially challenging.

4.5.1 Does the modelling reflect the impacts of eligible works only and are other structures (illegal, changed as a result of trading of entitlements, or otherwise) assumed to be included or excluded from the models and do they allow for disaggregation of the Plan limit into volumetric shares?

4.5.2 Is the adopted base case scenario clear within the model in terms of the timeframe it is intended to represent and is this supported by the best available evidence?

4.5.3 Is the data, information and assumptions used to identify on-farm diversion and take works, permanent storages, irrigated areas, and modelling of how they have been/are used, appropriate, supported by the best available evidence, and consistent with the Floodplain Harvesting Policy intent?

4.5.4 Is the data, information and assumptions used to identify on-farm temporary storages, and model representation of how they have been/are used, appropriate, supported by the best available evidence, and consistent with the Floodplain Harvesting Policy intent?

4.5.5 What has been/is the relative significance of the volumes taken into temporary storages and is the management of any risks associated with that significance appropriate?

4.6 Appropriate On-Farm Water Use Considerations

On-farm water use is influenced by location, crop and soil type, watering system, irrigator behaviour, among other things. On-farm water use can come from several sources, including direct irrigation and irrigation from storages that hold supplementary water access entitlements, floodplain harvesting water, rainfall runoff, used and contaminated water.

4.6.1 Is the data, information and assumptions used to generate/estimate crop (and any pre-water) irrigation demand volumes, timings, frequencies and durations appropriate and supported by the best available evidence? Do they represent the different cropping conditions in the relevant basins?

4.6.2 Where floodplain harvesting in unregulated systems is to be assessed, is the process available for determining rate of water use, groundwater use, unregulated water an appropriate method for determining floodplain harvesting entitlements?

4.6.3 Is the data, information and assumptions used to generate/estimate on-farm irrigation supply system and in-field efficiencies appropriate and supported by the best available evidence?

4.6.4 Is the data, information and assumptions used to validate on-farm cropped areas appropriate and supported by the best available evidence?

4.7 Appropriate On-Farm Water Balance Considerations

There are a range of water sources measured, estimated or exempt from licensing (with allowances such the harvestable right from dryland areas) that are managed (taken,

interfered with, used or recycled) on-farm at any given time – daily, weekly, monthly, seasonally, annually, multi-yearly.

4.7.1 Is the data, information and assumptions used to validate on-farm water balances appropriate, supported by the best available evidence and consistent with regulation and policy, including allowances for contaminated runoff and used irrigation water?

4.7.2 In reconciling the water balance, what other losses are included or implicit in the on-farm modelling and how are these handled in terms of rainfall-runoff assessments, for example?

4.7.3 Are the uncertainties in the water balance calculations known and understood to the extent that any residual unknowns in the water balance calculations can be meaningfully and reliably determined?

4.8 Appropriate Application of Water Accounting Rules

Some stakeholders were of the view that there is insufficient information currently available to determine the potential impact of floodplain harvesting volumetric limits and account management rules on downstream flows, recognising their importance to downstream landholders' livelihoods, Matters of National Environmental Significance and the ecological character of floodplain and instream environmental assets.

4.8.1 Are the account management rules effectively represented in the model and is that representation consistent with the Floodplain Harvesting Policy intent.

4.8.2 Does the numerical model configuration allow for appropriate simulation of downstream flows and is it sufficiently sensitive for assessing impacts that may arise from floodplain harvesting licences, changes in floodplain harvesting volumes and account rules, including impacts on Matters of National Environmental Significance, and the efficient and effective use of environmental water holdings?

4.8.3 What is the effectiveness of the account management rules to mitigate event based environmental risks, and the evidence used to determine residual risk?

4.8.4 What is the effectiveness of the account management rules, or other event based mechanisms, to protect held environmental water from floodplain harvesting, including under a future scenario within constraints relaxed operating conditions?

4.9 Appropriate Measurement and Monitoring

A draft Floodplain Harvesting Monitoring and Auditing Strategy (November, 2018) has been released by the Department for consultation. Public feedback on the draft Strategy has been invited until 15 February, 2019.

While appropriate measurement and monitoring, reporting and auditing, compliance and enforcement are integral elements of implementation of the Policy, consideration of the draft Strategy per se is not within the scope of this independent review.

Nevertheless, the independent reviewers may have regard to their implications when considering the matters outlined above, and requirements for the management of any risks

that could emerge. This may also include identifying any potential inconsistencies or misalignments of the measurement and compliance regime with the intent and implementation of the Policy, including any arrangements for trading of entitlements.

4.10 Consideration of Any Suggestions to Overcome Any Identified Limitations in Policy Implementation

The review process will also be used to determine whether there are any limitations in the information collected for modelling and its treatment in the modelling that critically compromises the meeting of key objectives of the Policy. The independent reviewers will make recommendations as to how these can be resolved, including consideration of whether this should occur within the timeframes of the review or at a later date.