

# Summary of Technical Analysis

2017/18 Desalinated Water Order Advice



May 2017



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# Summary of Technical Analysis

## PURPOSE

1. This report summarises the technical analysis supporting the 2017/18 desalinated water order advice provided by Melbourne Water to the Department of Environment, Land, Water and Planning (DELWP). The intent is to summarise the key aspects of the context, process and findings of the technical analysis undertaken to support the 2017 desalinated water order advice.

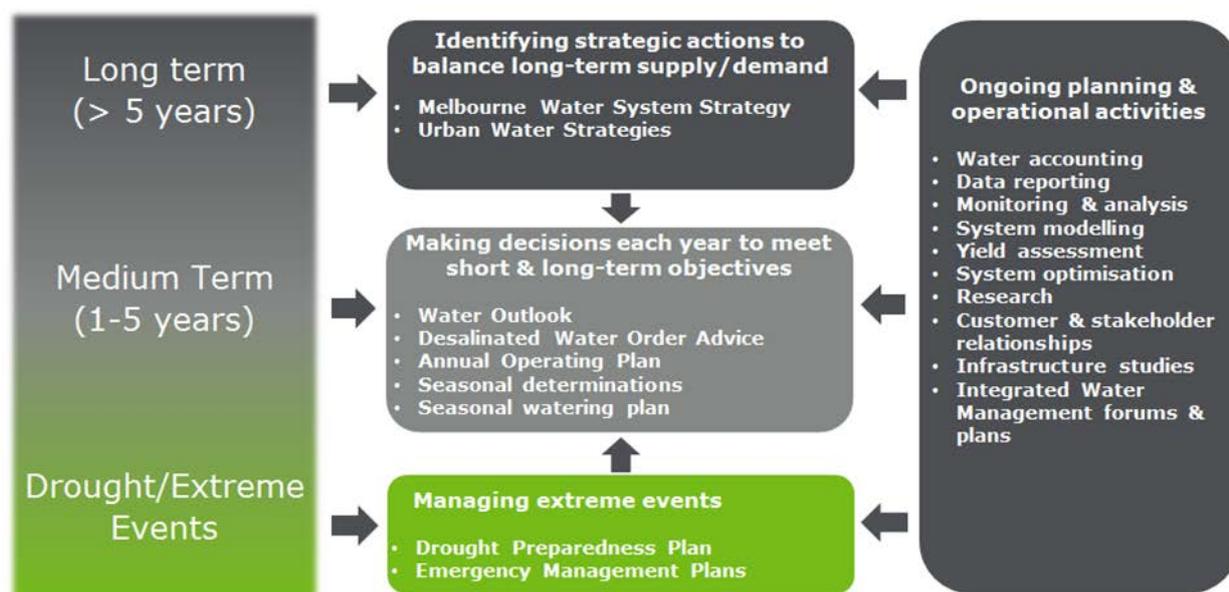
## BACKGROUND

2. The Melbourne water supply system harvests streamflows from 156,700 hectares of forested catchments which are stored and transferred via a network of 10 reservoirs to over four million people in the Melbourne and surrounding region. The total system storage capacity of 1,812 gigalitres is more than four times Melbourne's current annual demand. The system is operated to keep a buffer of water in storage, subject to pricing impacts, for maintaining supply throughout future severe droughts which could last for more than a decade, and to manage other extreme events like bushfires. Thomson Reservoir, providing 60% of total system storage capacity, is Melbourne's drought reserve and was last full in 1996. A number of projects to secure water supplies were initiated during the 1997-2009 Millennium Drought, including the Victorian Desalination Plant (VDP). The VDP was completed in 2012 and is connected by an 84-kilometre underground transfer pipeline to Cardinia Reservoir in the Melbourne system.
3. The State is required to place a desalinated water order with Aquasure by 1 April each year under the *Project Deed* between the two parties. Prior to this, the *Water Interface Agreement* between the Minister for Water, Melbourne Water and the Secretary of the Department of Environment, Land, Water and Planning (DELWP), requires Melbourne Water to provide to the State (represented by DELWP) each year:
  - a) Its opinion of the volume of desalinated water required for the next financial year (*i.e.* 2017/18)
  - b) Its opinion of the constrained months (if any)<sup>1</sup> that it considers should be subject to a constrained month cap and the proposed volume of such caps
  - c) A non-binding forecast of the quantity of desalinated water required for the subsequent two financial years (*i.e.* 2018/19 and 2019/20).

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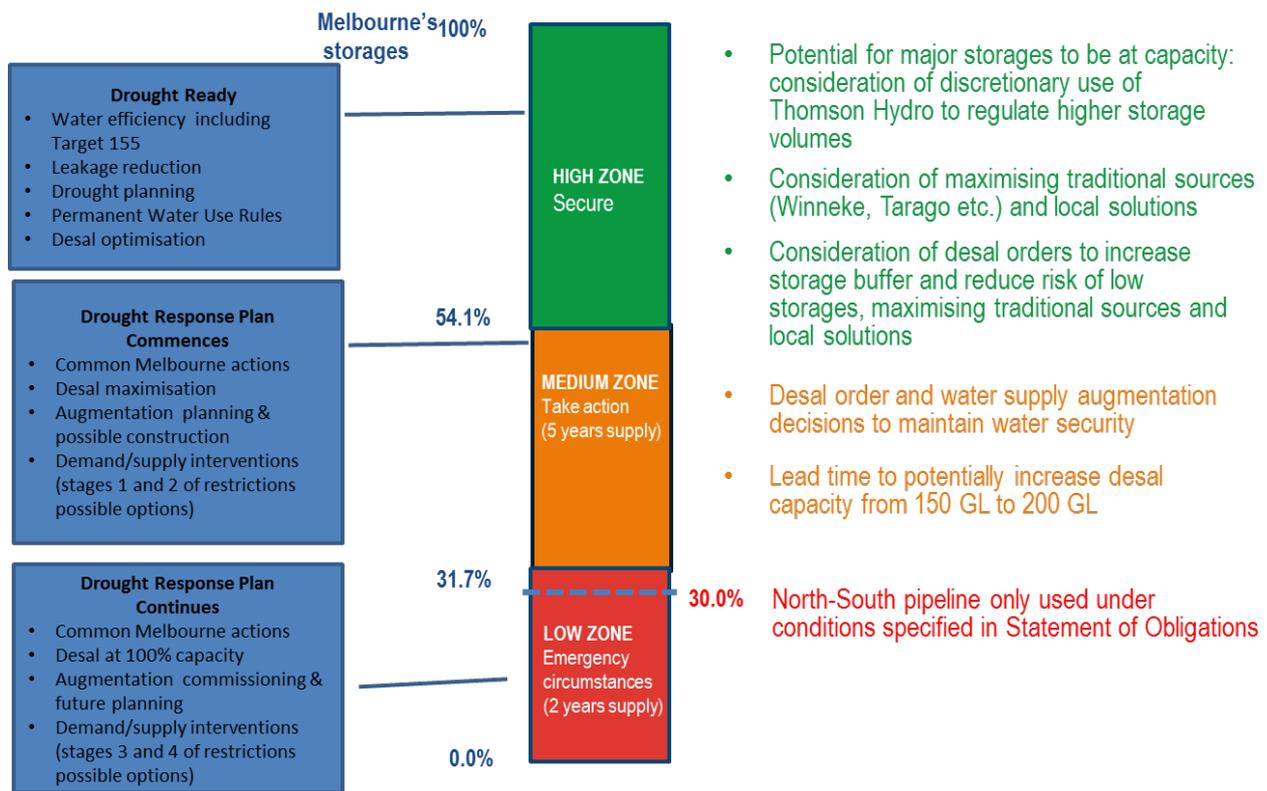
<sup>1</sup> Subject to conditions specified in the Project Deed, the State may specify the maximum total volume of desalinated water which can be delivered (*i.e.* a constrained month cap) during the months of August, September, October and November

4. Melbourne Water works with the Melbourne Retail Water Corporations (City West Water, South East Water, Yarra Valley Water) and DELWP to coordinate the process of consultation and undertakes the technical analysis required to support the development of the 2017/18 desalinated water order advice. This advice is one component of supporting long and short term water planning for the Melbourne system. The preparation of the advice follows from the publication of the *Water Outlook for Melbourne* by the metropolitan water corporations on 1 December each year. The various elements in managing Melbourne’s water security, ranging from drought events to long term planning are shown in Figure 1.



**Figure 1: Melbourne water security planning context**

5. The Retail Water Corporations’ *Drought Response Plans* (DRP) incorporate a three zone adaptive framework based on the volume of water in Melbourne’s storages, as shown in Figure 2 below. Notable features of the framework are:
- Proactive management of storages for possible future severe drought events when storage levels are in the High Zone including ensuring water is used efficiently and drought response measures are identified.
  - When storages are in the Medium Zone actions are taken to ensure at least 5 years of supply is available even under severe drought conditions. Stages 1 and 2 of the Retailers’ water restrictions by-laws may also be used in this zone.
  - Ensuring water storages do not enter the Low Zone except in extreme circumstances. Stages 3 and 4 of the Retailers’ water restriction by-laws are available to be used in such a severe event.
  - Ordering water from the Victorian Desalination Plant (VDP) is an option in all three zones however the amount taken is determined through detailed analysis that considers and balances the 5 principles and other factors (discussed below).



**Figure 2: Melbourne's adaptive water security framework**  
(storage volumes assessed at 30 November each year)

## PRINCIPLES

- Consistent with the approach established by the water corporations and used in previous years, the 2017/18 desalinated water order advice is based around five principles. These were developed by the water corporations to balance the benefits of using the VDP in maintaining the short and long term security of supply to customers against the costs of placing an order and the potential for spill/foregone water harvest from the system. The advice is based on the water corporations assessing a balance across these principles as it is not possible to completely satisfy all of them simultaneously throughout the three year advice period. The advice is prepared recognising that while the first year order is binding, the opportunity to revisit the volume required in each of the second and third years, as part of the annual planning and ordering cycle, allows adaptation based on the storage levels and outlooks at the time.
- Principles 1, 2 and 3 can be considered to be security principles which may be met by ordering desalinated water, while Principles 4 and 5 may be better met by minimising desalinated water orders in wetter years or when storage levels are higher. Principle 3 is considered in the context of the current total system storage, noting it has been in the High Zone since water restrictions were lifted in Melbourne in December 2012. Increased reservoir spills when storages are at capacity are considered a disbenefit to

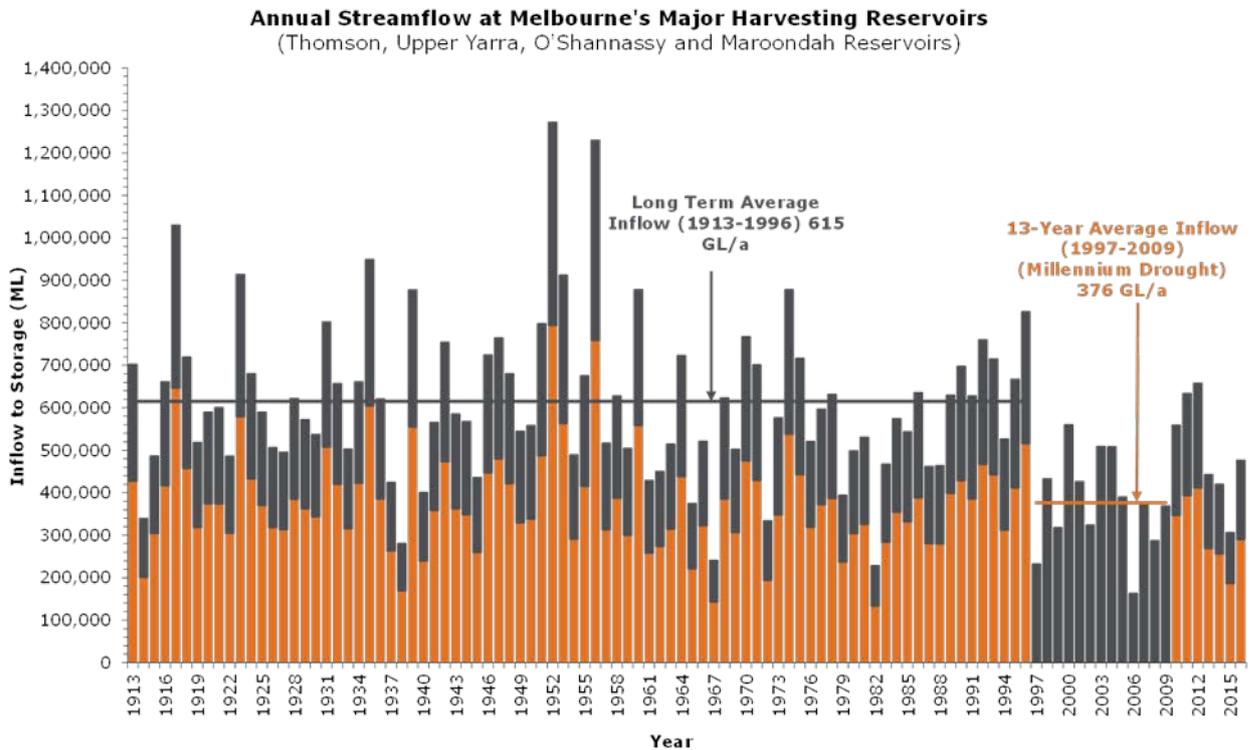
consumptive users under Principle 4 but they may also provide potential environmental benefits for downstream waterways.

- **Principle 1: Risk of storage level falling below the Low Zone Action Point** - *Storages should remain above the Low Zone described in the Retailers' Drought Response Plans on 30 November 2017, 30 November 2018 and 30 November 2019 under a severe drought sequence.*
  - **Principle 2: Risk of storage level falling below the Medium Zone Action Point** - *Storages should remain above the Medium Zone described in the Retailers' Drought Response Plans on 30 November 2017, 30 November 2018 and 30 November 2019 under 90 per cent of modelled streamflow sequences from the 'Return to Dry Conditions' streamflow scenario (based on the 1997 to 2009 period as described below in the Technical Analysis Background section).*
  - **Principle 3: Storage Recovery** - *Storages should display a "recovery" trend such that total system storage levels are increasing for the median (50 percentile) of the possible streamflow sequences tested.*
  - **Principle 4: Risk of desalinated water causing avoidable foregone harvest** - *The Desalinated Water Order Advice should not induce an unacceptable risk of significant additional foregone harvest. "Foregone harvest" is the modelled additional spills from the Melbourne water supply system and/or reduced harvest into Sugarloaf Reservoir for each scenario due to the desalinated water order volumes supplied. The following benchmarks are used for assessment in applying this principle and are based on detailed modelling of the Melbourne water supply system. There should be a less than 50% chance of foregoing an additional 12.5 gigalitres (GL)/year and a less than 10% chance of foregoing 25 GL/year. Some of Melbourne's smaller storages may spill harvested water in most years even without the VDP operating.*
  - **Principle 5: Customer impacts** - *The impacts on the Retailers' customers' bills should be minimised while providing an acceptable security of supply.*
8. Potential desalinated water order pathways were assessed against the five principles using detailed water supply system modelling, and considered factors including:
- Current and possible future system storage levels under a range of streamflow scenarios including drought and high streamflow periods based on the observed record from 1913 to 2016.
  - Forecast demand provided by the Retail and Regional Water Corporations
  - Bureau of Meteorology (BoM) outlooks
  - Water supply system operational considerations
  - The ability to annually review desalinated water orders to manage inherent uncertainty in longer term forecasts
  - The current water storage levels and past trends

- Potential extreme events, and other relevant information.
9. The 2017/18 desalinated water order advice has been prepared consistent with the approach, key assumptions and assessment principles used in previous years. Melbourne Water and the Retail Water Corporations will subsequently undertake and complete a review of these assumptions and principles before next year's advice. The review will include consideration of the Retailers' new *Drought Preparedness Plans* following their five yearly review, revised minimum annual desalinated water order volumes, and the streamflow scenarios outlined in DELWP's recently released *Guidelines for Assessing the Impact of Climate Change on Water Supplies in Victoria*.

## TECHNICAL ANALYSIS BACKGROUND

10. The analysis was supported by modelling with storage inflows based on the 'Return to Dry Conditions' scenario described in the *Guidelines for the Development of a Water Supply Demand Strategy (2011)* prepared by the former Department of Sustainability and Environment. The use of the 'Return to Dry' streamflow is conservative compared to the full historical record but representative of streamflows observed in the past 20 years and provides for more severe drought scenarios than have occurred historically. The 'Return to Dry Conditions' scenario was used again this year (rather than newer streamflow scenarios outlined in DELWP's recently released guidelines) because it was also used to derive other key elements of the current desalinated water order advice process such as the principles and Water Security Framework zones described above.
11. The 'Return to Dry Conditions' streamflow scenario uses the observed streamflows for the 1997 to 2009 period with the observed streamflows from 1913 to 1996 and 2010 to 2016 adjusted to the average of 1997 to 2009 period (as specified by the Department's *Guidelines for the Development of a Water Supply Demand Strategy*). The difference between the observed streamflows (grey bars) and the 'Return to Dry' streamflows (orange bars) is illustrated in Figure 3 below.



12. As noted above, the technical analysis supporting the 2017/18 desalinated water order advice also took account of a number of factors including water demand, climatic conditions, and the current 2017 water resources context. These included:

- Total system storage on 1 March 2017 was 1,217 GL (67.2%), compared to 1,164 GL (64.2%) at the same time last year – an increase of 53 GL following a decline of 164 GL (9.1%) over the preceding 12 months.
- Aquasure plan to deliver the 2016/17 desalinated water order of 50 GL across the March - June 2017 period.
- As of 20 March 2017 total system storage was 1,187 GL (65.5%), with details of each storage in Table 1.

**Table 1: Water supply storages as at 20 March 2017**

Reservoir	Capacity at Full Supply (ML)	Volume (ML)	% Full
<b>Thomson</b>	1,068,000	708,115	66.3%
<b>Upper Yarra</b>	200,579	97,413	48.6%
<b>O'Shannassy</b>	3,123	1,994	63.8%
<b>Maroondah</b>	22,179	12,599	56.8%
<b>Sugarloaf</b>	96,253	79,833	82.9%
<b>Yan Yean</b>	30,266	26,131	86.3%
<b>Greenvale</b>	26,839	23,966	89.3%
<b>Silvan</b>	40,445	35,033	86.6%
<b>Cardinia</b>	286,911	168,384	58.7%
<b>Tarago</b>	37,580	33,585	89.4%
<b>Total</b>	<b>1,812,175</b>	<b>1,187,053</b>	<b>65.5%</b>

- On 1 March 2017 Thomson Reservoir, the largest storage in the Melbourne system and the main drought reserve for Melbourne and surrounding areas was 728 GL (68.2%), compared to 678 GL (63.4%) at the same time last year and 824 GL (77.2%) on 1 March 2015.
- As of 20 March 2017 Thomson was at 66.3% of capacity. The last time Thomson Reservoir was near capacity was over twenty years ago on 10 November 1996.
- Demand forecasts were provided by the Retailers and Regional Urban Water Corporations connected to the Melbourne water supply system and amounted to:

<b>2017/18:</b> 418 GL	<b>2018/19:</b> 421 GL	<b>2019/20:</b> 424 GL
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- Permanent water use rules and the Target 155 efficiency program are in place.
- The Thomson environmental entitlement of 18 GL from July 2016 is included in the modelling. This includes the additional entitlement of 8 GL committed to by the State Government in the *Gippsland Region Sustainable Water Strategy (2011)*.

13. The analysis by the water corporations took into account operational factors which could affect the ability to satisfy the principles when determining the appropriate volume of desalinated water. The main factors were:

- **2016/17 VDP supply:** The analysis includes the supply of the Government's 2016/17 order of 50 GL of desalinated water which is due to be delivered by 30 June 2017.
- **Cardinia transfer operations:** Cardinia Reservoir currently supplies an annual demand of approximately 100 GL. This water has historically been sourced from the Thomson and Upper Yarra systems via Silvan Reservoir and can now be supplemented with water from the Victorian Desalination Plant. Cardinia Reservoir levels must be managed to integrate these water sources.
- **Cardinia dam management:** Maximum limits are currently in place at Cardinia (287 GL theoretical maximum capacity) consistent with dam management guidelines until planned embankment improvement works are carried out in 2021/22. The technical analysis took into account a 2.0m maximum height restriction (263 GL effective capacity). Given the current storage level at Cardinia is well below this, it does not influence the 2017/18 Water Order Advice.
- **Upper Yarra dam management:** Upper Yarra Reservoir is currently operating without restriction, however embankment improvement works to address dam management guidelines are planned to take place in 2018/19, when the reservoir will be drawn down to enable these works to occur. The operational management is planned to commence in mid-2018, with the works to be completed over the summer of 2018/19. Depending on streamflow and storage conditions leading up to these works, this may result in additional water being transferred to Cardinia Reservoir. The management of Upper Yarra dam has been considered in modelling and development of the water order advice.

14. Other key assumptions used to model the system were consistent with those in previous years and included:

- No net drawdown of Southern Rural Water or environmental water allocations currently stored in the Melbourne system in the standard demand scenario. A demand sensitivity analysis assumed increased use of these annual entitlements.
- Winneke and Tarago treatment plant usage consistent with current strategies (up to 130 GL/year and 12 GL/year respectively)
- Additional treatment facilities are expected to be commissioned at Yan Yean storage in 2017/18, allowing average annual output of around 10 GL per annum.
- Sugarloaf pipeline will not be operated unless total system storage volumes are below 30% on 30 November, as per Melbourne Water's *Statement of Obligations*.
- Updated 2016 streamflow data for the Melbourne water supply system.

## TECHNICAL ANALYSIS RESULTS SUMMARY

15. The Minister for Water announced on 19 March 2017 that:

- Victoria will introduce a minimum annual water order of 15 GL from the VDP to be reviewed in three years.
- Water customers will not face additional charges on their water bills for this year's 50 GL water order or the subsequent three minimum water orders of 15 GL.

16. The water supply system was modelled using simulation models for a range of potential streamflow conditions and desalinated water order scenarios (or pathways) over the period covered by the 2017 advice. The modelling results were assessed in relation to the five principles, and results for various pathways are summarised with reference to the principles in Table 2.

17. The base case of a 15 GL order in each of the three years of the desalinated water order advice is used as a benchmark scenario to assess potential desalinated water order pathways. Figure 4 shows the potential range of modelled future total water storage levels for the base case, and highlights 30 November in each year, the point for the annual *Water Outlook* issued by the water corporations, and the key point in time for Principles 1 (Low Zone) and 2 (Medium Zone). Also included is a scenario showing a repeat of the recent drought years of 2006, 2007 and 2008 (which represents the worst three-year streamflow sequence recorded for the main Melbourne Water supply system reservoirs) to assess the implications and potential mitigation pathways should Melbourne experience a similar sequence of severe low flow years over the desalinated water advice period.

18. A 15 GL desalinated water order in 2017/18 would satisfy Principles 1 (Low Zone) and 2 (Medium Zone) for 30 November 2017 (refer to Figure 4 below). However, successive 15 GL orders in 2018/19 and 2019/20 would see an increasing chance of entering the Medium Zone (11% at 30 November 2018 and 23% at 30 November 2019). A repeat of the severe drought sequence of 2006-2007-2008 (shown as the yellow line in Figure 4), would see storages in the Low Zone in 2020 and would not satisfy Principle 1.

**Table 2: Summary of model results**

	Principle 1 Chance of being in the low zone (Nov 30)			Principle 2 Chance of being in the medium zone (Nov 30)			Principle 3 Median storage change (GL)			Principle 4 Incremental foregone harvest* volumes due to desal water		
Principle Benchmarks =>	0%			≤ 10%			≥ 0 GL			Median ≤ 12.5 GL (10 %ile ≤ 25 GL)		
Desal Scenario (streamflow)	2017	2018	2019	2017	2018	2019	2017/18	2018/19	2019/20	2017/18	2018/19	2019/20
										Median (10% ile)	Median (10% ile)	Median (10% ile)
15-15-15 (Return to Dry)	0%	0%	0%	0%	11%	23%	-49	-95	-65	0 (2)	5 (14)	0 (3)
15-50-50 (Return to Dry)	0%	0%	0%	0%	10%	17%	-49	-61	-44	0 (2)	17 (30)	1 (12)
50-50-50 (Return to Dry)	0%	0%	0%	0%	7%	14%	-14	-71	-42	1 (6)	22 (50)	3 (13)
15-150-150 (Return to Dry)	0%	0%	0%	0%	7%	8%	-49	-10	33	0 (2)	66 (97)	27 (60)

\* "Foregone harvest" is the modelled additional spills from the Melbourne water supply system and/or reduced harvest into Sugarloaf Reservoir for each scenario due to the desalinated water order volumes supplied.

Numbers highlighted in red do not satisfy the principle benchmarks.

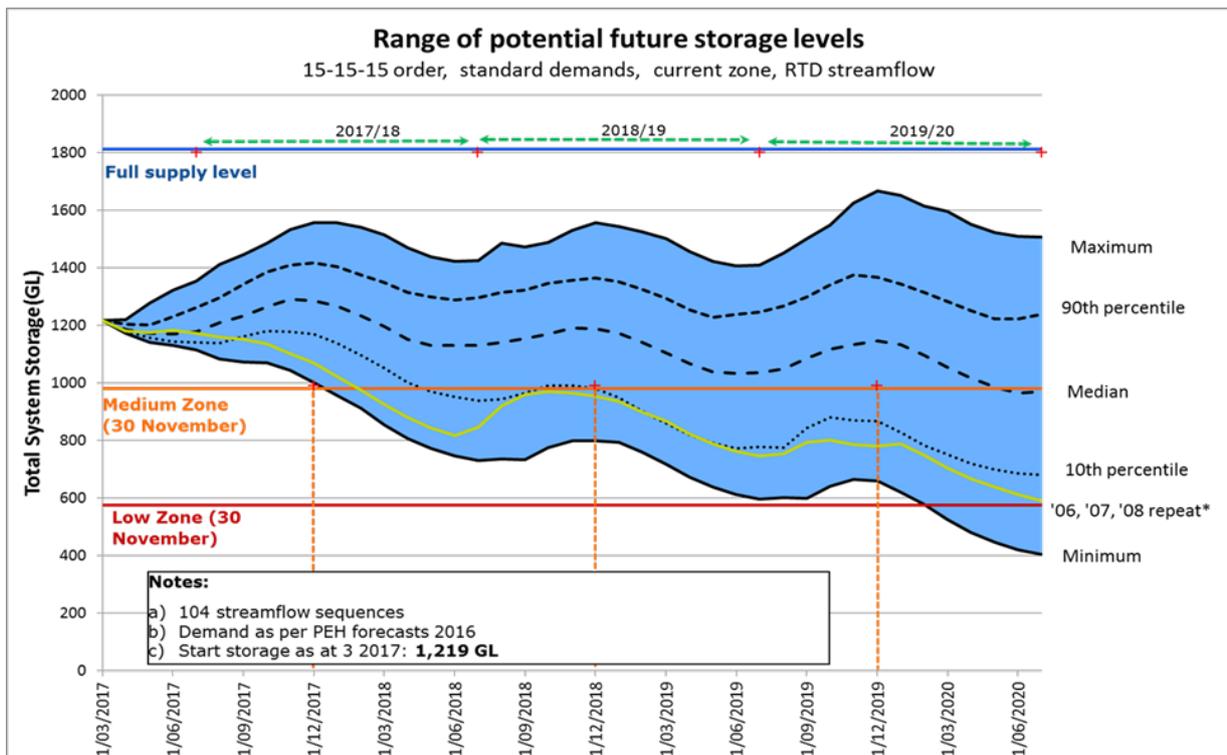


Figure 4: Modelled storage levels under 15-15-15 GL water orders (base case)

19. Desalinated order volumes are reviewed annually to respond to the annual variability in streamflow and climate conditions. If 15 GL was ordered in 2017/18 and prolonged severe drought conditions occurred, then subsequent orders of 150 GL could be made in 2018/19 and 2019/20. Figure 5 below shows that a 15-150-150 GL order pathway would satisfy Principles 1 and 2 by maintaining modelled storages above the Low Zone and less than 10% of sequences in the Medium Zone in all three years. This pathway would also enable some storage recovery on the median storage trend (Principle 3) in the third year.

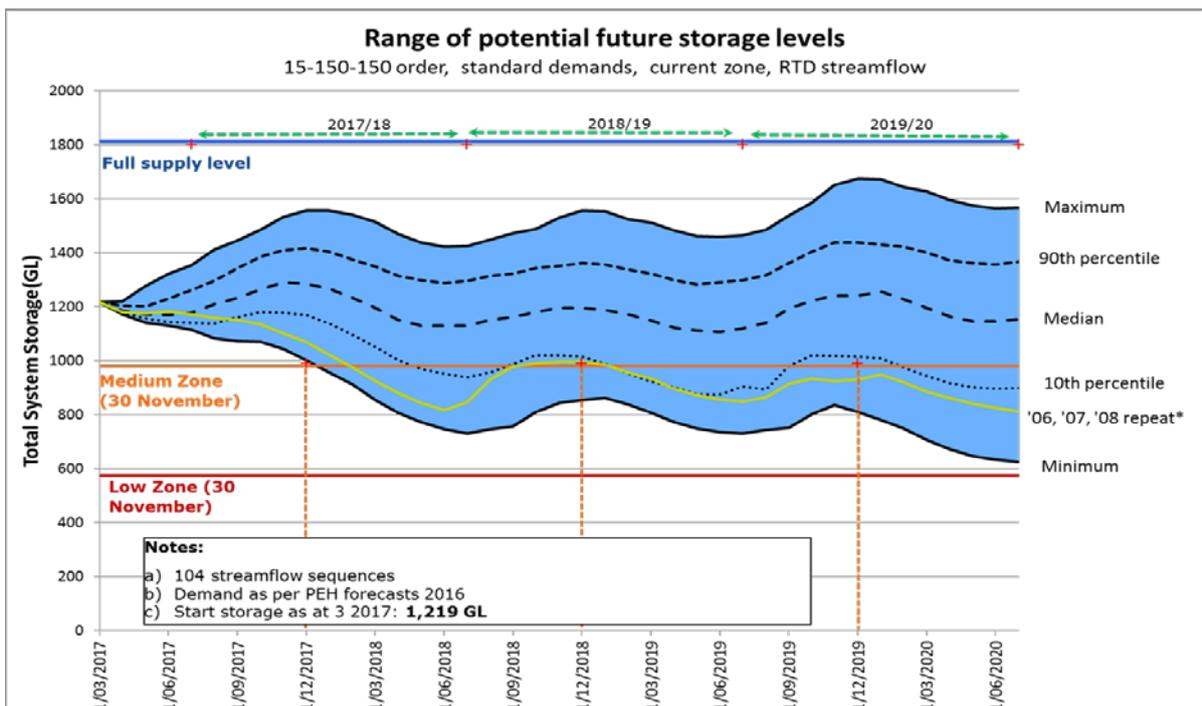


Figure 5: Modelled storage levels under 15-150-150 GL desalinated water orders

20. Figure 6 shows the range of modelled storage levels for a 15-50-50 GL pathway over the advice period, and Table 2 provides further details. A 15-50-50 GL order pathway would satisfy Principles 1 (Low Zone) and 2 (Medium Zone) for all three years, except Principle 2 on 30 November 2019. Also under this pathway there is a downward storage trend of about 50 GL per year under the median percentile over the three years. However the opportunity to revisit the volume required in each of the second and third years, as part of the annual planning and ordering cycle, and the planned review of the assumptions and principles during 2017 to take account of the revised water security zones, allows adaptation based on the latest storage levels and outlooks at the time.

21. A 15-50-50 GL order pathway satisfies Principle 4 (foregone harvest risk) for all three years except 2018/19. If this became significant with wetter conditions, the minimum water volume could be ordered in 2018/19 to address this. The modelling also indicates that a 15-50-50 GL pathway provides sufficient water for storages to remain above the Low Zone in a repeat of the recent low flow years of 2006, 2007 and 2008.

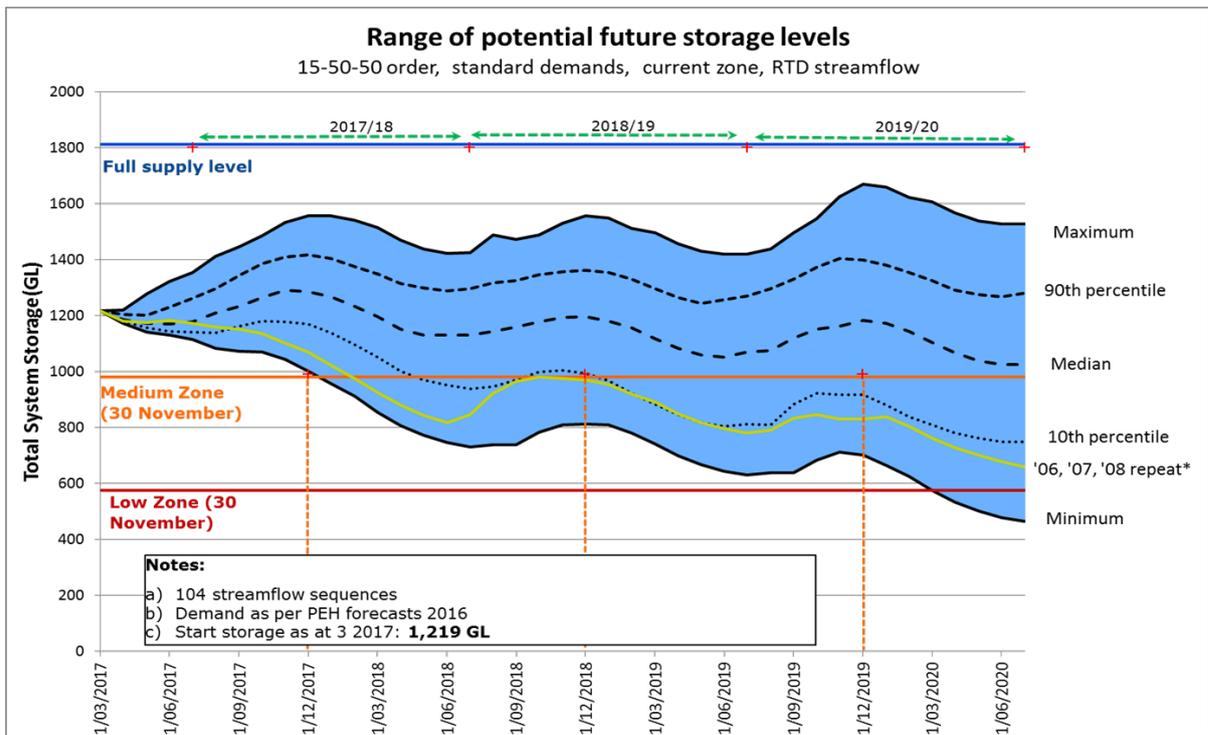


Figure 6: Modelled storage levels under 15-50-50 GL desalinated water orders

## Other considerations

22. Other relevant information considered in the technical analysis includes:

- Melbourne's actual total system storage volume increased by 47 GL (2.6%) over 2016 to 71.3% at 1 January 2017. This followed a decline of 152 GL (8.4%) in 2015. However, in a relatively wet year such as 2012 Melbourne's storages can gain 264 GL (14.6%).
- Planned works at Upper Yarra dam in 2018/19 will temporarily constrain operation of the water supply system at that time – these works will require the storage level at the dam to be reduced, and scheduled water transfers from Upper Yarra to other storages including Cardinia from mid-2018. Lower range desalinated water orders in 2017/18 and 2018/19 provide operational flexibility that would assist in delivering these works.

### **Short term climate outlook**

- The BoM's seasonal streamflow forecast for Melbourne's four major harvesting storages indicated for March to May 2017 that the following inflows are more likely: low at Thomson, average at Maroondah and O'Shannassy, and high at Upper Yarra.
- The BoM's ENSO Wrap-Up (issued 14 March 2017) indicates that the El Niño-Southern Oscillation (ENSO) currently remains neutral. By comparison, at this time last year the strong 2015 El Niño event was gradually declining. While the ENSO Outlook is currently neutral, the likelihood of El Niño forming in 2017 is around double the average chance at 50%. However, some caution should be taken as models have lower accuracy when forecasting through the autumn months than at other times of year.

### **Customer impacts**

- The Minister for Water announced on 19 March 2017 that a minimum annual water order from the VDP will be introduced for the next three years (from 2017/18) at no additional charge to customers. The Minister also indicated that Melbourne Water should consider and account for a minimum volume of 15 GL per annum in preparing its desalinated water order advice.
- Table 3 shows the additional costs for two order pathways. The costs for 2018/19 and 2019/20 are estimated based on the latest 2016/17 costs provided by DELWP in 2016 with adjustments taking account of the decision to place minimum water orders.
- In line with the Minister for Water's commitment, Melbourne Water consumers will not pay for minimum water orders delivered for each of the next three years. Based on the water order (15GL), water consumers will pay zero in 2017/18. Water consumers will pay for amounts ordered in addition to the minimum water orders in 2018/19 and 2019/20.

**Table 3: Additional desalinated water order costs each year (nominal dollars) following the decision to place minimum water orders**

Scenario	2017/18	2018/19	2019/20	Total
15-15-15 GL	\$0 m	\$0 m	\$0 m	\$0 m
15-50-50 GL	\$0 m	\$20 m	\$21 m	\$41 m

23. When storages enter the Medium Zone, there is the option to implement mandatory water restrictions. However, the combination of other initiatives including voluntary water efficiency measures and additional volumes from the VDP could avoid implementing mandatory water restrictions which can have a significant impact on the community. For example, the Productivity Commission (2011) estimated that *"the net welfare costs of mandatory restrictions are significant and can amount to several hundred million dollars per jurisdiction per year."*
24. The benefits of avoiding (or delaying) the costs of water restrictions are important, but difficult to quantify in any economic assessment of desalinated water advice. Melbourne Water is currently collaborating on projects that will assist in better explaining the economics of restrictions and assessing the economic value of water in storage. The initial outcomes of these two initiatives are expected to be available to inform future desalination water order advice.
25. The review of the desalinated water order advice process and principles to be undertaken by Melbourne Water and the Retailers in 2017 will consider the initial outcomes from these studies.

## CONCLUSION

26. Desalinated water order advice of 15-50-50 GL balances all principles because:
- The combination of catchment inflows to the water supply system in 2016 and the 2016/17 desalinated water order to be supplied over March – June means that Melbourne's total system storage was effectively 103 GL better off at 1 March 2017 than 1 March 2016.
  - Advice of 15 GL in 2017/18 would satisfy all principles in that year except Principle 3 (Storage Recovery). If conditions were to become dry, it could be augmented with further orders in subsequent years. If wet conditions eventuate in 2017/18, it is not expected to result in any foregone harvest.
  - In the event of a severe drought sequence, modelling suggests that Melbourne's storages would be above the Medium Zone on 30 November 2017 if 15 GL was ordered. Additionally, maximum orders of 150 GL in 2018/19 and 2019/20 would enable Principles 1 (Low Zone) and 2 (Medium Zone) to be satisfied in 2018/19 and 2019/20.

- Non-binding forecasts of 50 GL per annum in 2018/19 and 2019/20 are based on managing the modelled annual decline in median storage levels over the next three years (rather than three-year severe drought sequences under the water security principles) and the operational constraints of the dam safety works at Upper Yarra.
- In general, there is less water supply system operational risk, such as foregone harvest, in managing smaller more frequent desalinated water volumes than larger infrequent volumes. This also helps to maintain a buffer against storage levels falling below the Medium Zone action point.
- A 15-50-50 GL order pathway, combined with annual reviews of the order advice in 2018/19 and 2019/20, strikes an appropriate balance between the water security principles and pricing impacts.

27. The 2017/18 desalinated water order advice, consistent with the requirements of the *Water Interface Agreement*, the minimum annual water volume announced by the Minister for Water and the general principles described above, is:

- 2017/18 – 15 GL
- 2018/19 and 2019/20 (non-binding forecast) – 50 GL in each of the years
- No constrained month caps are required in 2017/18.