NATIONAL WATER REFORM INQUIRY SUBMISSION

We thank the Australian Government and Productivity Commission for the opportunity to make a short submission on the National Water Reform 2020 Issues Paper. Our submission briefly addresses information requests 1, 2, 3, 4, 5, 6 and 13. The submission draws on some of the collective works from the multidisciplinary UNSW Connected Waters Initiative[1] and our individual experience as academics and practitioners who research, teach or practice in the area of surface water and groundwater at UNSW Sydney. The views expressed are however our own and do not reflect the position of our institution.

Professor Cameron Holley, Connected Waters Initiative & School of Law, UNSW Sydney

Associate Professor Bryce Kelly, Connected Waters Initiative & School of Biological, Earth and Environmental Sciences, UNSW Sydney

Associate Professor Martin Andersen, Connected Waters Initiative & School of Civil and Environmental Engineering, UNSW Sydney

Professor Andy Baker, Connected Waters Initiative & School of Biological, Earth and Environmental Sciences, UNSW Sydney

Dr Hamid Roshan, Connected Waters Initiative & School of Minerals and Energy Resources Engineering, UNSW Sydney

Associate Professor John Triantafilis, Connected Waters Initiative & School of Biological, Earth and Environmental Sciences, UNSW Sydney

Georgia Regan, Connected Waters Initiative, UNSW Sydney

Submission Overview

Although Australia has come a long way in water management under the National Water Initiative (NWI), the design and implementation of the NWI is not sufficient to meet future water challenges, particularly regarding groundwater. Further reforms and changes will be required. We believe the following issues have seen slow progress and we identify four priorities that should be considered and addressed by governments, civil society and industries if we are to achieve a sustainable groundwater future for Australia:

1. **Water quality: improving understanding and integration of water quality in decision making**

2. **Water planning and energy sector integration: enhancing understanding and management of energy sector impacts on groundwater**
3. **Compliance and enforcement: increase investment and share learning about intelligent water regulation**
4. **Strategic monitoring and improvement: rebuild and intensify system wide monitoring and benchmarking**

Each of these four priorities responds to a number of the Productivity Commission's information requests, as detailed in Table 1 below.

Priority		**Information request number & question**
1.	Water quality: improving understanding and integration of water quality in decision making	**1:** which elements of the NWI have seen slow progress **2:** current or emerging water management challenges where the NWI could be strengthened **3:** matters that should be considered for inclusion in a renewed NWI **4:** what lessons have recent extreme events (bushfires and COVID-19) provided for planning **6:** is the monitoring and assessment of environmental outcomes sufficient
2.	Water planning and energy sector integration: enhancing understanding and management of energy sector impacts on groundwater	**1:** which elements of the NWI have seen slow progress **2:** current or emerging water management challenges where the NWI could be strengthened **3:** matters that should be considered for inclusion in a renewed NWI **13:** areas for future reform of the NWI that have not been raised in this issues paper that should be investigated for inclusion
3.	Compliance and enforcement: increase investment and share learning about intelligent water regulation	**1:** which elements of the NWI have seen slow progress **2:** current or emerging water management challenges where the NWI could be strengthened **3:** matters that should be considered for inclusion in a renewed NWI **5:** how could the NWI be amended to support best practice monitoring and compliance across jurisdictions
4.	Strategic monitoring and improvement: rebuild and intensify system wide monitoring and benchmarking	**1:** whether the signatories to the NWI are achieving the agreed objectives and outcomes of the agreement **2:** current or emerging water management challenges where the NWI could be strengthened **5:** How could the NWI be amended to support best practice monitoring and compliance across jurisdictions **6:** is the monitoring and assessment of environmental outcomes sufficient

Table 1: Reform priorities and associated information request questions

We outline these four points in more detail below, with a primary focus on groundwater. We argue that entrenching and extending national reforms is vital to Australia's future water security. The context and justification for each priority reform is given by briefly evaluating the performance of the NWI. The discussion focuses particularly on non-urban water management, given agriculture remains the largest consumer of Australia's water, making it the area where some of the biggest gains can be made in securing sustainable groundwater management.

Four priorities for National Water Reform

1. **Water quality: improving understanding and integration of water quality in decision making**

The management of water quantity and quality are vital to securing economic, environmental and social outcomes for Australia. And yet, these two issues have rarely been sufficiently connected. As the Productivity Commission noted in its 2017 review: "The limited mention of water quality in sections of the NWI relating to water planning has become increasingly conspicuous and out of step with contemporary water management issues … water quality is an important consideration". [2] Certainly, there have been various attempts to better connect quality to water decision-making by the Australian, state and territory governments. This includes, investment in mapping Groundwater Dependent Ecosystems, the updated Charter for the National Water Quality Management Strategy (NWQMS), the progress on water resource plans under the Basin Plan, and the National Groundwater Strategic Framework 2016–2026 which involves actions to embed water quality into regulatory frameworks, including through the National Water Quality Management Strategy: Guidelines for Groundwater Quality Protection in Australia.

Even so, where water quality has been included in water management decision making, the focus has tended to be on salinity. While important, salinity is only one of several relevant quality issues, particularly regarding groundwater and its management. For example, nutrients, including organic carbon, can affect water quality overtime. Notably, there are increasing risks of nutrient inputs to subsurface water and connected rivers, given the potential for longer fire seasons and greater fire extent in Australia. These risks are particularly conspicuous given that nutrients were implicated in the 2019 mass fish-kills in Menindee and fire-related nutrients in the 2020 fish kills in the Macleay region.[3] Yet, there have been few, if any, systematic analysis of soluble-ash products affecting water quality in the vadose zone or groundwater before and after fire. Such studies are needed, including pairing them with river baselines. [4]

There are also increasing risks for agricultural production from sodicity (sodium adsorption ratio), which can lead to altered soil structures with reduced permeability and low nutrient holding capacity when nitrogen fertilisers are applied.[5] Furthermore, hydrochemical analysis has had limited use in constraining catchment-scale water balance modelling for proportioning recharge components or guiding sustainable groundwater allocations, despite the need to use multiple techniques (including hydrochemical insights) to increase the reliability of recharge and discharge estimates.[6] Better hydrogeochemisty can assist water managers to work out the origin of groundwater (e.g. surface water, artesian discharge into to alluvial aquifer, landscape wide deep drainage or floodwater recharge). Moreover, to the extent that national and state water reforms seek to increase trading of groundwater across zones and catchments, issues of quality will remain a significant challenge, given different aquifers and locations have different ecologies and water requirements.

What is needed is better utilisation of low cost, but regular and wider scale hydrogeochemistry studies and data to better inform water planning, trading and management decisions. Because water quality processes are dynamic, such work needs to be regularly conducted. Furthermore, such studies need to go beyond isolated attention to single issues, and be pursued in a more coupled and integrated way. One example of this would be the development of an integrated national water carbon budget (surface water, groundwater) as well as other nutrients. This type of work could align with broader efforts and opportunities to reduce carbon emissions from agriculture,[7] such as through CO2e accounting and offsetting linked to improved nitrogen use,[8] with multiple likely environmental benefits for surface water and groundwater.

The keys to addressing the above issues and needs is increasing investment in relevant knowledge generation and innovation, including isotope studies, extensive hydrogeochemical data studies across catchments, and new data analytics studies using easily obtainable data[9] sets.[10] Examples of the types of work that is needed include:

- developing and implementing machine learning techniques to estimate the hydrogeological properties of geological formations responsible for groundwater flow and contaminant transport, using easily attainable data measured by surface and downhole geophysical tools. This includes the use of Deep Learning (ANN) algorithms to estimate the permeability and water storage across formations of interest, as well as predicting the temporal and spatial contaminant plume migration in aquifers. Machine Learning techniques can also be used to verify or improve existing numerical models of fluid/mass transport in geological formations applicable to both water resources and impacts from the energy sector.
- statistical analysis and visualisation of large groundwater quality and recharge datasets, such as mixed linear modelling of continental-scale global water quality data and time-series analysis of large (>3 million data-point) hydrology data to quantify

groundwater recharge thresholds, as well as modelling of unsaturated zone recharge processes, focusing on the use of lumped parameter models of soil and unsaturated zone water balance, and use of water isotope tracers. [11]

- predicting spatial and temporal properties of hydrogeological and hydrogeochemical data sets using machine learning techniques, as well as modelling groundwater fluctuations using impulse response functions, and constructing 3D Geological Models using machine learning techniques in faulted and folded environments from field mapping data, borehole logs, and historical geological maps.[12]
- coupling physical, chemical and ecological groundwater processes to understand how physical groundwater management impacts on water quality and ecological processes. This can include consideration of nutrients (Carbon, Nitrogen, Phosphorous) in groundwater and connected surface waters. [13]
- the use of near-surface geophysical sensors to create digital soil maps of the soil and vadose-zone to better understand where recharge occurs in irrigated agricultural landscapes.[14]

These and similar studies are vital to better inform practices and reflect interactions between water quality and quantity in water decision making, planning, trading and enforcement to better identify risks to water resources and optimise management. [15]

2. Water planning and energy sector integration: enhancing understanding and management of energy sector impacts on groundwater

Australia's rivers and aquifers have different local ecologies and are used by many different agricultural communities. Collaborative water plans are the core mechanism for incorporating and managing these diverse contexts and users. While there has been substantial experimentation in water planning across states and territories,[16] most plans set environmental outcomes, i.e. rules for the allocation and trading of water for consumption, and monitoring and reporting requirements. Despite a slow start, there have been noted improvements in the quality and extent of planning across Australia.[17] Despite this progress, water plans continue to suffer from fragmented coverage of uses and a history of limited community engagement.

One of the most prominent examples of fragmentation is the water use and impacts of the mineral and petroleum sectors, particularly unconventional gas. While these sectors have been a significant driver of the Australian economy, they were recognised as facing 'special circumstances' (e.g., short durations, isolation and difficulties accounting for water extraction), and were to be addressed outside of the NWI and its plans.[18] However, these non-NWI regimes did not achieve the level of integration necessary to attend to the interdependencies between these developments and their impacts on water, not least reduced water availability and altered flows.[19] Significant public concern about these failures[20] led to a recent patchwork of federal and state reforms (e.g., the Commonwealth's water trigger, bioregional assessments and NSW's Aquifer Interference Policy). However, across some states, these regimes remain limited, ad-hoc or partial, with industries' water use, including cumulative impacts, not always well integrated with broader regional water planning processes, and various states continuing to allow industries to sit outside of NWI water plans.[21] Certainly, there had been improvements over time, but doubts exist about the effectiveness of water and unconventional gas governance frameworks, whether because of the economic benefits that arise from gas investment or that governments are sometimes perceived to be conflicted, underprepared, and under-resourced. As governments seek to promote greater investment in unconventional gas developments across Australia, existing governance arrangements are more a mix of ad-hoc rather than coordinated processes, leaving in place loose ends and hanging threads (e.g., data gaps; power imbalances) and discordances (e.g., practices and private agreements that may limit appeal and consultation opportunities in broader regional impact assessment and approvals process).[22] These must be addressed, and it is an open question whether governance instrument mixtures across water and energy sectors that have evolved over time can achieve ambitious environmental and social goals in an efficient and effective way, at least when compared to more collaborative holistic designs (discussed below) that are more consciously created to meet these contemporary water-energy nexus challenges.

In terms of community engagement, there are many instrumental reasons why community consultation in planning is pursued, including encouraging trust and buy-in, and developing effective responses to local problems (e.g., water cutbacks).[23] However, government designed planning process have tended to focus on traditional, quick and easy consultation methods (e.g., community meetings or panels), leading to Indigenous and many other interests (e.g., environmental and local farmers) being poorly engaged.[24] While there are signs of improving consultation in more recent plans,[25] these advances were arguably slow in coming and have produced continuing and profound legitimacy shortfalls and mistrust across affected communities.

To successfully resolve the above shortcomings, planning processes must prioritize integration and commitments to deeper stakeholder engagement. This will require new obligations to identify all beneficiaries and interests affected by planning up front (so as to ensure more widespread engagement and avoid sectoral fragmentation causing difficulties during implementation);[26] joining up currently separate water planning processes and mining and gas development approval processes (as well as many largescale renewable developments, which are estimated to require society to devote up to 1,000 times more land area to energy production than today[27]);[28] and legislating commitments to create, sustain and fund deeper deliberative engagement across a broader range of interests.[29] Part of this process requires closer collaboration between water regulators, industry, community groups, water researchers and energy researchers to share and integrate understandings. Pursuing such reforms will enhance opportunities for greater community 'buy-in' and produce more innovative, integrated and effective responses to local water problems.

3. Compliance and enforcement: increase investment and share learning about intelligent water regulation

A core element of Australia's water governance approach is traditional regulation, conducted primarily by state-based regulatory agencies. Although groundwater and surface water both have confronted (and continue to confront) compliance challenges, groundwater presents a particularly diabolical compliance and enforcement problem. For instance, compared to surface water, groundwater's subterranean location makes it far less visible. This concealed nature means that individual and collective extraction impacts are often not immediately evident (compared to more visible and easily monitorable drops in rivers and other surface waters). This can mean illegal extraction of groundwater becomes comparatively more clandestine than in surface water contexts, and thus limits the effectiveness of peer or other forms of monitoring and persuasion that can foster social norms of compliance. Augmenting this problem is the historic under-investment in monitoring of groundwater, which in turn increases uncertainty over the extent and condition of aquifers and creates significant challenges in measuring and modelling consumption levels and the impacts of extraction. More generally, ensuring groundwater users comply with extraction limits and other rules is a truly complex challenge. This is because groundwater use often involves multiple points of extraction (e.g. numerous bores for irrigation and stock and domestic, which can have different regulatory obligations). Groundwater also tends to be used sporadically (representing a small proportion of overall water use, but relied on heavily during dry periods). Bores are also dispersed over large geographic areas (often being the only form of water available in some remote/rural areas) and can have impacts on numerous locally variable and dynamic systems (often with long time lags between extraction and response).

Despite these unique challenges, groundwater compliance and enforcement in Australia has largely been subject to the same compliance and enforcement policies and regulatory regimes as surface water. This global approach to regulating water sources means it is often difficult to discretely separate the compliance and enforcement trends and experiences of groundwater from surface water. Even so, it is clear that compliance and enforcement remains a major issue for both types of water in Australia and internationally.

Notwithstanding some positive developments in compliance activities (e.g. National Frameworks on non-urban water metering and compliance and enforcement systems for water resources), by the end of 2016 a decline in national reform funding was notable. Within this context, another shift occurred in NSW, with the NSW Government altering institutional arrangements for compliance staffing and functions. During this transition, a number of allegations were made about performance of statutory functions, and the adequacy of enforcement actions. This was closely followed by allegations of non-compliance aired on a national television current affairs program, particularly regarding surface water extraction in the Barwon-Darling River system in Northern NSW.

These nationally broadcast claims sparked tangible concern over NSW and other states' water compliance and enforcement. Public inquiries followed, with one reporting "water related compliance and enforcement arrangements in New South Wales have been ineffectual and require significant and urgent improvement". [30] "Considerable frustration" was also levelled at the intersecting role of the Murray Darling Basin (MDB) Authority and its response to alleged serious breaches. [31] A subsequent MDB Authority inquiry found differences in Basin state compliance vigilance, with South Australia reportedly having a long commitment to a compliance culture, including extensively codified rules and comparatively higher resourcing, while Queensland, NSW and to a lesser extent Victoria evidenced a notable lack of transparency, patchy metering and a low level of compliance resourcing.[32]

Following this recent series of inquiries, the NSW Government recently announced the creation of a new and independent Natural Resources Access Regulator (NRAR) to strengthen water compliance and enforcement in NSW. The NRAR independent board was established in January 2018 and the new agency is now operating. Ongoing research has suggested there is strong in-principle support of the need for water regulation, with personal values and social reputation being key compliance motivators.[33] Fear of legal enforcement has historically not appeared to be as significant a driver of water users' compliance behaviour, most likely reflecting a previous lack of staff on the ground. The potential deterrent of enforcement powers may also have been compromised by a lack of knowledge of, in particular, enforcement actions and penalties. Similarly, a widespread lack of knowledge of broader water policy goals and mechanisms has the potential to undermine compliance initiatives in a range of areas, although most water users appear to support and have a good understanding of metering technology and its use in compliance and on-property management. However, knowledge and support of metering is greatest in those regions with more regular extraction/irrigation and more metering experience. Economic advantage remains a primary driver for non-compliance, suggesting compliance and enforcement tools need to target such benefits (e.g. using enforcement to leverage higher fines or recoup profits).[34] Research also suggests water users displayed a distinct preference for relying on information from trusted sources, in particular, family, neighbours and water user groups. This suggests working with third parties (given the limited public resources), in the provision of more detailed information may assist compliance activities to complement other information initiatives.[35] Moreover, emerging agent based computer modelling studies of compliance data[36] suggest that enforcement 'sticks' will not be sufficient to ensure compliance with groundwater regulations (especially in the absence of sufficient compliance and enforcement staff on the ground) and that using non-government actors (community leaders or unconditional rule-followers) to promote broader social norms will provide the true 'glue' that cements and holds cooperative compliance behaviours together. With new reforms underway in states such as NSW, there is an opportunity for responding more strategically and intelligently to these insights and broader lessons on compliance and enforcement.

Although responses must be tailored to context, enhancing NWI compliance and enforcement efforts will likely require increased and continued investment, and shared learning amongst regulators, researchers and affected stakeholders to advance intelligent water regulation. Such investment and learning must be directed toward advanced monitoring, metering and modelling technology in compliance and enforcement design and strategy; increasing and publicising compliance officer activities (e.g. education and periodic targeting of regions/sectors); creating networks of third party regulators and compliance promoters (e.g. using farming peers in promoting compliance); and utilising a responsive regulatory regime that maintains the support of water users.[37]

4. Strategic monitoring and improvement: rebuild and intensify system wide monitoring and benchmarking

Intergovernmental action under the Council of Australian Governments (COAG) led National Competition Policy and the National Water Initiative (NWI) has defined Australia's water reforms. The latter agreement has demarcated Australia as a leading laboratory of water governance.[38] Even so, as the NWI is rapidly approaching its 20th year in 2024, its defining features are getting pulled in different directions via multiple and often ad hoc inquiries.[39] Notwithstanding the Productivity Commissions useful periodic reviews, coordinated learning and adaptation opportunities are easily getting lost between the gaps of these typically isolated interventions and stand-alone reform proposals at different levels of government. This risks jeopardizing Australia's long-term water sustainability, as reforms risk becoming less strategic, more fragmented and unaligned.

This current state of affairs is unfortunate, given one the most successful features of the NWI was its system of monitoring and continuous improvement. Significant government funding was committed to monitoring, oversight and continual "learning by doing" activities, including major investment in the Bureau of Meteorology (which gathered significant national water information); and financial backing for an independent National Water Commission (NWC) – a skills-based body whose tasks included conducting periodic assessments of the reforms and producing a series of related products, research studies, performance indicators and position statements.

As a tool for improving and progressing the NWI, the NWC assessments, and its detailed reviews of planning, position papers and various other studies were arguably vital products, helping to facilitate mutual learning amongst states and benchmarking performance. The assessments shed light on gaps in the agenda, and publicly 'prodded' governments and other stakeholders when they were dragging the chain on water reform.[40] This success is worth noting given that, subsequent to the National Competition Reforms and their incentive arrangements, there has been comparatively less funding to encourage State commitment to implementation (other than those tied to specific programs or places like the National Framework for Compliance and Enforcement and the Murray Darling Basin national partnership agreement payments).

Despite the success of the NWC, its abolition around 2015 was based on the view that progress in implementing the NWI was such that its detailed, coordinated and strategic monitoring of national reforms was no longer needed, with statutory functions transferred elsewhere, such as to the Productivity Commission.[41] With progress on monitoring left to a greater multiplicity of actors and interventions (e.g. the Productivity Commission, government self-assessment, and diverse and ad hoc senate and independent inquiries) some of the more centralized and transparent disciplinary drivers that arose from the NWC's targeted public transparency and comparisons have arguably fallen away.[42]

At a minimum, the NWI's commitment to monitoring and improvement goals should be improved through increasing monitoring budgets (e.g., for water plans and monitoring infrastructure) and reembracing a more robust and strategic approach to learning via an independent oversight body like the NWC. A fundamental change would extend the NWI monitoring and improvement model so as to mirror a more experimentalist learning architecture,[43] replete with new obligations for state and localised benchmarking of water plans, greater horizontal diffusion of information between water catchments (facilitated by an oversight body like the NWC), and setting and ratcheting up minimal standards of good performance and process. Doing so would enhance opportunities for sharing more detailed and fine-grain learning and innovation (such as how best to integrate gas and mining in water planning, how to pursue the most effective approach to water regulation and how to effectively and efficiently manage groundwater assets) across contexts, as well as enhancing opportunities for accountability.

Opportunities for additional participation and input

The Connected Waters Initiative is pleased to provide further input regarding the priorities and issues detailed above. Please feel free to contact us via the Connected Waters Initiative's Administrator, Georgia Regan

[1] This work, and a fuller list of references and citations for this submission's content can be found here: Andersen M, Barron O, Bond N, Burrows R, Eberhard S, Emelyanova I, Fensham R, Froend R, Kennard M, Marsh N, Pettit N, Rossini R, Rutlidge R, Valdez D & Ward D, *Research to inform the assessment of ecohydrological responses to coal seam gas extraction and coal mining*, (Department of the Environment and Energy, Commonwealth of Australia, 2016), http://www.environment.gov.au/water/publications/assessment-ecohydrological-responses; Charlotte P. Iverach, Dioni I. Cendón, Karina T. Meredith et al, A multi-tracer approach to constraining artesian groundwater discharge into an alluvial aquifer. Hydrol. Earth Syst. Sci., 21, 5953–5969, (2017); Burrows, R.M., Rutlidge, H., Bond, N. *et al.* High rates of organic carbon processing in the hyporheic zone of intermittent streams. *Sci Rep* 7, 13198 (2017), https://doi.org/10.1038/s41598-017-12957-5 ; Liza K. 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[7] See e.g. Kath Sullivan, National Farmers Federation calls for Australia to reduce net emissions to zero by 2050, 20 August 2020, https://www.abc.net.au/news/2020-08-20/farmers-back-zero-emissions/12576806.
[8] See e.g., Reef Credit Scheme, https://www.reefcredit.org.
[9] For example, the NSW NCRIS Groundwater Infrastructure field sites and data in operation since 2013 have generated a large database of high frequency groundwater level time series; similarly there have been a series of Cotton Research and Development Corporation projects by ANSTO/UNSW/Qld DNRME that have developed large water chemistry data sets on specific catchments.
[10] For example, the NSW NCRIS Groundwater Infrastructure field sites and data in operation since 2013 have generated a large database of high frequency groundwater level time series; similarly there have been a series of Cotton Research and Development Corporation projects by ANSTO/UNSW/Qld DNRME that have developed large water chemistry data sets on specific catchments.Andersen et al, 2016, above n 1; Burrows et al. 2017, above n 1; McDonough et al. 2020a & 2020b, above n 1; Graham et al, above n 4.
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[14] Zhao et al, 2019, above n 1; Zare et al, 2020, above n 1.
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