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integrity of water
resource management

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GUIDE TO THE SUPPORTING PAPERS (AND DESCRIPTOR)

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Key points

- Given the demands on water in Australia, water users and the broader community need to be able to trust that it is being managed to best effect.
- Recent reviews into compliance and enforcement in the Murray–Darling Basin found numerous shortcomings around governance, practice and resourcing. Growing mistrust and a lack of confidence in water system management during the drought were a consequence.
- While such problems have not been seen elsewhere, the Murray–Darling Basin experience contains important lessons for national policy, and recent government responses offer insights on best practice.
- Credible information about how water is used (and by who, when and why), combined with robust institutional processes, underpins the integrity of water management systems.
- A renewed National Water Initiative (NWI) would be strengthened by broadening the water accounting element to ensure the provision of credible and reliable information and institutional processes that provide assurance that:
 - entitlement holders are operating in line with their rights and water use is consistent with established rights and plans
 - water resource systems are being managed to best effect for all users.
- Provision of trusted information on the broader water context is also needed to improve understanding of key water resource challenges and potential risks, enabling entitlement holders, industry and communities to better plan for the future.
- To ensure the integrity of water use, a renewed NWI should require fit-for-purpose:
 - metering and measurement of surface water and groundwater take
 - registers and reporting on use that reflects the benefits of this information for water resource management and supports compliance and enforcement systems
 - compliance and enforcement systems, including a focus on proactive regulation to increase entitlement holders' awareness of their obligations.
- To promote trust and confidence, a renewed NWI should require water system managers to:
 - take a risk-based approach to developing and maintaining information and data collections
 - ensure that information and data sources are publicly available and effectively communicated
 - implement transparent quality assurance processes to ensure that information is credible
 - ensure that information about their operations is transparent.
- Information regarding the broader water context (which enables entitlement holders, industry and communities to better plan for the future) must align with users' needs.

Given the demands on water in Australia, water users and the broader community must be able to trust in water resource management. They need to have confidence that water users are complying with their obligations and that water managers are managing this valuable resource to best effect. In other words, system management should have integrity.

The integrity of Australia's water resources management rests on the provision of credible and relevant information combined with effective compliance and regulation. Information

plays a critical role in all decision-making in water resource management. Robust processes and trusted institutions can provide confidence that water users are complying with their obligations and that water system managers are undertaking their roles to best effect for the benefit of all entitlement holders and the environment.

Integrity can be gauged by the degree of trust in water management institutions and systems held by water users, communities and the market. Where there is integrity in water system management, public confidence follows.

This paper considers key issues in the provision of information and the regulation of access entitlements. These issues were highlighted in fully allocated systems in the Murray–Darling Basin (MDB) by the recent drought. There are lessons for the rest of Australia from this MDB experience that should be considered in a renewed National Water Initiative (NWI). Moreover, recent government responses offer insights on potential best practice to strengthen the integrity of water resource management given a changing climate.

1 Confidence in water management has been tested

1.1 Water accounting, metering and compliance under the NWI

Water accounting is ‘a systematic process of identifying, recognising, quantifying, reporting and assuring information about water, the rights or other claims to that water and the obligations against that water’ (BOM 2016). Metering is a key contributor to water accounts, providing data on when and how much water is being used. And monitoring of user compliance with metering requirements, with enforcement action where necessary, is needed to give confidence that information from metering is credible.

Water accounting and registers were to support confidence in water use

Under the NWI, parties agreed that:

... the outcome of water resource accounting is to ensure that adequate measurement, monitoring and reporting systems are in place in all jurisdictions, to support public and investor confidence in the amount of water being traded, extracted for consumptive use, and recovered and managed for *environmental and other public benefit outcomes*.¹

To enable this outcome, parties agreed to:²

- benchmark jurisdictional water accounting systems to encourage continuous improvement and adoption of best practice

¹ NWI paragraph 80.

² NWI paragraphs 81-85.

-
- the development and implementation of:
 - accounting system standards, standardised reporting formats and water resource accounts that can be reconciled annually
 - integrated accounting of groundwater and surface water use (where there is close interaction)
 - principles for environmental water accounting
 - a register of, and annual reporting for, environmental water.

The aim of these water accounting actions was to provide credible information to assess whether water use (both for consumption and by the environment) is consistent with established rights and water plans. That is, to ensure that water accounting is robust and protects the integrity of the access entitlement system and the markets that depend on it.

Parties also agreed to open reporting of: metered water use, compliance and enforcement actions; trade outcomes; environmental water releases and management actions; and availability of water access entitlements against rules for availability. Compatible, publicly accessible and reliable registers of all water access entitlements and trades were also to be established: these were to enable, among other things, the monitoring of trade and water use volumes by system managers in water accounts.³ Transparent reporting against water use supports public and investor confidence — water users doing the right thing can be seen to be doing the right thing, and where they are not it can hopefully be picked up.⁴

Metering and measurement were to underpin the credibility of water accounts

The metering and measurement of water used underpins the credibility of water accounts. Meters determine the volume of water taken directly from surface water or groundwater using a pump or offtake; measurement estimates the water taken when metering is not practical, such as when water is intercepted through farm dams, forestry or floodplain harvesting.

Under the NWI, parties agreed that information from metering needed to be ‘practical, credible and reliable’ and actions were articulated to ensure it was undertaken consistently across the country. Commitments included development of: a national meter specification, national meter standards for installation, and national standards for the ancillary data collection systems associated with meters.⁵ Further, in 2009 COAG agreed to a *National Framework for Non-Urban Water Metering* (the Non-Urban Metering Framework) to help meet those commitments (DAWR 2009). The Framework was to be implemented over a ten year period to 2020, with jurisdictions publicly reporting on progress every two years via the Bureau of Meteorology website.

³ NWI paragraph 59 and schedule F(6).

⁴ NWI paragraph 89.

⁵ NWI paragraphs 87–88.

Compliance and enforcement were given little focus in the NWI

Systems to monitor and enforce compliance with metering requirements depend on accurate and reliable metering and on a sound governance framework to be effective (MDBA 2017).

Compliance and enforcement were given little focus in the NWI — in fact, they were only mentioned in the context of four water access entitlements and water resource accounting actions. Parties agreed that:⁶

- water entitlements would be enforceable and enforced
- a robust compliance monitoring regime would be implemented for interception in catchments that were approaching, at or beyond full allocation
- standardised reporting formats would be developed and implemented to enable compliance against entitlements
- national guidelines would be developed and applied, covering reporting for metered water use and compliance and enforcement actions.

However, in 2009 COAG agreed to the development of the *National Framework for Compliance and Enforcement Systems for Water Resource Management* (the National Compliance Framework) to improve compliance and enforcement efforts and to set a nationally agreed standard for pursuing consistency in compliance with jurisdiction-based water laws and regulations (COAG 2012).

The Australian Government provided \$53.4 million over four years (ending 30 June 2016) through National Partnership Agreements to States and Territories to implement the National Compliance Framework (PC 2017, p. 456). In particular, the funding was to ‘assist the transition to adopting the new framework and increasing the compliance and enforcement effort’ (COAG 2012, p. 1).

The Department of Environment (Cth) (2016) stated that the National Compliance Framework is important because it:

- protects the rights of water entitlement holders by having extra compliance officers on the ground and by using smart technology to detect non-compliance
- protects water-dependent natural ecosystems by focusing compliance efforts on river systems at the highest risk
- contributes to the sustainability of water use and thereby protects the interests of communities
- deters the unlawful taking and use of water by improving and harmonising water laws around Australia

⁶ NWI paragraph 31(vi), paragraph 57(i)(c), paragraph 82(ii) and paragraph 89(i).

-
- treats the unlawful taking and use of water as a national problem, with all Australian states and territories implementing strengthened compliance programs.

1.2 Compliance has been under scrutiny in recent years

Despite metering and compliance frameworks being in place, events in the MDB, including during the recent drought, has shown that they have not been enough to ensure the integrity of water system management in times of stress. A lack of commitment to compliance and enforcement, insufficient metering by and monitoring of entitlement holders and a growing mistrust and lack of confidence in water system managers in the MDB over the last few years have highlighted the critical importance of establishing credible and trusted water management in all water systems before they become as highly contested as the MDB.

The Commission's 2017 assessment of jurisdictions' progress against their NWI commitments found that a lack of progress towards meeting the commitments under the Non-Urban Metering Framework had undermined compliance. Difficulties with certifying meters to the required standard and a lack of water user buy-in presented challenges with implementing the framework within the timelines it set out (PC 2017; Sinclair and Holley 2015).

The Commission also found that, while progress had been made in implementing the National Compliance Framework, the framework 'does not seek to cover all factors that may contribute to effective compliance, such as broader institutional and governance arrangements' (PC 2017, p. 459).

The broadcast of the ABC Four Corners program *Pumped* in 2017, on water management in the Barwon-Darling river system, raised questions about the effectiveness of compliance and enforcement regimes in the MDB (particularly in New South Wales and Queensland⁷) and was a wake-up call to many stakeholders and communities around the country. Governments announced a number of reviews in response (box 1).

Key findings from these reviews included:

- shortcomings in the transparency, independence and effectiveness of the agencies responsible for regulating access entitlements for water resources
- a lack of commitment to accurate metering and measurement of water take
- low levels of compliance resourcing, and a weak compliance and enforcement culture
- an inappropriate range of penalties and sanctions available for enforcement
- a preference for customer service over regulation.

⁷ The 2017 review into compliance found that Victoria and South Australia had strong compliance systems and cultures in place with the main issues being an inadequate suite of penalties and sanctions and an aging meter fleet respectively (MDBA 2017, pp. 12–13).

While these findings were not universal for regulatory agencies and governments in MDB jurisdictions, they highlighted the inadequacies of the prevailing frameworks.

Box 1 **Reviews in response to issues raised by Four Corners**

A number of reviews with a compliance and enforcement focus were announced following the ABC Four Corners program, *Pumped*, which aired in July 2017.

- The interim report for the *Independent Investigation into NSW Water Management and Compliance* (Matthews Report) concluded that ‘water related compliance and enforcement arrangements in NSW have been ineffectual and require significant and urgent improvement’ (Matthews 2017b, p. 4).
- The *Murray Darling Basin Water Compliance Review* (2017) raised concerns about: a lack of comprehensive reporting on compliance; deficiencies in the compliance efforts of some water regulators, including the commitment to accurate metering and measurement of water take; and relatively low levels of compliance resourcing in some Basin jurisdictions.
- The NSW Ombudsman’s (2018, p. j) water investigation found evidence that DPI [Department of Primary Industries (NSW)] Water and WaterNSW had failed to:
 - adequately resource, or secure funding to adequately resource, their compliance functions
 - take appropriate and timely action on instances of clear breaches of the law
 - meet acceptable standards of public administration in the conduct of their compliance functions, and that
 - DPI Water failed to ensure water meters met the requirements of the Interim Metering Standards for non-urban water meters — undermining compliance efforts.
- Findings from the *Independent Audit of Queensland Non-Urban Water Measurement and Compliance* (2018, p. v) included:
 - a series of deficiencies in current arrangements for measuring the take of water from supplemented and unsupplemented waters, and from overland flows
 - an absence of appropriate water accounting and management control systems
 - a deteriorating situation in relation to water metering and measurement including understaffing in technical and operational areas
 - a weak enforcement and compliance culture leading to ineffective water management.
- With respect to compliance, the South Australian Murray–Darling Basin Royal Commission (2019, p. 650) found that:

...vast differences in penalty regimes and a scarcity of previous successful prosecutions across Basin States ... make it difficult ... to assess any interstate differences in how courts have responded to conduct such as water theft

State laws generally appear to be sufficiently robust ... Concern [has focused on] the operational capacity of States to monitor, and cultural willingness to pursue, enforcement outcomes ... even though a range of national agreements has attempted to promote consistent national standards.
- The Independent Commission Against Corruption’s investigation into the management of water in New South Wales (2020, p. 11) found that the finding there was ‘a certain lack of support for strong compliance and enforcement measures, a preference for customer service over regulation and a lack of commitment to properly resourcing compliance functions’.

The New South Wales and Queensland governments responded to the findings with major reform programs — *Securing our Water: NSW Water Reform Action Plan* (December 2017) and the Queensland *Rural Water Management Program* (July 2018), respectively.

As well as the reforms initiated by New South Wales and Queensland, all MDB jurisdictions signed the Murray–Darling Basin Compliance Compact (MDBCC) in June 2018. Subsequently endorsed by COAG in December 2018, the MDBCC aimed to:

...restore confidence in water resource management in the Basin by providing transparency and accountability of surface and groundwater management and regulation, and a consistent approach to compliance and enforcement practices by governments across the Basin. (MDB Ministerial Council 2018, p. 1)

Jurisdictions’ progress in implementing commitments under the MDBCC is to be verified and reported on annually. The second annual assurance report found Basin jurisdictions and the Australian Government continuing to make progress and acknowledged the impact of drought conditions on implementing actions (MDBA 2019d). Notable delays were observed in: the rollout of AS4747 compliant meters in New South Wales; Victoria’s compliance strategies; and Queensland’s and South Australia’s improvement programs. A lack of progress on the ACTs metering policy and implementation plan was also noted.

More recently the interim report of the MDB water markets inquiry (ACCC 2020, p. 24) identified metering requirements as a key element of market architecture that ‘provide a framework for managing trade, ensuring compliance with individual entitlement limits and system limits, and limiting the opportunities for water theft’. The interim report found that the variation in key elements (such as metering) across jurisdictions may undermine confidence in the integrity of the market, with participants doubting that they are all treated fairly. Potential reform options identified for further exploration included ‘improving consistency across Basin States’ accounting and metering requirements’ (ACCC 2020, p. 37).

Further changes will occur in the compliance space for the MDB with the Australian Government announcing in September 2020 that the Interim Inspector–General of Water Compliance will take over the statutory compliance and enforcement functions of the Murray–Darling Basin Authority (MDBA) (Pitt 2020). The Inspector–General will be supported by the Office of Water Compliance to be established in the Department of Agriculture, Water and Environment once amendments are made to the *Water Act 2007* (Cth) (IGWC 2020).

While other jurisdictions have escaped the spotlight on their compliance regimes the MDB has faced in the last three years, the Environmental Defenders Office notes that:

...compliance and enforcement in Western Australia appears to be prima facie problematic. For example, we have been unable to find any publicly reported prosecutions brought by the state for alleged breaches of the *Rights in Water and Irrigation Act 1914* (WA). (sub. 54, p. 8)

Although jurisdictions outside of the MDB have not initiated any major reforms in the last three years with respect to metering or compliance, implementation of and reviews into existing policy have continued. Western Australia will finalise the implementation of its

Measuring the Taking of Water Policy by 31 December 2020 so that all water licences greater than 10 megalitre will be subject to metering requirements. Tasmania is currently consulting on a *Rural Water Use Strategy*, and the Northern Territory is implementing its *Non-Urban Water Metering Code of Practice for Water Extraction Licences* (introduced in mid-2017). While Tasmania has made some changes to how compliance activities are delivered in the last three years, neither Tasmania nor the Northern Territory report on compliance activities (*Assessment*: section 5).

1.3 Mistrust and a lack of confidence in water system management has been growing

In addition to raising issues about compliance and enforcement in the MDB, recent reviews have identified a growing mistrust and a lack of confidence in water system management in the MDB. Water resources in the MDB are highly developed and fully or overallocated — and there is a huge water market which facilitates about \$2 billion worth of water trading annually (MDBA 2020c) (box 2).

Box 2 Mistrust in MDB water system managers has been growing

Several reviews found growing mistrust in water system managers in the Murray–Darling Basin (MDB).

- The Interim Inspector-General of MDB Water Resources (2020, pp. 29–30) found that the river operations process is not well understood by the community, and that there was a lack of trust and confidence among irrigators that river operators were delivering water efficiently. It recommended that the Murray–Darling Basin Authority provide clear and accessible information about Special Accounting measures to increase trust in and transparency about water-sharing, and for the Basin Operations Committee to implement a single authoritative information platform to provide higher levels of transparency and trust (IIGMDB 2020, p. 15,41).
- Sefton et al. (2020, p. 24) noted that there were concerns from the community about degradation of waterways, which were believed to have been caused by system management issues. The report recommended that transparency of river operations and governance arrangements needed to be improved.
- Craik and Claydon (2020, pp. 5–7) found that there was a high level of mistrust and a perceived absence of transparency in New South Wales' water management. This was exacerbated by the recent 2020 Northern Basin First Flush event, which involved a series of temporary restrictions on water extractions in New South Wales to manage inflows and prioritise water for critical human and environmental needs (discussed in section 6.4). A key finding of the review was that delays in publishing information about the event, and after it was over, led to views of mistrust, secrecy and mismanagement by the system manager.
- Vertessy et al. (2019, p. 30) found that communities had conveyed scepticism and a lack of trust in the information being used by system managers to make decisions about river operations and management. For example, there was dispute about the evaporation rates used to inform operational decisions.

Events in the MDB, including the recent drought (*Report*: chapter 2), have contributed by reducing the amount of water available. Water is a highly valuable resource, and its value (along with public expectations for system managers to manage the resource well) increases in times of water shortage.

But these events have not been the only factor — mistrust has also been fuelled by a lack of information, poor communication of the information that is available, and difficulties for stakeholders in accessing, navigating and reconciling available data collections. A lack of transparency around water system managers’ decision-making, operations and performance has contributed to concerns that they are not being held accountable. Inadequate transparency has also contributed to misperceptions or misinformation about water availability, worsening the relationship between communities and water system managers (and the governments that fund them) (IIGMDB 2020, p. 40).

There have been some national initiatives to improve water information collected and made available to the public. For example, the *National Industry Guidelines for Hydrometric Monitoring* provide guidance and technical information on hydrometric practices (Bewsher Consulting Pty Ltd 2018, p. 10). And in 2007, the Bureau of Meteorology received about \$80 million over five years to fund the *Modernisation and Extension of Hydrological Monitoring Systems Program*. This funding was used to improve and expand jurisdictional water monitoring systems and data collection (NWC 2014, p. 56).

However, such initiatives do not address the issues observed in the MDB. Renewal of the NWI presents an opportunity to put in place initiatives to address the types of issues that have arisen in the MDB before they arise in other systems. As Australia’s climate changes, the effects on water resources and availability will make water system management more challenging; they are likely to generate greater public scrutiny as inflows reduce and the value of water rises. The current Agreement does not explicitly include provisions to address the integrity of water system management. This is a gap that could be remedied to prevent the issues currently evident in the MDB.

2 A framework for trusted and credible water resource management

Trusted water resource management is underpinned by credible and reliable information and by robust institutional processes that provide assurance that:

1. entitlement holders are operating in line with their rights, and that water use (both for consumption and by the environment) is consistent with established rights and water plans
2. water systems are being managed to best effect for all users.

Trust in water governance frameworks is also influenced by the availability, and understanding, of information regarding the broader water context. Such information is often referred to in commentary about building community water literacy (BOM 2017, p. 9;

IWG 2016, p. 2). It can help individuals, communities and businesses to understand key water resource challenges and understand their own potential risks, and can more effectively allow them to plan for the future.

Figure 1 conceptualises the requirements needed to ensure the integrity of the entitlements system and water resource management more generally.

2.1 Demonstrating water users comply with their licence obligations

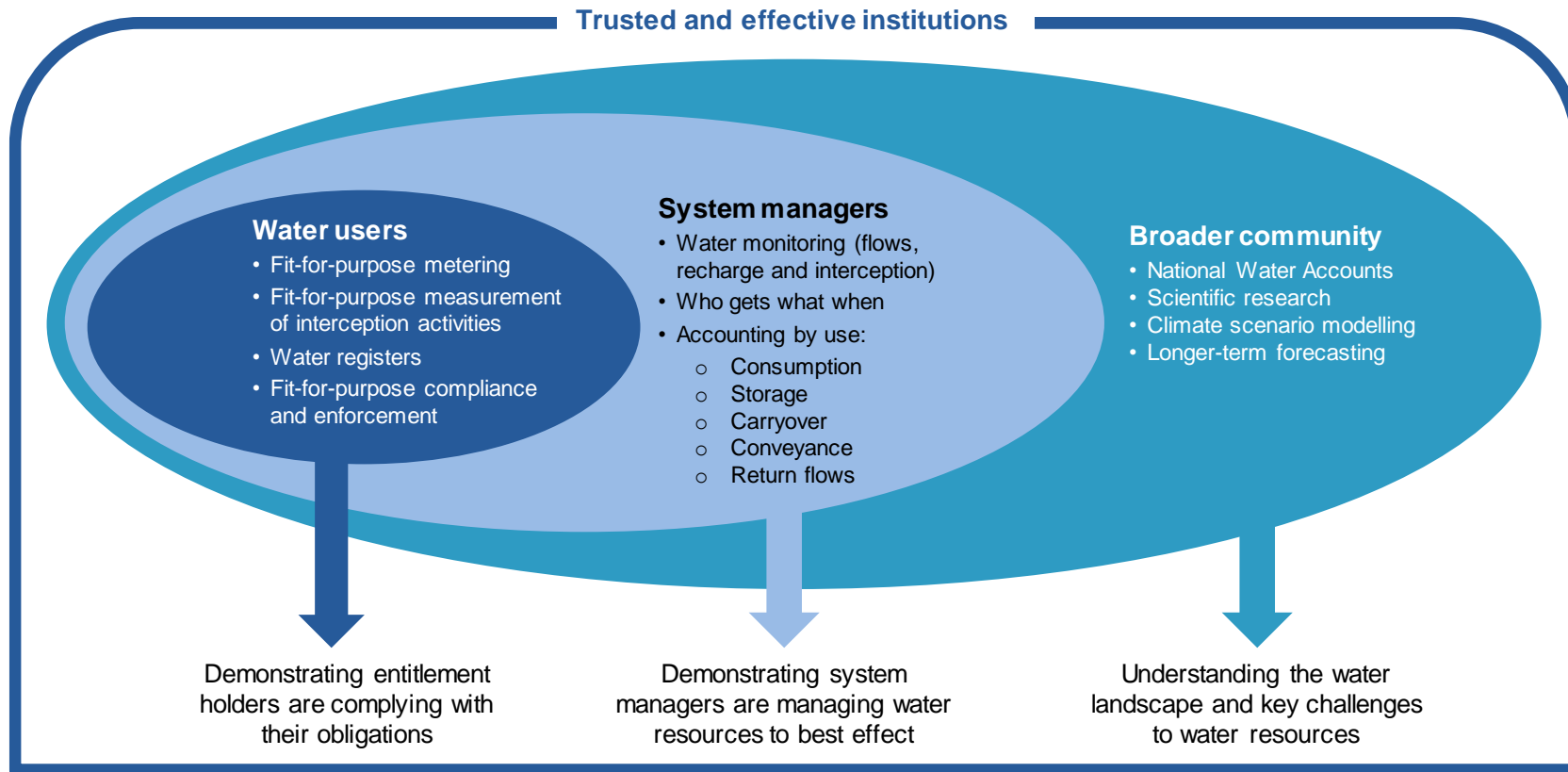
Water users and communities need to be confident that all entitlement holders are complying with their water entitlement obligations in both their use and trade of water. It is well understood that non-compliance will impact on other entitlement holders in the system and/or the environment.

The ability to provide assurance on this relies on a range of key institutional processes being in place and operating effectively, and on information being transparently available to the community. Key processes include metering and measurement, the use of water registers, and compliance and enforcement efforts.

Metering and measurement for both surface water and groundwater take provide the basic evidence that entitlement holders are only taking as much water as they are allowed, when and where they are allowed. How and how often entitlement holders report their water use depends on individual jurisdictions' non-urban water metering policy.

Water access regulators use metering and measurement information to assure entitlement holders and water users that their property rights are protected, underpinning the integrity of the access entitlement system. This information is also used at an aggregate level to reconcile opening and closing water balances with total water inflows and outflows reported at the system level and is 'essential for comprehensive water accounting' (MDB Ministerial Council 2018, p. 5).

Figure 1 Framework for ensuring integrity in water resource management^a



^a Water use includes access through entitlements, stock and domestic use, interception activities, environmental use (planned), cultural use and community use through drinking water, recreation and liveability.

Water registers provide basic information on water access entitlements and trades — including location, prices of trades and identities of entitlement holders.⁸ Jurisdictions have agreed to implement ‘compatible, publicly-accessible and reliable water registers of all water access entitlements and trades (both permanent and temporary) on a whole of basin or catchment basis’.⁹ By providing this basic information publicly, water registers enable the efficient (by minimising transaction costs through information provision), and equitable (by recognising and protecting environmental needs and third-party users), operation of water markets and inform water system managers of the authorised movement of water between users.¹⁰ Water registers also enable system managers to ‘monitor and accumulate trade and water use volumes accrued under water entitlements in a separate water accounting system’¹¹ (discussed in section 3.2). Registers are discussed in more detail with respect to trade in the *SP B Trading*: section 3.1.

State and Territory Governments are responsible for ensuring compliance with water laws within their jurisdictions and managing water systems. Trusted and effective institutions regulating and reporting on water use are critical to the integrity of water resource management across Australia:

An effective and fair compliance system is critical ... It underpins the integrity of water resource plans, environmental watering, water property rights and the water market. (MDBA 2017, p. 11)

As noted above, the recent focus on compliance and enforcement in the MDB has shone a light on weaknesses in the national frameworks agreed to in 2009 that have implications for all jurisdictions in a changing climate. Particular gaps relate to governance in compliance and enforcement regimes (including independence, transparency, adequate resourcing and capability), as well as the engagement needed with entitlement holders to improve understanding of their water licence conditions. Best-practice principles for the regulation of non-urban water resources and for engagement with entitlement holders are discussed in section 3.3.

2.2 Demonstrating that water systems are being managed to best effect

System managers use information from a broader range of sources (including water users) in order to understand and manage their water resources to best effect (to maximise benefits for entitlement holders and the environment).

Broadly, water system managers need to understand their system hydrology and infrastructure, user demands (including likely volumes and locations), environmental requirements (including likely multi-year demands and locations) and system losses under a range of climatic scenarios. They then need to use this knowledge to create operating

⁸ NWI schedule F.

⁹ NWI paragraph 59.

¹⁰ NWI paragraph 58.

¹¹ NWI schedule F(6).

practices that allow them to allocate water inflows to entitlement holders throughout a season, manage their storages and transfer bulk water to different parts of the system to maximise water availability to entitlement holders and deliver water to users when and where they want it. Achieving these outcomes involves a complex optimising function built on information collection and system knowledge, informed by modelling and refined through operational practice. It becomes particularly complicated in large, highly regulated and connected systems like the southern MDB, the Melbourne system and the Hawkesbury–Nepean systems.

Entitlement holders need to have confidence that the system manager is undertaking this function to best effect given that it can affect the volume of water available to them within a season and the deliverability of that water. System managers need to be able to adequately demonstrate this outcome to water users. To that end, the information needed to support their operations should be available to stakeholders and the public — to promote transparency and accountability and to increase confidence that water systems are being managed efficiently and effectively.

Section 4 discusses in more detail: the role of water system managers; how to address current issues (including growing mistrust in water system management, which has been fuelled by a lack of publicly available information) and some examples of leading practice.

2.3 Building understanding of the broader water context

The broader community needs information to understand the water landscape, the impact of key challenges on water resources and the potential risks that these pose to communities and businesses. Better informed community members are more likely to understand how water systems are managed and what that means for them, including future risks. Information puts them in a position to proactively plan and make decisions about their future. The MDBA noted that information must be accessible, timely and user-focused to help communities build knowledge and capacity to navigate and adapt to the water management system (sub. 23, p. 11).

This type of information is also of value to policy makers, urban water utilities and academics, and includes:

- system water accounting (including at the national scale)
- water market and trading trends
- scientific research, including on future risks to water resources
- climate scenario modelling and impacts on water resources
- longer-term forecasting.

It provides the longer-term context for water resource management and can support improved planning for water management, communities, businesses and utilities when it is independent or independently reviewed, transparent and publicly accessible.

Best-practice principles for information collection on the broader water context are discussed in section 5. A more detailed discussion of role of research and modelling is provided in SP K *Knowledge* and the need for governments to improve water information accessibility and comprehensibility is discussed in SP J *Engagement*.

3 Ensuring water users comply with their licence obligations

The need to account for differences in water systems across all elements of water resource management to ensure effective and efficient outcomes is established in *Report*: chapter 5. For issues like metering by entitlement holders, the requirements and standards applied should increase with the level of system development and risks to the environment and other users. Likewise, compliance and enforcement systems should differ according to the level of development and environmental risk in a system.

The following sub-sections apply the framework set out in *Report*: chapter 5 for water resource management to metering and measurement of entitlement holders' water use and compliance and enforcement systems. The role of water registers and leading-practice principles for compliance and enforcement are also discussed, as is the importance of engaging with entitlement holders so that they understand the conditions of their water access entitlements.

3.1 Fit-for-purpose metering and measurement is required

Metering and measurement of non-urban water is critical ...

The importance of metering and measurement of water use to effective water resource management has been highlighted recently. As the MDBA noted:

A compliance system depends on accurate, reliable, tamper-proof meters, good data on river flows and groundwater, and modelling appropriate for annual auditing of water take. Accurate metering and measurement are fundamental for water management, compliance and community confidence. (2017, p. 17)

And as the Australian Competition and Consumer Commission observed:

Without adequate and consistent metering across the Basin, it is not possible to maintain an effective compliance and enforcement regime. (2020, p. 468)

Inquiry participants also noted the interdependency of water measurement and accounting with effective compliance and enforcement of water rights:

... compliance and enforcement — together with accurate water measurement, water accounting and auditing — form the basis of good water governance. (EDO, sub. 54, p. 7)

... robust compliance is dependent on accurate measurement and auditing to ensure compliance with actual permitted usage. (IRN, sub. 86, p. 11)

Without strong water accounting capabilities and practices, effective compliance is highly unlikely and trust in the water management system is unachievable. (MDBA, sub. 23, p. 4)

Effective metering and measurement of water take is a prerequisite to ensuring compliance with entitlements and protections of rights to water. (LBA, sub. 70. p. 19)

... but the Non-Urban Metering Framework is yet to be fully implemented

In our assessment of the implementation of the Non-Urban Metering Framework, the Commission found that — despite progress in recent years (particularly in New South Wales) — no jurisdiction had fully implemented the requirements in the timeframes set out (*Assessment*: section 5). Irrigation Australia, in their submission to the inquiry stated that:

... states and territories have fallen short of the expectations and objectives on the National Water Initiative with respect to the area of metering and measurement ... had the NWI and the National Framework been implemented in accordance with the undertakings provided, then a national metering standard would have been achieved. (sub. 3, pp. i -ii).

They also observed that compliance with the NWI and the Non-Urban Metering Framework has been ‘generally poor’ in a number of areas (Irrigation Australia, sub. 3, pp. 3–6):

- The National Framework has not been implemented on a national and consistent basis.
- Despite the principle agreed in the framework that states & territories will use certified installers, maintainers, and validators, not all states have complied with this.
- Several states have not complied with the AS 4747 standard as required by 1 July 2020; some states have simply exempted themselves.
- Meters installed after 30 June 2010 in every state & territory did not comply with the national metering standard by 2020, however NSW introduced this requirement on 1 April 2019, South Australia on 1 November 2019 and Victoria in March 2020 (with exemptions). Other States are showing little intention to comply with this requirement some eleven years after the adoption of the framework.
- No states have adopted the requirement to replace a meter installed before 2010 with a compliant pattern approved meter by 1 July 2020 however Victoria are requesting water corporations to prioritise the replacement of non-compliant meters by June 2025.

The lack of consistency between states on water measurement, metering, assurance standards and compliance was also raised by other inquiry participants (CICL, sub. 7, NIC, sub. 13), with the Environmental Defenders Office noting that the NWI ‘leaves room for significant discretion regarding its application (and implies that legislative exemptions are acceptable)’ with respect to metering (sub. 54, p. 4).

Of particular concern to a number of inquiry participants was the difference between metering and measurement in regulated and unregulated systems within the MDB:

The above clause [NWI 87] was to be implemented by the end of 2007, fast forward to today, and there is still no accurate metering of flood plain harvesting take in the Northern Basin ... There has been no metering of water in the north on any consistent basis. (SRI, sub. 77, p. 12)

In terms of unauthorised use or monitoring of diversions, the southern connected basin in NSW, Victoria and SA [South Australia] have had a long held culture and practice of high quality monitoring and metering of actual water use. Recent and well publicised failings in the largely unregulated river systems in the northern Murray Darling Basin must be corrected to underpin public confidence in the wider irrigation industry. (RGA, sub. 82, p. 9)

There has been inequitable application of Nationally Agreed metering standards. (MVPD, sub. 101, p. 4)

In our view, FPH [floodplain harvesting] is the elephant in the room. The total volume taken is not known and estimates are thought to be conservative. This is a concern as models are only as good as their inputs and the assumptions applied to those inputs. In our view, the lack of a consistent MDB-wide accounting framework and accurate metering of all forms of take, especially FPH, provide further evidence that basin states are failing to meet NWI objectives and outcomes. (AFA, sub. 45, p. 3)

While MDB jurisdictions have all revised their non-urban metering policies to meet requirements under the MDBCC consistent with the Non-Urban Metering Framework and the NWI, albeit under revised timeframes, these concerns are likely to remain until revised non-urban metering and floodplain or overland flow harvesting policies are fully implemented.

Real-time data provides timely information but at a cost

In a changing climate where the stresses on water resources are increasing, timely information on who is using water, how, where and when becomes incredibly useful for regulators and system managers. A number of inquiry participants commented that making this type of information available in real time would help to demonstrate that licence conditions are being met — particularly with respect to entitlements where the timing of take is critical, such as floodplain or overflow harvesting in the northern MDB and the MDB more generally (EDO, sub. 54, p. 5; Engineers Australia, sub. 63, p. 12; SRI, sub. 77, p. 16; AWA, sub. 89, p. 10).

The Victorian Government already ‘aims to keep real-time balances of water allocation in individual allocation accounts’ and uses this information as part of their compliance system to determine if there is sufficient allocation to account for the use (sub. 108, p. 10). The Victorian Farmers Federation submitted that in other MDB jurisdictions, where real-time accounting is not in place, there are ‘direct river diverters taking water they do not have available in their accounts’ (sub. 99, p. 9). Victoria requires telemetry at sites where water take on average is more than 5000 megalitres per year; however, water corporations may define a lower threshold for take in higher risk systems or for higher risk water users (DELWP (Vic) 2020, p. 13).¹²

¹² Victoria recommends telemetering of information when the net cost of automation is lower than the cost of manual meter reading or to improve safety - over half of Victoria’s meters have telemetry installed (DELWP (Vic) 2020, p. 11).

New South Wales now requires all non-urban metered take from pumps greater than 200 mm diameter to have telemetry and automatically transmit water take data in real time (DPIE (NSW) 2020a, p. 10). This initiative will be progressively rolled out between now and 2023. Queensland, Western Australia, South Australia, and Tasmania require that meters are capable of telemetry, but currently do not require the automatic transmission of data (DEW (SA) 2019; DNRME (Qld) 2019; DOW (WA) 2009; DPIPWE (Tas) 2014).¹³ The ACT requires that all new meters from 2015 on that have water take greater than 5000 ML per year comply with the AS4747 (ACT Government 2015, p. 3).

A number of inquiry participants expressed concerns about rolling out more accurate meters and telemetry without proper consideration of the benefits against the costs (NIC, sub. 13, p. 13, AgForce, sub. 24, p. 5, NFF, sub. 42, p. 24).

In 2017, the Commission considered that policies guiding the implementation of non-urban metering and measurement should follow the principle of being risk-based with reforms to metering arrangements subject to scrutiny through standard regulatory and economic review processes. In particular, the Commission noted that cost-benefit analyses of proposals for more comprehensive metering, such as setting targets to meter 95 per cent of water take, should be made available to the public (PC 2017, p. 292). The National Irrigators Council emphasised that ‘achieving the highest possible standards in metering requires genuine consultation and engagement with users and manufacturers to ensure standards and targets are practical and effective’ (sub 13, p. 14).

A risk-based approach is needed

The MDBA has recently developed guidelines explicitly setting out that a risk-based approach should be taken in setting metering thresholds (box 3). While the guidelines were an action under the MDBCC, they were developed collaboratively by the MDBA and all jurisdictions; they include guidelines for zones outside of the MDB for both MDB jurisdictions and for non-MDB jurisdictions.

In the main, the guidelines are similar for MDB and non-MDB jurisdictions. The key difference is that all meterable take must be metered, and non-urban water meters must meet the Australian Standard AS4747, by 2025 in Basin jurisdictions. Non-Basin jurisdictions’ non-urban water meters must meet the Metrological Assurance Framework requirements (set out in the Non-Urban Water Metering Framework) at a date they determine (MDBA 2019g). The Metrological Assurance Framework specifies key requirements for non-urban water meters — including for installation, maintenance, validation and reporting — with the primary objective that ‘national metering standards should seek to provide an acceptable level of confidence that measurement performance under *in situ* conditions is within maximum permissible limits of error of +/- 5%’ (DAWR 2009).

¹³ South Australia has committed to exploring opportunities to mandate telemetry for high risk sites (DEW (SA) 2019, p. 4).

Box 3 **Best-practice guidelines for minimum metering thresholds**

Best-practice guidelines for minimum metering standards were developed collaboratively by the Murray–Darling Basin Authority and all Australian states and territories. The first two principles relate to meeting commitments made under the National Water Initiative, and (for MDB jurisdictions) the Basin Compliance Compact. The third principle acknowledges that State and Territory Governments are responsible for determining their non-urban water metering policy and regulations, including metering thresholds. The remaining principles (clauses three to six) are the same for all jurisdictions.

- In setting metering thresholds, governments should take a risk-based approach that maximises the measurement of water taken, particularly for high-risk users, and avoids imposing undue costs, particularly for low-risk users.
- Risks that are relevant to setting the metering thresholds include risks to meeting the environmental, social, economic or cultural requirements for the water.
- The basis upon which the metering thresholds have been set, including any exemptions to thresholds, should be justified and published on the relevant state agency website.

Following the principles, two guidelines (clause seven and eight) set out when licenced take is to be metered and the exceptions allowed.

1. Licensed water take or utilised water take capacity will be metered by a date determined by the jurisdiction, including for:
 - (a) Licensed surface water and groundwater take
 - (b) Large or high risk licensed water take for stock and domestic uses, mining and industrial uses; and
 - (c) Water captured through floodplain harvesting and by collecting overland flows, but only when it is possible to meter or measure the water through best practice means.
2. A government can determine that exemptions apply to their metering threshold requirements. Exemption criteria can apply for individuals or groups of entitlement (allocation) holders, and may include exemptions:
 - (a) For small entitlements (determined by volume or infrastructure size)
 - (b) Where the water taken is not capable of being measured by a meter
 - (c) Where the costs of metering would otherwise significantly outweigh the benefits
 - (d) Where the entitlement holder can demonstrate that water cannot be taken (for example inactive infrastructure)
 - (e) Where any environmental, social, economic or cultural requirements for the water are not at risk through the use of the exemption.

Source: MDBA (2019a, pp. 3–5).

The MDBA is coordinating a revision of the Metrological Assurance Framework with the states and territories (MDBA 2019b; NMI and DIIS 2019). The revised Framework will look

to include a greater use of risk management to prioritise metering implementation and management requirements (pers. comm., MDBA, 23 November 2020).¹⁴

Report: chapter 5 illustrates conceptually how the level of metering effort and the standards applied should increase with the level of development and risks to the environment (figure 5.1). For example, the MDB would be considered an example of a fully developed system, with some systems within it being highly developed/overallocated. The New South Wales non-urban water metering policy prioritising the roll out of meters that meet AS4747 in pumps over 500 mm and the northern inland region (including requiring telemetry for pumps over 200 mm) is consistent with such a risk-based framework and considered by some inquiry participants as comprehensive and leading practice (Irrigation Australia, sub. 3, p. 1; NSWIC sub. 27, p. 22; LVW, sub. 40, p. 3). Canegrowers (sub. 72) provided the Wet Tropics region in far north Queensland as an example of a water resource management area where there is low competition for water and supplementary bores are rarely used. There, they noted, ‘the installation of meters and especially any requirement for meters to have telemetry would be redundant with the resulting benefit ... likely to be significantly less than the additional costs’ (sub. 72, p. 2).

Given that the Metrological Assurance Framework is currently being reviewed to incorporate a greater use of risk management, a renewed NWI should reflect any changes that result from the review so that metering and measurement requirements are fit-for-purpose. The Commission considers that some form of engagement with industry and stakeholders on changes to the Metrological Assurance Framework to confirm the practicality of implementation would be of value, given the difficulties in implementing its first iteration in a timely manner.

3.2 Registers and reporting on use

Water registers are a secure and accurate public record that capture the identity of all water access entitlement holders and trades of those entitlements, including location.¹⁵ Metering provides information on individual water use which is then included in the register as the public record, providing transparency. The form of water registers differs from jurisdiction to jurisdiction, but they generally contain information on:

- water licences associated with a water resource and their conditions
- ownership details

¹⁴ Unlike the National Compliance Framework, the Non-Urban Metering Framework did not reference risk-based implementation when it was agreed to in 2009. Instead, a distinction was made between priority meters (those with a capacity of 5000 ML/year or greater or otherwise identified as a priority meter for management purposes) and other meters (DAWR 2009). The main impact of this classification for entitlement holders lay in requirements that priority meters were to be self-audited twice a year (compared with once a year for other meters) and that priority meters were to be replaced with compliant meters by 30 June 2014 (30 June 2016 for other meters).

¹⁵ NWI Schedule F(1).

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- water trading statistics
 - water determinations/allocations.

Although accessibility and reliability vary, information provided in water registers can often be explored using a search function or via a map, and in most cases basic information is freely available online (*Assessment*: section 2).

While water registers fulfil a key function by providing information that supports the smooth functioning of water markets (*SP B Trading*), they are also a critical source of information for water system managers, environmental water managers, regulators, policy analysts, irrigation infrastructure operators and the wider community. Water registers enable all these groups to understand who has an entitlement and how they are using it over time in a clear and transparent way, underpinning the integrity of the water entitlement system.

Technology innovations are improving options for accessing and using water register data in cost-effective ways. These technology benefits offer opportunities for more responsive and adaptive management and are highlighted in the Victorian Water Register 10 Year Strategy 2019–2028:

Improving access to data and information will help water managers and users to make better informed decisions about if, when and how to engage in water markets; support water resource practitioners to make better decisions; and, support improved community understanding of the Water Register, the water entitlement framework and water markets. Improving access to data and information will also provide opportunities for third parties to develop value added products and services. (DELWP (Vic) 2019b, p. 6)

As with metering and measurement above, reporting in real-time against water entitlement conditions and use should be fit for purpose, with the timeliness of reporting and the information reported increasing with the level of development and risks to the environment. Engineers Australia outline some of the factors that would need to be considered in assessing the level of reporting:

Consideration should be given to reporting diversions against water entitlements publicly, in real time, and metered diversions against permitted take. Such an option is not without issues: cost, data accuracy, privacy and commercial interests would all need to be considered. However, this would increase transparency, simplify compliance and reporting requirements, and provide a detailed database for later assessments. (sub. 63, p. 12)

As with many other aspects of water resource management, these decisions should not be ‘set and forget’ but regularly reassessed, particularly as technological developments will continue to improve accuracy and reduce costs.

While water registers have been progressively improved over the years in response to the evolution of water markets and needs of water users in those markets (*Assessment*: section 2), only one guideline out of six on water registers¹⁶ explicitly acknowledges the

¹⁶ NWI schedule F.

critical function they serve for water resource managers in monitoring trade and water use as an input to water accounting systems. In addition to supporting trade decisions, a renewed NWI should consider reflecting the benefits that water registers and other reporting can deliver more broadly for water management — specifically the role that water registers and reporting can play in ensuring the integrity of water use by entitlement holders, water management at the system scale and the broader water context.

3.3 Commitment to leading-practice compliance and enforcement is needed

Trusted and effective institutional processes regulating and reporting on water use are critical to the integrity of water resource management across Australia.

As highlighted in section 1.2, compliance with water obligations in the MDB has been under scrutiny in recent years, and as a consequence there has been a large amount of reform activity in the MDB jurisdictions over the last three years.

As with metering and measurement and registers and reporting, compliance and enforcement activities should be fit for purpose and risk-based. It is also important, given improvements in technology, that compliance and enforcement systems are open to innovation. The level of compliance monitoring and the types of enforcement activities should increase with the level of development and risks to the environment. A fit-for-purpose, risk-based approach is also more likely to be supported by stakeholders:

It is important that in seeking to deliver effective transparency and accountability that the requirements placed on water users are fair, cost effective and in proportion to the risk of non-compliance in a catchment. (AgForce, sub. 24, p. 5)

In its evaluation of the National Compliance Framework, KPMG (2016) found that jurisdictions had most progressed and aligned with the risk-based compliance and enforcement, best practice tools, public and stakeholder education and monitoring elements — with further work required on legislative framework and annual public reporting. However, while the Framework laid out good foundations for compliance and enforcement systems, such as monitoring and reporting, they alone are not enough — with a number of jurisdictions still failing to meet those requirements (*Assessment*: section 5). Findings from the reviews into compliance in the MDB highlighted gaps in the Framework that need to be addressed in all jurisdictions going forward for leading-practice compliance including a strong independent compliance culture and sufficient resourcing and capability — critical components of leading-practice compliance and enforcement systems.

The MDBCC (action 2.1) required MDB jurisdictions to publish a revised compliance framework addressing a recommendation made in the Murray–Darling Basin Compliance Review (2017) to improve compliance and enforcement outcomes (box 4). Many of the required elements MDB jurisdictions are to include in their revised compliance frameworks

are consistent with good governance such as transparency, enabling of technologies, secure funding and capability.

Box 4

Compliance framework requirements for Murray–Darling Basin jurisdictions

Two key commitments made by each Murray–Darling Basin jurisdiction and the Murray–Darling Basin Authority through the Basin Compliance Compact were to:

1. publish a revised compliance framework addressing the following requirements from recommendation six of the Murray–Darling Basin Compliance Review:
 - (a) a risk-based strategy for guiding compliance monitoring effort
 - (b) annual audit priorities
 - (c) an escalation pathway to apply once non-compliance is detected
 - (d) a mandatory protocol for entitlement holders to follow in the event of meter failure
 - (e) a statement of the penalties and sanctions regime, and any improvements required
 - (f) annual reporting of data on compliance activities by location including the timeliness with which allegations are addressed
 - (g) provisions to ensure compliance staff are adequately trained
 - (h) a program to ensure information about entitlements, allocations, licence conditions, meter readings, account balances and so on are easily accessible to the public in real time
 - (i) a program to ensure meters are identified by a unique reference number, and entitlement and pump details are publicly accessible
 - (j) a commitment to effectiveness and efficiency, including the adoption of new technologies
 - (k) adequate resourcing based on a cost recovery pathway, with compliance budgets protected from the normal exigencies of government budgets.
2. establish a network of water compliance practitioners, co-ordinated by the Murray–Darling Basin Authority, to promote best practice and innovation in water compliance.

Sources: MDBA (2017, pp. 21–22); MDB Ministerial Council (2018, p. 4).

Further, the MDBCC also provides a good blueprint for accountability principles, building public confidence in compliance arrangements as they ‘will be measured, publicly reported on in a timely manner and independently verified’ (MDB Ministerial Council 2018, p. 3). Measures to support transparency and accountability of governance arrangements to ensure a strong culture of compliance may include publication of (MDBCC action 1.1):

- a statement of obligations for non-urban water management
- Ministerial letters of expectations (including an expectation of regulatory best practice)
- compliance metrics as a performance indicator for executive staff
- ethics training for compliance staff.

Under the MDBCC transparency and accountability section (action 1.2), each MDB jurisdiction had to publish:

- a reporting framework for identified significant water management decisions involving discretion
- a work program to improve the transparency of information about water take under entitlements, addressing
 - real-time information on flows, extractions and related rules in unregulated river systems
 - location of take and levels of take in all surface and groundwater systems
 - changes to water registers to ensure that information about water entitlements and trades can be easily accessed by the public.

Water registers in particular, as outlined above, serve a critical compliance function — allowing regulators and others to observe whether the conditions of the water access entitlement and trades are being adhered to.

A number of inquiry participants identified the need for a renewed NWI to explicitly include an element addressing effective compliance and enforcement:

The NWI says relatively little about compliance and enforcement at the individual and catchment scales, which is arguably out of step with community expectations ... The next iteration of the NWI should emphasise the need for: Strong compliance and enforcement culture including appropriately resourced, independent water regulators (modelled on the NRAR) underpinned by appropriate governance arrangements. (EDO, sub. 54, pp. 7,9)

Any update to the NWI should include consideration of the critical importance of effective and transparent compliance regimes in water management arrangements. (MDBA, sub. 23, p. 6)

Clearly water use compliance should be part of the NWI and there is a need for consistency between the states on how this is achieved. (Engineers Australia, sub. 63, p. 11)

Renewing the NWI provides an opportunity to explicitly include leading-practice principles for the compliance and enforcement effort, including good governance and clear regulatory objectives, to facilitate confidence and trust in the institutional processes responsible for supporting water entitlement property rights. The principles and actions set out under sections one and two of the MDBCC provide a sensible starting point for these discussions.

3.4 Water users need to understand their entitlement obligations

Unintentional non-compliance due to complex water legislation and management

The complexity of water legislation and water management in most Australian jurisdictions means that many water users may be unintentionally non-compliant with their licence conditions (and complicates the compliance task).

In Ken Matthews' final report into New South Wales' water management and compliance, he made it clear that it was not his view that 'non-compliance by irrigators is rife'; instead he wrote, the 'overwhelming honest majority of NSW irrigators take compliance seriously' (2017a, p. i). However, unintentional non-compliance may have a larger cumulative impact on water resources than the deliberate actions of a few. Sinclair and Holley (2015, p. 32) in a survey of New South Wales water users found that 47 per cent of respondents agreed that water laws and regulations were too complex and 27 per cent agreed that they found it difficult to understand their licence or approval conditions. If these users are unintentionally overdrawing against their entitlements or taking water at a time inconsistent with their entitlement, this can undermine the integrity of water entitlements and water plans. As part of their Compliance Monitoring and Audit program NRAR engage with communities to ensure water users understand their rights and responsibilities as approval and licence holders. In 2019-20, NRAR found that 18 out of 21 properties audited in the Barwon-Darling region had numerous non-compliance issues associated with works approval conditions and just 10 out of 61 properties audited in the Hunter River reach were found to be fully compliant (DPIE (NSW) 2020b, p. 23).

The complexity of water legislation and licensing has been noted in a number of recent reports. In their investigation into corruption in the management of water in New South Wales, the Independent Commission Against Corruption (ICAC) found that:

The water regulatory system in NSW, and indeed the Commonwealth, is exceptionally complex. Not only are the relevant state and Commonwealth water Acts and Regulations long, detailed and interdependent, there are many different WSPs, each with unique and contingent rule settings and historical precedents. Monitoring and enforcing compliance with market rules is therefore a significant challenge. (2020, p. 157)

The Northern Basin Commissioner had similar findings, referring a water licence 'to several experts in water management agencies in order to interpret the licence conditions' (Keelty 2019, p. 12). Finding 2a of the Northern Basin Commissioner's first year report was that:

Simplification of rules over water access, and the communication of those rules would make it easier for water users to be compliant, and conversely, it should be easier to detect and ultimately prosecute those who are non-compliant. (Keelty 2019, p. 13)

While the issue of complex water legislation hampering effective regulation is illustrated here in the context of New South Wales, it is likely that all jurisdictions face similar challenges. As part of the NWI renewal process, jurisdictions should consider, investigating the extent of unintentional non-compliance due to the complexity of their water laws and whether their existing strategies to educate and engage with entitlement holders on their obligations are effective and whether a broader review of the legislation might be warranted.

Adequate resourcing for proactive regulation to encourage compliance

Resourcing is likely key to the level of proactive regulation being undertaken by jurisdictions. The MDBA's (2017, p. 14) review found that New South Wales and Queensland both had low

levels of compliance resourcing, and that the low level of compliance resourcing in New South Wales contributed to its ineffective and inconsistent compliance regime. The KPMG (2016, p. 55) evaluation of the National Compliance Framework found that the cessation of funding associated with its implementation would result in a narrower range of stakeholder information products being maintained going forward.

The National Compliance Framework uses the responsive compliance pyramid developed by Ayres and Braithwaite (1992) which focuses the largest share of compliance resources on less coercive, less interventionist and cheaper regulatory strategies to encourage and assist with compliance. Activities in this tier include incident investigations, prevention programs, information, guidance, education and advice (COAG 2012, p. 1).¹⁷ Examples of preventative and informative programs are provided in box 5.

While funding for regulating non-urban water use has been forthcoming in the MDB jurisdictions in the past two years, the Environmental Defenders Office (discussing New South Wales) made the point that ‘the NRAR’s continued success will depend on ongoing funding, which has proven to be problematic in the past’ (sub. 54, p. 8). A similar point was made by ICAC which ‘has residual concerns that NRAR will not remain properly funded in the longer-term’ and recommended that the New South Wales Government guarantee funding at least equivalent to that recommended by the Independent Pricing and Regulatory Tribunal over the longer term (2020, p. 158). As long as funding is subject to annual budget processes, there is a risk that regulatory agencies will need to prioritise reactive regulatory activities over proactive regulatory activities.

¹⁷ Where jurisdictions report compliance actions undertaken with respect to water entitlement holders (that is, in New South Wales, Victoria, Western Australia and South Australia), final prosecutions make up approximately less than three per cent of total warning/advisory letters sent out.

Box 5 Proactive compliance programs

New South Wales Natural Resources Access Regulator (NRAR)

As well as having a monitoring and auditing function with New South Wales's water laws, NRAR also undertakes proactive campaigning or routine monitoring. The aim is to achieve on-the-ground presence and improve public confidence.

NRAR undertook a campaign looking at water take in horticulture in the Hawkesbury–Nepean basin in 2020. Key outcomes of this campaign included that:

- 43 properties were inspected
- of these, 38 had state-owned meters installed, 26 of which were not working properly
- 8 formal warnings were issued for administrative offences and 26 cautions were given to those with faulty meters.

South Australia Department of Environment and Water

South Australia's annual *Water Compliance Reporting and Planning* reports include both 'business as usual' compliance activities and targeted compliance activities undertaken by the Department of Environment and Water in a water year. The *Compliance Strategy Plan 2015–18* requires the annual development of risk-based priorities and delivery of targeted operations to address identified high-risk issues of non-compliance and the *Targeted Water Compliance Monitoring Framework* sets out the principles and steps involved.

In 2019-20 the Statewide targeted compliance activity assessment of all 4082 River Murray Prescribed Watercourse water accounts to measure compliance with the quarterly accounting requirements and penalties introduced for that system area on 1 July 2019 (DEW (SA) 2020, p. 2). Previous targeted compliance activities have focused on regions outside of the Murray–Darling Basin — including the Northern Adelaide Plains, McLaren Vale, Western Mount Lofty Ranges, Lower Limestone Coast and Tatiara.

Murray–Darling Basin Authority 2019 Metering Reviews

In 2019, the Murray–Darling Basin Authority conducted four reviews to assess the adequacy and effectiveness of metering and monitoring processes for water licence holders across Murray–Darling Basin jurisdictions. The key findings from the four reviews were that:

- Victorian Lower Murray — effective mechanisms are in place to ensure that metered surface water usage is accurately captured and reported on and can be relied on to support the determination of actual annual take in the region
- Lower Murrumbidgee — effective measures are in place to ensure that metered surface water usage is accurately determined and reported, however, some areas of improvement were identified such as the reasoning behind telemetry requirements
- Condamine Alluvium — despite a number of measures being implemented to strengthen the integrity of the self-meter read process, the control environment is insufficient to provide adequate assurance that measurement and reporting of water take is reliable and requires improvement
- South Australia — adequate systems are in place to record and report metered surface water extraction; however, there are also a number of processes that could be improved to strengthen the integrity of the self-meter read system.

Sources: DEW (2018, 2020); MDBA (2019f, 2019g, 2020b, 2020a); NRAR (2020).

4 Ensuring the integrity of water system management

In addition to ensuring the integrity of water use, the integrity of water system management must be safeguarded in order to build trust and confidence, and to demonstrate that systems are being managed to best effect. That is, to maximise benefits for entitlement holders and the environment.

Water system management is the responsibility of State and Territory Governments — with the exception of the River Murray system, which is operated by the MDBA on behalf of the New South Wales, Victorian and South Australian governments (MDBA 2020d). Jurisdictions employ different models of water system management. For example, some have established state-owned corporations; in others, responsibility for water system management sits within government departments (box 6).

Water system managers are responsible for managing water resources and regulating infrastructure to ensure that they are meeting stated objectives. While there is some variation in these objectives between managers (box 6), in general, they are trying to optimise between maximising resource capture for resource allocation (benefiting entitlement holders), meeting environmental and other obligations and ensuring that water can be delivered to users when and where they want it. At the same time, system managers may need to balance other objectives including flood management, while having regard for the economic, social, environmental and cultural activities, and values of communities using the water system (MDBA 2018a, pp. 10–11). It is a complex task, and entitlement holders and communities need have confidence that the system is being managed to best effect given the range of competing objectives.

The growing mistrust and a lack of confidence in water system management in the MDB (section 1.3) highlights the important role that water system managers play and provides lessons for water system managers nationally. This section provides advice on what is required to regain and maintain trust and confidence in system managers to assure the public that systems are being managed to best effect. This includes ensuring that:

- water system managers have the information they need to manage systems
- relevant information is effectively communicated and shared
- information is quality assured and credible
- water system managers are both responsive and accountable.

Box 6 **Examples of water system managers and their roles**

- In operating the River Murray system, the **Murray–Darling Basin Authority** has general objectives that include:
 - operating the system efficiently and effectively to maximise the water available to Murray–Darling Basin jurisdictions
 - ensuring that River Murray Operations assets are fit for purpose
 - contributing to the safety of communities and having regard to economic, social, environmental and cultural activities
 - contributing to the protection and restoration of environmental assets and ecosystems
 - ensuring that the best available data, tools and systems are used, that stakeholders are well informed, and that decision making and actions are transparent (MDBA 2018a, pp. 10–12).
- **WaterNSW** is a State-Owned Corporation established under the *Water Act 2014* (NSW) and operates under an Operating Licence issued and monitored by the Independent Pricing and Regulatory Tribunal. It has several objectives and its functions include a ‘system operator’ role (WaterNSW 2019, p. 8). This includes managing the New South Wales’ surface and groundwater resources to maximise reliability for users through operation of the state’s river systems and bulk water supply systems. WaterNSW works in collaboration with the Murray–Darling Basin Authority.
- **Northern Victoria’s Resource Manager** makes seasonal determinations for all northern Victorian regulated river systems. These determinations specify the water that is available to entitlement holders. It determines this by estimating water storage in dams, expected inflows, and losses from storages, rivers and channels (NVRM 2020a, 2020c).
- The **Western Australian Department of Water and Environmental Regulation** is responsible for managing the state’s water resources including groundwater, surface water and waterways (such as rivers and estuaries). This role includes: investigating and modelling water resources to inform water allocation plans, collecting and analysing data about rivers and their catchments to provide information on environmental flows and river health, and modelling projections of future water demand (DWER (WA) 2019, pp. 76–82).

4.1 **Water system managers require a range of information**

System managers require a significant amount of information. They need to have a deep understanding of their water resource system, its infrastructure, how the water system behaves under different climate conditions and the key risks to the water resource.

They also need forecasting and modelling systems to keep track of where and when water is being used, and to manage the system dynamically to ensure that it meets the needs of users throughout the year. This can be a complex job requiring a range of clear and transparent operating rules combined with some judgement. In the southern MDB, it is further complicated by cross-jurisdictional water sharing arrangements.

Water system managers use a variety of approaches to generate relevant information. Broadly, water information can be categorised based on its source:

- direct measurement, using measurement instruments in monitoring or hydrometric networks.¹⁸ This includes direct measurement of surface water, groundwater, meteorology and water quality (MDBA 2018b, p. 2)
- inference from remote sensing, through passive or active remote sensing instruments such as satellites, aircraft or drones. This is useful for estimating: water held in floodplains; on farm water storages; interception; irrigated areas; environmental take; and monitoring environmental or flood flows (BOM 2017, p. 12; MDBA 2018b, p. 2)
- estimation from models, which can be used to fill information gaps from direct measurement and remote sensing instruments. Models can fill gaps in water monitoring networks and time-series data, predict future conditions and synthesise large amounts of data obtained from catchments (BOM 2017, p. 12)
- administrative data collections, including information related to water entitlements, water pricing and management regimes (BOM 2017, p. 13).

Often, some or all of these approaches are employed. For example, the Northern Victoria Resource Manager uses direct measurement, model estimations and administrative data to determine how much water is allocated to entitlement holders during a season — also known as seasonal determinations (figure 2).

... however, there are gaps in data collections

In the MDB, there are concerns that water system managers are not operating water systems to best effect, in part because of inadequate data.








First, some commentators have pointed to gaps in the data collections of water system managers which adversely affect management activities. For example, a review of water system management by WaterNSW found gaps relating to Queensland flows, floodplain harvesting flows, extraction and in-river flows, extraction from unregulated systems and flow behaviour during extreme events (Craik and Claydon 2020, pp. 49–50). The Local Government Association of Queensland (sub. 32, p. 3) noted that data sets and catchment modelling may be inadequate for the task of understanding the impacts of water allocation decisions on the sustainability of systems and the regional communities relying on them.

Second, several reviews found that models used for water system management had poor track records, particularly in estimating low- and zero-flows (NRC (NSW) 2019, pp. 100–101; Vertessy et al. 2019, p. 59). The Wentworth Group (2020, pp. i–iii) compared observed river flows with expected flows modelled by the Murray–Darling Basin Authority and found

¹⁸ The term ‘hydrometric network’ refers to a group of data collection activities for different components of the hydrological system. Data can be collected from a range of measures, including surface water gauges, groundwater bores and climate (rainfall and evaporation) stations (DELWP (Vic) 2019a, p. 1).

substantial differences. Between 2012-13 and 2018-19, 13 out of 27 sites had observed flows that were about 75 per cent of what was expected.

Figure 2 How seasonal determinations are made in northern Victoria^a
For high-reliability entitlements and for regulated river systems

	Add: Volume in storage and useful forecast inflows to storage over the following 6 weeks. (In some river systems, inflows to storage over 3 months are included)
	Add: Any resources available from other water systems (i.e. inter-valley trade commitments, supplements)
	Subtract: Volume below minimum operating level, storage and river losses
	Subtract: Trade commitments (i.e. inter-valley) to other systems
	Subtract: Carryover commitment from previous season
	Subtract: Remaining volume required to be delivered at current seasonal determination (i.e. volume allocated minus volume supplied to date)
	Equals: Volume available to increase allocation to high-reliability entitlements in the current season

^a Assessments of resource availability during the irrigation season, and seasonal determinations are made and announced fortnightly, on the Northern Victorian Resource Manager’s website.

Source: Adapted from Northern Victorian Resource Manager (2020b).

Gaps are particularly significant in some areas of water information; one key example is interception (farm dams and bores, floodplain harvesting and large-scale plantation forestry). These activities can have significant impacts by stopping, reducing or redirecting flows and preventing them from reaching surface water and groundwater resources (SP A *Entitlements and planning*). However, inquiry participants and past reviews have stated that there is insufficient information collected on interception activities and their impacts on water resources (box 7). Several inquiry participants also highlighted that accurate information on interception activities is not being collected by water system managers — and that if it is collected, it is not being shared with the public (MDBA, sub. 23, p. 5; IWF, sub. 30, p. 9; LBA, sub. 70, p. 4).

As the National Water Commission noted in a report that it commissioned, NWI interception commitments can only be addressed by accurately accounting for water use as a result of interception (Sinclair Knight Merz, CSIRO and Bureau of Rural Sciences 2010, p. ix). Improved measurement and accounting of interception activities is needed to support better incorporation of interception activities into entitlements frameworks (SP A *Entitlements and*

planning). Jurisdictions have invested in measures to address this information gap, but progress has been slow.

Box 7 Inadequate accounting of interception activities

Inquiry participants and past reviews have raised concerns that accounting of interception activities is inadequate. For example, the Environmental Defenders Office stated that:

Over two-thirds of diversions in the Queensland portion of the MDB are unmetered or otherwise unmeasured. This leaves considerable scope for unauthorised diversions, particularly given the large volumes of unmeasured water that are taken from floodplains, low levels of telemetry and the widespread practise of self-reading meters ... [although the Queensland] Government has announced plans to improve measurement of water diversions, it remains to be seen what percentage of extractions will be accurately measured and subject to telemetry, particularly given the large volumes of diversions attributable to floodplain harvesting ... Further, the ability of floodplain earthworks to divert water is poorly identified and not measured. (sub. 54, pp. 5–6)

The Institute for Water Futures – Australian National University noted that:

Large unmitigated risks will remain for all water users without transparent and audited water accounts that include measures or reliable estimates of recoverable return flows, floodplain water harvesting and climate change ... These risks jeopardise the successful implementation of the NWI principles, including future levels of SDLs, and also the reliability of water entitlements and water trading within Catchments and Basins. (sub. 30, p. 11)

And Turner et al. (2019, p. 22) noted that:

Accounting treatment of floodplain harvesting, run-off dams and return flows has been identified as an issue in the SDL [water accounting] framework.

It is recognised that poor accounting is, in part, due to difficulties measuring interception activities:

Not all forms of water take can be metered. Floodplain harvesting, or overland flows, in the northern Basin are the most prominent example, with recent estimates at 210GL annual take (noting the high uncertainty of this estimate) ... Farm dams and forestry plantations are also instances of non-metered take. For these forms of take, the hydrometric network and hydrological modelling are the way in which estimates are derived. (MDBA 2017, p. 19)

... data relating to floodplain harvesting diversions is only in the form of estimates provided from river system models. The effect of floodplain harvesting activities on streamflows within and between systems can only be known with certainty through collection of accurate information on floodplain harvesting volumes. (Vertessy et al. 2019, p. 80).

A risk-based approach to address information needs

While information is essential for effective system management, there can be considerable costs and time involved with collecting, processing and analysing data (Bewsher Consulting Pty Ltd 2018, p. 4). For example, it has taken many years and more than \$37 million to develop the databases and models needed to regulate floodplain harvesting in New South Wales (DPIE (NSW) 2019, p. 1).

It is therefore important to consider both the costs and the benefits associated with meeting information needs. However, in many cases, there are risks involved in realising benefits, and so a risk-based approach is required.

A risk-based approach weighs up the costs and benefits of meeting information needs, in light of risks within a water system (*Report*: chapter 5). For example, in water systems that are highly developed and fully allocated, the costs of inadequate information (and the risk of mismanagement) are likely to be higher than in a water system that is less developed. In highly developed systems, the benefits of collecting adequate information are likely to outweigh the associated costs.

Technology advances are potentially reducing costs. For example, remote sensing and emerging technologies could replace traditional types of hydrometric data collections systems, which are more expensive (Bewsher Consulting Pty Ltd 2018, p. 17). The Australian Water Association (sub. 89, p. 10) noted that various technologies now available (such as remote sensing) can inform monitoring for active management of river systems, and can help identify and monitor water quality.

Several factors should be taken into account in determining relevant risks associated with managing a water system (and, therefore, the types of information that need to be collected). These include the level of development, whether it is fully allocated or overallocated, and whether it is regulated or unregulated.

4.2 Effective communication and sharing of information builds trust and confidence

While water system managers need to collect the right data to inform their operations, simply collecting data is not enough to assure the broader community that managers are doing a good job. Effective communication and sharing of information is needed.

As noted above, under the NWI, parties agreed that the intended outcome of water resource accounting is to support public and investor confidence in how water resources are being managed.¹⁹ If information is not shared with the public, understanding of and trust in the operations of water system managers can be seriously undermined. The Environmental Defenders Office stated that ‘a great deal of mistrust in governments and between stakeholders could be avoided if more information was made publicly available (and in an accessible format)’ (sub. 54, p. 9).

Water system managers already provide a large amount of information through reports and websites; however, there are concerns that important and relevant information is not always made publicly available (IWF, sub. 30, p. 9; EDO, sub. 54, pp. 9–11). The management of the 2020 Northern Basin First Flush event provides examples of information being poorly communicated and shared, highlighting the importance of adequate provision and communication of information with stakeholders and the public (box 8).

¹⁹ NWI paragraph 80.

Box 8 2020 Northern Basin First Flush event — poor communication and sharing of information

At the start of 2020, north-west New South Wales and southern Queensland experienced significant rainfall, leading to substantial inflows to the Border Rivers, Peel, Namoi, Gwydir and Macquarie valleys and along the Barwon–Darling River for the first time in several years.

In response, a series of temporary restrictions on water extractions were introduced in New South Wales under the provisions of the *Water Management Act 2000* (NSW) to manage the first flows and prioritise water for critical human and environmental needs. This became known as the 2020 Northern Basin First Flush event.

An Independent Panel Assessment of the management of the event found that it achieved improved outcomes for the environment and surrounding communities in need.

However, many water users and affected communities believed that the water systems manager (and other agencies involved) did not adequately manage the event. In particular, there was a lack of transparency and poor communication:

- information was not released prior to the event
- systems to communicate information during the event were inadequate
- there were delays in information being published after the event
- where information was available, the manner of publication was not conducive to improving the community's understanding of how water was being managed.

This contributed to confusion among communities and speculation about extraction, impacts and outcomes of the event. It also exacerbated mistrust in New South Wales' water management.

There was a strong unmet demand for information about the event as it unfolded and after it was over. Adequate resources were not put aside to meet this demand. Delays in publishing information allowed speculation about extraction, impacts and outcomes of the event to become de facto truths, and promoted views of mistrust, secrecy and mismanagement. It inhibited a productive, fact-based discussion on the benefits and costs of first flush events and constrained the Panel's assessment, particularly for its draft report. (Craig and Claydon 2020, p. 6)

The independent assessment made several recommendations to improve management of such events in the future. These included: developing a communications plan for stakeholders (including water users and affected communities) and improving, and resourcing communication coordination and capability.

Source: Craig and Claydon (2020).

Where information is provided, it can be difficult to access, navigate and understand, particularly because managing water systems can be a complex process. For example, a review found that the MDBA's management of the River Murray system was not well understood by the community and that the processes and outcomes were not clearly set out in an easily accessible and readily available format (IIGMDB 2020, p. 25, 29). The review found that '[m]any of the concerns that the inquiry heard might have been redundant if individuals were able to readily see and understand the way available water has been shared over time' (IIGMDB 2020, p. 14).

Another issue is that information may be inconsistent across different sources. This is largely an issue in the MDB where a number of agencies are responsible for management and river operations (IIGMDB 2020, p. 40). In particular, there are problems concerning:

- inconsistencies in language used between websites and reports (of relevant agencies)
- inconsistencies in information that is distributed across multiple websites (for example, data on storage volumes for the same dam may differ between websites of the MDBA, Goulburn–Murray Water and WaterNSW) (IIGMDB 2020, p. 40).

Information related to a specific water system must be available and easily accessible in one location. And water system managers should be responsible for this. In the case of the MDB (where multiple agencies are responsible for its management), system managers must collaborate more to ensure that data and language are consistent, and that information is accessible from a single website. Work on this is underway, with the Australian, New South Wales and Queensland Governments developing a new website (to be led by the MDBA and the Bureau of Meteorology). This work aims to improve the transparency, consistency and accessibility of MDB-related information, and to ensure that information is easy to access in one place (Minister for Resources, Water and Northern Australia, Minister for Water, Property and Housing (NSW) and Minister for Regional Development and Manufacturing and Minister for Water (Qld) 2020).

Making information public and ensuring that it is effectively communicated is not without costs. It can involve time spent preparing reports or other materials, as well as developing and maintaining data portals and dashboards.

A key step is to determine the objective of sharing information (in this case, to build trust and confidence in water system management), and then decide what is required to achieve this outcome. In doing so, it must be acknowledged that there are different types of data users, with different levels of skills in accessing and interpreting data, as well as different purposes for using the data. For example, quarterly data may be sufficient for invoicing and compliance evaluation, but not for modelling and planning (Engineers Australia, sub. 63, p. 7). Engagement with stakeholders is necessary to achieve this.

There are examples of initiatives by water system managers to improve communications with stakeholders and the public. For example, the MDBA recently responded to concerns about how operations of the River Murray system were affecting entitlement holders' allocations by publishing a report explaining the main components of, and factors that influence, river losses (MDBA 2019c, p. iii). The main factors influencing losses had been hot and dry conditions, combined with low inflows, high demands and the need for overbank transfers, resulting in conveyance losses of about 620 gigalitres during the year. An accompanying report summary highlighted key findings in simple language and included infographics to make the analysis more accessible (MDBA 2019e, p. 1).

Water system managers and government agencies have also established interactive data portals and dashboards. For example, WaterNSW has developed a WaterInsights Portal, which provides information on: annual allocations of water to entitlement holders and water

usage (by licence category); daily storage volumes, inflow and releases for dams; and the daily recorded levels and flow rates for all river gauges and aquifer bores (WaterNSW 2020). And the Queensland Department of Natural Resources, Mines and Energy (2020) has developed an interactive dashboard which provides a range of information on water systems, including on the volume of water that is traded and unallocated, storage capacity and the average annual environmental flow.

Notwithstanding the benefits of communicating and sharing information, there are limits to what can be shared given privacy concerns. AgForce (sub. 24, p. 5) noted that transparency towards the public should not come at the cost of personal privacy and that data should be aggregated and de-identified. Further, Engineers Australia (sub. 63, p. 7) stated that while transparency is essential, there are valid commercial and privacy issues associated with reporting information related to water diversion and trading.

4.3 Quality assurance can enhance the credibility of information

Water information is most trusted and valued when its quality is assured. Public confidence can be improved by applying sound management procedures and systems to all stages of the water data management process, from planning data acquisition and collecting and processing data through to publishing water information and responding to critical feedback (Bewsher Consulting Pty Ltd 2018, p. 3).

However, the public does not always believe that information made available by water system managers is credible. As the MDBA observed, '[e]ven when information is provided, there is a lack of trust in the agency providing the information' (sub. 23, p. 14).

This particularly applies to water information generated through modelling. Model calculations or estimates may be made publicly available, but often the model itself is not (Horne 2015, p. 2167). Although model estimates are always approximate, steps need to be taken to promote trust and confidence in the underlying work, particularly because a significant amount of water cannot be directly measured — for example, only 25 to 51 per cent of surface water is metered in the northern MDB (Bewsher Consulting Pty Ltd 2018, p. 13). To build credibility, water system managers need to ensure that their models are regularly tested, evaluated and updated to encourage ongoing improvement; peer-reviewed, and (in shared systems) accredited. A best-practice process for model and method quality assurance was developed for Basin water authorities and is provided in box 9.

At present, there are no national guidelines that classify water data quality or support improvements in water data and information quality. For example, Engineers Australia (sub. 63, p. 7) noted that quality codes (which help data users understand the uncertainty associated with a measurement) are inconsistent. This increases the difficulty and costs of using data and can lead to inappropriate design recommendations. Development of a standardised approach to support data quality was considered during the review of the National Industry Guidelines for Hydrometric Monitoring in 2018, but the task was considered too large to undertake at the time (Bewsher Consulting Pty Ltd 2018, p. 4).

There are, however, some sub-national examples of frameworks and approaches. For example, the MDBA has developed a *Water Information Quality Assurance Framework* (MDBA 2018b, p. 2). The framework sets out a process to guide fit-for-purpose water data collection, which includes analysing water information needs, strategically reviewing water information sources to identify areas for quality improvements, implementing identified improvements, and undertaking reviews (MDBA 2018b, pp. 5–6). Further, there are other approaches that could improve transparency around data quality. One is to publish standardised accuracy classes (that specify how accurate data are) alongside water information, particularly for information where concerns have been raised by stakeholders (table 1). Another is to ensure that water information is independently audited.

Box 9 A process for model and method quality assurance

A number of steps help to build quality information through models and methods.

- The best available data are used to establish, calibrate and validate models and methods. Where data deficiencies exist, improvements to the coverage of the existing hydrometric networks should be considered so that the data deficiencies can be rectified.
- Model methodologies are documented and made publicly available. This documentation should identify assumptions and limitations, and detail the purposes to which the models or methods could appropriately be applied. Consideration could be given to utilising a standardised system for classification of result accuracies.
- Models and methods are subject to independent peer reviews.
- Models are subject to on-going reviews and refinements to ensure that they are fit for purpose and are using the most appropriate procedures for simulating take — including take from interception activities such as floodplain harvesting.
- A timetable for reviews of the models or methods, including foreseeable improvements, is prepared and published.

In cases where data or science available are insufficient to facilitate robust modelling, deficiencies should be documented, as should the justification for the adopted estimation procedure (Bewsher Consulting Pty Ltd 2018, p. 17).

The *Basin Salinity Management 2030* strategy provides an example of where robust quality assurance processes are required. The strategy aims to hold the Murray–Darling Basin Authority and Murray–Darling Basin (MDB) jurisdictions responsible for managing salinity in the MDB. The strategy requires independent auditing of performance against commitments, for both the Murray–Darling Basin Authority and MDB jurisdictions. The audit process includes reviews of models, Salinity Registers and identification of knowledge gaps, to inform recommendations for improvement. Audits are undertaken biennially (Wickes, Smith and Walker 2020, p. 1,6).

In renegotiating the NWI, jurisdictions should agree to have formal quality assurance processes in place for information collected and used by water system managers. There could be merit in a standardised national approach for determining and reporting data quality for key types of water information. Jurisdictions should consider this in renegotiating the NWI.

Table 1 **Example of standardised accuracy classes for water information^a**

<i>Accuracy class</i>	<i>Description</i>	<i>Numerical accuracy range</i>
A	High Accuracy	± 5 %
B	Medium Accuracy	Between ± 5% and ± 20%
C	Low Accuracy	Greater than ± 20%

^a Some water information is estimated — for example, streamflows for ungauged sites. Various techniques (such as calculating the deviation from the rating curve) can show how close an estimate might be to the actual value. The numerical accuracy range indicates the percentage deviation from the actual value or range of values.

Source: Bewsher Consulting Pty Ltd (2018, p. 4).

4.4 Transparency is required to hold water system managers to account^a

Water system managers’ decisions and actions can affect a range of stakeholders, including entitlement holders and communities. For example, Steinfeld et al. (2020, p. 1, 10) compared the outcomes of two river systems that were governed by the same water system manager and the same legislative and policy framework, but had different management rules in place. They found that the rules significantly influenced water allocations and water availability.

Therefore, there must be processes in place to hold water system managers accountable. First, appropriate governance arrangements need to be in place. For example, in the MDB, governance arrangements, agreements and processes have been established for operating the River Murray system. This includes a framework for how operational decision-making is undertaken (IIGMDB 2020, pp. 27–28). A comprehensive review of governance arrangements for all system managers is beyond the scope of this inquiry. Nonetheless, the Commission acknowledges that governance arrangements (which outline processes for decision making and implementation) are in place and are not a key concern.

Second, there must be transparency. Water system managers need to publish sufficient information about how they make operating decisions. However, there are concerns that this is not presently the case. For example, Steinfeld et al. (2020, p. 11) found that some management rules were omitted from agency reports — and that public records regarding resource assessment processes, how allocation decisions were made, and justification of management rules were not available. Further, there may be a lack of transparency around the performance of water system managers. For example, the Interim Inspector-General of MDB Water Resources (2020, pp. 28–29) stated that while the Independent River Operators Review Group annually assessed the MDBA’s performance in managing the River Murray system, the assessments were not made publicly available. (That said, the most recent assessment has been published on the MDBA’s website (IRORG 2020, p. vi)). Independent audits of water system managers are important for promoting accountability; making them publicly available would reinforce this and improve transparency.

Finally, water system managers need to be responsive to public concerns and engage with stakeholders to improve information provision. The MDBA has been criticised for being slow to respond, or not responding at all to concerns raised by communities about its management of the River Murray system (MDBA 2017, p. 14; South Australia 2019, p. 442). This may diminish transparency, and lead to increased uncertainty, misperceptions or the misappropriation of available information — which is what has been observed in the MDB (IIGMDB 2020, p. 38). In addition, engagement with stakeholders would help system managers determine whether available information adequately demonstrates to the public that water systems are being managed to best effect.

5 Building understanding of the broader water context

Information about the broader water context is important to a range of stakeholders because it helps them understand the key challenges faced by water resources and potential risks (section 2). For example, entitlement holders, water dependent communities, urban water utilities and businesses may require this information to manage their operations and plan for the future. It includes information from water accounts, trading registers, broader research, and climate projections and scenario modelling. Information principles for water trading and markets are discussed in SP B *Trading* and, as noted above, broader research is discussed in SP K *Knowledge*.

5.1 Information that meets the needs of water users and communities

There are concerns that information on the broader water context does not meet the needs of water users and communities. For example, the MDBA noted that:

... there is a need for governments to reconsider the way information is shared. The focus must shift from providing more information about ‘what Governments are doing’ to providing better information addressing ‘what water users need’ to navigate the system, run their businesses and have confidence in management arrangements. This should consider ways to create an effective operating environment in which water users and communities have information that is accessible, understandable, timely, relevant and credible. This approach could be highlighted in any update to the NWI to ensure governments provide the information stakeholders require to have confidence in water management. (sub. 23, p. 12)

In particular, concerns have been raised regarding system water accounts and national water accounts. Climate data, projections and scenarios are generally available and providing necessary information.

System water accounts

System water accounts provide information related to a specific water system. The accounts include information collected by water system managers, as discussed above (section 4). Stakeholders may access this information to understand operational decisions made by

system managers, but may also access it for other reasons. For example, the Local Government Association of Queensland (sub. 32, p. 4) noted that access to information regarding the processes and triggers for the release of unallocated water would help communities and businesses with their strategic planning.

However, inquiry participants raised shortcomings and gaps in information provision. For example, the Environmental Defenders Office (sub. 54, p. 9) noted that public access to water-related information (including for licensing and allocation details, applications and approvals for trades and statutory permits) is lacking or non-existent in some jurisdictions. This makes it difficult to scrutinise approvals and assess their lawfulness. In the MDB, stakeholder engagements continue to find that the needs of water users, communities and the broader public are not being met (MDBA, sub. 23, p. 12). The National Farmers' Federation (sub. 42, p. 18) noted that water users must be informed to adequately assess their own risks and benefits, and to make meaningful contributions to broader decision-making processes, but current information provision does not enable this.

It is important that water system managers engage and consult with stakeholders (including water users and communities) to ensure that information provided in system accounts is relevant and useful (*SP J Engagement*). This would increase the potential benefits from these accounts.

National water accounts

As noted above, under the NWI, jurisdictions agreed to benchmark accounting systems.²⁰ There has been significant progress in the development of national water accounts. Since 2007, the Bureau of Meteorology (BOM) has assumed a central role in the collection and publication of water data and information, including on water stores and flows, water rights and water use (PC 2017, p. 448). National information is also provided through the ABS Water Account, including on the supply and use of water (ABS 2020). Both national water accounts can be used to inform national policy and priorities, water resource planning, water market activity, investment and environmental management decisions. They also inform research and contribute to the development of water information and knowledge (BOM 2015, p. 1).

More recently, there have been efforts to improve national water accounts and to streamline reporting for entities submitting data. For example, BOM and the ABS have integrated a set of water accounts for the ACT as a pilot to: aid environmental management; support a more collaborative approach to environmental-economic accounting; and improve data sharing. BOM has also made developments to reduce reporting burdens, for example, by establishing a single portal for urban utilities (BOM 2020; *Assessment*).

National water accounting is generally providing practical, credible and reliable information, largely without duplication of efforts by jurisdictions (*Assessment*); however, there is scope

²⁰ NWI paragraphs 80-81.

to improve the accounts. For example, connectivity between surface water and groundwater systems is only accounted for in some areas and is not typical (Turner, Vanderbyl and Kumar 2019, pp. 22–23). An inquiry participant noted that BOM’s integrated groundwater data collection has lost value due to a declining monitoring network that provides the data (Campbell, sub. 60, p. 1).

Inquiry participants stated that there are information gaps in national water accounts and these accounts are not independently audited (IWF, sub. 30, p. 8; EDO, sub. 54, p. 6; LBA, sub. 70, attach. 1, p. 2). A national water audit would verify, check, evaluate and interpret catchment and basin-wide water accounts (IWF, sub. 30, p. 11). However, it would not identify gaps in information. This would require a broader review with stakeholder engagement.

Climate data, projections and scenarios

Climate data, projections and scenarios are used to estimate water availability and inform water planning and management decisions. For example, in New South Wales, the long-term average annual extraction limits for regulated rivers are determined using models that simulate river basin behaviour based on climate data, irrigation development and water plan rules (Weber and Claydon 2019, p. 26). Australia’s climatic variability suggests that there will be a continuous need for water information to help governments and communities manage climate risks (ANAO 2014, pp. 13–14).

Inquiry participants noted the importance of climate data and provided examples of how it is used. For example, the NSW Water Directorate (sub. 37, p. 4), the peak industry body for local government owned water utilities, noted that up-to-date drought data and climate modelling are needed for water security modelling. In terms of farm management, historical climate data are used to estimate farm income and inform resource management (Langford, sub. 91, attach 1, p. 17).

Climate data, projections and scenarios are generally available and are providing necessary information; however, there are concerns that up-to-date data are not being used to inform water plans and management (AFA, sub. 45, p. 6; IRN, sub. 86, p. 4). This issue is discussed further in *SP A Entitlements and Planning* and further advice is provided, including the need for better coordination to account for climate change. Climate information is made available through multiple government agency websites, including BOM and the CSIRO, and through international organisations, such as the Intergovernmental Panel on Climate Change.

Overall, a renewed NWI should advocate for information on the broader water context to be shared in an accessible, timely and user-focused way to ensure it meets the needs of water users and communities. Governments must also recognise that information needs of water users and communities may change over time (MDBA, sub. 23, p. 12). This means that system water accounts and national water accounts will need to be reviewed and updated accordingly.

5.2 Improving water literacy

‘Water literacy’ broadly refers to a combination of water-related knowledge, attitudes and behaviours. It is viewed as an umbrella term for several areas of knowledge, ranging from the understanding of scientific properties and the role of water in systems to the sustainable use, and conservation of, water (McCarroll and Hamann 2020, pp. 7–8). Water literacy is not confined to water planners, managers and researchers — it is relevant to all individuals.

High levels of water literacy can have several positive impacts. Research shows that it is important for: sustainable water management; building trust between system managers and water users; and gaining public support for water reform and management decisions (McCarroll and Hamann 2020, pp. 1–2). Inquiry participants also highlighted these benefits, and the importance of improving water literacy (LGNSW, sub. 75, p. 5; Urban Utilities, sub. 85, p. 6; AWA, sub. 89, p. 11). For example, VicWater noted that:

Improved water literacy is critical in enabling the community to define its needs and expectations ... The better informed the community is on matters of water management, values, and trade-offs, the more empowered it will be to participate in decision making – which will also contribute to systemic and societal resilience. Victorian research into water literacy found that once community members have a greater understanding of the water system, they have an increased desire [to] participate in decision-making. The new NWI has an opportunity to combine efforts to improve water literacy with genuine opportunities for communities to play a co-design role in the determination of fundamental matters such as levels of service, risk appetite and liveability outcomes. (sub. 66, pp. 8–9)

A national survey on water literacy found that Australians had relatively high levels of knowledge about some aspects of water, but poor knowledge about others (Fielding et al. 2015, p. 31). Areas where respondents were not as knowledgeable included: how water is treated; the costs, and sources of drinking water; and how complex processes for water treatment can be. More specifically, the Interim Inspector-General of MDB Water Resources (2020, pp. 41–42) found that water literacy across the Basin varies substantially and that it has changed over time — for example, irrigators now need to understand how water markets operate.

Improved water literacy could further support trusted and credible water resource management. This includes by improving communication between water users and communities with water system managers (section 4.2); assisting individuals to understand information on the broader water context (section 5.1); and driving greater stakeholder engagement in water policy reform and management. *SP J Engagement* identifies the need to improve community water literacy to achieve effective community engagement.

6 NWI renewal

The NWI laid the foundations for the integrity of water resource management by requiring parties to establish water registers and water accounts to collect credible information on water resources and water use — or, in other words, through robust water accounting.

However, ensuring integrity requires more than this. Reviews into compliance and enforcement in the MDB have found numerous shortcomings around governance, practice and resourcing that have undermined the integrity of water resource management regimes. And mistrust and a lack of confidence in water system management is growing, fuelled by a lack of transparency.

A renewed NWI would be strengthened by a new ‘system integrity’ element that draws on the lessons learnt in the MDB.

DRAFT NWI RENEWAL ADVICE 10.1: BUILDING SYSTEM INTEGRITY THROUGH A RENEWED ELEMENT

A renewed National Water Initiative would be strengthened by acknowledging that ensuring the integrity of water resource management requires more than robust water accounting. To build integrity into system management, consideration should be given to broadening the water resource accounting element to ensure that the provision of credible and reliable information and robust institutional processes provide assurance that:

- entitlement holders are operating in line with their rights and that water use is consistent with established rights and water plans
- water systems are being managed to best effect for all users.

The provision of information regarding the broader water context is also needed to improve understanding of key water resource challenges and potential risks, enabling entitlement holders, industry and communities to better plan for the future.

DRAFT NWI RENEWAL ADVICE 10.2: ENSURING THE INTEGRITY OF WATER USE

To ensure the integrity of water use, a renewed National Water Initiative would be strengthened by requiring fit-for-purpose:

- metering and measurement of surface water and groundwater take
- registers and reporting on use that reflect the related benefits for water resource management and support compliance and enforcement systems
- compliance and enforcement systems, including a focus on proactive regulation to increase entitlement holders’ awareness of their obligations.

Inclusion of leading-practice compliance principles would also strengthen the agreement. Compliance framework requirements from the Murray–Darling Basin Compliance Review provide good foundation principles, but consideration should be given to augmenting them with requirements consistent with leading-practice governance.

DRAFT NWI RENEWAL ADVICE 10.3: ENSURING THE INTEGRITY OF WATER SYSTEM MANAGEMENT

To ensure the integrity of water resource management, a renewed National Water Initiative would need to require water system managers to:

- adopt a risk-based approach to developing and maintaining information and data collections necessary for effective water system management. These collections should include information about how much water is in a system, where it is, how much is extracted (including by interception activities), how much is carryover, and who gets what and when
- ensure that information and data sources are publicly available and information is accessible and effectively communicated. Where multiple agencies are responsible for a system's management, collaboration is needed to ensure that data and language are consistent and information is accessible from a single online source
- implement quality assurance processes for information and data sources to enhance the credibility of information, including independent audits for highly developed and regulated systems
- ensure information about their decisions, operations and performance is transparent and that public concerns and information requests are responded to expediently.

Stakeholder engagement would improve information provision and help system managers determine if available information adequately demonstrates to the public that water systems are being managed to best effect.

DRAFT NWI RENEWAL ADVICE 10.4: ENSURING INFORMATION ON THE BROADER WATER CONTEXT ALIGNS WITH USERS' NEEDS

In renegotiating a renewed National Water Initiative, jurisdictions should commit to providing information on the broader water context that meets the needs of system participants (including water planners, managers, users and communities).

National and system water accounts should be reviewed. In undertaking these reviews, system participants must be engaged to ensure useful and meaningful information is reflected in accounts in the future.

A renewed National Water Initiative should acknowledge the utility of national water accounts and require their regular publication and avoidance of unnecessary duplication of effort in their preparation.

References

- ABS (Australian Bureau of Statistics) 2020, *Water Account, Australia, 2017-18*, 6 May, Cat. no. 4610.0, Canberra.
- ACCC (Australian Competition and Consumer Commission) 2020, *Murray-Darling Basin Water Markets Inquiry*, Interim report, Canberra.
- ACT Government (Australian Capital Territory Government) 2015, *Water Meter Installation, Maintenance and Replacement Guideline*, Environment Protection Authority, Canberra.
- ANAO (Australian National Audit Office) 2014, *Administration of the Improving Water Information Program*, 18, Canberra.
- Ayres, I. and Braithwaite, J. 1992, *Responsive Regulation: Transcending the Deregulation Debate*, Oxford University Press, New York.
- Bewsher Consulting Pty Ltd 2018, *Background to the Development of Guidelines for Improved Water Information to Aid Basin Plan Compliance*, Canberra.
- BOM (Bureau of Meteorology) 2015, *The National Water Account*, Information Sheet.
- 2016, *Australian Water Information Dictionary*, www.bom.gov.au/water/awid/initial-a.shtml (accessed 20 September 2016).
- 2017, *Good Practice Guidelines for Water Data Management Policy: World Water Data Initiative*, Melbourne.
- 2020, *Integrated water accounts for the Canberra region, 2013–14 to 2016–17*, www.bom.gov.au/water/nwa/2018/canberra-integrated-pilot/index.shtml (accessed 16 October 2020).
- COAG (Council of Australian Governments) 2012, *National Framework for Compliance and Enforcement Systems for Water Resource Management*, Canberra.
- Craik, W. and Claydon, G. 2020, *Independent Panel Assessment of the Management of the 2020 Northern Basin First Flush Event: Final Report*.
- DAWR (Department of Agriculture and Water Resources) 2009, *National Framework for Non-urban Water Metering: Policy Paper*, Canberra.
- DELWP (Vic) (Department of Environment, Land, Water and Planning (Vic)) 2019a, *Hydrometric Network Review*.
- 2019b, *Victorian Water Register - 10 Year Strategy 2019-2028*.
- 2020, *Victorian Non-Urban Water Metering Policy*.
- DEW (SA) (Department for Environment and Water (SA)) 2019, *Metering Improvement Plan*.
- 2020, *Water Compliance Reporting and Planning 2019-2020*, Adelaide.

-
- 2018, *Water Compliance Reporting and Planning 2017-2018*, Adelaide.
- DNRME (Qld) (Department of Natural Resources, Mines and Energy (Qld)) 2019, *Queensland Interim Water Meter Standard for Non-urban Metering*.
- 2020, *Natural Resources Inventory for Queensland: Water*, https://inventory.dnrme.qld.gov.au/water?p1=water&p2=queensland&p3=mp_w_total_res&& (accessed 16 October 2020).
- DOE (Department of the Environment) 2016, *National Framework for Compliance and Enforcement Systems for Water Resource Management (Archived Website)*, <https://webarchive.nla.gov.au/awa/20160106180441/www.environment.gov.au/resource/national-framework-compliance-and-enforcement-systems-water-resource-management> (accessed 22 October 2020).
- DOW (WA) (Department of Water (WA)) 2009, *Guidelines for Water Meter Installation 2009*, Perth.
- DPIE (NSW) (Department of Planning, Industry and Environment (NSW)) 2019, *Floodplain Harvesting Action Plan*, Parramatta.
- 2020a, *NSW Non-Urban Water Metering Policy*, November.
- 2020b, *The Natural Resources Access Regulator: Progress Report 2019-20*, NSW Government.
- DPIPWE (Tas) (Department of Primary Industries, Parks, Water and Environment (Tas)) 2014, *Tasmanian Standard for Non-Urban Water Meters*, Hobart.
- DWER (WA) (Department of Water and Environmental Regulation (WA)) 2019, *2018-19 Annual Report*, Joondalup.
- Fielding, K., Karnadewi, F., Mitchell, E. and Newton, F. 2015, *A National Survey of Australians' Water Literacy and Water-related Attitudes*, Cooperative Research Centre for Water Sensitive Cities, Melbourne.
- Horne, J. 2015, 'Water information as a tool to enhance sustainable water management—the Australian experience', *Water*, vol. 7, no. 5, pp. 2161–2183.
- ICAC (NSW) (Independent Commission Against Corruption (NSW)) 2020, *Investigation into Complaints of Corruption in the Management of Water in NSW and Systemic Non-compliance with the Water Management Act 2000*, Sydney.
- IGWC (Interim Inspector-General of Water Compliance) 2020, *Home / Interim Inspector General of Water Compliance*, www.igwc.gov.au/ (accessed 7 December 2020).
- IIGMDB (Interim Inspector-General of Murray-Darling Basin Water Resources) 2020, *Impact of Lower Inflows on State Shares Under the Murray–Darling Basin Agreement*, Canberra.
- IRORG (Independent River Operations Review Group) 2020, *Review of Performance against Objectives and Outcomes 2019/20*.

-
- IWG (Interagency working group) 2016, *Providing Water Information to the Commonwealth*, Canberra.
- Keelty, M. 2019, *Northern Basin Commissioner First Year Report 2019*, Northern Basin Commissioner, Canberra.
- KPMG 2016, *Evaluation Report for the National Framework for Compliance and Enforcement Systems for Water Resource Management*, March, Department of Agriculture and Water Resources, Canberra.
- Matthews, K. 2017a, *Independent Investigation into NSW Water Management and Compliance: Advice on Implementation*, New South Wales.
- 2017b, *Independent Investigation into NSW Water Management and Compliance: Interim Report*, New South Wales.
- McCarroll, M. and Hamann, H. 2020, ‘What we know about water: a water literacy review’, *Water (Basel)*, vol. 12, no. 2803, pp. 1–28.
- MDB Ministerial Council (Murray-Darling Basin Ministerial Council) 2018, *Murray-Darling Basin Compliance Compact*, An Agreement between Commonwealth, New South Wales, Victoria, Queensland, South Australia, Australian Capital Territory, Canberra.
- MDBA (Murray-Darling Basin Authority) 2017, *The Murray-Darling Basin Water Compliance Review*, Canberra.
- 2018a, *Objectives and Outcomes for River Operations in the River Murray System*, May 2017 (Updated June 2018), Canberra.
- 2018b, *Water Information Quality Assurance Framework*, Canberra.
- 2019a, *Best Practice Guidelines for Minimum Metering Thresholds*, Guidelines agreed between the governments of New South Wales, Victoria, Queensland, South Australia, Australian Capital Territory and the Australian Government, Canberra.
- 2019b, *Compliance Priorities 2019-20*, Canberra.
- 2019c, *Losses in the River Murray System 2018-19*, Canberra.
- 2019d, *Murray-Darling Basin Compliance Compact Assurance Report 2019*, December, Canberra.
- 2019e, *Report Summary: Conveyance Losses in the River Murray System*, Canberra.
- 2019f, *Review of Metering in the Lower Murrumbidgee Regulated Surface Water System*, Canberra.
- 2019g, *Review of the Condamine Alluvium Groundwater Self-meter Read Process*, Canberra.
- 2020a, *Review of Metering in the Riverland Regulated Surface Water System*, Canberra.
- 2020b, *Review of Metering in the Victorian Lower Murray Regulated Surface Water System*, Canberra.

-
- 2020c, *Water markets and trade*, www.mdba.gov.au/water-management/managing-water/water-markets-trade (accessed 18 November 2020).
- 2020d, *Who manages the Murray–Darling Basin*, www.mdba.gov.au/water-management/allocations-states-mdba/managing-murray-river (accessed 18 December 2020).
- Minister for Resources, Water and Northern Australia, Minister for Water, Property and Housing (NSW) and Minister for Regional Development and Manufacturing and Minister for Water (Qld) (Pitt, Pavey and Butcher) 2020, *Joint media release: \$35 million to improve Murray–Darling Basin water information*, Media Release, 14 December.
- NMI and DIIS (National Measurement Institute and Department of Industry, Innovation and Science (Cth)) 2019, *Regulator Performance Framework, Self-Assessment Report 2018–2019*, National Measurement Institution.
- NRAR (Natural Resources Access Regulator (NSW)) 2020, *Water Take in Horticulture in the Hawkesbury-Nepean Basin*, Campaign report, Department of Planning, Industry and Environment (NSW).
- NRC (NSW) (Natural Resources Commission (NSW)) 2019, *Review of the Water Sharing Plan for the Barwon Darling Unregulated and Alluvial Water Sources 2012*, Final Report, NSW Government, Sydney.
- NSW Ombudsman 2018, *Water: compliance and enforcement*, A Special Report to Parliament under section 31 of the Ombudsman Act 1974, 17 August.
- NVRM (Northern Victoria Resource Manager) 2020a, *About the Resource Manager*, <https://nvrn.net.au/about/resource-manager.aspx> (accessed 30 November 2020).
- 2020b, *How Seasonal Determinations are Made*.
- 2020c, *How Seasonal Determinations Work*, <https://nvrn.net.au/seasonal-determinations/how-allocations-work> (accessed 13 January 2021).
- NWC (National Water Commission) 2014, *Australia’s Water Blueprint: National Reform Assessment 2014*, Canberra.
- PC (Productivity Commission) 2017, *National Water Reform*, Report no. 87, Canberra.
- Pitt, K. (Minister for R., Water and Northern Australia) 2020, *New chapter in Murray Darling Basin Plan centres on communities | Ministers*, Media Release, <https://minister.awe.gov.au/pitt/media-release/new-chapter-mdbp> (accessed 7 December 2020).
- Sefton, R., Peterson, D., Woods, R., Kassebaum, A., McKenzie, D., Simpson, B. and Ramsay, M. 2020, *Final Report: Independent Assessment of Social and Economic Conditions in the Murray-Darling Basin*, Panel for Independent Assessment of Social and Economic Conditions in the Murray-Darling Basin, Melbourne.
- Sinclair, D. and Holley, C. 2015, *Water extraction in NSW: Stakeholder views and experience of compliance and enforcement*, Sydney.
- Sinclair Knight Merz, CSIRO and Bureau of Rural Sciences 2010, *Surface and/or Groundwater Interception Activities: Initial Estimates*, Barton.

-
- South Australia 2019, *Murray-Darling Basin Royal Commission*, Report, 29 January, Bret Walker SC Commissioner, South Australia.
- Steinfeld, C.M.M., Sharma, A., Mehrotra, R. and Kingsford, R.T. 2020, 'The human dimension of water availability: Influence of management rules on water supply for irrigated agriculture and the environment', *Journal of Hydrology*, vol. 588, p. 125009.
- Turner, G., Vanderbyl, T. and Kumar, S. 2019, *Final Report of the Independent Panel's Review of the Sustainable Diversion Limit (SDL) Water Accounting Framework*, Canberra.
- Vertessy, R., Barma, D., Baumgartner, L., Mitrovic, S., Sheldon, F. and Bond, N. 2019, *Independent Assessment of the 2018-19 Fish Deaths in the Lower Darling*.
- Waldron, T., Tan, P.-L. and Johnson, I. 2018, *Independent Audit of Queensland Non-Urban Water Measurement and Compliance*, Brisbane.
- WaterNSW 2019, *Annual Report 2018-19*, Parramatta.
- 2020, *WaterInsights Portal*, <https://waterinsights.watarnsw.com.au/> (accessed 16 October 2020).
- Weber, T. and Claydon, G. 2019, *Independent Review of NSW Floodplain Harvesting Policy Implementation*, Final Report, Alluvium.
- Wentworth Group of Concerned Scientists 2020, *Assessment of River Flows in the Murray-Darling Basin: Observed versus Expected Flows under the Basin Plan 2012-2019*, Sydney.
- Wickes, R., Smith, G. and Walker, G. 2020, *Report of the Independent Audit Group for Salinity, July 2017-June 2019*, Murray-Darling Basin Authority, Canberra.