



NSW HEALTHY FLOODPLAINS

# Floodplain harvesting entitlements for the Gwydir Valley regulated river system

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Model scenarios

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## Executive summary

In 2008 the NSW Government announced that water users harvesting water from floodplains would need a licence and approval to use the water harvesting works that they had installed. To facilitate this, the Department of Planning and Environment introduced the *NSW Floodplain Harvesting Policy* (the policy) in 2013. The policy sets out the floodplain harvesting licensing eligibility criteria and the licensing process where licences define the volume of water (overbank and rainfall-runoff) that users can legally harvest from floodplains. The policy is now being implemented across the northern Murray-Darling Basin.

Floodplain harvesting limits are set out in NSW Water Sharing Plans. These limits were estimated at the time of policy introduction and are now being updated using improved information and modelling developed under the NSW Floodplain Harvesting Program.

This report describes how the Gwydir Valley regulated river system model<sup>1</sup> (the Gwydir Valley model) has been used to recalculate the long-term diversion limit set in the *Water Sharing Plan for the Gwydir River Regulated River Water Source* (referred to as the 'plan limit'), estimate individual floodplain harvesting entitlements, and demonstrate that the new floodplain harvesting water access licences will bring total diversions within the plan limit. Model scenarios have been developed that represent different combinations of levels of development, entitlements, and account management rules to ensure equitable distribution of the individual floodplain harvesting entitlements.

Each scenario is run through the Gwydir Valley model, over the period 1 January 1890 to 30 June 2019 with simulated data from July 1895 to 30 June 2009 used to calculate an estimate of long-term average annual total diversion<sup>2</sup>. Issues such as compliance with the plan limit, equitable distribution of entitlements and risk of growth in use are considered when evaluating the combination results to determine the revised plan limit and the volume of access licences and associated management rules.

Comparing results of diversions permitted under the existing plan limit against current levels of development and management rules for eligible infrastructure shows that, as a consequence of growth in development, long-term average diversions have increased by about 37.2 GL/year, from 410.5 GL/year to 447.7 GL/year. These results assume that the tailwater exemption is in place. Introducing the combination of entitlements and account management rules will reverse this growth by reducing the long-term average annual diversions back within the plan limit. Under this scenario, the non-exempt floodplain harvesting component of total average annual diversions reduces from 137.1 GL/year under current conditions to 94.0 GL/year. These impacts don't occur in every year; reductions primarily occur after a series of wet years. Impact on individual properties has been tested using an individual impact scenario which shows that the impacts are equitably distributed, with an overall valley reduction in the non-exempt floodplain harvesting component of 24.8%.<sup>3</sup> Some properties will also have greater impacts as they have ineligible works which are not included in the entitlement determination process.

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<sup>1</sup> The companion Model Build report (DPE Water 2021a)

<sup>2</sup> 1895–2009 period is based on the Basin Plan assessment period and refers to water years rather than calendar years.

<sup>3</sup> Individual impacts on all floodplain harvesting (i.e. including exemption) is variable, with the average about 12.9% across all properties.

The scenario modelling reported herein has been used to create an updated estimate of the plan limit for the Gwydir valley regulated river water source. It has also been used to determine floodplain harvesting entitlements. Evaluation of results shows that the proposed entitlements and account management rules can equitably manage floodplain harvesting such that total diversions are managed within the required plan limit.

While all care has been taken in this modelling and the work undertaken has substantially improved the estimation of floodplain harvesting, uncertainty can be further reduced with better information through ongoing monitoring of harvesting volumes and management practices, and better representation of return flows from floodplains to river channels.

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# 1 Introduction

In 2008 the NSW Government announced that water users harvesting water from floodplains would need a licence and an approval to use the works. To facilitate this, the Department developed the *NSW Floodplain Harvesting Policy* (the policy). The policy was introduced in 2013 and is now being implemented across the northern Murray-Darling Basin. The policy sets out the floodplain harvesting licensing eligibility criteria and the licensing process.

Floodplain harvesting licences define the volume of water that users can legally harvest from floodplains. Bringing floodplain harvesting into the water licensing system will ensure the volume of total diversions stays within the limits established in NSW *Water Sharing Plans* (WSPs) for each valley.

NSW WSPs set out how much, and how, water is shared between users within the state. They define how limits to total diversions, including for floodplain harvesting, are to be calculated in each valley, and include estimates for these limits. The floodplain harvesting estimate is now being updated using improved data and methods developed under the NSW Floodplain Harvesting Program.

The updated data and modelling for the Gwydir Valley regulated river system are described in detail in the companion Model Build report (DPE Water 2021a).

The model has been used to recalculate the diversion limit set in the *Water Sharing Plan for the Gwydir Regulated River Water Source 2016* (updated 2018), (the Gwydir WSP), and calculate floodplain harvesting licences to ensure that total diversions are within that limit.

## 1.1 Gwydir Valley river system model

The model of the Gwydir Valley regulated river system (Gwydir Valley model) was built to:

- support the policy and planning development and implementation in this water system, including its contribution to the Murray Darling *Basin Plan 2012* (the Basin Plan). This includes being able to estimate the Baseline Diversion Limit (BDL) and Sustainable Diversion Limit (SDL) as required by the Basin Plan
- determine volumetric floodplain harvesting entitlements as required by the policy.

The model was developed using multiple lines of evidence and best available industry data to ensure that the assessment of floodplain harvesting capability at each irrigation property is realistic. Assessment criteria<sup>4</sup> measured how well the model reproduced system behaviour, that is inflows, diversions, and flow distribution, necessary to meet the modelling objectives, and whether model performance was better or worse than an alternate model. The Model Build report (DPE Water 2021a) provides evidence and assessments to demonstrate that the model has made the best use of available data and methods to produce the estimates of limits to diversions required for implementation of the policy. In addition, the quality of the model build process (as described in the Model Build report) has been favourably assessed through several rounds of independent external review, with findings publicly available (Alluvium, 2019, 2020).

### 1.1.1 Model scenarios

Meeting policy purposes required configuring and running a set of defined model scenarios. Scenarios reflect a particular level of development and management rules in the river system, usually at a point in time. The scenarios to be discussed in this report have been qualitatively defined by the Gwydir WSP and, separately, by the policy.

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<sup>4</sup> Ref Table 27 in DPE Water (2021a)



Scenarios are developed as modifications to the inputs to the base river system model. When run over long-term climate sequences, the modified model can then simulate **long-term average annual diversions** under the level of development and management rules described in the scenario.

The modifications to create these scenarios are described in this report.

## 1.2 Report purpose and structure

This report describes how the Gwydir Valley model was used to recalculate the diversion limit in the Gwydir WSP and estimate individual floodplain harvesting entitlements. This includes discussion of the relevant policy instruments, how models are used to implement these, and how development levels and water management rules (the two key components of the scenarios) were determined.

Section 2 introduces the key elements of the Gwydir WSP and the policy, particularly the definitions for the Cap and Plan Limit Scenarios, and the framework for establishing floodplain harvesting entitlements.

Section 3 describes the model scenarios and their data requirements in more detail and how they have been combined to estimate floodplain harvesting entitlements.

Section 4 presents the modelled results, summarised at whole of river system scale as required by the Basin Plan and the policy. Results are categorised by (1) determining the Gwydir WSP's diversion limit, (2) growth in use assessment, (3) plan limit compliance, and (4) entitlement distribution. Summary information on individual entitlements is reported, including estimated changes in diversions as a consequence of implementing these entitlements.

Section 5 concludes with an assessment of how the requirements of the policy have been addressed, along with identification of future work.

## 1.3 Companion reports

How the model has been used to update the Water Sharing Plan limit and calculate floodplain harvesting entitlements to bring total diversions back within that limit is described in this report.

The building of the river system model which provides the data for assessing entitlements is described in companion report *Building the river system model for the Gwydir Valley regulated river system* (DPE Water 2021a).

The use of the model results for predicting potential environmental outcomes is described in companion report *Environmental outcomes of implementing the Floodplain Harvesting Policy in the Gwydir Valley* (DPE Water 2021b).

The three reports together serve to describe how the modelling meets the objectives of the *Floodplain Harvesting Policy*.

## 2 Floodplain Harvesting Policy background

### 2.1 Purpose

Allowable limits of water diversions in NSW's regulated rivers and the Barwon-Darling are determined in WSPs established under the *2000 NSW Water Management Act*. Following accreditation of NSW Water Resource Plans, WSPs will be amended to ensure these limits will also reflect the Sustainable Diversion Limit set out in the Basin Plan. These limits allow for flows in the river and on associated floodplains that provide for environmental outcomes and a level of reliability to downstream water users.

Unconstrained harvesting of water from floodplains has resulted in growth in diversions above those limits, resulting in reduced downstream and lateral flow with consequent impacts on reliability of water supply to downstream water users including the environments of the river and its floodplains and wetlands.

The purpose of the policy is to protect the environment and the reliability of downstream water supply by managing the diversion of water for consumptive use through floodplain harvesting. These diversions will be managed to be within authorised long-term average annual extraction limits (LTAAELs). **This LTAAEL will be henceforth referred to as the 'plan limit'**.

The policy ensures compliance with the *2000 NSW Water Management Act* which requires all diversions to be taken under an appropriate water access licence, a basic landholder right or a licence exemption. The policy also meets the objectives of the National Water Initiative by bringing these diversions into the water access entitlement framework.

### 2.2 Implementation

The policy provides a framework for licensing floodplain harvesting diversions (comprising overbank flow harvesting and rainfall-runoff harvesting), setting out five stages (Figure 1) of the administrative process for eligibility for a floodplain harvesting entitlement, from registration of interest through to the issue of entitlements. The *Implementation Guideline* (DPE 2020) provides further detail on this process.



**Figure 1 The five stages in floodplain harvesting implementation**

The Department of Planning and Environment's (the department's) river system models for each valley are being extended to determine all regulated river floodplain harvesting entitlements, through:

- updating estimates of the plan limit defined in each valley's WSP
- assessing floodplain harvesting capability of eligible works
- using the eligible works capability assessment to equitably estimate entitlements such that total diversions can be managed within the plan limit.

The role of the models in stages 4 and 5 is described in the following sections. Their revision and estimates of plan limits rely on information collected in stages 1, 2 and 3.

The entitlements process described here is restricted to the regulated river system. Entitlements in the unregulated river system are determined using a separate process as is outlined in the *Implementation Guideline* (DPE 2020).

## 2.3 Definition and estimates of diversion limits

The policy requires that total diversions do not exceed the plan limit. This also means that total diversions cannot exceed that allowed for under the Cap<sup>5</sup>.

The plan limit for the Gwydir regulated river system is established in clause 29(1) of the Gwydir WSP as the lesser of the long-term average annual extraction for this water source that would occur:

“(a) ... with the water storages, water use development that existed in 1999/2000, the share components existing at the commencement of this Plan, a limit on supplementary licence available water determinations of 1 ML per unit share, and application of the rules defined in this Plan, or

(b) ... under Cap baseline conditions.”

The Gwydir Valley model has been designed to be able to determine which set of development conditions and management rules ((a) or (b)) results in the lower long-term average annual diversion. The sets are configured as model scenarios and run through the model, using a long period of climate data, to estimate the long-term average annual total diversion under each scenario.

- Clause 29(1)(a) is configured as the Water Sharing Plan Scenario (the WSP Scenario)
- Clause 29(1)(b) is configured as the Cap Scenario.

The Plan Limit Scenario then is whichever of these has the lower result. Both scenarios have been run and are described in Section 3.2.1.

The categories of diversions included in the plan limit definition are specified in the Gwydir WSP. The limit estimate in the Gwydir WSP is based on the department’s river system model that was in use at that time. This included an estimate of floodplain harvesting; however, this was a less reliable estimate as that part of the model was not sufficiently developed for that purpose.

A revised estimate of the plan limit is being made as part of implementation of the policy. The same estimate will be used for the Baseline Diversion Limit (BDL) under the Basin Plan – consequently, the BDL estimate used by the Murray-Darling Basin Authority will also be updated, and by inference, the Sustainable Diversion Limit (SDL).

As results are averaged (i.e. the long-term average annual extraction), the time period is critical. To comply with the Basin Plan, the period 01/07/1895 to 30/06/2009 is used for calculating long term averages for the implementation of the policy.

## 2.4 Eligible works capability assessment and determination of entitlements

The policy states that the determination of individual entitlements will not be based on history of use. Instead, determination is informed by a capability assessment that considers the works (physical infrastructure) used for floodplain harvesting and the opportunity to access floodplain

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<sup>5</sup> The Cap is as defined in Schedule F of the *Murray Darling Basin Agreement* and as agreed under the *Murray Darling Basin Ministerial Cap on Diversions*.

flows based on location and climatic variability. Note that the assessment includes only those works deemed eligible for consideration<sup>6</sup>.

This capability has been included in the rebuilt Gwydir Valley model.

Growth in total diversions **above** the plan limit is addressed through two steps:

- Firstly, growth resulting from ineligible works is addressed by not including those works in the capability assessment
- Secondly, to bring total diversions back within the plan limit, entitlements are designed so that, in conjunction with the account management rules, each irrigation property has a uniform reduction in long term average non-exempt portion<sup>7</sup> of floodplain harvesting.

If total diversions are **below** the plan limit, then the entitlements will be designed so that there is no impact. The assessment of impact on both cases is based on eligible works only.

To implement the above, 4 model scenarios are required to assess:

- the plan limit (called the Plan Limit Scenario)
- current infrastructure (called the Current Conditions Scenario)
- eligible works (called the Eligible Development Scenario)
- implementation of the policy (called the Valley Scale Compliance Scenario).

These scenarios are described in Section 3.

Determination of entitlement volumes depends on the accounting rules used. The proposed accounting rules are discussed in the following section. The method to calculate entitlements is further described in Section 3.2.4 on the implementation of the policy.

## 2.5 Proposed accounting rules

Accounting rules affect the sizing of entitlements; for example, if there is no carryover, larger entitlements are required to achieve the objectives of the policy. The amount of floodplain harvesting over the long term is affected by climate variability. These all need to be considered when designing entitlement volumes and account management rules. We undertook extensive analysis of combinations of entitlements and account management rules.

Issues such as equitable reductions and risk of growth in use were considered when evaluating the combinations of entitlement volumes and accounting rules. This process was overseen by an NSW interagency working group including the Department of Primary Industries (Fisheries), Department of Primary Industries (Agriculture) and the department's Energy Environment and Science division. A summary of the analysis and recommendations were provided for stakeholder consultation to seek feedback (DPI 2018a) and outcomes of the consultation were published (DPI 2018b).

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<sup>6</sup> The process of assessing eligible works is described in the *Floodplain Harvesting Policy Implementation Guideline* (DPE 2020)

<sup>7</sup> Properties with a larger proportion of exempt floodplain harvesting would generally be less impacted by the licensing framework in terms of total floodplain harvesting diversions.

**The proposed accounting rules for each floodplain harvesting entitlement are:**

- 100% of an entitlement to be credited annually to the account up to a maximum value of 500% of the entitlement
- Annual floodplain harvesting is limited to the balance left in the account except where an overdraw is required to retain contaminated rainfall runoff from developed areas
- The account is debited annually for all floodplain harvesting in that year, allowing for exclusions such as rainfall runoff harvesting during exempt periods
- Any unused balance can be carried over into the next water year subject to the 500% account limit.

These proposed rules, along with some additional initialisation rules, will be further described during water sharing plan consultation. Appendix A illustrates how these accounting rules work.

NSW has introduced a partial rainfall-runoff harvesting exemption to the policy, which means that there will be times when rainfall-runoff harvested from the irrigation property is not required to be accounted for against the licence. This provision is taken into account by removing exempted harvesting from results when determining the entitlement. The exemption is also reflected in the modelling of accounting rules. For modelling purposes:

- exempt rainfall-runoff harvesting is defined as that which occurs from fallow or cropped areas on days when no water is being harvested from outside the irrigation property<sup>8</sup>.
- non-exempt rainfall harvesting is considered part of floodplain harvesting and as such will be included in the floodplain harvesting results in this report.

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<sup>8</sup> Draft regulation under the *Water Management Act 2000*, publicly exhibited in October 2020.

## 3 Scenarios: use and data

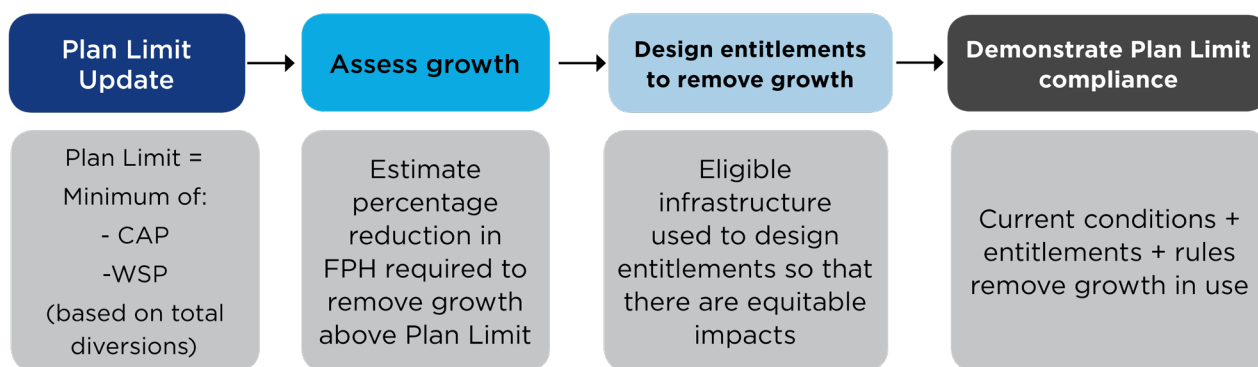
### 3.1 Overview

The intent of the policy is to bring floodplain harvesting into the water licensing framework, including managing any growth above statutory limit through a combination of entitlement volumes and account management rules as noted in Section 2.5. These two factors combined are hereafter referred to as the 'floodplain harvesting licensing framework'.

Four model scenarios have been developed to implement this framework in the Gwydir valley (Table 1). The relationship between the scenarios is shown in Figure 2.

**Table 1 Scenarios developed to implement the floodplain harvesting licensing framework in the Gwydir valley**

	Scenario name	Description, including title used in Figure 2
(a)	Plan Limit Scenario	Plan limit update  There are two clauses in the plan limit definition in the Gwydir WSP: the Water Sharing Plan limit and the Murray Darling Basin Ministerial Council Cap on diversions. The Plan Limit Scenario is whichever has lesser long-term average total diversions
(b)	Current Conditions Scenario	Assess growth  Current levels of development and management rules used to estimate the level of diversions without the licensing framework in place and determines the reduction, if any, required to comply with Plan limits
(c)	Eligible Development Scenario	Design entitlements  In accordance with the policy, this scenario is based on the levels of farm infrastructure development that were present or otherwise eligible as at 3 July 2008. It is used to determine individual shares of the total volume of floodplain harvesting entitlements
(d)	Valley Scale Compliance Scenario	Demonstrate plan limit compliance  An evolution of the Current Conditions Scenario with the floodplain harvesting licensing framework applied to bring diversion back to statutory limits, with shares of the total floodplain harvesting entitlements based on distribution of floodplain harvesting volumes from (c)



**Figure 2 Process for using the model scenarios to determine floodplain harvesting entitlements. The four steps, moving from left to right, reflect the relationship between the four model scenarios**

These scenarios are described in more detail in Section 3.2, including how the modelled implementation of the licensing framework equitably distributes impacts.

## 3.2 Descriptions of scenarios

This section gives a general description of each model scenario. All Scenarios have been adapted from the 2008/09 Scenario described in the companion Model Build report (DPE Water 2021a). The Model Build report should be read in conjunction with this report for further detail on how the 2008/09 Scenario was developed and model performance assessed. Changes from that scenario are described in Section 3.3.

### 3.2.1 Plan Limit Scenario

The Plan Limit is to be assessed through two separate scenarios as defined in the Gwydir WSP and as described in Section 2.3. Depending on results, one of these scenarios becomes the Plan Limit Scenario. This is reported in Section 4.1.

**Table 2 The two scenarios used to assess the plan limit**

Scenario name	Description
Water Sharing Plan (WSP) Scenario	Reflects the level of development at 1999/00 and management arrangements set out in the Gwydir WSP
Cap Scenario	Reflects agreements made under the Murray Darling Basin Ministerial Council Cap on diversions. For the Gwydir valley, as for most valleys in the basin, this refers to the development levels and management arrangements in place at 1993/94

The varying levels of development and management rules that should be used in each scenario are summarised in Table 3. Both scenarios have been built from the 2008/09 Scenario – this means that most other parameters are the same as those used in that scenario and as described in the companion Model Build report (DPE Water 2021a).

**Table 3 Levels of development and management rules used in CAP and WSP Scenarios**

	<b>CAP Scenario</b>	<b>WSP Scenario</b>
On-farm storage capacity	30 June 1994	30 June 2000
On-farm storage pumps	30 June 1994	30 June 2000
Developed area	30 June 1994	30 June 2000
River pumps	30 June 1994	30 June 2000
Water management rules	1993/94	As per the WSP
Resource assessment	Annual accounting	Continuous accounting as per WSP

### 3.2.2 Current Conditions Scenario

This scenario uses the best available information on most recent known levels of irrigation infrastructure and entitlements in the Gwydir regulated river system, and existing management arrangements as defined under the Gwydir WSP. The information is described in Section 3.3.

Apart from infrastructure, entitlements (noting all Held Environmental Water is modelled as irrigation use) and some system operation rules introduced post-2008, the Current Conditions Scenario is the same as the 2008/09 Scenario.

This scenario is used to estimate diversions **prior** to implementing the floodplain harvesting licensing framework so as to assess whether there has been growth in total diversions compared to the plan limit. It will require ongoing monitoring by the department to ensure that development levels are kept up to date and to assess whether there have been behaviour changes, for example changes in cropping practices and efficiency of irrigation.

### 3.2.3 Eligible Development Scenario

This scenario is used to estimate the floodplain harvesting that would have occurred **with only eligible infrastructure**. This is used to determine the distribution of floodplain harvesting entitlements, as was described in Section 2.4.

All information on eligible works is provided by the NSW Natural Resource Access Regulator (NRAR) who conducted the eligible works assessment against the eligibility criteria in the policy on behalf of the department.

It is the same as the 2008/09 Scenario except the inclusion of eligible infrastructure that was approved, but as of timing of writing this report not yet constructed at one property.

### 3.2.4 Plan Limit compliance

Plan Limit compliance is assessed using two model scenarios to assess compliance at two scales – individual and valley.

#### **Individual entitlements (Individual Impacts Scenario)**

Entitlements were calculated by analysing the results from the Eligible Development Scenario using a utility program to simulate the effect of the proposed accounting rules on floodplain



harvesting<sup>9</sup>. The utility estimates the entitlement that would be required, in conjunction with the accounting rules, to achieve the required impact on long term floodplain harvesting diversions.

The utility assumes that the same impact should apply to each individual entitlement. To test this, the entitlements and proposed accounting rules have been added into the Eligible Development Scenario to create a new scenario, the Individual Impacts Scenario.

This process of designing the entitlement and assessing the impact of the rules takes into account the partial rainfall runoff harvesting exemption. The exemption is described in Section 2.5.

### **Valley scale (Valley Scale Compliance Scenario)**

This scenario uses the Current Conditions Scenario with proposed accounting rules and individual floodplain harvesting entitlements to demonstrate modelled diversions comply with the Plan Limit, which is set for the valley.

This scenario is not used to report on individual impacts as there may be other issues, such as entitlement changes, that cause changes in results compared to the Eligible Development Scenario.

## **3.3 Data for scenarios**

The sources and characteristics of data for each model component are detailed in the companion Model Build report. Most of the data discussed relates to model calibration (data such as climate, inflows, crop water usage, transmission losses) and are therefore the same for each scenario. The model components that may vary between scenarios are:

- distribution of entitlements
- the level of irrigation and river system infrastructure development in place
- management rules at the relevant point in time.

The data required for each of these components is summarised below.

### **3.3.1 Entitlements**

The distribution of entitlements information come from Department databases and is available from the start of the Gwydir WSP on 1 July 2004. All post-2008 scenarios use the distribution of shares at 30 June 2014, while all pre-2008 scenarios use the distribution of shares at 30 June 2000<sup>10</sup>. The Current Conditions Scenario uses the distribution of shares at 30 June 2016. The total volumes are very similar (Table 4).

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<sup>9</sup> The utility program was run outside of the Gwydir Valley model for efficiency (run-time) reasons. To replicate the proposed accounting, including the partial runoff exemption, it is applied to the non-exempt part of floodplain harvesting only.

<sup>10</sup> This refers to all entitlements in the Gwydir Valley but the groundwater entitlements. These are distributed according to shares at 1 July 2008 for all pre and 2008 scenarios, and as at 1 July 2015 for all post-2008 scenarios, noting Supplementary groundwater entitlements were ceased to exist by start of 2015/16.

**Table 4 Total valley scale entitlements for scenarios (shares)**

Entitlement category	Pre-2008/09	2008/09	Post-2008/09
High security <sup>1</sup>	18,952	18,794	18,794
General security	509,369	509,585	509,585
Supplementary <sup>2</sup>	178,000	177,347	177,352
Stock & Domestic	2,788	2,744	2,744
Groundwater	38,785	27,259	20,282

Notes: <sup>1</sup> – includes Utility and other small non-irrigation licences; <sup>2</sup> – Supplementary entitlements were introduced with 2004 WSP (totalling 177,347 ML), replacing the previous valley-wide limit in the CAP scenario.

A significant amount of NSW entitlement was purchased by the Commonwealth and NSW governments for environmental water use<sup>11</sup>. This entitlement has been represented as a consumptive water use with an irrigation pattern in the Current Conditions Scenario as not enough is known regarding how this Held Environmental Water (HEW) will be used for environmental watering. This issue has been addressed in other reporting for Basin Plan compliance. We plan to explicitly represent how HEW is used in future versions of the model.

### 3.3.2 Development levels for scenarios

The farm development levels refer to the physical attributes of an irrigation property that provide ongoing capability to use water; specifically

- the area of the property that can be irrigated
- the additional area from which rainfall runoff can be harvested
- volumetric capacity of on-farm storages
- the rate at which water can be pumped both from the river as well as separately for floodplain harvesting.

Table 5 summarises the data types and sources of information used in each scenario.

<sup>11</sup> The entitlement data for the 2015/2016 water year included 4,508 ML of high security shares, 89,525 ML of general security shares, and 20,451 ML of supplementary access shares held by the Commonwealth for environmental water use. In addition, the NSW government holds 1,249 ML of high security shares, 17,092 ML of general security shares, and 3,141 ML of supplementary access shares for environmental water use. There has been no change to the number of shares held by the Commonwealth or NSW governments since then. The combined total represents around 19% of the total shares in the Gwydir regulated river system.

**Table 5 On-farm development data types and sources of information used for each scenario**

Farm development type	(Plan Limit) Cap	(Plan Limit) WSP	Eligible Development & Individual Impacts	Current Conditions & Valley Scale Compliance	Data sources
On-farm storage capacity (GL)	30 June 1994	30 June 2000	3 July 2008 <sup>1</sup>	2020	LIDAR / storage survey
On-farm storage pump capacity (ML/day)	30 June 1994 <sup>4</sup>	30 June 2000	3 July 2008 <sup>1</sup>	2020	NRAR works data <sup>2</sup>
Floodplain harvesting intake rate (ML/day)	30 June 1994 <sup>4</sup>	30 June 2000	3 July 2008 <sup>1</sup>	2020	NRAR works data <sup>2</sup>
River pump capacity (ML/day)	30 June 1994	30 June 2000	3 July 2008	2014	Farm survey <sup>3</sup> / WaterNSW records
Area developed for irrigation (ha)	30 June 1994	30 June 2000	3 July 2008	2020	Farm survey <sup>3</sup> and remote sensing
Maximum planted area (ha)	30 June 1994	30 June 2000	3 July 2008	2014	Farm survey <sup>3</sup> and remote sensing
Undeveloped farm area (ha)	30 June 1994	30 June 2000	3 July 2008	2014	Farm survey <sup>3</sup> and remote sensing

<sup>1</sup> Eligible works as defined by NRAR, which may include some storages developed after 2008

<sup>2</sup> NRAR works data are data collected under the policy, primarily from site inspections

<sup>3</sup> The Farm Survey dataset covers water years from 1993/94 to 2012/13 but does not include all years in between and does not specify exact dates. It did include 1993/94 and 99/00 so we have used that data for the Cap and Water Sharing Plan scenarios.

<sup>4</sup> Eligible works associated with storages existing in 1994.

The valley total data used for each scenario is summarised in Table 6. These data include all regulated water user nodes in the Gwydir regulated river system.

**Table 6 On-farm development levels for the four development scenarios<sup>1</sup>**

Farm development description	(Plan Limit) CAP	(Plan Limit) WSP	Eligible Development	Current Conditions
On-farm storage capacity (GL)	310.9	398.2	462.7	523.5
On-farm storage take rate <sup>1</sup> (ML/day)	31,033	39,421	47,393	48,390
Temporary storage capacity <sup>2</sup> (GL)	28.1	28.1	28.1	27.8
Floodplain harvesting intake <sup>1</sup> rate (ML/day)	67,868	67,868	67,868	70,142
River pump capacity <sup>3</sup> (ML/day)	20,162	20,162	20,162	20,162
Area developed for irrigation (ha)	121,030	129,466	134,061	134,467
Maximum summer crop area (ha)	92,341	99,655	100,768	99,988
Maximum winter crop area (ha)	5,817	5,817	17,799	17,799
Undeveloped farm area <sup>4</sup> (ha)	107,810	102,148	99,719	98,315

<sup>1</sup> Includes capacity of pumps and gravity pipes where appropriate and confirmed by NRAR. There is no information available prior to 2008/09, and the same rate is assumed for all pre-2008 scenarios where storages exist.

<sup>2</sup> Verified using Remote Sensing and confirmed by NRAR. There is no information available prior to 2008/09, and the same rate is assumed for all pre-2008 scenarios where storages exist.

<sup>3</sup> Operational rather than installed capacity is used in modelling.

<sup>4</sup> For properties where the area of irrigation fields has increased over time, the undeveloped area within the property has been reduced accordingly.

## On-farm storage capacity

We identified at an early stage that floodplain harvesting results are very sensitive to on-farm storage capacities. Significant effort has been put into improving the accuracy of this information by using LIDAR or photogrammetry data with verification against a sample of surveyed storages (Morrison and Chu 2018). Where survey data were available, it was reviewed as part of a submissions process and adopted where suitable. This process, including the function of the Healthy Floodplains Review Committee, is further described in the *Implementation Guideline* (DPE 2020).

NRAR determined which of these storages were eligible under the policy and this information was used in the Eligible Development Scenario.

We determined which storages existed at earlier dates by using Landsat satellite imagery.

## Pump capacity

River pump capacity was based on farm survey data for all floodplain harvesting properties which provided the data and WaterNSW's data on historical water use and/or orders for the remaining properties and other small users.

On-farm storage pump capacity was estimated using NRAR works data. These data were developed based on on-site inspections that documented the size and type of work, including any

upgrades. For a given pump type and size, a standard set of rates were adopted to determine the total on-farm storage pump capacity<sup>12</sup>.

NRAR determined which pumps should be included in the Eligible Development Scenario. The on-farm storage capacity for earlier dates was based on the analysis of which storages existed at that date. Where there was no evidence that the storage existed at that date, the capacity of the associated lift pumps associated with that storage was not included in the Plan Limit Scenario. Farm survey data were also reviewed for information on pump upgrades.

The rate of intake of floodplain harvesting water into the property is generally set to the on-farm storage pump rate. Exceptions to this include either a lower rate where the intake is restricted by pipe capacities, or a higher rate to represent gravity filling of significant buffer storages<sup>13</sup>.

An example, with diagram, to describe how the storage capacity, pump capacity and floodplain harvesting capacity were determined for different scenarios is provided in Appendix B .

### **Developed and undeveloped areas**

The developed area refers to the area developed for irrigated cropping. Both developed and undeveloped areas were based on farm survey data for all floodplain harvesting properties<sup>14</sup>. For other relatively small water users, this information was based on earlier survey data as per the existing IQQM water sharing plan model (DNRM & DLWC 1998).

#### **3.3.3 Crop model and planting decisions**

Irrigation water use is estimated using a crop model component which: (i) estimates how much area is planted in that year based on water availability; and (ii) estimates irrigation water demand on the basis of daily historical climate data. The crop area planting component was derived by combining published data, farm surveys and remote sensing as described in the companion Model Build report.

The crop model and planting decisions parameters and settings are the same as those in the 2008/09 Scenario and are fully described in the companion Model Build report.

#### **3.3.4 Management rules**

All scenarios, with the exception of the CAP Scenario, include the Gwydir WSP rules as described in the companion Model Build report.

- The Cap Scenario includes changes to a range of water management rules, including supplementary access rules, environmental flow rules, and allocation rules.
- The proposed floodplain harvesting accounting rules are included in the two scenarios which test the impact of these rules, i.e. the Valley Scale Compliance Scenario and the Individual Impact Scenario.

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<sup>12</sup> Rates are described in Appendix G of the companion Model Build Report (DPE Water, 2021a)

<sup>13</sup> These rate exceptions are further described, with examples, in Appendix G of DPE Water (2021a).

<sup>14</sup> Some of the data was amended following farm data validation and submission process in 2020.

## 4 Results

The key results from running the scenarios through the Gwydir Valley model relate to long term average diversions prior to and with the estimated entitlements. These are reported in summary tabular and graphical format at valley scale in this section.

Diversions are reported for each entitlement category for the 1895 to 2009 Basin Plan comparison period and include annual time series graphs for total diversions. From this reporting, we are able to provide some commentary on key differences between scenarios.

The versions of the model used to run the scenarios are listed in Appendix C.

### 4.1 Plan Limit Scenario results

The Cap Scenario has a larger (0.7%) long-term average total diversion than the WSP Scenario (Table 7). This means that the WSP Scenario defines the plan limit and is referred to hereafter as the Plan Limit Scenario.

**Table 7 Long term (1895-2009) average total diversion under the Cap and WSP Scenarios**

Diversion component	CAP Scenario (GL/year)	WSP Scenario (GL/year)
General and high security <sup>1</sup>	218.8	215.0
Supplementary access	115.3	91.1
Floodplain harvesting		
Overbank flow harvesting	74.0	91.8
Non-exempt rainfall runoff harvesting	10.1	12.6
Exempt rainfall runoff harvesting	28.2	32.9
<b>Total (less exempt rainfall runoff)</b>	<b>418.2</b>	<b>410.5</b>
<b>Total</b>	<b>446.4</b>	<b>443.4</b>

<sup>1</sup>Includes 3.8 GL/year of diversions by Local Water Utilities.

Note: diversion categories may not add to totals exactly due to rounding

### 4.2 Growth in use assessment

The Plan Limit Scenario and Current Conditions Scenario were both configured in the Gwydir Valley model and run for the period of climate record (1890 to 2019). Results for the benchmark climate period defined in the Basin Plan (1 July 1895 to 30 June 2009) for categories of diversions were calculated and are summarised in Table 8.

**Table 8 Predicted long term (1895 to 2009) average diversions (GL/year) under the Plan Limit (WSP) Scenario and Current Conditions Scenarios to determine growth in use**

<b>Diversions component</b>	<b>Plan Limit Scenario (GL/year)</b>	<b>Current Conditions Scenario (GL/year)</b>
General and high security	215.0	217.7
Supplementary access	91.1	93.0
Floodplain harvesting		
Overbank flow harvesting	91.8	121.6
Non-exempt rainfall runoff harvesting	12.6	15.5
Exempt rainfall runoff harvesting	32.9	36.4
<b>Total (less exempt rainfall runoff)</b>	<b>410.5</b>	<b>447.7</b>
<b>Total</b>	<b>443.4</b>	<b>484.1</b>

Note: diversion categories may not add to totals exactly due to rounding

With the tailwater exemption in place, these results show that total long-term average diversions have increased by 37.2 GL/year, an increase of 9.1%. This growth needs to be reversed through the implementation of the *policy* by introducing entitlements and accounting rules.

Without the tailwater exemption in place, these results show that total long-term diversions have increased by 40.7 GL/year above the level in the Plan Limit Scenario, an increase of 9.2%.

### 4.3 Plan limit compliance results

The implementation of the Valley Scale Compliance Scenario (Section 3.2.4) brought the floodplain harvesting component of the Gwydir regulated river system within plan limit levels as reported in Table 9. There were minor changes in other components that exceed Plan Limit levels but are still less than the growth-in-use provisions of the Gwydir WSP.

**Table 9 Modelled long term (1895 to 2009) average annual diversions (GL/year) under the Valley Scale Compliance Scenario compared to the Plan limit**

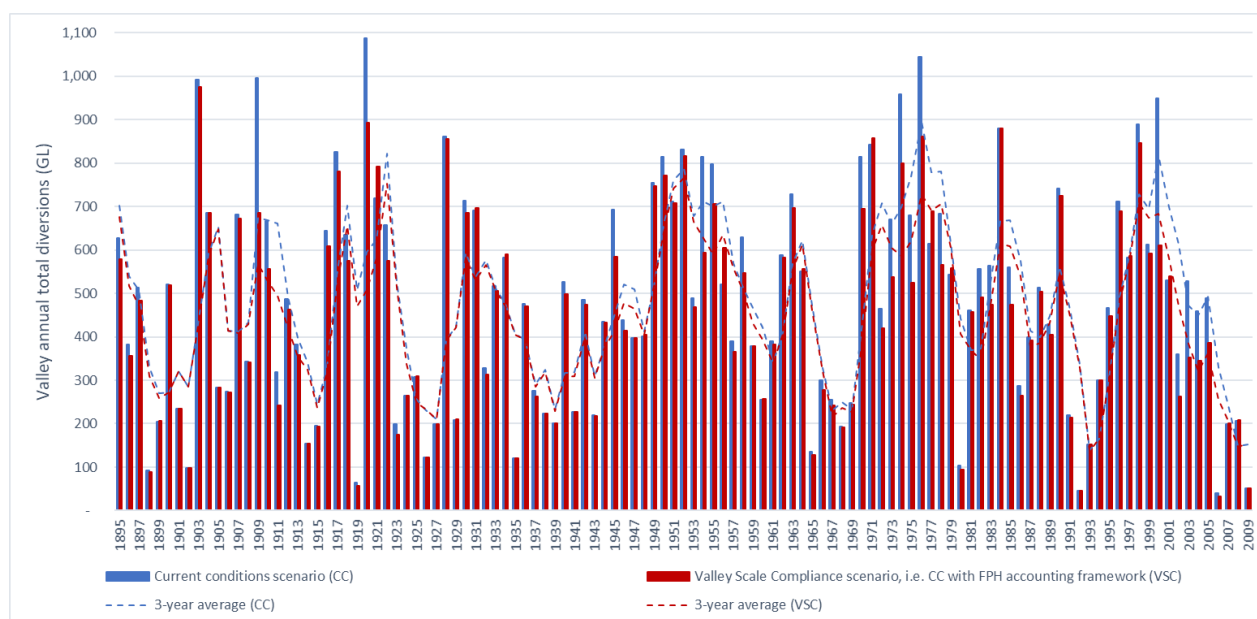
<b>Diversions category</b>	<b>Plan Limit Scenario (GL/year)</b>	<b>Valley Scale Compliance Scenario (GL/year)</b>
General and high security	215.0	220.6
Supplementary access	91.1	92.8
Floodplain harvesting		
Overbank flow harvesting	91.8	82.7
Non-exempt rainfall runoff harvesting	12.6	11.3
Exempt rainfall runoff harvesting	32.9	42.7
<b>Total (less exempt rainfall runoff)</b>	<b>410.5</b>	<b>407.5</b>
<b>Total</b>	<b>443.4</b>	<b>450.2</b>

Note: diversion categories may not add to totals exactly due to rounding

The entitlements and account management rules will not have impacts on floodplain harvesting diversions in every year. In some years there will be no impact. The impacts will typically be during extended wet periods when water accounts reach zero.

The variable impacts in total annual diversions over the benchmark climate period (1895 to 2009) are shown in Figure 3. The columns show the year to year variation with little apparent variation for most years. Most years are marginally lower, with some years marginally higher. The effect is more clearly demonstrated by the solid lines showing the average of the prior three years of diversions. This shows that the greatest impact is apparent during wet periods when the accounting rules restrict diversions after the first wet year. Examples of this are apparent during mid-1900s, early parts of the 1950s, 1970s and 2000s.





**Figure 3 Predicted annual total diversions over the benchmark climate period (1895 to 2009) under the Current Conditions and Valley Scale Compliance (with accounting) scenarios. The plot also includes the three-year moving average for both results**

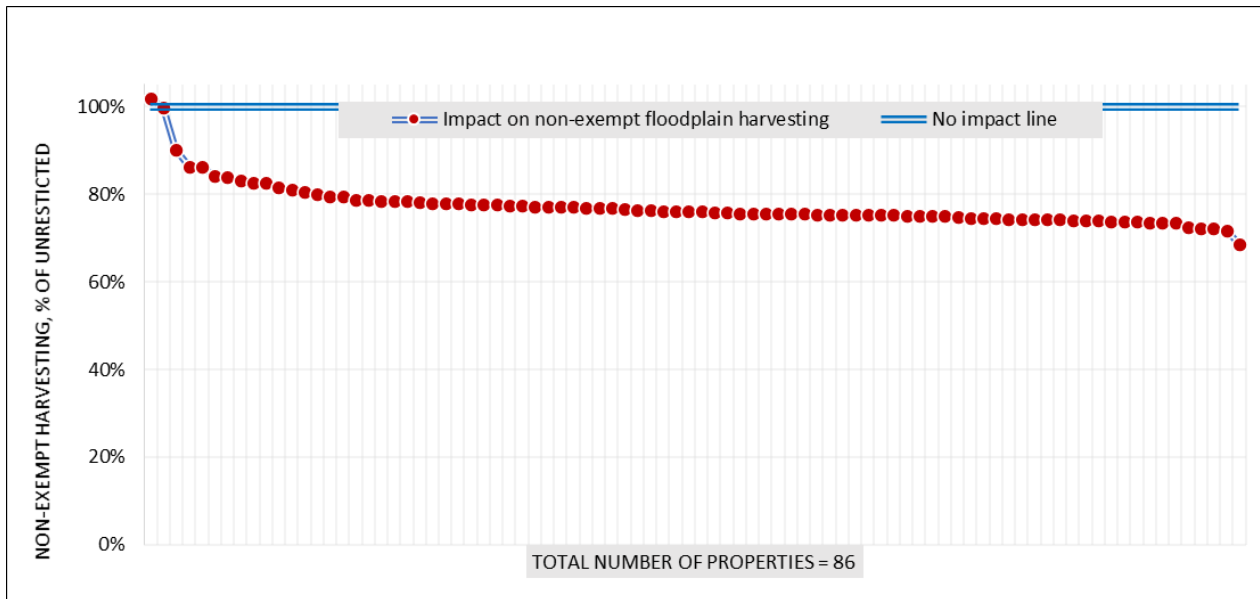
## 4.4 Entitlement distribution

The entitlements have been designed so that the impacts required to remove growth in diversions above the plan limit are shared equitably. Impacts on individuals were tested using the Plan Limit Individual Impacts Scenario<sup>15</sup>. This test allowed us to isolate all other changes which may have occurred in recent years (e.g. changes in other entitlement products). The results confirm that the relative impacts on individual properties are very similar over the long-term period.

Under implementation of this scenario, individual properties have an overall reduction in the non-exempt floodplain harvesting diversion component over the 1895 to 2009 reporting period of 24.8% to ensure total valley diversions are within the plan limit. Figure 4 shows the change in percentage of non-exempt floodplain harvesting diversions pre and post the licensing framework (in both cases using the Eligible Development Scenario) across the 86 properties or groups of properties<sup>16</sup>. In some cases, the model indicates that some properties have impacts which are less than the overall 24.8% reduction. This is because when we model the rules, the reduction in upstream diversions increases the water availability for downstream properties. We have made a similar comparison using total diversions which demonstrates smaller impacts and less variability in impacts. Some properties will also have greater impacts as they have ineligible works which are not included in the entitlement determination process.

<sup>15</sup> As described in Section 3.2.4, the Individual Impacts Scenario was created by adding the entitlements and accounting rules to the Eligible Development Scenario.

<sup>16</sup> Those Irrigation farms that were assessed as eligible for floodplain harvesting entitlements have been represented in the model individually or as a group. The remaining, generally smaller, farms and other water users have been aggregated in the model within the reach they are located. As a result, 114 individual eligible floodplain harvesting farms within Gwydir Regulated Water Sharing Plan area were represented using 86 *Irrigator nodes*, of which 13 represent groups of up to five individual eligible properties (mostly enterprises consisting of several properties with one owner and properties that have been subdivided post 2008). There are several Irrigation Nodes representing Unregulated or Groundwater water only floodplain harvesting properties and the model is not used for their floodplain harvesting assessment. (Sourced from Section 6.2.2 DPE Water 2021a)



**Figure 4 Distribution of change in floodplain harvesting diversions for individual properties under the Individual Impacts Scenario. The x-axis is the number of individual eligible properties represented in the Gwydir Valley model (each data point represents individual property as modelled)**

## 5 Conclusions and future work

Water Sharing Plans (WSPs) made under the *Water Management Act 2000* define how the limits to extractions are to be calculated within NSW water sources. The WSPs include an estimate of these limits which are also used as estimates of the Baseline Diversion Limit (BDL) and included in the Basin Plan. The Basin Plan allows for BDL estimates to be revised whenever a demonstrably better estimate is available.

The river system models used for the original WSPs and BDL estimates represent river diversions and flows to the best available standard of accuracy at that time and were independently reviewed as fit for that purpose; however, the floodplain harvesting diversions were not well represented.

As part of the *NSW Floodplain Harvesting Policy*, there has been significant investment in data and modelling to quantify floodplain harvesting more accurately. This has been incorporated into the current IQQM Model of the Gwydir Valley Regulated River System. The development of the model is described in the companion Model Build report (DPE Water 2021a).

The model has been used to create an updated estimate of the Long-Term Average Annual Extraction Limit (LTAAEL), or plan limit, as defined by the Gwydir WSP. This model will also be used to determine regulated river floodplain harvesting entitlements in the Gwydir Valley regulated river system. Through the analyses reported in this report, we have demonstrated that the proposed entitlements and accounting rules can equitably manage floodplain harvesting such that total diversions are managed within the required limits.

The work undertaken as part of implementing the policy has substantially reduced uncertainty in our estimates for floodplain harvesting. Despite this improvement, uncertainty can be further reduced with better information. The companion Model Build Report (DPE Water 2021a) lists several areas of future work. Three key areas of improvement are:

- review of floodplain harvesting measurement data following implementation of the policy to determine whether any further model improvements are required
- continued update of the Current Conditions Scenario, including consideration of irrigation behaviour changes and management of held environmental water
- better representation of return flows from floodplains to river channels. This will require further research to develop a methodology for addressing this limitation in the models.

## 6 References

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(NSW) *Water Management Act 2000* No 92. Last updated 2020.  
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*NSW Floodplain Harvesting Policy*. First published May 2013, updated September 2018.  
[http://www.water.nsw.gov.au/\\_\\_data/assets/pdf\\_file/0012/548499/floodplain\\_harvesting\\_Policy.pdf](http://www.water.nsw.gov.au/__data/assets/pdf_file/0012/548499/floodplain_harvesting_Policy.pdf). Referred to in this report as the policy

### Gwydir specific

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## Appendix A Illustration of accounting rules

Table 10 illustrates how the proposed 5 yearly accounting rules work. The example does not include some of the account initialisation rules. The example is for a floodplain harvesting entitlement of 3,850 ML. Table 10 shows, for every year:

- unrestricted usage – the volume that could be harvested if no rules were in place
- restricted usage – how much could have been harvested with eligible works after the accounting rules are in place. It is the lesser of the unrestricted usage and the opening account balance
- opening and closing accounts keep track of the accounting rules:
  - the closing account is the opening account minus the usage (restricted usage)
  - the opening account is equal to the closing account from the prior year plus the annual water determination (AWD) of 100% (3,850 ML). The account is limited to the account balance limit of 500% of the entitlement (5 x 3,850 ML = 19,250). Any volume above this is forfeited.

**Table 10 Example of annual floodplain harvesting under 5-year accounting rules**

Year	Unrestricted usage (ML)	Opening account (ML)	Restricted usage (ML)	Closing account (ML)
1	2,658	19,250	2,658a	16,592
2	586	19,250b	586	18,664
3	90	19,250	90	19,160
4	0	19,250	0	19,250
5	13,592	19,250	13,592	5,658
6	0	9,508	0	9,508
7	11,979	13,358	11,979	1,379
8	0	5,229	0	5,229
9	10,615	9,079	9,079c	0
10	8,344	3,850	3,850c	0
11	407	3,850	407	3,443
12	0	7,293	0	7,293
13	4,723	11,143	4,723	6,421
14	138	10,271	138	10,133
15	0	13,983	0	13,983
16	6,838	17,833	6,838	10,994

Year	Unrestricted usage (ML)	Opening account (ML)	Restricted usage (ML)	Closing account (ML)
17	226	14,844	226	14,618
Total	60,197		54,166	

<sup>a</sup> the account opens full at 500% of entitlement. The account balance is greater than unrestricted harvesting so there is no impact in this year and 2,658 ML is harvested.

<sup>b</sup> the account closed at 16,592 in the previous year and then 100% AWD is added at the start of the water year to give a total of 20,442ML. This is greater than the account balance limit, so the opening account is reduced to the limit of 19,250ML.

<sup>c</sup> the unrestricted usage is larger than the opening account balance, so harvesting is reduced in these years

You can see that in most years the accounting rules have no impact on harvesting; it is only in a cluster of wetter years that there are impacts. In this example, the entitlement, in conjunction with the rules, resulted in total harvesting over the period being reduced by 10%. This is a hypothetical example, for illustrative purposes.

We follow a similar process to determine entitlements with the exception that we use long term results. We scale the entitlements up and down until the required impact is achieved. This means that the determination of entitlement is dependent on the accounting rules adopted as the two things work together in the assessment to achieve the required impact.

## Appendix B Worked example for development levels (scenarios)

The following describes an example property in the Border Rivers where there are multiple storages and floodplain harvesting intake points. Figure 5 is a schematic of the property. Data in this example are hypothetical, for the purposes of illustrating the modelling method.

The property has multiple works:

- two eligible storages with a total estimated pump capacity of 720 ML/day based on the works installed. Both storages were present at June 1994
- one ineligible storage built after 2008. The lift pumps associated with this storage (capacity 4,320 ML) have an estimated combined capacity of 360 ML/day
- multiple pipes bring water in from the channels into the developed part of the farm and allow delivery to the storages. The total capacity of these pipes was estimated at 768 ML/day assuming a 0.2m head.

For the Eligible Development Scenario, the on-farm storage pumps were considered the limiting factor. For the Current Conditions Scenario, the intake pipes are smaller in capacity and hence are adopted for the intake rate (Table 11).

**Table 11 Hypothetical property works and their sizing under the various model scenarios**

Parameter	Plan Limit – Cap & WSP Scenarios	Eligible Development Scenario	Current Conditions Scenario
On-farm storage capacity (ML)	6,520	6,520	10,822
On-farm storage pumps (ML/day)	720	720	1,080
Floodplain harvesting intake rate (ML/day)	720	720	768

The capacity of pumps and pipes are all determined using farm inspection works data provided by NRAR and standard rates for each type and size of work. This is described further in Appendix G4 of the companion Model Build report (DPE Water 2021a). In some cases, there was additional and/or supporting information provided by the landholders during submission process about higher capacity and upgrades to pumps and pipes both on storages and elsewhere at the property. The information was sometimes contained in the farm survey or NRAR notes; these were reviewed and adopted where relevant for historical scenarios.

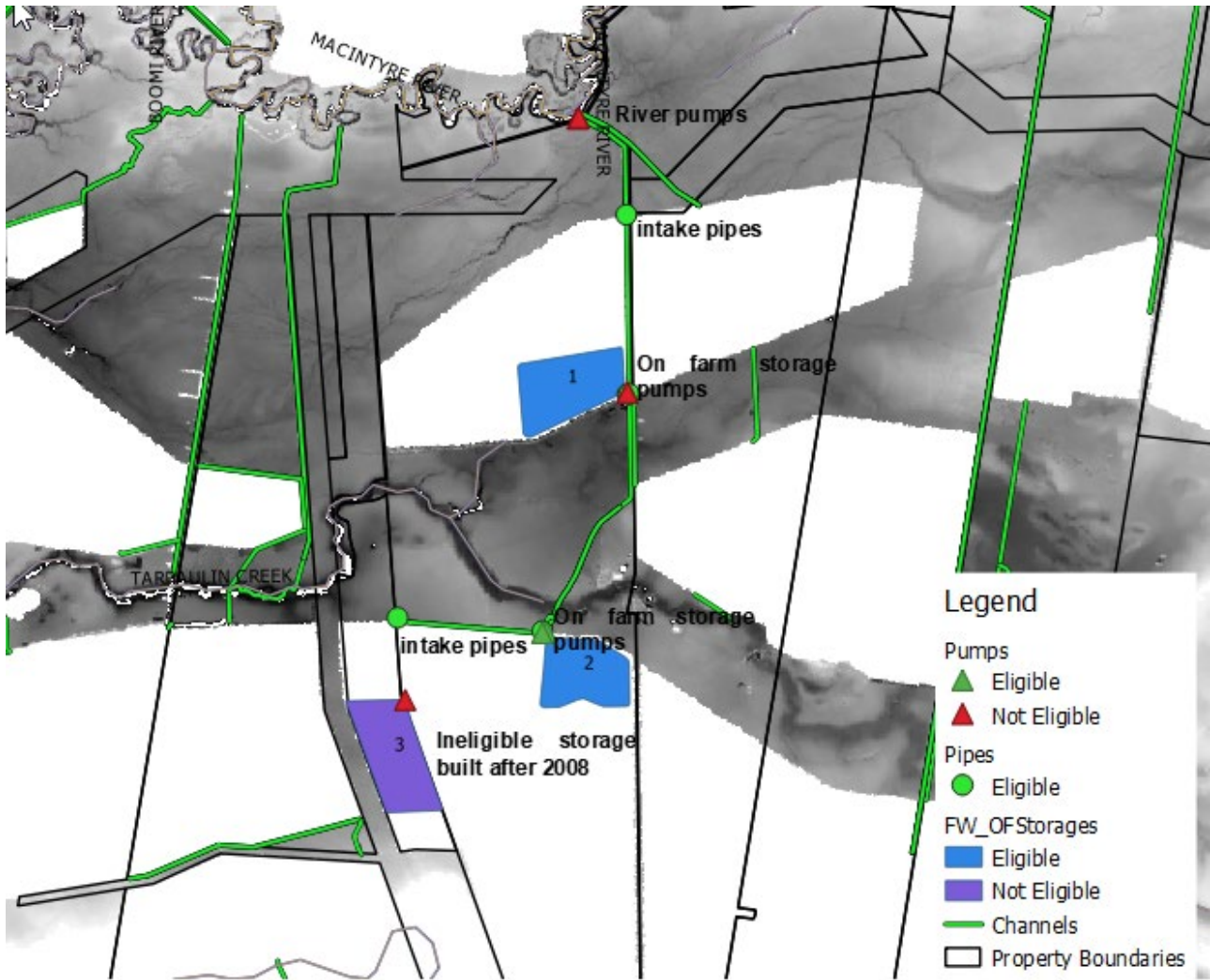


Figure 5 Example property with multiple storages and intakes



## Appendix C Model version

All scenarios have been developed based on the following version of the model software:

- IQQM Version: 7.103.0 RC4 [Rev4104]; Date: 2021/03/22 09:43am

Each scenario is implemented by creating a different input set contained within the scenario file. The separate scenario files are as follows.

**Table 12 Input sets for model scenarios**

Scenario	Scenario Input Set
Cap Scenario	CAP_v27_11.sqq
Plan Limit (WSP) Scenario	BDL_v27_11.sqq
Current Infrastructure Scenario	CC_v27-11.sqq
Eligible Development Scenario	0809_eligible_v27-11.sqq
Individual Impacts Scenario	IIS_v27_11.sqq
Valley Scale Compliance Scenario	VSC_v27_11.sqq

## Appendix D Glossary and abbreviations

**Table 13 Abbreviations and acronyms**

Abbreviation/ acronym	Expansion
BDL	Baseline diversion limit
HEW	Held environmental water (by the Commonwealth Environmental Water Office and the NSW Department of Planning Industry and Environment)
LTAEL	Long term average annual extraction limit
MDBMC	Murray Darling Basin Management Committee
NRAR	Natural Resources Access Regulator
OFS	On-farm storage
SDL	Sustainable diversion limit
WSP	Water Sharing Plan

**Table 14 Terms**

Term	Description
2008/09 Scenario	Model baseline scenario representing floodplain harvesting works in place in 2008/09. The derivation of this baseline scenario is described in companion Model Build report
2020/21 water year	A water year runs from 1 July to 30 June, in this example from 1 July 2020 to 30 June 2021. A slash is used to identify this and to be consistent with Basin legislation. (2020–2021 would refer to the range of years, 2020 and 2021)
Cap Scenario	Model scenario that reflects agreements made under the Murray Darling Basin Ministerial Council Cap on diversions. Candidate for the Plan Limit Scenario (details in 3.2.1)
Current Conditions Scenario	Model scenario that uses the best available information on most recent known levels of irrigation infrastructure and entitlements (details in Section 3.2.2)
Eligible Development Scenario	Model scenario used to estimate the floodplain harvesting that would have occurred with only eligible infrastructure (details in Section 3.2.3)
Long-term average annual extraction limit (LTAEL)	The upper limit on the average of annual extractions from the water source over the period for which an assessment is carried out. (Source: <a href="https://www.waternsw.com.au/customer-service/service-and-help/tips/glossary#l">https://www.waternsw.com.au/customer-service/service-and-help/tips/glossary#l</a> )

Term	Description
Gwydir WSP	Shortened term for the Water Sharing Plan for the Gwydir Regulated River Water Source
Plan limit	The authorised long-term average annual extraction limit (LTAAEL) as defined in the Water Sharing Plan
Plan limit compliance	Compliance with the plan limit, which is assessed using long-term modelling.