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Macro water sharing plans – the approach for groundwater

A report to assist community consultation

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1 Planning for groundwater sharing

1.1 Groundwater and aquifers

Groundwater is the water that occurs beneath the ground surface in the saturated zone.

An aquifer is a geological structure or formation, or an artificial landfill that is permeated with water or is capable of being permeated with water.[1]

Groundwater can be found in all areas of NSW, although its yield and quality vary widely. It is an important resource for many landholders who extract water from the ground for domestic and stock purposes, which is a basic landholder right under the *Water Management Act 2000* (WMA 2000). In addition, many towns, industries and irrigators rely on groundwater extraction to support their activities.

Groundwater is also important for the environment. Its extraction can impact on both the integrity of a groundwater system and the health of its dependent ecosystems. Over-extraction can have serious, long-term and sometimes permanent impacts that may ultimately reduce the volume of water available for groundwater-dependent ecosystems and other users.

Groundwater is an important resource for NSW Aboriginal people both in the present but also in the past. This is evident in the 60,000 year connection through Dreamtime stories, dances and song lines. As groundwater can be a source of water in a dry landscape, is deemed culturally significant and has been key to Aboriginal survival for the many millenia. Today, Aboriginal communities rely on groundwater as a source for town water supply, as a basic landholder right, maintenance of culture,community development and survival. In the 1990s, increased pressure from extraction and the declining health of our water resources highlighted the need to review water sharing strategies in NSW. Environmental water rules were introduced in 1997 for all of the major river systems in the NSW part of the Murray-Darling Basin. In 2001 NSW began developing water sharing plans for surface water and groundwater systems under the WMA 2000. These water sharing plans aim to:

- clarify the rights of the environment, basic landholder rights users, town water suppliers and other licensed users
- define the long-term average annual extraction limit (LTAAEL) for water sources
- set rules to manage impacts of extraction
- facilitate the trading of water between users.

The first round of water sharing plans was finalised between 2004 and 2008. These water sharing plans cover all the major regulated[2] river systems, their associated major groundwater systems and a number of unregulated systems. These plans were prepared as Minister's plans under section 50 of the WMA 2000 and each one was developed with the assistance of a water management committee, established to advise the Minister as they were being developed. The groundwater systems covered by these water sharing plans have been intensively managed for many years, as they are high-yielding and have high levels of extraction by water users. They include the major inland alluvial groundwater systems in the Lower Gwydir, Lower Lachlan, Lower Macquarie, Lower Murray, Lower Murrumbidgee, and the Upper and Lower Namoi.

The plans developed for the remaining major groundwater systems in NSW cover much larger areas than each of the first round plans. These are called 'macro' water sharing plans.

[1] *Water Management Act 2000*, Dictionary section.
[2] Regulated river systems are those with major State owned and operated dams and declared as regulated under State legislation, which were built mainly for irrigation purposes.

The groundwater systems covered in each of these plans are divided into 'water sources'[3]. See www.water.nsw.gov.au for a current list of existing plans covering groundwater.

This document explains the work that began in 2004 to develop macro water sharing plans to cover all remaining groundwater sources in NSW. This work is ongoing and the process will continue to be refined.

1.2 National water reform

The National Water Initiative (NWI)[4] was signed by NSW in 2004 and the Commonwealth *Water Act 2007* has commenced. This Act requires a Murray Darling Basin Plan ('Basin Plan') to be developed. The Basin Plan commenced in November 2012. It sets limits on the quantities of surface water and groundwater that can be taken from the Murray-Darling Basin.

All NSW water sharing plans located within the Murray Darling Basin commenced prior to the commencement of the Basin Plan. Water sources in the Great Artesian Basin (proper) and North West NSW are not included in the Basin Plan.

Water sharing plans that commenced prior to 25 January 2007 are termed 'transitional plans' under the *Water Act 2007* and are listed in Schedule 4 of the Water Act. These plans expire 10 years from their date of commencement. The major NSW inland alluvial groundwater system water sharing plans fall within this status. Water sharing plans that commenced after the 25 January 2007 are termed 'interim plans' under the *Water Act 2007.* These plans expire at 31 December 2014 or 5 years from their commencement date, whichever is the later. NSW water sharing plans relating to hard rock aquifers and the shallow Great Artesian Basin fall within this status. States are working with the Commonwealth to provide for the extension of the plans under Commonwealth legislation to allow for them to be made as Water Resource Plans.

NSW signed up to implementing the Basin Plan in 2014. Under the Basin Plan agreement NSW is required to develop water resource plans that are consistent with the Murray Darling Basin Plan by 2019 (or 2017 for pilot WRP areas). Water resource plans will be broader than water sharing plans; however NSW's water sharing plans are expected to form a component of the broader water resource plans.

1.3 What's in a NSW water sharing plan for groundwater?

Water sharing plans made under the WMA 2000 are prepared as Minister's plans under Section 50 of the Act.

Water sharing plans for groundwater specify:

- water sources covered by the plan (see 3.1)
- environmental water provisions (see 3.2)
- requirements for water for basic landholder rights (see 3.3)
- requirements for water for extraction under access licences (see 3.4)
- limits to the availability of water – specified as long-term average annual extraction limits (see 3.5) and groundwater storage extraction limits (see 3.5.4 and 3.5.5)
- limits to the availability of water – available water determinations (see 3.6)
- rules for granting access licences (see 3.7)
- rules for managing access licences (see 3.8)
- rules for water supply work approvals (see 3.9)

[3] A 'water source' can also be a river or part of a river system.
[4] Council of Australian Governments, 2004. For further details please see www.coag.gov.au

- access licence dealing rules (see 3.10)
- mandatory conditions on access licences and water supply work approvals (see 3.11)
- rules on how the plan may be amended (see 3.12).

Each of these topics is explained in detail in Part 3.

1.4 Principles at a glance

The following principles inform the development of water sharing plans:

1.4.1 Water sources covered by the plan

Principle 1 – Boundaries are defined for plans and water sources that:

- are geologically appropriate
- are administratively practical
- consider the degree of hydraulic connection
- are geographically acceptable.

Principle 2 – Within the boundary of a plan, water sources are defined based on hydrogeological types.

Principle 3 – Hydrogeological units of similar type may be grouped together to form one groundwater source.

Principle 4 – Groundwater sources with little or no surface expression may be identified as partly or fully buried.

Principle 5 – Most alluvial groundwater sources have a relatively high degree of connectivity with their associated surface water sources. Accordingly, most alluvial water sources are included in a water sharing plan that covers both surface water and its connected alluvial groundwater. Most porous rock, fractured rock and coastal sands groundwater systems, however, are considered to have a lesser degree of connectivity and so are included in plans that only cover groundwater.

Principle 6 – There are four broad boundaries for macro planning based on administrative requirements:

- Coastal NSW.
- Murray-Darling Basin NSW.
- Great Artesian Basin (GAB) NSW.
- North-western NSW (outside both the Murray-Darling Basin and the GAB).

Principle 7 – Plan boundaries should be geographically logical and understandable to the communities to which they apply.

1.4.2 Environmental water provisions

Principle 8 – Water is reserved for the environment in each water source in a water sharing plan.

Principle 9 – Recharge is used as a basis for water sharing between the environment and extractive users. Recharge is calculated on a long-term average annual basis.

1.4.3 Requirements for water for basic landholder rights

Principle 10 – Plans define a total volume of water required to meet the needs of holders of basic landholder rights (BLR) in each water source, based on an estimate of their usage.

Principle 11 – Two methods for estimating basic landholder rights have been adopted. The method that has been applied depends on the groundwater source type and location. These estimates will be based on the best available information but may change over time should improved information become available.

1.4.4 Requirements for water extraction under access licences

Principle 12 – Plans recognise the existing licensed entitlements in each groundwater source.

1.4.5 Limits to the availability of water

Principle 13 – Best available information is used for setting long-term average annual extraction limits (LTAAELs).

Principle 14 – Plans set LTAAELs for all water sources.

Principle 15 – Some buried or partly buried porous rock water sources that receive little or no recharge from rainfall may have a groundwater storage extraction limit, which allows a very small portion of storage to be made available for extraction, in addition to the recharge-based LTAAEL.

Principle 16 – Inter-linkages between surface and groundwater water sources are to be considered in setting LTAAELs in plan areas.

Principle 17 – Current levels of entitlement in coastal alluvial groundwater sources are considered to have acceptable impacts on surface water sources.

Principle 18 – Current levels of groundwater pumping from alluvial and other highly connected groundwater sources in the Murray-Darling Basin are considered to have acceptable impacts on surface water sources.

Principle 19 – Rules that mitigate identified risks can be applied to protect the resource from the impacts of extraction, minimising the risk to the groundwater system yet increasing the portion of water available for extraction and therefore reducing the socio-economic risk to those communities and enterprises that rely on the groundwater source.

Principle 20 – Risks to surface and groundwater sources can be addressed through specific management rules in the plan.

Principle 21 – Available water determinations (AWDs) are used to manage growth in use above the LTAAEL by reducing the maximum AWD that can be credited to accounts during a water year.

Principle 22 – Any groundwater taken, whether deliberately or unintentionally, through aquifer interference activities is accounted for within the LTAAEL.

Principle 23 – Plans include provisions for AWDs to be made to credit water to access licence water accounts.

Principle 24 – Alluvial groundwater systems that are highly connected to regulated rivers have specific rules that recognise the level of connectivity, by linking the AWDs for the groundwater to the AWDs for the surface water.

Principle 25 – Compliance with the LTAAEL is the primary tool for managing annual extraction volumes.

Principle 26 – Entitlement reduction will not be undertaken where entitlement is greater than the LTAAEL.

Principle 27 – Before any unassigned water is released through a controlled allocation order made under section 65 of the WMA 2000, future priority extraction requirements for that water source must be considered.

1.4.6 Rules for granting access licences

Principle 28 – Plans may allow new specific purpose access licences to be granted under the WMA 2000 and may limit the volumes that may be granted under these licences.

1.4.7 Rules for managing access licences

Principle 29 – Accounting rules recognise the capacity of the groundwater source to cope with variability around annual extraction limits (i.e. to permit unused allocations to be carried over and extracted in the next water year).

Principle 30 – Connectivity between groundwater sources and surface water is considered when setting access rules. This is done to limit the impacts of groundwater pumping on surface water flows.

Principle 31 – 'Highly connected' systems for the purposes of applying management rules are defined as those systems where 70 percent or more of the groundwater extraction volume is derived from surface water within an irrigation season. All other systems are considered 'less highly connected'.

Principle 32 – For management purposes, highly connected alluvial groundwater sources and their associated river reaches are classified as regulated, perennial, or non-perennial to determine the type of management rules required.

Principle 33 – Alluvial groundwater systems that are highly connected to perennial unregulated systems have specific rules that recognise the level of connectivity based on daily access linking their management to the associated unregulated surface water daily access rules. Non-perennial systems will have groundwater only rules.

1.4.8 Rules for water supply work approvals

Principle 34 – Plans include rules on the location of new works and extraction from existing works to limit impacts on surface water base flows, sensitive environment areas, groundwater dependent ecosystems, Aboriginal culturally significant sites and other water users.

Principle 35 – Plans provide rules for replacement works to acknowledge usage rights related to existing water supply works.

Principle 36 – Plans identify high priority groundwater dependent ecosystems (GDEs). The high priority GDEs are to be protected from future impacts of extraction by limits on placement of new works and by limiting extractions from existing works within specified distance criteria around the GDE.

Principle 37 - Plans identify high priority Aboriginal groundwater dependent culturally significant sites, Thehigh priority sites are to be protected from future impacts of extraction by limits on placement of new works and by limiting extractions from existing works within specified distance criteria around the Aboriginal groundwater dependent culturally significant sites. The location of high priority Aboriginal groundwater dependent culturally significant sites are listed in the Aboriginal Water Initiative System database (AWIS), maintained by the Aboriginal Water Initiative (AWI) team.

1.4.9 Access licence dealing rules

Principle 38 – Plans include dealings rules that encourage trade while protecting environmental values and minimising third party impacts.

1.4.10 Rules on how the plan may be amended

Principle 39 – Plan development is based on the best available information. A lack of information should not prevent planning being undertaken. Planning should recognise the limitations on which it is based, and where possible allow for amendments to be made to the plan when further information becomes available.

2 Process for developing macro plans

2.1 Development approach

Water sharing plans are developed through a 'macro' process involving technical assessments, classification and development of appropriate rules by interagency panels. This approach enables extraction limits and rules to be developed and applied across a number of groundwater sources reasonably quickly and cost-effectively. The plans contain many generic rules that apply to all groundwater users and some more specific rules to manage issues in particular areas. An outline of the approach taken to develop water sharing plans is shown in Appendix 1: Diagram showing the process for developing groundwater sharing plans.

2.2 Project groups

In 2005 a State Groundwater Panel was established to oversee the development of policy for the macro water sharing planning process for groundwater. This Panel has members from Department of Primary Industries, Water (DPI Water) (chair), Office of Environment and Heritage (OEH), and Industry & Investment NSW. Local Land Services is also represented by an inland and coastal representative.

In 2006 regional assessment working groups, including various representatives from within DPI Water, completed risk assessments for each groundwater source and developed draft rules. This information was provided to the State Groundwater Panel for consideration at a state scale, as many groundwater sources extend over large areas covered by multiple working groups. The State Groundwater Panel reviewed the information to ensure an optimal balance between consistency across groundwater sources and recognition of local factors. It has had an ongoing role in water sharing plan development for groundwater to ensure that plan rules are practical, easily understood and capable of being implemented.

A State Interagency Panel, with members from the same government organisations as the State Groundwater Panel, is responsible for overseeing policy and planning development for both surface water and groundwater plans. This panel ensures that the interaction between groundwater and surface water is properly considered and reflected in plan rules, although in some areas the regional interagency panels provide more tailored application of policy. For example, alluvial groundwater systems are closely linked to the associated unregulated system and the relevant regional panel can provide further refinement to rules.

The Aboriginal Water Initiative within DPI Water will provide the opportunity to engage the relevant Aboriginal community's prior to public exhibition of a plan, enabling the AWI to inform the community of the process and identify any Aboriginal groundwater dependent culturally significant sites that require protection under the plan.

2.3 Consultation and plan finalisation

Major stakeholder organisations and community members have knowledge and expertise which is essential for the development of macro plans. The draft water sharing plan rules, therefore, are taken to targeted consultation with major stakeholder organisations prior to public consultation of the draft plan. These organisation include water users associations, Aboriginal communities, environmental groups, local governments and major utilities Feedback received during this time is considered by the panels and amendments may be made as a result.

The draft water sharing plan is then placed on public exhibition. DPI Water manages the consultation process, and ensures that stakeholders and other interested parties have an opportunity to review the proposed plans. In particular, public exhibition aims to:

- identify local knowledge and expertise to complete existing information sets; for example, there may be further Aboriginal culturally significant groundwater values, environmental values and socio-economic values that are only known to locals
- gain feedback on the practical elements of the proposed water sharing plans to make certain they are easily implemented
- identify any unintended outcomes of the implementation of the plans.

Final changes are incorporated into the draft water sharing plan and then the Minister, with the concurrence of the Minister for the Environment, makes the plan by order under the WMA 2000.

3 Topics covered in a water sharing plan

3.1 Water sources covered by the plan

Each plan covers more than one water source. A plan may cover both surface water and groundwater sources. Occasionally a groundwater source is split into management zones. The approach to defining each plan boundary, the water sources and any management zone boundaries within each plan, is based on the following principle:

Principle 1 – Boundaries are defined for plans and water sources that:

- are geologically appropriate
- are administratively practical
- consider the degree of hydraulic connection
- are geographically acceptable.

Further details on plan boundaries can be seen at www.water.nsw.gov.au.

3.1.1 Geology

Principle 2 – Within the boundary of a plan, water sources are defined based on hydrogeological types.

Geology plays a fundamental role in defining groundwater system types, their characteristics and flow mechanisms. Accordingly, the plan and water source boundaries relate to hydrogeological types. These are:

- **porous rock groundwater systems**, including the sedimentary basins of sandstone with inter-bedded siltstone, shale and coal (for example Oxley Basin, Gunnedah Basin and Sydney Basin), and the 'consolidated' sands of the Western Murray groundwater system
- **fractured rock groundwater systems**, including the large tectonic fold belts consisting of metamorphic and igneous rocks, basalt caps and calcareous formations (for example, New England Fold Belt, Lachlan Fold Belt, Orange Basalt, Young Granite)
- **alluvial groundwater systems**, including unconsolidated sand, silt, clay and gravel associated with rivers and streams, usually larger alluvial deposits with a mapped extent, (for example, Peel Valley Alluvium, Upper Macquarie Alluvium)
- **coastal sands groundwater systems**, including sand, silt, shells and clay along the coast of NSW (for example, Botany Sands, Tweed Coastal Sands, South East Coastal Sands).

Principle 3 – Hydrogeological units of similar type may be grouped together to form one groundwater source.

A groundwater source consists of one or more overlying or adjacent, hydrogeologically similar units that make up a geological province. This approach recognises the substantial level of internal hydraulic connection likely between hydrogeological units of similar type.

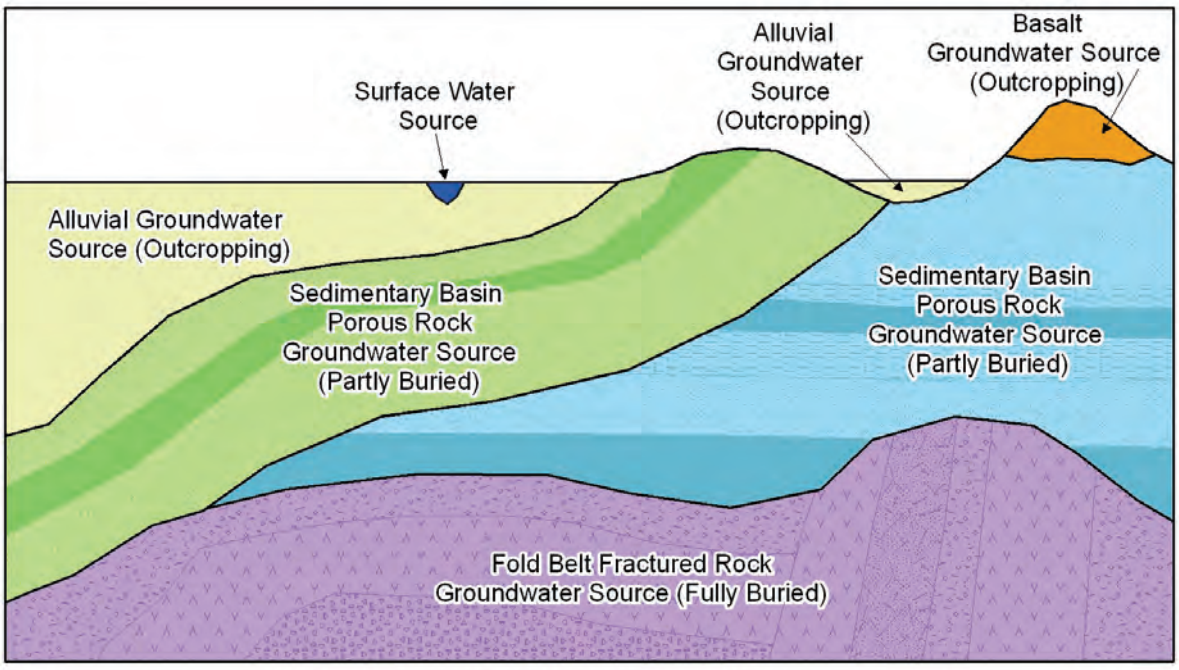
For example, a number of porous rock formations within a sedimentary basin (one geological province) that are hydrogeologically similar and layered over one another have been defined as a single groundwater source. Similarly, the fractured rock formations of the deep fold belt (one geological province) have been defined as a separate groundwater source to the overlying sedimentary basin water sources.

Principle 4 – Groundwater sources with little or no surface expression may be identified as partly or fully buried.

The definition of a groundwater source will include the surface expression and subsurface extent of that groundwater source, define the geological formations and provinces that it comprises and detail whether the groundwater source extends beneath (and/or above) adjacent water sources.

Where groundwater sources overlie one another, or are vertically stacked next to each other, each groundwater source will be managed independently of adjacent, underlying or overlying water source(s). Groundwater sources with no surface expression are called 'fully buried'. Groundwater sources with some part buried and some area of outcrop are called 'partly buried'. An example of fully and partly buried groundwater sources is shown in Figure 1. In this example, the coloured areas are separate groundwater sources while the different shades within those colours are individual aquifers. The identification of fully and partly buried groundwater sources has occurred in inland NSW with porous rock and fractured rock groundwater sources that overlie one another.

Figure 1: Conceptual cross-section showing examples of fully and partly buried groundwater sources



3.1.2 Hydraulic connectivity

Principle 5 – Most alluvial groundwater sources have a relatively high degree of hydraulic connectivity with their associated surface water sources. Accordingly, most alluvial water sources are included in a water sharing plan that covers both surface water and its connected alluvial groundwater. Most porous rock, fractured rock and coastal sands groundwater sources, however, are considered to have a lesser degree of connectivity and are included in groundwater-only plans.

The determination of hydraulic connectivity between groundwater and surface water is based on a number of criteria (Barrett and Broadstock, 2010) including:

- sufficiently shallow **water table** in the groundwater source to be connected to the associated surface water
- average alluvial **saturated thickness** of no more than 30 metres
- average width of the groundwater source of no more than four kilometres
- whether the associated river reach is **regulated, perennial or non-perennial**.

Regulated systems are rivers fed by a regulated dam. The water table of the associated alluvial groundwater system can be located above or below the stream bed.

Perennial systems are river reaches that have dominantly permanent or persistent flow. The water table of the associated alluvial groundwater system is located above the stream bed for most of the year.

Non-perennial systems are river reaches that only flow for up to a few days after a rainfall event. The water table of the associated alluvial groundwater system is usually located below the stream bed for most of the year.

In some cases, a highly connected groundwater source may not fit clearly into one of the above categories. In these instances, local technical experts will assign the groundwater source into the appropriate category. Appendix 4 provides a table listing those groundwater sources across the State identified as having high hydraulic connectivity, as well as the management rules applied to perennial and regulated systems to address connectivity.

Whether an alluvial groundwater system is combined with its associated surface water into one water source or not will depend on the individual characteristics of the alluvium, its level of connectivity with surface water sources and its location.

In plans developed prior to 2010 on the NSW coast, the combined surface water and alluvial groundwater approach only applied to coastal upland alluvials (i.e. the alluvials upstream of the tidal limit). This combined approach has since been extended to include coastal floodplain alluvials. Plans that were draft at the change of date of the policy will be amended during their term to include the coastal floodplain alluvial areas and provisions whereas commenced plans for unregulated rivers will be amended at the end of their term.

Notably, coastal alluvial groundwater in water sharing plans is not mapped. Instead it is defined in words to be all water contained within all alluvial sediments below the surface of the land shown on the registered plan for the specified water source(s).

3.1.3 Administration

Principal 6 – There are four broad boundaries for macro planning based on administrative requirements:

- Coastal NSW.
- Murray-Darling Basin NSW.
- Great Artesian Basin (GAB) NSW.
- North-western NSW (outside both the Murray-Darling Basin and the GAB).

In the future, NSW will be required to have water resource plans in the Murray-Darling Basin accredited under the Basin Plan. As a result, water sources in water sharing plans are either wholly within the Murray Darling Basin or wholly outside it.

The management of water sources associated with the GAB also guided the setting of these boundaries, as the GAB is both inside and outside the Murray-Darling Basin.

3.1.4 Geography

Principle 7 – Plan boundaries should be geographically logical and understandable to the communities to which they apply.

3.1.4.1 Coastal NSW

This principle was particularly applied to plan boundaries in coastal NSW where surface water and the associated alluvial groundwater are included in the same plan. The boundary used is usually based on major surface water catchments. A number of existing water sharing plans along the NSW coast are groundwater specific, for example the Water Sharing Plan for the Stuarts Point Groundwater Source and the Water Sharing Plan for the Tomago, Tomaree and Stockton Groundwater Sources. For the Greater Sydney Metropolitan region there are two water sharing plans with the same boundary; one covers all surface water and the other covers all groundwater.

Three plans are proposed for the rest of the groundwater on the NSW coast. Plan boundaries will again be based on major surface water catchment boundaries. The three groundwater plans yet to be made are:

- North Coast Porous and Fractured Rock.
- North Coast Coastal Sands.
- South Coast Groundwater Sources (Porous, Fractured Rock and Coastal Sands).

Where groundwater system boundaries extend beyond a surface water catchment boundary, the system is divided into separate groundwater sources, for example, Sydney Basin (South Coast), Sydney Basin (Greater Metropolitan) and so on. This eliminates the difficulties associated with water sources occurring across a number of plans.

Table 1: Defining groundwater plan boundaries for Coastal NSW

	Fractured rock, porous rock and coastal sands	Upland alluvial	Floodplain alluvial
Application of the principles	Groundwater systems are included as separate water sources based on geological type within the associated groundwater plan for that geographical area.	Groundwater systems and their associated surface water are to be included in one combined surface and groundwater source in the combined surface water and alluvium plan for that geographical area.	Depending on the level of connectivity, coastal floodplain alluvial groundwater systems may be included in the same water source as the upland alluvial and associated surface water source or as a separate groundwater only water source in the associated combined surface water and alluvium plan.
Connectivity	These groundwater systems are considered to have a lesser degree of connectivity to their associated surface water system than alluvial systems.	These groundwater systems are considered to have a high degree of connectivity to their associated surface water system.	Groundwater systems are considered to have a lesser degree of connectivity compared to the upland alluvial groundwater systems but still display a significant level of connectivity to surface water features.
Basis for plan boundary	Geographical area.	Geographical area.	Geographical area.
Basis for water source boundary	Geological type and geographically acceptable boundaries generally based on surface water catchment. Where the same geological type extends beyond a plan area then it will be split into a separate water source in each plan area to avoid planning and reporting complications.	Hydrogeological type and the associated surface water source. The alluvial groundwater system component of this water source is limited to the alluvial groundwater system that occurs above the tidal limit in the geographical area.	Hydrogeological type. The water source is limited to the alluvial groundwater system that occurs below the tidal limit within the associated surface water source and the geographical area.
Basis for management zone boundary	Based on the need for specific management rules to apply to a particular area	Need for specific management rules to apply to a particular area. Separation of management zones between alluviums associated with regulated or unregulated surface water should be based on ‘closing off the neck of the unregulated area’ based on cadastral boundaries and/or bore hydrographs to estimate hydraulic gradients.	Need for specific management rules to apply to a particular area. Separation of management zones between alluvial associated with regulated or unregulated surface water should be based on ‘closing off the neck of the unregulated area’ based on cadastral boundaries and/or bore hydrographs to estimate hydraulic gradients.

	Fractured rock, porous rock and coastal sands	Upland alluvial	Floodplain alluvial
Exception		**Greater Metropolitan Region groundwater sharing plan** Treats Hawkesbury Alluvium as a separate groundwater source in the groundwater plan. The surface water plan was already significantly progressed and highly complex when the groundwater plan was requested to be developed. The Hawkesbury Alluvium is also a significant alluvial groundwater system with reasonable levels of storage that is managed differently to other coastal upland alluvial groundwater systems. **Gazetted water sharing plans** Will be amended at end of term to include associated coastal upland alluvial groundwater system. **Miscellaneous unmapped alluvium** These are included in the combined surface and groundwater plans as water sources and are described as all the surface water and all the groundwater contained within all alluvial sediments below the surface of the land, within the mapped boundary of the water source– thus there should be no miscellaneous alluvial. The exception to this is in the Greater Metropolitan Regional Groundwater Sharing Plan – where the miscellaneous unmapped alluvium will be included as part of the underlying porous or fractured rock water source.	**Gazetted water sharing plans** Will be amended at end of term to include coastal floodplain alluvial provisions. **Water sharing plans under development** Will include amendment provisions for coastal floodplain alluvial provisions to be added during the term of the plan. **Miscellaneous (unmapped) alluvium** These are included in the combined surface and groundwater plans as water sources and are described in the plan as all the surface water and all the groundwater contained within all alluvial sediments below the surface of the land, within the mapped boundary of the water source– thus there would be no miscellaneous alluvial.

3.1.4.2 Murray-Darling Basin NSW

Within the Basin, it was traditionally not practical for groundwater and surface water to be treated as one water source due to the Murray-Darling Basin Ministerial Council Cap Agreement made between NSW and the Commonwealth. From 1995 until 2012, this Cap operated to limit surface water extraction in the Basin to the levels of extraction that were occurring under 1993/94 levels of development and management rules. The Cap did not apply to groundwater extraction, however, so new entitlements (licences) for groundwater continued to be granted in some groundwater sources up until 2008 when embargo orders were applied to most new licences in all groundwater systems in inland NSW[5.]

Most of the Basin's mapped alluvial groundwater sources are included in combined water sharing plans for unregulated surface water and alluvial groundwater. Groundwater, however, is defined as a separate water source with its own LTAAEL, which is the limit on the volume that can be extracted from the water source. Small areas of shallow alluvial sediments that are not mapped occur along minor creeks and eroded fractured rock formations and generally yield small volumes of water that are only suitable for domestic or stock supply. These unmapped 'miscellaneous alluvials' will be managed as part of the underlying porous or fractured rock groundwater source.

There is a separate plan for the groundwater sources in the GAB and another plan that covers the water sources that overlie the GAB (see 4.1.4.3 below). There are two other plans that cover most of the remaining groundwater in major hard rock groundwater systems in the Basin. These are the Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2011 and the Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011.

There are also some specific plans that include small fractured or porous rock groundwater sources. For example, the Water Sharing Plan for the Peel Valley includes the Peel Fractured Rock Water Source.

Table 2: Defining groundwater plan boundaries for Murray-Darling Basin area of NSW

	Fractured rock and porous rock	**Alluvial**
Application of the principles	All fractured rock within the Basin is included in one groundwater plan, i.e. Water Sharing Plan for the NSW Murray-Darling Basin Fractured Rock Groundwater Sources All porous rock within the Basin is to be included in one groundwater plan, i.e. Water Sharing Plan for the NSW Murray-Darling Basin Porous Rock Groundwater sources. All unmapped miscellaneous alluvial sediments will be included in the underlying porous or fractured rock groundwater plan.	The Basin's mapped alluvial groundwater systems are included as a separate groundwater source in the associated combined surface water and alluvial plan for the applicable geographical area (i.e. the unregulated macro plan boundaries, generally major catchment boundary)
Connectivity	The Basin fractured rock and porous rock groundwater systems are all considered to have a lesser degree of connectivity to their associated surface water system than alluvial systems.	Alluvial groundwater systems are considered to have a relatively high degree of connectivity to their associated surface water system.

[5]By 2008 embargo orders made under section 113A of the *Water Act 1912* applied to all groundwater in the Murray Darling Basin. These orders no longer apply, as all groundwater in the Murray Darling Basin is now included in water sharing plans.

	Fractured rock and porous rock	Alluvial
Basis for plan boundary	Geographical area and the administrative requirements of their location within the Basin.	Geographical area, for example Macquarie-Bogan Unregulated and Alluvial water sharing plan, Namoi Unregulated and Alluvial water sharing plan.
Basis for water source boundary	Geological type. Where the same geological type extends beyond a plan area, it will be split into a separate water source for each plan area to avoid planning and reporting complications.	Hydrogeological type. The alluvial groundwater source is limited to the mapped alluvium that occurs in associated surface water catchment. These are separate groundwater only water sources for inland alluvial groundwater systems as the administration of Murray-Darling Basin Ministerial Council Cap on extraction creates inequities if managed with the associated surface water as one water source
Basis for management zone boundary	Surface water catchments initially and then based on the need for specific management rules to apply to a particular area.	Need for specific management rules to apply to a particular area. Separation of management zones between alluviums associated with regulated or unregulated surface water should be based on 'closing off the neck of the unregulated area' based on cadastral boundaries and/or bore hydrographs to estimate hydraulic gradients.
Exception	**Peel Fractured Rock** Included as part of a plan that covered all water sources in the Peel Valley as it was the most acceptable plan boundary for the local community. **Gazetted water sharing plan areas** Existing plan areas for these types of systems are excluded from the plans.	**Mapped alluvium associated with gazetted surface water sharing plans (both regulated and unregulated) not already covered by a water sharing plan** Included in the respective unregulated and alluvial macro plan for that geographical area. **Peel Alluvium** Included as part of a plan that covered all water sources in the Peel Valley as it was the most acceptable plan boundary for the local community **Gazetted water sharing plan areas** Existing plan areas covering these types of systems are excluded from the above plans. **Barwon-Darling Alluvium** This alluvium boundary is of a greater extent than the associated Barwon-Darling surface water boundary which is essentially within the bed and banks of the river. Despite this the Barwon-Darling Unregulated and Alluvial water sharing plan includes the unregulated surface water source and the alluvial groundwater source, as this is a more practical application of the principles.

	Fractured rock and porous rock	Alluvial
		Lower Murray Shallow Alluvium Has greater connectivity with the underlying deep alluvium than with the associated Murray unregulated surface waters so prepared separately and will be later merged with the original Lower Murray Deep Alluvium water sharing plan. **Miscellaneous unmapped alluvium** Included as part of the underlying porous or fractured rock groundwater source.

3.1.4.3 Great Artesian Basin NSW

A water sharing plan has been completed for the Great Artesian Basin (GAB) water sources. The groundwater sources overlying the GAB are covered in a separate groundwater sharing plan. Boundaries for the groundwater sources overlying the GAB are based on surface water catchment boundaries and the requirement to separate water sources within and outside the Basin.

Table 3: Defining groundwater plan boundaries for Great Artesian Basin area of NSW

	GAB groundwater sources	Groundwater sources overlaying the GAB
Application of the principles	This groundwater system is included in one groundwater plan, i.e. Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources.	This groundwater system is included in one groundwater plan, i.e. Water Sharing Plan for the NSW Great Artesian Basin Shallow Groundwater Sources.
Connectivity	This groundwater system is considered to have a lesser degree of connectivity to its associated surface water system.	This groundwater system is considered to have a lesser degree of connectivity to its associated surface water system.
Basis for plan boundary	Geological type, associated with the GAB geographical location.	Geological type, associated with the GAB geographical location.
Basis for water source boundary	Geological type.	Geological type.
Basis for management zone boundary	N/A.	Need for specific management rules to apply to a particular area.

3.1.4.4 North-western NSW

For the remaining groundwater sources in north-western NSW (outside both the Murray-Darling Basin and the Great Artesian Basin), a combined surface and groundwater plan has been made. Due to the limited amount of groundwater extraction and management in this area, separate groundwater sharing plans for each water source is not warranted.

Table 4: Defining plan boundaries for north-western area of NSW

	North-western NSW
Application of the principles	A combined surface and groundwater plan covering the geographical extent of the north-western corner of NSW outside the Basin, excluding the Water Sharing Plan for the NSW Great Artesian Basin Shallow Groundwater Sources
Connectivity	The groundwater systems in this area do not have significant connectivity with the respective surface water systems and a combined plan is administratively practical.
Basis for plan boundary	Geographical area and administrative requirements.
Basis for water source boundary	Geological type. Where the same geological type extends beyond a plan area then it has been split into a separate water source for each plan area to avoid planning and reporting complications.
Basis for management zone boundary	Need for specific management rules to apply to a particular area.

3.2 Environmental water provisions

Principle 8 – Water is reserved for the environment in each water source in a water sharing plan.

The reservation of planned environmental water is a requirement of section 8 of the WMA 2000. Planned environmental water must be reserved in at least two of the following ways (whether by two separate ways or a combination of two ways):

- By reference to the commitment of the physical presence of water in the water source.
- By reference to the long-term average annual commitment of water as planned environmental water.
- By reference to the water that is not committed after basic landholder rights entitlements and sharing and extraction under any other rights have been met.

Plans also provide for water access licences to be committed for adaptive environmental water purposes.

3.2.1 Reservation of groundwater storage

Groundwater systems can store large volumes of water, often accumulated over thousands, or even tens of thousands of years. This is referred to as 'storage'. The volume of water in storage is recharged in a number of ways, depending on the type of the groundwater system.

In most groundwater sources in plans 100 percent of groundwater storage is reserved as planned environmental water. In a small number of buried or partly buried groundwater sources, a very small percent of the total volume of groundwater storage (less than 1 percent) may be made available for extraction (see Section 3.5 Limits to the availability of water), with the remainder (more than 99 percent) reserved as planned environmental water (NSW Office of Water 2011). This additional groundwater is made available only in groundwater sources where a groundwater storage extraction limit is specifically provided for within a porous rock water sharing plan. This percentage of storage potentially available for extraction is less than the seasonal fluctuations in volume within a groundwater system. Access to this storage water will only be considered once the total water requirements plus future priority requirements have reached the LTAAEL.

3.2.2 Groundwater recharge

Principle 9 – Recharge is used as a basis for water sharing between the environment and extractive users. Recharge is calculated on a long-term average annual basis.

Recharge is the addition of water to a groundwater system. It is expressed as a volume in megalitres per year (ML/year). Recharge usually comes from rainfall and surface water bodies, such as rivers, but also comes from through-flow from adjacent groundwater systems.

Estimating recharge is difficult due to variations in geology, rainfall distribution and varying sources of recharge, so a broad, precautionary approach to calculation of recharge has been taken. Further, in coastal groundwater plans made after 2012 (see Appendix 2); recharge is rounded to two significant figures. For example 213,824 ML/year becomes 210,000 ML/year and 8,787 ML/year becomes 8,800 ML/year.

Recharge is shared between the environment and extractive users in most groundwater sources and only a proportion of recharge is available for extraction. The remainder of recharge is reserved for the environment. The proportion of recharge reserved for the environment is designed to reduce the risk of unsustainable groundwater extraction in the long term.

3.2.3 Reservation of a portion of recharge in less highly connected groundwater sources

Only recharge resulting from rainfall has been estimated in less highly connected groundwater sources, although more recharge sources are known. A portion of recharge from rainfall is reserved as planned environmental water.

Rainfall Recharge (ML/year) = Average Annual Rainfall (ML/year) x Infiltration factor

The infiltration factor applied to calculate recharge varies depending on the hydrogeological type (see Appendix 6 for more detail). The recharge amount may change during the life of the groundwater sharing plan as a result of improved information.

3.2.4 Reservation of a portion of recharge in water sources with significant river recharge

For water sources with significant river recharge, recharge estimates can include long-term average annual rainfall recharge, side slope recharge and river recharge.

For inland NSW, where groundwater use is more intense, other sources of recharge are considered in recharge calculations.

For coastal NSW, alluvial groundwater systems with significant river recharge are combined with the associated surface water system in the same water source. Recharge is not considered in setting the extraction limit. Therefore rainfall recharge, side slope recharge and river recharge are not considered. These coastal upper alluvial river systems can deliver sufficient base flow recharge to support current extraction and maintain river flows.

Planned environmental water is defined as the volume of recharge in excess of the extraction limit.

Environmental water may also be provided through daily access rules which are linked to surface water flows. These rules are described in section 3.8.

Details of recharge-based planned environmental water are in Table 5 for inland NSW groundwater sources and in Table 6 for coastal groundwater. The methodology for calculating recharge is detailed in Appendix 6.

Table 5: Recharge estimation principles for inland NSW

	Fractured Rock, Porous Rock, NSW North West, groundwater sources overlying the GAB	**Murray-Darling Basin Alluvial**
Application of the principles	Long-term average annual rainfall recharge is used as the basis for water sharing. Only rainfall recharge is used as these water sources are less highly connected and therefore generally do not need to consider river recharge. More highly developed areas may consider other forms of recharge if necessary. Recharge estimates can consider long-term average annual rainfall recharge, side slope recharge and river recharge as the basis for water sharing. A precautionary approach should be taken when considering the basis of water sharing. There is likely to be less risk in utilising rainfall recharge alone as the basis	Recharge estimates for inland alluvials can consider long-term average annual rainfall recharge, side slope recharge and river recharge as the basis for water sharing in both highly connected and less highly connected systems. A precautionary approach should be taken when considering the basis of water sharing. There is likely to be less risk in setting extraction limits based on rainfall recharge alone, although more recharge sources are known. When groundwater use is more intense a less conservative approach may be taken and other sources of recharge are also considered. For example, In the Peel Alluvium water source it was recognised that groundwater

	for sharing, although more recharge sources than just rainfall infiltration are known. When utilisation of the resource is more intense a less conservative approach may be taken and other sources of recharge should be considered in the basis for water sharing.	pumping would have an impact on surface water flows, i.e. the Peel Alluvium water source would also receive recharge from connected surface waters. Despite this, the volume of recharge from surface water could not be estimated with a high level of certainty and so a conservative approach to water sharing was taken by basing the LTAAEL on an estimate of rainfall recharge only. Should there have been an LTAAEL greater than the volume of rainfall recharge; a less conservative approach that considers these additional sources of recharge could have been taken.

Table 6: Recharge estimation principles for coastal NSW

	Fractured rock, porous rock, coastal sands	**Coastal upland alluvial**	**Coastal floodplain alluvial**
Application of the principles	Long-term average annual rainfall recharge is used as the basis for water sharing. Rainfall only recharge used as these water sources are less highly connected and therefore generally do not need to consider river recharge. More highly developed water sources consider other forms of recharge where necessary. Note: Recharge estimates can consider long-term average annual rainfall recharge, side slope recharge and river recharge as the basis for water sharing. A precautionary approach should be taken when considering the basis of water sharing. There is likely to be less risk in utilising rainfall recharge alone as the basis for sharing, although more recharge sources than just rainfall infiltration are known. When utilisation of the resource is more intense a less conservative approach may be taken and other sources of recharge should be considered in the basis for water sharing.	Recharge not considered as a basis for water sharing as these alluvial groundwater systems are combined with the associated surface water system in the same water source. Alluvials associated with a regulated river that are considered highly connected may use estimates of rainfall and river recharge contributions to inform the linkage between groundwater and surface water for the purposes of making available water determinations.	Long-term average annual rainfall recharge is used as the basis for water sharing if there no evidence of significant connectivity. Recharge from areas within 100m of a surface drain is disregarded as groundwater in the vicinity of drains tends to be intercepted by the drain and becomes surface water. Recharge is compared to the current level of usage to determine if surface water is providing significant recharge to the groundwater system, i.e. if usage is greater then rainfall recharge then there are likely to be significant contributions from river recharge to the water that is being extracted. If there are significant contributions from river recharge, the surface and groundwater sources are connected and treated as the one water source and combined with the rest of the water source including the unregulated river and associated upland alluvials. If recharge exceeds current use/entitlement then treated as a separate water source in the combined surface water and alluvial plan for that geographical area as would be

	Fractured rock, porous rock, coastal sands	Coastal upland alluvial	Coastal floodplain alluvial
			considered 'less highly connected'.
Exception			**Richmond water sharing plan** Coastal upland alluvial, floodplain alluvial and surface water all treated as one water source and recharge not considered as a basis for water sharing.

Table 7: Provision of all planned environmental water

	Fractured rock, porous rock, coastal sands, coastal floodplain alluvial, North West NSW, groundwater sources overlying the GAB[6]	Coastal upland alluvial	Murray-Darling Basin Alluvial
Application of the principles	Planned environmental water consists of a groundwater storage component and a recharge component. The groundwater storage component is the volume of groundwater in storage in the groundwater system. The recharge component is determined separately using the risk assessment method described in Appendix 6. To ensure that high conservation value areas (for example national parks, nature reserves etc) are protected from the impacts of extraction, and recognising that access licences are not likely to be issued in these areas, 95-100 percent of the rainfall recharge estimate for these areas is reserved as environmental water (see exception). A sustainability factor, derived from the macro groundwater risk assessment, is applied to the rainfall recharge over the remaining area of the water source to share this portion of recharge between the	Planned environmental water is defined as the water remaining in the water source after the plan rules have been applied[7]. Planned environmental water consists of a groundwater storage component and a recharge component. The groundwater storage component is the volume of groundwater in storage in the groundwater system. The river recharge component is defined as the volume of recharge in excess of the LTAAEL. Environmental water is also provided through daily access rules where the associated surface water stream is unregulated, as the groundwater and	Planned environmental water consists of a groundwater storage component and a recharge component. The groundwater storage component is the volume of groundwater in storage in the groundwater system. The river recharge component is defined as the volume of recharge in excess of the LTAAEL. Environmental water is also provided through daily access rules in highly connected alluvial groundwater systems associated with unregulated rivers.

[6] Environmental water for these groundwater sources was determined using the macro risk assessment process. For details of the terminology used in this table please see Appendix 6.
[7] As surface and groundwater are treated as the one water source for these systems, the community report for unregulated rivers (see the macro water sharing plan page at www.water.nsw.gov.au) has already defined environmental water in many cases in Appendix 10.3.

	Fractured rock, porous rock, coastal sands, coastal floodplain alluvial, North West NSW, groundwater sources overlying the GAB[6]	**Coastal upland alluvial**	**Murray-Darling Basin Alluvial**
	environment and extractive users, for example for a water source with 70 percent sustainability factor, 30 percent of recharge is planned environmental water and 70 percent is available for extraction.	surface water are included in one water source and generally access rules for aquifer access licences relate to surface water flows in the associated stream.	
Rule	Include standard provisions in the plan for reservation of environmental water.	Include standard provisions in the plan for reservation of environmental water. Include rules for access licences in alluvials associated with unregulated water sources	Include standard provisions in the plan for reservation of environmental water. Include rules for access licences in alluvials highly connected to unregulated water sources

	Fractured rock, porous rock, coastal sands, coastal floodplain alluvial, North West NSW, groundwater sources overlying the GAB[6]	**Coastal upland alluvial**	**Murray-Darling Basin Alluvial**
Exception	**Some coastal sands water sources and other sources where there is a current or expected future demand during the term of the plan to meet existing entitlement for town or urban water supply** Not all recharge in the high conservation value areas is reserved as planned environmental water. It is reasonable to assume that some through flow would occur from these areas into the remaining part of the groundwater system. Therefore, 5 percent of the recharge from these areas may be attributed to through flow and made available for extraction under the LTAAEL. For groundwater sources with little surface expression (partly buried) the extraction limit may include a very small percent of storage in addition to the percentage of recharge. The remaining volume of storage will be reserved as environmental water. For groundwater sources that have no surface expression (buried) the extraction limit will be a very small percent of storage and the remaining volume of storage will be reserved as environmental water. For groundwater sources on the coast which have a LTAAEL determined by estimating future water requirements, environmental water is determined by subtracting the proposed LTAAEL from rainfall recharge. In this instance, environmental water is significantly more than the portion that would be reserved by applying the sustainability factor.		**Paroo, Warrego, Lower and Upper Darling Alluvium** For these saline alluvials that have low levels of connectivity with surface water features, an approach similar to the hard rock groundwater systems (first column) is adopted which applies the macro planning risk assessment method for determining environmental water and the LTAAEL.

3.3 Requirements for water for basic landholders rights

Principle 10 – Plans define a total volume of water required to meet the needs of holders of basic landholder rights (BLR) in each water source. This volume is based on an estimate of their usage.

Principle 11 – Two methods for estimating basic landholder rights have been adopted, depending on the groundwater system type and location. These estimates are based on the best available information but may change over time should improved information become available.

The first method is an area-based estimation, which uses area-based information such as land use data and housing census information to calculate groundwater stock and domestic use. It divides the State into four 'stock and domestic' zones, based on differences in climate and topographic settings. The four zones are: coast, tablelands, slopes and plains.

The second method involves database extractions and is considered to be more appropriate in heavily urbanised areas. It involves assigning a volume to approved water supply works (i.e. bores) according to their licensed purpose of stock watering and/or domestic consumption. These works and associated purpose have been retained on DPI Water's database.

Under section 52 of the WMA 2000 landholders in NSW who own or occupy land can take water without a licence from any groundwater source underlying the landholding for domestic and stock purposes, for example, cooking, washing, watering household gardens, and to water stock on the property (but not intensively). A water supply work approval is required to take groundwater for domestic and stock purposes. Under section 20 of the WMA 2000 water sharing plans are required to identify the water requirements of persons entitled to basic landholder rights in each plan area.

Table 8: Principles for management of basic landholder rights

	Coastal porous and fractured rock	**All other water sources**
Application of the principle	Extract all approved water supply works within a water source from the corporate database. Apply a prescribed volume according to the purpose of stock watering and/or domestic consumption. Assumptions that apply to individual water sources in the standard database extraction method may be amended based on further local knowledge.	Apply an area-based method for the calculation of BLR estimates for all water sources. Assumptions that apply to individual water sources in the standard area-based method may be amended based on further local knowledge.
Rule	Include standard provision in the plan for estimates of BLR, calculated using the database extraction method	Include standard provision in the plan for estimates of BLR, calculated using the area-based method Include a note in plan to highlight that estimates of BLR may be amended based on improved information.
Exception	**Existing gazetted plans** Have a number of different methods utilised to calculate the BLR estimates. Figures will be revised and updated either on the extension of the plan under section 43A of the WMA 2000 or when a new plan is made.	

The methodologies for calculating the BLR volume for each groundwater source are detailed in Appendix 3.

In some areas, groundwater extraction for BLR is a significant proportion of total groundwater usage and can have impacts on other users and the environment. Mandatory guidelines for the take and use of water under domestic and stock rights can be made under section 336B of the WMA 2000 to set limits on the

taking of water for domestic purposes and for stock watering to reasonable volumes. Additionally, temporary water restrictions orders can be made under section 324 of the WMA 2000 to prohibit or restrict groundwater extraction if the Minister for Water is satisfied it is necessary to do so:

- in the public interest
- to maintain or protect water levels in an aquifer
- to maintain, protect or improve the quality of water in an aquifer
- to prevent land subsidence or compaction in an aquifer
- to protect groundwater dependent ecosystems
- to protect Aboriginal groundwater dependent culturally significant sites
- to maintain pressure, or to ensure pressure recovery, in an aquifer.

3.4 Requirements for water for extraction under access licences

Principle 12 – Plans recognise the existing licensed entitlements in each groundwater source.

Under section 20 of the WMA 2000 water sharing plans are required to identify the requirements for water for extraction under access licences.

Table 9: Principles for establishment of requirements for extraction under access licences

	All water sources
Application of the principle	Include licensed volume information provided from DPI Water licensing administration system during the development of the plan. Licensed volumes may be updated as a result of addressing anomalies such as licences currently without a volumetric entitlement.
Rule	Include standard provision in the plan for estimates of share components of each licence category.

3.5 Limits to the availability of water

Principle 13 – Best available information is used for setting LTAAELs.

Principle 14 – Plans set long-term average annual extraction limits (LTAAELs) for all water sources.

Principle 15 – Some buried or partly buried water sources that receive little or no recharge from rainfall may have a very small portion of storage available for extraction in addition to the recharge-based LTAAEL.

To protect the water for the environment and the supply to existing users, a maximum volume of water available for extraction is determined for each water source. This limit is a 'long-term average annual extraction limit' (LTAAEL) and is expressed in mega litres per year. The other type of extraction limit, which is applied to the water in the storage of some buried or partly buried groundwater sources, is a 'long-term groundwater storage extraction limit'.

Fully buried or partly buried groundwater sources have little or no surface expression, and therefore have very little or no water available for extraction based on rainfall recharge. Fractured rock groundwater systems generally have relatively small volumes of water in storage, whereas porous rock groundwater systems can be capable of storing large volumes of water. Consequently, consideration has been given to the release of a very small percentage (0.002 percent) of the volume of water in storage in fully or partly buried porous rock groundwater systems (DPI Water 2011). This percentage is based on a generic three-dimensional groundwater model, which showed it to be equivalent to or less than seasonal fluctuations.

3.5.1 Setting long-term average annual extraction limits in less highly connected groundwater sources

For less highly connected water sources the LTAAEL is set by applying the macro groundwater planning risk assessment methodology. This method determines the percentage of estimated rainfall recharge which should be reserved as planned environmental water. By deduction the remainder of the rainfall recharge estimate is the LTAAEL (see Appendix 6 for more detail).

In coastal fractured rock groundwater sources, generally where current entitlement is low, the LTAAEL calculated using the risk assessment methodology outlined above is termed an 'upper extraction limit'. The LTAAEL is then based on a calculation of current and future water requirements for the term of the plan or 10% of the upper extraction limit, whichever is higher. In these instances, the LTAAEL can be increased if required via an amendment to the plan up to the maximum 'upper extraction limit'. Future water

requirements is estimated using various types of information such as expected population increase, residential development, large scale developments (mining) and augmentation of urban water supply. The combination of current entitlement and estimated future water requirements is based on the 10 year life of the plan. Similar to recharge figures in some coastal groundwater plans, the LTAAEL determined using current entitlement and estimated future water requirements is rounded to two significant figures. If during the life of the plan information becomes available to indicate an expected increase in water requirements, the plan can be amended to increase the LTAAEL up to the upper extraction limit (see Appendix 6 for more detail).

In coastal porous rock groundwater sources, further work has been undertaken to understand how they are recharged annually. Where this additional information exists, the LTAAEL is calculated using the risk assessment methodology outlined above. This is the maximum extraction limit over the life of the plan, and a separate 'upper extraction limit' does not apply.

3.5.2 Setting long-term average annual extraction limits in water sources with significant river recharge

For some areas of NSW, if the LTAAEL is set by applying the macro groundwater planning risk assessment methodology, then the LTAAEL may be less than total licensed volumes, total water usage, or both. This situation is most likely to arise in the case of alluvial systems which receive a significant contribution to recharge from the adjacent river. In this case, setting the LTAAEL by applying the macro groundwater planning risk assessment methodology is inappropriate because the significant contribution to recharge from the adjacent river is not taken into account. Accordingly, a different approach is taken for setting the LTAAEL in water sources with significant river recharge.

The following principles apply to setting the LTAAEL for groundwater systems in NSW which do not use the macro groundwater planning risk assessment approach:

Principle 16 – Inter-linkages between surface and groundwater water sources are to be considered in setting LTAAELs in plan areas.

A change in the management of highly connected groundwater or surface water sources can have repercussions across all connected water sources i.e. the concentration of groundwater use in dry periods can increase regulated river losses to the extent that there is a significant increase in transmission losses to deliver high security water via the regulated river.

3.5.2.1 Coastal NSW

Principle 17 – Current levels of entitlement in coastal alluvial groundwater sources are considered to have acceptable impacts on surface water sources.

This principle is based on an acceptance of the level of environmental impacts that may occur under current levels of entitlement and acknowledgement that many water sources are embargoed for the issuing of new licences. Therefore, the LTAAEL that will be applied to coastal alluvial and highly connected groundwater sources will be based on the best estimate of the current level of entitlement.

3.5.2.2 Inland NSW

Principle 18 – Current levels of groundwater pumping from alluvial and other highly connected groundwater sources in the Murray-Darling Basin are considered to have acceptable impacts on surface water sources.

Since the signing of the 1995 MDBMC Cap Agreement to limit surface water extractions to 1993/1994 levels, new entitlements in some groundwater systems have been granted and investments have been made to access groundwater. In highly committed groundwater systems, where total entitlements are close to or exceed the LTAAEL, there have been embargo orders and other tools for limiting growth in use. By

2008, embargoes applied in the Murray-Darling Basin NSW to new groundwater licences. The approach taken recognised that retrospective application of policy to redress the impact of groundwater pumping on surface water since 1993/94 would result in unacceptable impacts on inland rural communities. Therefore, the LTAAEL applied to alluvial and highly connected systems in inland NSW is based on the best estimate of the average level of extractions occurring at the time the plan was made.

Principle 19 – Rules that mitigate identified risks can be applied to protect groundwater from the impacts of extraction, minimising the risk to the groundwater system while increasing the portion of water available for extraction. This reduces the socio-economic risk to those communities and enterprises that rely on the groundwater source.

Principle 20 – Risks to surface and groundwater sources can be addressed through specific management rules in the plan.

For highly connected water sources, specific rules that recognise that the same water resource is both above and below the ground surface are applied. For example, groundwater sources that are highly connected to a regulated surface water source will be subject to annual management through linked available water determinations. Groundwater sources that are highly connected to unregulated surface water sources may have linked daily access rules.

Less highly connected systems may have specific access rules that recognise connectivity, for example, rules to manage extraction in the immediate vicinity of the surface water. This recognises that groundwater extraction close to surface water expressions, for example a spring or gaining stream, will affect base flows. In most cases, this will be restricted to the management of new extraction and the location of bores.

For the method behind setting the long-term average annual extraction limit in water sources with significant river recharge see Appendix 7.

Table 10: Principles for the definition of long-term average annual extraction limits

	Fractured rock, porous rock, coastal sands, coastal floodplain alluvial, NSW North West, groundwater sources overlying the GAB	**Coastal upland alluvial**	**Murray-Darling Basin alluvial**
Application of the principles	LTAAEL is based on the macro groundwater risk assessment.	The LTAAEL will equal the sum of all existing unregulated entitlement located within the surface waters and the groundwater entitlement of the alluvium , plus an estimate of current annual extraction for basic landholder rights, plus the sum of any new licences or additional entitlement granted during the life of the plan	LTAAEL applied to water sources (both highly and less highly connected) will be based on the best estimate of average usage over a specified period for these systems. Explicit recognition that in highly connected systems extraction beyond current average usage from alluvial groundwater systems will further decrease base flows in surface water systems.
Rule	Plan to set LTAAEL based on the macro groundwater risk assessment and include standard LTAAEL	Plan to set LTAAEL based on above method and include standard LTAAEL provisions	Plan to set LTAAEL based on above method and include standard LTAAEL provisions.

	Fractured rock, porous rock, coastal sands, coastal floodplain alluvial, NSW North West, groundwater sources overlying the GAB	**Coastal upland alluvial**	**Murray-Darling Basin alluvial**
	provisions		Water sources that have utilised estimates of usage can have amendment provisions included to allow for amendment of the LTAAEL during the term of the plan
Exception	**Buried water sources** In some porous rock groundwater sources with no surface expression, a very small portion of groundwater storage may be potentially available and this is expressed as a long-term groundwater storage extraction limit. **Coastal fractured rock groundwater sources** In coastal fractured rock groundwater sources the LTAAEL based on the macro groundwater risk assessment is termed the 'upper extraction limit'. The LTAAEL specified in the plan is based on current and future water requirements or 10% of the upper extraction limit (whichever is the higher) and can be increased up to the upper extraction limit if required.		**Paroo, Warrego, Lower and Upper Darling Alluvium** These saline alluvials that have low levels of connectivity with surface water features adopt an approach similar to the hard rock water sources (first column). **Billabong Alluvium** This system adopts an approach based on the history of extraction due to system characteristics and high risk of growth in use impacts on users.

3.5.3 Managing compliance with the long-term average annual extraction limit

Principle 21 – Available water determinations (AWDs) are used to manage growth in use above the LTAAEL through a reduction in the maximum AWD that can be credited to accounts during a water year.

DPI Water will monitor annual extractions. If extractions are exceeding the LTAAEL, then AWDs for aquifer access licences will be reduced until total extraction is brought back into line with the LTAAEL – (for more information see Appendix 7A)

3.5.4 Setting a long-term groundwater storage extraction limit for some buried and partially buried groundwater sources

Three-dimensional numerical groundwater modelling has been undertaken to inform the development of limits on the availability of water from storage for buried and largely buried groundwater sources (for more detail see Appendix 7B). Based on the findings of this modelling, water sharing plans for largely buried or fully buried groundwater sources may include a long-term groundwater storage extraction limit of the equivalent of 0.002 percent of the total volume of water in storage. The figure of 0.002 percent was chosen as the modelling showed extracting up to 0.002 percent of storage did not present any significant risk to the environment.

3.5.5 Managing compliance with the long-term groundwater storage extraction limit

Compliance with the long-term groundwater storage extraction limit will be managed on a cumulative basis. Once total cumulative extractions from storage exceed the long-term groundwater storage extraction limit then available water determinations for licences to access storage in that groundwater source will be reduced to zero mega litres per unit share and the licences cancelled. Non-compliance with the long-term groundwater storage extraction limit is unlikely because licences to access storage will not be granted in a groundwater source if it would cause total cumulative extractions from storage to exceed the long-term groundwater storage extraction limit.

3.5.6 Accounting for water taken through mining and other aquifer interference activities

Principle 22 – Groundwater taken, whether deliberately or unintentionally, through aquifer interference is accounted for within the long-term extraction limit(s).

Aquifer interference activities can impact on the local and regional environment, especially the structural integrity of a groundwater source and its dependent ecosystems. Groundwater sources within mining areas, such as the Hunter, Sydney Metropolitan/ South Coast and the Gunnedah Basin, are especially affected by this issue.

It is important that the groundwater taken, whether deliberately or unintentionally, through aquifer interference is accounted for in the water budget and included in the assessment of extractions against the LTAAELs. These volumes require an access licence under the WMA 2000, unless an exemption applies in the Water Management (General) Regulation 2011. Most aquifer interference activities were licensed for 'dewatering' purposes under Part 5 of the *Water Act 1912*. These licences convert to WMA 2000 licences when water sharing plans commence. Some aquifer interference activities may also require an aquifer interference approval under the WMA 2000 when the relevant provisions of the WMA are commenced[8].

Principle 23 – Plans include provisions for available water determinations (AWDs) to be made to credit water to access licence water accounts.

[8] The Aquifer Interference Policy (2012) explains the water licensing and approval processes for activities that interfere with an aquifer.

3.5.7 Managing groundwater systems highly connected to regulated rivers

Principle 24 – Alluvial groundwater systems that are highly connected to regulated rivers have specific rules that recognise the level of connectivity, by linking the AWDs for the groundwater to the AWDs for the surface water.

This principle recognises that a component of groundwater recharge is derived from the regulated river system. Annual management is the most appropriate mechanism for managing extraction in these alluvial systems. Hydrogeological modelling will be used to quantify the impact of groundwater pumping on regulated rivers under an average annual pumping regime and this impact will be used as the basis for linking AWDs.

3.5.8 Managing groundwater systems highly connected to unregulated rivers

Available water determinations in unregulated water sources are used to control growth in use above the LTAAEL only, and do not relate to resource availability. As such, AWDs for access licences in alluvial systems that are highly connected to unregulated rivers are not linked to AWDs for access licences in those unregulated rivers. However, daily access rules may be linked to the access conditions for access licences in the highly connected unregulated rivers.

Table 11: Principles for managing growth in use and linking available water determinations

	Fractured rock, porous rock, coastal sands, coastal floodplain alluvial, NSW North West, groundwater sources overlying the GAB	**Coastal upland alluvial and Murray-Darling Basin alluvial**
Application of the principles	AWD used as management tool for growth in extraction above the LTAAEL AWD not linked to surface water AWDs in these systems	AWD used as management tool for growth in extraction above the LTAAEL AWD linked to surface water AWDs in systems connected to regulated surface water. Hydrogeological modelling will be the basis for linking AWDs between the regulated river and the alluvium. AWD not linked to surface water AWDs in systems connected to unregulated surface water.
Rule	Rules for compliance with the LTAAEL to be assessed over a 3 year period with a response tolerance of 5 percent. Plan to include standard AWD provisions for crediting water to accounts and managing GIU	Rules for compliance with the LTAAEL should be tailored on a plan by plan basis. Plan to include standard AWD provisions for crediting water to accounts and managing GIU If the groundwater is highly connected to a regulated river, AWDs for aquifer access licences are linked to the AWDs for regulated river access licences (general or high security, depending on the characteristics of the system).
Exception		**Paroo, Warrego, Lower and Upper Darling Alluvium** These saline alluvials have low levels of connectivity with surface water features so approach taken is similar to that for the hard rock groundwater systems (first column).

3.5.9 Managing highly committed systems

Principle 25 – Compliance with the LTAAEL is the primary tool for managing annual extraction volumes.

Principle 26 – Entitlement reduction will not be undertaken where entitlement is significantly greater than the LTAAEL.

Where the total licensed volume (entitlement) is significantly greater than the LTAAEL developed for a water source, the LTAAEL will be the primary tool for managing extraction. Any growth in use above the LTAAEL will be managed through a reduction in the maximum AWD.

Supplementary water access licences which are based on a history of use have been issued in some inland groundwater sources to mitigate the impact of a significant reduction in the maximum AWD.

Entitlement reduction will not be undertaken at this stage. However, in some circumstances appropriate amendment clauses may included in water sharing plans.

3.5.10 Managing unassigned water

Principle 27 – Before any unassigned water is released through a controlled allocation order made under section 65 of the WMA 2000, future priority extraction requirements for that water source are considered.

All surface water sources in NSW are fully committed. Most highly connected (mainly alluvial) groundwater is also considered fully committed because of its connectivity to surface water. There are some groundwater sources, however, where the LTAAEL is higher than the total volume of licensed entitlement plus water required to meet basic landholder rights. In this case, 'unassigned' water exists and is potentially available to be allocated as new entitlement. Groundwater sources with unassigned water are usually non-alluvial.

Section 65 of the WMA 2000 requires an order to be made before any unassigned water is allocated as a new licence. This is known as a 'controlled allocation' order. Only a portion of the total unassigned water in a groundwater source will be released per controlled allocation order.

Table 12: Principles for managing unassigned water

	Fractured rock, porous rock, coastal sands, coastal floodplain alluvial, NSW North West, groundwater sources overlying the GAB	**Upland alluvial**	**Murray-Darling Basin alluvial**
Application of the principles	Unassigned water may be available to be allocated in some water sources.	LTAAELs set at current entitlement so no unassigned water available.	LTAAELs set at current average extractions so no unassigned water available.

3.6 Rules for granting access licences

3.6.1 Specific purpose access licences

Principle 28 – Plans acknowledge that new specific purpose access licences may be granted under the WMA 2000 and may, where appropriate, limit the new licence types or volumes that may be granted.

The WMA 2000 allows for specific purpose licences to be granted in a particular water source. These types of licences and any limits on the maximum volume that can be granted, are detailed in the 'Rules for granting access licences' section in each plan.

Plans may include additional specific purpose access licences not specified under the regulations where warranted. Plans may also continue limitations or allowances currently provided for in the embargo orders they replace.

Table 13: Principles for granting new access licences

	All
Application of the principle	Include standard provisions for granting specific purpose access licences in accordance with the WMA 2000 and its regulations. Consider limiting the volume of subcategory 'Aboriginal cultural' for each licence application. Make specific provision for Aboriginal community development licences where appropriate.
Rule	Standard rules for granting of specific purpose access licences under the *Water Management (General) Regulations 2004*. Limit the volume of subcategory 'Aboriginal cultural' for each licence application.

3.6.2 Local and major water utilities (urban water supplies)

Access licences for local water utilities in areas covered by the plans maintain the access conditions specified in their current *Water Act 1912* licences. Once the plans commence, these licences become specific purpose access licences under the WMA 2000.

New entitlement for local water utilities is allowed under the WMA 2000. Plans can ensure the strategic reservation of groundwater for future urban water supply by:

- ensuring that future urban water needs are calculated and reserved before any releases of unassigned water from a groundwater source for commercial purposes are made through controlled allocation orders
- defining management zones within a groundwater source and specifying rules for those zones which restrict or prohibit future extraction for non-urban water supply purposes in the zone.

3.6.3 Aboriginal People and Groundwater

Aboriginal people have a spiritual, customary and economic relationship with land and water. These relationships provide important insight into 'best practice' for natural resource management.

The NSW Government is determined to ensure that Aboriginal culture is maintained and that Aboriginal communities benefit from new opportunities that access to water can bring. As well as having the same rights to groundwater as other members of the community, including basic landholders rights to domestic and stock water, water sharing plans provide for access to additional groundwater through rules for granting specific purpose access licences for Aboriginal cultural purposes or Aboriginal community development.

Applications can be made for an access licence for Aboriginal cultural purposes. This will allow an Aboriginal person or community to apply for a water access licence to take water for cultural purposes such as watering bushfoods/medicines, maintaining base flow to a billabong There is generally a volumetric limit of 10 mega litres per year per application in each groundwater source for this type of licence. As at 1 July 2014 all fees relating to Specific Purpose Access Licenses and Works Approval have been waived by NSW Treasury and do not apply, however water usage charges remain.

In most coastal groundwater sources, applications can also be made for an access licence for Aboriginal community development. These licences are designed to provide opportunities for Aboriginal communities

to develop water-based industries and can be used for commercial activities owned and/or operated by Aboriginal people such as irrigated cropping, aquaculture or manufacturing. There is no volumetric limit per application for these licences but an appropriate volumetric limit per groundwater source up to a maximum of 500 megalitres per year is generally proposed. Aboriginal community development licences can be traded permanently to other Aboriginal groups or individuals. They can be traded temporarily without that restriction.

Feedback is requested from Aboriginal communities during the public exhibition period for a draft water sharing plan. This feedback is in relation to the proposed provisions, such as volumetric limits for Aboriginal cultural and community development water access licences and the Aboriginal groundwater dependent culturally significant sites identified by the Aboriginal Water Initiative team.

3.6.4 Access licences to take water from storage

Where access to a small percent of storage is provided for in a water sharing plan, access to storage will only be permitted once the sum of total licence entitlements, basic landholder rights requirements and future priority requirements, reaches an amount that is equivalent to the recharge-based LTAAEL (DPI Water 2011).

A supplementary water access licence (subcategory ‘storage’) will be required to take water under the groundwater storage extraction limit. Supplementary water access licences (subcategory ‘storage’) will only be issued as a one off volume up to the groundwater storage extraction limit. Once this limit is reached no further licences will be permitted.

Controlled allocation orders will allow for supplementary water access licences (subcategory ‘storage’) to be made available under section 65 of the WMA 2000.

3.7 Rules for managing access licences

3.7.1 Water allocation account management rules

Principle 29 – Accounting rules recognise the capacity of the groundwater source to cope with variability around annual extraction limits (i.e. to permit unused allocations to be carried over and extracted in the next water year).

Water allocation account management rules specify how water is managed in water allocation accounts.

Account management rules may provide for the carryover of unused water allocations from one water year to the next where the groundwater source has the capacity to absorb a higher level of annual extraction on a short term basis.

Carryover provisions provide flexibility of access for water users to better cope with climate variation.

For highly connected systems, carryover provisions and accounting periods should match those for the connected surface water source.

Table 14: Principles for managing water accounts

	Less highly connected	**Highly connected with unregulated surface water**	**Highly connected with a regulated river**
Application of the principle	Annual accounting May have some carryover.	Three or five year accounting	Annual accounting
Rule	Standard accounting	Standard accounting	Standard accounting

	Less highly connected	Highly connected with unregulated surface water	Highly connected with a regulated river
	provisions.	provisions.	provisions.

3.7.2 Access rules for managing surface water and groundwater connectivity

Principle 30 – Connectivity between groundwater sources and surface water is considered when setting access rules to limit the impacts of groundwater pumping on surface water flows.

A key objective of the National Water Initiative (2004) is 'recognition of the connectivity between surface and groundwater resources and connected systems managed as a single resource'. For alluvial groundwater sources defined as 'highly connected' to an unregulated river system, a combined unregulated river and groundwater water sharing plan generally provides for the linking of access rules. The plans include rules that acknowledge the potential impact of groundwater pumping and surface water flow management on water availability in both surface and groundwater sources. The rules reflect the degree of connectivity and the time lag between extraction and impact. The linking of access rules is managed differently for coastal and inland areas.

For coastal areas it has generally proved too complex to define multiple new water sources or management zones and apply different management rules assuming decreasing connectivity with increasing distance from a river. As a result, where access rules are to be applied, the approach has been simplified to rules applying within 40 metres (the most highly connected portion) and those beyond 40 metres of the high bank of the river. However there is flexibility in the application of this approach to ensure local conditions are addressed.

Some groundwater sources have a high degree of hydraulic connection with surface water but the time lag of the impact on the surface water body is greater than one irrigation season, and thus they are defined as 'less highly connected'. For these systems, restricting the daily or annual groundwater access does not correspond to an improved outcome for the surface water flow in that season, so alternate management options (linking of AWDs as described earlier) are applied to address these longer term impacts. It is also evident that the level of resource management information required to manage this connectivity at a more refined level is not currently available for most groundwater sources.

Groundwater sources that are defined as being 'less highly connected' may still have generic rules which recognise there may be some level of connection to surface water. These rules may limit existing extraction in the immediate vicinity of the surface water or be restricted to the management of new extraction and placement of works.

This definition is a simplified version of, but still reasonably consistent with, the key findings and conclusions released for discussion amongst state jurisdictions by the Murray-Darling Basin Commission in their report 'Evaluation of the connectivity between surface water and groundwater in the Murray-Darling Basin' (July 2006). It has been specifically set to enable short term impacts of groundwater pumping on surface water to be managed with appropriate rules.

Principle 31 – 'Highly connected' systems for the purposes of applying management rules are defined as those systems where 70 percent or more of the groundwater extraction volume is derived from surface water within an irrigation season. All other systems are considered 'less highly connected'.

Principle 32 – For management purposes, highly connected alluvial groundwater sources and their associated river reaches are classified as regulated, perennial or non-perennial to determine the type of management rules required.

Principle 33 – Alluvial groundwater systems that are highly connected to perennial unregulated systems have specific rules that recognise the level of connectivity based on daily access linking their management

to the associated unregulated surface water daily access rules. Non-perennial systems will have groundwater only rules.

Groundwater systems associated with non-perennial streams that meet the definition of highly connected during the periods when flow occurs may be treated as less highly connected for the purposes of applying management rules. This ensures recognition of the significant periods of time during which there is little connectivity between the stream and the groundwater system and the significant impact that linking groundwater management rules to surface water availability would have on groundwater users.

Table 15: Principles for management of surface and groundwater connectivity across coastal NSW

	Fractured rock, porous rock, coastal sands	**Coastal upland alluvial**	**Coastal floodplain alluvial**
Application of the principles	Groundwater licences that have daily access rules will apply from year 6 of the plan, apart from exempted licence categories.	Groundwater licences that have daily access rules will apply from year 6 of the plan, apart from exempted licence categories.	Groundwater licences that have daily access rules will apply from year 6 of the plan, apart from exempted licence categories.
Within 40m of a high bank of a river or creek	Assume that this portion of the groundwater source more likely to be highly connected, so daily access rules applied same as for the associated unregulated surface water source. (Note: If the surface water is regulated then no daily access rules as linkage is though annual management.)	Assume that this portion of the groundwater source more likely to be highly connected, so daily access rules applied same as for the associated unregulated surface water source. (Note: If the surface water is regulated then no daily access rules as linkage is though annual management.)	Where there is a **tidal pool**, daily access rules applied same as for the associated unregulated surface water source.
Outside 40m of a high bank of a river or creek	No daily access rules are applied as it is not likely to be highly connected.	Likely to be highly connected but with some delay in impact and buffering ability depending on the characteristics of the groundwater source. As such, daily access rules are applied as for the associated unregulated surface water source with a lag time. Lag times are based on groundwater system characteristics.	No daily access rules applied as not likely to be highly connected
Rule	Include daily access rules for groundwater access within 40 m of unregulated river or stream	Include daily access rules for groundwater access within 40 m of unregulated river or stream Include daily access rules with a lag time for groundwater access outside 40 m of unregulated river or stream	Include daily access rules for groundwater access within 40 m of unregulated river or stream if a tidal pool present.

Exception		**Hunter water sharing plan** The whole water source may be considered highly connected due to the nature of the geology and river flows for example highly sandy, permeable soils in systems with flashy flows the whole water source may have the rules applied rather than the standard 40m application.	

Management of connectivity in inland alluvials is based on an assessment of the level of connectivity of each groundwater system with the associated surface water. The typical 40 metre boundary was not used for these systems as it was consistent with the principle for setting the LTAAEL, where current levels of groundwater pumping results in acceptable impacts on surface water sources. Management of existing works (extraction limits) and prohibitions of new works within this 40 metre boundary, as discussed previously, provide alternate management options.

Recent modelling[9] shows that groundwater systems quickly become disconnected as the stream flow drops in non-perennial streams, and as such the linking of access rules shall only occur for highly connected alluvials associated with perennial unregulated streams in Murray-Darling Basin NSW. For large areas of inland NSW the surface water systems are non-perennial and groundwater users within 40 metres would be subject to cease to pump rules most of the time, resulting in undue impacts on access.

Table 16: Principles for management of surface and groundwater connectivity across inland NSW

	Fractured rock, porous rock, NSW North West, groundwater sources overlying the GAB	**Murray-Darling Basin alluvial**
Application of the principles	Groundwater licences that have daily access rules will apply from year 4 (Murray-Darling Basin only) or year 6 of the plan, apart from exempted licence categories.	Groundwater licences that have daily access rules will apply from year 4 of the plan, apart from exempted licence categories.
Highly connected	Not applicable	Within and outside 40 m of a high bank of the river or creek daily access rules applied as for the associated unregulated surface water source with a lag time. Lag rules vary depending on several groundwater system characteristics, primarily its storage capacity and connectivity to surface water which affect the ability for a groundwater system to buffer the impacts of extraction on surface water.
Less highly connected	No daily access rules applied as less highly connected	No daily access rules applied as specifically defined as less highly connected
Rule	No access rules specified	Include daily access rules with a lag time for groundwater access in highly connected systems only.

[9] Barrett, C. and Broadstock, B., 2010 Impact of groundwater pumping and assessment of river reaches for highly connected water sources in NSW

3.8 Rules for water supply work approvals

Principle 34 – Plans include rules on the location of new works and extraction from existing works to limit impacts on base flows, sensitive environment areas, groundwater dependent ecosystems, culturally significant sites and other water users.

Plans will specify rules for managing the quality of the water in the groundwater source and mitigating impacts of extraction on the environment and other users. Macro plans may also specify daily access rules for licences in groundwater systems that are highly connected to unregulated surface water sources.

3.8.1 Distance rules for water supply work approvals

Rules may restrict the granting or amending of water supply work approvals:

- in the vicinity of a high priority GDE to mitigate impacts of extraction on the high priority GDE
- in the vicinity of high priority Aboriginal groundwater dependent culturally significant sites to mitigate impacts of extraction on the high priority Aboriginal groundwater dependent culturally significant sites;
- near an existing water supply work to mitigate impacts of extraction on existing users
- near a contamination source to protect the quality of the water in the groundwater source.

Distance rules are used to minimise interference and impacts as a result of the placement of water supply works. Extraction limitations for existing works located within these distances are also applied to protect from further impacts beyond current levels should additional shares and allocation be transferred onto the licence nominating that work. This recognises existing use rights but prevents further impacts through limiting extractions to those levels at plan commencement.

To provide reasonable consistency between similar hydrogeological types across plan areas, rules are based on a standard suite of recommended rules per groundwater system type, amended where appropriate, and based on input from local hydrogeological and/or licensing staff, to suit local conditions with justification – see Appendix 8A: Standard distance criteria for water supply work approvals.

A set of exemptions to the distance criteria has been developed to recognise existing property rights and circumstances where the standard distance rules impose unacceptably large buffer distances on small lot sizes, which could result in many users unable to relocate works. This includes an exemption for replacement groundwater works. Variation from the standard distance rules can result from a detailed hydrogeological study, submitted by an applicant and assessed as adequate by the Minister, which demonstrates that the location of the water supply work at a lesser distance will result in no greater impact on the groundwater source, its dependent ecosystems or other water users. For Aboriginal groundwater dependent culturally significant sites the Aboriginal Water Initiative holds the information of the location and significance of these sites on the secure AWIS database.

In the first round of water sharing plans, which commenced in 2004, distance rules for water supply works were combined with other rules relating to water quality and water level management. These rules were collectively termed ‘management of local impacts’ and relied on the establishment of a ‘local impact area’. However there was no clear legal mechanism for the establishment of such areas soy the WMA was amended in 2008 to allow for the issuing of orders under section 324(2) to address a range of issues including the need to maintain or protect water quality or water levels in a groundwater source.

Rules relating to the management of water quality and water levels are no longer included in a water sharing plan. Orders made under section 324 of the *Water Management Act 2000* are made independently of the plans.

Table 17: Principles for granting water supply works

	Fractured rock, porous rock and coastal sands	Alluvial
Application of the principle	Inclusion of rules for replacement works. Distance rules for new water supply works to: • minimise interference between water supply works, • minimise the future impact of works located near contaminated sites, • minimise the future impact of works located near sensitive environmental areas, including rules that manage future impacts: • on connected surface water where new works are not to be located: o within 40m of the high bank ofa 3rd order river or stream, or o within 40m of the high bank of 1st and 2nd order streams unless drilled through the underlying parent material and cased through to this hard rock. o on high priority GDEs • minimise the future impact of works located near Aboriginal groundwater dependent culturally significant sites. Limit extraction from water supply works that exist within the specified distance criteria to the volume represented by the share component attached to the licence that nominated the work at the start of the plan	Inclusion of rules for replacement works. Distance rules for new water supply works to: • minimise interference between water supply works, • minimise the future impact of works located near contaminated sites, • minimise the future impact of works located near sensitive environmental areas, including rules that manage future impacts: o on connected surface water where new works are not to be located within 40m of the high bank of a river or stream, o on high priority GDEs • minimise the future impact of works located near Aboriginal groundwater dependent culturally significant sites. Limit extraction from water supply works that exist within the specified distance criteria to the volume represented by the share component attached to the licence that nominated the work at the start of the plan.
Rule	Standard rules with distance criteria specific for the groundwater system type and water source. Standard set of exemptions from the distance criteria. Standard rules for extraction limit on existing works within identified distance criteria. Standard rules for replacement groundwater works	Standard rules with distance criteria specific for the groundwater system type and water source. Standard set of exemptions from the distance criteria. Standard rules for extraction limit on existing works within identified distance criteria. Standard rules for replacement groundwater works
Exception	**Existing gazetted plans** May have a variation on these rules and exemptions.	**Existing gazetted plans** May have a variation on these rules and exemptions.

3.8.2 Replacement groundwater works

Principle 35 – Plans provide rules for replacement groundwater works to acknowledge usage rights related to existing water supply works.

The rules for replacement groundwater works are included in the rules for water supply work approvals section of each plan commencing after June 2010. The definition of replacement groundwater work:

- acknowledges use rights related to existing water supply works used for the purpose of taking water from a groundwater source for water supply
- is appropriately narrow so as to limit impacts from amending water supply work approvals for replacement groundwater works on the environment and other users to no greater than those impacts arising from the existing water supply work
- is consistent with the WMA 2000, specifically section 107.

Mandatory conditions specify that a work must be decommissioned in compliance with standards specified by the Minister, except in limited circumstances when the work is required by the Minister as a monitoring or observation bore or where the replacement groundwater work is in the same location as the existing work. By requiring the existing water supply work to be decommissioned, this ensures that the existing water supply work is not used in addition to the replacement groundwater work, or provides a path for contaminants to enter the groundwater source or allow cross aquifer contamination.

3.8.3 Groundwater dependent ecosystems

Principle 36 – Plans list high priority groundwater dependent ecosystems (GDEs). The high priority GDEs are to be protected from future impacts of extraction by limits on placement of new works and by limiting extractions from existing works within specified distance criteria around the GDE. The plans include provision to revise the high priority GDE schedule when further information becomes available about GDE location, dependence on groundwater and / or priority for protection.

The method for identifying and assessing GDEs is outlined in Appendix 8B. Groundwater dependent ecosystems (GDEs) are ecosystems which have their species composition and natural ecological processes determined to some extent by the availability of groundwater. GDE types include cave systems (including Karsts), springs, base flow rivers, wetlands and terrestrial vegetation. GDEs which are identified as high ecological value are then categorised as high priority if they are currently under threat of groundwater extraction are listed in the water sharing plans (WSPs). To limit the impacts due to groundwater extraction setback distances for water supply works have been applied through the use of distance rules in the WSPs. The initial stage for identifying GDEs (Stage 1) was based on a list of currently known GDEs provided from various sources such including other government (e.g. protection through Threatened Species Conservation Act 1995) and published site specific scientific research. Whilst Stage 1 GDES are currently being listed in the WSPs, a process of identifying GDEs of high ecological value across the state is currently being undertaken (Stage 2) based upon a number of data sources including groundwater, ecological data and spatial wetness and greenness data and scientific evidence from published literature.

Table 18: Principles for the protection of groundwater dependent ecosystems

	All
Application of the principle	GDEs identified for each water source in the plan area.
Rule	Distance rules and extraction limits on water supply work approvals specified for protection of high priority GDEs from future impacts.

3.9 Access licence dealing rules

Principle 37 – Plans include dealings rules that encourage trade whilst protecting environmental values and minimising third party impacts.

Dealing (trading) rules are intended to provide for efficient water markets whilst recognising and protecting the needs of the environment and third-party interests. In most macro plans, dealings are allowed within a groundwater source but not into or out of the groundwater source. This is consistent with the Minister's *Access Licence Dealing Principles Order 2004* which prohibits trade between surface and groundwater and only allows trade between water sources which are hydrologically connected.

Where appropriate, in highly connected groundwater sources the dealing rules for aquifer access licences should mirror the relevant rules for the respective surface water source, for example pick up on any unregulated or regulated river trading rules. However, trade between the highly connected groundwater source and respective surface water source is prohibited if they are different water sources.

Table 19: Dealings principles for groundwater sources across NSW

	All
Application of the principle	Within water source transfers only and other rules as applied to management zones and water sources as required to manage environmental and third party impacts.
Rule	Standard dealings provisions and specific rules for each water source or management zone as required.
Exception	Licences within coastal alluvial and floodplain alluvial groundwater sources may transfer between surface and groundwater where they are in the same water source.

3.10 Mandatory conditions

In order to give effect to the rules in the Plan, it sets out a number of standard conditions that will be applied to water access licences and water supply work approvals. Mandatory conditions on licences and approvals cannot be removed or altered unless the plan itself permits.

3.11 Amendment of the plan

3.11.1 Adaptive management

Principle 38 – Plan development is based on the best available information. A lack of information should not prevent planning being undertaken. Planning should recognise the limitations on which it is based, and where possible allow for amendments to be made to the plan when further information becomes available.

Adaptive management is the practice of changing a management regime in response to new information, either from monitoring or other improvement in understanding. Adaptive management is an important ongoing process for the plans as it allows management decisions to be improved over time. Adaptive

management is a requirement of both the WMA 2000 and the National Water Initiative and its application in each plan is balanced against the need licence holders have for a reasonable degree of certainty.

In some groundwater sources, particularly those that are not highly committed, there is insufficient information to develop perfect plan rules to manage environmental or socio-economic risks. In these cases, further analysis or data collection may be desirable or necessary during the life of the macro plan. The plans include provisions which make allowance for adaptive management. An important aspect of a water sharing plan is that it provides certainty to licence holders in terms of their access to water over the term of the each plan. Where any aspects of the plan may change as a result of new information, this will be stated in the plan to give certainty and clarify to water users which rules may be varied during the life of the plan as a result of adaptive management.

Table 20: Adaptive management principles for groundwater sources across NSW

	All
Application of the principle	Incorporate adaptive management in development of plans.
Rule	Include amendment provisions in plans to provide for adaptive management where applicable.

3.12 Other information

3.12.1 System operation rules

Operational rules may be specified for access licences held by utilities where relevant.

Glossary

Aboriginal groundwater dependent culturally significant sites is a site, place that is deemed groundwater dependant and significant by the relevant Aboriginal person or community**.**

Access licence: As defined by the *Water Management Act 2000.*

Alluvial: Sediment transported and deposited by running water, e.g. rivers and flood plains.

Alluvium: Unconsolidated sedimentary deposits made by rivers or streams or found on alluvial fans, floodplains that consist of gravel, sand, silt and clay.

Aquifer: As defined by the *Water Management Act 2000*.

Aquifer interference activity: As defined by the *Water Management Act 2000.*

Available water determination: As defined by the *Water Management Act 2000.*

Basalt: A dark-coloured fine grained volcanic rock.

Basic landholder rights: As defined by the *Water Management Act 2000.*

Beneficial use: A general categorisation of groundwater uses based on water quality and the presence or absence of contaminants. Beneficial use is the equivalent to the 'environmental value' of water.

Dealing: As defined by the *Water Management Act 2000.*

Dual porosity: Where a groundwater system has two types of porosity; primary porosity resulting from the voids between the constituent particles forming the rock mass, and secondary porosity resulting from solution, faulting and jointing of the rock mass.

Ecological values: The intrinsic or core attributes associated with naturalness, diversity, rarity and special features, but excluding representativeness used to classify water sources for apportioning water management rules. The natural significance of ecosystem structure and functions is expressed in the terms written in italics.

Ephemeral: Temporary or intermittent; for instance, a creek or wetland which dries up periodically.

Extraction management unit (EMU): A single water source or group of water sources; defined for the purpose of managing long-term annual average extraction.

Granite: Coarse grained plutonic igneous rock composed principally of quartz and feldspar.

Groundwater: Water that occurs beneath the ground surface in the saturated zone.

Groundwater dependent ecosystem (GDE): An ecosystem relying on groundwater for their species composition and their natural ecological processes. A water dependent ecosystem is defined in the *Water Act 2007.*

Groundwater management area (GWMA): A groundwater source, identified by mapped boundaries and a groundwater management area number.

Hydrologically connected: As defined by the *Access Licence Dealing Principles Order 2004.*

Hydraulic connection: A path or conduit allowing fluids to be connected. The degree to which a groundwater system can respond hydrologically to changes in hydraulic head.

Hydraulic head: A measure of the energy potential which the groundwater has, and which drives flow from areas of high to low hydraulic head.

Local water utility: As defined by the *Water Management Act 2000.*

Long-term average annual extraction limit (LTAAEL): The long term average volume of water (expressed in megalitres per year) in a water source available to be lawfully extracted or otherwise taken.

Major water utility: As defined by the *Water Management Act 2000*.

Macro water sharing plans: Plans that apply to a number of water sources across catchments or different types of groundwater systems. The macro planning process is designed to develop broader-scale plans covering most of the remaining water sources in NSW.

Management zone: An area within a water source used for defining the location of applicability of water sharing rules, but secondary to the water source. A management zone is more likely to be designated where local dealing restrictions are in place or where 'cease to pump' rules for work approvals apply.

Mandatory conditions: Those conditions as are from time to time required to be imposed on the access licence or approval by the relevant management plan or Minister's plan.

Murray-Darling Basin Ministerial Council Cap: The limit imposed in 1995 on the volume of water which could be diverted from rivers in the Murray-Darling Basin for consumptive uses. For NSW and Victoria, the cap is defined as 'the volume of water that would have been diverted under 1993/94 levels of development.' The cap does not apply to groundwater extraction.

Planned environmental water: As defined by the *Water Management Act 2000*.

Recharge: The movement of water into a groundwater system by infiltration, flow or injection from sources such as rainfall, overland flow, adjacent groundwater sources, irrigation, or surface water bodies.

Regulated river: As defined by the *Water Management Act 2000*.

Sandstone: Sedimentary rock composed of sand-sized particles with varying amounts of a fine-grained matrix of silt or clay.

Saturated thickness: The thickness of a groundwater system that is fully saturated.

Upper extraction limit: The total volume (ML/year) of groundwater that may be made available in most non-alluvial coastal groundwater sources to licensed or approved extraction, via an amendment to the LTAAEL.

Water allocation: As defined by the *Water Management Act 2000*.

Water sharing plan (plan): A plan made under the *Water Management Act 2000*. These plans set out the rules for sharing water between the environment and water users within whole or part of a water management area or water source.

Water source: As defined in the *Water Management Act 2000*.

Water supply work: As defined by the *Water Management Act 2000*.

Water supply work approval: As defined by the *Water Management Act 2000*.

Water table: Upper surface of groundwater at atmospheric pressure, below which the ground is saturated.

Yield: The amount of water that can be supplied over a specific period.

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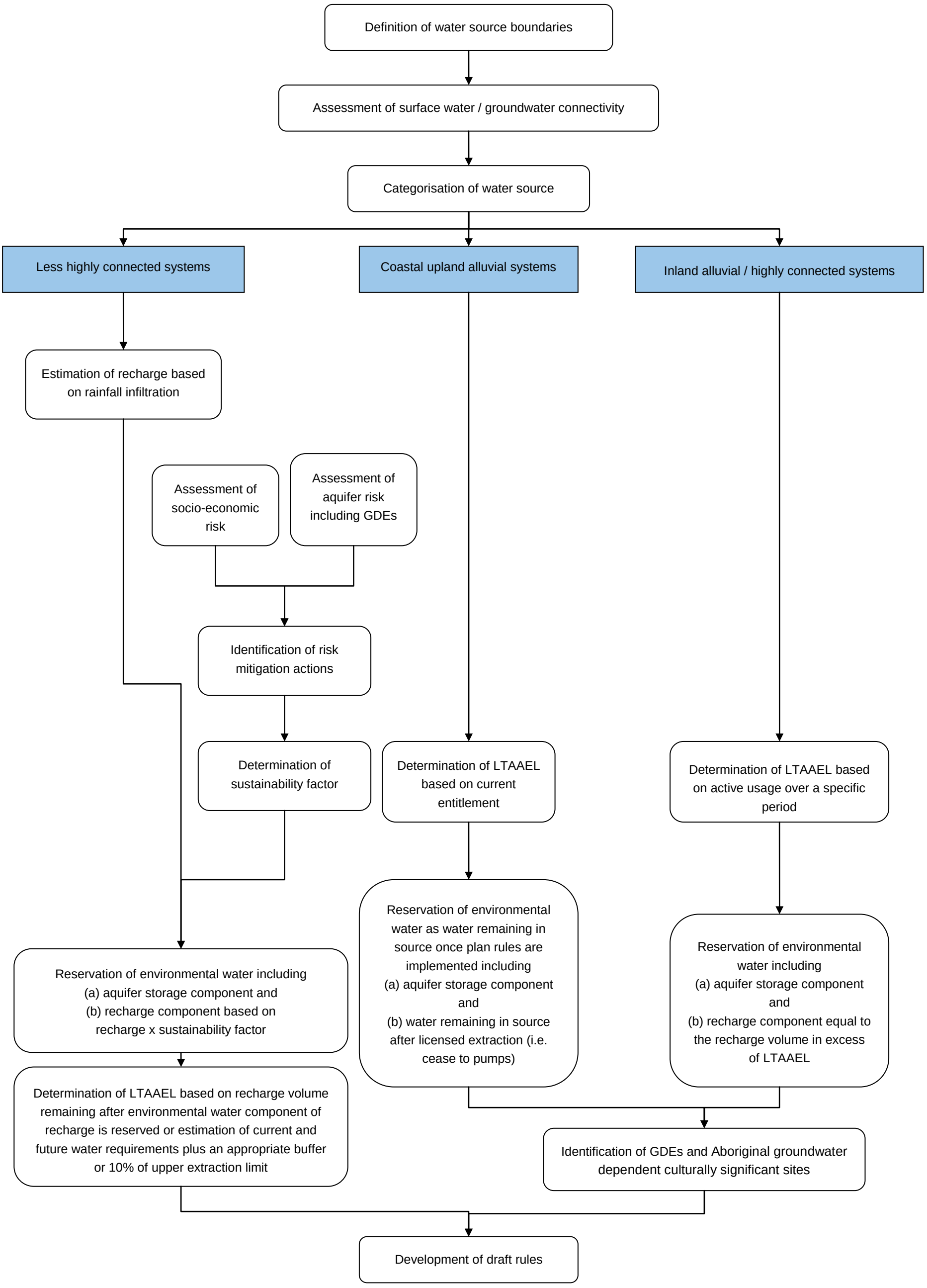
Appendix 1: Diagram showing the process for developing groundwater sharing plans

Figure 2: Process for developing groundwater sharing plans



Appendix 2: Groundwater planning

Table 21: Water sharing plans under development

Water sharing plans under development
North Coast Fractured and Porous Groundwater Sources
North Coast Coastal Sands Groundwater Sources
South Coast Groundwater Sources

Note the plan areas may change as planning continues in these areas. Additional plans are being completed which contain groundwater sources however these are not listed above.

Appendix 3: Methods for estimating usage under basic landholder rights

Historically the method for calculating groundwater usage to meet basic landholder rights (BLR) varied. Examples of BLR calculation methods used in existing plans are in Table 22.

Table 22: Examples of BLR calculation methods used in the current water sharing plans

Water Source	Method Used	Comments
Lower Murrumbidgee Groundwater Source	All stock and domestic purpose bores (excluding bores with entitlement) were extracted from the Licensing Administration System database (LAS). The number of bores extracted was doubled, because it was assumed there are actually twice as many bores as are recorded in LAS. The number of bores was then multiplied by 5 ML/yr (assumed 2ML/yr for domestic and 3ML/yr for stock usage).	This method does not allow for differences in water use between urban and rural areas and does not take into account the differences in stocking rates across an area. It also can assign multiple BLR volumes to a property. Does not take into account other water sources such as surface water, farm dams, tanks etc.
Lower Macquarie, Lower Lachlan Groundwater Sources	Average property size was estimated and divided by the water source area. It was assumed that each property has one domestic bore. A domestic volume (approximately 2ML/yr) was then multiplied by the number of properties. Stock was estimated by multiplying a stock rate (approximately 2 or 3ML/yr) by the carrying capacity of the land within the water source.	This method does not allow for differences in water use between urban and rural areas. Does not take into account other water sources such as surface water, farm dams, tanks etc.
Former Barwon Region surface water plans.	The number, average size and length of riparian properties with river frontage were measured using shire property maps. BLR requirements for each property were determined using DLWC farm water supplies data. The demand per property was expressed as demand per km river and extrapolated to estimate total demand for the length of the river.	This method does not allow for differences in water use between urban and rural areas. Does not take into account other water sources such as groundwater, farm dams tanks etc.

Application of BLR methodologies

In developing the current round of (macro) water sharing plans a consistent approach to the calculation of BLR was sought.

The main outcome from the calculation of BLR is to allocate a BLR volume to each water source based on the fair and equitable sharing of water, while preventing double accounting. Therefore all sources of water should be considered in the method used to calculate BLR.

Due to variations in topography and climate across the state, the use of groundwater to meet domestic and stock requirements differs significantly between coastal and inland areas, as well as between urban and rural landscapes. The main factors that influence the difference in the use of groundwater between urban and rural areas are:

- whether there is a reticulated mains water supply
- housing density and property sizes
- access and infrastructure constraints on bore installation in urban areas

- airborne contamination in urban areas.

To account for variations that occur in groundwater usage for domestic and stock purposes due to these factors, two methodologies for estimating the groundwater taken for domestic and stock purposes have been developed. These are the area-based estimation method and the database extraction method.

Domestic and stock use estimates for groundwater usage in alluvial, coastal sands and inland porous and fractured groundwater sources have been derived using the area-based estimation approach. Domestic and stock use estimates for groundwater usage in fractured and porous rock groundwater sources in coastal areas have been derived using the database extraction approach.

Area-based method for estimating BLR

This method for calculating BLR uses the reasonable take and use zones and domestic and stock consumption allowances outlined below. Both surface and groundwater estimates are considered in the calculations to reduce the instance of 'double accounting'.

Areas with significant reliance on groundwater and surface water were determined. The assumptions used to determine the reliance on groundwater are outlined below.

Land use data was used to determine 'grazed area' and a volume allocated by applying a stock consumption allowance (ML/ha) to determine stock use in each water source.

Population and housing census data from the Australian Bureau of Statistics were used to calculate the proportion of houses close to surface water courses.

While the overall method for calculating BLR will not change, the assumptions that apply to individual water sources, such as the percentages used for groundwater, may be altered where local hydrogeological knowledge can supply better information.

Groundwater reliance assumptions

The following details the assumptions used for estimating reliance on groundwater by zone outside the areas that are assumed to be using primarily river and creek water:

Coast

- High rainfall; meaning water tanks and dams are likely to be used rather than groundwater.
- Easy access to groundwater in coastal sands areas, large number of spear points.

ASSUMPTION:

Domestic – assume 10 percent

Stock – assume 15 percent

Tablelands

- Relatively reliable rainfall meaning dams and water tanks are likely to be used over groundwater.
- In general groundwater access gives low yields with varying quality.

ASSUMPTION:

Domestic – assume 25 percent of houses within the water source would use primarily groundwater over rainwater.

Stock – assume 40 percent of the grazed area within the water source would use primarily groundwater for stock watering over dams.

Slopes

- Less reliable rainfall, meaning dams and water tanks are still likely to be used over groundwater where possible.
- In general groundwater access gives varying yields with varying quality.

ASSUMPTION:

Domestic – assume 35 percent of houses within the water source would use primarily groundwater over rainwater.

Stock – assume 50 percent of the grazed area within the water source would use primarily groundwater for stock watering over dams.

Plains

- Unreliable rainfall, meaning groundwater will be used over dams and water tanks.
- In general groundwater access gives varying yields with varying water quality.

ASSUMPTION:

Domestic – assume 70 percent of houses within the water source would use primarily groundwater over rainwater, in some areas groundwater is unfit for human consumption.

Stock – assume 80 percent of the grazed area within the water source would use primarily groundwater for stock watering over dams.

Great Artesian Basin (GAB) – Proper and groundwater sources overlying the GAB

- Confining rock and alluvium water sources overlay the GAB Proper.
- The GAB Proper has a gazetted water sharing plan in which BLR volumes have already been estimated.
- Local hydrogeological knowledge recommends apportioning 5 percent of the total calculated BLR volume to the groundwater sources overlying the GAB, assuming the rest would be sourced from the underlying GAB Proper.

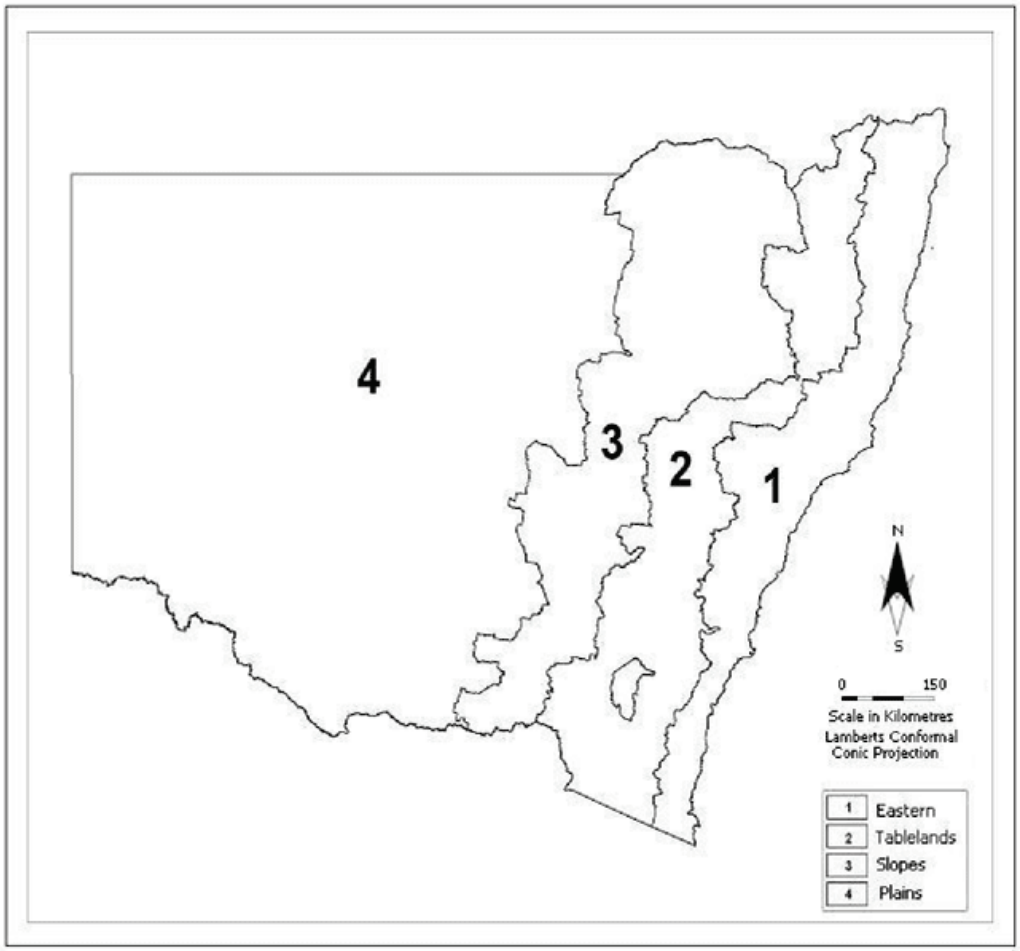
Calculating surface water stock use (ML/yr)

Excluding areas of reticulated town water supply, the potential grazed area likely watered by surface water was established by selecting the stream orders detailed in Table 23 by zone (Figure 3);

Table 23: Stream orders assumed to provide reliable access for stock watering

Zone	Stream Order
Eastern	2nd order and above
Tablelands	2nd order and above
Slopes	3rd order and above
Plains	4th order and above

Figure 3: State zones



- The stream orders were selected for each zone based on the stream's reliability to provide basic landholder right water for the majority of the year on average.
- Each side of the selected streams was then buffered based on the assumed distance stock will walk to water:
    - for the slopes, tableland and eastern (coastal) zones a buffer of 400m either side of a river was used.
    - for the plains zone, a buffer of 1km either side of the river was used.
- The buffered streams were divided into surface water and groundwater sources.
- Within each buffered surface water source the areas of unimproved, improved, irrigated grazed pasture were determined using the NOW 2005 Land Use data.
- The estimated stock use volume within the buffered areas was calculated by multiplying area of unimproved, improved, irrigated grazed pasture by the stock watering allowances for rural land in Table 24.

Table 24: Stock watering allowance by zone

Zone	Pasture type	Take Allowance (ML/Ha)
Eastern	Unimproved pasture	0.025
	Improved pasture	0.045
Tablelands	Unimproved pasture	0.020
	Improved pasture	0.045
Slopes	Unimproved pasture	0.015
	Improved pasture	0.045
Plains	Unimproved pasture	0.010
	Improved pasture	0.020
All zones	Irrigated pasture	0.050

- It was assumed a percentage of use within the buffered areas is sourced from groundwater.
- A percentage of the total estimated stock use volume within the buffered streams was assigned to the underlying groundwater source using the percentages in Table 25.

Table 25: The percentage of total estimated stock use within the buffered stream area assumed to be sourced from the underlying groundwater system

Zone	Groundwater system type
Eastern	All 5%
Tablelands	Alluvials 20% Other groundwater system 10%
Slopes	Alluvials 20% Other groundwater system 10%
Plains	Alluvials 40% Other groundwater system 30%

Calculating surface water domestic use (ML/yr)

- The GIS layer of reticulated town water supply area was used to differentiate urban and rural areas.
- It was assumed domestic use within urban areas is covered by reticulated town water supply that has surface water and/or groundwater entitlement and therefore any private surface water extraction for domestic consumption would be negligible.
- Excluding areas of reticulated town water supply, the rural areas of significant domestic surface water use was determined by selecting the stream orders as detailed in Table 26 by zone.

Table 26: Stream orders assumed to provide reliable access for domestic supply

Zone	Stream order
Eastern	3rd order and above
Tablelands	3rd order and above
Slopes	4th order and above
Plains	5th order and above

- The stream orders were selected for each zone based on the stream's reliability to provide basic landholder right water for the majority of the year on average.
- Each side of the selected streams was buffered by 400 metres.
- The buffered streams were divided into surface water and groundwater sources.
- Using the ABS Population and Housing census data, the average number of houses per collector district was calculated by dividing the total number of houses in that collector district by the area of that collector district.
- The area of buffered river within each collector district was determined and multiplied by the average number of houses per hectare for that collector district, then added together for each water source within the buffered area to determine the number of houses in each water source.
- The number of homes in each water source was multiplied by the domestic consumption allowances for rural land (Table 27) to determine the rural domestic volume for a water source.

Table 27: Domestic water consumption for rural lots (per year) by zone

Zone	Rural Consumption (ML/yr)
Eastern	1.0
Tablelands	1.1
Slopes	1.4
Plains	2.1

- It is assumed a percentage of use within the buffered areas is sourced from groundwater.
- A percentage of the total estimated domestic use volume within the buffered areas was assigned to the underlying groundwater source using the percentages in Table 28.

Table 28: The percentage of total estimated domestic use within the buffered stream area assumed to be sourced from the underlying groundwater system.

Zone	Groundwater system type
Eastern	All 5%
Tablelands	Alluvials 20% Other 10%
Slopes	Alluvials 20% Other 10%
Plains	Alluvials 30% Other 30%

Calculating groundwater stock use (ML/yr)

- Excluding areas of reticulated town water supply and the buffered surface water use areas as described in the surface water method, the potential grazed area of each groundwater source was established.
- Within each groundwater source, reasonable proportions of unimproved, improved and irrigated grazed pasture were identified using the NOW 2005 land use data.

- The total area of unimproved, improved and irrigated grazed land within each groundwater source was determined and the area of significant reliance on groundwater calculated using the percentage figures by zone in Table 29.

Table 29: Estimated percentage of stocked area with significant reliance on groundwater by zone.

Zone	Stock: significant reliance on groundwater (%)
Eastern	15
Tablelands	40
Slopes	50
Plains	80

- The improved, unimproved and irrigated grazed areas with significant reliance on groundwater was multiplied by the stock watering allowances for rural land in Table 30 to determine the stock use volume for a water source.

Table 30: Stock watering allowance from the RUG by zone.

Zone	Pasture type	Take Allowance (ML/Ha)
Eastern	Unimproved pasture	0.025
	Improved pasture	0.045
Tablelands	Unimproved pasture	0.020
	Improved pasture	0.045
Slopes	Unimproved pasture	0.015
	Improved pasture	0.045
Plains	Unimproved pasture	0.010
	Improved pasture	0.020
All zones	Irrigated pasture	0.050

Calculating domestic groundwater use (ML/yr)

- Excluding areas of reticulated town water supply and the buffered surface water use areas as described in the surface water method, the potential groundwater domestic use area in each groundwater source was established.

Urban

- It was assumed domestic use within urban areas is covered by reticulated town water supply that is covered by a surface water and/or groundwater entitlement and therefore any private groundwater extraction for domestic consumption would be negligible.
- Within the coastal sands areas of the eastern/coastal zone an assumption will need to be made about domestic use within urban areas.

Rural

- Using the ABS population and housing census data, the average number of houses per collector district was calculated by dividing the total number of houses in that collector district by the area of that collector district.
- The area of each groundwater source within each collector district was determined and multiplied by the average number of houses for that collector district, then added together to determine the number of houses in each groundwater source.

- The number of houses in each groundwater sources with significant reliance on groundwater was calculated by multiplying the total number of houses within each groundwater source by the percentage figures by zone in Table 31.
- The houses with significant reliance on groundwater were multiplied by the domestic consumption allowances for rural land (Table 31) to determine the rural domestic volume for each groundwater source.

Table 31: Domestic water consumption for rural lots (per water year) and estimated percentage of homes with significant reliance on groundwater by zone

Zone	Rural domestic consumption (ML/yr)	Domestic: significant reliance on groundwater (%)
Eastern	0.9	10
Tablelands	1.0	25
Slopes	1.3	35
Plains	2.0	70

Database extraction method for estimating BLR

- Searches carried out within a defined boundary of individual water sources using this method result in the grouping of licences into commercial-based (i.e. industrial, irrigation) or landholder-based (i.e. domestic, stock, domestic and stock) authorisations. The latter licences are then assigned with the following volumes to provide an estimate of BLR: For domestic licences in the coastal region a volumetric allocation of 1 ML per year is assumed.
- For stock licences in the coastal region a volumetric allocation of 2 ML per year is assumed.
- For combined domestic and stock licences in the coastal region a volumetric allocation of 3 ML per year is assumed.

The total BLR attributed to domestic and stock use can then be tallied for individual water sources by allocating volumes to the number of licences in each of the above categories.

This approach has the advantage of allocating groundwater to the actual number of extraction points known to occur within a water source. The disadvantage to this approach is that bores that are not licensed are not captured, and so the volume allocated may be an underestimate.

This methodology lends itself heavily to urbanised areas where the scale of groundwater development is highly variable and the cost of drilling, as well as the availability of a reticulated mains water supply, usually makes the use of bores unattractive to landholders.

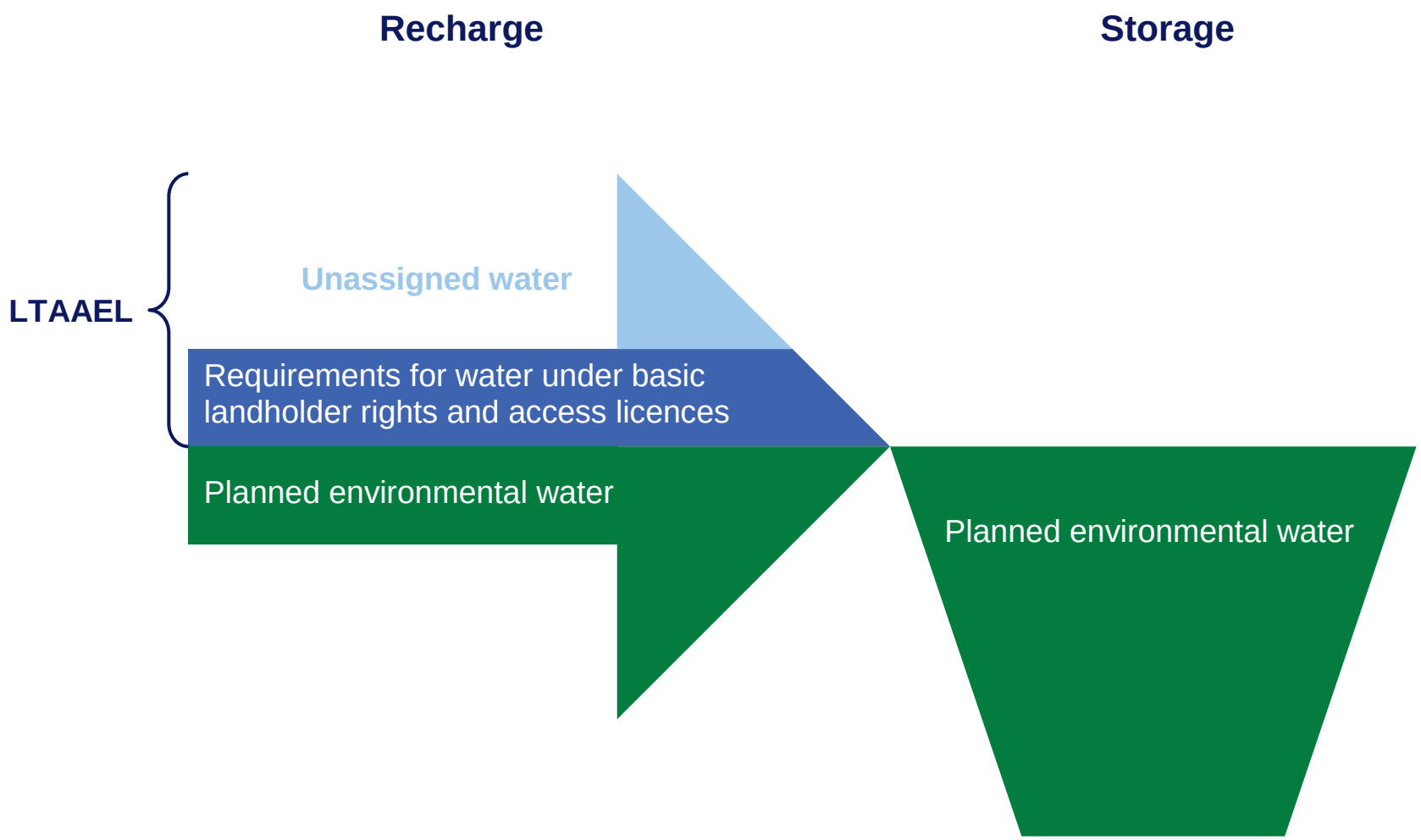
Appendix 4: List of highly connected groundwater sources

Table 32: Highly connected groundwater sources

Catchment	Water source	Highly connected zone	Associated surface water stream	Management rules
Border Rivers	Macintyre Alluvium	All	Regulated Macintyre River	Link to surface water AWD
	Ottleys Creek Alluvium	All	Unregulated Ottleys Creek	Groundwater only rules
Castlereagh	Castlereagh Alluvium	All	Unregulated Castlereagh River	Groundwater only rules
Gwydir	Upper Gwydir Alluvium	All	Regulated Gwydir River	Link to surface water AWD
Namoi	Manilla Alluvium	All	Regulated Manilla River and Namoi River, Unregulated Namoi River and Halls Creek	Regulated: Link to surface water AWD Unregulated: Link to surface water access rule with lag time
	Peel Alluvium	Peel Regulated River, Cockburn River, Dungowan Creek and Goonoo Goonoo Creek Alluvium	Regulated Peel River, Unregulated Cockburn River, Dungowan Creek and Goonoo Goonoo Creek	Regulated: Link to surface water AWD Unregulated: Link to surface water access rule with lag time
	Currububula Alluvium	All	Unregulated Currububula Creek	Groundwater only rules
	Werris Creek Alluvium	All	Unregulated Werris Creek	Groundwater only rules
	Quipolly Creek Alluvium	All	Unregulated Quipolly Creek	Groundwater only rules
	Quirindi Creek Alluvium	All	Unregulated Quirindi Creek	Groundwater only rules
Macquarie	Cudgegong Alluvium	All	Regulated Cudgegong River Unregulated Lawsons Creek	Regulated: Link to surface water AWD Unregulated: groundwater only rules
	Coolaburragundy-Talbragar Alluvium	Coolaburragundy River Alluvium	Unregulated Coolaburragundy River	Groundwater only rules
	Bell Alluvium	All	Unregulated Bell River	Groundwater only rules
Lachlan	Belubula Valley Alluvium	All	Regulated Belubula River	Link to surface water AWD
	Upper Lachlan Alluvium	Upstream of Cowra	Regulated Lachlan River	Link to surface water AWD
Murrumbidgee	Mid Murrumbidgee Alluvium	Upstream of Narrandera	Regulated Murrumbidgee River Unregulated Tarcutta Creek	Regulated: Link to surface water AWD Unregulated: Link to surface water access rule with lag time
Various	All Coastal Alluvium	Upstream of the tidal limit	Various	Regulated: Link to surface water AWD Unregulated: Link to surface water access rule

Appendix 5: Macro groundwater source water balance

Figure 4: Macro groundwater source water balance



Appendix 6: Calculating recharge and the risk assessment method

Defining planned environmental water and the long-term average annual extraction limit for less highly connected groundwater sources

For less highly connected systems, the macro risk assessment approach was applied to define environmental water and the LTAAEL. The amount of data available for each groundwater source was variable. The risk assessment allowed for input of as much information as possible. Where information was limited, interagency staff applied their local knowledge and technical expertise.

The assessment involved the following steps:

1. Estimation of recharge

Recharge for any water source is calculated on long-term average annual figures. For groundwater sources where only rainfall recharge was calculated river recharge, side slope or upward recharge were not included. Direct measurement of recharge is difficult, as the hidden nature of groundwater makes monitoring or measuring recharge expensive and difficult, and because of the enormous variation in geology and surface features across groundwater systems. Therefore, a broad approach to calculating recharge has been adopted:

Rainfall Recharge (ML/year) = Average Annual Rainfall (ML/year) x Infiltration factor

For coastal groundwater plans currently being developed (see Appendix 2) recharge will be rounded to two significant figures.

Average annual rainfall figures for NSW were drawn from 12,983 stations located on the Australian mainland with data of acceptable quality (Hutchinson and Kesteven, 1998). The groundwater source area and the rainfall distribution were summed from 500m grid squares to give a volume of rainfall in ML/year. In coastal floodplain alluvial systems, 100 metre buffers around floodplain drainage channels were excluded from the recharge area, as rainfall in these buffered areas was not considered to infiltrate into the groundwater system.

The water source rainfall volume was converted to a recharge volume depending on the infiltration factor, which is influenced by the dominant rock type. The infiltration factors applied to calculate recharge rates for the macro plans are shown in Table 33 below. These were recently updated based on modelling done up to 2009. Infiltration factors may be modified for specific water sources as a result of additional information or expert knowledge. See Appendix 9: Further reading for further information regarding infiltration factors for specific groundwater systems.

Table 33: Infiltration factors for hydrogeological types in NSW

Hydrogeological type	Infiltration factor (% of rainfall)
Coastal sands	30
Coastal alluvials	10
Inland alluvials	Factor varies from 2-5
Coastal porous rock	Factor varies from 1-6
Inland porous rock	6
Fractured rock (excl. North Coast Volcanics)	4

Hydrogeological type	Infiltration factor (% of rainfall)
North Coast Volcanics	8

The recharge amount may change during the life of the macro groundwater sharing plan as a result of improved information.

2. Reservation of recharge as planned environmental water in high conservation areas

Planned environmental water is water set aside for the environment in accordance with section 8 (1) (a) of the WMA 2000.

Planned environmental water is calculated separately for high conservation value areas and for areas that do not have high conservation value. High conservation value areas include national parks, nature reserves, historic sites, Aboriginal areas, State conservation areas and karst conservation areas.

All groundwater in storage and all rainfall recharge calculated for high conservation value areas within each groundwater source was reserved as planned environmental water, with some exceptions explained below. This water is reserved to ensure long term integrity of the groundwater system and also to protect the groundwater dependent ecosystems (such as caves, wetlands and vegetation) within these areas from the impacts of extraction. This approach also recognises that few access licences are likely to be issued in these areas.

For some groundwater sources, mainly coastal sands, where there is a current or expected future demand (during the term of the plan) to meet existing entitlements for town or urban water supply, not all recharge is reserved as planned environmental water. For these groundwater sources, five percent of recharge is attributed to through flow. This through flow can be made available for extraction, while the remaining 95 percent of recharge was reserved as planned environmental water.

Risk assessments were then undertaken to calculate the planned environmental water for the areas of each groundwater source that do not have high conservation value. The risk assessment included assessing groundwater system integrity and socio-economic risk, identifying mitigation actions, and determining a sustainability factor for the groundwater source.

3. Assessment of groundwater risk

Each groundwater risk assessment considered the risk that groundwater extraction places on the groundwater source and its high priority GDEs and Aboriginal groundwater dependent culturally significant sites. The GDEs were identified and assessed using the method detailed in Appendix 8B and C.

Precise assessment of risks was not generally possible at the scale required for the development of macro plans so the process used simple assessments to indicate different levels of risk - 'high', 'medium' or 'low'. This relative assessment identified the most appropriate provisions for inclusion in the macro plans. The risk assessment sheets and guides are in Appendix 6B: Socio-economic risk assessment sheet and guide.

This assessment was completed for each groundwater source and identified risks to three main groundwater source assets – ecological, water quality and groundwater system integrity: The groundwater risk assessment sheet lists all the questions answered for the groundwater risk assessment. The guide to the groundwater risk assessment sheet directed interagency regional panels with further information regarding each question. The overall risk to the groundwater source is the highest score attained by any asset i.e. there is no ranking or weighting of assets in this process to remove subjectivity.

4. Assessment of socio-economic risk

A socio-economic risk assessment was undertaken for each groundwater source. This assessed the dependence of local communities on groundwater extraction (not the ability of the groundwater source to supply the community needs) in terms of the risk to financial and social assets as detailed in Appendix 6B:

Socio-economic risk assessment sheet and guide: The socio- economic risk assessment sheet lists all the questions addressed by the regional interagency panels for the socio-economic assessment and the guide directed the interagency regional panels with more information regarding each question.

The analysis in this assessment was based on current licensed entitlement, which was greater than actual usage in most groundwater sources. Usage data was not available for the many groundwater sources in NSW where usage is not metered. Where usage data was available it was used, but where usage data was not available, local technical knowledge and professional expertise of agency staff guided assessments.

Each risk was rated as high, medium or low. The maximum risk rating became the risk valuation for the overall water source. Consideration was also given to the likelihood that the community will increase its dependence on groundwater extraction, for example, through town water supplies or aquifer interference. This is important to future community development opportunities as limits on the extraction of groundwater may control local development potential. Macro plans may establish rules that instigate a review of the LTAAEL established by the plan should future development pressures on the groundwater source be apparent. Initially, a precautionary approach was used when setting the LTAAEL as it is defined based on groundwater recharge estimated from rainfall only. During the life of the plan there may be opportunity to review these recharge estimates, which would in turn impact the LTAAEL and planned environmental water reserved for the groundwater source. As part of this review a change to the sustainability factor for the groundwater source may also be considered.

5. Identification of risk mitigation actions

Mitigation measures, applied through rules in the water sharing plan, can reduce the impact of extraction on a groundwater source. For example, a groundwater source which is at high environmental (groundwater) risk may have its risk reduced to medium or low if the effect of extraction can be successfully mitigated. Mitigation actions will be expressed as rules in the macro plans to ensure their effectiveness. Mitigation is primarily applied to managing the impact to the groundwater source from extraction. Examples are:

- Limiting extraction from within buffer zones around GDEs and Aboriginal groundwater dependent culturally significant sites.
- Setting extraction limits specific to works.
- Bore construction requirements, for example introducing pressure cementing in all bores screened in units containing fresher groundwater but overlain by units containing more saline groundwater (i.e. sealing off the more saline part of the groundwater system).
- Actions to prevent contamination movement such as exclusion zones, water level management, GDE protection rules, restrictions on domestic extraction, monitoring in pollution plume areas, restricting extraction from future water supply work approvals within areas around contaminated sites and trading restrictions to within management zones.
- Reducing concentration of bores and the impact of extraction.
- Local impact management where required utilising hotspots.
- Setting access rules based on the associated unregulated stream.

This step involved identifying actions that could be implemented to mitigate the risk to the groundwater source from extraction. This did not change the overall environmental risk from extraction, but provided a strategy for ensuring that extraction is sustainable. Mitigation actions differ from management actions in that they are generally in addition to DPI Water's good practice in managing groundwater resources in the State. Mitigation actions are likely to require additional funding and resourcing to ensure their implementation. Some of the actions listed above and not included as rules in the plan. Instead they require an order to be made under s. 324 of the WMA.

6. Determination of the sustainability factor

As discussed previously, either 95 or 100% of rainfall recharge is reserved as planned environmental water in high conservation parts of each groundwater source. For the remaining area of the groundwater source, a sustainability factor determined the percentage of recharge that was reserved as planned environmental water.

Figure 5 shows the sustainability factor matrix that was used to determine the sustainability factor applied to each individual groundwater source. The matrix matches the environmental groundwater risk assessment (with possible mitigation) with the socio-economic risk. For example, a source with moderate environmental risk and low socio-economic risk has a sustainability factor of 25 percent which means that 75 percent of the recharge outside of high conservation value areas was reserved as environmental water.

Figure 5: Sustainability factor - Percentage of recharge available for extraction

High environmental risk	5	25	50
Moderate environmental risk	25	50	60
Low environmental risk	50	60	70
	Low socio-economic risk	**Moderate socio-economic risk**	**High socio-economic risk**

The planned environmental water reserved for the water source outside the high-conservation value areas has been set at a minimum of 30 percent and a maximum of 95 percent, reflecting the variation in risk to groundwater sources identified in the assessment process.

7. Determination of the long-term average annual extraction limit

For less highly connected water sources, the LTAAEL was set by applying the macro groundwater planning risk assessment methodology. This assessment has determined the percentage of the estimated rainfall recharge which is reserved as planned environmental water and the remainder of the rainfall recharge estimate is the LTAAEL. This percentage varies as shown in Figure 5.

For most coastal groundwater sources with low current entitlement, the macro groundwater planning risk methodology is used to determine the percentage of the estimated rainfall recharge reserved as planned environmental water. The remainder of the rainfall recharge estimate is termed the ‘upper extraction limit’. The LTAAEL is determined using either information relating to current and future water requirements such as population increase, residential development, large scale developments (mining) and augmentation of town water supply or 10% of the upper extraction limit, whichever is higher. Where either of these methods is used, the resultant LTAAEL is significantly less than the upper extraction limit. If, during the term of the plan, additional water is required the LTAAEL can be increased via an amendment to the plan up to the maximum volume expressed as the upper extraction limit.

The risk assessments balanced the economic benefit of groundwater extraction to a community against its groundwater protection requirements. This is because over-extraction can have serious, long-term and permanent impacts on a groundwater source and its dependent ecosystems and may reduce the volume available for extraction in the long term. The proportion of planned environmental water, LTAAELs and plan rules vary between the groundwater sources in recognition of the different levels of risk to the environment and to communities.

8. Buried groundwater sources

Groundwater sources with no surface expression may have their LTAAEL defined as a portion of their storage.

Using the risk assessment approach, the LTAAEL is a proportion of the rainfall recharge that occurs on the surface outcrop area of the groundwater source. The surface outcrop may be relatively small in comparison to the full extent of the groundwater source which can extend underground for hundreds of kilometres under other water sources and across multiple major river catchments.

There are also cases where a groundwater source is completely buried with no surface outcrop and therefore there is no area to which a LTAAEL based on rainfall recharge can be applied. In these cases water is extracted from storage and the LTAAEL will be determined as a percentage of storage with specific extraction requirements to meet minimal harm criteria.

Water may also be extracted from storage in porous rock groundwater sources where minimal harm criteria can be met. This extraction is in addition to that permitted under the rainfall recharge based LTAAEL. Where a groundwater-storage extraction limit is included in a water source it represents the maximum volume that can be extracted under a specific purpose access licence, provided minimal harm criteria can be met.

Appendix 6A: Groundwater risk assessment sheet and guide

Table 34: Groundwater risk assessment sheet

Geological type:						
Groundwater source name:						
GWMA number:						
	Risk			**Method and source**	**Mitigation action**	**Relevant plan rules**
	High	**Moderate**	**Low**			
Ecological asset						
What will be the risk of a change in groundwater levels on GDEs?						
What will be the risk of a change in the timing of groundwater level fluctuations on GDEs?						
What will be the risk of changing base flow conditions on GDEs?						
Water quality asset						
What is the risk of changing the chemical conditions of the water source?						
What is the risk on the water source by a change in the freshwater/salt water interface?						
What is the likelihood of a change in beneficial use of the water source?						
Aquifer integrity asset						
What is the risk of substrate compaction?						
Risk valuation						
Mitigation effect on sustainability factor						
Risk						

Table 35: Groundwater risk assessment guide

Geological type:						
Groundwater source name:						
GWMA number:						
	Risk			**Method and source**	**Mitigation action**	**Relevant plan rules**
	High	**Moderate**	**Low**			
Ecological asset						
What will be the risk of a change in groundwater levels on GDEs	Reduction in groundwater level(s) or piezometric pressure beyond established trigger levels or seasonal variation, resulting in **permanent loss** of defined habitat type.	Reduction in groundwater level(s) or piezometric pressure beyond established trigger levels or seasonal variation, resulting in **temporary loss** of defined habitat type.	No change to habitat type.	Check GDS database. Use hydrographs if available or point source data	i.e. hot spots modelling	
What will be the risk of a change in the timing of groundwater level fluctuations on GDEs	Fluctuation in groundwater level(s) or piezometric pressure beyond established trigger levels or seasonal variation, resulting in **permanent loss** of defined habitat type.	Fluctuation in groundwater level(s) or piezometric pressure beyond established trigger levels or seasonal variation, resulting in **temporary loss** of defined habitat type.	No change to habitat type.	Check GDS database. Use hydrographs if available or point source data	i.e. hot spots modelling	
What will be the risk of changing base flow conditions on GDEs	**Permanent reversal** of base flow conditions.	**Temporary reversal** of base flow conditions exceeding seasonal variation.	No change to habitat type.	Check GDS database. Use hydrographs if available or point source data	i.e. hot spots modelling	
Water quality asset						
What is the risk of changing the chemical conditions of the water source	**Permanent change** in pH, temperature and/or turbidity	**Temporary change** in pH, temperature and/or turbidity	Negligible change (<5%)	Check contaminated sites and Triton databases.	i.e. distance rules for works	
What is the risk on the water source by a change in the freshwater/salt water interface	**Permanent change** in location or gradient of salt/freshwater interface	**Temporary change** in location or gradient of salt/freshwater interface	No change or not applicable	Check Triton database.	i.e. distance rules for works	

Geological type:						
What is the likelihood of a change in beneficial use of the water source	Reduction in water quality **beyond designated BU** category (for identified trigger parameters)	Reduction in water quality **within designated BU** category (for identified trigger parameters)	Negligible change for identified triggers (<5%)	Check contaminated sites and Triton databases.	i.e. distance rules for works	
Groundwater system integrity asset						
What is the risk of substrate compaction	**Permanent** destruction the of groundwater system matrix	**Temporary** adjustment to the groundwater system matrix	No change	Check DMR data sources	i.e. groundwater modelling	
Risk valuation						
Mitigation effect on sustainability factor				Add reason for mitigation and other comments as required.		
Risk	**High, Moderate or Low**					

Appendix 6B: Socio-economic risk assessment sheet and guide

Table 36: Socio-economic risk assessment sheet

Geological type:						
Groundwater source name:						
GWMA number:						
	Risk			**Method and source**	**Other management tools**	**Relevant plan rules**
	High	**Moderate**	**Low**			
Financial asset						
What is the risk to security of access from extraction?						
What is the risk to ongoing groundwater usage?						
What is the risk to dependence on Town Water Supply?						
What is the risk to dependence on groundwater related activities?*(irrigation, industry*)						
What is the risk to investment in agriculture/ industry?						
Sociological asset						
What is the risk to employment in agriculture or industry?						
Risk valuation						
Risk						

Table 37: Socio-economic risk assessment guide

Geological type:						
Groundwater source name:						
GWMA number:						
	Risk			**Method and source**	**Other management tools**	**Relevant plan rules**
	High	**Moderate**	**Low**			
Financial asset						
What is the risk to security of access from extraction?	**No Option** for alternative water supply (source)	**Limited options** for alternative water supply (source)	**Alternative** water supply readily available (i.e. able to extract all entitlement at all times of the year).	Check Departmental LAS database, Council maps. Other sources include reticulated surface water.		
What is the risk to ongoing groundwater usage?	Large volume of groundwater extracted in proportion to total licensed (i.e. >70%)	Average volume of groundwater extracted in proportion to total licensed (i.e. 30 - 70%)	Small volume of groundwater extracted in proportion to total licensed (i.e. <30%)	Use Departmental metered or card entry data where available.	Ensure metering installed and monitored.	
What is the risk to dependence on Town Water Supply?	Large Volume of groundwater licensed for TWS in proportion to total licensed extraction (i.e. >70%)	Average Volume of groundwater licensed for TWS in proportion to total licensed extraction (i.e. 30 - 70%)	Small Volume of groundwater licensed for TWS in proportion to total licensed extraction (i.e. <30%)	Check Departmental LAS database, Urban Water Management and State Water data	Allow for population growth during term of plan. Identify planning needs in Strategy document.	
What is the risk to dependence on groundwater related activities?*(irrigation, industry*)	Large volume of groundwater extracted in proportion to total licences (i.e. >70%)	Average volume of groundwater extracted in proportion to total licences (i.e. 30 - 70%)	Small volume of groundwater extracted in proportion to total licences (i.e. <30%)	Check Departmental LAS database, DPI advice.	Define public irrigation districts if growth envisaged during plan term.	
What is the risk to investment in agriculture/ industry?	Significant investment in activities requiring groundwater (%GDP of Council area)	Moderate investment in activities requiring groundwater (%GDP of Council area)	Little investment in activities requiring groundwater (%GDP of Council area)	Bureau of Statistics Census data, DPI advice.	Define public irrigation districts if growth envisaged during plan term.	

Geological type:						
Sociological asset						
What is the risk to employment in agriculture or industry?	Majority of local population employed in associated activities (i.e. >70%)	Average proportion of local population employed in associated activities (i.e. 30- 70%)	Minor proportion of local population employed in associated activities (i.e. <30%)	Check DPI data sources and Bureau of Statistics Census data.		
Risk valuation						
Risk	**High, Moderate or Low**					

Appendix 7A: Calculating extraction limits for water sources with significant river recharge

9. Defining the term average annual extraction limit for water sources with significant river recharge

For highly connected sources including most alluvial systems, active usage includes rainfall and river recharge components and therefore incorporates current impacts on the highly connected surface water system. Accepting active usage as the LTAAEL assumes that current impacts on highly connected surface water systems are acceptable and that risks to surface and groundwater sources can be addressed through specific management rules in the plan.

10. Estimation of LTAAEL using metered data

Active use should be determined utilising State Water metered data where available. Where State Water metered data is not available, active usage should be estimated using an agreed consistent method across all water sources – see below.

Water sources that do not have reasonable metered usage records and have utilised estimates of usage based on the agreed method can have amendment provisions included in the plan to allow for amendment of the LTAAEL during the term of the plan, if improved usage information becomes available (for example from metering, monitoring, surveys).

11. Estimation of LTAAEL comparing usage patterns

Where usage is not metered, a standard method must be used to estimate the LTAAEL. The method compares usage patterns between similar highly connected alluvial groundwater sources based on the relationship between active usage and total entitlement. In some alluvial systems total allocated entitlement may be significantly higher or lower than the sustainable yield of the groundwater source. Also the way in which entitlement was historically allocated within a groundwater source varied significantly between regions and over time.

It is acknowledged that this method is not an accurate determination of actual usage but rather an estimate of potential active entitlement within unmetered alluvial groundwater sources to be used as a starting point for the macro planning process.

To allow for the potentially large degree of uncertainty in these estimations:

- an amendment option will be included in the plans to allow for more accurate usage estimates to inform the amendment of the LTAAEL levels where better data becomes available during the term of the plan
- DPI Water will request feedback during the consultation process on the estimated usage figures.

To allow for some degree of calculation error and to account for the seasonal variability in usage from year to year, appropriate growth in use response triggers that reflect this variability may also be considered. Growth in use is assessed to have occurred if the average extraction over a period exceeds the LTAAEL by a percent response tolerance, given:

- the time period over which the growth in use assessment is made will be based on a 3 or 5 year rolling average of extraction
- the response tolerance will be determined for the unmetered alluvials based on the usage statistics from the comparative metered alluvial systems.

12. Responding to growth in extraction by users

For highly connected systems, the LTAAEL is based on the policy position that current impacts of groundwater extractions on any connected surface water systems are acceptable, when considering socio-economic and environmental factors. As such, the response to growth in extraction of water by users (termed 'growth in use' (GIU)) is required.

The GIU approach will be tailored on a plan by plan basis with due consideration of the level of storage and use. Regional water sharing plan working groups will review the information available to determine the appropriate period and percentage response tolerance for specific plan areas as the plans are developed.

For less highly connected systems growth in use will be assessed over a three year period with a response tolerance of five percent.

Appendix 7B: Calculating storage-based extraction limits for buried and largely buried groundwater sources

For buried or largely buried groundwater sources, where little water is available for extraction based on the rainfall recharge, consideration has been given to the release of a very small percentage of the volume of water in storage.

Generic three-dimensional numerical groundwater modelling has been undertaken to inform the extent to which water in storage can be taken without posing unacceptable risks to the environment. The modelling assumed 5 GL of extraction from a 2500 GL storage (which equates to 0.002 percent) could be taken over one year from the deepest of a six layer stacked water source system, using a median leakage factor. Based on these assumptions the modelling showed that the drawdown impact on the water table aquifer would be less than 0.5mm. This is less than the natural seasonal and diurnal variation in the water table. The drawdown impact on the water table aquifer would be even less where the extraction period was greater than one year.

Based on the findings of this modelling, water sharing plans for largely buried or buried groundwater sources may set a groundwater storage extraction limit of the equivalent of 0.002 percent of the total volume of water in storage. The figure of 0.002 percent was chosen as the modelling showed extracting up to 0.002 percent of storage it did not appear to present any significant risk to the environment.

There are number of groundwater sources across the state that are buried or largely buried. The release of a percentage of water in the storage of these groundwater sources will be considered on a case by case basis. Considerations will include the application of the precautionary principle and that there should not be any unacceptable risk to the environment or the integrity of groundwater sources.

There is a high level of uncertainty estimating the impacts of extraction on the environment, other water users and other groundwater sources. To plan for this uncertainty, water sharing plans which provide access to storage will contain provisions to reduce the storage-based extraction limit if monitoring and/or further studies demonstrate that such a reduction is necessary to ensure there will be no more than minimal impact on any water source or its dependent ecosystems as a consequence of water being taken from storage.

Appendix 8A: Standard distance criteria for water supply work approvals

13. Rules to minimise interference between water supply works

Table 38: Standard distance criteria to minimise interference between water supply works

	Coastal sands	Alluvium	Fractured rock	Porous rock
Distance from an approved water supply work nominated by another access licence (metres).	200	200	400 for works extracting greater than 20 ML/year. 200 for works extracting less than 20 ML/year.	400
Distance from an approved water supply work from which water for basic landholder rights is being extracted (metres).	50	200	200	100
Distance from property boundary (metres).	50	100	100	50
Distance from an approved water supply work nominated by a local or major utility access licence (metres).	300	500	500	1000
Distance from a DPI Water observation bore (metres).	200	100	400	200

14. The above distance criteria may be reduced if a hydrological study, submitted by an applicant and assessed as adequate by the Minister, demonstrates that the location of a water supply work at a lesser distance would result in no more than minimal impact on existing extractions within the groundwater source.

15. Rules for water supply works located near contamination sources

Table 39: Standard distance criteria for water supply works located near contamination sources

	Within 250 metres of the plume associated with a contamination source	Between 250 metres and 500 metres of the plume associated with a contamination source	More than 500 metres from the plume associated with a contamination source
Rule	A water supply work approval shall not be granted or amended.	A water supply work approval shall not be granted or amended unless the Minster is satisfied that no drawdown of water will occur within 250 metres of the plume associated with the contamination source.	A water supply work approval shall not be granted or amended if the Minister has determined that it is necessary to protect the water source, the environment or public health or safety.

16. The above distance criteria may be reduced if a hydrological study, submitted by an applicant and assessed as adequate by the Minister, demonstrates that the location of a water supply work at a lesser distance would result in no more than minimal impact on dependent ecosystems and public health and safety.

17. Rules for water supply works located near sensitive environmental areas

Table 40: Standard distance criteria for water supply works located near sensitive environmental areas

	Coastal sands	Alluvium	Fractured rock	Porous rock
Distance from a high priority groundwater dependent ecosystem for a water supply work not used solely to take water pursuant to basic landholder's rights (metres).	100 for works extracting less than 20 ML/year.	100 for works extracting less than 20 ML/year.	200	100
	400 for works extracting between 20 - 100 ML/year.	400 for works extracting between 20 - 100 ML/year.		
Distance from a high priority groundwater dependent ecosystem for a water supply work used solely to take water pursuant to basic landholder's rights (metres).	100			
Distance from a high priority karst environment groundwater dependent ecosystem (metres).	500			
Distance from the top of the high bank of any third order or higher order stream, or lagoon (metres).	40			
Distance from a first or second order stream (metres).	40			
Distance from the top of an escarpment (metres).	100			

18. The above distance criteria may be reduced if a hydrological study, submitted by an applicant and assessed as adequate by the Minister, demonstrates that the location of a water supply work at a lesser distance would result in no greater impact on the groundwater source and its dependent

ecosystems and/or no more than minimal drawdown of water will occur at the perimeter of any high priority groundwater ecosystem listed in the plan.

19. Rules for water supply works located near groundwater dependent culturally significant sites

Table 41: Standard distance criteria for water supply works located near Aboriginal groundwater dependent culturally significant sites

Rule – Distance from Aboriginal groundwater dependent culturally significant sites *	Distance (metres)	
Water supply work not used solely to take water pursuant to basic landholder rights.	100 for works extracting less than 20 ML/year.	100 for works extracting less than 20 ML/year.
Water supply work used solely to take water pursuant to basic landholder rights.	400 for works extracting between 20 - 100 ML/year.	400 for works extracting between 20 - 100 ML/year.

* Where a culturally significant site is also a high priority groundwater dependent ecosystem, the more restrictive distance restriction applies to the granting or amendment of a water supply work approval.

The above distance criteria may be reduced if a hydrological study, submitted by an applicant and assessed as adequate by the Minister, demonstrates that the location of a water supply work at a lesser distance would result in no more than minimal impact on the groundwater source and its Aboriginal groundwater dependent culturally significant sites.

20. Rules for amending water supply work approvals for replacement groundwater works

Water sharing plans provide rules for the replacement of an existing water supply work. Replacement groundwater works are generally exempt from standard distance criteria for water supply works.

The following are standard rules for replacement groundwater works:

- The existing water supply work must have a water supply work approval.
- The replacement groundwater work must be constructed to extract water from the same water source as the existing water supply work.
- The replacement groundwater work must be constructed to extract water from:
    - o the same depth as the existing water supply work; or
    - o a different depth if the Minister is satisfied that doing so will result in no greater impact on a water source or its dependent ecosystems.
- The replacement groundwater work must be located:
    - o within 20 metres of the existing water supply work; or
    - o a distance greater than 20 metres of the existing water supply work if the Minister is satisfied that doing so will result in no greater impact on a water source or its dependent ecosystems.
- If the existing water supply wok is located within 40 metres of the high bank of a river, the replacement groundwater work must be located:
    - o within 20 metres of the existing water supply work but no closer to the high bank of the river; or
    - o more than 20 metres of the existing water supply work, but no closer to the high bank of the river, if the Minister is satisfied that doing so will result in no greater impact on a water source or its dependent ecosystems.
- The replacement groundwater work must not have a greater internal diameter or excavation footprint than the existing water supply work, except where the internal diameter of the casing of the existing water supply work is no longer manufactured, in which case the internal diameter of the replacement groundwater work is to be no greater than 110 percent of the internal diameter of the existing water supply work it replaces.

The above distance criteria may be reduced if a hydrological study, submitted by an applicant and assessed as adequate by the Minister, demonstrates that either the construction of a water supply work at a different depth or location of a water supply work at a distance greater than 20 metres from the existing water supply work would result in no greater impact on the groundwater source or its dependent ecosystems.

Appendix 8B: Method for identification of groundwater dependent ecosystems

Groundwater dependent ecosystems (GDEs) are ecosystems which have their species composition and natural ecological processes determined to some extent by the availability of groundwater. GDE types include cave systems (including Karsts), springs, base flow rivers, wetlands and terrestrial vegetation. GDEs which are identified as high ecological value* are then categorised as high priority if they are currently under threat of groundwater extraction are listed in the water sharing plans (WSPs). To limit the impacts due to groundwater extraction setback distances for water supply works have been applied through the use of distance rules in the WSPs.

Since the development of the initial WSPs in 2004, the process for the identification of high priority GDEs and their subsequent inclusion in a plan has developed. For plans developed between 2004 and 2008, GDE identification was based on a list of currently known GDEs provided from various sources such including other government (e.g. protection through Threatened Species Conservation Act 1995) and published site specific scientific research. These GDEs included karsts, springs, wetlands (including Ramsar), and in some WSPs terrestrial vegetation and are termed stage 1 GDEs. Consequently, plans created in this period have limited GDEs identified and lack specific location co-ordinates in many areas. In addition, there were no standard distance rules placed on work approvals which resulted in highly variable distance rules between plans, even in similar groundwater system types.

For plans developed from 2008 to 2012, Stage 1 GDE identification has been used. In addition, a set of standard distance rules for groundwater system types was developed to guide decision making during plan development and to ensure a level of consistency in the rules for groundwater systems of similar hydrogeological type. The new plans for 2013/14 have also had SEPP14 wetlands added (See Table 9.1 below).

Whilst Stage 1 GDES are currently being listed in the WSPs, a process of identifying GDEs of high ecological value* across the state is being undertaken (Stage 2). Initially terrestrial vegetation is being identified, with most of the coastal WSP areas being completed and the Namoi being determined presently. Wetlands and base flow systems will then commence after the vegetation has been completed across the state. Once the Namoi has been completed, the results of an inland and coastal WSP areas will be the bases of discussion with the interagency panel for updating the GDEs (Schedule 11) in all current plans for the coast and Namoi with the identified high ecological value (high priority) GDEs for terrestrial Vegetation. As the identification of GDEs for each of the remaining WSP area is completed, this will be presented to the interagency panel for approval to update the Schedule.

Under the Water Management Act 2000, all GDEs are considered when assessing a water access licence application. At present only high priority GDEs are listed in a plan, although other potential high ecological value GDEs will be listed on the DPI Water GDE register and will continue to be considered during the licence application assessment process. This latter point is reflected in a note within many recently commenced plans.

In applying the definition of Stage 1 wetlands for the current 2013/2014 WSPs under development the following approach, pending refinements, has been adopted:

Table 9.1: Stage 1 Definitions

GDE	BASIS	SOURCE	NOTES
Springs including	Ecosystems that are identified and acknowledged as being entirely (or	Geographical Names Board Peter Serov preliminary quality	

mound springs	obligate) dependent on groundwater for their survival	checking and assessment Included in metadata for Stage 1	
Caves	Ecosystems that are identified and acknowledged as being entirely (or obligate) dependent on groundwater for their survival	OEH Included in metadata for Stage 1	
Karsts	Ecosystems that are identified and acknowledged as being entirely (or obligate) dependent on groundwater for their survival	OEH Included in metadata for Stage 1	
Some Wetlands including hanging swamps	Ecosystems that are identified and acknowledged as being entirely (or obligate) dependent on groundwater for their survival AND/OR Ecosystems that have already been identified as important by other environmental agencies or within existing legislation or international agreements; i.e. those GDEs that are partly or wholly located within a State or Federal Reserve System; e.g. National Park/ Reserve; or are a recognised high conservation area	SEPP 14 (Maps held by Planning NSW and available on the EDB) Ramsar (agreed under the Ramsar convention and available on the EDB)	Note this does not include all wetlands listed in the Directory of Wetlands Australia. DIWA wetlands were overlaid over SEPP 14, and in most cases they overlap and DIWA are captured by SEPP 14. It is assumed that wetlands on coastal sands are GDE. This same assumption cannot be made for DIWA wetlands in non-coastal areas. Further assessment of DIWA wetlands will be picked up in Stage 2. Assessment has been undertaken to remove any SEPP14 in mangrove/salt marsh as well as any anomalies. A literature review is being completed on the dependence of mangroves. If science supports their inclusion, they will be listed in Stage 2.

*High ecological value for an ecosystem is defined as an ecosystem which is in a natural or near-natural condition, or that fulfils any of the below criteria. They include:

a. Groundwater dependent communities where a slight to moderate change in groundwater discharge or water table levels would result in a substantial change in their distribution, species composition and/or health. This includes all ecosystems that are identified and acknowledged as being entirely (or obligate) or partially (facultative) dependent on groundwater for their survival. These ecosystems included all karts, springs, mound springs, subterranean groundwater ecosystems, some wetlands including hanging swamps, base flow river systems and terrestrial vegetation.

b. Those ecosystems that have already been identified as important by other environmental agencies or within existing legislation or international agreements; i.e. those GDEs that are partly or wholly located within a State or Federal Reserve System; e.g. National Park/ Reserve; or are a recognised high conservation area, such as a sub-catchment identified as high conservation value; e.g. stressed rivers; high value vegetation, SEPP wetlands, DIWA wetland etc.

c. Any natural groundwater dependent system that is habitat for any endemic, relictual, rare, or endangered biota (fauna or flora) populations or communities as listed under the NSW Threatened Species Act 1995, NSW Fisheries Management Act 1994 or the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 or identified by an acknowledged expert taxonomist / ecologist[10].

[10] Note these are not necessarily captured as part of Stage 1, but will be considerations as we progress to Stage 2.

Appendix 9: Further reading

General

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