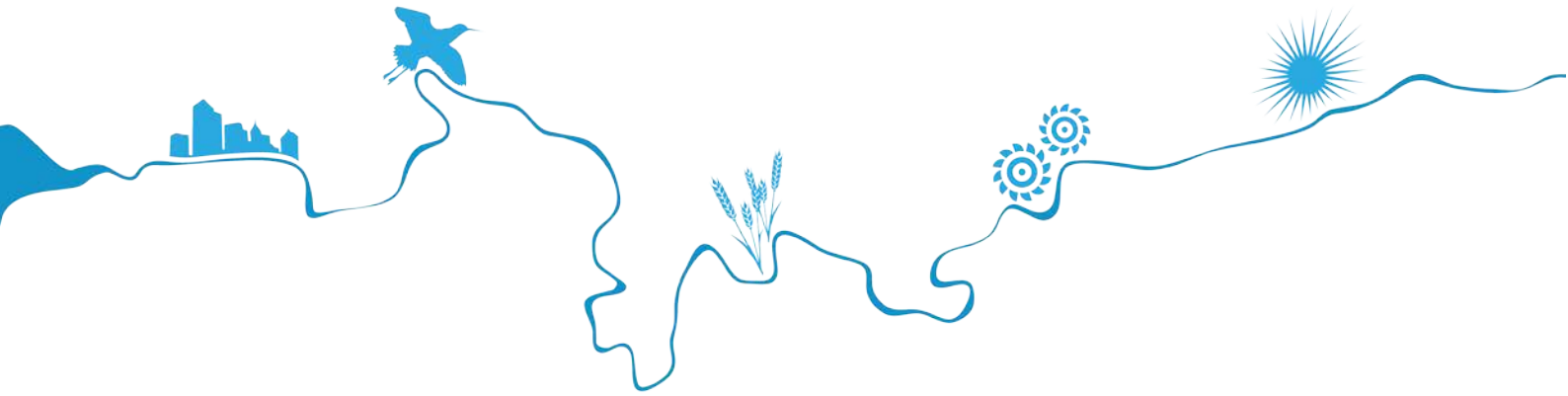
# High-level assessment of a water rating system for South Australian water sources

Bethany Cooper, Lin Crase, Courtney Regan, Sarah Wheeler and Craig T. Simmons



Goyder Institute for Water Research
Technical Report Series No. 22/14

www.goyderinstitute.org

**Goyder Institute for Water Research Technical Report Series ISSN: 1839-2725**

The Goyder Institute for Water Research is a research alliance between the South Australian Government through the Department for Environment and Water, CSIRO, Flinders University, the University of Adelaide and the University of South Australia. The Institute facilitates governments, industries, and leading researchers to collaboratively identify, develop and adopt innovative solutions for complex water management challenges to ensure a sustainable future.

Enquires should be addressed to: Goyder Institute for Water Research
The University of Adelaide (Manager)
209A, Level 2 Darling Building, North Terrace,
Adelaide, SA 5000
tel: (08) 8313 5020
e-mail: enquiries@goyderinstitute.org

**Citation**
Cooper B, Crase L, Regan C, Wheeler S and Simmons CT (2022) *High-level assessment of a water rating system for South Australian water sources.* Goyder Institute for Water Research Technical Report Series No. 22/14.



**Disclaimer**
The University of South Australia, Flinders University, and The University of Adelaide as the project partners, advise that the information contained in this publication comprises general statements based on scientific research and does not warrant or represent the completeness of any information or material in this publication. The project partners do not warrant or make any representation regarding the use, or results of the use, of the information contained herein about to its correctness, accuracy, reliability, currency or otherwise and expressly disclaim all liability or responsibility to any person using the information or advice. Information contained in this document is, to the knowledge of the project partners, correct at the time of writing.

# Contents



# Figures



# Tables

# Respect and reconciliation

Aboriginal people are the First Peoples and Nations of South Australia. The Goyder Institute for Water Research acknowledges the range of First Nations' rights, interests and obligations and the cultural connections that exist between different First Nations and seeks to support their equitable engagement.

Aboriginal peoples' spiritual, social, cultural and economic practices come from their lands and waters, and they continue to maintain their cultural heritage, economies, languages and laws which are of ongoing importance.

# Executive summary

The Department for Environment and Water (DEW) sought to investigate the potential to create an environmental, social and governance (ESG) rating system for the state's water sources, whether they be native (i.e., natural waterways and groundwater systems) or manufactured (e.g., desalinated, recycled wastewater, stormwater, etc.). The purpose of such a rating system would be to provide a high-level, but robust method for identifying and demonstrating where native and manufactured water sources are delivering on sound environmental and cultural/social (including economic) outcomes and are judiciously governed.

The project used two main approaches:

- A literature review; and
- Stakeholder consultations.

Several key findings emerged from the systematic literature review phase:

- No ESG rating scale for water sources that can be applied at the state-wide level is currently available.
- A water rating system of the form sought will necessarily require some form of multi-criteria decision-making and the published literature can guide how to limit the criticisms that can attend these approaches.
- Within the peer-reviewed literature, the Driver-Pressure-State-Impact-Response (DPSIR) framework is likely worthy of closer inspection as a means of guiding the development of a water rating system.
- Within the grey literature, existing water rating systems do not match needs of DEW, primarily because of the unique scale sought. The Alliance for Water Stewardship has some overlaps with the requirements of DEW, albeit currently operationalised at a site scale.
- Other natural resource rating scales/indices offer direction, especially around potential risks. These include:
    - Ensuring any 'new' ratings are harmonised to limit costs for water using industries and to maximise interpretability by end-of-supply-chain consumers; and
    - Noting that water is only one element within many ESG ratings currently used by industry and thus the net benefits for a specific water rating system for water using industries should be viewed though that lens.

Collectively, the stakeholder consultations support the view that:

- A water source rating system based on ESG principles likely has broad support from water users, other government agencies and investment communities.
- South Australia (SA) has an opportunity to take the national lead on this front, although ultimately a national system will hold more weight.
- Continued involvement with stakeholders will be required to optimise the design of the rating system and to ensure that it adds value and does not compete with existing ESG work across different groups.

Both the literature review and stakeholder consultations emphasised that producing a water rating system based on water sources and at the level of the state is a significant undertaking. In that regard, we recommend a stock-take of existing information to gain insights into the workplan that would be required. The next step is to thus undertake an audit to see what information can be collated into a water rating system at low cost.

There is a gap between how water sources are currently classified and reported upon and the ambitions for an ESG water source rating system. That does not mean that the task is insurmountable and this report has

provided evidence that a water rating system would be valued by a range of stakeholder groups. There is also some evidence that a rating system developed in SA could advantage the state, but the extent of that benefit has not been quantified. Accordingly, the development of a water rating system is best undertaken in iterations that allow DEW to reflect on the relative costs and benefits at each stage of development.

# Acknowledgments

We are grateful to the numerous stakeholders who participated in the consultation phases of this project. They gave generously of their time and knowledge. In addition, we acknowledge the support and direction provided by staff of DEW, particularly Noëlle Overdevest, Neil Power and Ben Bruce.

# 1 Introduction

The Department for Environment and Water (DEW) sought to investigate the potential to create an environmental, social and governance (ESG) rating system for the state's water sources, whether they be native (i.e., natural waterways and groundwater systems) or manufactured (e.g., desalinated, recycled wastewater, stormwater, etc.). The purpose of the rating system is to provide a high-level but robust mechanism for identifying where native and manufactured water sources are delivering on sound environmental and cultural/social (including economic) fronts and are judiciously governed.

Most rating systems are based on underlying scores that are then aggregated in a way that provides meaning to a range of stakeholders, including non-experts. Common examples include energy and water rating systems for household appliances (based on a star rating). Similarly, the nationwide house energy rating system (NatHERS) uses star rating to provide a simplified aggregate assessment of house size, function, orientation, construction and location. These types of ratings help guide choices and investments by individuals, enterprises and governments. Arguably, a water source rating system could do the same.

In the context of water sources, the ecological status of some waterways is captured in broader environmental condition reports, often using aggregated ratings. For example, in South Australia overall environmental condition is reported across four ratings covering 'very good', 'good', 'fair' and 'poor'[1]. These condition categories do not take account of social and governance measures and are a composite of environmental factors, beyond water. The ratings also do not directly capture the benefits of using alternative water sources when more than one options is at hand. This is potentially a complex issue inasmuch as ESG risks potentially interact across different water sources. Any ratings system should be helpful to end users but require data and expert assessment to facilitate their development.

Potential end-users for the water source rating system comprise the South Australian Government, industries that might be attracted to the notion of being able to report their activities against/within the rating system and investors who are looking to ensure that their funds are being applied to projects that are aligned with their values. Having a rating system that can be consistently applied across the state would allow each of these users to make more informed choices.

The investigation into the rating system commenced with an expectation from the DEW that a high-level assessment of the viability of generating such a rating system would be provided. An initial assessment concluded that additional exploratory work was warranted and that was then undertaken with iterations guided by DEW.

These iterations shifted the initial focus of the work – initially a workshop was to have been used to explore alternatives and scenarios, however DEW later recognised that more could be gained by additional in-depth interviews with key stakeholders. Accordingly, the resources for this project were redirected at detailed interviews with additional key stakeholders identified by DEW. The scope of this work did not extend to building the rating system; rather the focus was on high-level assessment of opportunities and challenges to its development.

This report:

- Outlines the analytical approach;
- Summarises the methods employed;
- Presents key findings; and
- Briefly reviews the status quo of reporting, discusses next steps and offers concluding remarks.

[1] The rating system also includes categories titled 'unknown' and 'not applicable'.

# 2 Analytical approach and rationale

The project used two main approaches across three phases. First, a systematic interrogation of the published literature was undertaken on water rating systems and potential indices used in other natural resource settings. The purpose of this phase was to identify if any existing rating systems could be easily leveraged to the task.

Second, preliminary interviews with potential stakeholders identified by DEW were undertaken to establish the extent to which such a system would be favoured by particular sectors and to explore challenges to development and deployment. These first two phases then informed the initial high-level feedback to DEW in February 2022, with a recommendation to continue investigating how a rating system might evolve.

The final phase comprised additional in-depth interviews and discussions with strategically influential individuals and groups to inform the next steps. The total number of interviews comprised 18 participants. The broad themes from these qualitative phases are combined in this report and partly underpin the recommendations offered.

### Why review published and grey literature?

To the knowledge of DEW and the investigating team, no similar water rating system exists at the scale proposed. Other jurisdictions in Australia have not yet developed a rating system at the level of water sources or established ways of integrating ESG information into a single metric. Any new rating system that brings together multiple ESG dimensions should thus draw from the best existing approaches.

Since an ESG rating system would, by definition, constitute a multi-criteria approach[2], it is also important to acknowledge that multi-criteria decisions can be contentious and attract criticism. One of the key concerns is understanding how criteria are combined and trade-offs managed within the rating system. It is thus important to first understand what rating systems currently exist and how trade-offs are made understandable.

### Why consult stakeholders about a water rating system?

While multi-criteria decision making can take place at an individual level, multi-criteria decision applications in environmental management have shifted towards multi-stakeholder processes aimed at structuring the problem or task and then facilitating dialogue on the relative merits of different options (Saarikoski et al. 2016).

There is also extensive formal literature that argues that involvement of the citizenry in the decision-making process is a prerequisite to success, especially in the management of natural resources, like water (e.g. Colfer, 2005; Zerner, 2000). The participation of individuals or groups in shaping a change in government approach, such as the introduction of a water rating system, can also enhance social justice and raise the legitimacy of decisions generally (Munroe-Clarke 1992). Ross et al. (2002) developed a relatively sophisticated typology based on public participation processes in natural resource management in Australia and noted one form of participation was 'consultation'. Here, the initiating agent (DEW in this case) "encourages two-way communication and is willing to shape the eventual decision according to public input" (p.215). The decision-making power nonetheless resides with the initiating party. Crase et al. (2005) and Crase et al. (2013) extend Ross et al. (2002) by including the costs of consultation relative to any merits. Key benefits to consider for the initiating party are the ability to gain additional information and the potential to reduce resistance to change.

[2] The multi-criteria approach uses a "general framework for supporting complex decision-making situations with multiple and often conflicting objectives that stakeholder groups and/or decision-makers value differently" (Saarikoski 2016, p.240)

Given the scope of the project the ambition to gain additional information and understand areas of potential tension, targeted consultation phases directed by DEW were considered most likely to add net benefit to the formulation of any water rating system.

# 3 Summary of methods

### Literature review phase

The high-level peer-reviewed literature review focused on two main questions:

- What existing water sustainability rating systems exist and do any have the potential to be adapted to suit classification at the water source scale (e.g. catchment)?
- What relevant natural resource management rating systems exist and do any have the potential to be adapted to a water source context (e.g. can forestry ESG systems be applied to water)?

A search for relevant ratings systems and methods was conducted through database searches in Google, Web of Science and Google Scholar. Where citations within discovered papers appeared relevant, these were also investigated. The search phrases included:

- Water sustainability rating systems;
- Water source sustainability rating systems;
- Regional water sustainability rating systems;
- Catchment sustainability rating system;
- ESG rating systems;
- ESG water rating systems; and
- System Sustainability Indicators water (including SSI water).

These keywords were used both independently and in combinations. The search timeframe included publications from 1990-2022 and 40 papers were reviewed in-depth.

The peer-review literature research was then followed by a review of the grey literature. This search explored other water rating systems, albeit with none covering the ESG dimensions of interest to DEW. The grey literature review was also extended to consider natural resource related rating systems to establish if there was scope for leveraging from some of this work.

### Stakeholder consultation phase

The initial consultation phase involved stakeholder interviewees being contacted by DEW to establish their willingness to participate. An invitation from the research team followed for those who were willing and were available. The consultation phase was undertaken with Human Research Ethics approval from UniSA (UniSA ethics number: 013/2022).

Interviews began on 21st February 2022 and concluded on 25th May 2022. The interviews comprised 18 participants, grouped into representatives from water-using industries, government agencies, industry accrediting bodies and infrastructure investment advisors. A breakdown by organisation is provided in Section 4.2. Interviews were undertaken mostly using Zoom/Microsoft Teams and generally occupied between half hour and an hour. Interviewees either participated individually or by being paired with someone in the same sector/industry. The interviews were semi-structured, where respondents were asked about:

- Awareness of water management issues in South Australia;
- Perceptions about rating systems for water;
- Direct and indirect benefits and costs of a water rating system;
- Relative support for progressing a water rating system; and
- Other industry/sector considerations, including impacts on customers.

The interviews were not digitally recorded but notes were taken and in some cases follow-up communication by email and phone was required. Participants also often offered directions to other resources that might help shape thinking about a rating system.

One of the outcomes from the initial interviews was suggestions from participants to consult more broadly with others such as the wine and forestry sectors and industry accrediting bodies. In these cases, clearance was first sought from DEW to proceed. These discussions were undertaken after February 2022 and following the decision by DEW to continue investigating the feasibility of a rating system.

The first round of consultations were dominated by industries that might be regarded as water users. Accordingly, the initial consultations tended to yield more information about what would be required to mitigate resistance to change, rather than establishing information required to build a rating system that was attractive to large scale investors. This gap was addressed by DEW later identifying individual investors who use ESG-type metrics to inform decisions. The interviews for these individuals were more extensive than the water user consultations and included participation by key DEW personnel.

The feedback from 18 stakeholder interviewees underpins the findings from this phase.

# 4 Key findings

The findings are reported in two parts addressing the literature review and the stakeholder consultation phases, respectively. The literature review is broken into reporting of peer-reviewed papers, a review of grey literature focused on water rating indices and a review of natural resource rating systems.

## 4.1 Finding from literature review phase

### Peer reviewed literature

ESG water rating systems and natural resource management (NRM) rating systems (including NRM rating systems) returned little relevant literature from the peer-reviewed search.

During the search for ratings and assessment tools, it was apparent that several frameworks were consistently used in the literature. They included multi-criteria analysis (MCA), life cycle assessment (LCA), material flow analysis (MFA) and sustainability impact assessment (SIA). These terms were subsequently included in the search.

Since 2010 there has been a significant increase in the number of publications returned for each of the search terms used (Figure 1). The terms with the most marked increase included system sustainability indicators (SSI) water, water sustainability rating systems, LCA water resources and SIA water resources.

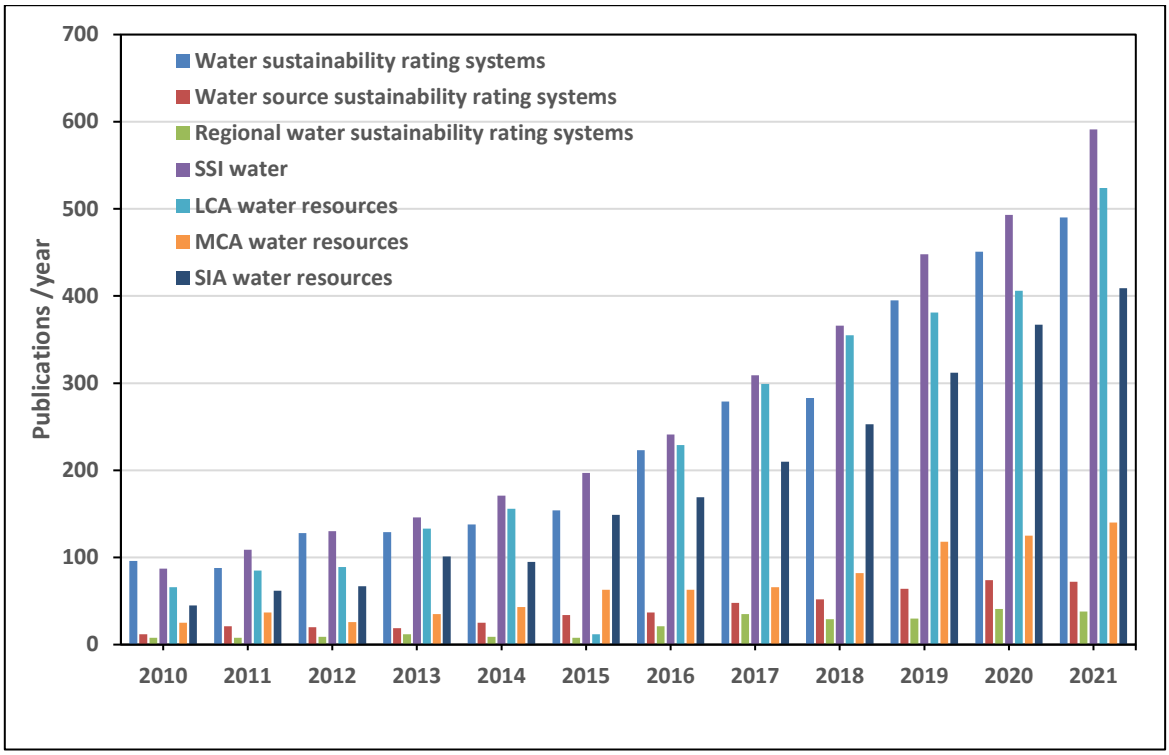



**Figure 1: Annual publication rates of key search phrases.**

Cursory review using the above search terms showed that many of the applications of MCA, LCA and SIA in the water resources field were bespoke and comprised mostly applied smaller case studies limited to confined geographical areas, or water supply systems. Few were applied at a scale beyond a single catchment or water source, certainly not in a way that would allow for consistent ratings across an entire state.

The terms ESG rating systems, ESG water rating systems and natural resource management rating systems (including NRM rating systems) also returned little relevant literature. However, several ESG rating systems

are operational and used in the peer-reviewed literature including the Global Reporting Initiative (GRI), United Nation Sustainable Development Goals (SDG), Morgan Stanley Capital International (MSCI) and the Sustainability Accounting Standards Board (SASB).

These ESG frameworks all follow different methodologies resulting in varied interpretations and there is little harmonisation across methods. They also seemingly have different foci. For example, the MSCI and SASB are particularly focused towards assessing investment risks and how ESG impacts financial performance. In contrast, the SDG has a comprehensive and holistic focus, incorporating such metrics as hunger and poverty, peace and access to education. Its broad nature thus makes measurement of water-specific dimensions difficult.

One framework of potential interest that appeared consistently in the literature was the Driver-Pressure-State-Impact-Response (DPSIR) framework (Figure 2). The DPSIR framework provides a structure suited to the development of indicators for policy makers on environmental quality and the resulting impact of the economic and political choices. The DPSIR framework assumes a chain of causal links starting with 'driving forces' (e.g. economic sectors, human activities) through 'pressures' (e.g. emissions, waste) to 'states' (e.g. physical, chemical and biological) and 'impacts' on ecosystems, human health and functions, eventually leading to political 'responses' (e.g. prioritisation, target setting, indicators) (Kristensen, 2004). .

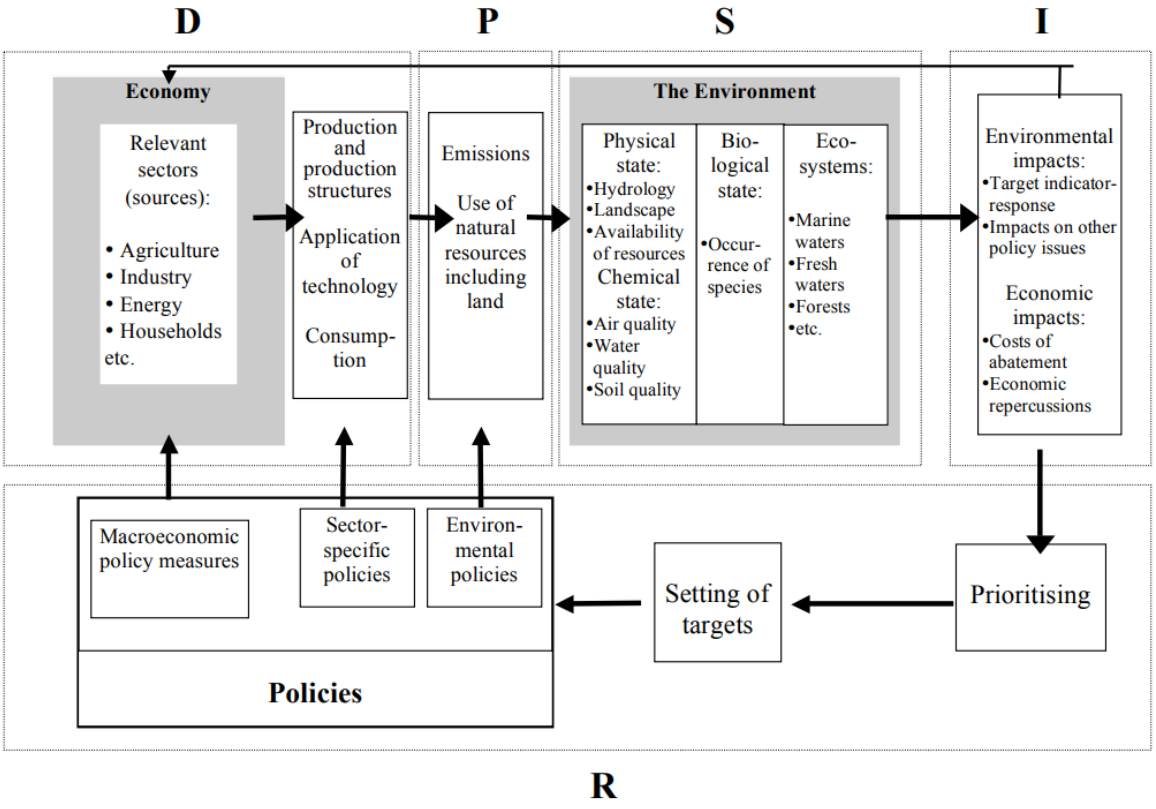



**Figure 2: Integrated Environmental Assessment in a Driver-Pressure-State-Impact-Response framework (Source: Kristensen, 2004, p.3). Shown are Driver (D), Pressure (P), State (S), Impact (I) and Response (R) components.**

DPSIR has been widely adopted internationally by organisations including the European Union, Organization for Economic Cooperation and Development (OECD), US Environmental Protection Agency and the United Nations Food and Agriculture Organisation (FAO). While being widely adopted, weaknesses have been noted that primarily relate to variation in interpretation (mainly between natural and social scientists) of the different components - particularly Pressure, State, and Impact. Concerns are also evident about over-simplification of environmental problems and treating the different DPSIR components as being mutually exclusive (Patrício et al., 2016).

The DPSIR model is an extension of the Pressure-State-Response (PSR) model developed by the Organization of Economic Cooperation and Development (OECD, 1993) to help decision makers understand the cause-and-effect relationships present in many environmental problems (Ashfaq et al., 2019). Initially developed as a concept for structuring and communicating environmental problems in a simple way and for classifying indicators for reporting, it has subsequently evolved into a tool for analysing instances of environmental degradation (Vannevel, 2018). The advantage of DPSIR is that it helps to identify relationships, and structure information in ways that aid understanding while providing an overview of an environmental problem (Ness et al., 2010). Application of the model often requires complex scientific modelling on the one hand and by necessity requires simplification of scientific data on the other hand. This can be a frustration for both policy-makers and scientists when implementing or applying the DPSIR model framework (Vannevel, 2018).

A search of the databases described above for the terms DPSIR water, and DPSIR water resource management returned 312 published articles since 2010. The results of the search showed that DPSIR has been applied widely to water resource management globally at a range of scales including ground water resources (Borji et al., 2018; Hazarika and Nitivattananon, 2016), marine management (Gimpel et al., 2013; Langmead et al., 2009; Patrício et al., 2016) and regional water supply (Sun et al., 2016). Notably, the DPSIR model has been applied to manufactured water such as desalination (Ashfaq et al., 2019; Khan and Al-Ghouti, 2021). The authors noted that the DPSIR framework was effective in this case by helping analyses of the overall water resource system and successfully identified the cause-and-effect relationships, while offering response actions that would reduce the impacts of desalination.

Díaz and Yeh (2015) provide a case study of the framework's application to the water cycle in a highly urbanised coastal city. They found that DPSIR analysis of impacts resulting from the effects from climate variability and urbanisation was useful in identifying policy for the management of water and reducing impacts of water demand on the environment. However, the authors also note that DPSIR did not pinpoint operational thresholds, such as increased salinity, within (a) the entire system; or (b) between subsystems. The authors further note that this may have ramifications if looking to assess the risks posed by slow moving climate threats that may not immediately manifest themselves.

In an Australian context DPSIR has been employed to assess ground water resources in the McLaren Vale Prescribed Wells Area (El Sawah et al., 2011); threats to water quality in the Murray-Darling Basin (Holland et al., 2015); the Australian State of the Environment (SoE) assessments (Jackson et al., 2016); and wetland health (Lynch, 2011). Versions of the DPSIR framework are also employed in state level SoE reporting including in Queensland and Victoria. While not explicitly referred to, the South Australian SoE appears to leverage from DPSIR principles. Regarding the suitability of DPSIR, El Sawah et al. (2011) found that it provided a framework for effective identification of the broader range of social, environmental, cultural and economic issues in the region. The framework provided an early glimpse of the main modelling components and data essential to link stakeholder views to modelling inputs, outputs and internal states. Holland et al. (2015) found that the DPSIR framework may be particularly useful in identifying trade-offs and synergies in systems. However, similarly to Díaz and Yeh (2015), they found that the framework is a high-level system representation that did not show the detailed causal links between system elements.

Overall, the analysis of the peer-reviewed literature indicates that the DPSIR framework comes closest to meeting the overall requirements of DEW around a water rating system at source scale and applicable state-wide. It is nonetheless a relatively complex framework that may be costly to shape in a way that uses existing data to populate the index.

## Review of other water rating systems currently in operation

Shifting to the grey literature, it was noted that several sustainable water ratings and assessment systems are currently operational globally and nationally. A summary of key systems found during the assessment appears in Table 1.

**Table 1: Sustainable water ratings and assessment systems found during a high-level assessment using a literature review.**

| Jurisdiction | System | Explanation |
|---|---|---|
| United States of America – Environmental Protection Agency | Index of Watershed Indicators<br><br>Index of Catchment Integrity | Index of Watershed Integrity (IWI) and Index of Catchment Integrity (ICI) are used to quantify and map integrity for 2.6 million stream segments across USA. The IWI and ICI were built on the conceptual model by Flotemersch et al. (2016, p.1654), who defined watershed integrity as "the capacity of a watershed to support and maintain the full range of ecological processes and functions essential to the sustainability of biodiversity and of the watershed resources and services provided to society." |
| United States of America – Water Foundation | Sustainable Water Management (SWM) Profile (Water Foundation, 2019). | The SWM Profile evaluates Stressors within four main themes: Environment, Supply, Demand, and Finance. The scoring system considers: 1) contextual information about the circumstances in which water is managed, unique to each region and Profile Subject; 2) the Stress Level for each of 10 Stressors, to highlight the greatest challenges to sustainable water supply management facing a Profile Subject and its region, and to pinpoint targets for management efforts; and 3) the breadth and success of management responses.<br><br>It appears focused towards water supply agencies/utilities and the vulnerability of supply to environmental, demand, financial and source risks. Examples include the Inland Empire Utilities Agency USA. |
| Victoria – Department of Environment and Primary Industries | Index of Stream Condition (DEPI, 2019) | The ISC provides information on five key aspects of river condition:<br>• hydrology<br>• streamside zone<br>• physical form<br>• water quality<br>• aquatic life.<br><br>The ICI Assesses environmental condition only using complex remote sensing data. |
| Australia – National Water Commission | Framework for the Assessment of River and Wetland Health | Key components which are considered to represent ecological integrity. These are:<br>• catchment disturbance<br>• hydrological change and spatial extent of wetland and temporal change<br>• water quality |

| | | |
|---|---|---|
| | | • physical form<br>• fringing zone<br>• aquatic biota.<br>The FARWH describes how to develop and combine indices so that nationally comparable assessments of river and wetland health can be achieved (National Water Commission, 2006). |
| Europe – European Environment Agency | Europe's water: An indicator-based assessment (Nixon et al., 2003) | This report aims to present an assessment of Europe's water resources based on 57 indicators chosen for their representativeness and relevance.<br><br>Four key issues addressed are:<br>• ecological quality<br>• nutrients and organic matter pollution of<br>• hazardous substances<br>• water quantity<br><br>Plus, a core set of indicators for six environmental issues<br>• Air pollution<br>• Biodiversity<br>• Climate change<br>• Terrestrial environment<br>• Waste and material flows<br><br>And five key sectors of the economy<br>• Agriculture<br>• Energy<br>• Fisheries<br>• Tourism<br>• Transport |
| Scotland/international – Alliance for Water Stewardship | Water Stewardship Standard | The AWS has its origins in the Australian Murray-Darling Basin but has since been extended internationally and is headquartered in Scotland.<br><br>"The objective of the AWS Standard is to drive water stewardship, which we define as: the use of water that is socially and culturally equitable, environmentally sustainable and economically beneficial, achieved through a stakeholder-inclusive process that involves site-and catchment-based actions" (AWS, 2019).<br><br>The standard requires collection of data on indicators to address 30 criteria under five framework steps. |

| | |
|---|---|
| | I. Gather and understand water-related data<br>II. Commit to water stewardship and create a water stewardship plan<br>III. Implement the plan<br>IV. Evaluate performance<br>V. Communicate and disclose progress with stakeholders<br><br>Fulfillment of the above criteria will lead to improved performance in five areas:<br>I. Improved water governance<br>II. Sustainable water balance<br>III. Good water quality<br>IV. Healthy status of important water-related areas<br>V. Access to water, sanitation, and hygiene (WASH) for all |

There are three main limitations in employing these approaches directly to establish a water rating system for water sources at a state scale. First, many are not sufficiently broad to capture ESG. Moreover, often such systems have a single focus (e.g. ecological; pollution) and are generally silent about governance arrangements. Second, few of these indices would appear to have scope to integrate manufactured water sources, or how such sources might impact the call on native water sources. Third, those that do attempt to incorporate Environmental, Social and Governance dimensions, do not operate at a scale sought by DEW.

Arguably, closest to meeting the needs of DEW is the AWS version 2.0 released in January 2020. While AWS ultimately generates a simplified rating (e.g. platinum, gold) it is underpinned by a detailed assessment rubric that operates at the 'site' level. The 'site' is structured around "boundaries of land owned or leased by the organisation, which may or may not be contiguous". We thus conclude that of the existing water rating systems in the grey literature, the AWS V2.0 offers some direction for DEW. Effort would be required to explore how this system might be applied to give consistent ratings across all the state's water sources.

## Other ratings systems used in natural resources

In addition to sustainability rating systems for the management of water resources, we have also conducted a high-level literature search for systems being employed in other industries such as forestry, agriculture, fisheries and the built environment. The findings from that review appear below, primarily for completeness. Nonetheless, it is also worth noting that during the stakeholder consultation phase several participants noted the benefits of having a state-based water rating system that seamlessly integrated with existing indices used by industries in the natural resources domain.

### *Fisheries*

The collapse of several high-profile fisheries in the early 1990s was the trigger for Unilever and World Wildlife Fund (WWF) to develop the earliest and most globally recognised rating framework the Marine Stewardship Council (MSC; www.msc.org) sustainable fisheries certification system (Agnew, 2019). MSC is a certification system based around a rigorous third-party assessment and certification against a common standard. Certification is a market-based mechanism seeking to reward sustainable fisheries by allowing retailers to sell fish distinguished by an ecolabel (Agnew, 2019).

Multiple other certifications, organisations, standards and processes have been established since the MSC that work with fisheries, the seafood supply chain, and associated stakeholders in fishery improvement projects (FIP). Initially these systems were established to help fisheries supply chain participants meet MSC standards. However, from the FIPs, a multitude of new certification systems have evolved creating concerns around the harmonisation of standards.

The increase in the number of systems has led to confusion among producers, retailers and consumers over how to recognise a credible seafood certification. To address this, the Global Sustainable Seafood Initiative (GSSI; www.ourgssi.org) was created in 2013, which convened working groups including industry, NGOs and the FAO to develop a tool to benchmark certification systems. Fisheries certification systems recognised by the GSSI are listed in Table 2. Several GSSI-recognised standards are based on the Responsible Fisheries Management (RFM) framework which is a certification model based on the FAO Code of Conduct for Responsible Fisheries (FAO, 1995). RFM has two certification standards:

I. Fisheries Standard

II. Chain of Custody Standard (CoC)

**Table 2: Fisheries sustainability ratings systems accredited under the Global Sustainable Seafood Initiative.**

| Certification system | Country | Link |
|---|---|---|
| Alaska Responsible Fisheries Management (RFM) Certification Program | United States of America | https://www.alaskaseafood.org/rfm-certification/ |
| Iceland Responsible Fisheries Management (IRFM) Certification Program | Iceland | https://www.responsiblefisheries.is/certification |
| Marine Stewardship Council (MSC) | International | https://www.msc.org/en-au |
| Best Aquaculture Practices (BAP) Certification | International | https://www.bapcertification.org/ |
| GLOBALG.A.P. Aquaculture Certification System | International | https://www.globalgap.org/uk_en/for-producers/globalg.a.p./integrated-farm-assurance-ifa/aquaculture/ |
| Audubon Gulf United for Lasting Fisheries (G.U.L.F.) Responsible Fisheries Management (RFM) Certification Program. | United States of America | https://www.audubongulf.org/about-g-u-l-f/ |
| BIM Certified Quality Aquaculture (CQA) scheme | Ireland | https://bim.ie/aquaculture/sustainability-and-certification/certified-quality-aquaculture-cqa-programme/ |
| Marine Eco-Label Japan (MEL) Scheme for Aquaculture and Fisheries | Japan | https://www.melj.jp/ |

An important 'take-home' message from this sector is that multiple indices and accrediting processes that are not well-aligned can serve to undermine usefulness. More specifically, there is a risk that multiple ratings add confusion and make decision making more difficult.

***Forestry***

Forestry rating systems are somewhat integrated into many of the "green" building ratings systems due to the linked nature of forestry and construction. Australia has seen the development and implementation of several third-party certification systems including the Australian Forestry Standard (AFS) and the Forest Stewardship Council (FSC). Both systems aim to provide greater confidence in claims about sustainable forest management and include Chain of Custody Certification with timber sourced from AFS certified forests meeting the Green Building Council of Australia (GBC) material selection requirements under its Green Star rating tool.

Forestry Stewardship Council (FSC) is the most recognised forestry certification system internationally. The FSC is a third-party certification program established in 1993 with the goal of promoting responsible forestry and certifying the resulting wood products. The standard is managed by the FSC while certification is awarded by third parties such as the Rainforest Alliance and Scientific Certification Systems. There are different standards for different forest products (FSC pure, FSC mixed, and FSC recycled) and different regions. The FSC chain of custody is a requirement of certification that follows the path of the wood product from forest to consumer. The FSC program uses a specific, prescriptive approach and provides assurance of good environmental and social stewardship of forests.

During the stakeholder engagement phase of this project, participants drew attention to the Responsible Wood standards employed by industry. This standard includes a water component, although this is primarily focused on limiting the detrimental impacts of forest and wood production systems on water sources.

***Agriculture***

In response to growing interest in the environmental sustainability of agriculture, the Australian Government committed $34 million to the Agricultural Stewardship Package (ASP) in 2018-19 and a further $32m in 2021-22. The aim of the ASP is to encourage adoption of improved on-farm land management practices through incentive mechanisms. A part of this package was the development of the Australian Farm Biodiversity Certification Scheme.

The National Farmers Federation and the Australian Farm Institute have provided an initial review of how the Australian Farm Biodiversity Certification Scheme could be developed and implemented concordant with other standards and certification systems (Dempster et al., 2020). A major finding of the review was that any biodiversity scheme should be developed within an overarching meta-standard or framework that is aligned with other global standards and does not disrupt rapidly emerging commercial opportunities (Dempster et al., 2020).

This has driven the development of the Australian Agricultural Sustainability Framework (AASF). The development of the AASF has been encouraged by a recognition that there is a lack of coordination and cohesion between already existing sustainability standards, which is causing confusion for participants and markets. This has potential to diminish the strategic value of participation and ultimately undermine the goals of the certification standards (Gregg, 2020).

The goal of the AASF is to communicate the sustainability status and goals of the Australian agricultural industry to markets and to the community. This entails developing a common set of principles for the agricultural sector that can be used to align sectoral and supply chain language towards a common understanding of sustainability deliverables. While the framework is still largely under development, a draft iteration states that it uses an ESG structure to clearly direct users to material principles and criteria (AFI, 2021). In addition, the AASF seeks to strongly reflect the Sustainability Assessment of Food and Agriculture Systems (SAFA), the Sustainable Development Goals (SDGs) and Sustainable Agriculture Initiative Platform (SA), as well as leading Australian industry sustainability frameworks such as Australian Beef Sustainability Framework, Dairy Sustainability Framework and Sustainable Winegrowing Australia (AFI, 2021). The AASF version 2 (AFI, 2021) outlines suggested principles and criteria with the release of the finalised framework due sometime in 2022.

While the efficacy of the AASF is hard to quantify at this point, the concept of an overarching meta-framework with which to incorporate data from multiple sources may have merit for communicating water resource sustainability in South Australia. Users of water across multiple industries are likely to already be engaged in sustainability certification programs that encompass water and water use. Such an approach may provide a mechanism by which data on water use at a company and industry scale and data on resource condition captured by government (e.g. in the State of the Environment Report and Trend and Condition Report Cards) could be incorporated into a combined metric to convey ESG information. This may also eliminate the need for any new onerous regulatory burdens on industry as data may already be captured, while reducing additional resources needed by government as it leverages existing data collection and reporting.

The relative success of other (i.e., non-water) rating systems hinges on the 'line of sight' for consumers and investors between their own choices and the resource management practices in place. Water is often a critical element for many products and activities but the knowledge base for consumers and investors varies. If DEW is to pursue a water rating system, building this line of sight for users of the system will be key.

*Several key findings emerge from the systematic literature review phase:*

- *No peer-reviewed ESG rating scale for water sources that can be applied at the state-wide level is currently available.*
- *A water rating system of the form sought by DEW will necessarily require some form of multi-criteria decision-making and the published literature can guide how to limit the criticisms that can attend these approaches.*
- *Within the peer-reviewed literature the Driver-Pressure-State-Impact-Response (DPSIR) framework is likely worthy of closer inspection as a means of guiding the development of a water rating system.*
- *Within the grey literature existing water rating systems do not match with the needs of DEW, although the Alliance for Water Stewardship has some promise, albeit currently operationalised at a site scale.*
- *Other natural resource rating scales/indices offer direction, especially around potential risks. These include:*
    - *Ensuring any 'new' ratings are harmonised to limit costs for water using industries and maximise interpretability by end-of-supply-chain consumers;*
    - *Noting that water is only one element within many ESG ratings currently used by industry and thus the net benefits for a specific water rating system for water using industries should be viewed through that lens.*

## 4.2 Findings from stakeholder consultation

Interviews began on 21st February 2022 and concluded on 25th May 2022. Refer to Section 3 for a summary of the method. Broadly speaking, participants can be grouped into representatives of water using industries, government agencies, industry accrediting bodies and infrastructure investment advisors. A breakdown by organisation is provided in Table 3, although individual details have been removed.

**Table 3: Breakdown of interviews with key stakeholders**

| Organisational type | Organisation | Interview Date |
|---|---|---|
| Water user | Primary Producers SA representation | 21.02.22 |
| Water user | SA Chamber of Mines and Energy | 23.02.22 |
| Water user | SA Chamber of Mines and Energy | 23.02.22 |
| Government | Department for Trade & Investment | 24.02.22 |
| Government | Department of Treasury & Finance | 03.03.22 |
| Water user | Renmark Irrigation Trust | 10.03.22 |
| Water user | Renmark Irrigation Trust | 10.03.22 |
| Government | Stormwater consultant, Local government | 15.03.22 |
| Government | SA Water | 16.03.22 |
| Government | SA Water | 16.03.22 |
| Industry accrediting | Water Stewardship Alliance | 17.03.22 |
| Water user | Green Triangle Forest Industries Hub | 24.03.22 |
| Water user | Forestry SA | 31.03.22 |
| Water user | Wine Grapes Australia | 08.04.22 |
| Water user | Wine Grapes Australia | 27.04.22 |
| Industry accrediting | Responsible Wood Accreditation | 13.04.22 |
| Investment advisor | Water Utilities Australia | 05.05.22 |
| Investment advisor | Igneo Infrastructure Partners | 25.05.22 |

There are a number of shared themes that emerged from consultations as well as some specific issues that relate to the individual stakeholder group.

### Shared themes

All participants expressed support for the idea of a water rating system that was able to simply capture the ESG status of water sources. Participants also appreciated that it would be important to strike a balance between 'the detail' that stood behind the rating system (to ensure the system withstood scrutiny) and the desire to communicate information succinctly.

Participants were appreciative of the fact that there were already a large number of different accreditation and rating scales in existence that covered parts of their activities. No participant was aware of any ESG water source rating system that operated at a state level.

Overwhelmingly, participants expressed a view that a rating system with wider geographic coverage had more advantages than one with a narrow coverage. Put differently, a rating system that was only applicable to one water source in one location would not offer much when comparing choices if more than one option

exists. In that context participants would generally prefer a national rating system, but also appreciated that SA could play a leadership role, especially given its track record on good water governance.

All participants were open to further inclusion in the development phase for a water rating system. In many cases, this was driven by interest to understand more about the operational aspects of an ESG water rating system and how this would synchronise with other tasks that related to their organisation. For example, primary industry water users would appreciate understanding how this rating system would integrate with the Australian Agricultural Sustainability Framework.

Participants showed interest in a water rating system that would ultimately cover both native and manufactured water sources. Some participants saw advantages in this approach, but the detail of how the integration of different water sources would occur was seen as an important component. Similarly, there was widespread interest in mechanisms that integrated different energy considerations, given the nexus between water and energy for manufactured water sources/carbon emissions.

### Water user themes

Whilst water users were supportive of the water rating approach, this group was primarily concerned with how any new rating system would interface with current governance arrangements. Participants from this group were particularly interested in how a rating system might relate to water access. Current water users acknowledged that the water they were using generated economic and social value, but there was also an acknowledgement that the environmental status of the water sources in the state varied from 'poor' to 'very good'.

In order to address this some water users had already invested significantly to limit their deleterious impacts on water resources, and it was not clear how those efforts might be expressed in a water rating system based on the total water source. For example, if an extractive water user had reduced their call on water to a minimum and ensured that returned water was of good quality, but the overall source itself remained 'poor' how would this impact the user?

Water users noted that there was pressure from all consumer groups to act responsibly in order to maintain social license. However, the capacity for different water users to then appropriate any value from responsible behaviours was questioned. Few water users saw any direct commercial value from a water rating system that showed responsible water use alone.

Water users noted that many operators were already part of accreditation or rating processes. Most of these rated their performance against others in the same sector or across sectors. The utility of a water source rating system that was applicable across all sources in the state would thus depend on how well the new rating system could be embodied in existing frameworks used to demonstrate ESG.

### Government agency themes

Other government agencies have existing agendas and programs around ESG. Water is part of that agenda but not always the highest priority. More specifically, much attention for many agencies is currently focused on climate change and this necessarily highlights energy use and related carbon emissions as a key concern.

Given the link between energy and manufactured water sources, this is arguably one way to sequence the DEW interest in water ratings with the activities of other agencies. Thus, a priority question for this group is how energy sources and water sources can be integrated and amalgamated into a single water rating score.

This raises important questions about operationalising the water rating system. For example, what is the impact on a water rating score when reclaimed water treated and pumped using renewable energy is used to offset water demand from the River Murray? What is the impact if the energy used in not renewable? What is the impact if desalination is used to offset potable demand using renewable energy?

An extension to these types of queries also came from those with a strong interest in water in the urban landscape and livability in Adelaide. Here there was enthusiasm for a water rating system that could highlight the benefits of harnessing specific water sources, like stormwater. Regardless of this enthusiasm, there remained a strong desire to better understand the detail and how this might impact on current programs of work in this area.

### Industry accrediting body themes

Although industry accrediting bodies were not initially identified by DEW as key stakeholders, other participants had recommended their inclusion, which DEW supported. Like the water user group, the main theme raised centered on how a water rating system would ultimately interface with existing rating schemes that tend to cover a range of factors.

The literature review phase identified that the water stewardship alliance (WSA) framework had some promise, inasmuch as its scope was similar to the preferred scope of DEW (i.e. had elements of ESG), and this framework was thus further explored through interviews. There was a view from WSA that its framework could be adjusted to suit the mandate of DEW (i.e. that it can be applied across all water sources in the state), but further exploration of this lay outside the scope of this project and remains a matter for DEW to consider in future work.

### Investment advisor themes

Given the focus on water sources, the views of advisors involved in water infrastructure investment were sought. A key finding from this group is that investment advisors are cognisant of ESG ratings, and they acknowledge that investors ultimately include these in their deliberations. The upshot is that a water rating system that highlights governance of water sources to achieve good social and environmental outcomes could advantage the state and act as an investment attractor.

The magnitude of any advantage that would attend an investment opportunity with a water rating versus one without was explored. It was noted that having a water rating system might bring a project into a short-list of options, but it would only be one of a number of considerations. The commercial prospects of a project would be paramount in most cases, but a project with more ESG credibility would be favored if returns were broadly equivalent. A rating system that applied at a wider scale (e.g. nationally) would be preferable to one that had a narrow application.

This group was particularly keen to see a rating system that would easily communicate to the investment community. As with the government agency group, there was often an overlap in the discussion around water and energy and this again needs contemplation in the design of any ESG rating.

***Collectively, the stakeholder consultations support the view that:***

- ***A water source rating system based on ESG principles likely has broad support from water users, other government agencies and investment communities.***
- ***SA has an opportunity to take the national lead on this front although ultimately a national system will hold more weight.***
- ***Continued involvement with stakeholders will be required to optimise the design of the rating system and to ensure that it adds value and does not compete with existing ESG work across different groups.***

# 5 The status quo, next steps and concluding remarks

## 5.1 Current approach to classifying water sources in SA

To better understand what is required to develop a water rating system, this short section provides a synopsis of the current approaches to classifying water sources in the state.

At the highest level, the state's native water resources are either identified as being prescribed or non-prescribed. Prescription is a way to manage water resources that are at risk of being over-used or used in a way that is not sustainable in the long-term[3]. This is done by limiting the amount of water that can be taken from the resource and providing rules on how the water can be used and allocated. By doing this, prescription aims to ensure that there is sufficient water available for all users, including the environment, now and into the future.

When a water allocation plan is developed for a prescribed resource, a risk assessment is undertaken to identify threats to the resource and water users, including the environment. This risk assessment is then used to determine how much water can be allocated to users and under what conditions. It does not classify each resource into a particular category based on its condition or sustainability or make judgement about social or cultural benefits from use.

The National Framework for Compliance and Enforcement Systems for Water Resource Management was established by the Council of Australian Governments (COAG) to improve compliance and enforcement for water resource management. As part of this framework, risk categories were devised to identify water resources that are 'at risk' and therefore require increased levels of monitoring and compliance activities. The categories (Category 1, 2, 3 and 3A) are based on competition for the resource, consumptive uses and whether the resource is fully allocated. The categories consider management (protection) afforded to the resource through legislation. The SA EPA Environmental Protection (Water Quality) Policy 2015 also classifies "environmental values of water" for water use purposes; aquatic ecosystems, drinking water for human consumption, primary industries, recreation and aesthetics.

These risk categories are the closest that South Australia has come to categorising its water resources for a specific purpose. However, these categories are limited in their scope and are generally used for compliance purposes. e.g. they do not take into consideration all aspects of the resource that may lead to it being 'of higher value'. For instance, cultural values associated with the water are not explicitly recognised.

The Department for Environment and Water has the responsibility to report annually on the status of prescribed groundwater and surface water resources. Data on water resources are regularly collected by the Resource Monitoring Unit (RMU), analysed, and reported in a series of annual reports. Three layers of reporting are generated and are targeted at a range of audiences with differing levels of detail. These include (DEW, 2021):

- Technical Notes which provide detailed information and assessment for each resource area and are used to identify the resource condition in detail.
- Fact sheets which provide summary information for each resource area with an Annual Resource Status Overview.

[3] Some non-prescribed resources are also potentially at risk of over-use.

- State-wide summary which summarises information for the main water resources across most regions in a quick-reference format.

The Technical Notes collate data on rainfall, water use (surface water and groundwater), groundwater level and salinity. Technical Notes, such as Water Resource Assessments outline the science and data in detail and inform higher level documents such as NRM Report Cards and the State of the Environment Reports. Figure 3 provides a schematic overview of this process.

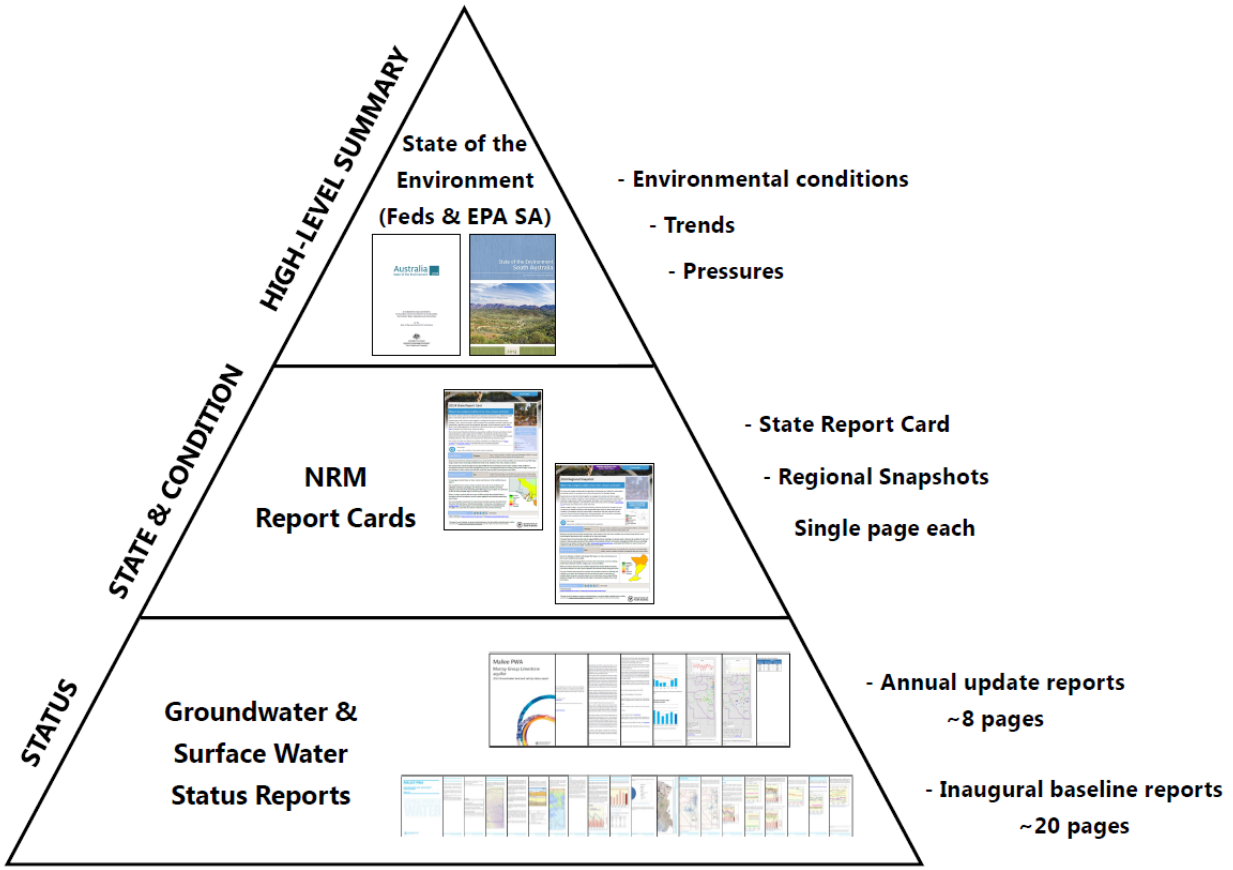



**Figure 3: Water resource information flow through DEW.**

DEW uses information in Technical Notes to prepare state-wide Report Cards on the condition and trend of water resource condition. These provide a snapshot of various aspects related to the state's water resources and attempts to represent, in an easily digestible way, changes to the resource condition over time. The Report Cards are an aggregation of the data from all monitored or prescribed water resources. As such the report cards present a generalised view of the resource across the state and any significant changes in individual water resources will likely not be represented. As noted, the condition reporting does not currently consider cultural assets related to the water or their economic values. Moreover, there is no attention to non-native (e.g. manufactured) water sources and how they might interface with native sources.

## 5.2 Next steps

Both the literature review and stakeholder consultations emphasised that producing a water rating system based on water sources and that can be applied uniformly at the level of the state is a significant but potentially worthwhile undertaking. In that regard, this report recommends a stock-take of existing information to gain insights into the workplan that would be required. The next step is to thus undertake an audit to see what information can be collated into a water rating system at low cost. It is likely that DEW and

agencies already hold other information outside the current reporting frameworks. It will be important to look across agencies to assess what is available at a whole-of-government level.

In addition, it is recommended that DEW maintain communication with stakeholder groups as a participatory approach is required to help optimise the design of any future rating system from different perspectives.

## 5.3 Concluding remarks

There is a gap between how water sources are currently classified and reported upon and the ambitions for an ESG water source rating system. That does not mean that the task of developing a water source rating system is insurmountable. This report has provided evidence that a water rating system would be valued by a range of stakeholder groups. There is also some evidence that a rating system developed in SA could advantage the state by providing information to investors and other decision makers, but the extent of that benefit has not been quantified. Accordingly, the development of a water rating system is best undertaken in iterations that allow DEW to reflect on the advantages to different users and understand the relative costs and benefits at each stage of development.

# References


AFI. 2021. Australian Farm Institute. AASF: Australian Agricultural Sustainability Framework Version 2. https://www.farminstitute.org.au/product/aasf-australian-agricultural-sustainability-framework/

Ashfaq, M.Y., Al-Ghouti, M.A., Qiblawey, H., Zouari, N., Rodrigues, D.F., Hu, Y. 2019. Use of DPSIR framework to analyze water resources in Qatar and overview of reverse osmosis as an environment friendly technology. Environmental Progress & Sustainable Energy 38, 13081.

Atlu Agnew, D.J., 2019. Who determines sustainability? Journal of Fish Biology 94, 952-957.

AWS, 2019. International water stewardship standard. Alliance for Water Stewardship, Scotland.

Barron O, Ali R, Hodgson G, Smith D, Qureshi E, McFarlane D, Campos E and Zarzo D. 2015. Feasibility assessment of desalination application in Australian traditional agriculture. Desalination 364: 33-45.

Borji, M., Moghaddam Nia, A., Malekian, A., Salajegheh, A., Khalighi, S. 2018. Comprehensive evaluation of groundwater resources based on DPSIR conceptual framework. Arabian Journal of Geosciences 11, 1-13.

Colfer, C. 2005. The Equitable Forest: Diversity, Community and Resource Management, Resources for the Future, Washington D.C.

Crase, L., Dollery, B., Wallis, J. 2005. Conceptualising community consultation in public policy formulation: the case of the Living Murray Debate in the Murray–Darling Basin of Australia. Australian Journal of Political Science 40 (2), 221–237.

Crase, L., O'Keefe, S., & Dollery, B. 2013. Talk is cheap, or is it? The cost of consulting about uncertain reallocation of water in the Murray–Darling Basin, Australia. Ecological economics, 88, 206-213.

Dempster, F., McRobert, K., Heath, R., Fox, T., Goucher, G. 2020. Recognising on-farm biodiversity management: Australian Farm Biodiversity Certification Scheme. Phase 1 report. Australian Farm Institute.

DEPI 2019. Index of Stream Condition: The Third Benchmark of Victorian River Condition. Melbourne. https://www.water.vic.gov.au/__data/assets/pdf_file/0024/34809/ISC_Part1_Introduction.pdf

DEW 2021. Marne Saunders Prescribed Water Resources Area 2019–20 water resources assessment. Department for Environment and Water, Adelaide.

Díaz, P., Yeh, D. 2015. Water supply resilience in coastal communities: using DPSIR to assess the next urban water paradigm. WIT Transactions on Ecology and the Environment 200, 15-27.

El Sawah, S., Guillaume, J., Mitchell, M. 2011. Using Participatory Rapid Appraisal and DPSIR approaches for participatory modelling: a case study for groundwater management in South Australia.

FAO. 1995. FAO Code of Conduct for Responsible Fisheries. Food and Agriculture Organisation of the United Nations, Rome. https://www.fao.org/documents/card/en/c/e6cf549d-589a-5281-ac13-766603db9c03/

Flotemersch, J., Leibowitz, S., Hill, R., Stoddard, J., Thoms, M., Tharme, R. 2016. A watershed integrity definition and assessment approach to support strategic management of watersheds. River Research and Applications 32, 1654-1671.

Gimpel, A., Stelzenmüller, V., Cormier, R., Floeter, J., Temming, A. 2013. A spatially explicit risk approach to support marine spatial planning in the German EEZ. Marine environmental research 86, 56-69.

Gregg, D. 2020. Sustainability standards and certification: A review of concepts and international practices for Australian Agricultural Sustainability Framework (AASF). Australian Farm Institute, https://www.farminstitute.org.au/wp-content/uploads/woocommerce_uploads/2021/06/AASF-Literature-review_Sustainability-standards-and-certification_2021-kzbpeu.pdf

Hazarika, N., Nitivattananon, V. 2016. Strategic assessment of groundwater resource exploitation using DPSIR framework in Guwahati city, India. Habitat International 51, 79-89.

Holland, J.E., Luck, G.W., Finlayson, C.M. 2015. Threats to food production and water quality in the Murray–Darling Basin of Australia. Ecosystem services 12, 55-70.

Jackson, W., Argent , R., Bax, N., Bui, E., Clark, G., Coleman, S., Cresswell, I., Emmerson, K., Evans, K., Hibberd, M., Johnston, E., Keywood, M., Klekociuk, A., Mackay, R., Metcalfe, D., Murphy, H., Rankin, A., Smith, D., Wienecke, B. 2016. Australia state of the environment. Australian Government Department of the Environment and Energy, Canberra.

Khan, M., Al-Ghouti, M.A. 2021. DPSIR framework and sustainable approaches of brine management from seawater desalination plants in Qatar. Journal of Cleaner Production 319, 128485.

Kristensen, P. 2004. The DPSIR Framework. Workshop on a comprehensive/detailed assessment of the vulnerability of water resources to environmental change in Africa using river basin approach. Nairobi. https://wwz.ifremer.fr/dce/content/download/69291/913220/.../DPSIR.pdf

Langmead, O., McQuatters-Gollop, A., Mee, L.D., Friedrich, J., Gilbert, A.J., Gomoiu, M.-T., Jackson, E.L., Knudsen, S., Minicheva, G., Todorova, V, 2009. Recovery or decline of the northwestern Black Sea: a societal choice revealed by socio-ecological modelling. ecological modelling 220, 2927-2939.

Lynch, A. 2011. The usefulness of a threat and disturbance categorization developed for Queensland wetlands to environmental management, monitoring, and evaluation. Environmental Management 47, 40-55.

Munroe-Clarke, M. 1992. Citizen Participation in Government. Hale and Ironmonger, Sydney

National Water Commission. 2006. Australian water resources 2005: a baseline assessment of water resources for the National Water Initiative: Level 1 assessment.

Ness, B., Anderberg, S., Olsson, L. 2010. Structuring problems in sustainability science: The multi-level DPSIR framework. Geoforum 41, 479-488.

Nixon, S., Trent, C., Maracuello, C., Lallana, C. 2003. Europe's water: An indicator-based assessment. European Environment Agency Copenhagen.

OECD, 1993. OECD core set of indicators for environmental performance reviews. Organisation for Economic Co-operation and Development.

Patrício, J., Elliott, M., Mazik, K., Papadopoulou, K.-N., Smith, C.J. 2016. DPSIR—two decades of trying to develop a unifying framework for marine environmental management? Frontiers in Marine Science 3, 177.

Patrício, J., Elliott, M., Mazik, K., Papadopoulou, K.-N., Smith, C.J. 2016. DPSIR—two decades of trying to develop a unifying framework for marine environmental management? Frontiers in Marine Science 3, 177.

Riato, L., Leibowitz, S.G., Weber, M.H. 2020. The use of multiscale stressors with biological condition assessments: A framework to advance the assessment and management of streams. Science of The Total Environment 737, 139699.

Ross, H., Buchy, M., Proctor, W. 2002. Laying down the ladder: a typology of public participation in Australian natural resource management. Australian Journal of Environmental Management 9 (4), 205–217

Saarikoski, H., Mustajoki, J., Barton, D., Geneletti, D., Langemeyer, J., Gomez-Baggethun, E., Marttunen, M., Antunes, P., Keune, H. and Santos, R. 2016. Multi-Criteria Decision Analysis and Cost-Benefit Analysis: Comparing alternative frameworks for integrated valuation of ecosystem services, Ecosystem Services, https://doi.org/10.1016/j.ecoser.2016.10.014

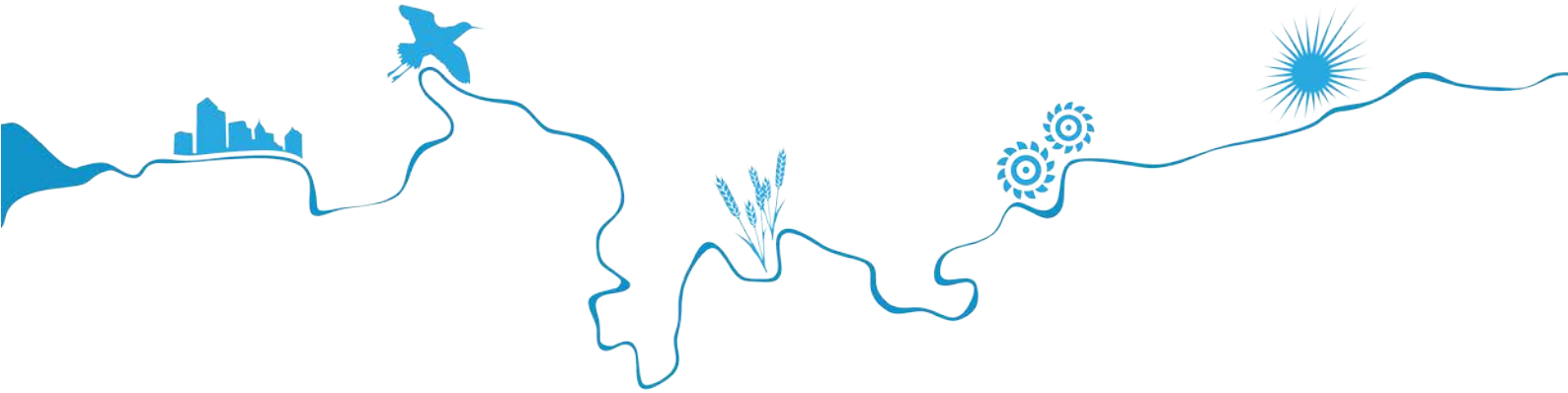
Sun, S., Wang, Y., Liu, J., Cai, H., Wu, P., Geng, Q., Xu, L. 2016. Sustainability assessment of regional water resources under the DPSIR framework. Journal of Hydrology 532, 140-148.

Vannevel, R., 2018. Using DPSIR and balances to support water governance. Water 10, 118.

Water Foundation. 2019. The Sustainable Water Management Profile: An Assessment Tool to Advance Water Supply Sustainability. The Water Foundation, https://waterfdn.org/wp-content/uploads/2020/03/The-Sustainable-Water-Management-Profile_An-Assessment-Tool-to-Advance-Water-Supply-Sustainability.pdf

Zerner, C., 2000. People, Plants and Justice. Columbia University Press, New York.

GOYDER INSTITUTE FOR WATER RESEARCH



Government of South Australia
Department for Environment and Water

CSIRO

Flinders University

THE UNIVERSITY of ADELAIDE

University of South Australia

The Goyder Institute for Water Research is a research alliance between the South Australian Government through the Department for Environment and Water, CSIRO, Flinders University, the University of Adelaide and the University of South Australia.