Technical information supporting the 2023 Projected rainfall environmental trend and condition report card

Department for Environment and Water
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Acknowledgement of Country

We acknowledge and respect the Traditional Custodians whose ancestral lands we live and work upon and we pay our respects to their Elders past and present. We acknowledge and respect their deep spiritual connection and the relationship that Aboriginal and Torres Strait Islanders people have to Country. We also pay our respects to the cultural authority of Aboriginal and Torres Strait Islander people and their nations in South Australia, as well as those across Australia.

Acknowledgements

This document was prepared by Graham Green (DEW) and Susan Sweeney (DEW) and technically reviewed by Darren Ray (DEW). Improvements were made to this report and associated report card based on reviews by Amy Ide (DEW), Jennie Fluin (DEW), and Fi Taylor (DEW).

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Summary

The 2023 release of South Australia's environmental trend and condition report cards summarises our understanding of the current condition of the South Australian environment, and how it is changing over time.

This document describes the indicators, information sources, analysis methods and results used to develop this report and the associated 2023 Projected rainfall report card. The reliability of information sources used in the report card is also described.

The Projected rainfall report card sits within the report card Climate theme. Report cards are published by the Department for Environment and Water and can be accessed at www.environment.sa.gov.au.

1 Introduction

1.1 Environmental trend and condition reporting in SA

The Minister for Climate, Environment and Water under the *Landscape South Australia Act 2019* is required to 'monitor, evaluate and audit the state and condition of the State's natural resources, coasts and seas; and to report on the state and condition of the State's natural resources, coasts and seas' (9(1(a-b)). Environmental trend and condition report cards are produced as the primary means for the Minister to undertake this reporting. Trend and condition report cards are also a key input into the State of the Environment Report for South Australia, which must be prepared under the *Environment Protection Act 1993*. This Act states that the State of the Environment Report must:

- include an assessment of the condition of the major environmental resources of South Australia (112(3(a))), and
- include a specific assessment of the state of the River Murray, especially taking into account the Objectives for a Healthy River Murray under the *River Murray Act 2003* (112(3(ab))), and
- identify significant trends in environmental quality based on an analysis of indicators of environmental quality (112(3(b))).

1.2 Purpose and benefits of SA's trend and condition report cards

South Australia's environmental trend and condition report cards focus on the state's priority environmental assets and the pressures that impact on these assets. The report cards present information on trend, condition, and information reliability in a succinct visual summary.

The full suite of report cards captures patterns in trend and condition, generally at a state scale, and gives insight to changes in a particular asset over time. They also highlight gaps in our knowledge on priority assets that prevent us from assessing trend and condition and might impede our ability to make evidence-based decisions.

Although both trend and condition are considered important, the report cards give particular emphasis to trend. Trend shows how the environment has responded to past drivers, decisions, and actions, and is what we seek to influence through future decisions and actions.

The benefits of trend and condition report cards include to:

- provide insight into our environment by tracking its change over time
- interpret complex information in a simple and accessible format
- provide a transparent and open evidence base for decision-making
- provide consistent messages on the trend and condition of the environment in South Australia
- highlight critical knowledge gaps in our understanding of South Australia's environment
- support alignment of environmental reporting, ensuring we 'do once, use many times'.

Environmental trend and condition report cards are designed to align with and inform state of the environment reporting at both the South Australian and national level. The format, design and accessibly of the report cards has been reviewed and improved with each release.

1.3 Climate change in Australia

Climate affects almost every part of our lives. Communities, industries, landscapes and ecosystems all develop with a tolerance for a range of climate variation. If the climate changes beyond that range of tolerance, then they must either adapt, migrate, transform or decline.

According to the Australian Academy of Science (2015), "Earth's climate has changed over the past century. The atmosphere and oceans have warmed, sea levels have risen, and glaciers and ice sheets have decreased in size. The best available evidence indicates that greenhouse gas emissions from human activities are the main cause. Continuing increases in greenhouse gases will produce further warming and other changes in Earth's physical environment and ecosystems."

The Bureau of Meteorology (BoM) and other science agencies employ a range of atmospheric, terrestrial and marine sensors to track climatic trends across Australia. Trends in rainfall are assessed using a high-resolution gridded dataset developed for CSIRO's Australian Water Availability Project (AWAP).

Climate change projections, including rainfall projections, are periodically improved and updated in line with advancements in climate modelling, and produced for, and incorporated into, international and Australian climate change assessment and reporting, such as the Intergovernmental Panel on Climate Change (IPCC) reports

1.4 Projected rainfall

The Climate: Projected rainfall report card reports on the decadal timescale outlook for rainfall change in South Australia under future climate scenarios, according to the Government of South Australia's downscaled climate change projections for South Australia (DEW 2023a). These projections were developed using data products of the New South Wales and Australian Regional Climate Modelling project (NARCliM 1.5), conducted as a partnership between the state governments of New South Wales, South Australia and Western Australia, the Australian Capital Territory and the University of New South Wales.

The report card provides textual comments on the projected change in rainfall in two graphs. These graphs show the percentage change in average annual and spring rainfall averaged across the projections of six NARCliM1.5 climate model combinations for each of nine South Australian landscape regions: Alinytjara Wiluṟara, South Australian Arid Lands, Eyre Peninsula, Northern and Yorke, Kangaroo Island, Murraylands and Riverland, Green Adelaide, Hills and Fleurieu, and Limestone Coast.

2 Methods

2.1 Indicator

The indicator used for the Projected rainfall report card is the projected future change in average annual and spring rainfall in the nine landscape regions of South Australia. The projections are derived from the modlling processes described in Section 2.2.

2.2 Data sources, collection and analysis

The NARCliM 1.5 climate projection downscaling project provides climate simulations for 1951–2100 on daily and monthly timesteps from six global/regional model combinations and two emissions scenarios. The base dataset is compiled in grid form (netcdf format data files) at grid resolutions of 10 km and 50 km. The part of South Australia to the west of a north-south line passing approximately through Ceduna has simulations of only 50 km resolution. To the east of this line both 10 km and 50 km resolutions are available.

Projections of rainfall are included from two Representative Concentration Pathways (RCPs): RCP 4.5 and RCP 8.5, which respectively represent medium and high future greenhouse gas emissions scenarios used in the modelling. These are two of a range of four RCPs, greenhouse gas concentration trajectories adopted by the IPCC for its fifth Assessment Report (AR5) (IPCC Working Group 1 2013).

It should be noted that the time horizon years – 2030, 2050, 2070 and 2090 – are not representing the exact years by which rainfall is projected to change by these percentages. Rather, they are marker years, each for a 20-year period spanning the marker year. For example, the rainfall change projection for the 2050 time horizon represents the percent change in model projection annual or spring rainfall averaged across the period 2040 to 2059, compared with the model projection annual or spring rainfall averaged across the historic baseline period of 1986 to 2005.

The Projected rainfall report card presents two graphs and discusses their main features.

2.2.1 Projected changes in regional average annual rainfall

The first of the two graphs shows the projected percentage changes in average annual rainfall in the nine landscape regions of South Australia at future time horizons of 2030, 2050, 2070 and 2090, as shown in the graph in Figure 2.1. This was prepared using data from the Government of South Australia's downscaled climate change projections (DEW 2023a).

At each grid point, the annual average rainfall was calculated and averaged across the 1986 to 2005 period for each of the six available model combinations. The annual average rainfall was calculated for the 20-year period around each timestep. Then, the percent difference between the 1986 to 2005 period annual average rainfall and each timestep period annual average rainfall was calculated for every grid point in a region, again for each of the six model combinations. Then the average was calculated for each region by averaging all grid-point values in that region, to reach the final value, again for each of the six model combinations. The range in the text represents the minimum and maximum of those six values, while the graph depicts the average of the six model projections. This was done for both the medium and high emissions scenarios.

There is considerable variability among the six model combinations in their projections of rainfall change for each region, which is not shown in these graphs. However the range of uncertainty in these projections, as well as other seasons and periods of the year, is provided in tabular format in the Guide to Climate Projections for Risk Assessment and Planning in SA (DEW 2022).

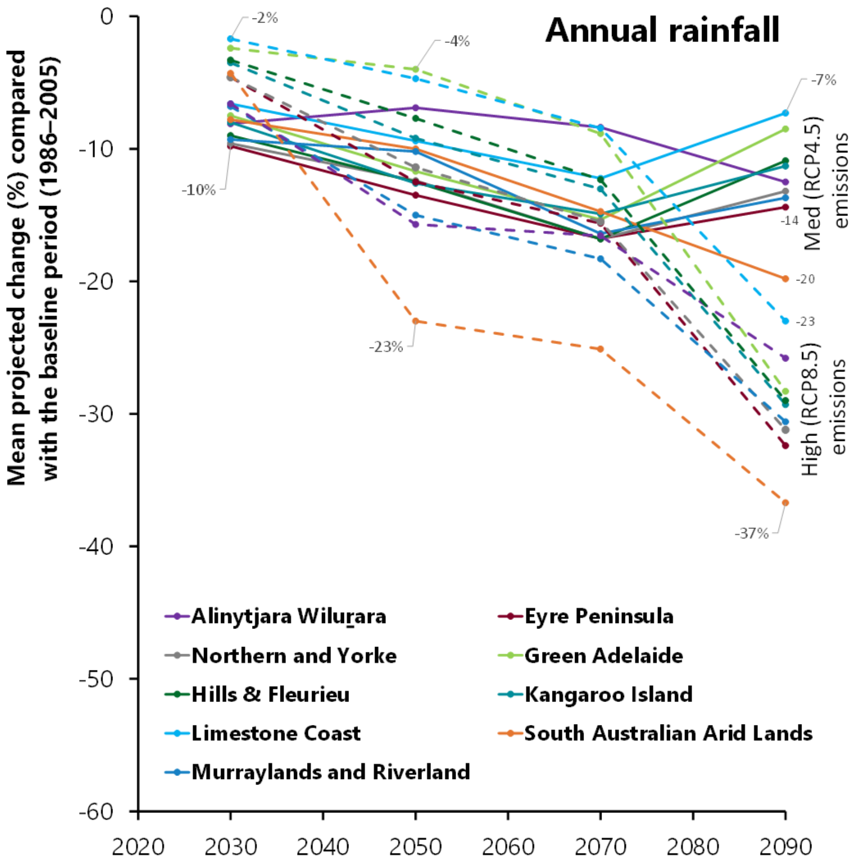


Figure 2.1. Projected rainfall report card 'top figure' – projected changes in average annual rainfall in South Australian landscape regions

Figure 2.2 contains percentage change in rainfall from the average of the six model combinations, calculated in the same manner as for Figure 2.1, but using just spring (September to November) rainfall totals, rather than annual rainfall totals, and again is show for both medium and high future emissions pathways.

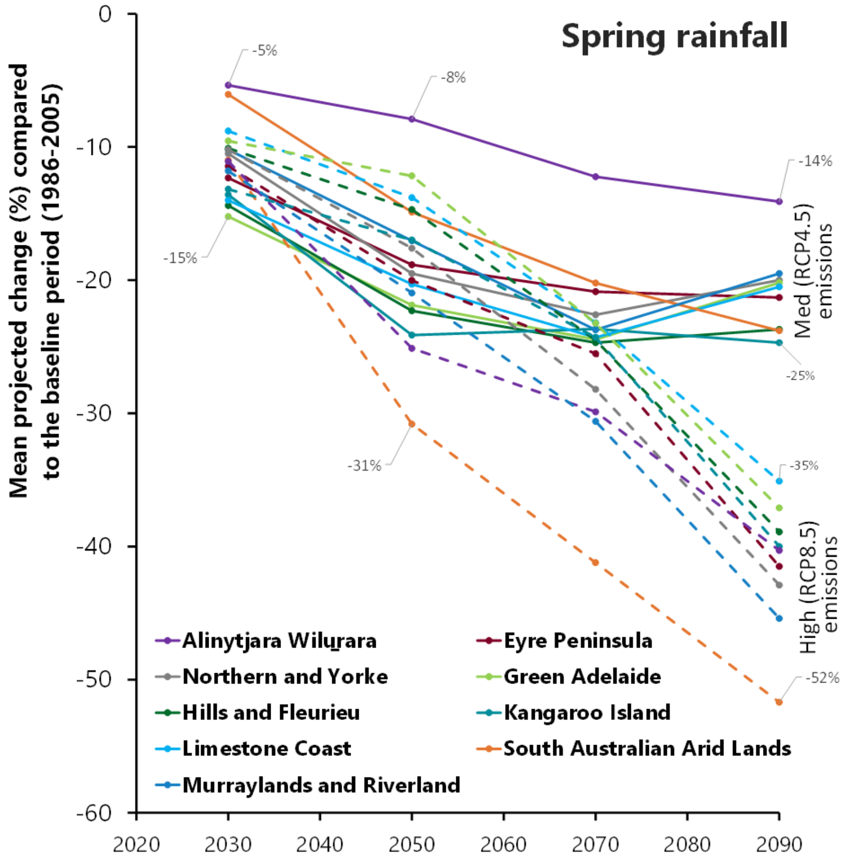
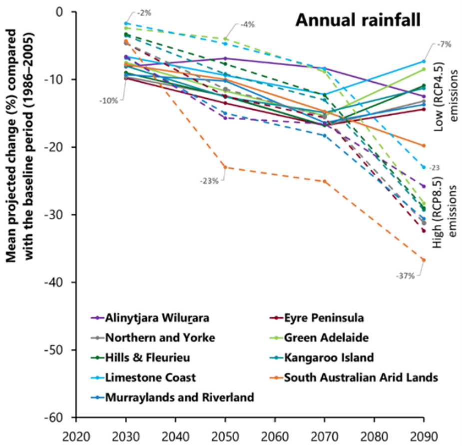
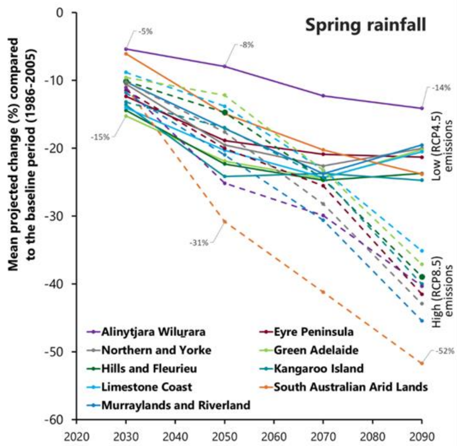


Figure 2.2. **Projected rainfall report card 'bottom figure' – projected changes in average spring rainfall in South Australian landscape regions**

The content of the Projected rainfall report card includes a combination of elements of textual information, graphical figures, trend and condition ratings, and summary statements about the projected future rainfall in South Australia. The information sources and analyses applied to derive each element of the report card content are summarised in Table 2.1. The method of selection of the trend, condition and information reliability ratings is described in Section 2.3.

Table 2.1. Summary of information sources and analysis

Report card element	Content	Data sources
Trend quote	Average annual rainfall across South Australia is projected to decrease by between 4% and 23% by 2050 under plausible emissions scenarios.	The range of projected rainfall change identified here (-4% to -23%) is simply the highest and lowest mean projected rainfall change among the nine landscape regions shown in the projected annual rainfall graph (top figure) at the time horizon of 2050. The rainfall changes illustrated by the graph are drawn from the South Australian Government's downscaled climate change projections (DEW 2023a, www.environment.sa.gov.au/topics/climate-change/climate-science-knowledge-resources).
Trend text	Under a medium emissions (RCP4.5) scenario, average annual rainfall is projected to decline by 7–10% by 2030 and by 7–14% by 2050. Beyond 2050, changes are greater under a high emissions (RCP8.5) scenario, particularly later in the century. By 2090, projected rainfall declines are 7–20% under a medium emissions scenario and 23–37% under a high emissions scenario (top figure). In most South Australian landscape regions, the projected decline is greater for average spring rainfall than for annual average rainfall. Under a medium emissions scenario, average spring rainfall is projected to decline by 8–24% by 2050. Beyond 2050, there is a further projected decline in the northern regions and Kangaroo Island, but not in the southern agricultural regions of the state. Changes are much greater under a high emissions scenario, with projected spring rainfall declines of between 35–52% by 2090 (bottom figure).	The ranges of annual rainfall change described are simply the highest and lowest mean projected rainfall change among the nine landscape regions included in the annual rainfall graph (top figure) at the time horizons of 2030, 2050 and 2090. The ranges of spring rainfall change described are the highest and lowest mean projected rainfall change among the nine landscape regions included in the spring rainfall graph (bottom figure) at the time horizons of 2030, 2050 and 2090. The rainfall changes illustrated by the two graphs are drawn from the Government of South Australia's downscaled climate change projections (DEW 2023a, www.environment.sa.gov.au/topics/climate-change/climate-science-knowledge-resources) and specifically the mean projections of rainfall change in each landscape region at the time horizons of 2030, 2050 and 2090. The projected rainfall changes are relative to the mean rainfall projected by the same models for a historic baseline period of 1986 to 2005.
Condition quote	A condition rating is not applicable as this is an assessment of projected rainfall under likely climate scenarios.	The report card condition rating is intended to report on the current status of the reported variable. As the Projected rainfall report card reports only on projected future rainfall change, it does not provide an assessment of the current condition of rainfall.
Condition text	This assessment draws from rainfall projections presented in the Government of South Australia's Guide to Climate Projections for Risk Assessment and Planning.	As this report card does not report on the condition of rainfall, the condition text is replaced by explanatory text on the nature and source of the rainfall projections.

Report card element	Content	Data sources
	Each of the graphed projections is the average of 6 projections from a combination of 3 global climate models with 2 regional climate models. The projected changes are relative to rainfall during a baseline period spanning 1986–2005. Two scenarios of global atmospheric greenhouse gas concentrations are shown, representing medium and high greenhouse gas emissions.	
Quote	Annual and spring rainfall across South Australia is projected to decline significantly by 2050.	This statement is based on the annual and spring rainfall decline shown in the graphs in the two figures, which indicates that the range of projected average annual rainfall declines in 2050 is from 4% to 23% and the range of projected spring rainfall declines is from 8% to 31%, a significant decline at either end of these ranges.
Top figure		The graph of projected annual rainfall was prepared using the Government of South Australia's downscaled climate change projections (DEW 2023a, www.environment.sa.gov.au/topics/climate-change/climate-science-knowledge-resources), specifically the mean projections of rainfall change in each landscape region at the time horizons of 2030, 2050, 2070 and 2090. The projected rainfall changes are relative to the mean annual rainfall projected by the same models for a historic baseline period of 1986 to 2005. Note, the time horizon years of 2030, 2050, 2070 and 2090 are not intended to represent the exact years by which rainfall is projected to change by these percentages. Rather, they are marker years, each for a 20-year period spanning the marker year. For example, the rainfall change projection for the 2050 time horizon represents the difference in the mean rainfall in the period 2040–2059, compared with the historic baseline period of 1986–2005.
Bottom figure		The graph of projected annual rainfall was prepared using the Government of South Australia's downscaled climate change projections (DEW 2023a, www.environment.sa.gov.au/topics/climate-change/climate-science-knowledge-resources), specifically the mean projections of spring seasonal rainfall change in each landscape region at the time horizons of 2030, 2050, 2070 and 2090. The projected rainfall changes are relative to the mean spring rainfall projected by the same models for a historic baseline period of 1986 to 2005. Note, the time horizon years of 2030, 2050, 2070 and 2090 are not intended to represent the exact years by which rainfall is projected to change by these percentages. Rather, they are marker years, each for a 20-year period spanning the marker year. For example, the rainfall change projection for the 2050 time horizon represents

Report card element	Content	Data sources
		the difference in the mean rainfall in the period 2040–2059, compared with the historic baseline period of 1986–2005.
Rationale	Climate affects almost every part of our lives. Communities, industries, landscapes and ecosystems all develop with a tolerance for a range of climate variation. If the climate changes beyond that range of tolerance, then they must either adapt, migrate, transform or decline. One example of the impact of a warming climate is declining rainfall in mid-latitudes (including South Australia), which will follow a widening of the tropics in a warmer planet. Declining rainfall impacts water security, agricultural yields, fire risk, and ecosystem function.	This is a general comment on the rationale for providing a report on the status of projected changes in rainfall in South Australia. The comment on the influence of a warming global climate affecting the decline in rainfall in mid-latitudes following a widening of the tropics is founded by a range of research papers, for example, Cai et al. (2012), Rainfall reductions over Southern Hemisphere semi-arid regions: the role of subtropical dry zone expansion, Nature Scientific Reports 2/702: https://www.nature.com/articles/srep00702
Drivers	According to the Australian Academy of Science, "Earth's climate has changed over the past century. The atmosphere and oceans have warmed, sea levels have risen, and glaciers and ice sheets have decreased in size. The best available evidence indicates that greenhouse gas emissions from human activities are the main cause. Continuing increases in greenhouse gases will produce further warming and other changes in Earth's physical environment and ecosystems."	This statement from the Australian Academy of Science was selected to describe this pressure as it encapsulates a statement of the primary cause of warming, the effects on the Earth's physical environment in the past and future. The statement is drawn from Australian Academy of Science (2015) www.science.org.au/climatechange
What is being done?	Climate change projections, including rainfall projections, are periodically improved and updated in line with advancements in climate modelling. Actions in response to the changing climate include those that mitigate South Australia's emissions as part of a global effort to stem further change in the global climate. The Government of South Australia has statewide goals to reduce net greenhouse gas emissions by more than 50% by 2030, achieve net zero emission by 2050, and achieve 100% renewable energy generation by 2030.	Information on current and future developments in climate change projections modelling and advancements in the science are presented in the Climate Projections Roadmap for Australia (DCCEEW 2023). Information on the South Australian Government's emissions reduction goals are drawn from DEW's Climate Change web page: Government action on climate change (DEW 2023b).

2.3 Methods to assign trend, condition and reliablity

2.3.1 Trend

Table 2.2. Definition of trend classes used

Trend	Description
Getting better	Over a scale relevant to tracking change in the indicator it is improving in status with good confidence
Stable	Over a scale relevant to tracking change in the indicator it is neither improving nor declining in status
Getting worse	Over a scale relevant to tracking change in the indicator it is declining in status with good confidence
Unknown	Data are not available, or are not available at relevant temporal scales, to determine any trend in the status of this resource
Not applicable	This indicator of the natural resource does not lend itself to being classified into one of the above trend classes

2.3.2 Condition

Table 2.3. Definition of condition classes used

Condition	Description
Very good	The natural resource is in a state that meets all environmental, economic and social expectations, based on this indicator. Thus, desirable function can be expected for all processes/services expected of this resource, now and into the future, even during times of stress (e.g. prolonged drought)
Good	The natural resource is in a state that meets most environmental, economic and social expectations, based on this indicator. Thus, desirable function can be expected for only some processes/services expected of this resource, now and into the future, even during times of stress (e.g. prolonged drought)
Fair	The natural resource is in a state that does not meet some environmental, economic and social expectations, based on this indicator. Thus, desirable function cannot be expected from many processes/services expected of this resource, now and into the future, particularly during times of stress (e.g. prolonged drought)
Poor	The natural resource is in a state that does not meet most environmental, economic and social expectations, based on this indicator. Thus, desirable function cannot be expected from most processes/services expected of this resource, now and into the future, particularly during times of stress (e.g. prolonged drought)
Unknown	Data are not available to determine the state of this natural resource, based on this indicator
Not applicable	This indicator of the natural resource does not lend itself to being classified into one of the above condition classes

2.3.3 Reliability

Information is scored for reliability based on the minimum of subjective scores (1 [worst] to 5 [best]) given for information currency, applicability, level of spatial representation and accuracy. Definitions guiding the application of these scores are provided in Table 2.4 for currency, Table 2.5 for applicability, Table 2.6 for spatial representation and Table 2.7 for accuracy.

Table 2.4. Guides for applying information currency

Currency score	Criteria
1	Most recent information >10 years old
2	Most recent information up to 10 years old
3	Most recent information up to 7 years old
4	Most recent information up to 5 years old
5	Most recent information up to 3 years old

Table 2.5. Guides for applying information applicability

Applicability score	Criteria
1	Data are based on expert opinion of the measure
2	All data based on indirect indicators of the measure
3	Most data based on indirect indicators of the measure
4	Most data based on direct indicators of the measure
5	All data based on direct indicators of the measure

Table 2.6. Guides for applying spatial representation of information

Spatial score	Criteria
1	From an area that represents less than 5% the spatial distribution of the asset within the region/state or spatial representation unknown
2	From an area that represents less than 25% the spatial distribution of the asset within the region/state
3	From an area that represents less than half the spatial distribution of the asset within the region/state
4	From across the whole region/state (or whole distribution of asset within the region/state) using a sampling design that is not stratified
5	From across the whole region/state (or whole distribution of asset within the region/state) using a stratified sampling design

Table 2.7. Guides for applying accuracy information

Reliability	Criteria
1	Better than could be expected by chance
2	> 60% better than could be expected by chance
3	> 70 % better than could be expected by chance
4	> 80 % better than could be expected by chance
5	> 90 % better than could be expected by chance

2.4 Data transparency

Data transparency for this report card is represented in Appendix A.

3 Results

3.1 Trend

The trend rating for projected rainfall was determined to be 'Getting Worse' as the projected changes for all the nine landscape regions reported on are for a decline in rainfall in the future. A decline in rainfall is assessed to be a trend that is 'getting worse' due to the increased risk of water security and potential impacts to agriculture and ecosystems that may result from a drying climate in regions that already have a dry climate.

3.2 Condition

As this assessment is of projected rainfall under future climate scenarios, a condition rating is not considered to be applicable.

3.3 Reliability

The overall reliability score for this report card is 2 out of 5, based on the minimum score for the reliability rating criteria (Table 3.1). Based on definitions in Section 2.3.3, this translates to an overall reliability rating of 'Fair'.

Table 3.1. Information reliability scores for projected rainfall

Indicator	Applicability	Currency	Spatial	Accuracy	Reliability
Projected average annual and spring rainfall	2	5	4	N/A	2

3.3.1 Notes on reliability

The NARCliM rainfall projections datasets are less than 3 years old. A currency score of 5 is assigned to these data.

An information applicability score of 2 is determined for these data. The projected changes in rainfall are determined from a combination of large scale modelling of climate systems and statistical modelling of historic weather at a location. The projections of future rainfall change that result from these modelling processes are all based on indirect indicators of future rainfall.

A spatial representation score of 4 is determined for the future rainfall projections. The projected changes in rainfall are determined from a combination of large scale modelling of climate systems and regional scale dynamic models that take account of landscape and topographic features covering the whole of South Australia as well as large scale climate systems that are representative of areas covering more than the whole of each landscape region. Any weather station location data can only be representative of the climate of a fraction (typically <25%) of each region.

As the projected changes in rainfall are only modelled projections of future changes in rainfall under scenarios of future greenhouse gas concentrations, the accuracy of the data cannot be compared against measurement. As a result, the accuracy assessment of the projections is considered to be not applicable (N/A).

4 Discussion

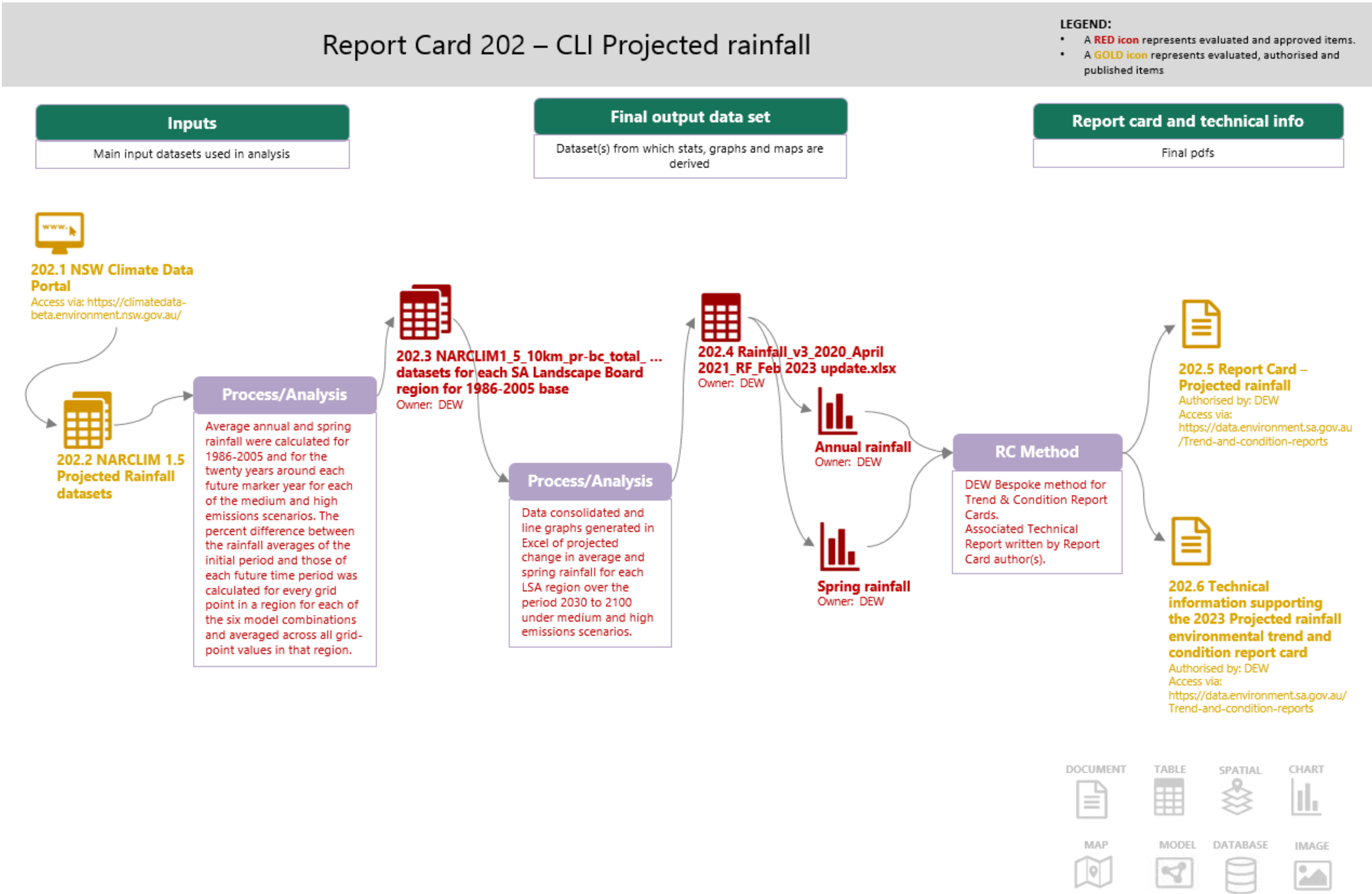
4.1 Trend

The trend rating for projected rainfall was determined to be 'Getting worse' as the projected changes for all the nine landscape regions are for a decline in rainfall in the future.

4.2 Condition

As this assessment is of projected rainfall under future climate scenarios, a condition rating is not considered to be applicable.

5 Appendix A: Managing environmental knowledge chart for Projected rainfall



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