Water

SA Water Regulatory Determination 2020: Guidance paper 7 (technical paper)

ESSENTIAL SERVICES COMMISSION OF SOUTH AUSTRALIA

The averaging period of the risk free rate

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Enquiries concerning this Guidance Paper should be addressed to:

Essential Services Commission
GPO Box 2605
ADELAIDE SA 5001

Telephone: (08) 8463 4444
Freecall: 1800 633 592 (SA and mobiles only)
E-mail: escosa@escosa.sa.gov.au
Web: www.escosa.sa.gov.au

Any queries on SA Water Regulatory Determination 2020 should be directed to:

Nathan Petrus, Director Consumer Protection and Pricing

Related reading

This Guidance Paper should be read in conjunction with the Framework and Approach paper and other Guidance Papers released by the Commission for SA Water Regulatory Determination 2020. Those papers and other information about SA Water Regulatory Determination 2020, are available on the Commission's website:

https://www.escosa.sa.gov.au/industry/water/retail-pricing/sa-water-regulatory-determination-2020

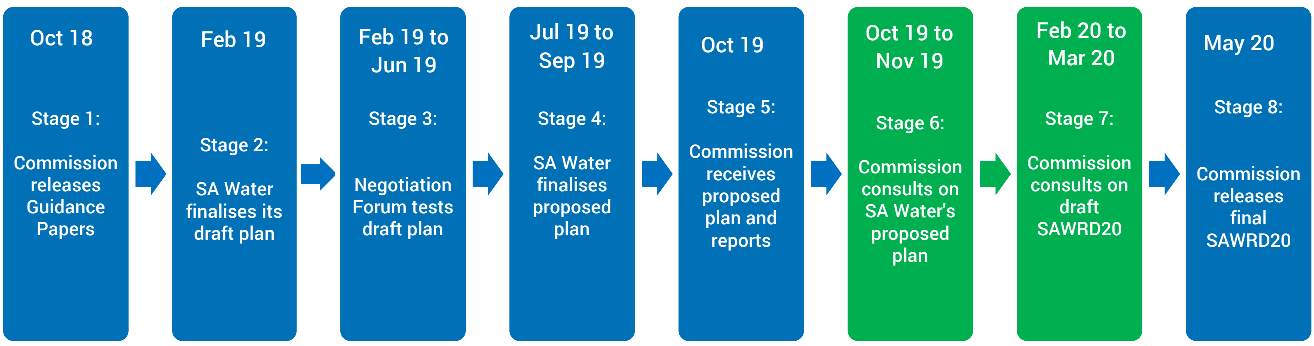
Timing for this review and upcoming consultation opportunities

While the Commission remains responsible for making the final regulatory determination, which will require SA Water to provide the water and sewerage retail services valued by customers for the lowest sustainable cost, the review process will involve multiple opportunities for stakeholders to be involved prior to that final determination.

Input from a diverse range of stakeholders is important, as it helps the Commission to make better informed and more inclusive decisions. The Commission will therefore draw on the full range of evidence provided by all stakeholders in making the final determination.

The timing of the key stages in SA Water Regulatory Determination 2020 are illustrated below, with the Commission's key consultation stages shown in green.

SAW RD20 review timeline



SA Water Regulatory Determination 2020 (SAW RD20) will set maximum revenues and minimum service standards for SA Water's drinking water and sewerage services, as well as setting pricing requirements for other miscellaneous retail services, to apply from 1 July 2020 to 30 June 2024.

SAW RD20 will challenge SA Water to:

- provide water and sewerage services at the lowest sustainable price for the quality and reliability levels valued by customers, and
- have in place sound long-term asset management, operating and financing strategies, which support the provision of those services for customers of today and tomorrow.

Those intended outcomes are consistent with the Commission's primary objective of protecting the long-term interests of consumers with respect to the price, quality and reliability of essential services.

Purpose of this document

In July 2018, the Essential Services Commission (**Commission**) established the framework and approach for SA Water Regulatory Determination 2020 (**SAW RD20**), which is intended to deliver the lowest sustainable prices for the services that SA Water's customers value.[1]

This is the seventh of a series of Guidance Papers released by the Commission to explain the requirements, methodology and process that will apply to SAW RD20. This Guidance Paper presents research that examines different averaging periods that may be used for determining the risk free rate as part of the regulatory rate of return for SAW RD20. Most utility regulators in Australia, including the Commission, use a short-term averaging period for yields on government-backed securities, typically calculated over twenty to sixty business days, to estimate the risk free rate for the four-year duration of the regulatory horizon.

The risk free rate is an important input into the regulatory rate of return to apply in SAW RD20. The averaging period for the risk free rate is likely to be an important issue for SAW RD20 for at least two reasons. First, given the low interest rate environment and the risk that interest rates might rise in the future, SA Water has previously suggested that a long-term (historical) averaging period (eg ten years) could be adopted. Second, given the range of averaging periods used by various regulators, the Commission recognised that it was timely to undertake research on the issue in the lead up to the determination.

This Guidance Paper:

- summarises theory and regulatory practice in Australia regarding approaches to forecasting the risk free rate, and
- tests which method of the averaging periods (short or long-term) most accurately predicts the risk free rate over the four-year regulatory horizon.

In undertaking the analysis, the Commission has had regard to the principles used by it for determining the regulatory rate of return in previous regulatory determinations and in SAW RD20 Guidance Paper 5 (Appendix A, noting that the principles are consistent with and explain relevant statutory requirements, such as factors which must be considered in making a determination). In particular, utilising a methodology that produces low forecasting errors for the risk free rate is consistent with minimising the expected costs of a prudent and efficient financing strategy of an incumbent water utility. Forecasting errors can lead to calculated real rates of return that are above or below efficient amounts. If the forecast risk free rate is well above actual risk free rates during the regulatory period, SA Water may earn returns that are above efficient amounts, which could lead to customers paying more for drinking water and sewerage services than they need to. If forecast risk

[1] See Commission (2018), 'SA Water Regulatory Determination 2020: framework and approach', July 2018, available at: https://www.escosa.sa.gov.au/projects-and-publications/projects/water/sa-water-regulatory-determination-2020-framework-and-approach.

free rates are well below actual rates during the regulatory period, SA Water may earn real returns that are insufficient to promote the ongoing investment that is necessary to deliver sustainable drinking water and sewerage services. Minimising forecasting errors is therefore consistent with the Commission's aim of delivering the lowest sustainable cost of drinking water and sewerage services (and, hence, with the Commission's primary statutory objective of the protection of the long term interest of consumers with respect to price, quality and reliability of essential services).

Why has the issue of the averaging period for the risk free rate been raised?

The concept of the risk free rate is simply the rate of return on an asset with no risk. As explained in Guidance Paper 5, it is a key parameter in determining the weighted average cost of capital (**WACC**), which is used to determine SA Water's regulatory rate of return. In particular, the risk free rate forms part of both the cost of debt and the cost of equity, with the latter determined under the Capital Asset Pricing Model (**CAPM**) approach.[2]

Selection of the risk free rate involves three key considerations: choice of the proxy asset, term of the asset, and the period of time over which the proxy rate of return is estimated. CAPM theory does not provide guidance on determining the choice of proxy asset or averaging period.[3]

The Commission's current approach is to use the yield on ten-year Commonwealth Government Securities (**CGS**). It then forecasts the risk free rate for the four-year regulatory horizon by taking an average of observed market yields over the twenty business days immediately preceding the commencement of the regulatory period.

SA Water's concern with the Commission's current averaging approach

SA Water has previously highlighted two main concerns with the Commission's current approach:

- the inconsistency between the averaging periods used to estimate the risk free rate used for the purposes of calculating the cost of debt and equity,[4] and
- the risk of higher interest rates, hence the potential for a sharp increase in the rate of return and therefore total revenues and customer prices at the time of the regulatory reset in 2024.[5]

In light of those concerns, SA Water has, on a number of occasions, indicated a preference for the use of a longer-term average to calculate the risk free rate.[6]

This is not the first time that a regulated utility in Australia has advocated for the use of a longer-term average for calculating the risk free rate. A number of regulated entities have, at various times of relatively low interest

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2 See Commission (2018), 'SAW RD20: Guidance paper 5 - the cost of funding and assets', November 2018, available at: https://www.escosa.sa.gov.au/ArticleDocuments/1200/20181101-Water-SAWRD20-GuidancePaper5-CostOfFundingAndUsingAssets.pdf.aspx?Embed=Y.

3 See QCA (2012), 'The risk free rate and the Market Risk Premium', November 2012, pp.1-31, available at: http://www.qca.org.au/getattachment/ea5f877a-36d2-42a9-bfe3-8103851364f1/The-Risk-free-Rate-and-the-Market-Risk-Premium-Dis.aspx.

4 The cost of debt is estimated on the basis of a ten-year average while the averaging period of the risk free rate, as noted above, is estimated based on a twenty-day average. SA Water's concerns about alignment were outlined in 2015; see SA Water (2015), 'SA Water Regulatory Rate of Return 2016-2020 Draft Report to the Treasurer (draft report)', submission, p. 12, available at: https://www.escosa.sa.gov.au/ArticleDocuments/423/20150204-SAWaterRateOfReturnDraftReportSubmissionSAW.pdf.aspx?Embed=Y.

5 See SA Water (2018), 'Re: Submission on Guidance Papers for the SA Water Regulatory Determination 2020', pp. 1-2, 6 November 2018, available at: https://www.escosa.sa.gov.au/ArticleDocuments/11293/20181206-Water-SAWRD20-GuidancePapersSubmission-SAWater.pdf.aspx?Embed=Y.

6 See SA Water, Re: Submission on Guidance Papers for the SA Water Regulatory Determination 2020, p. 2, and SA Water, SA Water Regulatory Rate of Return 2016-2020 Draft Report to the Treasurer (draft report), p.12.

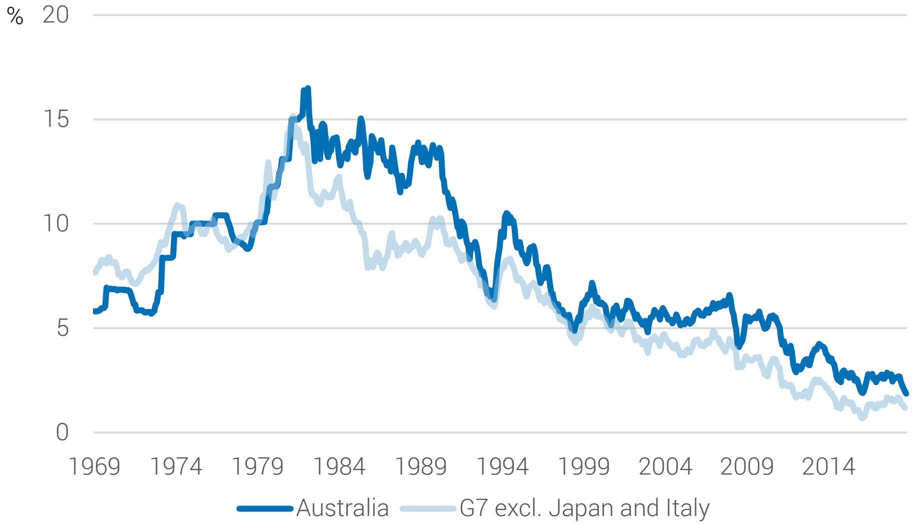
rates over the past two decades, advocated for the use of a longer-term averaging period for the risk free rate.[7]

While there is limited evidence in support for the argument for alignment between the averaging periods used in debt and equity calculations, given the different nature of the concepts involved,[8] there is a question of which averaging period of the risk free rate leads to the most accurate forecasts of the risk free rate over the regulatory horizon. This Guidance paper examines that question.

Determining an appropriate averaging period

The outlook for bond yields is inherently difficult to predict. There are two well-known reasons for this. First, financial market variables exhibit 'excess volatility' reflecting the importance of frequent changes in investor sentiment due to the continual stream of new information.[9] Second, as seen in Figure 1, yields on ten-year CGS have not tended to fluctuate around a stable average level. Rather, domestically and globally, yields have been characterised by long-term trends (such as the period of inflation in the 1970s and the downward trend since then).[10]

Figure 1: Yields on ten-year government securities



Source: OECD

Research suggests that few, if any, forecast approaches for financial variables, including bond yields, have been able to consistently improve upon the 'random walk' model.[11] The random walk model assumes that increases and decreases are equally likely over the forecast horizon and therefore a no-change assumption should be followed. Consistent with this, most Australian utility regulators apply the no-change assumption to

7 See Economic Regulatory Authority (ERA) (2012), 'Inquiry into the Efficient Costs and Tariffs of the Water Corporation, Aqwest and the Brusselton Water Board', Released Final Report, 28 March 2013, p.146, available at: http://www.parliament.wa.gov.au/publications/tabledpapers.nsf/displaypaper/3910025ad8c4b4d8e4164e9848257b4f0027e686/$file/25.pdf, and QCA, p.3.

8 The ten-year averaging period for the cost of debt is used to account for a private firms' ability or need to roll over and refinance debt. In contrast, the cost of equity is a forward-looking concept where the risk free rate is a major component in its calculation. Investors' expectations of future cash flows from the risk free asset take into account all current available information and that information is captured in current pricing.

9 See Bauer (2017), 'Bridging the Gap: Forecasting Interest Rates with Macro Trends', FRBSF *Economic Letter*, July 31 2017, available at: https://www.frbsf.org/economic-research/publications/economic-letter/2017/july/bridging-gap-forecasting-interest-rates-with-macroeconomic-trends/.

10 See Reserve Bank of Australia (RBA) (2019), 'Box B: Why are Long-term Bond Yields So Low', May 2019 RBAStatement of Monetary Policy, pp. 27-31, available at: https://www.rba.gov.au/publications/smp/2019/may/pdf/box-b-why-are-long-term-bond-yields-so-low.pdf.

11 See Duffee (2013), 'Forecasting interest rates', Chapter 7 in Handbook of Economic Forecasting, volume 2A, edited Elliott and Timmermann, Amsterdam, Elsevier. The chapter can be found online at: http://www.econ2.jhu.edu/people/Duffee/handbookForecast.pdf.

forecast the risk free rate over the regulatory horizon, though, as noted earlier, they use a short-term average of recent observations (typically calculated over a twenty to sixty business day period) to lower the risk that pricing anomalies on any particular day might affect the calculation used in the regulatory determination (Table 1).

Table 1: A comparison of current regulatory practice[12]

Regulator	Averaging period (business days)	Measure of risk free rate
ESCOSA	20	Ten-year CGS
QCA	20	One-year CGS
AER	20-60 (nominated by the regulated entity)	Ten-year CGS
ICRC	40	Ten-year CGS
OTTER	Hybrid (mid-point between 40 days and ten years)	Ten-year CGS
IPART	Hybrid (mid-point between 40 days and ten years)	Ten-year CGS
ERA	60	Five-year CGS

In contrast, and as noted above, SA Water have previously suggested that the Commission move away from a twenty-day average and use some form of longer-term average. For example, at the time of SAW RD20, SA Water proposed using a ten-year average for the calculation of the risk free rate to be used to estimate the cost of equity.[13]

While the future movements in yields on CGS is uncertain,[14] there are ways to manage uncertainty and lower the size of forecast errors. This includes through evaluating forecast errors and considering mechanisms to mitigate forecast risk. Moreover, when evaluating forecasts it is important to differentiate between what we know in hindsight and what we would have known at the time the forecast is made. For instance, sometimes backward-looking averages are presented as evidence of the appropriateness of a particular averaging period; by construction these calculations lower measures of volatility,[15] yet they do not tell us about forecast accuracy.

This Guidance Paper tests the forecasting accuracy of a ten-year average compared with both the Commission's current approach of using a twenty-day average as well as alternative short-term approaches. Other regulators have previously undertaken similar testing.[16]

Our testing of forecasting accuracy is premised on the principle that revenues should recover SA Water's efficient forecast costs over the four-year regulatory period. Should those costs change from period to period, SA Water's prices may also change, impacting on SA Water's stated price stability objective. However, the testing does not consider an alternative policy regime such as one that might have a regulatory horizon beyond four years (as implicitly argued by SA Water in its response to the Commission's release of the

[12] See Commission, SAW RD20: Guidance Paper 5 - the cost of funding and assets, pp. 31-33.
[13] See SA Water, SA Water Regulatory Rate of Return 2016-2020 Draft Report to the Treasurer (draft report), pp. 34.
[14] The Deputy Governor of the RBA has described the future evolution of interest rates as 'inherently uncertain'; see Debelle (2018), 'Risk and return in a low rate environment', address at Financial Risk Day 2018, available at: https://www.rba.gov.au/speeches/2018/sp-dg-2018-03-16.html.
[15] See SA Water, SA Water Regulatory Rate of Return 2016-2020 Draft Report to the Treasurer (draft report), p. 12.
[16] See ERA, pp 145-153. The ERA tests the forecast of a short-term approach compared with the use of a five-year average.

SAW RD20 Guidance papers in November 2018[17]). Further, the research in this paper does not examine alternative approaches to forecasting the risk free rate (including model-based forecasts).[18]

Overall, the Commission's conclusions are that:

- a ten-year average approach tends to have a much lower forecast accuracy than the Commission's current approach (of using a twenty-day average)
- the estimated large and persistent forecast errors likely to result from using a ten-year average suggests its use in forecasting could lead to sizeable adverse impacts on allowed revenues, and
- relative to the Commission's current approach, there is likely to be limited additional forecasting accuracy to be gained from using a shorter (five) or longer (sixty) day average.

Analysis

The Commission has used two approaches to test the forecasting accuracy and potential revenue consequences of the averaging periods of the risk free rate.

First, it has assessed the forecasting accuracy of the twenty-day average used by the Commission (and the 'on the day' rate and short-term averages used by other regulatory agencies) compared with the use of a ten-year average. It has done this assessment by calculating and comparing standard measures of forecast accuracy, including root mean square error (**RMSE**)[19] and mean absolute error (**MAE**). Both are common methods of testing forecasting accuracy.[20] We then use the Diebold Mariano (**DM**) test to assess whether or not the forecast errors resulting from the shorter-term approaches are statistically different from those of the ten-year average and different from each other. This is a common test when assessing forecasting approaches.[21] A statistically significant difference in forecast errors indicates a certain level of confidence that one approach produces observable differences over another.

Second, the Commission has calculated the hypothetical consequences to revenues in net present value terms if a ten-year average approach had been used in previous determinations, such as in SA Water Regulatory Determination 2013 (**SAW RD13**) and SA Water Regulatory Determination 2016 (**SAW RD16**). The aim is to illustrate the adverse consequences of inaccurate forecasts.

Comparing model-free forecasts

To test forecasting accuracy, the yield on ten-year CGS was estimated one to four years ahead using a twenty-day average (and other shorter-term averages[22]) and the predictions were compared to actual observations. The same exercise was undertaken for the ten-year average. The testing works as follows: if today is 1 April 2019 and an average of yields (including today) is 1.9 per cent, this number would be used to forecast yields over the regulatory horizon. Four years on from that day, the forecast can be tested against the

[17] See SA Water, 'Re: Submission on Guidance Papers for the SA Water Regulatory Determination 2020, p. 2.

[18] Forecasting approaches could include the use of long-run macroeconomic relationships (including the inflation expectations augmented Fisher equation), market-implied forward rates, or the use of the predictions of professional forecasters. An example of an organisation that uses medium-term and long-term projections of interest rates is the Australian Government Actuary; see Department of Finance (2018), 'Long term cost report 2017', a report on the long term cost of the public sector superannuation scheme and the Commonwealth superannuation scheme', 25 June 2018, pp.14-15, available at: https://www.finance.gov.au/sites/default/files/CSS%20PSS%202017%20LTCR.pdf. International research suggests there could be forecasting accuracy gained at the five year horizon by using long-run macroeconomic relationships; see Bauer.

[19] RMSE is essentially the sample standard deviation of the forecast errors (without any degrees of freedom). If the RMSE is calculated for two or more forecasts, the one with the smallest number indicates the least error.

[20] See Tulip and Wallace (2012), 'Estimates of Uncertainty around the RBA's Forecast', Research Discussion Paper 2012-07, pp.6-8, available at: https://www.rba.gov.au/publications/rdp/2012/pdf/rdp2012-07.pdf.

[21] See Tulip and Wallace, pp. 6-8, and also see Diebold FX and RS Mariano (1995), 'Comparing Predictive Accuracy', Journal of Business & Economic Statistics, 13(3), pp. 253-263, available at: https://www.sas.upenn.edu/~fdiebold/papers/paper68/pa.dm.pdf.

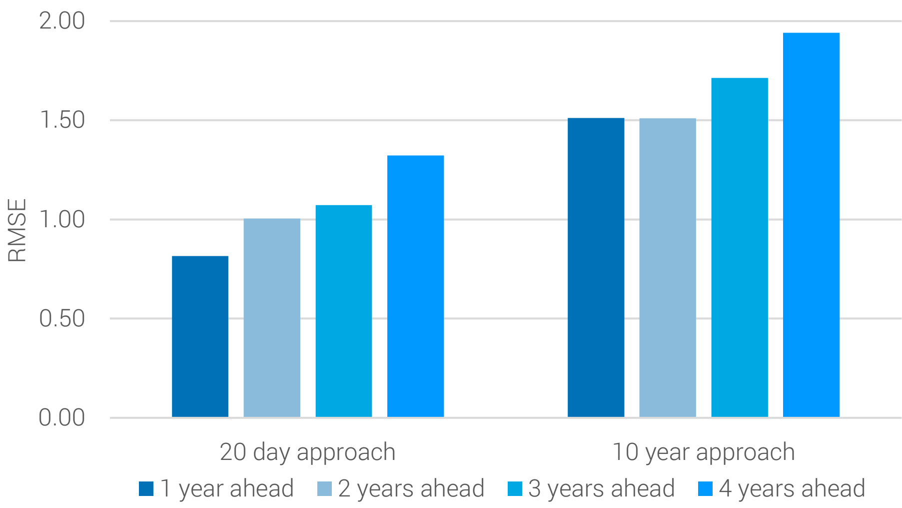
[22] Of the other short-term approaches, we only test the 'on the day' approach as well as the five day and sixty day averages.

actual observed yields on 1 April 2020, 1 April 2021, 1 April 2022 and 1 April 2023. The calculated difference is the forecast error.

The assessment was undertaken on a rolling basis using daily data available since 1995 (data prior to this are only available on a monthly basis). The full sample of data used is from 1995 to January 2019; however, testing of forecasts cannot take place until ten years has passed. For that reason the testing starts from 2005.[23] While the time period assessed can be viewed as a limitation, it can also arguably be seen as appropriate. This is because it excludes the period prior to 1995 when economic and financial policy in Australia was quite different; for instance, financial deregulation had not yet occurred in full and monetary policy operated differently.[24]

The forecasting errors calculated in the exercise are summarised using RMSE (see Figures 2 and 3) and MAE (see Appendix B). The results suggest that the ten-year average approach would result in large, persistent and statistically significant forecast errors compared with the use of a twenty-day average.[25] Similar results were found in testing of the period from 1983 to 2012 undertaken by the Economic Regulatory Authority (ERA) in Western Australia.[26]

Figure 2: Size of errors (ppt), by approach and forecast horizon, 2005-2018



Source: Commission

As expected, the longer the outlook horizon, the larger the forecast errors. Of note, the largest error (the fourth year) from using the twenty-day approach is slightly below the smallest error from using the ten-year average (the first year). Also, the results show almost no difference in the size of errors generated from the use of various shorter-term averaging approaches (Figure 3).[27]

23 Data to 18 January 2019 is included in the testing sample. To calculate errors we match forecasts to outcomes on the exact dates one year, two years, three years and four years into the future. A limitation, however, is that the dates may not align to days of the week and this can lower the number of observations in the testing sample. For instance, the average of yields over the twenty days to 8 July 2004 may not be directly comparable with the market observation on 8 July 2005 as the latter lies on a weekend. Where forecasts were to lie on weekends, they were tested against data on the following business day/s. That test did not change the overall results of the analysis. As such, the results presented in this paper are those that match forecasts to outcomes on exact dates where they are available.

24 See, for example, Debelle (2017), 'Global influences on monetary policy', speech given at CEDA Mid-Year Economic Update Adelaide 21 July 2017, available at: https://www.rba.gov.au/speeches/2017/sp-dg-2017-07-21.html.

25 A hybrid approach was also tested (calculated as the mean between a twenty-day average and a ten-year average). It results in larger errors than those resulting from short-term approaches, though the error size was less than those from the ten-year average.

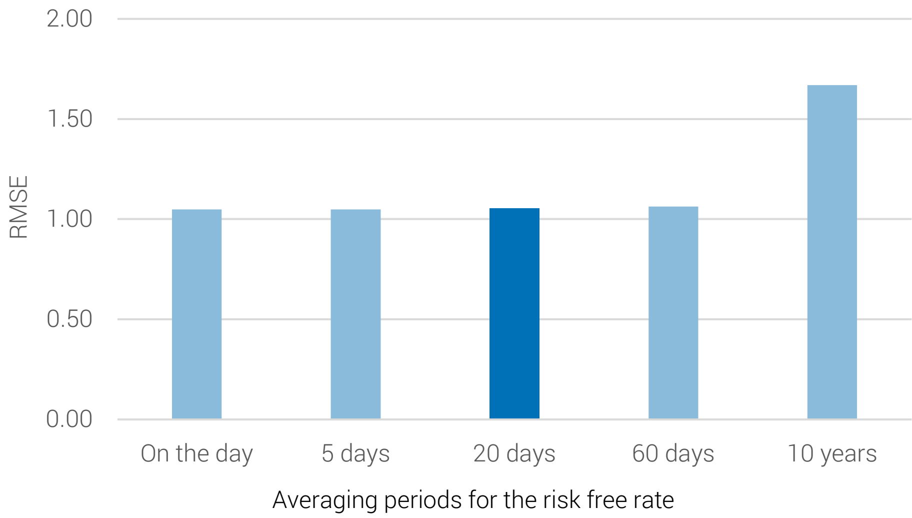
26 In 2012, the ERA examined the forecasting accuracy of a five and one year averaging period compared with a short-term average. It used daily data on ten-year CGS from 1983 to 2012 sourced from Bloomberg. Their results concluded that the longer-term approaches produced less accurate forecasts for the five year forecast horizon relative to a short-term average. See ERA, pp 145-153.

27 For example, the difference in RMSE between the one and sixty day approaches was very small (ie 0.01 ppt).

An important feature is that the results differ across the sample of data tested:

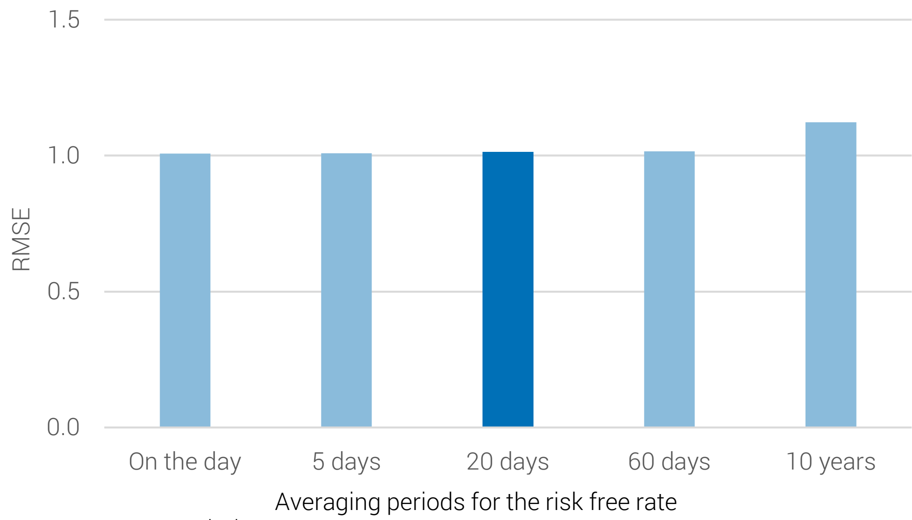
- 2005 to 2012: while the ten-year average approach results in larger errors than those arising from the use of shorter-term averages, the difference tends to be small and is not statistically significant (see Figure 4 and Appendix B for detailed results).
- 2012 to 2018: given the testing results for 2005 to 2018 and for 2005 to 2012, it can be implied that during the 2012-18 the results indicate large, persistent and statistically significant errors from using the ten-year average approach.

Figure 3: Average errors over the four-year forecast horizon (ppt), by type of averaging approach, 2005-2018



Source: Commission

Figure 4: Average errors over the four-year forecast horizon (ppt), by type of averaging approach, 2005-2012



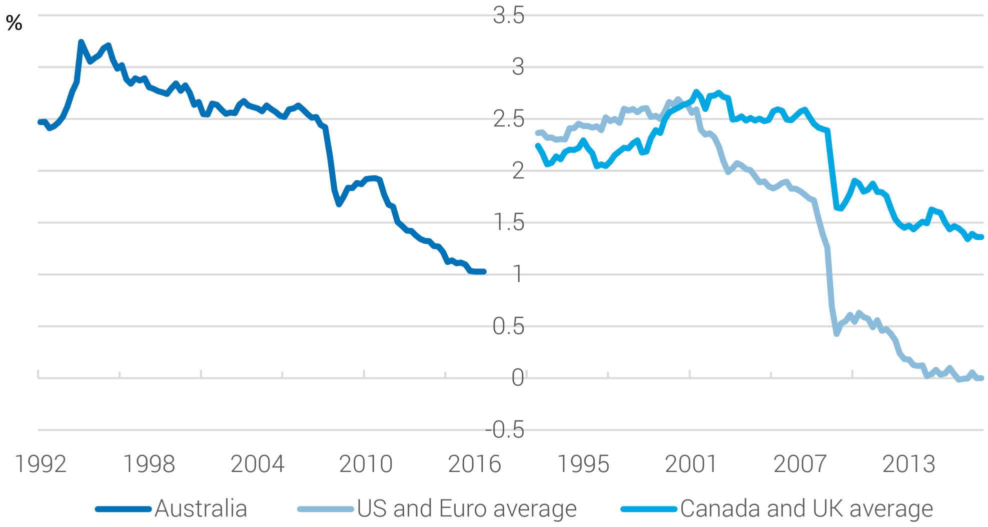
Source: Commission

The differing results largely reflect that there has been a structural decline in yields since around 2009. The structural decline has been driven by the fall in the neutral real interest rate caused by a decline in the economy's potential growth rate and an increase in the risk aversion of households and firms (left panel, Figure 5).[28] To the extent that the decline in neutral real interest rates reflects developments in overseas

[28] The neutral real interest rate is the real policy interest rate required to bring about full employment and stable inflation over the medium term. See McCririck and Rees (2017), 'The Neutral Real Interest Rate', RBA Bulletin, September quarter 2019, pp. 9-18, available at: https://www.rba.gov.au/publications/bulletin/2017/sep/pdf/bu-0917-2-the-neutral-interest-rate.pdf, and Debelle, Global

economies, this can help explain the similar trends between Australia and some other advanced economies (right panel, Figure 5).[29]

Figure 5: The decline in neutral real interest rates[30]



Source: McCririck and Rees 2017

The recent structural decline in yields means the use of a ten-year average for SAW RD20 will likely capture out-dated information about risk aversion and potential growth in the Australian economy. Hence, there are likely to be large, persistent and foreseeable errors from the use of a ten-year average approach to calculate the risk free rate for SAW RD20.

Taken at face value, and assuming forecast errors are unbiased and normally distributed, Figure 6 shows yields on CGS projected over the regulatory horizon using an on the day approach. The projection, which is based on data as of 14 May 2019, is accompanied by approximations of the 70 per cent confidence bands, estimated as the projection plus or minus RMSE prediction errors at each forecast horizon.[31] A 95 per cent confidence band would widen the range even further, from 0 (or even below[32]) to 4.5 per cent at the end of the horizon.[33] Those confidence bands illustrate the percentage of future outcomes that could be expected to lie within the range. In practice, the ranges show the increasingly uncertain outlook for yields the further ahead the time frame. It is noted, however, that there are limitations in estimating these types of uncertainty bands when, among other things, assumptions about symmetrical and unbiased errors may not be plausible and the effective zero lower bound on nominal interest rates could become a constraint.[34]

influences on monetary policy. There is uncertainty about the exact level of the neutral real interest rate. This reflects that it is not observed and is difficult to estimate.

29 Where capital can move reasonably freely across international borders, global interest rates can influence domestic interest rates. The implication is that trends in overseas productivity growth, demographics and risk appetite can affect the neutral risk interest rates in Australia; see Debelle, Global influences on monetary policy.

30 Data for the neutral real interest rate is estimated up to the start of 2017; see McCririck and Rees, p. 14.

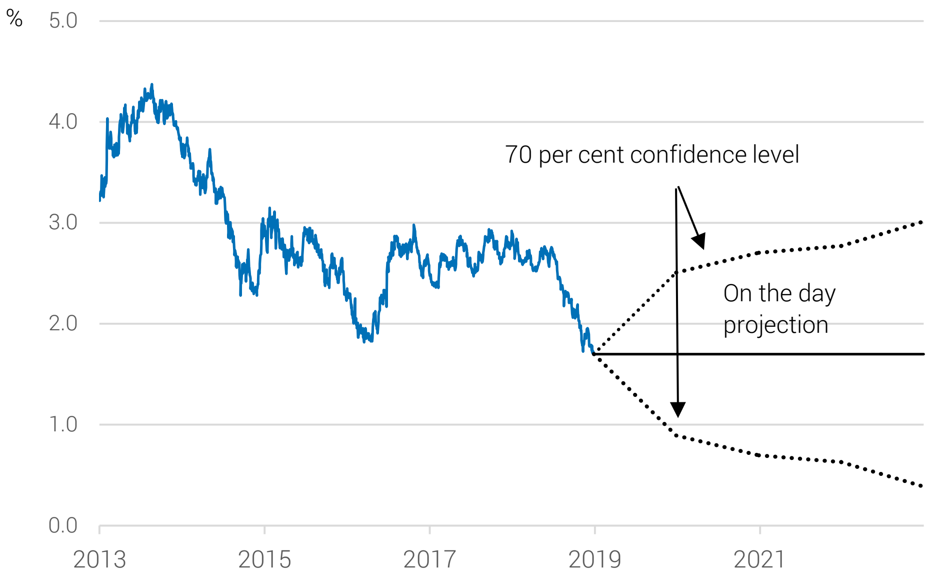
31 If prediction errors are stable, unbiased and normally distributed, approximately 70 per cent of future outcomes can be expected on average to fall within one RMSE, and approximately 95 per cent of future outcomes can be expected on average to fall within two RMSEs.

32 Ten-year government securities in some countries, including Germany, Japan and Switzerland, have been negative at various times in recent years; see Debelle, Risk and return in a low rate environment.

33 In addition, a simple Monte Carlo simulation, using the sample of data from 1995 to January 2019 and based on an expected value following a random walk (without trend), produces a similarly wide range of potential future outcomes for yields on CGS.

34 For a discussion of these limitations, see Reifschneider and Tulip (2017), 'Gauging the uncertainty of historical forecast errors: the Federal Reserve's approach', Reserve Bank of Australia Discussion Paper 2017-01, pp.16-20, available at: https://www.rba.gov.au/publications/rdp/2017/2017-01/fan-charts.html.

Figure 6: A simple illustration of the uncertain outlook for yields on CGS



Sources: Commission; RBA

Forecasting accuracy of the various short-term averages

The risk of one-off market pricing anomalies from trading errors, reporting errors or opportunistic behaviour by a regulated firm has been highlighted in previous research.[35] These pragmatic concerns have supported regulators' use of short-term averages rather than use of the market price on the day prior to the regulatory period. However, as noted earlier, the results in this paper suggest there is likely to be limited difference in forecast accuracy between the various short-term approaches. As such, the Commission is open to an averaging approach in line with that used by the Australian Energy Regulator (AER); that is, where the regulated entity chooses an averaging period of between twenty and sixty business days, provided the choice was announced no earlier than seven months and no later than three months before the start of the period.[36]

Implications for revenues from forecasting errors

Table 2 presents a simple illustration of the hypothetical revenue impact from large forecasting errors for both SAW RD13 and SAW RD16. The revenue impacts presented are calculated as the difference between the revenue that was set and that which might have occurred under various averaging periods for the risk free rate (both short- and long-term), holding all other inputs constant in line with those at the time of the regulatory determinations.

The results indicate that if the ten-year approach were applied, customers as a whole would have paid a cumulative total of around $560 million over the two regulatory periods more than under the twenty-day averaging approach. In contrast, there are only relatively small differences in the revenue impacts from the use of the other shorter-term approaches. It should be noted that if the hypothetical scenario was undertaken during a period of a persistent upward trend in yields on CGS there would likely be an under recovery of revenue.

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35 See QCA, p.3.

36 See AER (2018), 'Rate of return instrument: explanatory statement', December 2018, p. 125, available at: https://www.aer.gov.au/system/files/Rate%20of%20Return%20Instrument%20-%20Explanatory%20Statement.pdf. The AER requires the nominated averaging period to be contained in the initial proposal by the regulated business.

Table 2: Hypothetical estimated revenue impacts under each approach in SAW RD13 and SAW RD16

	Revenue impact (NPV difference), $m	
	SAW RD13	SAW RD16
On the day	-29	-1
5 day average	-17	8
60 day average	35	-0.3
10 year average	352	211

Assessment

The research in this Guidance Paper was undertaken in order for the Commission to better understand which averaging period might produce the lowest forecasting errors, and therefore be consistent with the Commission's aim to deliver the lowest sustainable cost of drinking water and sewerage services.

The research, while having a number of limitations, shows that the use of a ten-year average for SAW RD20 is likely to produce much larger forecasting errors than the use of a short-term approach. In part, this reflects the structural decline in yields since 2009 caused by a decline in the economy's growth potential and the increase in risk aversion of households and firms. The Commission, therefore, remains supportive of the twenty-day averaging period for the risk free rate, used for the purposes of calculating the cost of equity.

An important but secondary finding is that there appears to be limited difference in forecasting accuracy between alternative short-term approaches. Accordingly, the Commission is open to the use of an approach similar to that used by the AER, where the regulated entity can choose an averaging period somewhere between twenty and sixty days, and must do so no later than three months before the start of the regulatory period.

Annual resets of the regulatory rate of return could potentially be a mechanism to help to mitigate forecasting risk for the risk free rate.

Appendix A: The Commission's rate of return principles

General principle: The rate of return should reflect the prudent and efficient financing strategy of an incumbent large water utility, which minimises expected costs in the long term, on a risk-adjusted basis.

Supporting principle 1: The rate of return should reflect a long-term obligation on the utility to provide reliable and secure water and sewerage services to consumers. It should not solely reflect the new entrant cost of capital.

Supporting principle 2: The rate of return should provide an incentive for SA Water to incur prudent and efficient investment in regulated assets and financing costs.

Supporting principle 3: The approach to setting the regulatory rate of return should be based on consistent principles over time and should be predictable. It should change only to reflect material changes in evidence or regulatory practice.

Supporting principle 4: The assumed prudent financing strategy should not depend on the ownership of the regulated business (that is, the approach is indifferent to whether the entity is in Government or private ownership).

Appendix B

This appendix presents some tests that were used to complement those presented in this paper. [37]

Root Mean Square Error (RMSE)

RMSE is the standard deviation of the residuals (prediction errors). It tells you how concentrated the data is around the line of best fit. RMSE is commonly used in forecasting analysis to verify results. The closer the RMSE is to zero the better the estimate was to the actual.

Table 3: RMSE values 2005 to 2018 (1 to 4 year horizon), ppt

Forecasting approach	1 year ahead	2 years ahead	3 years ahead	4 years ahead
On the day	0.81	1.00	1.07	1.31
5 day average	0.81	1.00	1.07	1.32
20 day average	0.81	1.00	1.07	1.32
60 day average	0.83	1.00	1.08	1.34
10 year average	1.51	1.51	1.71	1.94

The table above demonstrates there is a clear difference between the ten-year averaging approach and the shorter-term approaches.

Due to the full sample period having an apparent downward trend, the ten-year average has the least amount of accuracy. This demonstrates the expected bias that would be built into any forecast derived using a ten-year average.

Table 4 shows RMSE during the period 2005-2012, which saw a relatively flat period of interest rates. During this period, the ten-year approach continues to produce the largest errors (though the difference between short-term and long-term approaches is smaller than was evident in the full sample).

Table 4: RMSE values 2005 to 2012 (1 to 4 year horizon), ppt

Forecasting approach	1 year ahead	2 years ahead	3 years ahead	4 years ahead
On the day	0.90	1.03	0.96	1.14
5 day average	0.90	1.03	0.96	1.14
20 day average	0.91	1.03	0.96	1.15
60 day average	0.92	1.02	0.95	1.17
10 year average	1.05	1.05	1.14	1.33

[37] Due to the nature of the approach used, there is likely to be autocorrelation bias in the statistical results. Although this is likely not a major issue (as it is expected to be a consistent bias across all estimates), it may be most impactful on the Diebold Mariano test of statistical significance. The need for adjustment for autocorrelation was tested using a Newey West adjustment; however, the adjustment indicated that it would likely not change the Diebold Mariano results in a material way.

Table 5: RMSE by rankings (1 being most accurate, 5 being least accurate)

Forecasting approach	1 year ahead	2 years ahead	3 years ahead	4 years ahead
2005 - 2018				
On the day	1	2	2	1
5 day average	2	1	1	2
20 day average	3	4	3	3
60 day average	4	3	4	4
10 year average	5	5	5	5
2005 - 2012				
On the day	1	4	4	1
5 day average	2	3	3	2
20 day average	3	2	2	3
60 day average	4	1	1	4
10 year average	5	5	5	5

Mean Absolute Error (MAE)

MAE measures the average magnitude of errors in a set of predictions, without considering whether it is a positive or negative error (plus or minus from the actual). It is calculated as the average over the test sample of the absolute differences between prediction and actual observation where all individual differences have equal weight. This explains why we see the MAE results having smaller errors than the RMSE. The closer MAE is to zero the better the forecast.

Table 6: MAE values 2005 to 2018 (1 to 4 year horizon), ppt

Forecasting approach	1 year ahead	2 years ahead	3 years ahead	4 years ahead
On the day	0.62	0.80	0.86	1.06
5 day average	0.62	0.79	0.85	1.06
20 day average	0.62	0.79	0.86	1.06
60 day average	0.63	0.77	0.87	1.07
10 year average	1.27	1.27	1.46	1.71

The results of MAE calculations are generally the same as those indicated by RMSE. The ten-year approach produces the largest errors, while shorter-term averaging periods have generally similar outcomes. Testing of the 2005-2012 sample period shows that the difference between the ten-year approach and other shorter-term averaging periods narrows; however, the ten-year average approach still has the largest errors. It should be noted that the errors are much smaller during this period due to the relative flatness in the rates.

Table 7: MAE values 2005 to 2012 (1 to 4 year horizon), ppt

Forecasting approach	1 year ahead	2 years ahead	3 years ahead	4 years ahead
On the day	0.68	0.82	0.73	0.81
5 day average	0.68	0.82	0.73	0.81
20 day average	0.69	0.82	0.73	0.81
60 day average	0.70	0.80	0.73	0.81
10 year average	0.76	0.76	0.82	1.01

Mean Absolute Percentage Error (MAPE)

The MAPE sets out the expected deviation from the actual in percentage terms. That is, the calculation sets out the distribution of the error around the actuals.

Table 8: MAPE values 2005 to 2018 (1 to 4 year horizon), per cent

Forecasting approach	1 year ahead	2 years ahead	3 years ahead	4 years ahead
On the day	17	23	25	32
5 day average	17	23	25	32
20 day average	17	23	25	32
60 day average	17	22	25	33
10 year average	41	41	49	58

The results demonstrate that the ten-year approach has the largest distribution of errors around the actuals, while the shorter averaging periods have much smaller distributions.

Table 9: MAPE values 2005 to 2012 (1 to 4 year horizon), per cent

Forecasting approach	1 year ahead	2 years ahead	3 years ahead	4 years ahead
On the day	15	19	17	19
5 day average	15	19	17	19
20 day average	16	19	17	20
60 day average	16	18	17	20
10 year average	19	19	21	26

Diebold Mariano (DM) test

The DM test assesses whether there is a statistical difference between forecasts. In effect, it tests if forecast errors from are statistically different from each other.[38] The p-value indicates whether or not we should reject or accept the hypothesis. A statistically significant difference in forecast errors would indicate whether we could be confident that a certain approach would provide less forecast error than the other approaches.

Table 10: DM test, 20 day average compared with 10 year average

	1 year ahead	2 years ahead	3 years ahead	4 years ahead
2005-2018				
p-value[39]	0.000***	0.000***	0.000***	0.000***
n=	2612	1789	1595	1437
2005-2012				
p-value	0.285	0.516	0.018***	0.911
n=	1395	886	714	567

Based on the test sample (2005 to 2018), there is a statistically significant difference in forecast errors from a ten-year average and a twenty-day average across all time horizons (one to four years) (Table 1). The results become less conclusive when the sample is divided into two periods: 2005-2012 and 2012-2018. Between 2005 and 2012, there is no statistically significant difference across the approaches, while after 2012 there is a statistically significant difference.

38 Put another way, the DM test can be thought of as a regression of the difference in the squared forecast errors (of two approaches) on a constant value. The hypothesis is that the constant is zero.

39 *** Indicates the results are statistically significant at the 5 percent level.