Modelling outcomes with and without access to contingent storage at Lake Pūkaki

Peer review

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1. Brief

In making the case for more ready access to contingent storage at Lake Pūkaki Meridian has modelled two scenarios of future outcomes for a range of hydrological situations. The outcomes of these scenarios cover the immediate 36 months i.e. the next three winter periods including 2025. Both rely on the same available generation capacity (including assumptions of plant expected to be commissioned and plant expected to be retired in the period) and a distribution of historical lake levels.

The two scenarios are the same except for the price Meridian would put on generation available from releases of storage. In Meridian's words:

> "The price of water is the only lever we have available and is used to achieve these behavioural changes in lake management."

The logic is that the distribution of lake levels is a function of the available range, and that the price assigned to generation includes the potential to use the consented range. The inherent assumption is that the operator (Meridian) would have the same risk profile based on the proximity of lake levels to the top or bottom of the range. However, the range of possibilities is wider in one scenario compared with the other.

The two resulting scenarios are:

Restricted: operating to a range of Pūkaki storage between 532.50 a.m.s.l and 518 a.m.s.l with operating below 518 a.m.s.l restricted.

Eased: operating to a range of Pūkaki storage between 532.50 a.m.s.l and 513 a.m.s.l.

We have been asked to peer review the modelling. The questions we address are:

1. Do both modelled scenarios accurately represent their respective realities?
2. Are there material differences between the modelling and the decision-making tools the Meridian trading team and portfolio managers use?

2. Assumptions

Meridian applies an orthodox systematic approach to managing the storage in their hydro lakes, including for Lake Pūkaki. They offer it in a way that balances the value of generating today versus the opportunity cost of being able to use it in the future. The mechanism they use to recognise this trade-off is the water value.

The water value is the marginal value, or expected future value, of the future storable inflows. The water value is not expressed as the value of water *per se*, it is expressed as the value of generation made possible by that water being available i.e. $/MWh.

Of course, weighing the trade-off is dynamic. The water values have to account for the uncertainty over the timing and scale of future inflows combined with the uncertainty of how much generation will be dispatched at a given water value.

If the calculation of water value is consistent and largely dispassionate, the resulting generation, i.e. the rate at which the lake is drawn down, represents the same value for generating from the lake, at any given level, for any given time of the year to Meridian and the New Zealand system.

The issue of whether the management of the lake level is consistent and dispassionate arises at both ends of the range. Operators of storage lakes try and avoid spilling at the top and hitting the bottom. The water values reflect the market dynamics on the day, so a *dispassionate operator* is acting to its comfort levels taking the lakes lower and that is the same as reflecting how comfortable the *system* is taking the lake lower.

We know as a consequence of the evolution of the trading conduct rules in the Code and the scrutiny Meridian has been placed under from claims of undesirable trading situations that Meridian seeks to closely follow the modelled water values so their offer behaviour is auditable and defensible. If Meridian continues to follow modelled water values then it is more the case that Meridian interests and the New Zealand wide systems interests are aligned.

3. Approach

We have undertaken a high-level conceptual review of the modelling undertaken by Meridian based on interviews and discussions. We have not undertaken a technical review of the model and have not assessed whether the inputs/assumptions have been correctly entered, or whether the model itself is working correctly/as intended.

Our understanding is that current access to contingent storage at Pūkaki has been set up so as to be accessible when the system's risk of shortage reaches a certain level.

Direct summary of resource consent or regional plan	Interpretation
Meridian Energy has consent to use water from Lake Pūkaki for electricity generation. Additional 5 meters a.m.s.l (from 518 meters a.m.s.l) made available for generation if the System Operator (Transpower), its delegate, or any other statutory body exercising like powers and functions declares an Official Conservation Campaign. In November 2019, Meridian informed the System Operator that all of the 5 meters of additional hydro storage is physically accessible, and that sufficient analysis and preparation have been carried out to support lake armouring in the event that contingent storage at Lake Pūkaki is triggered.	A total of 545 GWh of additional hydro storage available for electricity generation; i) 331 GWh if reported storage falls below the New Zealand or South Island Alert Contingent Storage Release Boundary. ii) 214 GWh if the System Operator or an authority with equivalent powers and functions declares an Official Conservation Campaign.

Source: Transpower, Contingent Storage additional information.pdf

3.1 Our understanding of the model and scenarios

The base model used to produce the two scenarios is the same as the model that Meridian uses in their operations to help inform their target contract positions and day by day generation offers into the New Zealand electricity market. In this exercise, the model optimises for the lowest cost outcome for electricity generation to meet supply. It uses historic sun, wind and hydrological sequences to produce the potential distribution of the forecast outcomes.

The modelling produces two scenarios, restricted access and eased access to contingent storage. To represent these two different realities, the water values for a given lake level and a given time of year are adjusted to reflect the range of storage available. The restricted scenario has the water value increasing more rapidly as the lake approaches 518 a.m.s.l. The restricted scenario has been tailored to align with the current restrictions, with considerable risk aversion to accessing water below the 518 a.m.s.l. level. The Meridian trading team know that as they approach 518 a.m.s.l, the possibility of accessing the contingent storage increases, but is dependent on a range of other factors, many of which are outside their own control. They may scale their offers to delay that event but in some hydro sequences, lake levels still breach 518 a.m.s.l. The eased scenario moves this risk aversion ramp up of water values to the 513 a.m.s.l. level.

Critically any material variation to the modelled outcomes would arise from new information coming to hand that might change the water values calculated by the model in real time.

4. Review findings

For the purpose of this review our focus is mostly on the difference between the two modelled outcomes and the reliability of the differences.

4.1 Modelling outputs

Conceptually the modelling of the two scenarios makes sense. The general conclusion is also logical from a mathematical modelling point of view: easing the constraint results in a more optimised/lower cost solution. In this case, under normal circumstances, it gives more 'headroom' at both sides of the range.

More generation is able to be offered in the eased scenario in the knowledge that there is more accessible water (between 518m and 513m), and therefore less risk of 'running out'. In doing so, the mean lake level is lower. The converse is true, having a broader range of storage allows for greater scope to reduce the incidence of spill i.e. wasted energy resource.

In the restricted scenario, less generation is made available through the water value rationing mechanism, but the Meridian trading team will be acutely aware that a change in water values may arise where access to the contingent reserves is granted. Under current settings it is highly likely that the System Operator would need to use its discretion for access to contingent storage to be granted. If the lake level is approaching 518m, the SO is more incentivised to use this discretion, as we saw in 2024.

The first question we address is: do both modelled scenarios accurately represent their respective realities?

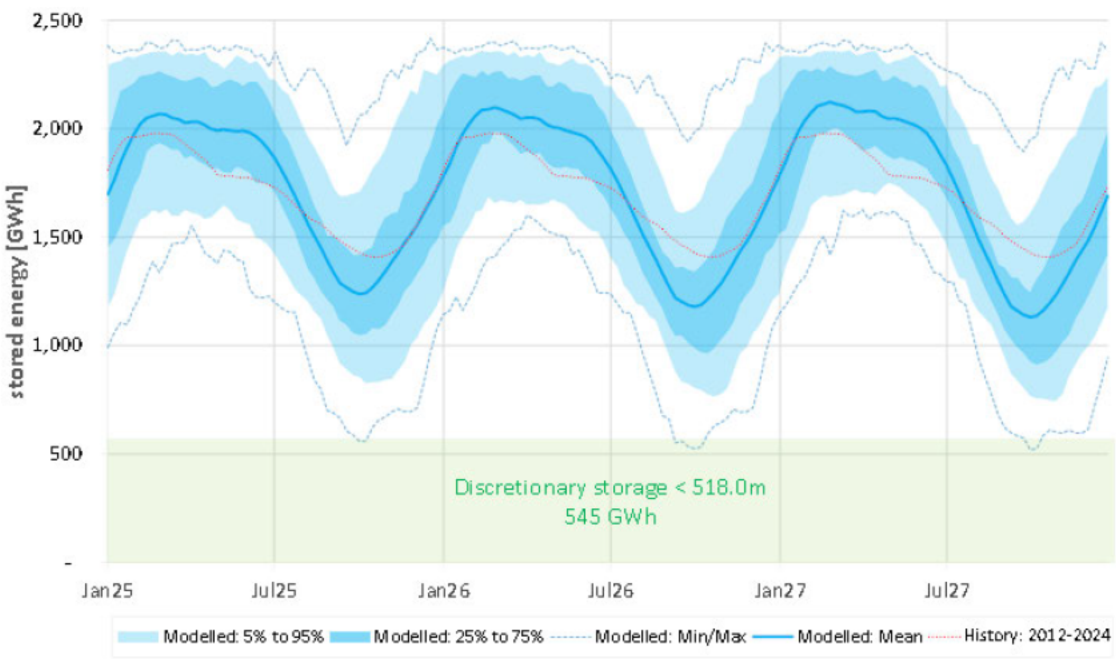
The range of the simulations somewhat accounts for the uncertainty regarding the future. However, it is possible that future scenarios of hydrology, demand, outages etc may fall outside the bounds of those tested in the model (for example the 2024 sequence is not included and there were some also unprecedented low inflows). Meridian also (understandably) makes operational decisions using up-to-date/live information. This enables Meridian to refresh their water values. Up to date information also feeds into the management of the hedge portfolio position where profit seeking and risk aversion are balanced.

The restrictions on access to contingent storage may create a distortion in the market. That is, with no certainty that access to the water below 518m will be available when needed, the operator must hedge their actions and positions on the probability that access will/will not be available. With a strong aversity to the risk that access is not available, the corresponding water values close to the 518m level will be relatively high. This may result in higher than efficient prices.

However, this does not mean that the findings of the modelling are not valid. It means that the actual path for storage on a given year between the two scenarios might be narrower or wider than modelled. The two charts below show the modelled differences in hydrological outcomes between the two scenarios. The spread of lake level outcomes is the same in each run but for the constrained range of operation in one compared to the other. All else being equal the difference between the two would be as modelled.

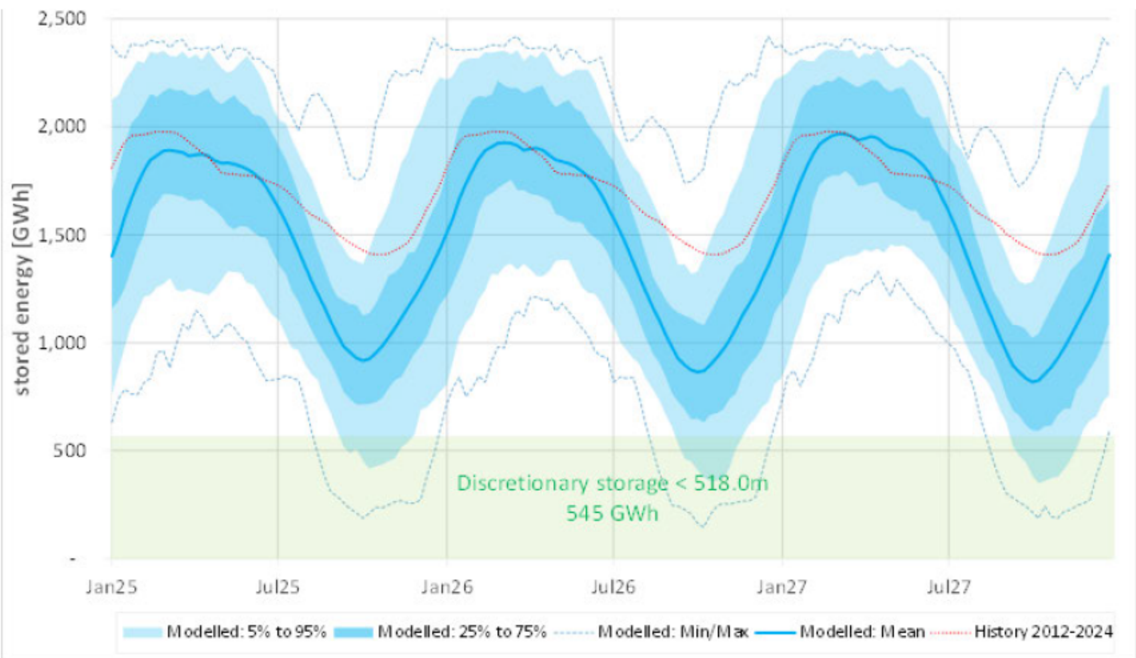
The snapshot for each week is a probability distribution for all the historical hydro sequences between 1931-2022. The model that generates these is also used to generate water values. The modelled minimum for the restricted scenario breaches the 518 m level a handful of times. This tells us that it would be infrequent and, as that became more likely, the SO will become more incentivised to exercise its discretion to enable contingent storage access.

Figure 1: Pūkaki weekly storage - restricted (2025-2027)



With access down to 513m, it makes sense that the optimised average lake level will be lower, as shown in the cart below. It also makes sense that the lake between 518m and 513m, is accessed considerably more often, with almost 25 per cent of sequences accessing this water.

Figure 2: Pūkaki weekly storage - eased (2025-2027)



Eased access reduces the risk of 'running out' as well as reduced spill. This enables more hydro generation to be offered and dispatched, generally resulting in lower prices by displacing higher cost fuels.

Figure 3: Total LWAP [$/MWh] - restricted vs eased access (2025-2027)

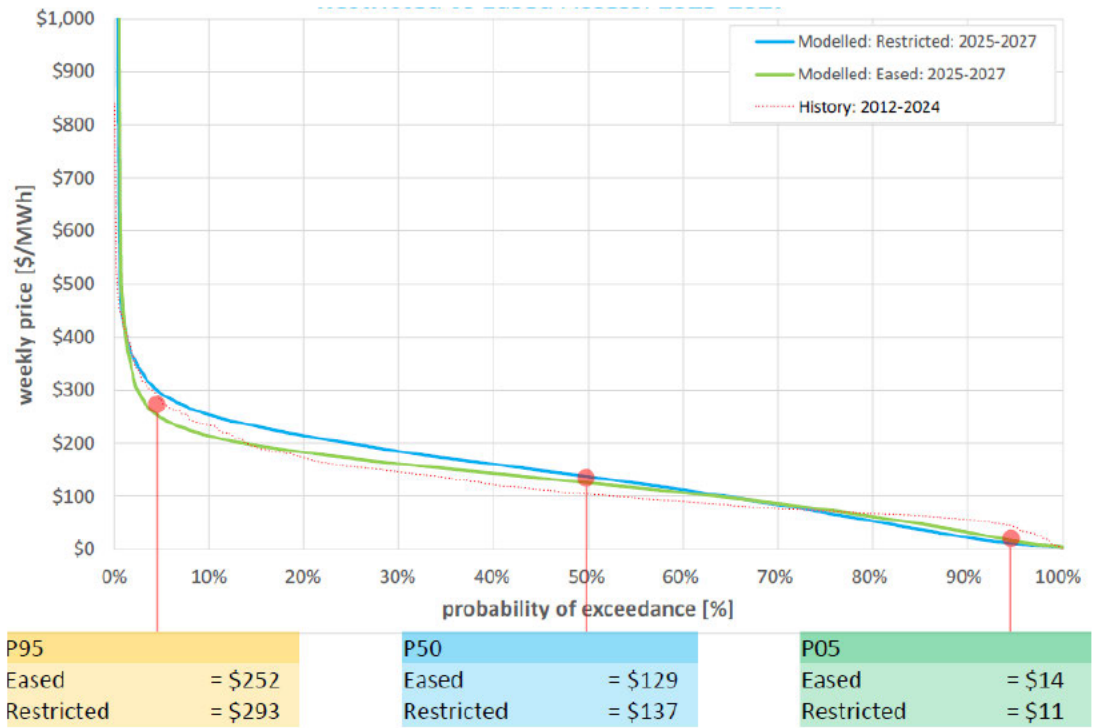


Figure 3 shows the modelled impact of the different hydro sequences on the distributions of the load-weighted average price (LWAP). We see that the eased scenario has a lower LWAP in the middle portion (approximately 65 per cent of the time) of the distributions.

The difference in LWAP is a representation of the difference in the market cost of electricity generation between the two scenarios. In answering our first question "*do both modelled scenarios accurately represent their respective realities?*" we stress the importance of assessing if the *difference* between these two modelled curves is likely representative of the differences in reality. In other words, even if these curves are not perfectly representative on their own, as long as there is no bias, the difference between them can still be relied on to assess the merits of easing restrictions.

4.2 Assessment

The modelling alters the only lever that a reservoir operator like Meridian has available to arrest storage decline, that is: the offer price, for any given storage level. If Meridian's operations are dispassionate, then its profile of risk aversion and New Zealand's profile of risk aversion are the same.

Apart from water values, no other changes to system assumptions have been made between the two scenarios. We know that the model is the basis for setting up the portfolio, for risk management assessment and establishing water values armed with real time information.

Factors that have not been modelled that may result in the difference between the two price curves being wider or narrowed include:

- The portfolios may be different between the two scenarios. This is unlikely to materially change the price curves, but could represent a transfer toward Meridian.
- Meridian may not strictly offer generation as per those produced by the model but their preference for an auditable, defensible offer strategy would mean variation is at the margin.
- There may be scenarios outside the distributions modelled. For instance, the 2024 hydrological sequence was not included in historic series – but this was the lowest lake level historically, with unprecedented low inflows, amongst other adverse conditions.
- The restricted scenario does not adjust for when access to contingent storage is granted. We can't account for when the SO exercises its discretion to lower the restrictions to access if deemed appropriate. At the point they do that the water values for the restricted scenario shift towards the water values for the eased scenario. As such, the difference between the LWAP curves may be overstated.

In our opinion, some of these factors could reduce the margin between the outcomes from the two scenarios, in terms of LWAP. Nonetheless, we still believe that a benefit can be relied on, just that the reality may be smaller than modelled. We also note that the more frequent parts (middle) of the distribution are less likely to be affected than at the extremes.

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