Initial report on the Independent review of the impacts of the bottled water industry on groundwater resources in the Northern Rivers region of NSW

NSW Chief Scientist & Engineer

1 February 2019

Errata

- Grammatical and formatting revisions: 'is' to 'has' (pg. iv); added ', which will' (pg. v); 'source' to 'sources' (pg. 15); 'Office of' to '-' (pg. 18); removed repetitive word 'relative' (pg. 20); '5.3.1' to '3.2.1', '5.3.2' to '3.2.2' and '5.3.3' to '3.2.3' (pg. 33); 'then' to 'Chapter 3' (pg. 74)
- pg. 32 – revised 'licensed for extraction' to 'extracted'
- pg. 33 – revised 'extraction rate' to 'total water access rights'
- pg. 33 – revised 'estimated' to 'calculated'
- Chap 3 – 'planned environmental water (PEW)' changed to 'recharge amount reserved for the environment (RRE)'

Addenda

- pg. 30 Table 3 – added word 'Supporting' to column 3
- pg. 33 – added '80 percent of'

Corrigendum

- pg. 33 – removed sentence - 'Where extraction is at or above the LTAAEL allocations can typically be traded within the groundwater source/management area(s).'

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The Hon. Niall Blair MLC
Minister for Primary Industries
Minister for Regional Water
Minister for Trade and Industry
52 Martin Place
SYDNEY NSW 2000

1 February 2019

Dear Minister

Independent review of the impacts of the bottled water industry on groundwater resources in the Northern Rivers region of NSW

In November 2018, you requested that I undertake an independent review of the impacts of the bottled water industry on groundwater resources in the Northern Rivers region of NSW. I now submit the initial report from this Review.

The first period of work focused on gathering information and undertaking a preliminary analysis of available reports and databases, and seeking input from relevant state government agencies, local government representatives, community members and industry to gain an understanding of issues and experiences.

This initial report sets out information currently available about the bottled water industry, our understanding of the local groundwater systems and the regulatory framework in which activities are undertaken.

The focus for the next period of work and final report will include further discussions with stakeholders, and drawing together additional data to better understand impacts of the bottled water industry, including at the local scale. As part of this work, the Review will consider how statistical uncertainty can be understood, quantified, communicated and used to inform future monitoring and modelling of groundwater and surface water.

Gaining an understanding of the range of stakeholder views has been an integral part of this initial period of work. I would like to acknowledge the time taken by local residents, the bottled water industry, farmers, community groups, local government councillors and staff, state government and local water utilities, who have been generous with providing information and data.

Yours sincerely

H. Durrant-Whyte.

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EXECUTIVE SUMMARY

In November 2018 the Minister for Primary Industries, Minister for Regional Water, and Minister for Trade and Industry requested an independent review of the impacts of the bottled water industry on groundwater resources in the Northern Rivers region of NSW. This initial report was requested as part of the Review's Terms of Reference.

The Terms of Reference address two overarching themes. The first goes to how much water is being extracted by the industry, how this is, or should be monitored, and the sustainability of extraction levels in the North Coast Fractured and Porous Rock Groundwater Sources. The second theme relates to impacts of the industry on both groundwater and surface water systems, with water bottling industry considered in its current, proposed and potential future scale.

The Review draws on a set of experts from hydrology and statistical disciplines and has relied heavily to date on consultations with industry, local residents, community groups, local government councillors and staff, and state government officers.

The Review is underway at a time when dry conditions are widespread across the state. Although the Northern Rivers region has one of the highest rainfall levels in NSW, at the time of this report it too has been declared as drought affected. The coincidence of a state-wide drought with the growing water bottling industry in the region has undoubtedly driven some of the concern expressed by the local community. People consulted have communicated the current challenges they face with water availability, and expressed concern about future dry periods, and impacts on the viability of agricultural practices and environmental values.

This Review report sets out the issues raised and provides a description of the hydrogeological system in the region, in particular around the Tweed Catchment in the north and the Alstonville Plateau further south. The report sets out the regulatory framework that governs water extraction for commercial purposes in NSW; so that readers can gain a clearer picture of how environmental water, drinking water and commercial water take is allocated and managed.

Data obtained through submissions and discussions carried out during the consultation phase were pivotal in identifying issues and hearing ideas for possible solutions to concerns. The issues chapter in this report reflects the range of topics covered, and provides some indication of those the Review will take forward. Issues discussed in this report and which will be the subject of further work include water availability, data availability and uncertainty, surface water and groundwater connectivity and monitoring.

It is evident that the availability of existing data sets is non-uniform and in some cases no data is yet available. To some extent this is not surprising given the historical high rainfall characteristics of the region as a whole, and the relative pressures on this location versus other drier locations around the state where more intensive monitoring has occurred. An issue during consultations was the availability of high quality data. Stakeholders raised concerns about the implications this has for regulatory decisions and management of the water system. The Review notes that metering requirements for bores and pumps are undergoing reform, with changes being progressively rolled out across the state, including the Northern Rivers region, with the rollout informed by risk prioritisation.

With these changes in mind, the Review is addressing future information needs in two ways: by developing advice on groundwater monitoring under TOR 1c; and by developing material for community and decision-makers to better understand and communicate how to deal with decisions where there is imperfect data. These will be taken forward to the final report.

A major component of the work of the Review is to develop advice on impacts of the bottled water extraction industry on surface water and groundwater with a view to both the current and future potential scale of the industry. To this end, an examination of the geological and hydrogeological setting of the region has been undertaken and will continue into the next phase of the Review to develop further a conceptual model of the groundwater system.

Advice on the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources is an explicit reference for the Review (TOR 1b) and a description of the process for developing the Water Sharing Plan, is presented in this report. The community and some experts have raised questions about the localised impacts in the region, in contrast to a more widespread regional view offered in the Plan. A consideration of local impacts will be addressed in the Review's advice on TOR 2, which will be informed by local climates and geography. The Review will employ approaches to understand and describe uncertainty in a range of these Review threads during the next phase and development of the Final report.

Key issues observed by the Review include:

1. **Water volume extracted by bottlers –** available data indicates a low quantity of water is currently licensed and extracted by existing bottled water operators. These data identify 220.5 ML/y across the four water sources in the Northern Rivers Region; or 383.5 ML/y if currently proposed bottled water operations are also included. This compares with 43,370 ML/y of requirements and licences for basic landholder rights, water utilities and other licences including for commercial use (refer to Table 13), equating to 0.5 percent of the water allocated to licences or (0.9 percent if current DAs were approved) (Section 3.3.4).
    - The number of bottled water extractors has been determined by the Review through interrogation of council and state databases, but could increase over the course of the Review.
    - Further work of the Review will examine the potential for localised impacts from extraction activities.
    - Community was also concerned about the potential scale of the industry should expansion occur, which will be considered further in the next phase of the Review.
2. **Water truck movements** –the number, size, and access time for water trucks is an issue for some community members (Section 2.3), with a total across the region of approximately 128 trucks per week.
    - There are relatively inexpensive technical solutions to monitoring water truck movements to determine their impact compared with other commercial truck movements.
3. **Plastic bottles** – concerns were expressed about the use of plastic bottles to hold beverages. There are no viable alternatives to plastic bottles for water for large quantity markets, given the weight of glass (Sections 2.2.3 and 2.2.4).
    - However, there are opportunities to recycle, and to use microfactories for new composite materials and products.
4. **Regulatory issues** –concerns were expressed that licences and development approvals were not being complied with, and whether breaches were systematic. A particular focus is quantity of water extracted. New metering requirements are being introduced (Section 2.2.4 and 2.5.2).
5. **Alstonville Plateau water source** – in general the Northern Rivers groundwater systems are low risk, however previous reports from the early 2000s identified the Alstonville aquifer as under stress, with some recovery after drought-breaking rainfall. Additional monitoring bores have been added, bringing the total to 31, data from which informed development of the 2016 WSP (Section 4.3.3).

- The next phase of the Review will examine the data from the monitoring bores and related models to gain a better understanding of this issue.

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1 INTRODUCTION

In November 2018 the Minister for Primary Industries, Minister for Regional Water and Minister for Trade and Industry asked the NSW Chief Scientist & Engineer to undertake an independent review and provide advice on the impacts on groundwater quantity arising from extraction by the bottled water industry in the Northern Rivers region of NSW.

Advice is to include sustainability of the extraction limits in the relevant Water Sharing Plans (WSPs) for groundwater sources, whether current or proposed groundwater monitoring bores are sufficient, potential impacts on groundwater resources and potential impacts of groundwater take by the bottled water industry on surface water. The full Terms of Reference are provided in Appendix 1.

Term of Reference 1 required a review of existing data and information on the entitlements and extractions of the bottled water industry in the context of total access rights and extraction limits established in statutory water sharing plans. Term of Reference 2 seeks to understand better the impacts on the surface water and groundwater that do or could occur from water extraction for bottling in the Northern Rivers given the current or potential future industry scales.

The Terms of Reference require an initial report by early February and a final report in mid-2019. This initial report describes the current settings, both environmental and regulatory, for the industry in the region; presents a number of the issues raised through consultations, and describes the approach planned by the Review in preparation for the Final Report.

The first section of this chapter provides an overview of the Northern Rivers region, followed by an overview of the bottled water industry. For the purposes of this Review, 'bottled water' is defined as water extracted from groundwater sources for the purposes of inclusion in beverages.

1.1 THE NORTHERN RIVERS REGION

1.1.1 Geography

For the purposes of this Review, the Northern Rivers region is defined as the upper portion of the NSW region of North Coast. Covering an area of 10,271 square kilometres, the region extends from the Queensland border to the southern boundaries of Kyogle and Richmond Valley local government areas, and from the east coast to the western boundary of Kyogle local government area. This region is also referred to as the Far North Coast.

It is the traditional land of the people of the Bundjalung Nation.

The region encompasses six local government areas: Ballina Shire, Byron Shire, Kyogle, Lismore City, Richmond Valley and Tweed Shire.

The topography of the region and coastal setting results in climate conditions that vary across the region. It is wet along the coast and on escarpments but otherwise drier inland. Summers are warm across the region, with cool winters in the hills.

The Northern Rivers region has alluvial, fractured rock, coastal sands and porous rock aquifers. In the context of this report, there are four relevant groundwater sources – the New England Fold Belt, the Alstonville Basalt Plateau, the North Coast Volcanics and the Clarence Morton basin, which are all fractured or porous rock aquifer systems and covered in the North Coast Fractured and Porous Rock Water Sharing Plan.

Figure 1: Northern Rivers region of NSW (outlined in blue) in the far north east of the state includes the local government areas of Ballina, Byron, Kyogle, Lismore, Richmond Valley and Tweed
Source: OEH (2019a)

1.1.2 Environmental Assets

The Northern Rivers region has high biological diversity and richness. There are 17 National Parks in the region, with many parts declared as 'wilderness' (i.e. untouched by modern human-based activities). These include: Arakwal National Park, Border Ranges National Park, Broadwater National Park, Broken Head Nature Reserve, Brunswick Heads Nature Reserve, Cape Byron State Conservation Area, Cudgen Nature Reserve, Mebbin National Park, Moore Park Nature Reserve, Nightcap National Park, Richmond Range National Park, Tweed Heads Historic Site, Tyagarah Nature Reserve, Victoria Park Nature Reserve, Whian Whian State Conservation Area, Wollumbin National Park and the Wooyung Nature Reserve (NPWS, 2019). Over 1,200 public reserves add to the network of public lands that help to protect the region's biodiversity. These estates are home to some of the region's most iconic landmarks, including Mount Warning and its associated volcanic caldera, and Cape Byron.

In addition to the Tweed, Richmond, Brunswick, Wilson and Evans Rivers, there are numerous estuarine environments, lakes and lagoons (both permanent and intermittent), and regionally significant wetlands in the region that provide habitat for freshwater, saltwater and estuarine fauna and flora.

There are also a number of NSW Threatened Species and Threatened Ecological Communities listed under the EPBC Act and the TSC Act in the region, such as populations of the Long-nosed Potoroo (Potorous tridactylus) and assemblages of littoral rainforest (DECCW, 2010).

1.2 RAINFALL

Figure 2 shows that rainfall in the areas of the region where bottled water operations have been undertaken to date (Tweed catchment and Alstonville Basalt Plateau), generally decreases from the coast inland, although with the highest values in the escarpments.

Average annual rainfall in the Tweed catchment varies from over 2200mm on the McPherson and Nightcap Ranges escarpments, to approximately 1600mm on the floodplain, to 1500mm at the western boundary. Average annual rainfall in the Alstonville Basalt is slightly lower and less spatially variable, ranging from around 1800mm on the coast to 1500mm on the western edge of the plateau (Figure 2).

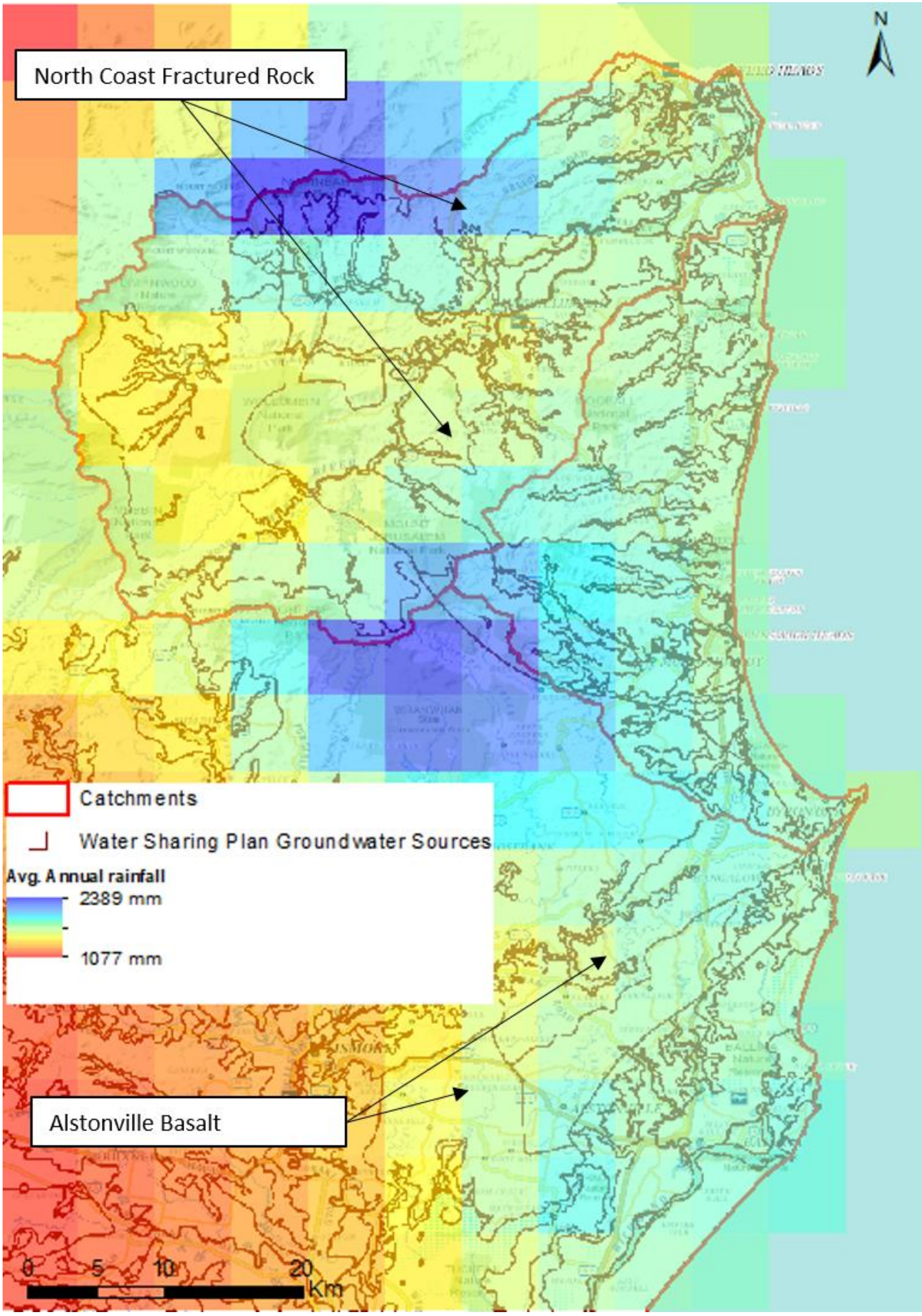

Figure 2: Average annual rainfall from 1960-2018 in the Tweed catchment and Alstonville Basalt Plateau areas

Source: Queensland Government's SILO database. Only data from 1960 are presented due to lesser reliability of rainfall estimates prior to this.

The rainfall can vary strongly from year to year, including multi-year periods of below-average rainfall, notably the 1991 to 2007 period (Figure 3 and Figure 4). For example, the highest annual rainfall within the Tweed catchment since 1960 was in 1974 with approximately 3200mm, with the lowest in 1986 of less than 900mm.

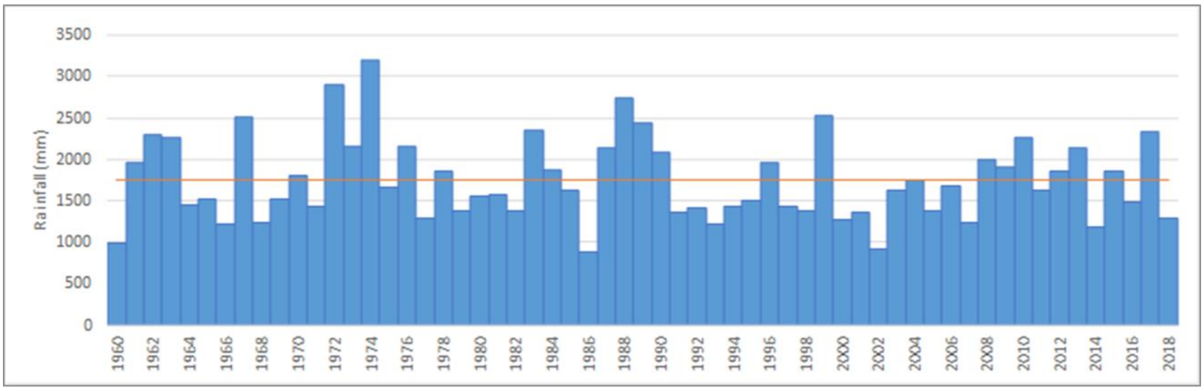

Figure 3: Annual rainfall from 1960-2018, over the North Coast Fractured Rock and Porous Rock Groundwater sources within the Tweed River basin
Red line is the long-term average

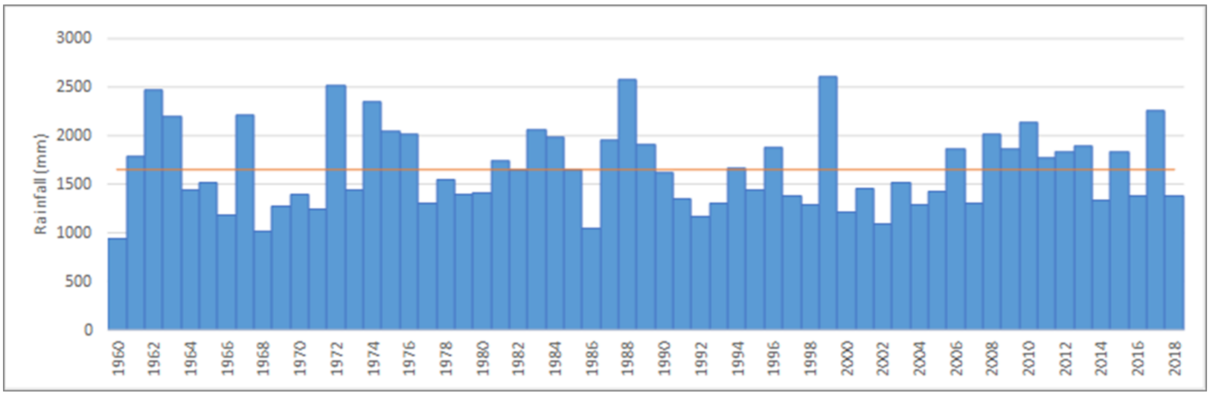

Figure 4: Annual rainfall, period 1960-2018, over the Alstonville Plateau Groundwater source

Figure 5 and Figure 6 show that there are distinct wet seasons, which may be considered to run from December to March in the North Coast Fractured and Porous Rock Groundwater sources within Tweed, and from January to April in the Alstonville Plateau Groundwater source. The year-to-year variability in wet season rainfall is closely reflected by the annual rainfall (Figure 5 and Figure 6).

No long-term trends in annual rainfall are evident from Figure 3 and Figure 4.

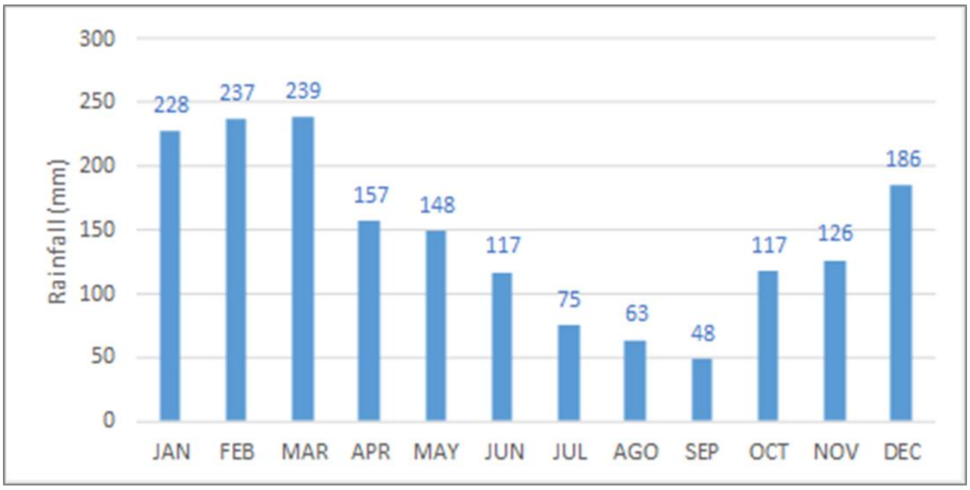

Figure 5: Average monthly rainfall over the North Coast Fractured Rock and Porous Rock Groundwater sources within Tweed River basin. Period 1960-2018

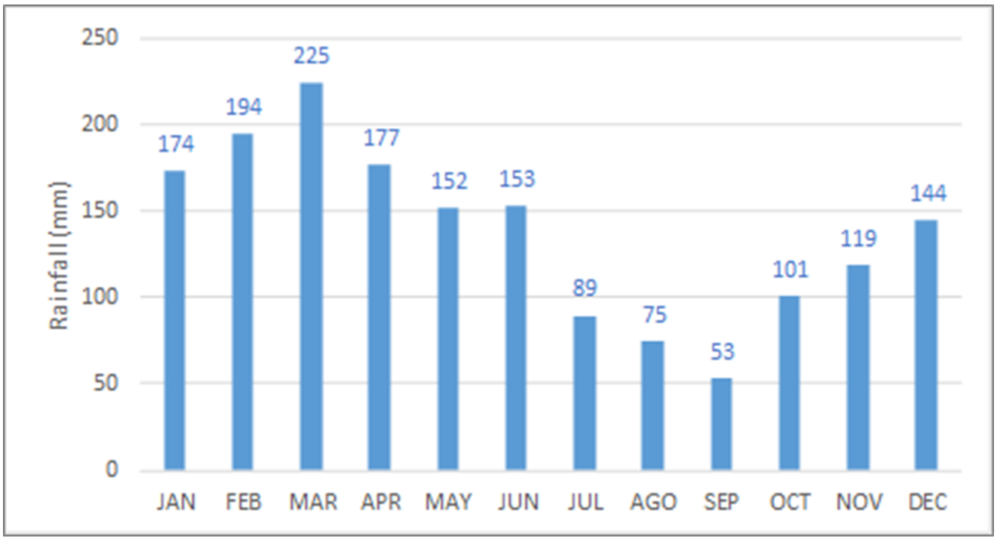

Figure 6: Average monthly rainfall over the Alstonville Plateau Groundwater source. Period 1960-2018

1.3 CURRENT HYDROLOGICAL CONDITIONS

The Northern Rivers region is considered presently to be 'Drought-affected' according to the Combined Drought Indicator used by the NSW Department of Primary Industries (DPI, 2019). Large areas of NSW are in 'Drought' or 'Intense drought', reflecting more severe current conditions further inland.

The Bureau of Meteorology Drought Report for December notes that the 2018 rainfall was exceptionally low in NSW (in the lowest 10 percent of records), and extreme heat has exacerbated soil moisture deficits and low runoff. This situation continues so far in 2019.

1.4 CLIMATE CHANGE PROJECTIONS

The NSW Office of Environment & Heritage North Coast Climate Change Snapshot[1] details that the North Coast region is projected to continue to warm in the near future (2020–2039) and far future (2060–2079), compared to recent years (1990–2009). The warming is projected to be on average about 0.7°C in the near future, increasing to about 2°C in the far future. The majority of climate models agree that autumn and spring rainfall in the region will increase in both the near and far future, and that winter rainfall will decrease for both timeframes. For summer rainfall, the majority of models predict a decrease in the near future and an increase in the far future. Table 1 presents selected relevant outputs from the models.

However, there is uncertainty about the direction of change. In a CSIRO and Bureau of Meteorology report (Dowdy et al., 2015), projected changes in the region's annual rainfall over the next 20 years range from -15 to +10 percent relative to 1986–2005. That study also concluded for the region that intensity of heavy rainfall events will increase (with high confidence) and there will be longer periods of meteorological drought by late in the 21st century (with medium confidence). However, natural climate variability will likely remain the major driver of rainfall changes in the next decades.

[1] The NSW Office of Environment & Heritage's 'Overview of North Coast Region climate change'[1] uses information from the NSW and ACT Regional Climate Modelling project (NARCliM) to make climate change predictions. The NARCliM analysis uses 12 predictive models (OEH, 2019b)

Table 1: Climate change impacts – projected changes in rainfall over aquifer formations of interest (from NSW Office of Environment & Heritage)

	Tweed		Alstonville	
	2020-2039	2060-2079	2020-2039	2060-2079
Change in average temperature (°C)	+0.69	+1.97	+0.70	+1.98
Change in rainfall (%)	+1.09	+6.94	+1.48	+9.16
Change in number of days a year max temp > 35ºC	+1.63	+5.56	+2.25	+6.87
Change in number of cold nights (min temp < 2ºC)	-0.34	-0.71	-0.03	-0.03

1.5 THE BOTTLED WATER INDUSTRY IN THE NORTHERN RIVERS REGION

Water can be extracted from groundwater for a multitude of uses depending upon the need, the quality, the quantity available and a range of other factors. In addition to well-known applications like irrigation and town water supplies, other uses can include, for example, bulk water supply for filling swimming pools or selling high quality water to a bottler for drinking. Groundwater is also extracted for dewatering excavations, for example during construction projects. Water is also used to manufacture a range of beverages, both alcoholic and non-alcoholic.

The focus of this Review is on the groundwater extraction for use in the bottled water industry. The Review considered how to define the bottled water industry in the Northern Rivers region and how wide this definition spans. According to a description by the Australasian Bottled Water Institute (ABWI), a division of the Australian Beverages Council (ABC), the bottled water industry produces plain and carbonated bottled water, bulk water and home and office water delivery. The ABC distinguishes between the manufacturers of soft drinks, fruit juices and bottled water within the overall non-alcoholic, non-dairy beverage industry (ABC, 2019).

The Review was informed in stakeholder meetings that most manufacturers of beverages such as cordials, soft drinks, and alcoholic drinks (e.g. beer, gin) use town water. In general, the Review was informed that these types of beverages, containing a mix of other components, do not need to use water of as high quality as bottled drinking water. Further, the case was made to the Review that the high cost of transporting water means that it would be cost prohibitive to transport it more than approximately 100km. Some expensive boutique bottling was an exception. This issue will be investigated further in the next phase to inform consideration of potential industry scale scenarios required under Terms of Reference 2.

The Review has to date found no suppliers of groundwater in the Northern Rivers region who supply water for use in other non-alcoholic beverages. The Review has also found no evidence of any surface water used in the Northern Rivers region for bottled water. All known operators are extracting groundwater. There was anecdotal information about one extractor supplying the local brewery as a good gesture measure to keep the brewery operating when the brewery was unable to access its surface water sources, but this was not a business-as-usual approach.

However, determining the exact extent of the bottled water industry in the Northern Rivers region is proving a challenging exercise. Water licences issued under the *Water Management Act 2000* are agnostic to the industrial or commercial purpose for the water take. The Review used a variety of sources, including searches of local council Development Applications (DAs) and related documents, internet searches and information from state agencies, the community and councils to identify active and proposed operations in the region. This work is ongoing and for this reason, information contained in this initial report about bottled water extractors and about the scope and extent of the industry are indicative and provided on a global level, based on information the Review has obtained to date. The Natural Resource Access Regulator (NRAR) is also undertaking work on a broader scale to identify the size of the industry. The Review will continue consultations with NRAR as this work progresses.

The Review has identified six operators who are actively extracting for water bottling purposes. Some bottle on site, some sell bulk water and some do both. At the time of this report, the Review was aware of:

- one operator (additional to those above) that has received DA approval but is not yet extracting
- one application to extend existing operations progressing through the DA process
- one application (additional to those above) progressing through the DA process to begin new bottled water operations
- one application (additional to those above) that has had the DA application refused.

There are also a handful of historical DAs that reference water bottling dating back to 1991, but the Review has not yet been able to determine whether these businesses are operating or not. There are cases where applications for licences or DAs are lodged with the relevant authority; but subsequently are not acted on.

1.6 PROCESS OF THE REVIEW

The first stage of the Review was undertaken by the NSW Chief Scientist & Engineer and technical experts in the areas of hydrology, groundwater and surface water interactions, modelling, data analysis, statistics and uncertainty. Additional groundwater expertise will become available in the second phase of the review. Experts Include:

- Associate Professor Will Glamore, Water Research Laboratory, School of Civil and Environmental Engineering, UNSW Sydney
- Alice Harrison, Engineer, Water Research Laboratory, School of Civil and Environmental Engineering, UNSW Sydney
- Professor Neil McIntyre, Centre for Water in the Minerals Industry, Sustainable Minerals Institute, University of Queensland
- Professor Louise M. Ryan, Distinguished Professor of Statistics, School of Mathematical and Physical Sciences, University of Technology of Sydney

1.6.1 Meetings and site visits

The Review has made two site visits to the Northern Rivers region, in December 2018 and January 2019 (Appendix 2). These initial site visits concentrated on the areas near and around Dungay, Urliup, Murwillumbah, Uki, Mt Warning, Ballina and Alstonville. Stakeholder meetings were conducted with representatives from local government, the local community and industry. Requests for relevant reports, additional information and data, and details of other interested stakeholders were made to all stakeholders as part of these site visits and meetings. The Review will undertake further consultations and site visits as its work progresses.

1.6.2 Briefings and data collection

The Review met with officers from the Department of Industry - Water (DOI Water) to gain an understanding of the water systems under study and current planning and regulatory arrangements, roles and licensing approval processes. The Review also received advice on relevant reports, modelling and monitoring undertaken or proposed as part of water access and compliance arrangements and data collections available to inform the review. This included information and advice from DOI Water, Water NSW and the Natural Resources Access Regulator.

1.6.3 Submissions

At the time of this report, the Review has received four submissions (Appendix 2). In addition to these, having been labelled as ‘submissions’ by the submitter, the Review also received correspondence, photographs, reports and copies of submissions to other processes (e.g. response to Development Applications). Issues raised to date are discussed in Chapter 2.

1.7 STRUCTURE OF THIS REPORT

- Chapter 2 summarises the issues raised in submissions and during consultations and site visits
- Chapter 3 provides an overview of the Water Sharing Plan for groundwater in the region including allocations for groundwater sources and associated processes and issues which will inform future work on extraction levels
- Chapter 4 provides an overview of the geology and hydrogeology of the region, which are relevant to assessing impacts, and describes next steps.

2 ISSUES RAISED IN CONSULTATIONS

This Chapter provides an overview of issues raised with the Review in submissions, during consultations and in reports provided by external stakeholders. These stakeholders include local councils, community members and organisations, bottled water businesses and industry representatives. To date, discussions with government agencies have focused primarily on understanding relevant legislative and policy frameworks, geological and hydrogeological systems, models and monitoring undertaken and identifying data sources.

Some of the issues outlined in this Chapter will be dealt with in more depth in the next period of work as the Review has the opportunity to interrogate information in more detail and as more data are obtained to inform the final report. While a range of the issues included in this chapter are outside the Terms of Reference of the Review (e.g. truck movements, plastic waste), it was nevertheless decided to report them here as it provides a clearer understanding of the breadth of the issue for people involved.

Stakeholders raised a range of topics with the Review, with a spectrum of perspectives presented on any one issue. While presented here thematically, issues were frequently inter-related. For example, concerns reported about water shortages were combined with concerns about adverse impacts of truck movements.

Concerns for many who oppose water extraction for bottling were related to the implications of potential industry growth. This was partly due to publicised plans for growth of some existing smaller-scale operations as well as 'new entrants'. Those consulted pointed to social and environmental impacts of declining water resources elsewhere in NSW, nationally and internationally, and the implications not only for themselves but also for future generations.

The Review received submissions and presentations on long-term demand and supply projections, alternative supply sources and storage options, which have been or are being scoped (including infrastructure or additional groundwater sourcing) and exploration activities by Rous County Council (RCC). RCC is the authority responsible for providing bulk potable water to Ballina (excluding Wardell), Byron (excluding Mullumbimby), Lismore (excluding Nimbin) and Richmond Valley (excluding land to the west of Coraki) Councils in the Northern Rivers area.

Notwithstanding high rainfall relative to other parts of the state and country, stakeholders drew the attention of the Review to reports projecting demand will match supply around year 2024 and the consequent need to manage water resources carefully (Rous Water, 2014)

2.1 WATER AVAILABILITY AND THE BOTTLED WATER INDUSTRY

Many of the people speaking with the Review reported that they, their families and neighbours were long-term residents of the Northern Rivers area, some for generations, and had observed local creeks, streams and other water sources drying over time. This included observations that the water table had dropped in places and has progressively worsened; that watercourses were drying more rapidly than in previous decades or years; and that previously reliable water sources were now increasingly variable, significantly depleted, or lost altogether. Community members commented on loss of aquatic wildlife (e.g. turtles, fish, and eels) and members of the local Aboriginal community also reported loss of traditional food sources.

Some of those consulted expressed a degree of uncertainty about causative factors, and specifically, the extent to which climate and weather – as opposed to human activities, in particular water extraction for bottling – were contributing to observed changes and impacts. While some expressed frustration with inconclusive expert reports on this issue, a consistent theme raised with the Review was that there is a fundamental challenge in drawing definitive conclusions from a lack of consistent and long-term data for the region as a whole.

Some felt the situation was complicated by a lack of understanding or shared understanding of the groundwater and surface water systems in the region, whether and where the systems are connected and how they interact. This included understanding connectivity between shallow and deep groundwater resources, connectivity between shallow bores and aquifers, and the need to account for cumulative impacts. There was concern about claims of 'nil' impacts, 'sustainable' supply and lack of connectivity when the systems, including aquifer recharge, were not well understood. The need to account for lag-times, which can sometimes be significant, for impacts to be observed or fully understood was also highlighted, with stakeholders providing local and international examples of this to the Review. In one meeting, stakeholders also reported observing a large unlicensed bore (not related to the industry), and expressed a belief that regulators did not have a grasp of the extent of 'illegal take' in the region by some landholders that has not been accounted for.

A core concern was that the industry could or would grow unchecked, and at the expense of other needs, including for domestic potable water, food production, for wildlife and groundwater-dependent ecosystems. A particular concern in areas where water resources were fully allocated related to existing landowners with licence allocations selling or leasing rights as a means of alternate or supplementary income to crop and animal husbandry. Many emphasised the issue as being particularly acute in the context of population increases and climate variability. In addition, there are property owners in the region that do not have access to town water, and being dependent on surface water, are concerned about the impacts that groundwater extraction may have on longer-term surface water supplies.

Others communicated a concern that sub-regional variability, such as localised rainfall patterns, have not been recognised or captured in data collections, and therefore, properly taken into account in decisions about access to and allocation of water resources.

Observed changes reported to the Review, with some that pre-date growth in the bottled water industry, include a decline in rainfall frequency and experience of more extreme events, such as extended periods of high temperatures, drought, and conversely, floods. Impacts reported include bores declining, drying, or obtaining only 'froth' when pumps are turned on.

The coincidence – and increased pace – of observed changes and impacts led many people to conclude that, notwithstanding a lack of data, the bottled water industry may have or has had some impact on available groundwater resources. How stakeholders expressed this to the Review varied, for example, that there is:

- a pressing need for improved data and more robust science to properly understand causative factors, inform decisions and increase transparency of decision-making
- a belief that water is not unlimited and that the industry poses an uncertain but unnecessary risk in the context of longer term demand and supply factors
- a belief that while observable changes cannot be wholly attributed to the bottled water industry, it is responsible for some of the observed impacts
- certainty that the bottled water industry is having a significant impact on available water resources
- a philosophical opposition to the bottled water industry, irrespective of any scientific findings.

Perspectives also varied on how risks and/or uncertainty should be managed. Comments included ensuring environmental and social impacts and not only economic factors are included in definitions of sustainability and inform decision-making. Some other suggestions were improved monitoring (utilising CCTV and tamper-proof water meters); improved mapping of groundwater systems and connections; greater transparency in data collection and reporting; prioritising environmental, domestic and primary industry needs; or including factors such as state significant farming land and world heritage site status in decision-making. Use of desalination technology for water intended for bottling purposes was also proposed. Also raised were suspension of any approvals subject to greater certainty or while the Review progressed, or banning the practice outright.

There were also suggestions that extracting water for bottled purposes should be separately identified or categorised differently to other businesses for the purposes of licence applications and approvals; although some also cautioned about the precedent and unintended consequence this may have for other business types.

One argument made to the Review in support of this position of treating bottling differently was that water accessed for bottling or bulk supply purposes is 'permanently lost' to the catchment and water cycle. The reasoning presented was that other activities, particularly primary industries, used water, but that some of the water at least was available for return to the catchment. This included irrigation activities.

Not all stakeholders shared this perspective, including some primary producers. In their view, the high cost of water and commitment to environmentally sustainable practices meant that only the amount of water essential for crop needs was used. Modern irrigation systems, including sensors, enabled a high level of control to be exercised, such that only the root system received water, and that any 'returns' to the water cycle would be non-existent or so small as to have no material impact.[2] When tested in subsequent consultations, other stakeholders suggested it would be material to the water cycle. The premise was that the moisture content in irrigated land, followed by rainfall, would provide the potential for material returns to the catchment and therefore, contribute to the water cycle.

Perceived differences in extraction methods was a further consideration raised with the Review. Some stakeholders suggested that farmers and other primary producers tend not to extract to the full limits of their allocated capacity, whereas bottled water businesses were believed to extract to the maximum capacity allowed at all times.

The Review asked stakeholders to provide any available data to assist its inquiry going forward, including any long-term logbooks or notes kept by local landowners that might provide greater detail about the observed trends, both historical and recent, that were reported.

2.2 THE BOTTLED WATER INDUSTRY AND PERCEIVED ENVIRONMENTAL, SOCIAL AND ECONOMIC TERMS

The character and intention of those involved or believed to be involved with the bottled water industry was the subject of considerable comment to the Review, as well as the value proposition of such enterprises.

2.2.1 Environmental considerations

Generally, those opposing the industry saw it as an unnecessary and wasteful use of a scarce and precious resource, and that approvals for these activities signalled a lack of value for this resource. A point of particular focus was businesses originating or headquartered from outside the Northern Rivers area purchasing or seeking to purchase water licences. This was regarded as particularly egregious by stakeholders who viewed groundwater as a shared asset of the community that should not be monetised.

Many community stakeholders expressed: clear support for the use of water resources for farming, stock and irrigation purposes as 'legitimate' or 'appropriate', irrespective of the relative amount of water used in production; opposition to extraction for bottling purposes as

[2] It should be emphasised that this was not necessarily used as an argument in support of water extraction for bottling purposes, only that the argument about irrigation was not supported.

squandering a precious and limited resource; and scepticism about the extent of local economic benefits. In employment terms, many commented on bottled and bulk supply being trucked to Queensland, negating local benefits, with some expressing particular opposition to the concept of exporting bottled water (nationally or internationally). Some were of the view that the scale of actual or potential communal and environmental harms arising from bottling water outweighed any individual benefits that might accrue from involvement in the industry as an owner, supplier or employee. Some also made comments about the actual contribution to jobs, particularly with automation.

2.2.2 Economic considerations

Others communicated that they were aware of community members with licences traditionally used for agriculture, horticulture or livestock, that were contemplating selling or leasing their rights. While disparaged by some as ‘easy money’, others commented on the challenges facing landowners associated with the decline of traditional primary industries and the consequent (and understandable) interest in an opportunity of ‘selling up’ or leasing licence rights for supplementary income. There was also comment that the amount of work and cost involved in running primary industry enterprises may make the apparent high returns from bottled water very attractive.

This potential sale of water licences from local landowners occurring at scale was a source of disquiet. Concerns included the potential for the bottled water industry to expand at the same time as those engaged in primary industries were contemplating a return to irrigating practices in response to declining rainfall patterns, contributing to tension around balancing use of resources. The core concern here was that water bottlers would compete with, and perhaps preclude access by long-standing primary industry businesses whose circumstances vis-a-vis water supply were changing significantly. An example given to the Review was local macadamia farmers, who, it was posed, may in due course be no longer able to rely on rainfall to sustain the trees. Other concerns related to broader social as well as environmental or economic impacts. One example was the inequity of community members having to purchase water because groundwater and surface water is over-allocated or depleted.

Some cited positive or potential economic and employment benefits arising from the industry, both domestically or for export, and having bottled water available for those unable to use local sources. This included, for example the inability to access or consume groundwater or surface water resources due to drought, contamination of watercourses or floods destroying usual supply infrastructure. The Review was advised that local bottled water suppliers had provided water to the Northern Rivers community following the 2017 flood during the period when energy and safe water supplies were compromised.[3] Energy saving benefits (reduced ‘food miles’) as well as creating local employment opportunities by offsetting currently imported bottled water with domestic product was also raised.

2.2.3 Social considerations

Expressions of concern about the social impacts of the scale-up of the bottled water industry were often accompanied by observations about the changing nature of the area. Many commented on the significant decline of traditional primary industries, including bananas, sugar cane, forestry and dairy farming; and concurrent population changes, such as the influx of people moving into the region for the lifestyle (referred to as ‘tree changers’ and ‘hobby farmers’). The Review asked about water consumption and large truck movements associated with primary industries that were previously common to the area. For the most part, water-use, including high-consumption activities for these purposes appeared acceptable to respondents. Some observed that relatively new arrivals would be less familiar

[3] This information was not communicated by the bottled water suppliers, rather, by others during consultations.

with traffic movements associated with traditional industries, or were both less dependent on local industries for income, and less tolerant of associated traffic impacts. Others noted that the changing population profile and industry activities had resulted in an increase in the footprint of residential housing and community infrastructure (e.g. schools) and a decline in where water could be captured and harvested.

Some stakeholders commented that the changing profile of the area translated into a loss of community connectivity and cohesion. Long-term residents commented that 'gentleman's agreements' previously existed between landowners in relation to water extraction. For example, in periods of dry, there was informal acceptance that everyone would 'pull back' on the amount of water extracted. Asked if this approach was still adopted, even at a smaller scale, respondents advised that it was now 'everyone for themselves'.

In addition to water availability, some stakeholders expressed in-principle opposition to extracting water for bottled purposes, regarding it as unnecessary and wasting a resource that should be retained for the environment or applied to traditional 'productive' enterprises. Also raised were the environmental impacts of extracting water to put in plastic bottles as being contrary to community expectations and initiatives to minimise or avoid the use of plastics altogether.

Further, most people the Review consulted understood that water from the Northern Rivers region was being used to bottle water for individual consumption (small bottles) or larger 'water cooler' bottles. In some cases, bottling was undertaken on the property where the water was extracted. In other cases, it was transported in bulk off-site for bottling. The Review understands some water is also used to supply allied industries including distilling (gin) and brewing.

2.2.4 Bottled water industry observations

The companies consulted by the Review ranged in their scale of operations and activities. A common perception was that the industry was being unfairly targeted given the relatively small proportion of its water 'take' in comparison with water allocated for other purposes such as domestic and stock use and other commercial enterprises. The industry peak body, the Australian Beverages Council also presented this position.

Companies indicated that for their own purposes or at the request of companies they supplied to, a range of quality and volumetric tests were undertaken of water extracted and records maintained. These testing requirements were stated to often be in excess of what regulators required. All reported they had monitoring bores in place to assess impacts, including on neighbours, and from December 2018 they were required to transition to telemetered tamperproof monitoring systems at a standard specified by regulators if they were not already in place.

In contrast to those opposing the industry, companies reported that:

- monitoring undertaken had shown no negative impact on available groundwater levels, and if (daily) recharge rates slowed, they adjusted their take from different bores
- water quality was an important characteristic of extracted water, so extracting at rates that avoided negative impacts on the quality was important
- they were required to provide independent hydrogeological reports as part of the approval process
- expanded operations would provide local employment opportunities
- there was interest from local businesses for 'niche' natural spring and mineral waters. However, this part of the market was highly competitive and could attract higher costs (e.g. requirements to supply in glass bottles) in contrast to providing bulk water to larger companies

- one used 50 per cent of recycled plastic content in its bottles, while another was looking to install equipment to mould bottles from recycled plastic

While those community members opposing the industry believed bottled water extractors only paid a few hundred dollars for the licence and Development Consent applications but made significant financial returns, industry members communicated a different picture. This included costs of tens of thousands of dollars for purchasing a share in new water allocations, costs of bore drilling, costs of new monitoring equipment (reported as over $15,000 per bore), transport, and further significant investments in plant and equipment. Industry also reported that timing of controlled allocation orders meant that they had to make business decisions on purchasing a share, without knowing whether they would receive approval through the local council DA process that followed.

2.3 INFRASTRUCTURE, SAFETY AND AMENITY: TRUCK MOVEMENTS

The most common infrastructure issue raised during consultations related to roads and truck movements. While truck movements per se are not part of the review Terms of Reference, issues communicated to the Review are reported here as they formed a significant point of discussion during consultations.

Key concerns included:

- dangers arising from the presence of large trucks on small roads, including single-lane roads and narrow-winding roads that limited visibility of oncoming traffic
- potential for more significant physical harms arising from larger vehicles in the event of an accident
- loss of visual amenity, ‘country’ community life and psychological stress from noise associated with truck movements, including large trucks ‘queuing’ early near extractive properties
- safety concerns about large-volume truck movements in school zones and during school hours
- increased frequency and scale of road damage and higher maintenance requirements associated with large truck movements
- that the community, through council rates, paid for the costs of road repairs and maintenance – i.e. individuals benefitting from the industry do not bear the costs of damage created.

However, while it was the dominant view communicated to the Review during its regional consultations, negative perceptions of larger truck movements were not universally held. Other views expressed included:

- that use of larger trucks may have less of an impact on amenity compared with smaller trucks, as larger capacity loads translated to fewer trips being required
- that multi-axle vehicles (specifically, B-double combinations) distributed the load and caused less damage to road surface than single axle rigid trucks
- that power, steering and brake requirements associated with modern rigs (prime movers) make them safer and quieter.

While observing that the trucks used were similar to other industries, during consultations company respondents for the most part appeared acutely conscious of tensions associated with truck movements and reported taking steps to minimise impacts. This included taking routes that would get trucks onto major roads as quickly as possible, instructing drivers to minimise brake noise on smaller roads and, in response to complaints, issuing instructions about abiding by hours of operation. One was aware of drivers queuing near the property entry point prior to admission hours and commented that some drivers tried to ‘push’ the entry time, which was unhelpful from their perspective in terms of community relations and was therefore monitored.

Another noted that two 'bottlers' in close proximity used the same transport company and thought there might have been confusion by the community members counting the truck movements that led to the perception of exceeding approvals. They reported having been investigated and found to be operating within the terms of licence.

A search through relevant DAs by the Review found a total of up to 128 trucks per week for the bottled water industry in the Northern Rivers Region.

While aware of community dissatisfaction and opposition to truck movements, companies also reported a mixed response from neighbours – i.e. some close by had 'no issues' while others further away made complaints. One in particular felt complaints were raised by people who were opposed to any kind of industry enterprise being undertaken in the area.

2.4 INFRASTRUCTURE: IMPACTS ON DOMESTIC BORES

Some stakeholders with domestic/stock bores reported experiencing loss of water pressure, decreased volumes and 'frothy' returns. The Review has not yet had the opportunity to explore this issue and possible causal factors. However, in the course of consultations, other stakeholders commented that historically, domestic bores were sunk only to the depth required under the conditions at that time to provide the relatively small quantity needed for domestic and stock purposes. This means that if a bore had been sunk at a time when water levels were high, it may have been shallower than at other times. Some speculated that longer-term changing weather and climate patterns have meant that if the works were undertaken today, the bores would be sunk to different depths. This is congruent with other statements made to the Review that domestic bores need to be sunk to lower depths. This is something that the Review will consider as part of its work going forward.

2.5 REGULATORY ISSUES

2.5.1 Local Government assessment and decision making

There were varied views across local government areas when considering Development Applications. For the type and scale of operations subject of this Review, councils are generally the consent authority and may grant the consent, unconditionally or subject to conditions, or refuse to grant consent.[4] Some had long-standing water bottling businesses in their area and had recent or current applications before them. Others had yet to receive applications, but wanted to ensure they were prepared and had access to guidance to assess any future applications. Representatives who had experience assessing applications discussed challenges of having to make decisions on a range of development applications for water bottling extractors with limited information, variable access to expertise and in the context of considerable community agitation.

Consultations indicated that changes over the last 10-15 years had influenced operations and perceptions of the industry. In the early 2000s, there were very few operations and extraction rates were relatively small (e.g. 3-12 ML). Subsequent changes in Queensland (industry growth and water costs) had resulted in increased interest in NSW as a source of water and existing licensed extractors seeking increases and modifications to previous approvals in terms of water volume and truck movements. In the process, modifications were sought to regularise what applicants had understood their rights to be. From discussions with

[4] *Environmental Planning and Assessment Act 1979* s 4.16(1). Under S.4.16(3) of the *Environmental Planning and Assessment Act 1979*, a grant of consent can be deferred until the application has satisfied conditions of that consent. Further detail about the legislative framework is in Appendix 4.

some stakeholders there appeared to be inconsistencies in how development approvals treated water quantity for water bottling extractors.

Issues raised by staff and Councillors included uncertainty about the extent to which local government was expected to (or should) interrogate the hydrogeological dimensions of DAs. This is in part due to water access licences already been granted by state authorities, and in the context of limited data and knowledge about connections between water systems and uncertainty of potential impacts. Representatives indicated that councils did not have hydrogeological expertise and were reliant on state agencies for advice. Many identified the challenge of exercising decision-making responsibility absent high-quality scientific data about the potential impacts of a proposal. Further, the necessary advice was not always available, or available to the extent to satisfy the range of questions arising and concerns about the adequacy of hydrogeological reports submitted by companies. Some noted they have outsourced hydrogeological expertise to assist decision-making, depending on their assessment of the risk or degree of impact.

This situation can be made more complex due to differences in the legislative focus of instruments (e.g. the *Water Management Act 2000* and the *Environment Planning and Assessment Act 1979*) and requirement on different decision-makers. In particular, the *Tweed Local Environment Plan 2014* requires that the consent authority (Council): "*is satisfied that development will not have an adverse impact on natural water systems or the potential agricultural use of the land".*[5] By comparison, the *Water Management Act 2000* requires that a *"water management work approval is not to be granted unless the Minister is satisfied that adequate arrangements are in force to ensure that no more than minimal harm will be done to any water source, or its dependent ecosystems, as a consequence of the construction or use of the proposed water management work."*[6] Councils also indicated that they would benefit from having access to more robust data, guidance on assessing applications, and understanding where they can seek further information and access to expertise.

Some community members indicated a mistrust arising from how councils had managed requests to modify consents and what determines a minor or a major modification. Councils indicated an awareness of this concern, noting that it had not always been clear at the outset of applications whether a modification was sufficient or a new DA would be required. Changes to policy and processes had also contributed to confusion for both applicants and the community. A further concern was compliance and enforcement actions undertaken by councils in managing application conditions, in the context of available resources and their role within the regulatory system.

Perspectives on who is best placed to make decisions relating to the bottled water industry varied. Preliminary comments included that:

- the local community wanted or would expect their local representatives to retain control of the process and be making decisions on their behalf
- the process may be better managed on a more 'arms-length' basis, such as at a regional level.

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[5] The *Tweed Local Environment Plan 2014* requires (s.15 Water bottling facilities in Zone RU2 Rural Landscape) that: (1) Despite any other provision of this Plan, development may be carried out with development consent for the purposes of a water bottling facility on land in Zone RU2 Rural Landscape if the consent authority is satisfied that development will not have an adverse impact on natural water systems or the potential agricultural use of the land; (2) Despite any other provision of this Plan, development may be carried out with development consent for the construction of a pipe or similar structure on any land for the purposes of conveying groundwater to a water bottling facility; (3) In this clause: *water bottling facility* means a building or place at which groundwater from land in Zone RU2 Rural Landscape is extracted, handled, treated, processed, stored or packed for commercial purposes.

[6] *Water Management Act 2000* s 97(2)

2.5.2 Regulatory oversight

Many community stakeholders saw a contradiction between state and local governments taking steps to secure water resources during heightened vulnerability from a drought period while at the same time issuing approvals for additional water extraction for the bottled water industry.

Lack of confidence and concerns were also expressed about the assessment and approval process and regulatory oversight. Issues included:

- hydrogeological reports in support of applications being paid for directly by the company concerned, and therefore, could not be trusted to be truly independent or reflect any issues not in the interests of the applicant
- insufficient data to make informed decisions, including:
    - a lack of measured data to support assessment of local impacts
    - over-reliance on aquifer-scale generalisations to support local scale assessment
    - the level of confidence with which conclusions supporting the application are reached
- perceived conflicts of interest by regulatory authorities being asked for advice about applications that have been approved for an access licence
- a lack of transparency about the process, including a lack of consistency in how water bottling applications are described. In places, community members felt application descriptors were deliberately obfuscated to avoid scrutiny
- a lack of monitoring and oversight once approvals are granted
- operators not having meters or log books as required
- that complaints were not acted on by Councils (responsible for issuing Development Applications and conditions relating to truck movement) or authorities responsible for issuing, monitoring and enforcing water extraction licences

The Review received presentations from community members about extensive interactions with non-bottled water businesses and reported lack of responsiveness by state and local government authorities to complaints of non-compliance and environmental harms. These experiences have undermined these people's confidence in the ability or willingness of relevant local and state government authorities to appropriately monitor and manage the perceived risks of the bottled water industry.

Reports provided to the Review also cited truck movements as a marker of non-compliance, which featured in consultations. Issues raised include:

- truck movements observed or recorded outside approved operating hours set under conditions of Development Approval, including number of daily or weekly movements allowed and exceeding weight restrictions
- truck movements observed or recorded at a frequency that led people to conclude that licensees must be exceeding their lawful allocation of water
- that Councils have or will retrospectively approve the permissible size and number of truck movements allowed.

Local government representatives affirmed that truck movements were a major source of opposition and complaints from the community. One commented that a difficulty with some reports was that point-in-time observations were extrapolated to annual impacts, which could not be assumed as accurate. They also observed a misalignment between some community views and the regulatory framework. For example, some members of the community distinguished between 'communal beneficial' use (domestic, farming use) as 'acceptable' and water extraction for bottling (perceived as individual, non-communal interest) as 'not acceptable' in a way the regulatory framework does not – the latter focusing on total volumes and being agnostic as to the specific commercial purpose.

2.6 SUMMARY AND COMMENT

Stakeholders raised a range of environmental, social and economic issues with the Review, as well as processes for establishing, allocating, monitoring and reviewing water access rights and regulatory oversight of activities.

Some issues raised go beyond the Terms of Reference of this review and are the responsibility of a range of agencies at local, state and Commonwealth level. Further, some pose underlying questions about what the community profile is or should be and how activities are prioritised and valued. Table 2 sets out the issues raised by stakeholders that are within the scope of this Review and will be the focus of work going forward.

Table 2: Stakeholder issues that will be the focus of further work

Management approach	Focus
Issues to be taken forward in the Review	• Water availability • Environmental water • Assumptions and calculations underpinning water projections, allocations and licences • Data • Monitoring • Modelling • Management of uncertainty • Localised impacts, including on domestic bores and natural springs • Decision-making processes (as relevant to the issues listed above)
Issues for other agencies, jurisdictions or stakeholders	• Economic considerations • Specific regulatory issues (individual cases) • Road traffic and safety • Social policy issues • Use of plastic

3 THE EXTENT OF BOTTLED WATER EXTRACTION

The first Term of Reference entails an examination of extraction levels in the WSP and seeks advice on extraction levels for the bottled water industry and future monitoring. In working to address these, the consultation process proved to be a rich source of information, data and ideas from the community and other stakeholders. The issues identified in those fora (set out in Chapter 2) that relate to the volume of water and allocation processes and issues are the focus of this chapter.

The quantity of water that is available for the bottled water industry in the Northern Rivers region, as with other extractors for commercial purposes is established through the *Water Management Act 2000* (WMA) and the WSP instruments.

Two fundamental principles for the WSP that are important for the framing of this Review are:

1. there are established priorities of allocation with environmental and ecological first, basic rights/stock and domestic second, and industrial and commercial extraction last
2. within the category of industrial and commercial, there is no distinction made between different 'product categories' or end uses – water involved in producing food, drink, minerals, manufactured products and services are all considered on a level playing field.

The following chapter discusses in more detail the relevant WSP for groundwater in the region. Further information about the regulatory framework is in Appendix 4 and the rules applying to the four groundwater sources relevant to the Review are at Appendix 5.

3.1 WATER SHARING PLAN FOR NORTH COAST FRACTURED AND POROUS ROCK GROUNDWATER SOURCES

Under the WMA, WSPs have been developed for many groundwater and surface water systems in NSW to control and limit usage of water resources, ensure that Basic Landholder Rights (BLR) can be met and ensure that there is sufficient water reserved as environmental water to support dependent ecosystems and maintain aquifer health. Table 3 sets out the WSPs in the Northern Rivers region.

Table 3: Northern Rivers region groundwater and surface water sharing plans

Water Sharing Plan	Plan Status	Supporting Documentation	Cease Date
Brunswick Unregulated and Alluvial	Commenced July 2016	• Brunswick water source rules • Background document	July 2026
North Coast Coastal Sands Groundwater Sources	Commenced July 2016	• North Coast Coastal Sands Groundwater source rules • Background document	July 2026
North Coast Fractured and Porous Rock Groundwater Sources	Commenced July 2016	• North Coast Fractured and Porous Rock Groundwater source rules • Background document	July 2026
Richmond River Area Unregulated, Regulated and Alluvial	Commenced Dec 2010	• Richmond River are water source rules • Background document	July 2021
Tweed River Area Unregulated and Alluvial	Commenced Dec 2010	• Tweed River area water source rules • Background document	July 2021
Alstonville Plateau Groundwater Sources	Commenced 2004 - Repealed	• Replaced by Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources	June 2016

Source: DOI (2019)

The Review is focusing on four specific groundwater sources in the Northern Rivers region where there is current, proposed or potential historical groundwater extraction for bottled water (Table 4). If the Review is made aware of additional groundwater sources in the Northern Rivers region used by the industry, these will be added to the scope as the Review progresses.

Table 4: Groundwater sources and descriptions

Groundwater Source	Description
Alstonville Basalt Plateau Groundwater Source	A fractured rock aquifer system in which Tertiary basalt extends to a depth of up to 150 metres. Groundwater is contained in fractures in the basalt. The hydrology of the area is complex and the degree of connectivity (both vertical and horizontal) is not uniform. The groundwater in this source is used for town water supply and irrigated agriculture. Discharge at the surface provides baseflow to surface waters and is important to the environment
Clarence Moreton Basin Groundwater Source	A porous rock aquifer system, overlain by the Mount Warning complex (comprised of the North Coast Volcanics and the Alstonville Plateau groundwater sources). On the eastern extent it is overlain by alluvial and coastal sand deposits. Groundwater is both contained within the system, and moves through it, due to the primary porosity of the rock as well as the fractures present due to the folding and faulting of the rock formation. Low bore yields of 1L/s, rising to up to 10L/s in highly fractured fault systems. All surface units are recharged by direct rainfall recharge with subsequent vertical leakage. Generally used for stock and domestic purposes with some sporadic irrigation/commercial supplies.
New England Fold Belt Groundwater Source	A fractured rock aquifer system, overlain by the Clarence Moreton Basin and North Coast Volcanics groundwater sources. On the eastern extent it is overlain by alluvial and coastal sand deposits. Groundwater is contained within, and moves through, fractures in the rock due to the folding and faulting of the rock formations. Low bore yields of 1L/s, rising to up to 10L/s in highly fractured fault systems. Recharge is typically by direct rainfall infiltration and, combined with the degree of mineral leaching that has occurred over time, has resulted in good quality water. Generally used for small scale irrigation, stock and domestic purposes.
North Coast Volcanics Groundwater Source	A fractured rock aquifer system comprised of the Lamington Volcanics, associated with the Mount Warning Complex. It is situated on top of the New England Fold Belt and Clarence Morton Basin groundwater sources. Typically composed of basalt and rhyolite, the groundwater is contained within, and moves through, fractures formed as a result of the rock cooling as well as the vesicular structures of basalt flows. Moderate bore yields of 5L/s, rising to up to 10L/s in highly fractured fault systems. Recharge is typically by direct rainfall infiltration, resulting in excellent quality water. Used for stock, domestic and irrigation water supplies. Stream and spring flow is reliant on groundwater discharge during non-rainfall periods. As a result, groundwater-dependant ecosystems are common with the groundwater source.

Source: Department of Primary Industries Water (2016) Report Cards for North Coast Fractured and Porous Rock Groundwater Sources: Report Cards 1, 3, 10 and 11

These sources are covered by the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources (DPI Water, 2016b) (WSP NCFPR) released in September 2016.

The WSP NCFPR covers 13 groundwater sources from Gosford to Tweed Heads, 10 of which had not previously been covered by a WSP. The total area covered by the WSP NCFPR is approximately 76,000 km^2 (DPI Water, 2016b). The groundwater sources covered by this plan are defined either as porous or fractured rock aquifers, all with the following connectivity characteristics according to the WSP:

- low-moderate connection between surface and groundwater
- low impact on in-stream values
- years to decades travel time between groundwater and surface water (DPI Water, 2016b)

Prior to the commencement of the WSP NCFPR, of the four groundwater sources in scope, only the Alstonville Plateau Groundwater Source was the subject of a WSP as noted in Table 4 above.

Prior to the finalisation of the WSP NCFPR, report cards for each of the groundwater sources were issued in February 2016. For the Alstonville Basalt Plateau Groundwater Source, which had been subject to a prior plan, the proposed rule changes and technical specifications like calculation of recharge were compared against the original WSP for Alstonville.

One significant change was that the previous division of the Alstonville Plateau into six groundwater sources changed to the groundwater sources merged into one with two management zones - the Alstonville-Tuckean and the Bangalow-Wyrallah management zones. These were based on levels of extraction, particular intensity of extraction in the Alstonville-Tuckean area, and to prevent localised impacts.

Within the whole groundwater source, no water is being made available for new licences, as the source has been capped at the current entitlement. However, trading is allowed within the groundwater source, but not if the trade results in a net increase to the sum of share components in the Alstonville-Tuckean Management Zone. There are no restrictions to trades within each of the management zones or from the Alstonville-Tuckean into the Bangalow-Wyrallah zones.

The WSP NCFPR is a regional water planning tool and a macro-scale instrument that considers a geographically large area to set guidelines and regulations to limit overuse or stress on an aquifer at a regional scale. The WSP does not specifically assess local scale risks, other than setting broad limits on the proximity of groundwater extractions to groundwater dependent ecosystems (GDEs), other groundwater users, aboriginal heritage sites and major water supply bores. These are summarised for the four groundwater systems in the rules in Appendix 3. The issue of potential localised impacts from extraction will be further investigated by the Review over the coming months.

Under the WSP NCFPR, priority is given to environmental water and basic landholder rights (BLR). The plan allocates an amount of water that is to be reserved for these priority uses, and prevents licensed extractions from accessing a portion of the estimated groundwater source. Licensed extractions for all other uses are secondary to BLR and environmental water. Some additional priority is given to groundwater extracted for local and major utilities that are typically licensed to extract reasonably large amounts for water security and to licensed stock and domestic bores.

Under the WMA 2000, granting of commercial water licences (e.g. groundwater extractions that are not for BLR or utilities) is independent of their intended use. This allows ready trade and aims to promote efficient use of resources, as well as allowing new industries to develop and water to be allocated to the highest value use (DPI Water, 2016b). Under the WMA 2000 and the WSP, extraction for bottled water is treated the same as any other commercial extraction, including commercial irrigation and horticulture. Further information about the WSPs, including audit and review processes are contained in Appendix 4.

The following sections review the purpose and methods used in the WSP NCFPR that governs groundwater licenses for the areas relevant to this review.

3.2 EXTRACTION LIMITS

A major output of the WSP NCFPR is the Long Term Average Annual Extraction Limit (LTAAEL) for each of the 13 groundwater sources. The LTAAEL determines the maximum average volume of water that can be extracted from one source in a given year. To prevent the overuse of groundwater resources, the water sharing plans generally enforce the LTAAEL to be a portion of the average recharge of the aquifer (i.e. versus water that is already stored in the aquifer). To quantify an appropriate LTAAEL, average recharge must be defined.

Groundwater sources in the WSP NCFPR are described as '*less highly-connected groundwater sources*' (DPI Water, 2016b), so the estimates of aquifer recharge only consider direct rainfall. While some surface water – groundwater connectivity may exist, no surface water contribution to recharge is considered in these calculations. Under that assumption, the LTAAEL for fractured rock aquifers is determined by the following simplified procedure (DPI Water, 2015):

1. estimation of the annual average rainfall (discussed in Section 3.2.1)
2. estimation of the recharge as a fixed percentage of rainfall (discussed in Section 3.2.2)
3. determination of areas of high environmental value and non-high environmental value
4. determination of current and future water requirements (the latter increased by 10 percent to ensure a conservative estimate)
5. determination of the Upper Extraction Limit (UEL), which is equal to the recharge in the non-high environmental value area multiplied by a sustainability index (described in Section 3.2.3)
6. determination of LTAAEL as the UEL or a lower value based on estimates of existing and future extractions.

The current total water access rights, including an estimate of BLR (which does not require a licence for extraction), was calculated for each of the groundwater sources as part of the WSP NCFPR in 2016. Where the total water access rights are less than the 80 percent of the LTAAEL, water can be made available as new licence allocations by state government agencies via a controlled allocation process.

When the WSP NCFPR was first released in 2016, the Alstonville Basalt Plateau Groundwater Source was the only source subject to the Review where licence allocations were at the LTAAEL, whereas (the other three sources subject of this Review were less than 60 percent allocated). There is a provision for the LTAAEL of fractured rock aquifers to be increased to a maximum of the UEL if demand for water increases beyond the predicted amount.

Within the area covered by the WSP NCFPR, licences entitle their holders to a certain 'share' of the water resource. Under ordinary circumstances, one share is equal to an entitlement of 1ML/year. However, at the Minister's discretion, the allocation of water per share can be reduced to minimise environmental or socio-economic impacts, such as during a drought or in response to a growth in use of local water utility or BLR use.

The following sections review the process for water allocation determination in the WSP NCFPR.

3.2.1 Average Annual Rainfall

Annual rainfall is variable over the relatively large area covered by the WSP NCFPR. Rainfall data used by the WSP NCFPR was sourced from the Bureau of Meteorology (BOM) gridded rainfall data (approximately 5 km^2 grid) from 1901 – 2011. More information on the rainfall data can be found on BOM (2015).

This rainfall model uses algorithms to estimate a weighted average rainfall in each grid based on the observations at the nearest BOM stations (see Section 1.2). This accounts for the spatial variability of rainfall throughout large catchments and is based on the best available data.

3.2.2 Recharge Rates

The WSP NCFPR simplifies the aquifer recharge to the relationship shown in Equation 1. The systems considered in the WSP are considered to be '*less highly-connected groundwater sources*' (DPI Water, 2016b), which means there is little recharge through creek beds, and therefore, only recharge through rainfall was considered.

Calculating recharge through this relationship assumes that the aquifer is homogenous, which is a simplification of the complex geology that occurs in porous and fractured rock aquifers. It also assumes that the recharge is generated over the entire surface area of the groundwater source that is not overlain by another defined groundwater source (i.e. the outcropping area).

$$\text{Average Recharge (ML/yr)} = \text{Average Rainfall (mm/yr)} \times \text{Area (km}^2\text{)} \times \text{Recharge Rate (\%)}/100$$

Equation 1: Average recharge

While rainfall and area are measurable (although the area over which the source is recharged is sometimes less clear, which is discussed further below, the recharge rate is more difficult to define. The transmissivity of different aquifers can vary significantly depending on the geology, and different recharge rates were applied by the WSP for each of the groundwater sources. DPI Water (2015) provides some guidance on the recharge rates applied for different groundwater source types (Table 5).

Table 5: Recharge rates recommended by DPI Water (2015)

Hydrogeological Type	Recharge Rate	Comment
Coastal Porous Rock	1 – 6%	Based on the findings of Coastal Porous Rock Rainfall Recharge Study
Inland Porous Rock	6%	
Fractured Rock (excl. North Coast Volcanics)	4%	
North Coast Volcanics	8%	Source is unclear

Table 6 shows the recharge rates adopted in the WSP NCFPR for the groundwater sources relevant to this report. (DPI Water, 2016b) and (DPI Water, 2015) acknowledge that regional estimates of recharge of large aquifers is not an exact science, and they state they that due to this uncertainty have taken a precautionary approach. DOI Water has advised that the precautionary approach was based on using zero percent recharge estimates for high value area, no allowance for recharge from anything other than direct rainfall, and sustainability indexes to ensure that use is significantly less than recharge (DOI Water, 2019b).

Table 6: Rainfall recharge rates adopted in the Water Sharing Plan

Groundwater Source	Rainfall Recharge Rate adopted	Based on
Clarence Moreton Basin	6%	There is little direct data and very little demand for groundwater, therefore the NSW default 6 percent was recommended, based on the Coastal Porous Rock Rainfall Recharge Study (DPI Water, 2016b)
North Coast Volcanics	8%	DPI Water (2016b)
New England Fold Belt	4%	DPI Water (2016b)
Alstonville Basalt Plateau	8%	Based on preceding WSP

3.2.3 Sustainability Index

The sustainability index (SI) is a qualitative risk based approach used in water sharing plans to account for the relative social, economic and environmental risks of extracting groundwater from a particular water source.

The environmental risk considers the prevalence of high priority groundwater dependent ecosystems and the risk to the groundwater source itself. It considers water quality, ecology and aquifer integrity. Environmental risk is rated as high (e.g. permanent and significant change), moderate (temporary change) or low (no change anticipated) and is a simple relative measure. If there are any mitigation actions (e.g. groundwater modelling or distance rules from sensitive areas), these may be considered to lower the environmental risk.

Socio-economic risk considers the financial and social dependence of local communities on a groundwater resource. For example, the socio-economic risk considers whether there is any readily available alternative to groundwater extraction, the contribution of groundwater dependent industry on the local economy (including employment rates) and the dependence of the local communities on groundwater resources for drinking water supplies. As per the environmental risk, the socio-economic risk is assigned a relative rating (high, moderate or low).

Following these assessments, the environmental (known as the 'aquifer risk') risk and the socio-economic risk are input into the matrix shown in Table 7 to define the final sustainability index. For example, if the aquifer risk is classified as 'High' and the socio-economic risk is 'Medium', the sustainability index would be 25 percent as illustrated in Table 7.

Table 7: Sustainability index matrix (DPI Water, 2016b), with an example calculation of a high aquifer, medium socio-economic risk sustainability index of 25%

Aquifer Risk	**High**	5%	25%	50%
	Medium	25%	50%	60%
	Low	50%	60%	70%
		High	**Medium**	**Low**
		Socio-Economic Risk		

The sustainability index is used to define the upper extraction limit (UEL – the maximum allowable extraction from the groundwater source) as per Equation 2 below. The sustainability index is the portion of estimated recharge that can be assigned to the UEL.

A lower sustainability index indicates less water is to be available for extraction (i.e. more water is assigned as environmental water). All the catchments are split into two areas – high conservation areas (e.g. National Parks) and the remaining areas. For all WSP NCFPR groundwater sources, the sustainability index over high conservation areas is, by default, 0 percent. This means that recharge over these areas is preserved for environmental use. The sustainability index calculated in Table 7 only relates to the remaining areas.

$$\text{UEL (ML/yr)} = \text{Recharge over non- high environmental areas (ML/yr)} \times \text{SI(\%)}$$

Equation 2

Table 8 summarises the sustainability indexes for the four groundwater sources considered in this report, including the assigned socio-economic and environmental risk. Environmental risk of the North Coast Volcanics is high due to the prevalence of springs, rainforests and groundwater dependent soils. The socio-economic risk in the Clarence Moreton Basin is largely due to the predicted (at the time) reliance of the coal seam gas industry on groundwater resources, as well as the dependence of the smaller industries on groundwater. No socio-economic or environmental risk was provided for the Alstonville Basalt Plateau in the WSP, as there were limited changes to the allowable extraction from the previous Water Sharing Plan for the Alstonville Plateau Groundwater Source.

Table 8: Sustainability index for relevant groundwater sources

Groundwater Source	Socio-Economic Risk	Environmental Risk	Sustainability Index
New England Fold Belt	Low	Moderate	25%
Clarence Moreton Basin	Moderate	Low	60%
North Coast Volcanics	Moderate	High	25%
Alstonville Basalt Plateau	-	-	~20%*

This is not presented in the current WSP but is based on the preceding legislation Water Sharing Plan for the Alstonville Plateau Groundwater Source

3.2.4 Estimates of LTAAEL

The LTAAEL is calculated differently depending on whether the groundwater source is defined as a porous or fractured rock aquifer. For fractured rock aquifers (New England Fold Belt, North Coast Volcanics and the Alstonville Plateau), the UEL is calculated as per Equation 2, as a direct relationship between the recharge and sustainability index. However, in an acknowledgement of the uncertainties surrounding the recharge estimates for fractured rock, the upper extraction limit is compared to the current and estimated future requirements for water (including a 10 percent buffer on the future requirements). The future estimated requirements were calculated considering the following (DPI Water, 2015):

- growth in BLR as a result of increasing populations. BLR was assumed to grow in proportion with population. Population forecasts were based on Department of Planning estimates
- increase in requirements for dewatering, based on dewatering in the previous decade increasing proportionally with population growth
- growth in town water supply requirements, sourced from future water strategies and consultation with the relevant councils;
- growth in agricultural, which was determined by the North Coast Interagency Regional Panel based on local knowledge and present agricultural requirements
- growth in mining requirements, based on industry statistics reviewed by the North Coast Interagency Regional Panel.

Once the future estimated requirement for groundwater was calculated, the following rules are applied to determine the LTAAEL:

1. if the future estimated requirement for groundwater (+10 percent) < 10 percent of UEL, LTAAEL = 10 percent of UEL
2. if the future estimated requirement for groundwater (+10 percent) > UEL, LTAAEL = UEL
3. otherwise, LTAAEL = future requirement for groundwater (+10 percent).

In cases where the LTAAEL<UEL, the LTAAEL can be increased during the life of the WSP if the entitlement reaches 80 percent of the LTAAEL. This would require a review of the LTAAEL (of one particular groundwater source) by the North Coast Interagency Region Panel or some other similar interagency panel (DPI Water, 2016a). DPI Water (2016b) notes that the future requirement estimates were ‘generous’ implying that it was considered unlikely that there would be an increase in LTAAEL in the life of the plan.

For the New England Fold Belt and the North Coast Volcanics, the LTAAEL is substantially smaller than (< 25 percent of) the UEL (Table 9). This provides a suitable buffer to account for the uncertainty related to the recharge rates for these areas, and results in what is likely a conservative allocation of groundwater resources. For the Alstonville Plateau, where the LTAAEL is based on the preceding WSP, the LTAAEL is relatively high compared to the average annual recharge.

Table 9: LTAAEL in fractured rock aquifers DPI (2016)

Groundwater Source	Average Recharge over non-high environmental areas (ML/yr)	Estimate Future Requirement (+10) (ML/yr)	UEL (ML/yr)	10% of UEL (ML/yr)	LTAAEL (ML/yr)
New England Fold Belt	1,500,000	60,000	375,000	37,500	60,000
North Coast Volcanics	220,000	13,000	55,000	5,500	13,000
Alstonville Plateau*	50,000	-	-	-	8,895

Based on the preceding legislation Water Sharing Plan for the Alstonville Plateau Groundwater Source, no future requirement or UEL was presented

For porous rock aquifers (Clarence Moreton Basin), the WSP NCFPR states a higher degree of confidence in the recharge rates due to the results of the Coastal Porous Rock Rainfall Recharge Study. Further investigation is needed to determine the basis for this higher degree of confidence.

Table 10: LTAAEL for porous rock aquifers (DPI Water, 2016b)

Groundwater Source	Average Recharge over non-high environmental areas (ML/yr)	Current Requirement (ML/yr)	LTAAEL (ML/yr)
Clarence Moreton Basin	500,000	4,562	300,000

LTAAEL values in the porous rock aquifers were calculated as per Equation 2, where the LTAAEL is equal to the UEL. Unlike fractured rock aquifers, no reduction is made in the LTAAEL to account for cases with low current and estimated future requirements for groundwater extractions.

As a result, the LTAAEL for the Clarence Moreton Basin, shown in Table 10, is large compared to the current water extraction. While this is an indicator that the groundwater source is unlikely to be currently under stress, there is no trigger for review of the LTAAEL if there is a large growth in extraction (as would be required for the New England Fold Belt or the North Coast Volcanics). However, the whole WSP NCFPR is reviewed after a period of ten years, so any significant growth in these porous rock aquifers could be reviewed at this time.

3.2.5 Environmental Water

The WSP requires an assignment of a portion of the annual average recharge to be classed as environmental water. As mentioned previously, 100 percent of recharge over high conservation areas, such as National Parks, is preserved for environmental water. The total volume of water assigned as recharge amount reserved for the environment (RRE) is defined by the relationship in Equation 3.

$$\text{RRE (ML/yr)} = \text{Average Recharge (ML/yr)} - \text{LTAAEL}$$

Equation 3

Table 11 shows the RRE for the four groundwater sources of interest. The allotment of total estimated recharge is illustrated graphically in Figure 7.

With the exception of the Clarence Moreton Basin, the RRE is in excess of 80 percent of the estimated recharge. RRE is typically higher in fractured rock aquifers due to the more conservative approach used to obtain a value of LTAAEL.

Table 11: Recharge amount reserved for the environment (DPI Water, 2016b)

Groundwater Source	Total Estimated Recharge[1] (ML/yr)	LTAAEL (ML/yr)	RRE (ML/yr)[1,2]	RRE as a percentage of estimated recharge[1]
New England Fold Belt	1,980,000	60,000	1,920,000	97%
Alstonville Plateau	50,079	8,895	41,184	82%
Clarence Moreton Basin	576,000	300,000	276,000	48%
North Coast Volcanics	310,000	13,000	297,000	96%

1. All numbers presented in this table are over the whole groundwater source and include recharge and environmental water from high-conservation areas and less environmentally sensitive areas combined, which may differ from numbers expressed in the WSP
2. Table 15 in WSP NCFRP Background document refers to these values as planned environmental water 'PEW'

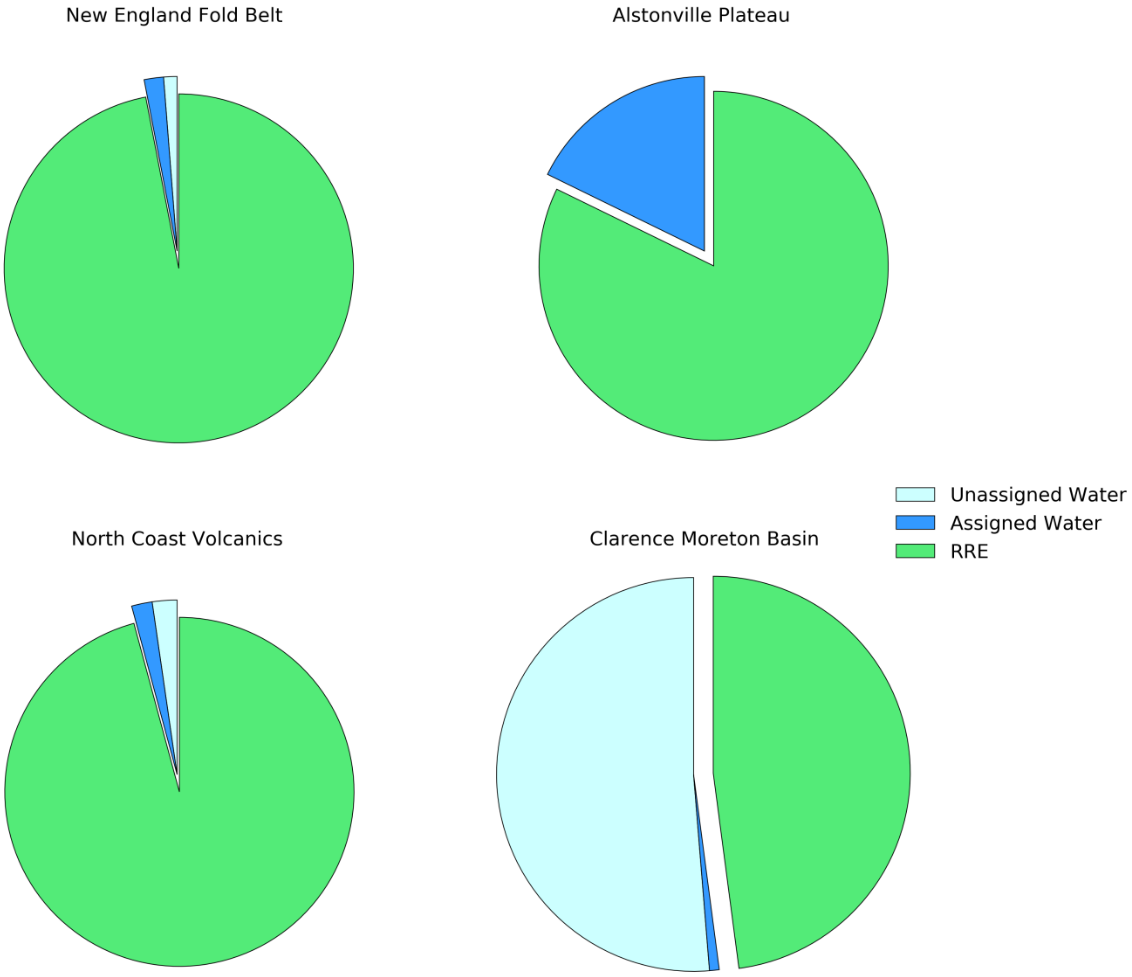

Figure 7: Allotment of estimated recharge to Recharge Amount Reserved for the Environment (total volumes differ between aquifers)

3.2.6 Continuing work on the WSP NCFPR

The Review will continue work to assess the extraction limits assigned in the WSP NCFPR and analyse the uncertainty around the values used and what impact that may have, as part of TOR 1b. This process will help inform Review recommendations that relate to further data requirements and in particular monitoring under TOR 1c.

Further information will be sought to inform a deeper analysis around how the recharge rates are determined. The estimates of recharge provide the basis of all other calculations in the WSP NCFPR. While uncertainty in the recharge estimate may be acceptable if the estimates are suitably conservative, or there is limited consequence resulting from any possible errors, it is important to recognise and understand how ambiguity may impact on the WSP.

The term uncertainty is used here to recognise that there are a range of possible values that could be assigned to a given attribute, such as the recharge rate or the sustainability index. When there is a substantial body of research on a given topic, the uncertainty is typically lower – there is a small range of values that might be possible, and a higher degree of confidence in the adopted values. Conversely, when there is limited available data and research, the uncertainty can sometimes be high and a large range of possible values. This is discussed further in Appendix 6. How this is managed will be subject of further work by the Review.

3.3 WATER ALLOCATIONS AND WATER TAKE

3.3.1 Water allocations (available water determinations)

Water users have entitlements under water access licences (or basic landholder rights) to a share of available water in a particular water source. WSPs provide a mechanism, a 'water allocation' or an 'available water determination' (AWD), to control water take by water users. The AWD is intended to ensure that water take is controlled, to prevent stress on the water source and associated consequences including potential environmental impacts. It also provides short-term certainty to water users, including industry, regarding the amount of water that can be taken and under what conditions.

To calculate the water allocation for each licensed water user each water year, the AWD process for groundwater sources determines the available water in the coming water year by considering the LTAAEL, water entitlements under access licences and basic landholder rights, and actual water take. The LTAAEL represents the extraction limit of a particular groundwater source over the long term, expressed as an average.[7] The AWD assigns a portion of the available water to each licensed water user based on their water entitlement (as specified in their water licence). This water is credited to that licensed water user's account at the start of the water year, and debited as water is extracted throughout the year (DPI Water, 2016b).

The actual water taken from a water source will vary from year to year based on a variety of factors. This includes business decisions, industry dynamics, residential and commercial development. While the AWD is conducted each water year, the focus of the AWD is to manage sustained growth in actual water take (not water entitlement) above the LTAAEL, which is a long-term measure. For example, the standard water allocation for licensed water users is 1ML/unit share, but the WSP NCFPR specifies that where growth in water take is assessed to have increased more than 5 percent above the LTAAEL extraction limit over a three-year period, the water allocation may be reduced to less than 1ML/unit share.[8]

On 1 July 2018, the Department of Industry issued a Water Allocation Statement for North Coast groundwater users for the 2018-19 water year commencing 1 July 2018. The statement allocated local water utility and aquifer licence holders covered by the WSP NCFPR groundwater sources an allocation of 100 percent of their entitlement, or 1 ML per share unit.[9] This statement covered the four groundwater sources under focus of this Review.[10]

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[7] To protect the groundwater source, the LTAAEL is calculated based on the annual recharge of the groundwater source, not on the total storage.
[8] *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016* cl 29(2)-(3).
[9] Available Water Determination Order for the North Coast Coastal Sands and the North Coast Fractured and Porous Rock Groundwater Sources 2018.
[10] The statement was issued under the Available Water Determination Order for the North Coast Coastal Sands and the North Coast Fractured and Porous Rock Groundwater Sources 2018 under the WMA 2000.

Table 13 below summarises the extraction limits, water entitlements and unassigned water in these four groundwater sources.

The Alstonville Basalt Plateau is the only groundwater source (of the four groundwater sources this Review is focusing on) that has reached full licence allocation. Under these circumstances, it is only possible to access new water entitlement by trading of licensed water entitlements. In addition, when water is allocated, the WSP may impose water trading rules that place restrictions on how water allocations can be traded, recognising that particular water sources within a water determination may require additional controls.

3.3.2 Controlled allocations

Water access licences may be granted to water sources with unassigned water, through a controlled allocation order.[11] Under Department of Industry policy, *Strategy for the controlled allocation of groundwater* (May 2017)(DPI Water, 2017), controlled allocation orders will only be made for a water source when the sum of water requirements is less than 80 percent of the LTAAEL. The most recent controlled allocation order for the four groundwater sources relevant to this Review was gazetted on 5 May 2017 (Table 12). The order did not provide for a controlled allocation release for licences in the Alstonville Basalt Plateau Groundwater Source as this groundwater source has reached full licence allocation.

Table 12: Controlled Allocation Order 2017

Groundwater Source	Quantity of unit shares per water source	Minimum bid price per unit share $
Alstonville Basalt Plateau Groundwater Source	N/A – fully allocated	N/A – fully allocated
Clarence Moreton Basin Groundwater Source	30,000	500
New England Fold Belt Groundwater Source	6,000	500
North Coast Volcanics Groundwater Source	1,300	500

Source: Government Gazette of the State of New South Wales, Number 53, Friday, 5 May 2017

Several tender periods occur under the allocation, with the next registration process scheduled for October 2019 and one round occurring at present. The controlled allocation process is described in more detail in Appendix 4.

3.3.3 Allocations versus actual water take

Entitlements under water access licences and basic landholder rights do not necessarily reflect the amount of water actually taken from a groundwater source. Water take under an individual licence is often lower than the water allocation for that licence. The total water take from a groundwater source, as a whole, is generally lower than the total water entitlements for that water source (under water access licences and basic landholder rights). This is because people may decide not to extract their full allocation; and in some cases, allocations may be subject to additional regulatory restrictions.

For example, through the DAs, some operators are restricted from accessing the full allocation of their water licence. This can be due to limitations on allowable truck movements and the corresponding volumes of water those movements represent. Alternatively, the amount specifically approved in the DA may be lower than the water access licence amount. Furthermore, some operators may not extract the full amount of their water access licence for bottled water use due to commercial or operational reasons such as fluctuating customer demand or supply chain bottlenecks.

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[11] *Water Management Act 2000* s 65.

The actual water take may be identified through logs maintained by the operators or installed meters required as a condition of licence and/or DA approval. The Review will continue to work agencies as the review progresses to determine precisely what information is reported to agencies and under what circumstances.

3.3.4 Water entitlements for bottled water facilities in the Northern Rivers

Section 1.5 described the challenges in determining the full scope of the bottled water industry in the Northern Rivers. Since the licences that the operators hold specify the allowable extraction and not the use for the extraction, other means are required at present to determine which licences are actively being used or proposed for bottled water extraction and the amount being taken.

Table 13 provides an overview of the total available water for all purposes by groundwater source. It includes landowner rights and entitlements, as well as an estimate of the water entitlements held by the bottled water industry in the Northern Rivers area. It is emphasised that Table 13 provides a summary of the licence *entitlements*, not a record of *actual* water taken. It also does not reference any additional restrictions imposed on water take imposed through the DAs or any self-imposed limits on water take, so it may overestimate actual water extraction.

Table 13: Available water, extraction limits and requirements by purpose and groundwater source

Groundwater Source	A Estimated Total Aquifer Storage ML/yr[1,a,b]	B Total annual aquifer recharge ML/yr[3]	C Recharge amount reserved for environment[3,a] ML/yr	D Upper Extraction Limit (UEL)[2,3] ML/yr	E LTAAEL[2,3,c] ML/yr	F Unassigned Water[3,4] ML/yr	G Total requirements (BLR and licences)[3] ML/yr	H Basic landholder rights (BLR)[2,3,d] ML/yr	I Local water utility access licences[4] ML/yr	J All other aquifer access licences ML/yr	K Bottled Water Licences (Existing Industry)[e,f] ML/yr	L Bottled Water Licences (Proposed Industry)[f,g] ML/yr	M Total no. water access licences (WALs)[4]
Alstonville Basalt Plateau	640,000	50,079	41,184	na	8,895	0[h]	9,086[h]	2,014	1,230	5,842[5,i]	7.5	100	196
Clarence Moreton Basin	na	576,000	276,000	na	300,000	294,857	5,143	2,341	31	2,771[4]	50	-	135
New England Fold Belt	24,000,000	1,980,000	1,920,000	375,000	60,000	37,532	22,468	9,605	240[k]	12,623[4]	143	63	554
North Coast Volcanics	4,380,000	310,000	297,000	55,000	13,000	6,327	6,673	3,402	0	3,271[4]	20	-	205
Relationship between columns		*B=C+E*	*(C=B-E)*	*D*	*E*	*F =E-G[j]*	*G=H+I+J*				*Subset of J*	*Subset of J*	

Information is based on best available as at February 2019. The Review will continue to monitor and adjust should further information become available.

Sources and notes:

1 Estimated based on total area, porosity, average saturated thickness of source (EMM Consulting, 2018)
2 WSP NCFPR (July 2016)
3 WSP NCFPR – Background document (Sept 2016)
4 NSW Water Register https://waterregister.waternsw.com.au/water-register-frame - data used is from 18/19 year for each groundwater source
5 Supplied by DoI Water (DOI Water, 2019b)

a. Sources 2 and 3 define Planned Environment Water as equal to the total recharge minus the LTAAEL plus the portion of storage not available for extraction. At the commencement of the WSP NCFPR, 100 percent of groundwater storage is reserved as planned environmental water.
b. Reserved as part of Planned Environment Water – allocations made only on recharge
c. LTAAEL is long-term average annual extraction limit.
d. Basic landholder rights comprise domestic and stock but do not include volumes for Native Title Rights due to difficulty predicting volumes used
e. Column K is based on the full volume of a licence entitlement where all or part of that licence may be extracted for bottled water. This number does not reflect any other restrictions on the licences, e.g. through DA conditions or voluntarily etc.
f. Due to difficulty in confirming bottled water industry participants, there may be some small extractions captured in 'all other aquifer licence entitlements' column J that are not yet captured in columns K and L.
g. Under Column L, WALs, water supply approvals or general terms of approval may have been issued; and there is some indication in the public domain of either works approval or DA in process to start/expand extraction.
h. There is no unassigned water in Alstonville Basalt Plateau Groundwater Source. The total requirements do not represent actual take. When considering AWDs, actual water take is assessed against LTAAEL to determine volume or percentage of unit share.
i. DoI Water noted that two licences were handed back to the Water Administration Ministerial for a total of 10 ML/yr. The figure reflects this (DOI Water, 2019b)
j. The WSP NCFPR (2016) reflects unassigned water as LTAAEL minus total requirements (p. 35). This method is used with updated figures.
k. The LWU licences for the New England Fold Belt reduced from 14,840 shares in the WSP NCFPR (2016) to 240 shares in the NSW Water Register (as of 31 January 2019) due to two large LWUs being attributed to the New England Fold Belt rather than the Macleay Alluvium and the Macleay Coastal Sands (DOI Water, 2019a)

Figure 8 to Figure 11 represent the known volume of the water access licences for the bottled water industry (both existing and proposed) compared with the total water requirements under water access licences and basic landholder rights for each of the four groundwater sources that are the focus of this Review (see also Table 13).

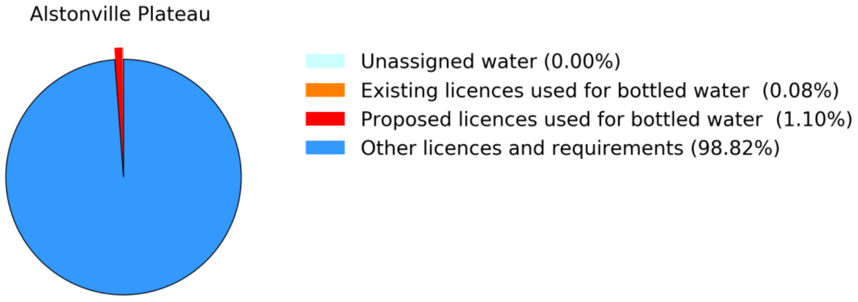

Figure 8: Percentage of existing and proposed licences for bottled water compared with total licences and requirements for the Alstonville Basalt Plateau GW Source

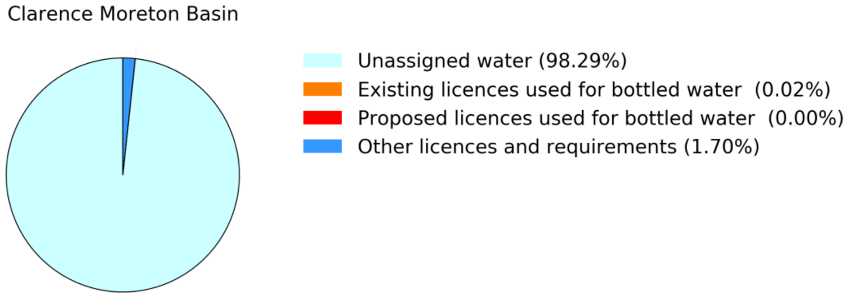

Figure 9: Percentage of existing and proposed licences for bottled water compared with total licences and requirements for the Clarence-Moreton Basin GW Source

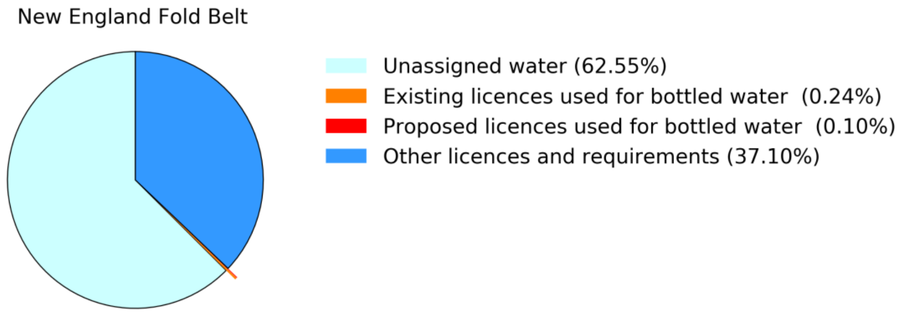

Figure 10: Percentage of existing and proposed licences for bottled water compared with total licences and requirements for the New England Fold Belt GW Source

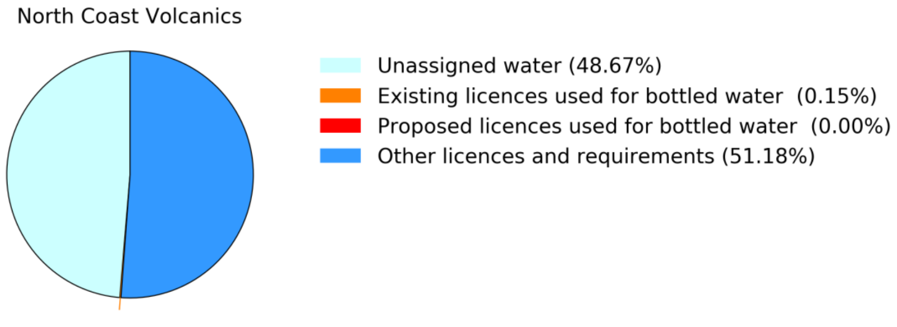

Figure 11:Percentage of existing and proposed licences for bottled water compared with total licences and requirements for the North Coast Volcanics GW Source

3.3.5 Concurrent activities in the Northern Rivers region

NRAR is response for compliance and enforcement of NSW water law (e.g. the *Water Management Act 2000* and regulations), including compliance and enforcement of water access licences and water use and management works approvals. In relation to the bottled water industry in the Northern Rivers, NRAR has undertaken a compliance investigation of four bottled water operators in the fourth quarter of 2018 based on information provided by the community regarding alleged breaches of licence and approval conditions.

NRAR assessed extraction amounts and on completion, reported that all four of the operators assessed had extracted within the limits of their licences. NRAR also used statutory directions to require three of the four operators to install accredited water meters on individual extraction bores in advance of the requirements under the State's new metering policy, *NSW Non-Urban Water Metering Policy (Nov 2018)* (DOI, 2018c). The Review understands that the fourth operator already had a meter installed that was compliant with the 2018 policy.

The Review will continue to liaise with agencies to obtain additional information during the course of the review. However, it is not within scope to make an assessment of or undertake auditing of compliance against any existing DAs or water licences.

4 GROUNDWATER AND SURFACE WATER SYSTEMS

4.1 REGIONAL GEOLOGY AND HYDROGEOLOGY IN THE NORTHERN RIVERS

The Northern Rivers region of NSW has alluvial, fractured rock, coastal sands and porous rock aquifers. In the context of this report, there are four relevant groundwater sources - New England Fold Belt, the Alstonville Basalt Plateau, the North Coast Volcanics and the Clarence Morton basin, which are all fractured or porous rock aquifer systems and cover in the North Coast Fractured and Porous Rock Water Sharing Plan. The locations of these regions are shown in Figure 12.

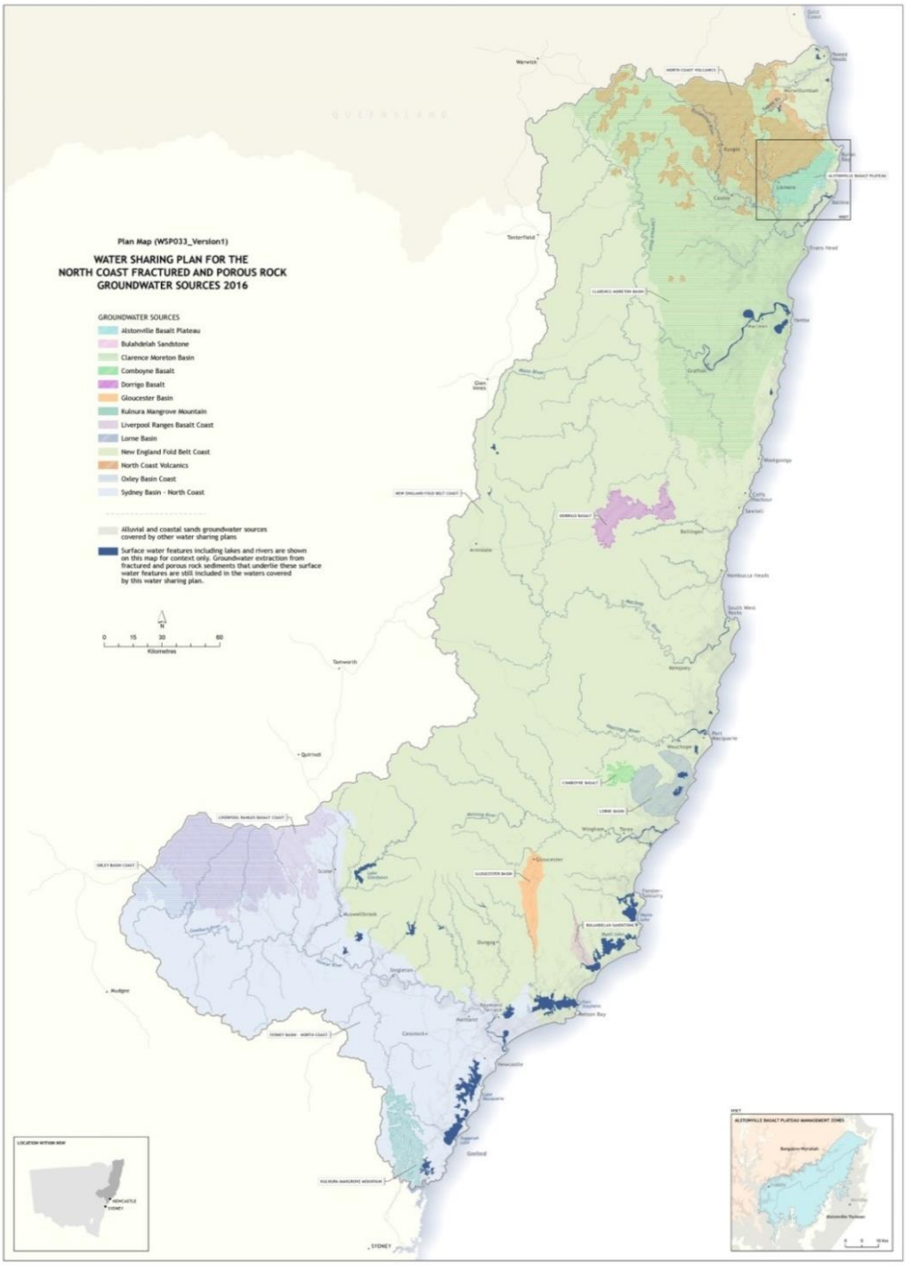

Figure 12: Map of the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016
Source: NSW Legislation (2019)

This section provides an overview of the conceptual understanding of the hydrogeology of the North Coast region, with specific emphasis on the four groundwater sources considered in this review. The depth of understanding varies significantly between the four sources. The Alstonville Plateau was considered at high risk of impacts from over-extraction in the 1990s (DLWC, 1998), and as a result, increasing the understanding of this system has been a priority. The other areas, which cover larger geographic areas and historically have had less intensive groundwater use, have more limited information. Data are still being collected as part of this Review, and the conceptual understanding of these aquifers may continue to change and evolve as more resources are accessed in the later stages of this project. Initial analysis of groundwater levels and river baseflows is in Appendix 3.

The hydrogeological regions considered by this report are all located in the north-eastern corner of NSW. A recent bioregional assessment (BA) was undertaken for the Clarence Moreton bioregion due to the prevalence of coal seam gas (CSG). The bioregional assessment (BA) considered the basin as extending into Queensland, and includes the parts of the geological formations that make up all of the groundwater sources considered in this report (North Coast Volcanics, Alstonville Plateau, New England Fold Belt and the Clarence Moreton Basin). The region assessed in the BA is illustrated in Figure 13. The Clarence Moreton BA is comprised of a number of different sections, written and released over a number of years. Of particular relevance to the geological context of the North Coast region are studies by Raiber, Murray, Bruce, Rassam, Ebner, Henderson, O'Grady, Gilfedder, and Cui (2016), McJannet, Raiber, Gilfedder, Marvanek, and Rassam (2015) and Cui et al. (2016) which are the primary sources used in the following description.

Raiber et al. (2016) describes the geology of the wider Clarence Moreton bioregional area in some detail, with a particular focus on the area that drains towards the Richmond River (see blue outline in Figure 13). It identifies three major hydrostratigraphic types:

- Alluvial aquifer systems: unconsolidated/semi-consolidated typically shallow aquifer systems, not addressed in this review;
- Fracture igneous rock aquifers: this includes the North Coast Volcanics and the Alstonville Plateau aquifer, both of which are part of the geological unit called the Lamington Volcanics;
- Sedimentary bedrock: a series of aquifers and aquitards extending to significant depths throughout the region. This includes both the Clarence Moreton Basin groundwater source and the older and deeper New England Fold Belt.

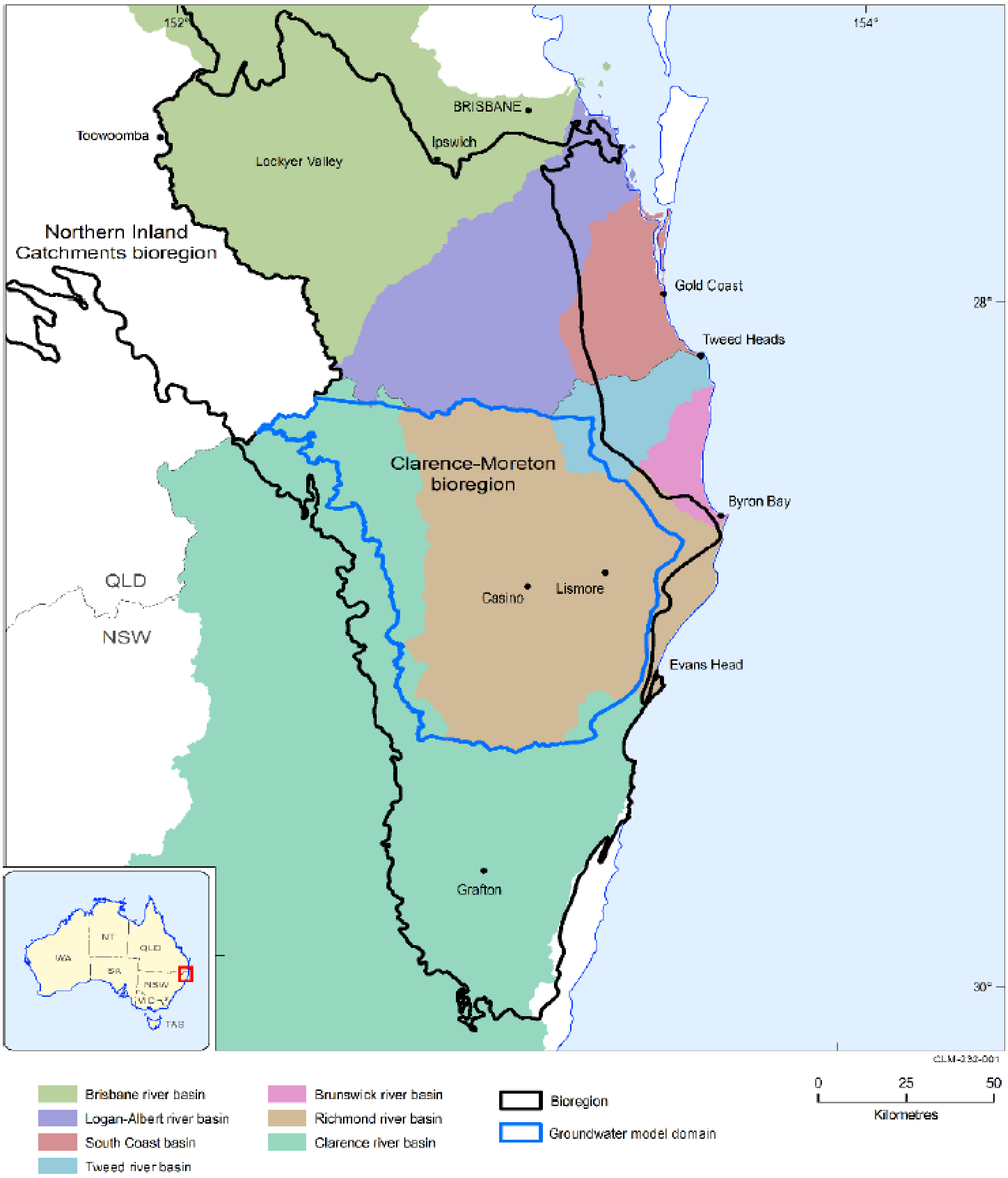

Figure 13: Clarence Moreton bioregion (black outline) and Richmond area groundwater model domain (blue outline)
Source: Raiber et al. (2016)

A typical hydrogeological cross section is shown in Figure 14, noting that the Lamington Volcanics are also an aquifer. Preliminary reviews of hydrogeological reports indicate the geological units associated with the New England Fold Belt relate to the older, deeper Bundamba group (which is close to the surface in areas beyond the BA), while the Clarence Moreton Basin typically relates to the shallower porous rock aquifers. While the BA does not cover the coastal region between Ballina and Byron Bay, the New England Fold Belt, which is the basement rock in the BA, continues throughout this area and is the primary aquifer accessed for bottled water west of the Clarence Morton bioregion.

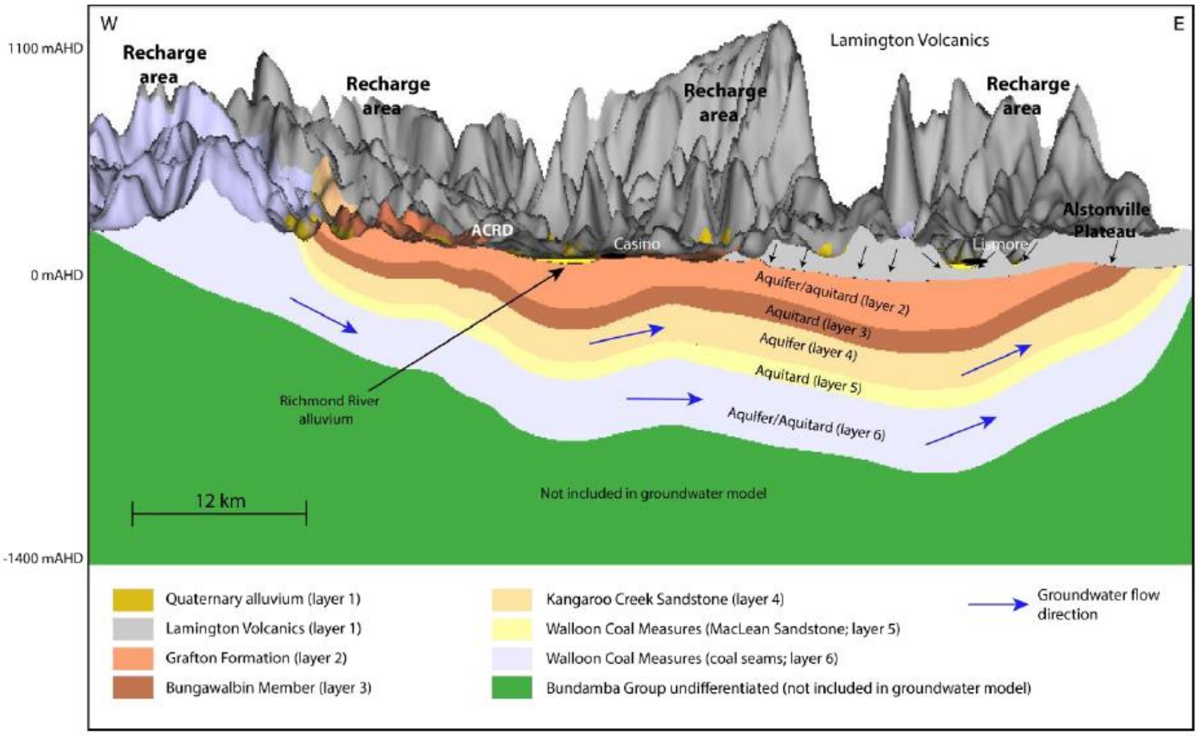

Figure 14: Typical geological cross section

Source: Raiber et al. (2016)

4.1.1 Lamington Volcanics Hydrogeology

Both the Alstonville Plateau and the North Coast Volcanics groundwater source are part of the Lamington Volcanics stratigraphic unit which overlays the Clarence Moreton Basin and the New England Fold Belt. Due to the nature of the periodic volcanic eruptions and subsequent basalt deposition, hydrogeology is defined by a series of overlying aquifers that formed approximately 20 million years ago, shown in Figure 15.

As the basalt cooled, some parts of the rock fractured which allows groundwater transmission and storage through the more fractured layers of rocks. The fractured layers are overlain by low permeability regions that limit connectivity between the different aquifer layers. However, fractures through the low permeability layers allow the transmission of water between the aquifers (see Figure 15). The Lamington Volcanics thickness varies significantly, but is typically in the order of 100 – 150 m. In some locations, the crest of the volcanic rocks can be very elevated and the thickness of this geological area is up to 825 m (Raiber et al., 2016).

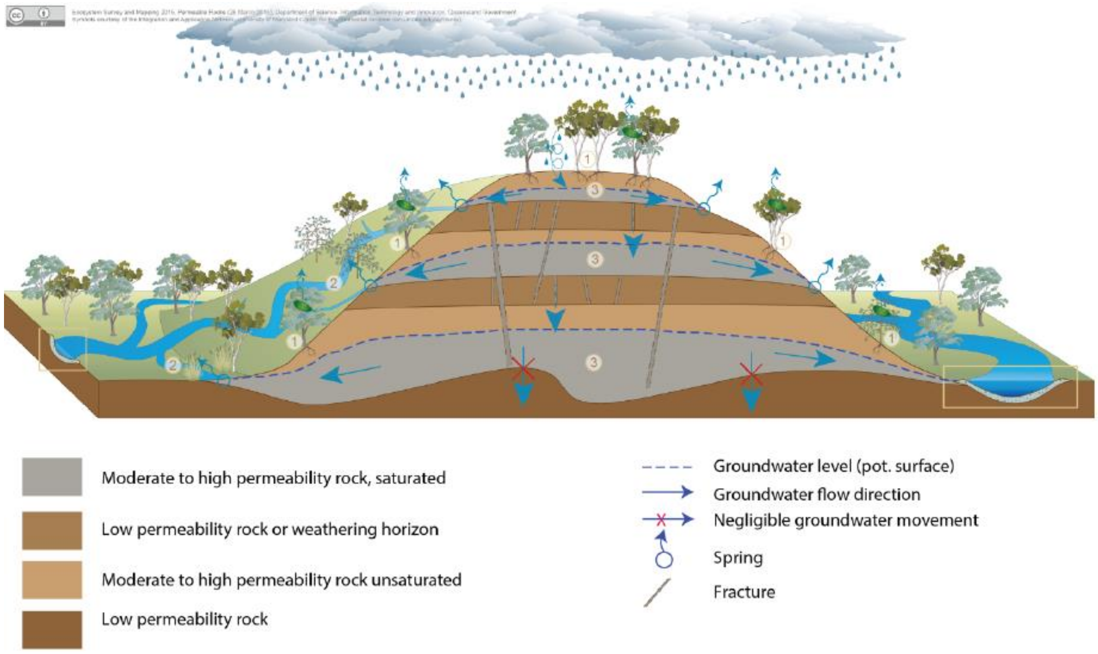

Figure 15: Conceptual figure of Lamington Volcanics multi-layer aquifer system
Source: Raiber et al. 2016

Due to the extensive fracturing of the Lamington Volcanics and the aerial extent of the fractured rock, recharge through rainfall is considered to be high. Raiber et al. (2016) estimates that the rainfall recharge in this region is an order of magnitude higher than some of the surrounding sedimentary bedrock units (such as the Walloon Coal Measures). However, Brodie et al and Raiber et al found a high degree of connectivity between the upper aquifers and surface water springs and creeks (Figure 15) (Brodie, Sundaram, Tottenham, Hostetler, & Ransley, 2007; Raiber et al., 2016). As a result, only a limited amount of recharge in this area makes it to the deepest of the volcanic aquifers (Raiber *et al*, 2016). Due to the significant groundwater contribution to springs and creeks, it is considered an area with high environmental risk if there is over-extraction of groundwater (DPI Water, 2016b). Water quality in the North Coast Volcanics is typically very fresh with median electrical conductivity in the Lamington Volcanics of 499 µS/cm (McJannet et al., 2015).

4.1.2 Sedimentary Bedrock Aquifers

Both the Clarence Moreton Basin and the New England Fold Belt are sedimentary groundwater sources. As illustrated in Figure 14, the sedimentary bedrock in the Clarence Moreton bioregion can be separated into layers based on their composition and original deposition. Depending on the composition, including porosity and fracturing, different layers are considered aquifers or aquitards (layers that allow limited transmission and storage of water). Raiber et al. (2016) identify the Kangaroo Creek Sandstone and the Woogaroo Sandstone aquifers as the two most utilised aquifers in the Clarence Moreton bioregion, although the Woogaroo Sandstone is not as heavily utilised in NSW due to greater depths. Regional groundwater flow through the sedimentary bedrocks is shown to be towards the east in Figure 14.

Understanding of the connectivity between the sedimentary bedrock aquifers and the shallower systems is limited due to minimal monitoring information. Raiber et al. (2016) indicate that the presence of low permeability layers would inhibit the connection of the sedimentary bedrocks to the upper volcanic and alluvial aquifers in most areas. However, some connectivity between the sedimentary aquifers, surface water systems and shallow alluvial groundwater systems is likely in areas where these aquifers are closer to the surface.

4.1.3 Alstonville Basalt Plateau Groundwater Source

DLWC (1998) identified the Alstonville Plateau as a groundwater source at high risk from over-extraction as it was already heavily utilised, there had been observed issues related to groundwater drawdown and it had a high occurrence of groundwater dependent ecosystems. As a result, a significant amount of additional research has occurred that is specific to this area. This section provides an overview of the hydrogeology of the Alstonville Plateau.

The Alstonville Plateau Groundwater Source covers an area of 391 km^2 and is in the Lismore Basalt belt that forms the southern part of the Lamington Volcanics overlaying the older sedimentary rocks in the Clarence Moreton Basin (DWE, 2003). The Lismore Basalt belt is associated with basalt flows from the Tweed Shield Volcano approximately 20 million years ago (Brodie & Green, 2002). As described previously, the Alstonville Groundwater Source (and surrounding groundwater sources of similar geology) is made up of a series of overlapping aquifers, separated by low permeability layers of clay or poorly fractured basalt, typically around 10 m in thickness (Brodie, 2007). As a result, the Alstonville Groundwater Source consists of a shallow unconfined aquifer overlaying a series of confined/ semi confined aquifers, illustrated in Figure 16. There is likely to be some limited connection between overlaying aquifers, through vertical fractures between layers or through slow percolation through low permeability layers. The maximum thickness of the basalt plateau is approximately 180 m (Brodie & Green, 2002). The basalt aquifers transmit and store groundwater through fractures in the rock profile. Due to the heterogeneous nature of the fractures, the yield from these groundwater sources can be highly variable.

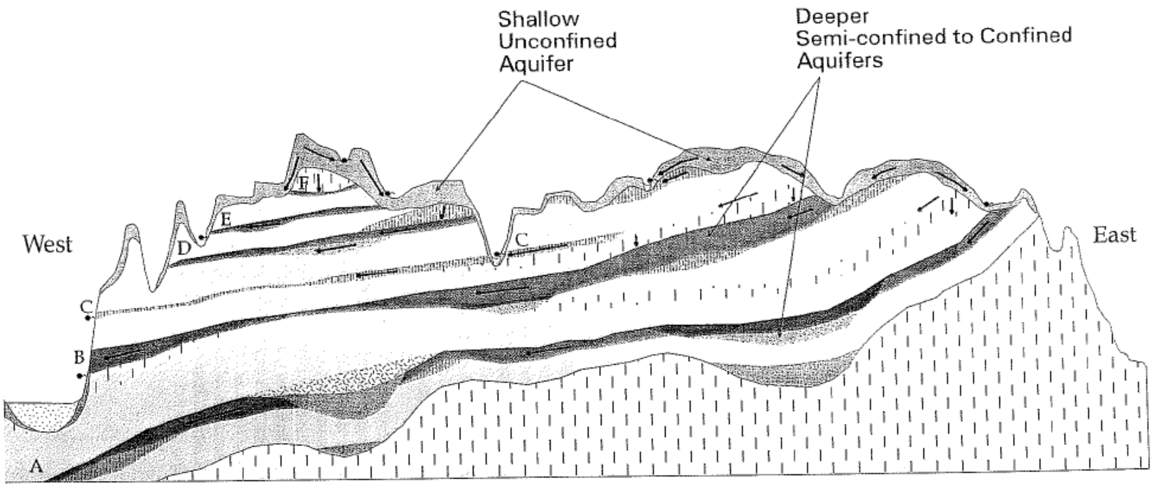

Figure 16: Conceptual diagram of aquifers in the Alstonville Plateau.
Source: Brodie and Green (2002)

The shallow aquifer is most commonly accessed by small water users, including those using water for BLR, and is typically 5 – 20 m thick (Brodie, 2007). Monitoring has shown that the shallow aquifer is very responsive to rainfall, is highly connected to local creeks and streams and has typical flow paths of less than 5 km. The shallow groundwater discharges into springs where the topography intersects the aquifer and groundwater flow directions are governed largely by the surface topography. The creeks and rivers are generally gaining systems in the Alstonville region (Green, 2006). During periods of drought or low rainfall, water levels in the shallow aquifer can be subject to significant drawdown as the recharge potential is small and more groundwater is extracted to compensate for low surface water flows. However, the groundwater table will typically recover rapidly with the onset of a large rainfall event (>100 mm/week), as shown in Figure 17.

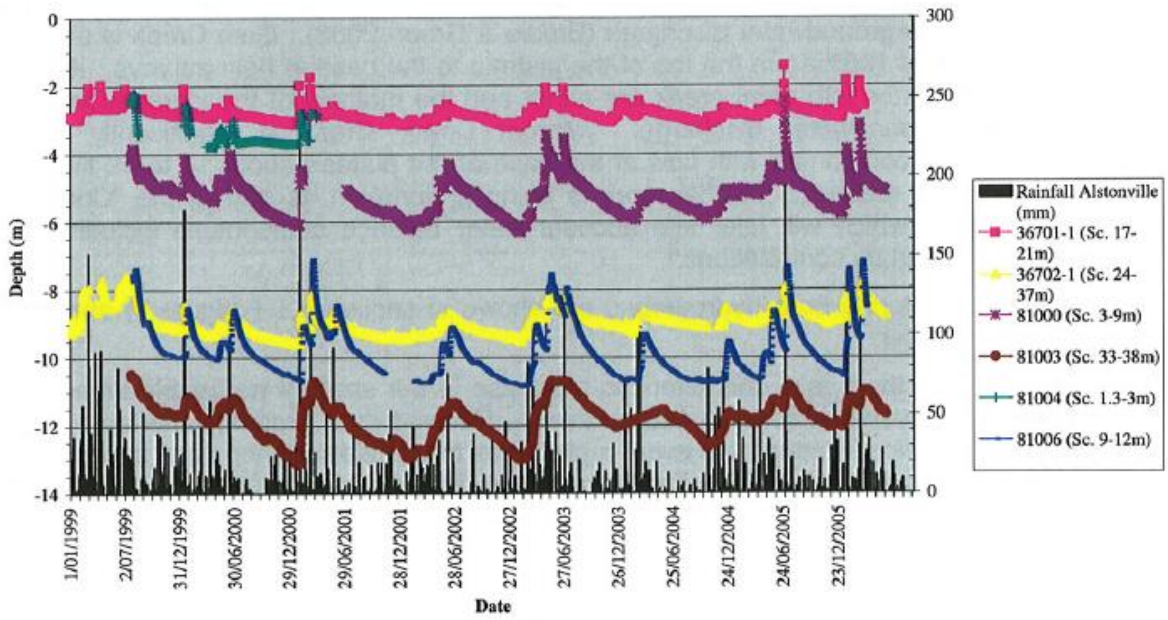

Figure 17: Shallow aquifer (<50 m depth) monitoring 1999 – 2006
Source: Green (2006)

The deeper groundwater system consists of a series of semi confined aquifers with limited surface interaction. The net direction of groundwater flows in the deep aquifers is controlled by the slope of the confining layers, which is typically 0 - 2° from the east to the north-west, as shown in Figure 16. Due to the general dip of the basalt layers, the deep aquifers tend to become semi-confined/unconfined towards the south-east of the plateau, so this area provides the majority of the recharge to the deeper aquifers (Brodie & Green, 2002). The connection of the semi-confined aquifers to surface water depends on the depth. For the intermediate depth aquifers, some of the larger tributary creeks (such as Marom Creek) may have incised the valley sufficiently to have some connection to the deeper groundwater (analogous to location C in Figure 16). The deepest aquifers, such as aquifer A in Figure 16, can be deep enough that the groundwater flow path can be tens of kilometres (Brodie & Green, 2002). The deep aquifers discharge towards the Wilsons River to the west of the Plateau.

As groundwater use in the Alstonville region is largely un-metered, conclusions about the impact of pumping and climate are difficult to differentiate in the deeper aquifers. However, Green (2006) states that the deep aquifers show limited response to rainfall events. While the aquifers do experience periods of drawdown and recovery, the recovery period can be substantially longer than that observed in the shallow aquifers, most likely due to the limited and slow recharge processes associated with these semi-confined systems. Monitoring wells in the deep aquifers (>50 m depth, shown in Figure 18) show that the changes and patterns in water level fluctuations can differ significantly throughout the spatial domain of the plateau. Some wells have appeared to be relatively stable in Figure 18, while others (particularly Station 36702-4) show 20 m differences in levels throughout the 7 year period.

As part of this Review, available monitoring data may be obtained and analysed to understand further changes in the aquifer since 2006. It is understood that the groundwater monitoring in the Alstonville Plateau now includes a network of 31 wells (plus one in the North Coast Volcanics) at 12 locations (often at several depths at a given location, also known as a multilevel well) (DECCW Water, 2011), but this data has yet to have been accessed.

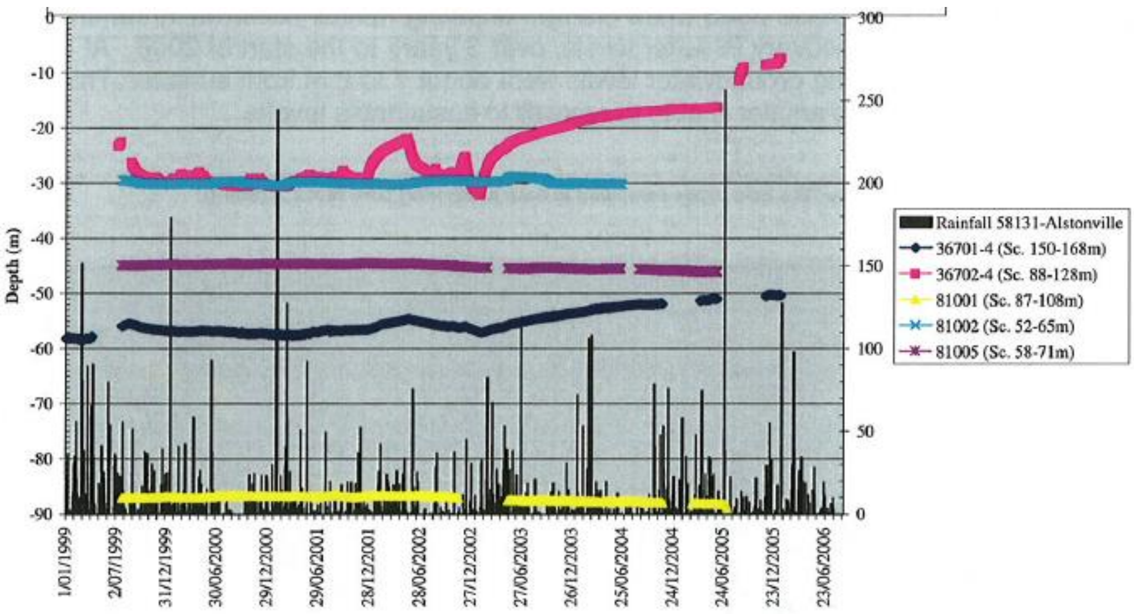

Figure 18: Deep aquifer (>50 m depth) monitoring 1999 – 2006
Source: Green, 2006

Connectivity between the shallow and deep aquifers is typically reported as being poor (Brodie & Green, 2002), due to the presence of poorly fractured basalt layers. This is supported by the differing responses to direct rainfall in the shallow and deep aquifers (Figure 18). However, Brodie and Green (2002) have also noted that some intermediate depth (screened at 33 – 38 m) wells do appear to be connected to the shallow aquifer and do show an observable response to rainfall patterns. This may indicate vertical fractures in the overlaying basalt layers, connecting the two aquifers, or be a result of a shallowing of the intermediate depth aquifer in the vicinity of monitoring where a more direct connection might exist (Brodie & Green, 2002).

4.2 GROUNDWATER LEVELS AND RIVER BASEFLOWS

The effects of groundwater extractions on groundwater levels and river flows are often difficult to separate from the effects of climate. Therefore, prior to considering the potential impacts of extractions, it is useful to understand how groundwater levels and river flows respond to climate and the presence of climate-related droughts. Of principal interest is the baseflow, which represents the catchment-scale groundwater contribution to river flows.[12]

There are several flow gauging sites in the relevant areas of the Northern Rivers. Figure 19 on the following page shows the three example gauges analysed here, as well as two deep groundwater monitoring bores with the longest historical records. Table 14 and Table 15 provide details of these sites. Further sites should be analysed to provide a more comprehensive picture over the region.

[12] Baseflow is the component of river flow that is considered to come from groundwater. When considering problems of groundwater extraction impacts, it is considered more useful than total river flows. It is derived from measured total daily flows using a standard baseflow filter of Eckhardt (2005) using a baseflow index of 0.25 (Eckhardt, 2005).

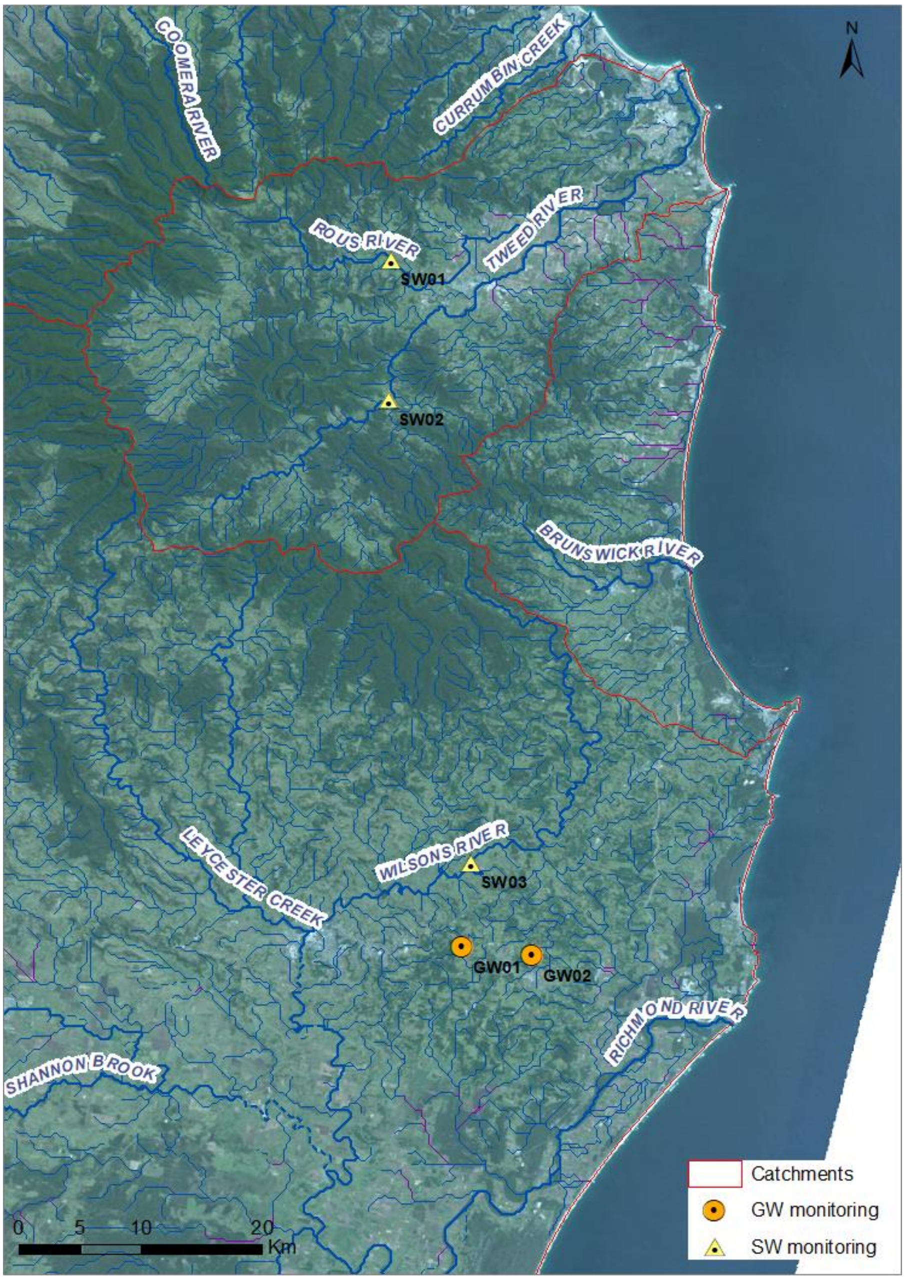

Figure 19: The river network in the Northern Rivers region, with locations of the example surface water and groundwater gauging stations

Note: GW01 and GW02 are the same as sites 36701 and 81005 in Figure 19

Table 14: Selected stream flow gauging stations

Legend	Station Nr.	Name	Latitude	Longitude	Drainage Area (km^2)
SW01	201005	Rous River at boat harbour No. 3	-28.3096	153.336	111
SW02	201900	Tweed River at Uki	-28.4132	153.3343	275
SW03	203014	Wilsons river at Altham	-28.7561	153.3955	223

Table 15: Groundwater monitoring bores

Legend	Site Nr.	Name	Latitude	Longitude	Start date	End date
GW01	GW036701.2.2	Wollongbar Research Center	-28.8181	153.3887	16/01/1990	14/12/2018
GW02	GW081005.1.1	Alstonville North - Maguires creek (deep)	-28.8244	153.4405	20/07/1999	14/12/2018

Figure 20 shows the baseflow responses to rainfall at the three flow gauges. This illustrates that baseflows have a seasonal pattern, typically peaking between January and April, with the magnitude of the peak reflecting the previous year's rainfall. Consistent with knowledge of the groundwater system, the baseflow is seen to be sensitive to years with low rainfall, and in some low-rainfall years such as 1998 and 2007, the baseflow peak is minimal or absent.

The minimum baseflow is also sensitive to rainfall, with several years historically in the Tweed catchment presenting near-zero baseflows. The three example rivers are quite large rivers with catchment areas 111 km^2 (Rous River), 275 km^2 (Tweed at Uki) and 223 km^2 (Wilsons River at Eltham). Smaller creeks may see greater variability in baseflows due to low rainfall potentially including zero baseflow periods.

Figure 20 shows no apparent long-term trends in rainfall or baseflows, although this should be verified by statistical analysis and analysis of evidence from longer-term drought studies**.** The figure also shows that, following high baseflows in 2017, baseflows in 2018 have been very low with no sign of recovery yet in 2019. However, neither the 2018 baseflows nor rainfall appear to be extreme in the historic context (this should also be confirmed by statistical analysis).

Figure 20 also shows water levels measured in two deep groundwater monitoring bores situated on the Alstonville Plateau. Bore GW02 show responses to rainfall over time scales of years with a clear fall during the millennium drought followed by recovery. Bore GW01 does not show any clear relationship with rainfall and its variations, including an almost continual increase in level since 2003, so may be more affected by changes in extractions.

This initial analysis of baseflows and groundwater levels provides basic information about the responses of groundwater to drought and the type and level of evidence of human influences. Further analysis including additional sites and reference to longer-term climate and drought studies is needed to reach conclusions.

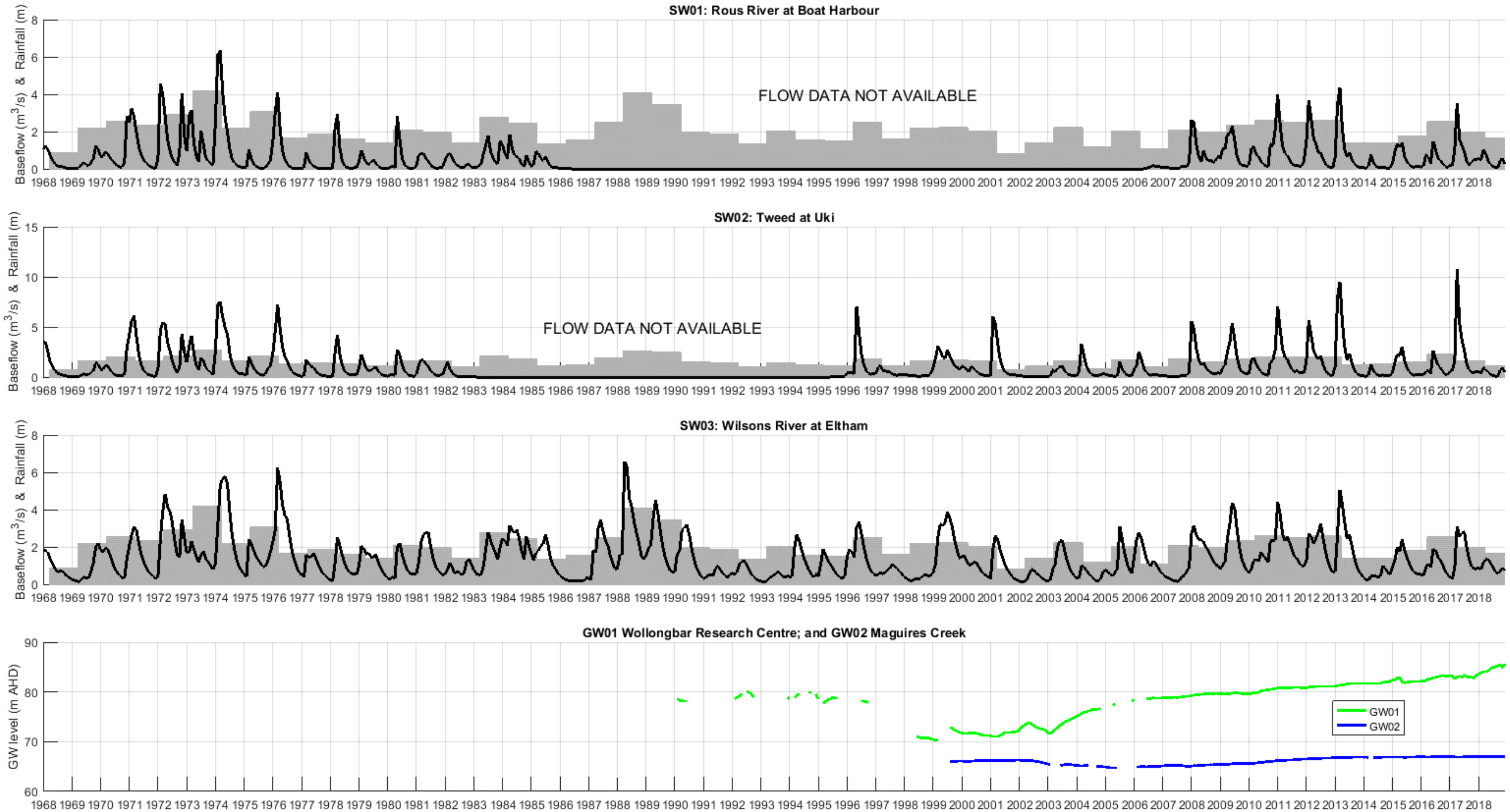

Figure 20: Baseflow and groundwater levels at selected gauges

Locations of gauges are in Figure A.1. GW01 and GW02 are same as sites 36701 and 81005 in Figure 19.
Annual rainfall measured from April to March is in grey bars, baseflow is in black lines

4.3 UNDERSTANDING AND MANAGING IMPACTS

During consultations, the Review frequently heard from stakeholders with concerns about the quality and quantity of information available for water extraction in the Northern Rivers region and whether there is enough to make decisions. In part, this issue was connected to the lack of current requirements for standardised monitoring of water extraction.

People working in business, government and the general community all face the challenge of making decisions from a position of imperfect information. A range of mathematical, statistical, scientific and engineering tools is available to assist in establishing a framework for information and decision-making, including in environmental decision-making. Developments in computation, software, sensor technology, monitoring platforms and web-portals have improved the overall quantity, quality, range and resolution of data and functionality of models to understand systems, predict outcomes and manage risks. These approaches and tools, including underlying assumptions, are subject to ongoing review as new knowledge emerges from observations, experience and research.

The quality and quantity of information available to address a science question will vary considerably, and one would always want more data, so how do decision makers make decisions when they are managing situations that involve risk with imperfect information?

The following section provides an overview of modelling and monitoring used to understand and manage groundwater and surface water resources, including work undertaken in relation to the Northern Rivers region. Further information about capturing and managing uncertainty is contained in Appendix 6.

4.3.1 Modelling

Conceptual models, in the context of groundwater and surface water systems, are the qualitative expressions (sketches, flow charts or text descriptions) representing an understanding of how water moves through the system. In cases, more detailed conceptual models will be developed for components of the system. Where uncertainty exists, it is common for alternative conceptual models to be developed, and for models to be updated as knowledge improves.

A numerical model is an equation (or set of equations) that approximates the relationship between inputs and outputs of a system. Relevant outputs might be groundwater level and flow, and relevant inputs might be rainfall and groundwater extractions. Numerical models are widely used to inform planning and operational decisions around water resources. In principle, this could include informing estimates of sustainable extractions such as those in the WSP as well as informing project approval applications and decisions.

The type of numerical model that is suitable for a particular task varies enormously depending on the task and the available data and budget to support the model. Three types of model with different levels of complexity are:

- **Statistical models**: these models can be used to fit lines and curves to observed data. For example, a statistical model might be used to detect a trend in groundwater levels and determine a correlation with extraction volumes. The model accuracy is limited by the accuracy, quantity and relevance of observed data used to fit the model, and its accuracy is unknown outside the range of the observed data. Hence, statistical models are not generally considered safe for predicting future changes or impacts.
- **Simulation models**: these models are based on prior knowledge of the elemental laws of physics (e.g. mass and momentum balance principles) applied to a conceptual model of the physical system (e.g. a conceptual model of groundwater flow). Simulation models of groundwater systems require computationally intensive numerical solutions, in some cases requiring super-computers to run the models and

months or years of model development work. They permit groundwater flow and pressure in groups of aquifers to be quantified, and they provide ability to predict impacts over varying space and time scales and input (e.g. recharge and extraction) scenarios. However, a well-developed hydrogeological database is a prerequisite for estimating model parameters such as aquifer transmissivity. Simulation models of surface water systems are also commonly used. They can be used to simulate natural river flows and, by comparing these with observed flows, the modeller can attempt to detect human influences on river flows such as groundwater extractions. In principle, such models can also incorporate an additional statistical component to reflect uncertainty in model parameters.

- **Analytical models**: these models are used where the laws of physics, after some simplification, can be expressed as an easy-to-solve equation. For example, an analytical model is often applied to determine local aquifer properties from pumping tests or to estimate local groundwater drawdowns due to extraction. Beyond the locality of the extraction (10s to 100s of metres), the increasing complexity of the aquifer system tends to reduce the applicability of analytical models. . As above, such models can also incorporate a statistical component to reflect uncertainty in model parameters

In summary, a range of model types may be applicable to quantifying the surface water and groundwater impacts of groundwater extraction. The ‘gold-standard’ models for making predictions are complex, expensive simulation models, which are only applicable for decision-support tasks where well-developed hydrogeological monitoring programs exist.

The potential cost of undertaking a modelling exercise means that the decision on whether to use a numerical model and on the approach to modelling should be related to planning risks. Only high-risk planning decisions warrant investment in the ‘gold-standard’ models and the associated necessary monitoring.

Irrespective of which type of model is used, the outputs of the model will contain significant uncertainty. The sources of uncertainty include:

- The assumptions and simplifications used in developing the model, for example neglecting the variability of hydrogeological properties within one aquifer.
- Uncertainty in the model’s inputs, initial conditions and boundary conditions, for example in the groundwater recharge estimate.
- Uncertainty and gaps in the data used to calibrate the model parameters, for example due to the limited number of monitoring bores, and the limitations in the reliability and accuracy of the pressure gauges installed in the bores.

Due to the inevitable uncertainty in model outputs, it is essential that uncertainty is assessed and reported according to established good practice modelling guidelines, and that this is considered if the model is used to support decision-making. In some cases, more than one type of model is used for comparison of outcomes. Furthermore, outputs of models should not be used as the sole piece of knowledge to support a decision. Expert opinion, anecdotal evidence and planners’ experience should also be considered. Finding effective ways to communicate the uncertainty is a challenging but critical aspect of modelling.

Usually, the adequacy of data to support conceptual and numerical groundwater modelling is questionable. An important role of modelling is to expose what new data are necessary to permit a more accurate prediction. This process begins early to determine what new data would be necessary to support models of different types. Thereafter, data needs should be assessed continually through the operational life of the model.

This Review will consider whether a research and monitoring strategy should be developed towards developing conceptual and numerical models of the regional groundwater systems to support assessment of sustainable extractions and/or project approvals applications. The next sections provide an overview of existing numerical models in the relevant region.

4.3.2 Regional Groundwater Modelling

Cui et al. (2016) developed a groundwater model (covering the domain shown in Figure 13) based on the conceptual understanding of the hydrogeology shown in Figure 14. The model was built using the modelling software MODFLOW and includes six hydrostratigraphic layers. The model was built to understand the impacts of CSG on the groundwater throughout the region, measured by changes in drawdown throughout the model domain. As the Walloon Coal Measure, the primary target of CSG in this region, is not a highly utilised aquifer for groundwater extraction, this model would have to be reviewed before it could be considered for use in any further water management decisions in the region. Nonetheless, modelling parameters and results provide a good platform to assist in the understanding of the hydrogeology of the system.

Model parameters, in particularly hydraulic conductivity and aquifer storage, were estimated as part of the initial stages of the report. Initial estimates of hydraulic conductivity were derived from pump tests that had been conducted previously and are summarised in Table 16. Initial estimates of storage parameters were taken from previous modelling for the Surat Basin (with similar geology) and is summarised in Table 17. Both the hydraulic conductivity and storage parameters were varied during sensitivity testing and uncertainty analysis, however the initial estimates provide a succinct summary of the expected values for different hydrogeological units. More information can be found in (Cui et al., 2016).

Table 16: Horizontal hydraulic conductivity from pump tests

Hydrogeological unit	Number of bores	Minimum (m/d)	Median (m/d)	Maximum (m/d)
Alluvium	73	0.04	1.20	233.59
Volcanics	45	0.05	0.82	9.40
Grafton Formation	5	0.21	0.66	3.97
Walloon Coal Measures	7	0.49	3.82	17.22

Source: (Cui et al., 2016)

Table 17: Initial estimates of storage parameters

Layer	Hydrostratigraphic unit	Generalised hydraulic characteristics	*Sy* and *Ss* range
1	Alluvium / volcanics / unconfined part of other units	Aquifer	*Sy*: 0.1 to 0.3 *Ss*: 1 x 10–5 to 1 x 10–3 m–1
2	Grafton Formation	Aquifer/aquitard	1 x 10–6 to 1 x 10-4 m–1
3	Bungawalbin Member	Aquitard	1 x 10–7 to 1 x 10-5 m–1
4	Kangaroo Creek Sandstone Member	Aquifer	1 x 10–6 to 1 x 10-4 m–1
5	Walloon Coal Measures (Maclean Sandstone)	Aquitard	1 x 10–8 to 1 x 10–5 m–1
6	Walloon Coal Measures (coal seams)	Aquifer/aquitard (variable)	1 x 10–7 to 1 x 10-4 m–1

Source: (Cui et al., 2016)

Cui et al. (2016) notes that the monitoring and understanding of the alluvial aquifers in this region is fairly extensive. However, there is little monitoring (such as nested wells to monitoring inter-aquifer connection) to define the hydraulic connectivity of the different aquifers and monitoring of the deeper, confined aquifers is more limited. No monitoring observations have been analysed in the early stages of this review, however any additional monitoring that has occurred since the release of this modelling paper may result in an improved understanding of the aquifers and provide a better understanding of potential impacts of groundwater extractions.

4.3.3 Alstonville Model

A conceptual and numerical model of the Alstonville Groundwater Source was developed by Bilge (2003). The models simplified the hydrogeology of Alstonville to a two layer system (Figure 21).

The top later is unconfined and has significant connection with local scale creeks and springs. The bottom layer is semi- confined, being unconfined on the north-west and south-west boundaries where it can drain towards the Wilsons River. Some leakage through the confining layer was included between the upper and lower layers. Extractions can occur from both the shallow and deep aquifers. Recharge was assumed to be a direct proportion of rainfall (8 percent), although it was acknowledge that a large proportion of recharge is subsequently lost as discharge to surface water systems. At the time of the model, there were only two monitoring wells, both in the deep aquifer, available for calibration of the MODFLOW numerical model, so the model developed as part of this project was only considered appropriate for educational purposes. However, the final model parameters for the lower aquifer were:

- Hydraulic conductivity (K) – 0.02 – 0.04 m/day (0.1 m/day for the lower layer, uncalibrated)
- Specific storativity (S_s) – $2x10^{-6}$ – $6x10^{-6}$
- Specific yield (S_y) – 0.09 (0.11 for the upper layer)

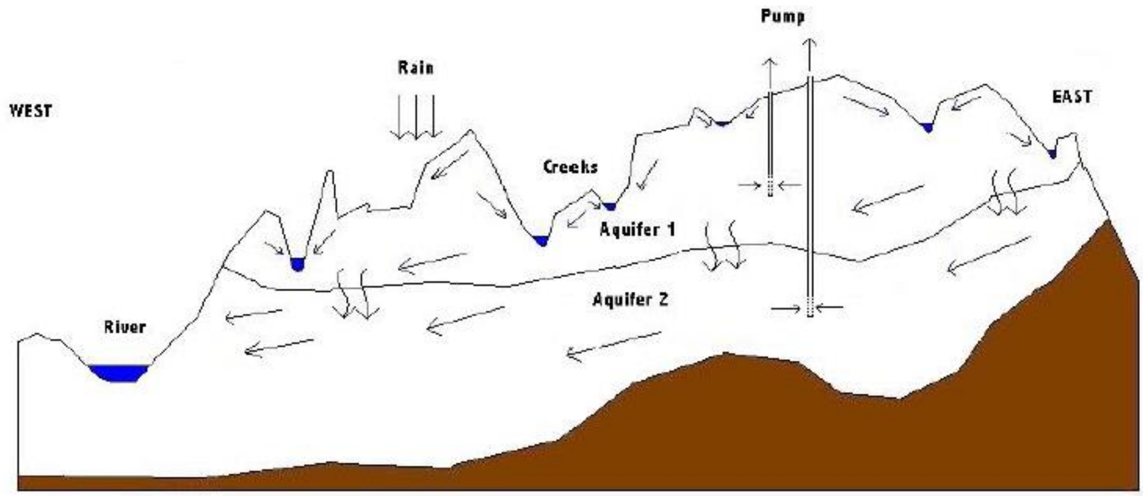

Figure 21: Simplified conceptual model of the Alstonville Plateau

Bilge (2003) states that the model results are highly sensitive to the aquifer parameters. As there was limited information on the extraction rates for the aquifer, the total groundwater use per year was used as a calibration parameter for the model. While Bilge (2003) reiterates the need for more water level monitoring data, metered extraction rates and physical properties of the aquifer to better calibrate and verify the model, the early results indicate that the total outflow (extraction plus outflows) from the deep aquifer exceeded the inflows between 1993 – 2001, meaning extractions were taken from aquifer storage during this period. This is consistent with groundwater level drops observed at two deep-water monitoring bores in the same years. Some publications (Brodie & Green, 2002; Ballina Shire Council, 2004) at the time identified the Alstonville Plateau source was showing signs of water decline and stress. Since this time additional groundwater monitoring bores have been added; 31 are now available across 12 sites (DOI Water, 2019b) (Figure 22). In 2016 new WSP NCFPR took effect and factored in understanding of the system at the time including from the monitoring bores.

DECCW Water (2011) references a MODFLOW groundwater model was being developed in 2009. As of yet, the Review has not seen additional results and developments to this new model. If possible, the improved understanding of the area as a result of the updated model will be included in the later stages of this Review.

4.3.4 Monitoring

Monitoring surface or groundwater is an essential part of understanding potential and actual impacts of human activities on water resources. Fresh water in the natural environment tends to be highly variable over space and time. Separating climate-driven changes in water resources from local or regional human influences relies on sufficient amount, accuracy and relevance of monitoring. As well as monitoring the natural system, monitoring the associated human activity such as groundwater extractions is important for determining the effect of that activity. Recent changes to the requirements for monitoring water extractions from groundwater and surface water bodies have been introduced in NSW. New metering rules are taking affect across NSW, with the introduction of the new rules in the coastal areas of NSW scheduled to come into force in December 2023.

Monitoring a hydrogeological system may include:

- groundwater pressures in multiple (unconfined and confined) aquifer layers
- climate, surface water and soil moisture relevant to groundwater recharge and discharge.
- groundwater and surface water chemistry, to trace sources and fates of water
- groundwater extractions and related variables such as land cover and land use
- groundwater dependent vegetation as an indicator of groundwater presence and to estimate evapotranspiration losses from groundwater
- geological variables such as stratigraphy that defines aquifers and aquitards, and presence and properties of fissures and faults.

Monitoring technology ranges from manual observations of water levels, which in some cases is a member of the community observing the presence or absence of water, to in-situ transducers of numerous types, often with communication systems that continually send data to a data logger or an on-line portal. This includes technology for continuously monitoring water levels, river flows, extraction rates, rainfall and other climate variables, and water quality parameters. Remote sensing from planes or satellites is increasingly used for developing spatial data sets on rainfall, soil moisture, GDE and surface water presence. Geophysical monitoring methods, based on detecting electromagnetic, gravimetric and acoustic signals from the ground, are used to support groundwater studies including detecting presence of faults and changes in underground water volumes.

Due to the rapid development of monitoring and communications technology, increasing volumes of data are available to support modelling and impacts analysis. However, critical data for hydrogeological studies include the relatively expensive installation of monitoring bores, to depths that can be up to 100m, or deeper for certain applications, and regular (at least once per month) measurements of water pressures. This investment in groundwater monitoring is rare in areas where, traditionally, groundwater resources are not perceived to be stressed, such as in Tweed Shire. Since observations in the early 2000s of a stressed Alstonville Basalt Plateau Groundwater Source, additional groundwater monitoring bores have been added; 31 are now available across 12 sites (DOI Water, 2019b) (Figure 22). Most sites used for bottled water extraction also have one or more disused extraction bores that have been converted into monitoring bores. These provide valuable data; however not necessarily over long periods and only representing localised areas. These data are of interest to the Review may be of relevance to further work on impacts.

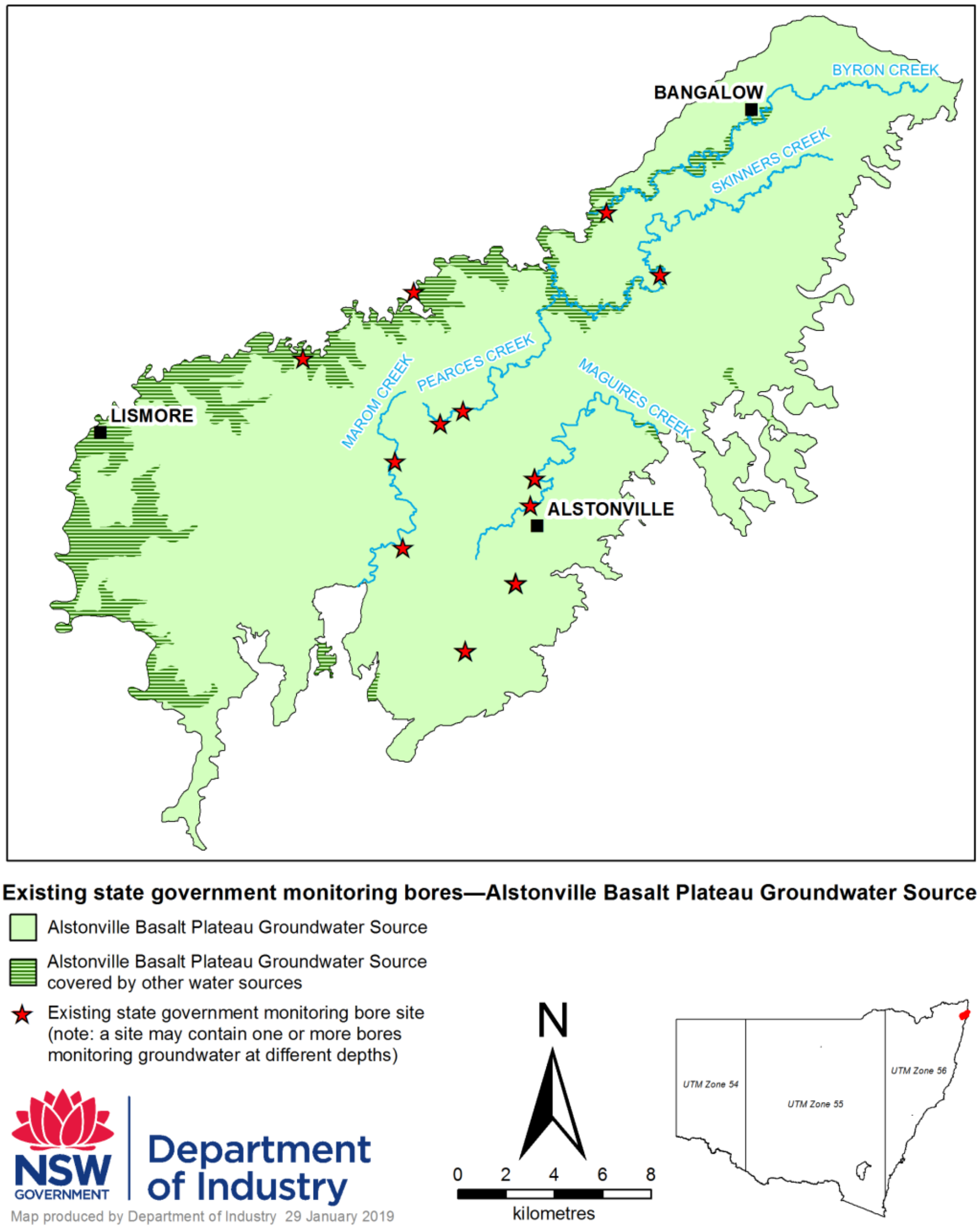

Figure 22: NSW Government monitoring bores - Alstonville Basalt Plateau Groundwater source

The limited existence of groundwater and hydrogeological monitoring in some locations, particularly but not only groundwater pressures in relevant aquifers, may be an obstacle to understanding the potential impacts of an expanded bottled water industry. The potential benefits of increased investment in monitoring, including defining the purpose of the monitoring and what that monitoring should consist of, needs further consideration from a risk perspective.

4.3.5 Accessible data

The role that monitoring and data access can play in supporting decision making has been described in a number of previous reports undertaken by the NSW Chief Scientist & Engineer, particularly in relation to environmental questions. These include in air quality, as well as water monitoring (OCSE, 2014). An important outcome of previous work was the establishment of the Sharing and Enabling Environmental Data (SEED) portal, which is available at www.seed.nsw.gov.au. This platform is a single portal for NSW researchers, policy makers, regulators and the public to access NSW environmental data, and currently includes over 1000 data sets, including on groundwater and topics relevant to this Review.

4.4 NEXT STEPS

The Review will undertake a series of consultations with stakeholders to obtain further information on dataset availability, groundwater modelling, processes and methodologies used in determining extraction limits and managing the system. In investigating monitoring, The Review will consider whether monitoring strategies could feasibly and cost effectively be developed to provide inputs to conceptual and numerical models of the groundwater systems, to inform decision making.

Feedback from the local community highlighted concern about localised impacts, so a particular strand of work for the next phase of the Review will be to look at localised characteristics.

The Review has been requested to consider the current, proposed and potential scale of the industry, so the Review will look at a set of industry growth scenarios, informed by industry input, against which impacts can be measured. These future scenarios would include consideration of future climate and population forecasts for the region.

Further site visits are also anticipated in the coming months.

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APPENDIX 1: TERMS OF REFERENCE

The Chief Scientist & Engineer is requested to conduct an independent review and provide expert advice on the impacts on groundwater quantity arising from extraction by the bottled water industry in the Northern Rivers of NSW.

1. In undertaking the review, the Chief Scientist & Engineer will:
    a. review existing data and information on the bottled water industry's entitlements and extractions in the context of:
        i. total water access rights (basic landholder rights and access licences); and
        ii. extraction limits established in statutory water sharing plans.
    b. provide advice on the sustainability of the extraction limits in the relevant water sharing plans for groundwater sources in the Northern Rivers of NSW.
    c. provide advice on whether the current or proposed groundwater monitoring bores on the Northern Rivers are sufficient.
2. Provide advice on potential impacts:
    a. on groundwater resources, having regard to the sustainable take of the resource and the scale of the current bottled water industry and proposed or potential expansion of the industry
    b. of the groundwater take of the bottled water industry on surface water
3. As needed, the Chief Scientist & Engineer may:
    a. seek advice from relevant Government agencies and other organisations
    b. draw on additional sources of advice and expertise
    c. commission or recommend studies.
4. The Chief Scientist & Engineer will:
    a. Consult with key local stakeholders
    b. provide an initial report by 1 February 2019
    c. provide a final report by mid-2019

APPENDIX 2: SITE VISITS, CONSULTATIONS AND SUBMISSIONS

Table 18: Consultations

Date	Location	Present
9 December 2018	Murwillumbah	Northern River Guardians • Daniele Voinot • Marian van Gestel • Gwyn Hooper • Scott Sledge Water Dragons • Greg O'Donnell • Michele Bevis Tweed Water Alliance • Julie Beesley
9 December 2018	Murwillumbah	Dungay Action Group • Betty Wood • Lucy Campeanu • Joy Baker • Jack Griffis • Dale Holt
9 December 2018	Murwillumbah	Tweed Water Alliance • Pat Miller • Pamela Veness • Denise White • Trevor White • Pamela Smith
9 December 2018	Murwillumbah	Bilambil Urliup Action Group • Anna Champ • Jasmin Derrington • Peter McIlveen • Barbara Downes • Louis Lambert
9 December 2018	Murwillumbah	Bunjalung community members • John Hunt • Thomas Paulson • Murray
10 December 2018	Murwillumbah	Tweed Shire Council • Michael Banks • Robyn Eisermann • Iain Lonsdale • Denise Galle • Danny Rose • Ray Clark • Tracey Stinson Lismore City Council • Leonie Walsh Richmond Valley Council • Mike Perkins
10 December 2018	Murwillumbah	Tweed Shire Council • Warren Polglase • James Owen • Katie Milne • Reece Byrnes • Pryce Allsop • Troy Green Hon Justine Elliot MP's Office • Jurgen Schanzenbacher
10 December 2018	Murwillumbah	Rous County Council • Phillip Rudd

		• Michael McKenzie
10 December 2018	Uki	• Graham Dietrich
20 January 2019	Murwillumbah	Combined Tweed Rural Industries Association • Colin Brooks
20 January 2019	Murwillumbah	Richmond Wilson Combined Water Users Association • Chris Magner • Catherine Richardson-Magner
20 January 2019	Ballina	• Ceridwen Quick • Clive Quick
21 January 2019	Rous Mill	• Bryan Douglas
21 January 2019	Alstonville	Nu-Pure Beverages • Brendan Moroney • Bruce Taylor Black Mount Spring Water • Tim Carey
21 January 2019	Alstonville	Save Alstonville Aquifer • Michael Hogan • Troy Outerbridge • David Huett
21 January 2019	Alstonville	Ballina Shire Council • Sharon Parry • Eoin Johnson • Ben Smith • Phillip Meehan • Sharon Cadwallader • Matthew Wood • David Wright • Andrew Smith • Simon Scott • Georgia Lee • Keith Williams (Chair of Rous County Council) Byron Shire Council • Jason Stanley • Andrew Cameron • Michael Bingham • Bryan Green

Table 19: Site visits

Date	Location	Facility
9 December 2018	Urliup	Karlos Family Trust • Larry Karlos
10 December 2018	Uki	Mount Warning Spring Water • Shaun Martin • Tessa Martin
20 January 2019	Kynnumboon	Pristine Water Supply Pty Ltd • Steve Bell
20 January 2019	Nobbys Creek	Rosehill Estate 1890 Pty Ltd • Gary Appleby • Trevor Johnson
21 January 2019	Lynwood	Prime Flowers Pty Ltd • Geoffrey Bottomley • Ian Cooke
21 January 2019	Alstonville	Rous County Council Groundwater Bore • Michael McKenzie

Table 20: Submissions

Sl No.	Organisation
SUB 001	Ballina Shire Council
SUB 002	Submission - Individual
SUB 003	Michael Hogan, Save Alstonville Aquifer
SUB 004	David Huett, Save Alstonville Aquifer

APPENDIX 3: INTRODUCTION TO GROUNDWATER SYSTEMS

Groundwater is the water below the earth's surface. Groundwater is an important supply of fresh water worldwide and in Australia groundwater accounts for 30 percent of total water usage (MDBA, 2019). This section provides a brief overview of a groundwater system and an explanation of some of the common terminology used in hydrogeology.

Geologic formations that are capable of holding groundwater are called 'aquifers' (Anderson, Rahman, Davey, Miller, & Glamore, 2013). Groundwater can be extracted from aquifers using water bores. While there is a common misconception of aquifers as underground lakes or streams(Harrington & Cook, 2014), the water stored and transmitted through an aquifer is through the pores and cracks in the sediments and geology. Aquifers are typically defined by the geology of the surrounding rock and there can be several aquifers at different depths in any given location, making groundwater systems complex.

Aquitards are geologic layers or strata (made of rock or clay) through which water moves extremely slowly (Anderson et al., 2013) and can separate different aquifers vertically. While aquitards can transmit water, this process is sufficiently slow such that these geological units are typically not considered a source of readily extractable groundwater. Aquicludes are similar to aquitards, except that these layers are not capable of transmitting any water.

Depending on the presence of overlying aquitards and aquicludes, aquifers are defined as confined or unconfined. Unconfined aquifers have no overlying aquitard – the groundwater surface is in direct contact with the atmosphere (Anderson et al., 2013). The upper groundwater surface in these systems is referred to as the water table, as illustrated in Figure 23 and the water table can move up and down depending on environmental conditions and extraction levels. These aquifers are often shallow systems in the most recently deposited geological layers. Their shallow nature also makes them a frequently used source for water extraction (MDBA, 2019) and they are commonly highly connected to the surrounding surface water systems.

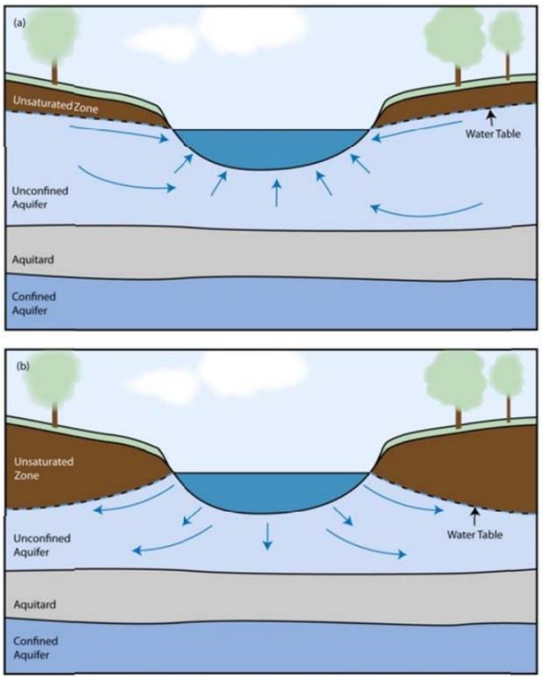

Figure 23: Aquifers (groundwater) and surface water interaction. Top: Gaining stream, Bottom: Losing stream
Source: Anderson et al. (2013)

A truly confined aquifer is separated from the atmosphere by an aquiclude, which prevents water movement from overlaying systems. In reality, many aquifers are overlain by imperfect confining layers (aquitards) that do allow some limited water infiltration from above over very long time periods. These are referred to as semi-confined or leaky aquifers, although they are often idealised as confined aquifers as there is limited transmission of water through the aquitard over short time periods. In these systems, there is no water table – increases or decreases in water are represented by a change in pressure in the system. Unlike in an unconfined system, when water bores are installed, the water level in the bore will rise above the level of the aquifer, as shown in Figure 24. This is a result of the pressure in the aquifer, and this level will change depending on the water extraction and water sources into the system.

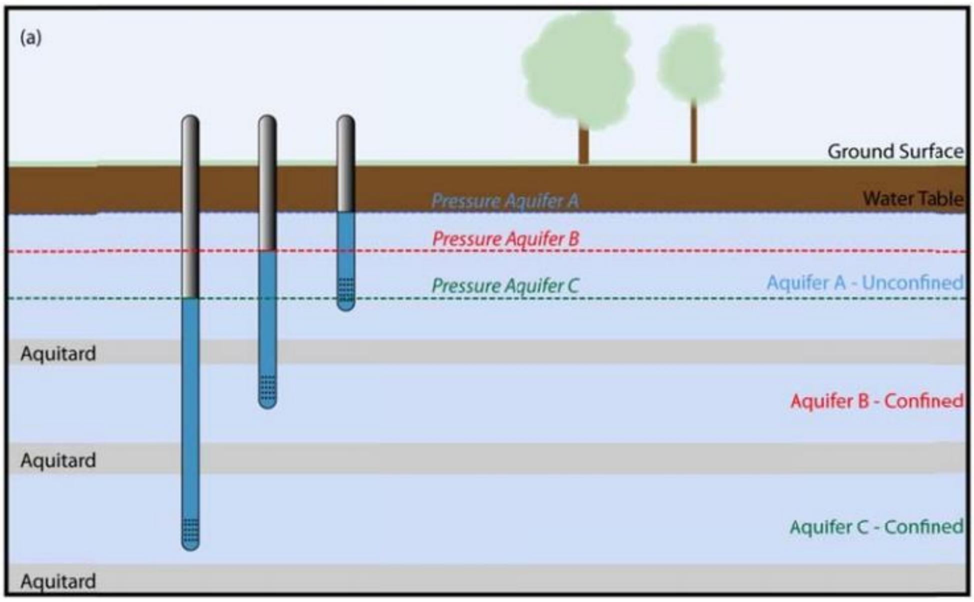

Figure 24: Pressure levels in different aquifer types .
Source: Anderson et al. (2013)

The processes of water entering or leaving the groundwater system are known as recharge or discharge (Geoscience Australia, 2019c). Depending on the type of the aquifer system, recharge and discharge sources can vary. Unconfined aquifers are typically recharged by rain or through a connection with surface water systems. As illustrated in Figure 23, surface streams can be gaining systems – there is groundwater discharge into the surface water, or losing systems – the surface water infiltrates and is a source of recharge into the groundwater system. Discharge can also occur due to losses to groundwater dependent ecosystems or direct water extractions. Groundwater extraction may deprive discharge to surface water systems (e.g. streams, lakes, rivers)

Recharge to truly confined aquifers can only occur through groundwater flow from areas where parts of the aquifer become unconfined, as shown in Figure 25. In semi-confined aquifers, there is also recharge through leakage of the overlying aquitard. This vertical leakage typically occurs over longer time periods than in unconfined aquifers.

In hydrogeology, beneath the earth's surface is divided into three zones:

- **the saturated zone:** which occurs below the water table and in which the soil pores are all filled with water; the fluid pressure in this zone is greater than atmospheric pressure
- **the tension saturated zone:** which occurs immediately above the water table and is a zone where all the pore space is saturated but the pressure is less than atmospheric pressure because water is held in the pores by surface tension

- **the unsaturated zone:** which occurs above the tension saturated zone. The pressure is less than atmospheric pressure and the pore space is only partially saturated.

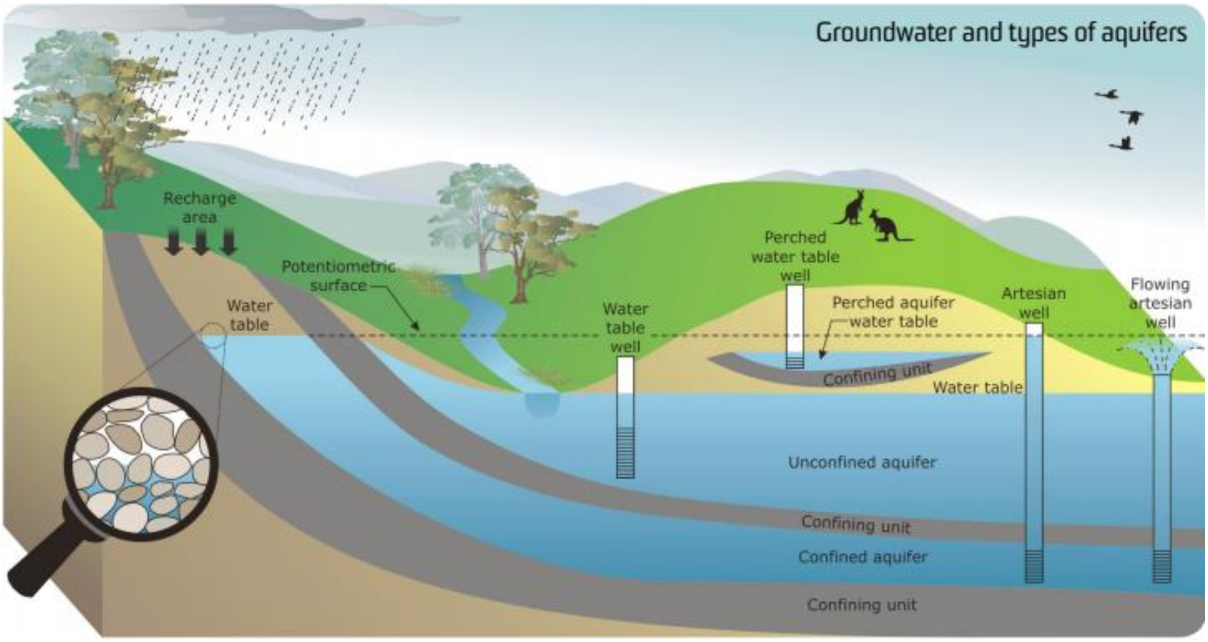

Figure 25: Aquifer recharge.
Source: UNSW, 2017

Based on geology, there are various types of aquifers. These include (DPI Water, 2016b):

- Alluvial aquifers consist of sediments such as gravel, sand, silt or clay deposited on floodplains and river channels. These aquifers account for around 60 percent of Australia's groundwater extraction and are a major source for irrigation, town, stock and domestic use (Geoscience Australia, 2019a)
- Coastal aquifers have unconsolidated sand sediments which contain groundwater in its pore spaces. These provide base flow to creeks and rivers during dry periods and are susceptible to seawater intrusion
- Fractured rock aquifers store and transmit water through fractures and joints of rock formations such as granite or basalt. The yield from these aquifers is dependent on the distribution of the major fractures. These aquifers account for 10 percent of groundwater extraction in Australia (Geoscience Australia, 2019b)
- Porous rock aquifers are found in rock formations such as sandstone or limestone, with groundwater found in pore spaces in the rock matrix (DPI Water, 2016b).

The principal hydrogeology of Australia is shown in Figure 26 below.

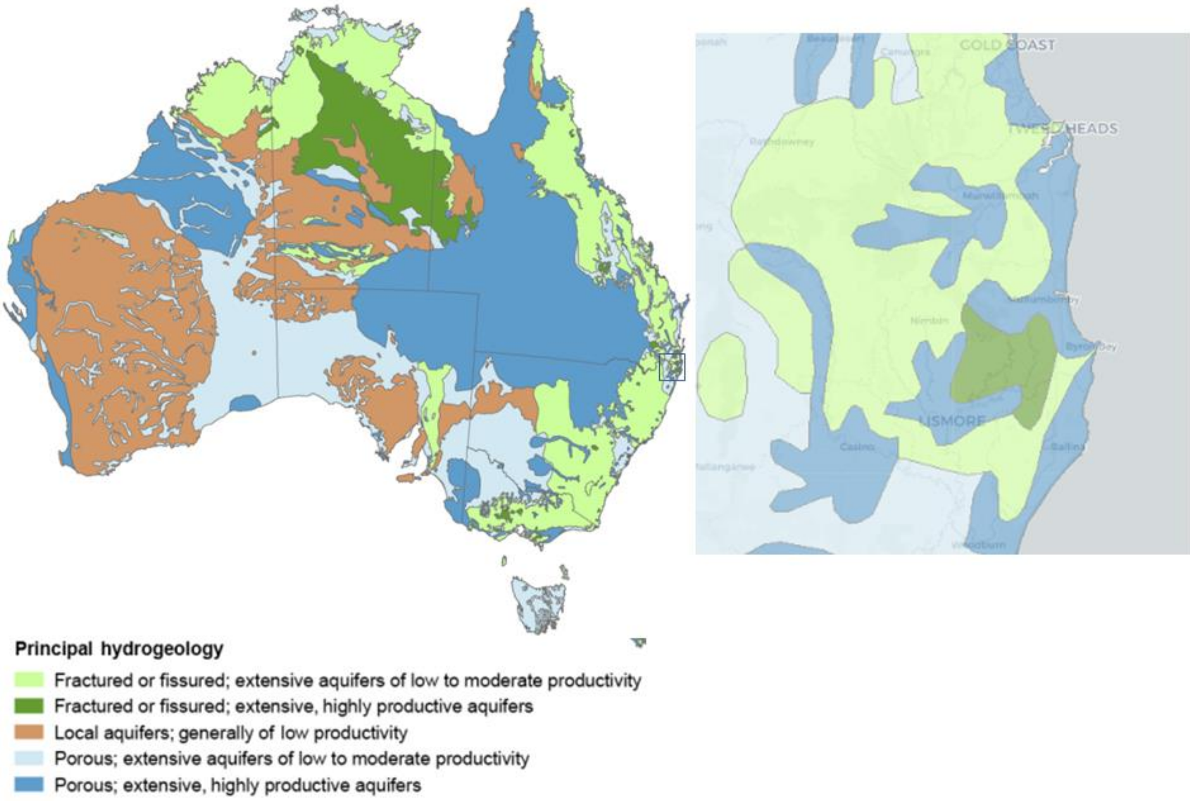

Figure 26: Principal hydrogeology of Australia. Inset: Northern Rivers Region
Source: BOM (2019)

APPENDIX 4: REGULATORY FRAMEWORK AND APPROVALS

The regulatory framework that governs water resources, their allocation and use, and ecological needs have evolved over decades, as understanding about environmental values have developed, technology has improved and communities have changed. Responsibility for water resource allocation and environmental protection sits primarily with Commonwealth and state legislation, while water utilities and distribution sits with local council authorities and state agencies.

A key legislative instrument that governs the allocation of water, including to the bottled water industry in the Northern Rivers region is the *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016 (WSP)* under the *Water Management Act 2000.*

This section provides a description of the various components of the regulatory framework, and Chapter 3 describes the specific groundwater volumetric attributes of the WSP and the associated water bottling industry.

Regulatory framework

The overarching legislation governing water management in NSW is the *Water Management Act 2000*, which regulates the extraction of water in NSW. It provides for water sharing plans (WSPs), basic landholder rights and governs the issue of Water Access Licences (WALs) and approvals for water sources in NSW.

Multiple NSW and federal agencies and bodies have direct legislative and policy roles for the water management framework in NSW (Table 22). The Department of Industry – Water (DOI Water) has responsibility for the development of plans and policies governing water management, including WSPs. WSPs define the rules for sharing the water resources, between the environment and water users in each regulated river valley, unregulated rivers and groundwater sources.

Responsibilities for granting and managing water licensing and approvals are split between WaterNSW and the Natural Resources Access Regulator (NRAR). A Water Access Licence (WAL) is generally required to access a specific amount of available surface water or groundwater to ensure the appropriate management of limited water resources.[13] *The Water Management Act 2000* also defines basic landholder rights that provide for water extraction and use without a licence under certain circumstances.[14]

The regulatory framework governing water management in NSW is described in further detail in the following sections.

Legislative objects and principles

The objects of the *Water Management Act 2000* are to provide for the sustainable, efficient and integrated management of limited water resources. This includes recognising interests in:

- ecologically sustainable development
- the associated water quality, ecosystems, ecological processes, and biological diversity of water sources
- social and economic benefits of sustainable and efficient water use to urban communities, agriculture, fisheries, industry and recreation, culture and heritage, and Aboriginal people

[13] *Water Management Act 2000* Ch 3, Pt 2
[14] *Water Management Act 2000* Ch 3, Pt 1

- community engagement in partnership with Government in resolving issues relating to the management of water sources
- the efficient and equitable sharing of water
- integrated management of water sources with the management of other aspects of the environment; shared responsibly for the sustainable and efficient use of water between the Government and water users
- encouraging best practice in the management and use of water.[15]

The legislative framework establishes a market-based approach to the management and licensing of water to balance environmental, social and economic interests in the use of limited water resources. The legislative framework adopts a 'cap and trade' model to control water use. A 'cap' on the available supply of water is established – after setting aside water for environmental purposes, domestic use, limited harvestable runoff and native title rights. Each water year (1 July to 30 June), holders of WALs with water entitlements are allocated a volume of water, based on the rules specified in the relevant WSP, the extraction limit of the water source, water entitlements and actual water take. Holders of WALs may trade the water in their accounts.

This 'cap and trade' model incentivises the efficient use of limited water resources, as well as the reallocation of those resources to the highest value uses. While this model prioritises certain uses of water (such as the reservation of planned environmental water and water required to meet basic landholder rights) over other uses (entitlements under WAL), the model is generally agnostic to the industrial or commercial purpose of water taken under one WAL as compared to another WAL. For example, the water licensing regime does not prioritise the use of water between commercial irrigation, commercial processing industries, or commercial water bottling. Note that there is some prioritisation between certain categories of WAL – for example, local water utility access licences have priority over access licences for commercial purposes (Table 21).

Table 21: Priorities between different categories of WAL under section 58 of the *Water Management Act 2000*

1	Local water utility access licences, major utility access licences, and domestic and stock access licences
2	Regulated river (high security) access licences
3	Other access licences – [including access licences for commercial purposes such as water bottling]
4	Supplementary water access licences

Responsibilities of the NSW and Commonwealth Governments

WALs are processed and issued by WaterNSW or the Natural Resources Access Regulator (NRAR). The responsible authority depends on the type of entity seeking a WAL and the purpose for which that WAL is sought. Generally, the proponent of a water bottling plant will seek a WAL from WaterNSW. NRAR was established in 2018 as an independent regulator with responsibilities for certain water-related licensing activities and most compliance activities. Table 22 summarises the responsibilities of the major state and federal entities involved in water regulation.

[15] *Water Management Act 2000* s 3

Table 22: Roles of Local, State and Commonwealth Government entities (NSW Government, 2018)

Local Government	
Local Council	• Generally responsible for planning functions in their local area and developing local environmental plans (LEPs). This generally includes initiating and periodically updating local environmental plans, including conducting public exhibition and consultation on those planning proposals. Note that other agencies are involved in the LEP process. • Generally responsible for the development consent process for developments in their local area including for integrated developments: receiving applications for development consent, working with other public authorities considering additional necessary approvals, notifying the public and receiving submissions, and determining those applications
State Government	
Department of Industry – Water (DOI Water)	• Responsible for planning, policy development and regulatory frameworks for regional water in NSW • Responsible for development, assessment and recommendation, including engaging with stakeholders, for regional water strategies, water sharing plans, water resource plans and water management rules • Responsible for ensuring that water services provided by regional NSW's local water utilities are safe, secure and sustainable
Natural Resources Access Regulator	• Responsible for compliance, monitoring and enforcement of NSW water law • Responsible for granting and managing water licences and approvals for government agencies, state owned corporations, water utilities, licensed network operators, mining companies, irrigation corporations, Aboriginal communities, floodplain harvesting, state significant developments (SSD), state significant infrastructure (SSI), schools and hospitals
WaterNSW	• Responsible for granting and managing water licences and approvals for rural landholders, rural industries, developments which are not SSDs or SSIs • Responsible for providing water transaction and information services for water licensing and approvals, water trades, billing and monitoring • Responsible for protection of the Greater Sydney drinking water catchment, supply from the catchment, management of water supply infrastructure
Office of Environment and Heritage	• Responsible for managing environmental water in NSW, including environmental water licences held by the NSW Government and planned environmental water allocations made under water sharing plans • Responsible for developing long-term environmental watering plans
Natural Resources Commission	• Responsible for providing independent advice to the Minister for Regional Water on water sharing plans which are subject to a decision by the Minister as to whether the replace or extend them (typically after a period of 10 years) • Responsible for providing advice to the Minister on: (a) the extent to which the water sharing provisions have materially contributed to the achievement of, or the failure to achieve, environmental, social and economic outcomes, (b) whether changes to those provisions are warranted[16]
Federal Government	
Commonwealth Environmental Water Holder	• Responsible for managing the Commonwealth's environmental water holdings to protect or restore environmental assets
Department of Agriculture and Water Resources	• Responsible for the management of water resources including the National Water Initiative, the Murray-Darling Basin Plan, urban water policy and reform and water quality improvement • Administers Commonwealth funding programs for water management reforms

Water sharing plans

Under the *Water Management Act 2000*, the Minister for Regional Water, with concurrence from the Minister for the Environment, defines statutory Water Sharing Plans (WSPs) covering particular areas or water sources.[17] At present, WSPs cover almost all of the major surface water and groundwater sources in NSW. WSPs define the sustainable annual allocations of water 'take' from particular surface water (such as rivers, lakes and dams) and

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[16] *Water Management Act 2000* s 43A(3)
[17] *Water Management Act 2000* s 41

groundwater sources for a 10 year period,[18] and set the rules for trading water access licences. WSPs aim to transparently and sustainably share water between users and the environment, but can be suspended by the Minister due to severe water shortages.[19]

Elements of water sharing plans

WSPs are specific to the relevant surface water or groundwater source. The *Water Management Act 2000* requires WSPs to include "*(a) a vision statement, (b) objectives consistent with the vision statement, (c) strategies for reaching those objectives, [and] (d) performance indicators to measure the success of those strategies.*"[20] In practice, WSPs address a wide range of issues related to water management of a water source or area, and seek to balance social, environmental and economic interests in limited water resources. Table 23 summarises the main elements of water sharing plans and how they align with the environmental, social and economic objects expressed in the *Water Management Act 2000*.

Table 23: Environmental, social and economic objects of the *Water Management Act 2000* and the major elements of water sharing plans

Objects of the *Water Management Act 2000*	Elements of water sharing plans
Environment – protection of water quality, ecosystems, ecological processes, and biological diversity of water sources.[21]	Establishment of environmental water rules for planned environmental water and adaptive environmental water, including defining the proportion of available water for fundamental ecosystem health and water that can be used at the direction of the environmental water manager within the WSP rules.[22] Establishment of measures for the protection and enhancement of the quality of water in water sources in the area, or for the restoration or rehabilitation of water sources or their dependent ecosystems.[23] This includes rules in groundwater plans to minimise impacts on other groundwater users, groundwater dependent ecosystems, groundwater quality and stability of the aquifer.
Environment, social and economic – integrated management of water sources with the management of other aspects of the environment;[24] and social and economic benefits of sustainable and efficient water use to urban communities, agriculture, fisheries, industry and recreation, culture and heritage, and Aboriginal people.[25]	Establishment of a bulk access regime which (i) establishes rules for the granting and management of water access licences; (ii) recognises the effect of climatic variability on the availability of water; (iii) establishes rules for priority of water use, so that supply can be prioritised amongst different water uses in periods of short supply; (iv) specifies any mandatory conditions on licence holders.[26] Identification of requirements for water for extraction under water access licences,[27] including the rates, times and circumstances under which water may be taken from any water source in the area, or the quantity of water that may be taken from any water source in the area or delivered through the area.[28] Identification of requirements to satisfy basic landholder rights.[29]
Social and economic – the orderly, efficient and equitable sharing of water;[30] and shared responsibly for the sustainable and efficient use of water between the Government and water users; and encouraging best practice in the management and use of water.[31]	Establishment of water access licence trading rules for the area or water source.[32] Sets out monitoring and reporting requirements.

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[18] *Water Management Act 2000* s 43(1)
[19] *Water Management Act 2000* s 49A.
[20] *Water Management Act 2000* s 35(1)
[21] *Water Management Act 2000* s 3(b)
[22] *Water Management Act 2000* s 20(1)(a)
[23] *Water Management Act 2000* s 21(d)
[24] *Water Management Act 2000* s 3(f)
[25] *Water Management Act 2000* s 3(c)
[26] *Water Management Act 2000* ss 20(1)(e) and (2)
[27] *Water Management Act 2000* s 20(1)(c)
[28] *Water Management Act 2000* s 21(a)
[29] *Water Management Act 2000* s 20(1)(b)
[30] *Water Management Act 2000* s 3(e)
[31] *Water Management Act 2000* ss 3(g)-(h)

Development of water sharing plans and consultation

DOI Water is responsible for developing WSPs for the state's water resources. The Minister for Regional Water, with the concurrence of the Minister for the Environment, approves these WSPs. To support the development of WSPs, and in particular groundwater WSPs, a number of interagency panels and working groups have been established (DPI Water, 2015):

- **the State Groundwater Panel** supported the development of the groundwater manual: *Macro water sharing plans – the approach for groundwater. A report to assist community consultation* (DPI Water, 2015). The Panel was also responsible for developing a number of water rules applied in WSPs including state-wide set back distance rules for water supply works approval, as well as the default rules for the percentage total extraction in the risk assessment process. The Panel is no longer functional, however it was responsible for the development of water planning principles, policies and approaches that are applied in the development of future WSPs.
- **a Department of Industry internal working group** for the relevant water source, comprising representatives of DOI Water, with experience in areas such as: planning and policy development, licensing and compliance, hydrogeology, hydrometrics and environmental protection; to consider available data and make recommendations.
- **an interagency regional panel** for the relevant water source, comprising representatives of NSW Government agencies (e.g. DOI Water, OEH, DPI, Local Land Services). The interagency regional panel is responsible for ensuring the WSP is consistent with state policy; assign economic, social and environmental values and undertake risk assessments for each groundwater source; reviewing existing WSPs; reviewing future water estimates to inform extraction limits; make recommendations on the water access and trading rules for each groundwater source; and reviewing public submissions.

Consultation with major stakeholder organisations and community members occurs during development of WSPs. The first stage involves taking the draft WSP including draft WSP rules to targeted consultation with major stakeholder organisations, such as water user associations, environmental groups, local government, major utilities and Aboriginal communities. The *Water Management Act 2000* requires that for the draft WSP, Local Land Services, local councils in the water management area, each holder of a water access licence or approval with respect to land within the water management area (and such other persons as the Minister for Regional Water determines) must be notified of the draft WSP. The notification must include the general aims and objectives of the WSP, and a description of the water management area for the WSP.[33] Those notified parties must be given an opportunity to make written submissions to the Minister for Regional Water on the draft WSP within 28 days.[34]

The internal working group and interagency regional panel must consider feedback from targeted consultation and may amend the draft WSP, before submitting the plan back to the Minister for Regional Water for consideration. Once the Minster for Regional Water is satisfied that the draft WSP is suitable for public exhibition,[35] DOI Water will place the draft WSP on public exhibition with an opportunity for public submissions for at least 40 days.[36] The Minister for Regional Water will release a public notice of the draft WSP, specifying where and when the draft WSP will be exhibited and welcoming written submissions from the public to the Minister for Regional Water.[37] The Department of Industry has published a

[32] *Water Management Act 2000* s 20(1)(d)
[33] *Water Management Act 2000* s 36
[34] *Water Management Act 2000* s 36(4)
[35] *Water Management Act 2000* s 38
[36] *Water Management Act 2000* s 38(2)(b)
[37] *Water Management Act 2000* ss 38(1)-(2)

groundwater manual (*Macro water sharing plans – the approach for groundwater. A report to assist community consultation*) (DPI Water, 2015) to guide the development of groundwater WSPs. The purpose of public exhibition of the draft WSP, as specified in the groundwater manual is 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"*(DPI Water, 2015)

The internal working group and interagency regional panel considers any public submissions received and may make amendments to the draft WSP and rules. The plan will then be resubmitted to the Minister for Regional Water with any comments on the submissions. The Minister may make alterations to the WSP as the Minister deems appropriate (provided the Minister has consulted with the panel)[38], and may require it to be re-exhibited.[39] Finally, the Minister, with the concurrence of the Minster for the Environment, makes the plan by order published on the NSW legislation website.[40]

The development of the *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016* is described in more detail in Section 3.1.

Review of Water Sharing Plans

WSPs apply for a 10 year period.[41] The *Water Management Act 2000* establishes a number of requirements for the review and audit of WSPs:

- **Initial review**: within 5 years of making a WSP, the Minister for Regional Water (in consultation with the Minister for the Environment and the Natural Resources Commission (NRC)) is to review that WSP to ascertain "*whether its provisions remain adequate and appropriate for ensuring the effective implementation of the water management principles [as described section 5 of the Water Management Act 2000]*".[42]
- **Audit**: WSPs are audited by the NRC within 5 years of their enactment, to ascertain "*whether its provisions are being given effect to*".[43] The terms of reference for this audit are set by the Minister, who must have regard to the last audit conducted of that plan when setting the terms of reference.[44]
- **Renewal/replacement report**: WSPs apply for a 10 year period, but may be renewed by the Minister for Regional Water on a recommendation of the NRC.[45] At the end of the 10 year period, the NRC will review a WSP and report to the Minister for Regional Water regarding "*(a) the extent that water sharing provisions have contributed to environmental, social and economic outcomes, [and] (b) whether changes to those provisions are warranted.*"[46] As part of this report, the NRC will call for public submissions and consider any received, as well as any relevant government policies or agreements.

The *Water Management Act 2000* only permits a party to seek judicial review of the validity of a WSP before the NSW Land and Environment Court within three months of the WSP, or

[38] *Water Management Act 2000* s 40(2)
[39] *Water Management Act 2000* ss 41(1)(b)-(c)
[40] *Water Management Act 2000* ss 41(1)(a)-(b), (2)-(3)
[41] *Water Management Act 2000* s 43(1)
[42] *Water Management Act 2000* s 43(2)
[43] *Water Management Act 2000* ss 44(1)-(2)
[44] *Water Management Act 2000* s 44(3)
[45] *Water Management Act 2000* s 43A(1)
[46] *Water Management Act 2000* s 43A(3)

amendment to a WSP, being published on the NSW legislation website.[47] A decision to extend a WSP does not give rise to a right of judicial review.[48]

Water licensing

Water licensing is the primary means by which water use is controlled and regulated under WSPs. A Water Access Licence (WAL) is generally required to extract water from surface water or groundwater sources (such as rivers, lakes, estuaries and aquifers) for use in irrigation, industrial or commercial purposes. Subject to some limited exceptions, it is an offence to take water from an area or water source without holding a WAL, or in a manner which contravenes the terms or conditions of a WAL.[49] However, there are several exemptions to the requirement to hold a WAL to extract water. Under the *Water Management Act 2000*, water may be taken without a WAL, pursuant to a basic landholder right:[50]

- Owners or occupiers of land overlaying an aquifer or with river, estuary or lake frontage can take water without a licence for domestic consumption or stock watering purposes (but not on an intensive commercial basis)[51]
- Landholders within specified harvestable rights areas can collect a proportion of the run-off on their property and store it in one or more dams up to a certain size[52]
- Native title holders, holding a native title right with respect to water under the *Commonwealth Native Title Act 1993*, can take and use water in exercise of those native title rights, including for a range of personal, domestic and non-commercial purposes.[53]

There are limited further exemptions to the requirement to hold a WAL specified in the *Water Management (General) Regulation 2018*.[54]

WALs for rural landholders, rural industries, and developments which are not state significant developments or state significant infrastructure, are issued by WaterNSW.[55] All new licence applications are examined to consider possible impacts on water resources, wetlands and neighbours (DOI, 2018b). The process by which WALs are assessed and issued is described below. The Natural Resources Access Regulator (NRAR) is the independent regulatory body responsible for the ensuring compliance with the conditions of WALs. Compliance requirements including metering are described below.

[47] *Water Management Act 2000* s 47
[48] *Water Management Act 2000* s 47(2)
[49] *Water Management Act 2000* ss 60A and 60B
[50] *Water Management Act 2000* s 60F(2)
[51] *Water Management Act 2000* s 52
[52] *Water Management Act 2000* s 53
[53] *Water Management Act 2000* s 55
[54] The *Water Management (General) Regulation 2018* sets out the conditions on these exemptions, which generally relate to the following: (i) collection of water from roofs in rainwater tanks by landholders; (ii) landholders with dams on a minor stream for specific purposes; landholders with dams or excavations located on a river or lake for domestic consumption and/or stock watering; (iii) landholders with works in the Western Division in lakes which are mainly dry; (iv) landholders with works which impound water on a minor stream or within the Western Division, where the water is taken for domestic consumption and stock watering; (v) domestic electricity generation by landholder where water is returned to the same water source and with the same quality; (vi) road construction and maintenance by road authorities; (vii) construction and maintenance of rail infrastructure by transport authorities; (viii) dust suppression by public authorities; (ix) operation of hydro-electric power station where water is returned to the same water source and with the same quality; (x) basic human water needs in urgent circumstances and in the public interest; (xi) environmental work construction, up to 0.5ML in a water year only; (xii) water carting for drought relief for domestic consumption and stock watering; (xiii) initial hydrostatic testing of gas pipelines, up to 7ML; (xiv) prospecting or fossicking for minerals or petroleum, up to 3ML in a water year only; (xv) water bore testing, during installation or approved testing periods; (xvi) exempt monitoring bores; (xvii) emergency safety measures; (xviii) establishment of sugar cane plantings where water is taken from an artificial channel constructed for the purpose of draining water from land on which sugar cane is grown, in specific Water Sharing Plans and where the volume is taken does not exceed 0.05ML in any continuous 12 month period. See also, *Water Management (General) Regulation 2018* cl 21(1), Sch 1 cl 1-9 and Sch 4 cl 2-7, 9-15, 17.
[55] The Natural Resources Access Regulator (NRAR) issues WALs for government agencies, state owned corporations, water utilities, licensed network operators, mining companies, irrigation corporations, Aboriginal communities, floodplain harvesting, state significant developments (SSD), state significant infrastructure (SSI), schools and hospitals.

Elements of water access licences (WALs)

A Water Access Licence (WAL) holder will be issued with a WAL Certificate specifying the key elements of their WAL (Table 24).

Table 24: Major elements of a Water Access Licence (WAL) Certificate

WAL element	Description
Number	To identify the WAL in the Water Access Licence Register and the NSW Water Register (available online at https://waterregister.waternsw.com.au).
Tenure	'Continuing' when the WAL is issued in perpetuity (e.g. for commercial purpose such as irrigation or industrial use); or for 'specific purpose' when the WAL is issued to permit water extraction for a specific purpose (e.g. town water or domestic and stock purposes), but which must be cancelled when the purpose for which the WAL was issued ceases.
Holder	Natural persons or legal entities (such as a corporation). A WAL can be held by multiple entities.
Encumbrances	Security interests (such as mortgages registered against the WAL) and term transfers (temporary transfers to another person for a period of time similar to a tenancy).
Category	WAL categories include: the type of water source from which water may be taken (such as regulated river (high security), regulated river (general security), regulated river (conveyance), unregulated river, aquifer, estuarine water, coastal water); and for specific purpose WALs, the purpose for which that water may be used (such as for domestic and stock purposes, Aboriginal cultural purposes and local water utility access licences). In accordance with the priority rules in WSPs, specific purpose WALs provide higher priority access to water than WALs for most commercial purposes.
Share component	The entitlement the holder of the licence has to passive and consumptive take in a share of the available water in a particular water source consistent with the licence shares and water allocations.
Extraction component	Defines the times, rates and circumstances when water can be taken; type of water source from which the water can be taken, for example surface water or groundwater; and whether water can be taken from the whole water source or only from within a specified management zone.
Nominated works	The approved water supply work (such as the pump or bore) authorised to take water under the WAL
Other conditions	Determined by the *Water Management Act 2000*, the regulations, the relevant local WSP, or imposed by the Minister for Regional Water. For example, restrictions on trading, metering requirements and requirements to keep a logbook.

The share component of a WAL specifies the quantity of unit shares of water that the WAL holder is permitted to extract. Each water year (1 July – 30 June), an available water determination is made, based on the relevant WSP (including the long-term average annual extraction limits specified in the WSP).[56] This determination specifies the water allocation (generally expressed in megalitre (ML) per unit share) which is available to be credited to the water allocation account of each WAL, based on the share component for available water expressed in that WAL. This water allocation process is described in more detail below. Where a WAL holder requires additional or lower water allocation, they can trade this on the water market or surrender it.

Water Access Licence application and approval process

Under the *Water Management Act 2000*, water taken for commercial use, including in water bottling facilities, must be licensed and taken in accordance with the conditions of that licence.[57] While the local council is generally the decision maker for the development

[56] Note that for some WALs, additional available water determinations may be made during the water year.
[57] *Water Management Act 2000* ss 60A and 60B

application for water bottling facilities,[58] extraction of water for commercial use will require the applicant to either obtain a water entitlement via a controlled allocation or purchase of existing entitlement, with the WAL title transfer to be processed by WaterNSW. WALs entitle their holders to specified shares in the available water within a specified water management area or from a specified water source. A WAL does not permit the use of water for a particular purpose nor permit the construction or use of a water supply work, for which water use approval and a water supply works approval are required (further detail below).

The *Water Management Act 2000* specifies that a person may apply for a 'specific purpose WALs' or a 'WALs with a zero share component', subject to restrictions specified in the relevant WSP on the issuance of WALs.[59] The local WSP specifies the requirements for these WAL applications, including any rules that impact the conditions of the WAL or the obligations of the WAL holder. In most cases where a WAL is sought by an industrial operator, a WAL is issued with a zero share component and licence shares or water allocations for each licence must be purchased from the water market. However WALs can generally be obtained through two other mechanisms:

1. **Specific purpose WALs:** Certain persons may be eligible to apply for a specific purpose WAL, which are not 'continuing' WALs, but rather limited WAL for a specific purpose only. Specific purpose WALs are subject to restricted trading rules and are generally location specific. Specific purpose WALs are cancelled if the purpose for which they were granted no longer exists. Specific purpose WALs include licences for purposes of domestic consumption, town water supply (supply to communities for domestic consumption and commercial activities), and Aboriginal cultural activities.[60] Specific purpose WALs are not available for commercial or industrial activities such as commercial agriculture or water bottling.
2. **Controlled allocation orders:** The right to apply for new WALs to unassigned water can also be provided through a controlled allocation order by the Minister for Regional Water.[61] Unassigned water occurs where the extraction limit specified in the WSP for that water source is more than current water users' requirements (based on current licensed volumes and water required to meet basic landholder rights). Water users may register their interest with DOI Water for current and future controlled allocation orders. Controlled allocation orders are subject to a competitive process, for example in accordance with the Department of Primary Industries' policy: *Strategy for the controlled allocation of groundwater* (May 2017) (DPI, 2017). Under this policy, unassigned water will be made available up to a maximum total entitlement of 80 percent of the appropriate extraction limit, generally defined as the long-term average annual extraction limit (LTAAEL). A minimum price per unit share is set in the controlled allocation process, however subject to a competitive bidding process a higher price may be paid. However, the portion of unassigned water made available in each water source will be at the discretion of the Minister.[62]

WALs for rural landholders, rural industries, and developments which are not state significant developments or state significant infrastructure, are issued by WaterNSW.[63] Generally, proponents of water bottling plants would obtain a water entitlement via a controlled allocation order or purchase of existing water entitlement. WaterNSW would conduct title transfer of the WAL associated with this water entitlement. Once it has received the application, WaterNSW will assess that the application satisfies the requirements of the

[58] Note that the relevant LEP will generally define the consent authority for the particular application based on the nature of the proposed development.
[59] *Water Management Act 2000* s 61(1)
[60] *Water Management Act 2000*, Dictionary; *Water Management (General) Regulations 2018* cl 5.
[61] *Water Management Act 2000* s 65
[62] *Water Management Act 2000*, s 65.
[63] Note that the Natural Resources Access Regulator (NRAR) issues WALs for government agencies, state owned corporations, water utilities, licensed network operators, mining companies, irrigation corporations, Aboriginal communities, floodplain harvesting, state significant developments (SSD), state significant infrastructure (SSI), schools and hospitals.

relevant WSP rules and the *Water Management Act 2000* and *Water Management (General) Regulation 2018*. This assessment might require WaterNSW to consult with Native Title representatives or local Aboriginal groups.[64] Note that for areas or water sources covered by a WSP, there is no opportunity for the general public or other stakeholders (aside from the Native Title representatives or Aboriginal groups) to object to the issuance of a WAL which meets the requirements of the relevant WSP and regulations.[65]

Note that in some instances, in addition to water entitlements under the *Water Management Act 2000*, there may also be licences issued under the *Water Act 2012* and licence applications made under the *Water Act 1912* before the WSP commenced that have not been decided.[66]

Water use approvals and water management work approvals

It is an offence under the *Water Management Act 2000* to use water without, or otherwise than as authorised by a water use approval, or to construct a water supply work without, or otherwise than as authorised by, a water supply work approval.[67] The *Water Management Act 2000* provides for water use approvals and water management work approvals:

- **water use approvals**: to use water for a particular purpose at a particular location[68]
- **water management work approvals**: to construct and use a specified water supply work ('water supply work approval'), drainage work ('water drainage work approval') or flood work ('flood work approval'), at a specified location. [69]

To simplify water management for individual water users and properties, a single approval for water supply work and water use approval is required to construct and use a water supply work to extract water from a groundwater body (e.g. a bore); and to store that extracted water (e.g. in tanks) or use it in other ways (e.g. other water bottling activities). A water use approval is not required to take water under a basic landholder right.[70] However, a water supply work approval may be required if a water user is seeking to construct a water supply work to take water under a basic landholder right.[71]

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[64] Where a specific purpose WAL is sought, WaterNSW will confirm that the amount of water sought is reasonable for the nominated purpose.
[65] However, where a WAL is sought for an area outside a WSP, any person may object to the granting of a WAL.[65]
[66] The *Water Act 1912* still applies to: taking water from a water source outside WSP management areas; construction and use of water supply works outside WSP management areas; drainage works in all areas of NSW; and aquifer interference activities in all areas of NSW.
[67] *Water Management Act 2000*, ss 91A and 91B.
[68] *Water Management Act 2000*, s 89.
[69] *Water Management Act 2000*, s 90.
[70] *Water Management (General) Regulation 2018*, cl 35(b)
[71] When taking water under to a basic landholder right, a water supply work approval is not required for pumps, pipes, troughs or tanks to take and store water from a river. However, a water supply work approval is still required to contract a bore, well, spear point or excavation.

Elements of water use and management works approvals

Water use approvals and water management work approvals are listed in the NSW Water Register (WaterNSW, 2019a), as set out in Table 25.

Table 25: Major elements of a water use and management works approvals

Element of the approval	Description
Types of approval	A water supply works approval, a water use approval, or a combined water supply works and water use approval.
Expiry date	Water supply works and water use approvals are generally issued for up to 10 years. Generally, a water supply work approval for a bore used solely for accessing water to which the holder is entitled as a basic landholder right has effect until it is cancelled.
Water use	Identifies the location and purpose for which water may be used.
Authorised water supply works	Identifies the type of water supply work, its location, and the water source and area from which the work extracts water.
Nominated works	Identifies the WAL linked to the work that authorises the water take.
Conditions	Each approval has conditions specified in the relevant WSP, and may have conditions specific to the particular approval and location.[72] For example, WSPs may apply distance rules to applications for water supply works approvals, such as bores.[73] These distance rules identify relevant sites, such as high priority groundwater-dependent ecosystems and groundwater dependent culturally significant sites, and specify minimum distance requirements to prevent unacceptable or damaging levels of water extraction occurring proximate to other water users, GDEs or culturally significant sites. Other distance rules may apply to minimise interference with neighbouring water supply works, to locate works away from contaminated sites, and manage groundwater connectivity. Note that the WSP may also specify that these distance rules be reduced based on local variations and site-specific information, for example, where the proponent can demonstrate in a hydrogeological study that the impacts of works at a lesser distance would be minimal or not occur.

Water use and management works application and approvals process

Applicants submit an application to WaterNSW for an approval or to amend an existing approval. To support an application for approval to construct and use a bore to extract water from a groundwater source within the coastal management area of NSW for irrigation, industrial, recreation or other commercial purposes, a pumping test is required to assess that application. WaterNSW requests that proponents of applications relating to use of groundwater of over 20 ML/year, engage an groundwater consultant to manage a pumping test and provide a hydrogeological investigation report consistent requirements specified in the *Coastal groundwater – test pumping groundwater assessment guidelines for bore licence applications* (WaterNSW, 2017). This report is site specific and includes a "*technical analysis of the pumping test information; and identification of the potential drawdown impacts of the proposed operation on neighbouring users and surrounding sensitive environmental assets*" (WaterNSW, 2017).

Certain applications for approval must need to be advertised.[74] This includes applications for bores for taking water, other than bores used solely for taking water for basic landholder rights.[75] The relevant WSP may also specify other types of applications for approval, which must be advertised.[76] Where an application is required to be advertised, it must be published in local newspaper(s) in the area, in a newspaper circulating among affected Aboriginal communities, and on the WaterNSW website.[77] Where an application for approval relates to an integrated development under the *Environmental Planning and Assessment Act 1979*

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[72] *Water Management Act 2000*, s 100.
[73] See, eg, Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources (September, 2016)
[74] *Water Management Act 2000*, s 92.
[75] *Water Management (General) Regulation 2018*, cl 26(1)(a)(ii)
[76] *Water Management (General) Regulation 2018*, cl 26(1)(c)
[77] *Water Management (General) Regulation 2018*, cl 26(7); Note that applications are advertised on the WaterNSW, NSW Water Register website accessible at https://waterregister.waternsw.com.au.

(‘EP&A Act’), the application is not required to be advertised in accordance with the requirements under the *Water Management Act 2000*.[78] However, for integrated developments, separate advertising requirements apply under the EP&A Act and are described below. Generally, proposed water bottling facilities will be considered as integrated developments under the LEPs in place in the Northern Rivers region (see discussion below).

Where an application for approval is advertised, any person may object in writing to the granting of that approval, within 28 days of that approval being advertised.[79] Where an objection is received, the applicant will be notified, both sides may be asked to provide additional information or be further consulted to assist determination of the application.[80] An application for a water use approval or water management work approval may be refused if there are not adequate arrangements in force to ensure that no more than minimal harm will be done to any water source, or its dependent ecosystems, as a consequence of the proposed use of the water or construction or use of the proposed water management work.[81]

The NSW Department of Industry released the Aquifer Interference Policy (AIP) in September 2012. The purpose of the AIP is to assist the assessment of proposed developments that have some level of aquifer interference, in particular a number of high risk activities where the purpose of water extraction is for disposal, not for use. These activities are listed in the AIP and include, for example, mine and construction project dewatering. These high risk activities tend to involve large volumes of water, of the order of hundreds of ML. WaterNSW and DOI Water have advised the Review that they consider all applicable policies when considering applications for licences and approvals or providing hydrogeological advice, respectively. However, they do not refer to the AIP for activities that are not defined as high risk under the AIP or do not involve large volumes of water (DOI Water, 2019a; WaterNSW, 2019b).

Development approvals

The *Environmental Planning and Assessment Act 1979* (‘EP&A Act’) and local environmental plans (LEPs) provide the framework for assessing and determining applications for development applications. LEPs guide planning decisions for local government areas through zoning and development controls governing the ways land can be used. Where a development is proposed, the LEP will specify either that: (i) no development consent is required, (ii) development consent is required before the development can occur, or (iii) the development is prohibited.

A development of a water bottling facility will require a development approval from the designated consent authority in accordance with the conditions of the relevant environmental planning instrument, the LEP. These instruments generally designate the local council as the consent authority for the application.[82]

Local Environmental Plans

LEPs zone land and impose standards to control development that occurs within their relevant area. LEPs are made in a standard form,[83] generally include a written set of conditions and maps defining development zones, and must comply with Ministerial Directions.[84] Local councils are generally responsible for initiating LEPs.[85] The Department

[78] *Water Management Act 2000*, s 99.
[79] *Water Management Act 2000*, s 93(1); *Water Management (General) Regulation 2018*, cl 27.
[80] *Water Management Act 2000*, s 93(2)
[81] *Water Management Act 2000*, s 97.
[82] *Environmental Planning and Assessment Act 1979* ss 4.5(b)-(d)
[83] See *Standard Instrument (Local Environmental Plans) Order 2006*.
[84] *Environmental Planning and Assessment Act 1979* s 9.1.
[85] An LEP can also be initiated by an authority appointed by the Minister. See *Environmental Planning and Assessment Act 1979* ss 3.32-3.33.

of Planning and Environment also provides guidelines to assist local councils in preparing LEPs (DPE, 2016).

LEPs specify the land use activities which can occur (with and without consent) in particular zones. They also can specify additional conditions or restrictions to control particular developments and types of development.[86] For example, clause 7.15 of the *Tweed Local Environmental Plan 2014* provides that water bottling developments may be carried out in a rural zone (Zone RU2 Rural Landscape) if the council is satisfied that the development will not have an adverse impact on natural water systems or the potential agricultural use of the land.[87] A proposed development's compliance with these conditions would be considered during the assessment of the development consent.

LEPs are updated periodically updated by councils as part of the exercise of their planning functions for their local area. However, landowners and developers may also request that the local council update or amend an LEP. For example, this might occur where a landowner or developer seeks to propose a development that would not be permitted under the existing LEP, due to zoning restrictions or other restrictions or conditions on certain types of development.

To update or amend an LEP, an applicant must submit a planning proposal to the local council. In practice, these planning proposals can be prepared by local councils, landowners or developers seeking to change planning controls in an area. An applicant (e.g. a landowner or developer) may request that a council prepare a planning proposal for an LEP. This proposal would amend an LEP, generally by changing a land use zone to permit certain types or developments, or to change other provisions specified in the LEP. Planning proposals covering an entire local council area would generally be prepared by the local council or relevant planning authority.

The local council must consider this planning proposal and elect to determine if they will support the proposed amendment to the LEP.[88] If they support it, they can submit it to the Department of Planning and Environment for consideration and Gateway determination. The Gateway determination specifies whether the planning proposal should proceed and under what circumstances, including what community consultation is required before consideration is given to making the proposed LEP or amendment.[89]

The Gateway determination will specify the nature of the community consultation that must be undertaken on the planning proposal. For low impact proposals (e.g. consistent with the pattern of surrounding land use zones and consist with the strategic planning framework) this requires public exhibition for is 14 days (DPE, 2016). For all other proposals, including proposals to reclassify land, this requires public exhibition for 28 days.[90] Public exhibition generally involves notification in a local newspaper, online and in writing to affected and adjoining landowners and occupiers to invite submissions (DPE, 2016). Additional public consultation may be undertaken, such as via public forum. The council must consider any submissions made concerning the proposed LEP or amendment and a report of any public hearing into the proposed LEP.

Once consultation is completed, the council will finalise the planning proposal, including a statement regarding how issues raised in submissions made during public exhibition have

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[86] Environmental Planning and Assessment Act 1979 s 3.14.

[87] Note that Tweed Shire Council has prepared a planning proposal to remove clause 7.15 from the Tweed Local Environmental Plan 2014. See Tweed Shire Council, *Planning Proposal PP18/0004: To Remove Clause 7.15 for Water Bottling Facilities* (December 2018).

[88] Where the council decides not to support the proposed amendment, the proponent may request a rezoning review by submitting a request to the Department of Planning and Environment for consideration on its strategic merits by the relevant Planning Panel. The Planning Panel may request that the council support the proposed amendment or appoint a planning authority to take the process to Gateway determination.

[89] *Environmental Planning and Assessment Act 1979* s 3.34

[90] *Environmental Planning and Assessment Act 1979* Sch 1.

been addressed by the council,[91] and submit it to the NSW Parliamentary Council's Office for drafting of the LEP as a legal instrument.[92] The LEP is then made by the council or the Minister for Planning depending on the nature of the proposed amendment (and whether the Minister has delegated authority).[93]

Development applications and approvals

The EP&A Act establishes multiple development approval pathways based on the type, scale and location of the proposed development. The EP&A Act specifies that 'integrated development' approval is required for development applications that require specified additional permits or approvals, such as certain approvals under the *Water Management Act 2000*.[94] For example, proposed water bottling facilities would generally be classified as integrated developments because, in addition to a development consent, they also require a WAL, and a water use and water management works approval.[95]

Generally, the LEP will designate the local council as the consent authority for development applications, including for integrated developments.[96] However, proposed large water bottling developments, with a capital investment value of over $30 million, would be considered to be 'regionally significant developments', and are subject to notification and assessment by a council and then determined by the Joint Regional Planning Panel for the area.[97]

To obtain an integrated development consent, the proponent will need to submit an application for a development consent which includes a description of the development, the estimated cost of the development, a plan of the land, a sketch of the development, and an environmental assessment (e.g. an environmental impact statement (EIS) or statement of environmental effects identifying the environmental impacts of the development and measures to be taken to protect or lessen harm to the environment).[98]

Once the local council has received a development application it must provide written notice of the application to adjoining landowners or occupiers and public authorities that may have an interest in the development.[99] It must also publish notice of the application in a local newspaper.[100] For an integrated development, the notice must: (i) describe the land and proposed development, (ii) identify the applicant and consent authority, (iii) state that the application may be inspected for 28 days and invite written submissions during that time, (iv) and indicate the other approvals required.[101]

Section 4.15(1) of the EP&A Act requires that the local council consider the following matters when determining a development application:

- the provisions of the current or proposed LEP, development control plan, planning agreement and the *Environmental Planning and Assessment Regulations 2000*
- the likely impacts of the development, including environmental impacts on both the natural and build environments, and social and economic impacts in the locality
- the suitability of the site for the development
- any submissions made

[91] *Environmental Planning and Assessment Act 1979* s 3.35
[92] *Environmental Planning and Assessment Act 1979* s 3.36(1); DPE (2016)
[93] *Environmental Planning and Assessment Act 1979* s 3.36.
[94] *Environmental Planning and Assessment Act 1979* s 4.46(1).
[95] A LEP may classify water bottling facilities as a 'designed development'. Designated development applications are be subject to additional requirements such preparation of an environmental impact statement (EIS), public notification for at least 28 days and can be the subject of a merits appeal to the Land and Environment Court by objectors. See *Environmental Planning and Assessment Act 1979* ss 3.17 and 4.10(1); *Environmental Planning and Assessment Regulation* 2000 cl 77-81.
[96] *Environmental Planning and Assessment Act 1979* ss 4.5(b)-(d)
[97] *State Environmental Planning Policy (State and Regional Development) 2011*, Sch 7.
[98] *Environmental Planning and Assessment Regulations 2000* Sch 1, Pt 1, cl 1.
[99] *Environmental Planning and Assessment Regulations 2000* cl 87(a) and 88
[100] *Environmental Planning and Assessment Regulations 2000* cl 87(b)
[101] *Environmental Planning and Assessment Regulations 2000* cl 89

- the public interest.[102]

The council may grant the consent, unconditionally or subject to conditions, or refuse to grant consent.[103] The council is limited in the types of conditions it can impose on developments. These include conditions relating to:

- the matters they were required to consider under section 4.15(1) of the EP&A Act when determining the development application
- the time period of the development and the removal of buildings and works at the end of the period
- express outcomes or objectives of the development and clear criteria for assessment
- contributions towards provisions or improvements of public amenities and services within the area.[104]

Consent for integrated developments cannot be granted until the public authority responsible for issuing the additional permit or approval (e.g. WaterNSW in the case of WALs and water use and management works approvals) has indicated that they will approve the additional permit or approval, and provided the local council (or other consent authority) with the General Terms of Approval.[105] The General Terms of Approval indicate that the necessary approvals can be granted, and set out the conditions that would be applied to those approvals. Once the council is satisfied that it has sufficient information, the council determines the application, either granting consent subject to conditions or refusing consent.

Where the council decides to issue consent, it must be consistent with the conditions of the General Terms of Approval. Where the council refuses consent, the General Terms of Approval cease to have any effect and no other approvals (e.g. water use and management works approvals are issued). An applicant may request the council review its determination of the development consent.[106] The applicant may also appeal the determination or aspect of the determination to the Court within 6 months.[107]

Hydrogeology reports

Hydrogeology reports have been commissioned by most of the operators or proponents of water bottling facilities to support their applications for development approvals and extraction approvals under the *Water Management Act 2000*. The hydrogeology report informs assessments of:

- the impact of the proposed development on groundwater
- the compliance of the proposed development with the WSP
- the impacts of the proposed development on surface water flows, water-dependent ecosystems and surrounding groundwater bores.

The hydrogeology reports also indicate the commercial viability of the bores. The council considers the hydrogeology reports in the DA application assessment process, which may include referral to WaterNSW and in some cases referral to a commissioned consultant for expert advice.

Contents of the hydrogeology reports

The WSP NCFPR has a set of criteria to be considered when preparing a hydrogeology report, including a risk assessment guide for groundwater-dependent ecosystems (GDEs)

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[102] Environmental Planning and Assessment Act 1979 s 4.15
[103] Environmental Planning and Assessment Act 1979 s 4.16(1). Under S.4.16(3) of the Environmental Planning and Assessment Act 1979, a grant of consent can be deferred until the application has satisfied conditions of that consent.
[104] Environmental Planning and Assessment Act 1979 ss 4.17(1) and 7.11-12.
[105] Environmental Planning and Assessment Act 1979 s 4.47
[106] Environmental Planning and Assessment Act 1979 s 8.3.
[107] Environmental Planning and Assessment Act 1979 ss 8.7, 8.9 and 8.10(1). Objectors to the development may only appeal to the Court within 28 days of a decision to grant consent to the designated development. See *Environmental Planning and Assessment Act 1979* ss 8.8 and 8.10(2).

published by DOI Water. The council may also provide guidance for preparing and submitting a hydrogeology report. The focus, depth and style of reports can vary depending on the project and the identified or perceived risks; however, in general the contents include description of:

- the proposed and existing extractions (including bore locations, bore and screen depths, target aquifers, extraction rate, licensed rate)
- the relevant assessment requirements of the water sharing plan
- the hydrogeological context (including descriptions of the target aquifer and overlying and underlying geological layers, proximate hydrological features such as creeks and springs, and regional hydrogeology and recharge rates as described in the water sharing plan)
- the presence of other extraction bores and groundwater-dependent ecosystems (GDEs)
- the method and results of pumping tests, and in some cases other hydrological, hydrogeological investigations at the site
- in some cases, recommendations for long-term monitoring, reporting, further investigation and/or impact triggers that define cease-to-pump conditions
- an assessment of potential impacts on GDEs, surface water and nearby extractions
- conclusions supporting the application.

Generally, hydrogeology studies are conducted at a level of detail and investment in monitoring commensurate with the perceived hydrogeological risks. The contents and level of detail aim to be commensurate with:

- the level of hydrogeological risk perceived by the applicant and the consultant;
- the requirements and guidance of the WSP
- what is considered acceptable level of analysis by the council and/or WaterNSW.

Investments in data collection to support the hydrogeology report for proposed water bottling are generally limited to pump tests (there are minor exceptions, for example the short-term monitoring of creek levels can occur) rather than hydrogeological investigations that are common where risks are perceived to be greater. In some cases, established groundwater equations (analytical models) are used to extrapolate results of pump tests rather than numerical models.

Opportunities for community input in the planning and approvals process

As described above, there are opportunities for community input into the planning and approvals process for WSPs, LEPs, water use and management works approvals, and the development consent process. These are summarised below:

- **Renewal report for WSPs:** As part of the renewal process for WSPs, the NRC conducts a report into "*(a) the extent that water sharing provisions have contributed to environmental, social and economic outcomes, [and] (b) whether changes to those provisions are warranted.*"[108] In preparing these reports, the NRC calls for public submissions and considers any received.
- **Amendment of LEPs:** As part of the amendment process for LEPs, community consultation will be undertaken on the planning proposal. This involves the local council (or other planning authority) placing the planning proposal on public exhibition for 14 to 28 days (depending on the significance of the amendments).[109] Public exhibition generally involves notification in a local newspaper, online and in writing to affected and adjoining landowners. Submissions are invited and a public forum may be held (DPE, 2016). The council must consider any submissions made concerning

[108] *Water Management Act 2000* s 43A(3)
[109] *Environmental Planning and Assessment Act 1979* Sch 1; DPE (2016)

the planning proposal, and prepare a report of any public hearing held and a statement regarding how issues raised in submissions have been addressed.[110]

- **Water use and management works approval:** As part of the application process for a water use and/or water management works approval (including for bores taking water), these applications are advertised and submissions invited.[111] The application must be published in local newspapers and on the WaterNSW website.[112] Within 28 days of an approval being advertised, any person may object in writing to the granting of an approval.[113] Where an objection is received, further information and consultation may be requested to assist determination of the application.[114] However, where an application for approval relates to an integrated development, the application is not required to be advertised in accordance with these requirements, but rather under the advertised development requirements of the EP&A Act.[115]
- **Consent process for integrated developments:** As part of the application process for integrated developments, the local council must provide written notice of the application to adjoining landowners or occupiers and public authorities that may have an interest in the development, and publish notice of the application in a local newspaper.[116] The notice must identify the applicant, describe the proposed development, and invite inspection of the application and submissions for 28 days.[117]

Ongoing activities: monitoring and reporting under licences, works approvals and DAs

The *Water Management Act 2000* and regulations impose monitoring obligations on water users, including record keeping and metering requirements. Further, consent authorities may impose some monitoring requirements as a condition of a development consent.

Requirements under the *Water Management Act 2000*, regulations and WSPs

The *Water Management Act 2000*, regulations and WSPs impose requirements to record water taken, under existing metering and record keeping requirements and under the new the non-urban water metering policy and regulations. WSPs generally require that most WALs and water use and management supply work approvals issued in the relevant area have conditions that require that records of water extracted be kept.[118] For example, the *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016* requires that access licences in the relevant groundwater sources be issued with requirements that a logbook be kept, or that the water supply works be metered with a data logger.[119]

In November 2018, the NSW Government released a new non-urban water metering policy and regulations. The *NSW Non-Urban Water Metering Policy* increases the coverage of non-urban water meters in NSW, and amended the metering requirements under the *Water Management Act 2000* and *Water Management (General) Regulation 2018* (DOI, 2018a). The policy requires that water supply works, authorised by a water supply work approval

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[110] *Environmental Planning and Assessment Act 1979* s 3.35
[111] *Water Management Act 2000*, s 92. *Water Management (General) Regulation 2018*, cl 26(1)(a)(ii). Note that the relevant WSP may also specify other types of applications for approval that must be advertised. See *Water Management (General) Regulation 2018*, cl 26(1)(c).
[112] *Water Management (General) Regulation 2018*, cl 26(7); Note that applications are advertised on the WaterNSW, NSW Water Register website accessible at https://waterregister.waternsw.com.au.
[113] *Water Management Act 2000*, s 93(1); *Water Management (General) Regulation 2018*, cl 27.
[114] *Water Management Act 2000*, s 93(2)
[115] *Water Management Act 2000*, s 99.
[116] *Environmental Planning and Assessment Regulations 2000* cl 87(a)-(b) and 88
[117] *Environmental Planning and Assessment Regulations 2000* cl 89
[118] Note that from 1 December 2019, this condition would apply across NSW, subject to some limited exceptions. See, eg, *Water Management Act 2000* s 115 and *Water Management (General) Regulations 2018* cl 250.
[119] *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016* cl 55 and 56.

under the *Water Management Act 2000* and works authorised to take water under the *Water Act 2012*, must have a meter where they meet the metering thresholds, for example:[120]

- The works are already required to meter or measure[121]
- The works comprise a single groundwater bore with a diameter of 200mm or greater[122]
- The works comprise two groundwater bores with a diameter of 160mm or greater[123]
- The works comprise three groundwater bores with a diameter of 130mm or greater[124]
- The works comprise four groundwater bores with a diameter of 120mm or greater[125]
- The works access at-risk groundwater sources (defined as those that are over allocated or where the entitlement and account rules result in extraction exceeding the Long Term Annual Extraction Limit).[126]

From 1 April 2019, new water supply works are required to meet the metering requirements. Existing water supply works within the coastal region of NSW, including works to which the *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016* applies, are not required to meet the metering requirements under the policy until 1 December 2023.[127] The metering requirements also specify standards for new and replacement meters for groundwater supply works, including that they are pattern-approved, installed to *Australian Standard 4747: Meters for non-urban water supply* (AS4747), have tamper-evident seals, have a data logging capability, and meet a maintenance standard.[128]

Requirements under development approvals

Under section 4.17 of the EP&A Act, consent authorities including councils, have powers to impose conditions on development consents. This includes conditions relevant to controlling and monitoring the "impacts of development, including environmental impacts on both the natural and built environments, and social and economic impacts in the locality."[129] For example, monitoring of groundwater sources, or metering or recording of water extracted.

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[120] *Water Management Act 2000* s 101A; Note: other metering thresholds apply. See, eg, *Water Management (General) Regulation 2018* cl 231.
[121] *Water Management (General) Regulation 2018* cl 231(4).
[122] *Water Management (General) Regulation 2018* cl 231(1)(c)
[123] *Water Management (General) Regulation 2018* cl 231(3)(a)
[124] *Water Management (General) Regulation 2018* cl 231(3)(b)
[125] *Water Management (General) Regulation 2018* cl 231(3)(c)
[126] *Water Management (General) Regulation 2018* cl 231(4)(b) and Sch 9. See also, DOI (2018a).
[127] *Water Management (General) Regulation 2018* cl 230(1)(c).
[128] *Water Management (General) Regulation 2018* cl 235 and Sch 8. See also, DOI (2018a).
[129] *Environmental Planning and Assessment Act 1979* ss 4.15(1)(b) and 4.17(1)(a).

APPENDIX 5: WATER SHARING PLAN RULES

Documents for the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources can be found at:

- https://www.legislation.nsw.gov.au/#/view/regulation/2016/375
- https://www.industry.nsw.gov.au/__data/assets/pdf_file/0004/166873/nth-coast-fractured-porous-rock-gw-background.pdf

The Rules Summary Sheets for all 13 groundwater sources for the North Coast Fractured and Porous Rock WSP can be found at the link below.

- https://www.industry.nsw.gov.au/__data/assets/pdf_file/0011/150140/North-Coast-Fractured-and-Porous-Rock-Groundwater-source-rules.pdf

The Rules Summary Sheets for each of the four groundwater sources of focus are reproduced in full below:

- Alstonville Basalt Plateau Groundwater Source
- Clarence Morton Basin Groundwater Source
- New England Fold Belt Groundwater Source
- North Coast Volcanics Groundwater Source.

Rules Summary Sheet
Alstonville Basalt Plateau Groundwater Source

Water sharing plan	North Coast Fractured and Porous Rock Groundwater Sources
Plan commencement	1 July 2016
Term of the plan	10 years

Rules summary

The following rules are a guide only. For more information please call DPI Water on 1800 353 104.

Limits to the availability of water	
Long-term average annual extraction limit	The long-term average annual extraction limit (LTAAEL) is 8,895 ML/yr.
Unassigned water	There is no unassigned water. **Note:** The volume of unassigned water may change throughout the life of the plan as a result of licences being cancelled.
Available water determinations	Available water determinations (AWDs) will be made at commencement of each water year for: • Domestic and stock, local water utility and other specific purpose access licences – 100% of the share component; and • Aquifer access licences – 1 ML/unit share or a lower amount as result of a growth-in-use response.
Compliance with the long-term average annual extraction limit	Growth in extractions will be assessed against the LTAAEL over a three year period. Averaged growth greater than 5% will result in a reduced available water determination, in order to keep extractions in line with the LTAAEL.
Rules for granting access licences	
Granting of access licences	Granting of water access licences may be considered for the following categories: • Specific purpose access licences including local water utility, major water utility, domestic and stock and town water supply; and • Aquifer (Aboriginal cultural) access licences up to a maximum of 10 ML/yr.
Rules for managing access licences	
Carryover and account limit	Carryover of up to 20% of account water is permitted, with a maximum account limit of 120% of share components plus any adjustments made for allocation assignments into or out of the account, subject to the installation of a meter.

Trading rules	
INTO groundwater source	Trades are not permitted into the groundwater source.
WITHIN groundwater source	Trades are permitted within the groundwater source subject to assessment. Trades resulting in a net increase in the sum of share components in the Alstonville Basalt Plateau (Alstonville-Tuckean) Management Zone are not permitted.
Conversion to another category of access licence	Trades which result in the conversion of an access licence to another category are not permitted within the groundwater source.

Rules for water supply works approvals	
Rules to minimise interference between bores	No water supply work (bores) to be granted or amended within the following distances: • 200 m of an existing bore that is licensed to extract up to 20 ML/yr; • 400 m of an existing bore that is licensed to extract more than 20 ML/yr; • 200 m of an existing bore that is used for basic rights; • 100 m of the boundary of the property (unless consent gained from neighbour); • 500 m of a local or major water utility bore; and • 400 m of a bore used by the Department for monitoring purposes. The plan lists circumstances in which these distance conditions may be varied. **Note:** These rules apply to **new** bores **NOT existing** or **replacement** bores.
Rules for bores located near contamination sources	No water supply work (bores) to be granted or amended within the following distances of a plume associated with a contamination source as identified in the plan: • within 250 m, or • between 250 m and 500 m if no drawdown of water will occur within 250 m of the plume, or • a distance greater than 500 m if necessary to protect the groundwater source, the environment or public health or safety. The plan lists circumstances in which these distance conditions may be varied. **Note:** These rules apply to **new** and **replacement** bores **NOT existing** bores. **Note:** Contamination sources are identified in Schedule 1 of the plan.

Rules for water supply works approvals	
Rules for bores located near high priority groundwater-dependent ecosystems	No water supply work (bores) to be granted or amended within the following distances of any high priority groundwater-dependent ecosystem (GDE), or a river or stream: • 100 m of a high priority GDE for bores that are used for basic rights; • 200 m of a high priority GDE for bores that are not used for basic rights; • 500 m of a high priority karst environment GDE; • 40 m from the top of the high bank of a river or stream; and • 100 m of an escarpment. The plan lists circumstances in which these distance conditions may be varied. The plan may be amended to add or remove high priority groundwater-dependent ecosystems. **Note:** These rules apply to **new** bores **NOT existing** or **replacement** bores. **Note:** Overview maps of the high priority GDEs identified in this plan are shown in Appendix 3. The legal map of the high priority GDEs (full colour and zoomable) can be found at http://www.legislation.nsw.gov.au/.
Rules for bores located near groundwater-dependent culturally significant sites	No water supply work (bores) to be granted or amended within the following distances of a groundwater-dependent culturally significant site: • 100 m for basic landholder rights bores; and • 200 m for bores not used for basic landholder rights. The plan lists circumstances in which these distance conditions may be varied. Where a culturally significant site is also a high priority GDE, the more restrictive distance restriction applies to the granting or amendment of a water supply work approval. **Note:** These rules apply to **new** bores **NOT existing** or **replacement** bores.

Rules for water supply works approvals	

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 groundwater source as the existing water supply work.
	• The replacement groundwater work must be constructed to extract water from:
	  ○ the same depth as the existing water supply work; or
	  ○ a different depth if the Minister is satisfied that doing so will result in no greater impact on the groundwater source or its dependent ecosystems.
	• The replacement groundwater work must be located:
	  ○ within 20 m of the existing water supply work; or
	  ○ a distance greater than 20 m of the existing water supply work if the Minister is satisfied that doing so will result in no greater impact on the groundwater source or its dependent ecosystems.
	• If the existing water supply work is located within 40 m of the high bank of a river, the replacement groundwater work must be located:
	  ○ within 20 m of the existing water supply work but no closer to the high bank of the river; or
	  ○ more than 20 m 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 the groundwater 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% of the internal diameter of the existing water supply work it replaces.

More information about the planning process for the North Coast Fractured and Porous Rock Groundwater Sources is available at the DPI Water website: www.water.nsw.gov.au.

Rules Summary Sheet
Clarence Moreton Basin Groundwater Source

Water sharing plan	North Coast Fractured and Porous Rock Groundwater Sources
Plan commencement	1 July 2016
Term of the plan	10 years

Rules summary

The following rules are a guide only. For more information please call DPI Water on 1800 353 104.

Limits to the availability of water	
Long-term average annual extraction limit	The long-term average annual extraction limit (LTAAEL) is 300,000 ML/yr.
Unassigned water	The volume of unassigned water is 295,438 ML/yr. **Note:** The volume of unassigned water may change throughout the life of the plan as a result of new licences being granted or existing licences being cancelled.
Available water determinations	Available water determinations (AWDs) will be made at commencement of each water year for: • Domestic and stock, local water utility and other specific purpose access licences – 100% of the share component; and • Aquifer access licences – 1 ML/unit share or a lower amount as result of a growth-in-use response.
Compliance with the long-term average annual extraction limit	Growth in extractions will be assessed against the LTAAEL over a three year period. Averaged growth greater than 5% will result in a reduced available water determination, in order to keep extractions in line with the LTAAEL.
Rules for granting access licences	
Granting of access licences	Granting of water access licences may be considered for the following categories: • Specific purpose access licences including local water utility, major water utility, domestic and stock and town water supply; • Aquifer (Aboriginal cultural) access licences up to a maximum of 10 ML/yr; • Aquifer (Aboriginal community development) access licences; and • Aquifer access licences. **Note:** Aquifer access licences may only be granted under a controlled allocation order made in relation to any unassigned water in this groundwater source.
Rules for managing access licences	
Carryover and account limit	Carryover of up to 20% of account water is permitted, with a maximum account limit of 120% of share components plus any adjustments made for allocation assignments into or out of the account, subject to the installation of a meter.

Trading rules	
INTO groundwater source	Trades are not permitted into the groundwater source.
WITHIN groundwater source	Trades are permitted within the groundwater source subject to assessment.
Conversion to another category of access licence	Trades which result in the conversion of an access licence to another category are not permitted within the groundwater source.

Rules for water supply works approvals	
Rules to minimise interference between bores	No water supply work (bores) to be granted or amended within the following distances: • 400 m of an existing bore that is not used for basic rights; • 100 m of an existing bore that is used for basic rights; • 50 m of the boundary of the property (unless consent gained from neighbour); • 1,000 m of a local or major water utility bore; and • 200 m of a bore used by the Department for monitoring purposes. The plan lists circumstances in which these distance conditions may be varied. **Note:** These rules apply to **new** bores **NOT existing** or **replacement** bores.
Rules for bores located near contamination sources	No water supply work (bores) to be granted or amended within the following distances of a plume associated with a contamination source as identified in the plan: • within 250 m, or • between 250 m and 500 m if no drawdown of water will occur within 250 m of the plume, or • a distance greater than 500 m if necessary to protect the groundwater source, the environment or public health or safety. The plan lists circumstances in which these distance conditions may be varied. **Note:** These rules apply to **new** and **replacement** bores **NOT existing** bores. **Note:** Contamination sources are identified in Schedule 1 of the plan.
Rules for bores located near high priority groundwater-dependent ecosystems	No water supply work (bores) to be granted or amended within the following distances of any high priority groundwater-dependent ecosystem (GDE), or a river or stream: • 100 m of a high priority GDE for bores that are used for basic rights; • 200 m of a high priority GDE for bores that are not used for basic rights; • 500 m of a high priority karst environment GDE; and • 40 m from the top of the high bank of a river or stream. The plan lists circumstances in which these distance conditions may be varied. The plan may be amended to add or remove high priority groundwater-dependent ecosystems. **Note:** These rules apply to **new** bores **NOT existing** or **replacement** bores. **Note:** Overview maps of the high priority GDEs identified in this plan are shown in Appendix 3. The legal map of the high priority GDEs (full colour and zoomable) can be found at http://www.legislation.nsw.gov.au/.

Rules for water supply works approvals	
Rules for bores located near groundwater-dependent culturally significant sites	No water supply work (bores) to be granted or amended within the following distances of a groundwater-dependent culturally significant site: • 100 m for basic landholder rights bores; and • 200 m for bores not used for basic landholder rights. The plan lists circumstances in which these distance conditions may be varied. Where a culturally significant site is also a high priority GDE, the more restrictive distance restriction applies to the granting or amendment of a water supply work approval. **Note:** These rules apply to **new** bores **NOT existing** or **replacement** bores.

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 groundwater 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 the groundwater source or its dependent ecosystems.
	• The replacement groundwater work must be located:
	  o within 20 m of the existing water supply work; or
	  o a distance greater than 20 m of the existing water supply work if the Minister is satisfied that doing so will result in no greater impact on the groundwater source or its dependent ecosystems.
	• If the existing water supply work is located within 40 m of the high bank of a river, the replacement groundwater work must be located:
	  o within 20 m of the existing water supply work but no closer to the high bank of the river; or
	  o more than 20 m 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 the groundwater 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% of the internal diameter of the existing water supply work it replaces.

More information about the planning process for the North Coast Fractured and Porous Rock Groundwater Sources is available at the DPI Water website: www.water.nsw.gov.au.

Rules Summary Sheet
New England Fold Belt Coast Groundwater Source

Water sharing plan	North Coast Fractured and Porous Rock Groundwater Sources
Plan commencement	1 July 2016
Term of the plan	10 years

Rules summary

The following rules are a guide only. For more information please call DPI Water on 1800 353 104.

Limits to the availability of water	
Long-term average annual extraction limit	The long-term average annual extraction limit (LTAAEL) is 60,000 ML/yr. **Note:** If, during the term of the plan, current entitlement reaches 80% of the LTAAEL, then a review of the LTAAEL will be undertaken by the North Coast Interagency Regional Panel or some other similar interagency panel. The LTAAEL may then be increased to a maximum of 375,000 ML/yr.
Upper extraction limit	The upper extraction limit is 375,000 ML/yr.
Unassigned water	The volume of unassigned water is 24,532 ML/yr. **Note:** The volume of unassigned water may change throughout the life of the plan as a result of new licences being granted or existing licences being cancelled.
Available water determinations	Available water determinations (AWDs) will be made at commencement of each water year for: • Domestic and stock, local water utility and other specific purpose access licences – 100% of the share component; and • Aquifer access licences – 1 ML/unit share or a lower amount as result of a growth-in-use response.
Compliance with the long-term average annual extraction limit	Growth in extractions will be assessed against the LTAAEL over a three year period. Averaged growth greater than 5% will result in a reduced available water determination, in order to keep extractions in line with the LTAAEL.

Rules for granting access licences	
Granting of access licences	Granting of water access licences may be considered for the following categories: • Specific purpose access licences including local water utility, major water utility, domestic and stock and town water supply; • Aquifer (Aboriginal cultural) access licences up to a maximum of 10 ML/yr; • Aquifer (Aboriginal community development) access licences; and • Aquifer access licences. **Note:** Aquifer access licences may only be granted under a controlled allocation order made in relation to any unassigned water in this groundwater source.
Rules for managing access licences	
Carryover and account limit	Carryover of up to 20% of account water is permitted, with a maximum account limit of 120% of share components plus any adjustments made for allocation assignments into or out of the account, subject to the installation of a meter.

Trading rules	
INTO groundwater source	Trades are not permitted into the groundwater source.
WITHIN groundwater source	Trades are permitted within the groundwater source subject to assessment.
Conversion to another category of access licence	Trades which result in the conversion of an access licence to another category are not permitted within the groundwater source.

Rules for water supply works approvals	
Rules to minimise interference between bores	No water supply work (bores) to be granted or amended within the following distances: • 200 m of an existing bore that is licensed to extract up to 20 ML/yr; • 400 m of an existing bore that is licensed to extract more than 20 ML/yr; • 200 m of an existing bore that is used for basic rights; • 100 m of the boundary of the property (unless consent gained from neighbour); • 500 m of a local or major water utility bore; and • 400 m of a bore used by the Department for monitoring purposes. The plan lists circumstances in which these distance conditions may be varied. **Note:** These rules apply to **new** bores **NOT existing** or **replacement** bores.

Rules for water supply works approvals	
Rules for bores located near contamination sources	No water supply work (bores) to be granted or amended within the following distances of a plume associated with a contamination source as identified in the plan: • within 250 m, or • between 250 m and 500 m if no drawdown of water will occur within 250 m of the plume, or • a distance greater than 500 m if necessary to protect the groundwater source, the environment or public health or safety. The plan lists circumstances in which these distance conditions may be varied. **Note:** These rules apply to **new** and **replacement** bores **NOT existing** bores. **Note:** Contamination sources are identified in Schedule 1 of the plan.
Rules for bores located near high priority groundwater-dependent ecosystems	No water supply work (bores) to be granted or amended within the following distances of any high priority groundwater-dependent ecosystem (GDE), or a river or stream: • 100 m of a high priority GDE for bores that are used for basic rights; • 200 m of a high priority GDE for bores that are not used for basic rights; • 500 m of a high priority karst environment GDE; • 40 m from the top of the high bank of a river or stream; and • 100 m from an escarpment. The plan lists circumstances in which these distance conditions may be varied. The plan may be amended to add or remove high priority groundwater-dependent ecosystems. **Note:** These rules apply to **new** bores **NOT existing** or **replacement** bores. **Note:** Overview maps of the high priority GDEs identified in this plan are shown in Appendix 3. The legal map of the high priority GDEs (full colour and zoomable) can be found at http://www.legislation.nsw.gov.au/.
Rules for bores located near groundwater-dependent culturally significant sites	No water supply work (bores) to be granted or amended within the following distances of a groundwater-dependent culturally significant site: • 100 m for basic landholder rights bores; and • 200 m for bores not used for basic landholder rights. The plan lists circumstances in which these distance conditions may be varied. Where a culturally significant site is also a high priority GDE, the more restrictive distance restriction applies to the granting or amendment of a water supply work approval. **Note:** These rules apply to **new** bores **NOT existing** or **replacement** bores.

Rules for water supply works approvals	

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 groundwater 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 the groundwater source or its dependent ecosystems.
	• The replacement groundwater work must be located:
	  o within 20 m of the existing water supply work; or
	  o a distance greater than 20 m of the existing water supply work if the Minister is satisfied that doing so will result in no greater impact on the groundwater source or its dependent ecosystems.
	• If the existing water supply work is located within 40 m of the high bank of a river, the replacement groundwater work must be located:
	  o within 20 m of the existing water supply work but no closer to the high bank of the river; or
	  o more than 20 m 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 the groundwater 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% of the internal diameter of the existing water supply work it replaces.

More information about the planning process for the North Coast Fractured and Porous Rock Groundwater Sources is available at the DPI Water website: www.water.nsw.gov.au.

Rules Summary Sheet
North Coast Volcanics Groundwater Source

Water sharing plan	North Coast Fractured and Porous Rock Groundwater Sources
Plan commencement	1 July 2016
Term of the plan	10 years

Rules summary

The following rules are a guide only. For more information please call DPI Water on 1800 353 104.

Limits to the availability of water	
Long-term average annual extraction limit	The long-term average annual extraction limit (LTAAEL) is 13,000 ML/yr. **Note:** If, during the term of the plan, current entitlement reaches 80% of the LTAAEL, then a review of the LTAAEL will be undertaken by the North Coast Interagency Regional Panel or some other similar interagency panel. The LTAAEL may then be increased to a maximum of 55,000 ML/yr.
Upper extraction limit	The upper extraction limit is 55,000 ML/yr.
Unassigned water	The volume of unassigned water is 7,093 ML/yr. **Note:** The volume of unassigned water may change throughout the life of the plan as a result of new licences being granted or existing licences being cancelled.
Available water determinations	Available water determinations (AWDs) will be made at commencement of each water year for: • Domestic and stock, local water utility and other specific purpose access licences – 100% of the share component; and • Aquifer access licences – 1 ML/unit share or a lower amount as result of a growth-in-use response.
Compliance with the long-term average annual extraction limit	Growth in extractions will be assessed against the LTAAEL over a three year period. Averaged growth greater than 5% will result in a reduced available water determination, in order to keep extractions in line with the LTAAEL.

Rules for granting access licences	
Granting of access licences	Granting of water access licences may be considered for the following categories: • Specific purpose access licences including local water utility, major water utility, domestic and stock and town water supply; • Aquifer (Aboriginal cultural) access licences up to a maximum of 10 ML/yr; • Aquifer (Aboriginal community development) access licences; and • Aquifer access licences. **Note:** Aquifer access licences may only be granted under a controlled allocation order made in relation to any unassigned water in this groundwater source.
Rules for managing access licences	
Carryover and account limit	Carryover of up to 20% of account water is permitted, with a maximum account limit of 120% of share components plus any adjustments made for allocation assignments into or out of the account, subject to the installation of a meter.

Trading rules	
INTO groundwater source	Trades are not permitted into the groundwater source.
WITHIN groundwater source	Trades are permitted within the groundwater source subject to assessment.
Conversion to another category of access licence	Trades which result in the conversion of an access licence to another category are not permitted within the groundwater source.

Rules for water supply works approvals	
Rules to minimise interference between bores	No water supply work (bores) to be granted or amended within the following distances: • 200 m of an existing bore that is licensed to extract up to 20 ML/yr; • 400 m of an existing bore that is licensed to extract more than 20 ML/yr; • 200 m of an existing bore that is used for basic rights; • 100 m of the boundary of the property (unless consent gained from neighbour); • 500 m of a local or major water utility bore; and • 400 m of a bore used by the Department for monitoring purposes. The plan lists circumstances in which these distance conditions may be varied. **Note:** These rules apply to **new** bores **NOT existing** or **replacement** bores.

Rules for water supply works approvals	
Rules for bores located near contamination sources	No water supply work (bores) to be granted or amended within the following distances of a plume associated with a contamination source as identified in the plan: • within 250 m, or • between 250 m and 500 m if no drawdown of water will occur within 250 m of the plume, or • a distance greater than 500 m if necessary to protect the groundwater source, the environment or public health or safety. The plan lists circumstances in which these distance conditions may be varied. **Note:** These rules apply to **new** and **replacement** bores **NOT existing** bores. **Note:** Contamination sources are identified in Schedule 1 of the plan.
Rules for bores located near high priority groundwater-dependent ecosystems	No water supply work (bores) to be granted or amended within the following distances of any high priority groundwater-dependent ecosystem (GDE), or a river or stream: • 100 m of a high priority GDE for bores that are used for basic rights; • 200 m of a high priority GDE for bores that are not used for basic rights; • 500 m of a high priority karst environment GDE; • 40 m from the top of the high bank of a river or stream; and • 100 m from an escarpment. The plan lists circumstances in which these distance conditions may be varied. The plan may be amended to add or remove high priority groundwater-dependent ecosystems. **Note:** These rules apply to **new** bores **NOT existing** or **replacement** bores. **Note:** Overview maps of the high priority GDEs identified in this plan are shown in Appendix 3. The legal map of the high priority GDEs (full colour and zoomable) can be found at http://www.legislation.nsw.gov.au/.
Rules for bores located near groundwater-dependent culturally significant sites	No water supply work (bores) to be granted or amended within the following distances of a groundwater-dependent culturally significant site: • 100 m for basic landholder rights bores; and • 200 m for bores not used for basic landholder rights. The plan lists circumstances in which these distance conditions may be varied. Where a culturally significant site is also a high priority GDE, the more restrictive distance restriction applies to the granting or amendment of a water supply work approval. **Note:** These rules apply to **new** bores **NOT existing** or **replacement** bores.

Rules for water supply works approvals	

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 groundwater 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 the groundwater source or its dependent ecosystems.
	• The replacement groundwater work must be located:
	  o within 20 m of the existing water supply work; or
	  o a distance greater than 20 m of the existing water supply work if the Minister is satisfied that doing so will result in no greater impact on the groundwater source or its dependent ecosystems.
	• If the existing water supply work is located within 40 m of the high bank of a river, the replacement groundwater work must be located:
	  o within 20 m of the existing water supply work but no closer to the high bank of the river; or
	  o more than 20 m 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 the groundwater 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% of the internal diameter of the existing water supply work it replaces.

More information about the planning process for the North Coast Fractured and Porous Rock Groundwater Sources is available at the DPI Water website: www.water.nsw.gov.au.

APPENDIX 6: DECISION MAKING UNDER UNCERTAINTY

Recent decades have seen increasing efforts to provide guidance on decision making in contexts where the underlying science is complex, where data are limited and where various stakeholders may have very different perspectives on what is needed. Leung, Noble, Gunn, and Jaeger (2015) provide a useful review of strategies that can potentially be used to handle uncertainty in the context of environmental impact assessment.

One obvious way to reduce uncertainty is to improve the prediction and modelling of environmental systems. This may include the gathering of additional data and/or refinements of the models being used for prediction. Unfortunately, both these steps can be a time consuming and expensive step, not always achievable in the timeframe needed for decision-making. In these cases, a pragmatic solution is to explicitly build uncertainty into the modelling process. This can be done in a number of ways, but includes scenario-based predictions that assess how changes in assumed baseline conditions might affect conditions over space and over various timeframes. Incorporating uncertainty analysis into the modelling step is not trivial.

A second broad strategy concerns how issues of uncertainty are communicated to various stakeholders and other audiences in order to facilitate the decision making process (Leung et al., 2015). There has been quite a lot of research on the effectiveness of visual and descriptive versus numerical representations of the uncertainty in risk (Spiegelhalter, Pearson, & Short, 2011). There has also been research on how increasing decision-makers understanding of risk and uncertainty will have an impact on their decisions. This relates to the broader question of how people make decisions in the presence of uncertainty.

The science of Decision Theory goes back to the work of probability theorists such as Pascal and Bernoulli in the 17th and 18th centuries who discovered that people do not always react completely rationally and predictably when it comes to making decisions under uncertainty. These early developments were done largely in the context of gambling games where the choices and associated losses or gains were fairly simple. As understanding progressed, the following approaches were established:

- **Utility**: the concept of Utility was developed to measure the value that people place on certain outcomes happening. In those simple early settings, the decision making could then be framed, for example, in terms of choosing the action with the highest expected utility. For example, suppose you are offered the choice between option A (you receive $10) or B (you receive $200 with 10 percent probability and $0 otherwise). Research shows that most people will choose Option A, even though the expected gain ($10) is lower than the expected gain ($20) associated with Option B.
- **Subjective probability**: As the science evolved further, it was also able to incorporate ideas of subjective probability, where a subject's opinions and experience inform judgement about whether an outcome is likely to occur. This extended the possibility of applying the theory in complex, perhaps data-poor real-world settings.
- **Multi-attribute utility**: there have been extensions to so-called multi-attribute utility analysis for settings involving multiple different outcomes. Cost benefit analysis is an example.
- **Multiple decision makers**: extensions to the setting of multiple decision makers led to the field of game theory, which of course has found wide application and interest from economists.
- **Bayesian networks**: in very complex settings, the number of scenarios needing to be considered can easily balloon out to an unmanageable level. Some new computational tools have been developed recently to handle this. For example, MIT researchers utilize Bayesian networks to efficiently evaluate and compare thousands of decision options in the context of robotics and autonomous vehicle management

(Kochenderfer, Amato, Chowdhary, How, Reynolds, Thornton, Torres-Carrasquillo, Ure, & Vian, 2015). Hodgett and Siraj (2019) describe a computational tool that builds uncertainty into a complex decision framework via a series of triangular distributions.

However, the greatest challenge in complex real-world settings is not so much running the models, but precisely describing all the different elements involved in the decision-making and characterising the associated probabilities and uncertainties associated with these events. In other words, the biggest challenge is not so much the computational aspect, but more the conceptualisation of the problem.

Environmental decision-making epitomises how complex things can quickly become, often being fraught with conflicting interests between industry/community gains if an action is allowed versus community concerns about adverse effects. Assessing the risks of adverse effects is often complicated by the limitations of scientific knowledge and lack of clear evidence, especially when risks tend to be low.[130]

A relatively recent report by the US National Academy of Sciences, though predominantly focussed around human health, offers some very useful guidance for more general environmental decision-making (Institute of Medicine, 2013). The report defined three different types of uncertainty:

1. Statistical variability and uncertainty
2. Model and parameter uncertainty
3. Deep uncertainty.

Statistical variability: also called aleatory uncertainty, refers to natural variation in the physical environment and in human behaviour and biology. In the present context, for example, there will be many different sources of natural variation, ranging from levels of rainfall through to what percentage of a water licensee's allocation is actually used. This type of uncertainty is inherent to the system and cannot be reduced by collecting further data, though it may be useful in helping decision-makers to further understand this kind of uncertainty. In principle, this first type of uncertainty is easy to accommodate through statistical modelling.

Model and parameter uncertainty: also called epistemic uncertainty, refers to the uncertainty associated with deciding on the best model to represent the situation of interest. Model uncertainty refers to the fact that there will inevitably be a number of different options regarding model choice. For example the basic mathematical formulation, which variables to include, which data sources to rely on etc. In data-rich settings, statistical methods can be used to guide the choice between different models or even to build a "meta-model" that includes multiple models as special cases. In complex settings such as groundwater modelling, model specification requires the input of experts with deep knowledge of the subject.

Once a model has been specified, there will still be a need to use a combination of data and informed expert knowledge to estimate model parameters. It is generally important to understand the impact of the uncertainty in those parameters since they will generally be known only within a range.

This second type of uncertainty can generally be reduced with additional research including additional data collection. Tools such as probabilistic risk assessment were proposed in the

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[130] The US Environmental Protection Agency (US EPA) has a long history of conducting risk assessments, publishing guidance documents and establishing environmental standards in such settings. Often the US EPA seeks independent advice from the National Academy of Science who, in turn, draws on a wide range of expertise from academic and industry to produce a guidance report. Membership on an Academy panel is highly prestigious because they draw only on recognized experts in the field. Academy reports are consequently perceived as being of high quality, reflecting the latest science, and as such, they are typically of high quality and very influential. The Academy has convened a number of different panels over the years to address different aspects of decision making under uncertainty.

late 80s and 90s[131] as means of incorporating uncertainty into the modelling process. While probabilistic risk assessment cannot remove uncertainty, it can assist decision-makers to gain a clearer understanding of the impact of various sources of uncertainty on the outcomes of interest. Probabilistic risk assessment typically uses Monte Carlo simulation and Bayesian methods to add extra layers to the modelling process. It works very well in terms of addressing the second type of uncertainty, model and parameter uncertainty.[132] However, it is typically less useful in the third setting, deep uncertainty.

Deep uncertainty: where there may be fundamental disagreements about the nature of the processes driving the situation of interest or where it is impossible to collect all the data needed to properly inform the system due to cost and time considerations. Deep uncertainty also arises in where decisions may have long term consequences and it is not possible to accurately predict the future.

While some probabilistic modelling in combination with expert judgments can be helpful in the context of deep uncertainty, broader strategies such as scenario analysis will be needed for decision-making in the presence of deep uncertainty. Rather than taking the traditional approach of predicting what is most likely to occur, scenario analysis develops more qualitative descriptions of possible future outcomes.

NAS (2013) describes a three-phase framework for decision-making where Phase I involves problem formulation and scoping, including consideration of the decision being faced, assessment of associated uncertainties and determination of whether there is any research that could be achieved within an acceptable timeframe to reduce those uncertainties. Phase II involves the planning and conduct of relevant risk assessments, and Phase III the risk management. The framework report emphasises the importance of engaging with stakeholders at all steps, particularly to ensure a full appreciation of all the uncertainties involved. Managing the interaction between the stakeholders, analysts and decision-makers feeds into the critical first step of formulating and scoping both the problem to be solved and the decisions to be made.

[131] See for example Freudenburg (1988) and Winkler (1996)
[132] For example, Probabilistic Risk Assessment has been adopted by the US Nuclear Regulatory Commission (US NRC, 2018)