Adelaide Aqua Pty Ltd - Australia

Water For Fodder 2020

Adelaide Desalination Plant Operations

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1 Introduction

In the recent climate events, the ongoing rainfall deficiencies have rendered intense drought conditions across Australia. As seen in figure 1, the reported the total average rainfall across the country in 2019-20 was 24% below average, the sixth driest on record according to the bureau of meteorology. Water storage levels across the basin have reduced to as low as 20% and much lower in the northern region. The significance of water level is critical as the Murray-Darling basin sustains 40% of Australia's agricultural food supplies and harbors a diverse array of ecosystems. In response to this, the state governments established a program in 2019, *Water for Fodder* to produce and supply water through desalination equivalent to the quantity released upstream of Murray River. This provision is then allocated to farmers and irrigators in the southern region of Murray-Darling basin at a discounted rate.

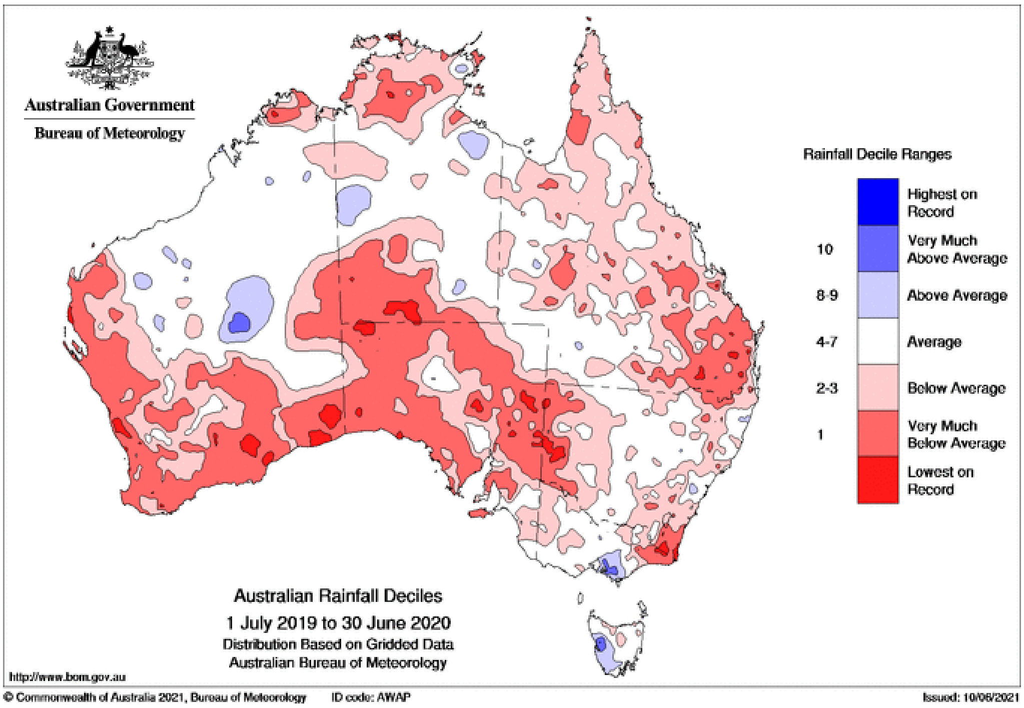

Figure 1: Average rainfall across Australia between 1st July 2019 to 30th June 2020.

It was September 2007 when the planning and construction of the Adelaide Desalination Plant (ADP) was announced. The initial design was completed in February 2009 and was designated produce 50 Gigalitres per annum (GL). Soon after, the state government provided further funding as part of the *Water for the Future* initiative to double the capacity and later commissioned in July 2012 with a total throughput of 100GL. As seen in figure 2, ADP presents a strategic location to be the only Desalination plant that falls within the southern west region of the basin. Therefore, it was dedicated under the *Water for Fodder* program to supply water to aid farmers and irrigators within the Murray-Darling basin.

Figure 2: Geographic highlight of the Murray-Darling Basin.

2 Operations History

The Adelaide desalination plant was built in response of drought to provide a reliable source of water that is independent of climate conditions. As seen in *figure 3* below. The monthly production profile between the year 2013 up to 2020 were distinct. The primary factors determining production are based on the state water shortages, demand, and emergencies. In addition to the state's reservoirs, stormwater and the River Murray, the Adelaide Desalination Plant serves as a reliable source of back-up, but at a cost. Given that desalination is an energy intensive process, the average cost is approximately 10 times more expensive than conventional water treatment processes.

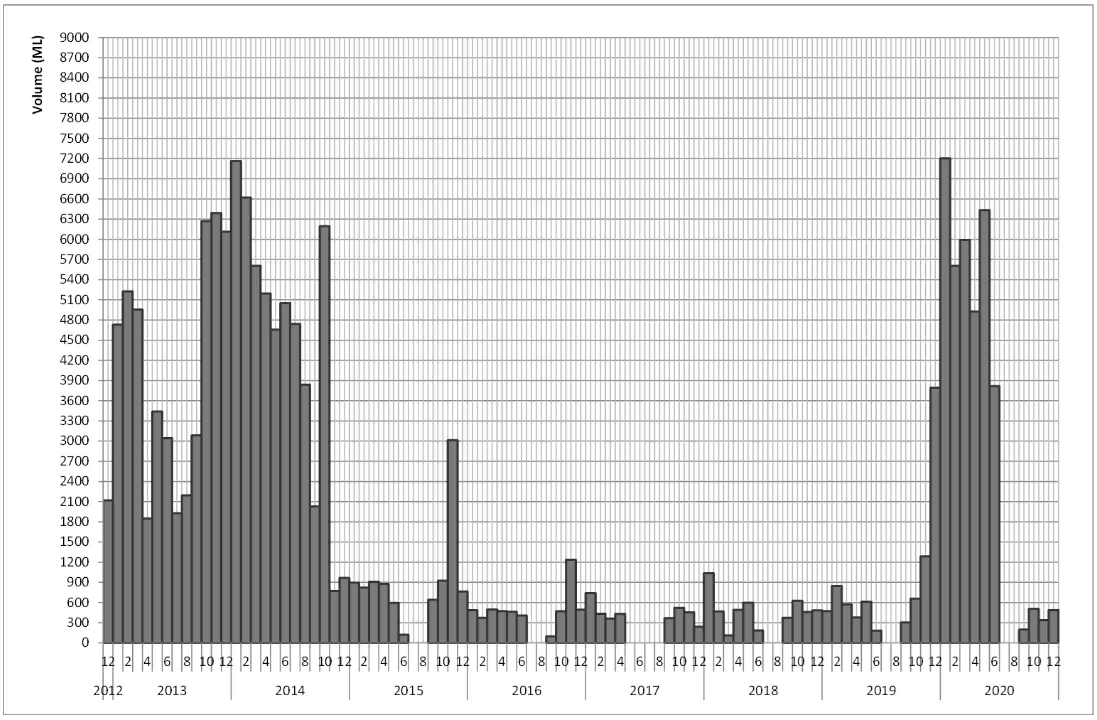

Figure 3: Monthly production profile between 2012 to 2020.

Referring to *figure 3*, the plant was in low production mode (at 5% of full capacity) from 2015 up to 2019 in accordance with SA-water weekly demand. Narrowing down to 2019-20, the production profile was ramped up in this period to full capacity to deliver 40GL under the Water for Fodder Initiative. There are many factors to consider in order to lift the plant back into full capacity. This includes chemical availability, modifications of process parameters and drinking water quality which will further be discussed in section 3.

3 Water for Fodder Production – Restart Process

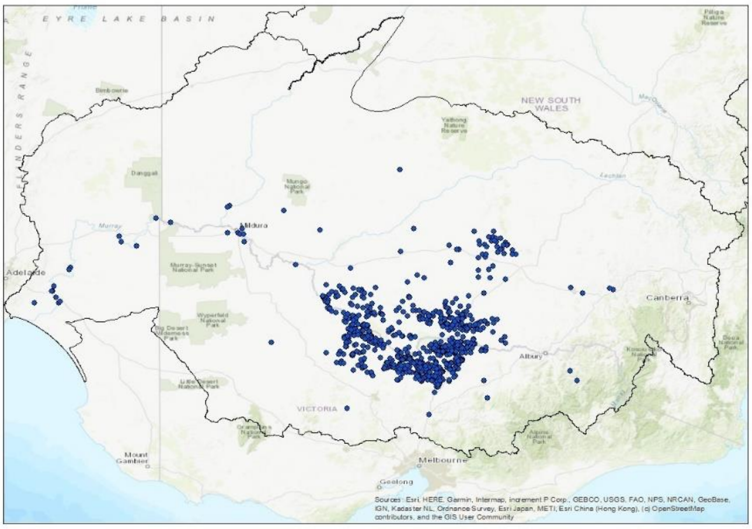

Figure 4: Allocated water provisions in the Murray-Darling Basin

In the 2019-20, the Adelaide desalination plant has successfully produced and transferred 40GL of water into the accounts of farmers located within the southern region of the basin as seen in *figure 4* above. As the year progressed, the drought conditions have reduced due to improved rainfall in Autumn. While round 1 was successful, water is more readily available in the basin due to the autumn rainfall. This has significantly reduced the need for remaining 60GL initially allocated in round 2 of the program. Therefore, the program will not proceed, and the remaining funding was redirected to other programs that benefit the farmers and communities in the Murray-Darling Basin.

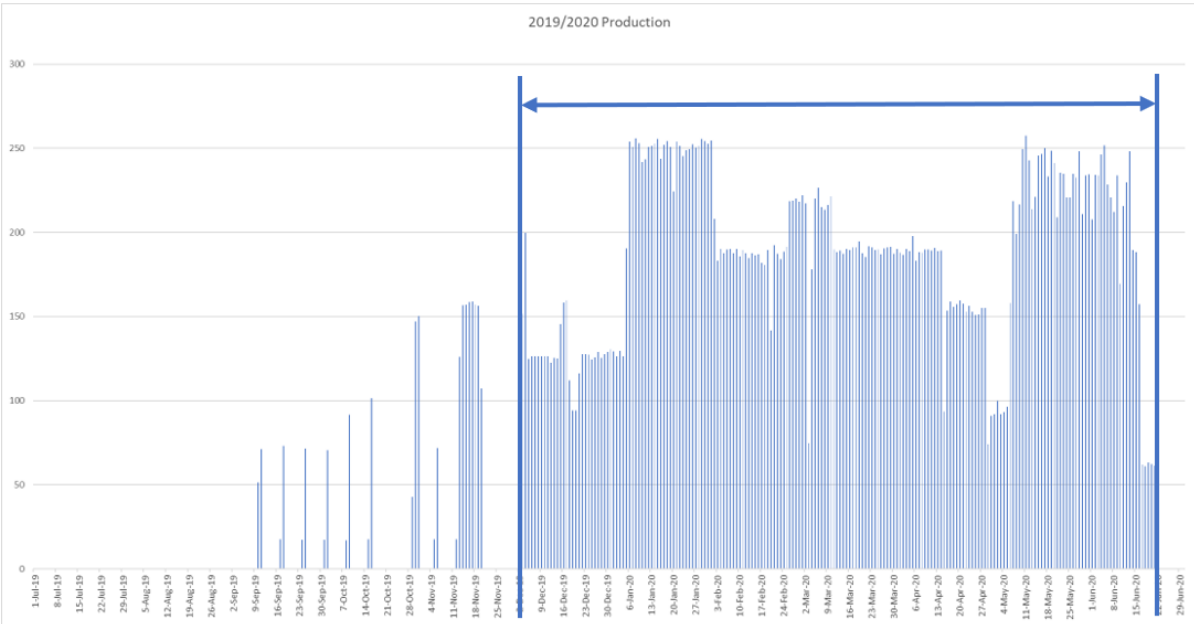

Figure 5: Weekly production profile of year 2019-20

During round 1 of the program, the 40GL were produced over the course of 7 months between December 2019 and June 2020. Referring to the figure above, plant production was ramped up over this period at an average of 195 Mega Litres per day (MLD) and a daily maximum of 257 MLD in compliance with SA Water's production plan. The following section will discuss the changes in operations that are specifically tailored to accommodate the high production profile during this period.

3.1 Pre-Treatment

The ADP uses ultrafiltration as a pre-treatment prior to reverse osmosis. As observed in *Figure 6* below. The ultrafiltration cells experienced an increase in resistance over this period. To accommodate the production, we have implemented backwash and chemical cleaning regime tailored to high flow production cycle during this period.

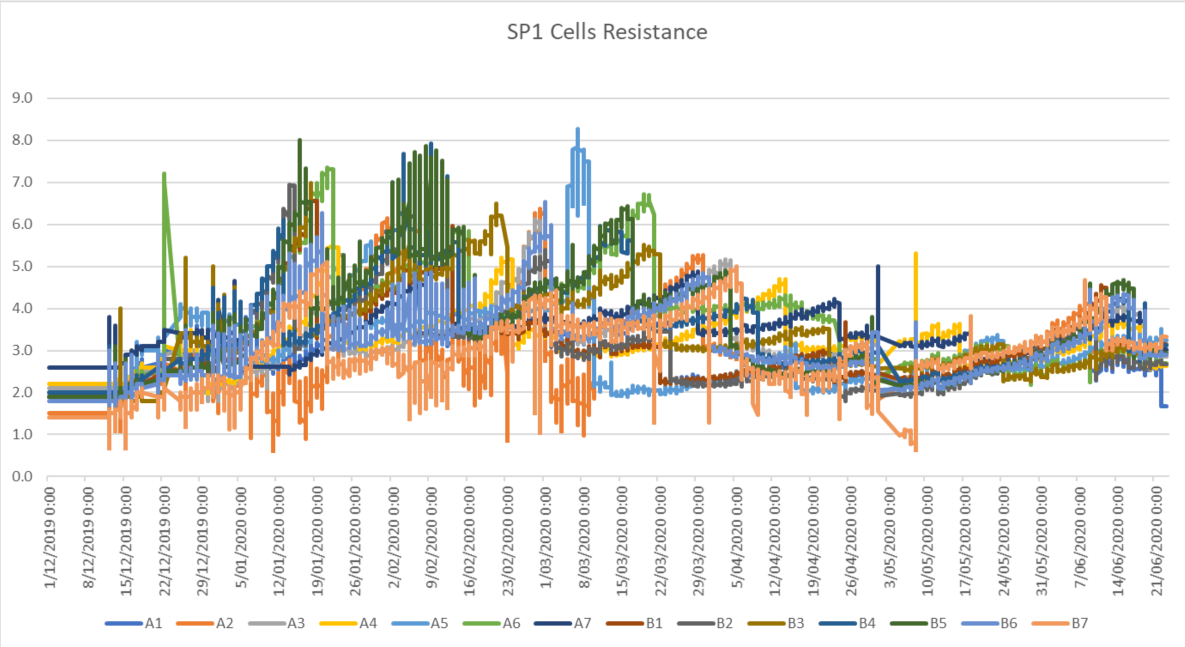

Figure 7 : SP1 (Separable portion 1) Ultrafiltration cell Resistance.

Table 1: Operational setpoint changes during 2019-20

Parameter	Normal Setpoint	High Flow Setpoint
Transmembrane pressure	75 kPa	70 kPa
Volume produced	4000 m^3	2500 m^3

The reduction of these setpoints in *Table 1* increases the frequency of backwash to prevent excessive build-up of silt and lowers the average transmembrane pressure across all cells.

Table 2: Chemical treatment activation setpoints

Process	Chemical Type	Volume produced
Maintenance Clean (MW)	Acid	150 MLD
	Hypo	300 MLD
Clean in Place (CIP)	Acid + Hypo	500 MLD

The chemical treatment processes involve *sulphuric acid*, *citric acid* and *sodium hypochlorite* The original parameter that triggers the chemical washes were based on the volume of water filtered. Instead, we have modified the chemical treatment activation based on resistance regardless of volume filtered. Referring *figure 6*, we activate the type of wash process based on the sharpness of the slope. if the slope is sharp and exceeds 7, a chemical clean is required otherwise a backwash will be triggered.

The resistance of the cell is based on this formula below where the difference in mechanical and osmotic pressure per unit of membrane flux:

$$R_m = \frac{\Delta P - \Delta J}{J_w}$$

Where,

$$Resistance = R_m$$

$$Differential\ Pressure = \Delta P$$

$$Osmotic\ Differential\ pressure = \Delta J$$

$$FLux = J_w$$

There were several parameters that were carefully adjusted to ensure optimal cleaning during the chemical treatment process such as:

- The pH, maintained between 2 – 2.5
- Chlorine concentration between 150 – 300 ppm
- The frequency and duration of chemical circulation and soak

3.2 Reverse Osmosis

The system uses a double pass configuration where the injection of *Sodium Hydroxide* occurs. As ADP became the primary supplier of water during this period, the boron concentration limit was reduced from 0.7 to 0.5. In conjunction with high production and higher seawater temperature due to summer, boron levels became a critical parameter to monitor. In this scenario, we have adjusted the concentration of Sodium Hydroxide injection to ensure sufficient boron rejection. Referring to *figure 8*, we have remained compliant to boron limit set out by the Australian Water Quality Centre throughout the span of the 40GL transfer.

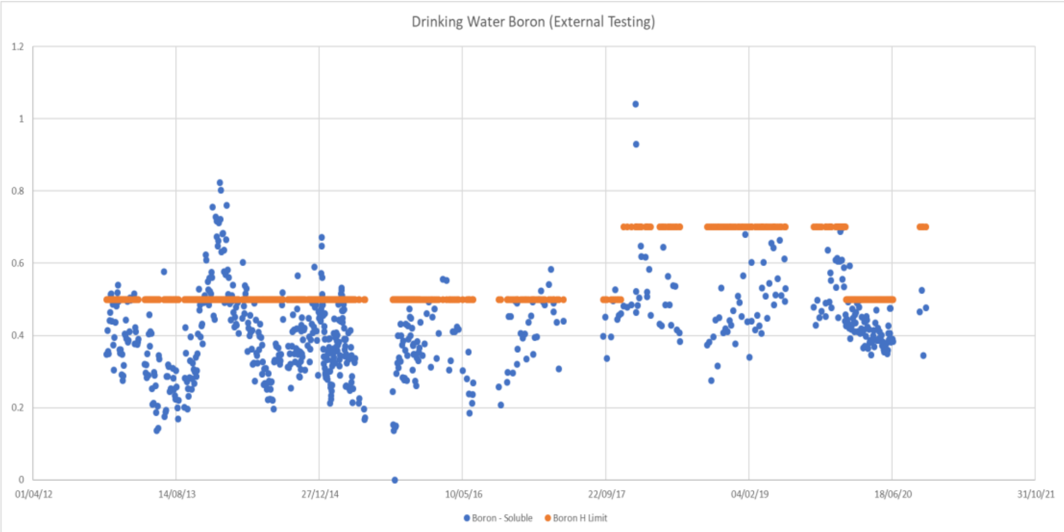

Figure 8: External analysis of Boron in treated water with reference to concentration limit.

Up to the period of WFF, the RO membranes commissioned in ADP were approximately 9 years to date. To ensure consistent membrane performance at a high level. Together with normal flushing, we implemented additional chemical flushes with *Sodium bisulfide* in the first pass and *Citric Acid* through the *second pass* membranes. In brief, these chemical flushing to maintain membrane integrity and prevents biofouling during extended runs. The following are the setpoints that were adjusted accordingly to trigger the type of flushing.

Table 3: Flushing activation setpoints

Parameter	Setpoint	Type of Flushing
First Pass differential Pressure	>1.2	Normal Process Water
	>1.3	Reverse Process Water
	>1.35	Sodium Bisulfite
Second Pass Rear Feed Pressure	>16 bar	Citric Acid

To manage membrane scaling, we also modified the concentration of *Antiscalant* dosing in the second pass rear units. By monitoring the feed pressure of the rack, we increased *Antiscalant dosing* while *stopping sodium hydroxide* dosing.

Parameter	Trigger Setpoint
Rack Feed Pump Speed	>95%
Rack Feed Pressure	>16.5 bar

3.3 Chemical Availability

High production profile at a continuous extended period requires a steady supply of chemicals. In the post treatment process, chemicals such as Hydrofluorosilisic Acid and Chlorine are used for fluoridation and disinfection. As for remineralisation, it is an essential part of post treatment where calcium ions are incorporated into the treated water to account for hardness. The compounds used for this process involve injection of carbon dioxide followed by lime dosing in the form of calcium hydroxide. Desalination of sea water is heavily dependent on the availability of these chemicals. Therefore, it is vital to ensure the forecast of usage and the logistics are well planned according to production. However, events such as shortages are inevitable and difficult to predict. Thus, the CO_2 shortage across Australia in 2020 has forced us to source from overseas at a cost. To control the consumption of CO_2 in a discerning manner, the alkalinity target (as $CaCo_3$) was reduced from 70 to 50mg/L whilst maintaining compliancy with the Australian Drinking Water Quality Centre.

4 Conclusion

In summary, the changes made during the WFF period in terms of operation and drinking water compliance are as followed:

- Implemented tailored chemical cleaning regime in Ultrafiltration.
- Implemented tailored flushing regime in Reverse Osmosis.
- Increased backwash frequency in UF unit.
- Reduction of Boron concentration limit from 0.7 to 0.5 mg/L.
- Reduction of Alkalinity Limit as $CaCo_3$ was reduced from 70 to50 mg/L.

The Water for Fodder program has proven that desalination is an essential process especially in events of severe drought. Given that the ADP were able to steadily produce the necessary water required, it plays a key role in sustaining the needs of the state regardless of climate situations and emergency events.