# Te Waihora Lake Ellesmere – the 2009 Living Lake Symposium: a summary of the key findings and conclusions

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**Executive summary**

The 2nd Te Waihora Lake Ellesmere Living Lakes Symposium was held at Lincoln University, 4th November 2009. The symposium had three main objectives: 1. to report on 'research' undertaken since 2007; 2. report and discuss PLOVER , a model of how lake values change in relation to lake opening scheduling/management; and 3. to consider where to from here for future management of the lake. Scientists reported on these objectives and contributed to evaluation of a range of potential future lake level management scenarios. These scenarios helped focus debate around some key issues and to clarify some potential ways forward, e.g.:

- higher lake opening trigger levels come with costs but few obvious gains;
- a higher average lake level can occur without raising the trigger level, but by incorporating other decision criteria;
- targeted openings around September and/or October have potentially great benefits for fisheries management; and,
- each of the former needs to be associated with a reconsideration of who pays the cost of management.

Future debate around these options is now much better informed by the modelling and by discussions which occurred at the symposium. It is clear also that the lake's future is tied to much more than the lake level management regime. Riparian (willow control, stream edge planting, and stream side fencing) management is clearly necessary now and has started, albeit in a very limited way.

## 1. Introductory context

Worldwide, lowland lakes are considered to be huge and ongoing challenges for management. They suffer because they are sinks for all upstream runoff, they frequently contain fisheries in decline, their marginal lands are often under pressure for development purposes, they often have indigenous peoples rights requirements, they contain multiple other values and they are debated over by multiple stakeholders. Te Waihora Lake Ellesmere has all these characteristics and more – it indeed typifies the enormous challenges faced by all such lakes. It is appropriate therefore that New Zealand's 5th largest lake by area, Te Waihora Lake Ellesmere, should be subject to much ongoing management attention.

This management attention was realised at the 2007 Living Lake Symposium. At that symposium scientists debated the current health of the lake – it was far from 'dead', indeed many values were thriving, some were at risk, some declining and one, the brown trout fishery' was hugely reduced (see Hughey and Taylor 2009).
In 2007, at Living Lake Symposium 1, we produced a State of the Lake report. We found overall that:

| ‘Value’ | Range of states |
|---|---|
| **Catchment Hydrology** | Upper: ‘very good’<br>Lower: ‘very bad’ |
| **Water quality of tributaries** | ‘good’ to ‘very bad’ |
| **Water quality of lake** | ‘fair’ to ‘bad’ |
| **Vegetation** | Vegetation (incl. macrophytes): ‘very good’ to ‘poor’<br>Rare plants: ‘very good’ to ‘very bad’<br>Woody weeds: ‘very bad’ |
| **Brown trout recreational fishery** | ‘very bad’ |
| **Commercial fisheries** | ‘good’ to ‘bad’ |
| **Wildlife** | ‘very good’ to ‘bad’ |
| **Recreation** | ‘very good’ to ‘very bad’ |
| **The Ngai Tahu Values** | ‘bad’ |

In other words the lake was in a reasonable state of health but some values were performing badly (e.g., Ngāi Tahu) and one, brown trout, very badly. We found, not surprisingly, that there were many things we still did not know and commitments were made to finding out more and reporting on these findings and other matters in 2009.

## 2. The 2009 Symposium:

The 2009 Symposium had three main aims:

1. to report on ‘research’ undertaken since 2007, namely: the water balance model, lake opening engineering, salinity, water quality, macrophytes and willow management;
2. report and discuss PLOVER[1], a model of how lake values change in relation to lake opening scheduling/management;
3. consider where to from here for future management of the lake.

The symposium was structured (Appendix 1) around responding to these three aims, and the remainder of these summary proceedings report on the findings relevant to each of these objectives.

## 3. Updates/new research since 2007

The following were all reported on and discussed in the update section of the symposium:

a) Water balance model: Graeme Horrell, NIWA
b) Lake opening engineering: Ross Vesey, ECan

[1] PLOVER = Planning Openings and Values for Ellesmere’s Resilience

c) Water quality: Shirley Hayward, Formerly ECan, now Dairy NZ
d) Salinity modelling: Bob Spigel, ECan
e) Macrophytes: Don Jellyman, NIWA
f) Willow control: Philip Grove, ECan

The following six subsections briefly summarise the key points made in these updates.

a) Water balance model - Graeme Horrell, NIWA (see Appendix 2(a)):
Background:

- Catchment area 2072 $km^2$2, 777 km2 hills, 1295 $km^2$ plains
- Historically the lake opened itself at an approximate height of 4 m, with an approximate area of 315 $km^2$
- When managed by Maori the lake was opened at approximately 2.7 m with an area of 290 $km^2$.
- Since the late 19th century it has been opened by Europeans and current lake opening levels are;
    - 1.13 m April to July
    - 1.05 m August to March
- Current area of 189 $km^2$, mean depth 1.4m

Table 1 shows the Lake Ellesmere (Te Waihora) water balance:

Table 1. Te Waihora Lake Ellesmere water balance

| (It + Ir + Ig + Ias + Irs) - (Os + Oe + Oa) = Δs | Flow | % | Precision of variables |
|---|---|---|---|
| where: period : June 1986 - 2007 | ($m^3s^{-1}$) | | ($m^3s^{-1}$) |
| It = tributary inflows | 12.5 | 62 | ± 1.2 |
| Ir = rainfall inflows | 3.3 | 16 | ± 0.3 |
| Ig = groundwater | 0.4 | 2 | + 0.4 or - 0.2 |
| Ias = artificial opening sea incursion inflows | 2.6 | 13 | ± 0.9 |
| Irs = rough weather sea incursion inflows | 1.5 | 7 | + 1.5 or - 0.7 |
| Os = Kaitorete spit seepage outflows | 1.2 | 6 | ± 0.3 |
| Oe = evaporation outflows | 6.6 | 34 | ± 1.1 |
| Oa = artificial opening outflows | 11.5 | 60 | ± 1.3 |
| Δs = change in storage 9-6-1986 to 31-12-2007 | 0.1 | | |

Purpose of the model is to enable lake ‘level’ opening scenarios to be tested and evaluated from two key outputs:

- new lake level regime

- number of openings that may occur.

Output from running the model shows:

- 134 actual openings – model 137 (38 years)
- Modelling from 1st January each year – 133
- Comparison with Maori openings is possible, as shown in Figure 1.

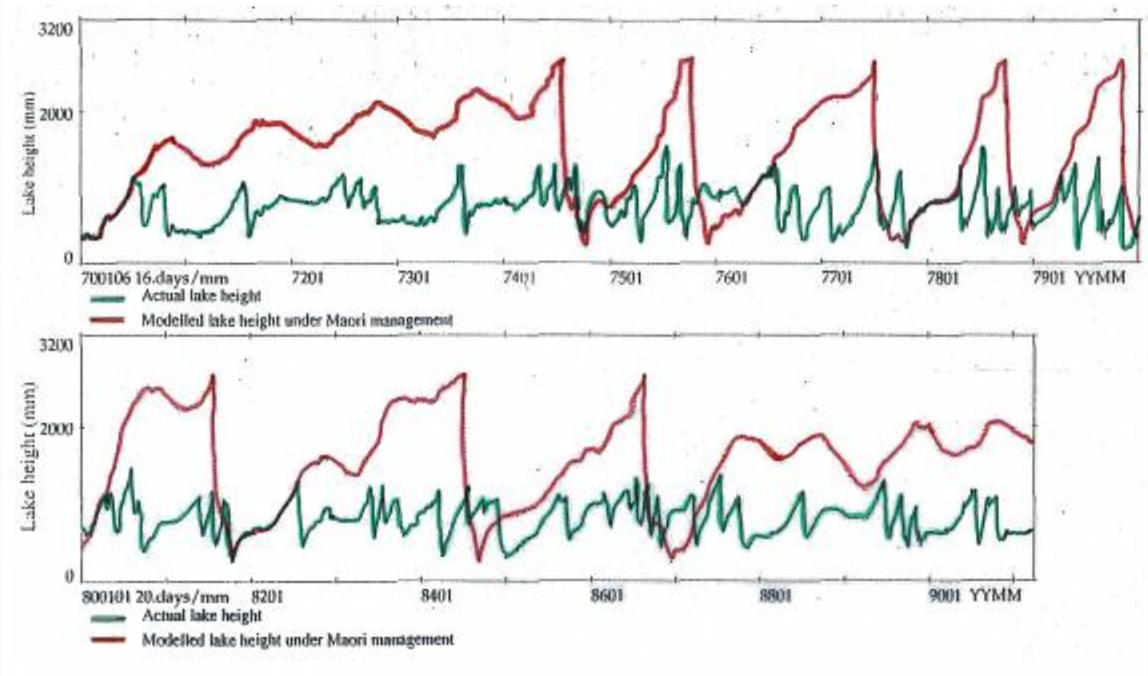


Figure 1. Modelled openings under traditional Maori regime versus present day

<u>b) Lake opening engineering – Ross Vesey, ECan (See Appendix 2(b)):</u>
Factors controlling openings include:

- Wind
- Swells and wave action
- Tides and hydraulic gradients
- Beach material
- Unstable, poorly graded gravels
- Eroding coastline.

The main options regarding managing levels are covered by two main reports.
Bray (1975) report:

- Canal through Halswell to Sumner
- Connect to Lake Forsyth + tunnel
- Connect to Rakaia lagoon.

Morris & Wilson Report:

- Canal
- Piped
- Stopbanking.

Previous attempts at more permanent opening regimes are:

- Dobsons culvert 1904
- Pannets culvert 1907 (Similar = Waihao box – very narrow beach, higher head).

Previous investigations show option costs significantly higher than mechanical openings.

The water conservation order provides also for a forced closure to prevent 'drying out'. Issues around a forced closure include:

- Width of channel(s) and lowered beach
- Material availability
- Sea conditions/tide (forecast)
- Lake level
- Natural closure imminent
- Gain =?
- Cost =?

A funding source would be needed for further investigations of any of the above options, presumably also within the timespan of the current temporary consent, which expires in 2011. But, the future of the current regime is also uncertain because:

- More difficult to find material for sea wall
- Beach monitoring programme doesn't yet show this
- Recession of crest
- Could lose deep pool and feeder channels
- New consent conditions
- Long term sea level rise
- Funding base is changing.

<u>c) Water quality: Shirley Hayward, Formerly ECan, now Dairy NZ (see Appendix 2(c)):</u>
Monthly sampling at multiple inflowing, lake edge and central lake sites began in 1992. The main indicators, and trends for the lake itself, are:

- Phytoplankton biomass, i.e., chlorophyll *a* – increasing trend over time; toxic algal bloom February 2009.
- Nutrients, i.e., nitrogen and phosphorus. In terms of phosphorus total P has remained static but dissolved P has increased substantially. Both total Nitrogen and Nitrate nitrogen have decreased over time although the lake is supersaturated in both.
- Clarity (visual depth) – the mid lake site is showing decreased clarity over time.
- Salinity – less frequent lake openings are leading to a reduction in lake salinity.
- Microbial quality – limited data but what is available indicates suitable for contact recreation.

Trends for inflowing streams for all indicators are mixed, although most demonstrate an ongoing worsening trend of inputs over time, exacerbated by reducing flows.

d) Salinity modelling - Bob Spigel, ECan (see Appendix 2(d)):

Ten surveys conducted by ECan in consultation with NIWA, June – September 2008. Three patterns emerged for salinity distributions, namely:

1. Lake fairly well mixed horizontally and vertically – lake closed, no rough sea inflow in previous week.
2. High salinities near outlet, but vertically mixed – lake open, lake levels low enough to allow seawater inflow through the opening.
3. High salinities near outlet, but vertically stratified near outlet – lake closed, but high seas and waves, strong southerly winds cause waves to overtop barrier spit.

e) Macrophytes - Don Jellyman, NIWA (see Appendix 2(e)):

Benefits of re-establishment:

- restoration to 'as it was"
- macrophytes act as a sediment trap and nutrient sinks (increased inshore water clarity, and reduction of areas where sediment becomes re-suspended and nutrients mobilised)
- reduce shoreline erosion
- increased dissolved oxygen
- produce shading and water temperature gradients
- greater fish and bird habitat diversity

Concerns about re-establishment:

- aesthetics (shoreline rotting macrophytes and reduced dissolved oxygen)
- fisher access and net fouling
- other recreational users e.g. power boats and wind surfers etc
- overall stability-could the lake flip again?
- viability of existing seed bank
- salinity changes and macrophyte species
- local de-oxygenation at night
- the risks of side-effects (phytoplankton blooms, especially blue-green algae, possible nuisance numbers of swans)
- control of swan browsing
- practicality and cost

In summary:

- Some potential in selected reaches of the lake
- Decision to proceed involves perceived benefits vs likelihood of success and costs
- A staged approach could be considered.

f) Willow control - Philip Grove, ECan (see Appendix 2(f)):

Environment Canterbury, working collaboratively with other key agencies, has mapped the distribution of exotic willows and other plant communities. Not all willows need to be controlled, with a total of 45 priority willow control sites identified. The total area of priority sites is 32 ha (out of 170 ha overall willow-infestation around lake).

# 4. An applied management model of the lake

A major focus through much of the 2009 preparation for the symposium was on future management. To that end Environment Canterbury commissioned, via Lincoln University, Dr John Raffensperger, from University of Canterbury, to produce a computer 'model' of the lake (see Appendix 3). Changes in the performance of selected values of the lake were related to the lake's opening regime[2]. As part of the model building process much dialogue occurred between the model development team and those with knowledge of a range of the lake's key values, e.g., native birdlife, iwi-cultural, commercial eel and flounder fisheries, farming, recreational duck hunting, salinity, water level, and risk of algal blooms. These experts provided the data that Dr Raffensperger used to populate the model – often this information was expert opinion based, being based on years of research or working on or around the lake which then helped formed defensible opinion. Sometimes the 'experts' were unable to provide any usable material for modelling.

The model contained the following components, all managed within an Excel spreadsheet:

- Opening cost
- Salinity
- Algae risk
- Turbidity
- Sprouting ruppia potential
- Eel migration
- Flounder recruitment
- Duck hunting, opening day water depth, i.e., the greater the depth then generally the best for duck hunting
- Wader habitat, i.e., the amount of habitat for short legged wading birds, e.g., banded dotterel
- Farm area covered.

Once the components were finalised within the model we were able to compare how the variables changed under different lake level management regimes. Lake level was chosen as the primary control factor because previous work reported in Hughey and Taylor (2009) showed that for almost all of the key lake values lake level was the key driver of change. To explore this influence further four operating regime scenarios were developed for the lake and compared in terms of performance against the status quo benchmark regime. The four scenarios were:

1. The baseline or status quo management, or the regime largely running in accordance with the national water conservation order for the lake;
2. A 'best for flounders' option that forces an opening in September to maximise flounder recruitment;
3. A 'best for eels' option which forces an October opening which is positive for eel management; and

[2] The lake is opened mechanically to the sea when it reaches trigger levels in winter and summer. The length of time of an opening may vary from hours, typically to weeks, but occasionally to months.

4. A higher lake opening option designed to increase average lake levels which is considered positive for a range of environmental reasons.

The model and the four scenarios were thus presented and evaluated by the scientists and other experts with relevant expertise attending the symposium. In summary their comments (See Appendix 4 for the full Hughey and Jellyman presentations, the two for which documentation was submitted) can be summarised as:

- Birds, duck shooting (Appendix 4(a)) – Ken Hughey, Lincoln University: The short legged wading birds are but one of a number of guilds (groups of species) that use the lake. Having said this, the results appear sensible and allow predictions to be made about wading bird habitat, acknowledging of course the multiple needs of many other guilds and individual species. In terms of duck shooting the modelling appears appropriate.
- Farming – John Lay: The model seems to accurately present changes in water level and given topographical limitations seems to generally present a good picture of farm flooding during different regimes. Farm economics is another matter and some more work maybe required to verify both the input data and the results.
- Fish (Appendix 4(b)) – Don Jellyman, NIWA: Having scenarios that deal with both flounder and eel seem appropriate, although the economic predictions may need more refinement and perhaps some sensitivity analysis could be undertaken.
- Ngāi Tahu values – Jason Arnold, Ngāi Tahu: None of the attributes is specifically cultural although thinking about flounder and eel are appropriate. Modelling a higher water level is something Ngāi Tahu are very interested in. More work is needed to incorporate Ngāi Tahu values.
- Native vegetation – Trevor Partridge, CCC: Salinity has a relationship with the distribution of native plants, so this is an important inclusion. Perhaps in future specific modelling of various native plant communities could occur, other than just *Ruppia*. The germination of *Ruppia* is highly problematic and may not be captured appropriately by the model.

The overall view was that the model is a useful first step in understanding some of the key relationships between the lake's values and the way the lake is being managed now, and how it might be managed in the future. Symposium participants were subsequently divided into six groups to then evaluate how particular scenarios might affect particular interests/values, e.g., insight into benefits or costs that might occur if a higher lake level operating regime was to be envisaged. Naturally a wide range of feedback was provided from this approach – key points made were:

- The model does not deal with the social cost of potential inundation, e.g., to the Selwyn Huts
- Wider catchment issues need to be included, e.g., the impact of an operational CPW scheme, also climate change
- Good to have a managed vs reactive approach to the lake
- Perhaps a bigger range of scenarios could have been trialled with more 'distance' between them

- Some 'locals', primarily farmers, think the status quo works
- Eels and flounders seem to dominate many value shifts – is this realistic?
- Some difficulty in really understanding what is going on, i.e., without visualisation the model is complex
- Perhaps need to introduce some weightings to particular values?

Some other points were noted during general discussion, when comparing the status quo to other three scenarios:

- Farmers want water off their farmland in September-October: they do not want a 'wasted' opening
- Might it be possible and desirable to aim for a higher average lake level without imposing higher maximum levels
- For some desirable native plant communities long periods of high, >1m, lake levels are bad.

The above led to the research and management question – 'would it be possible to have a higher winter average lake level to improve September-October opening prospects?'

Clearly the existing regime has winners and losers, with the winners (farmers generally) paying for the lake level management regime, and the losers not being compensated in any way. Any change to the current regime would likely lead, as shown by the modelling, to a new arrangement where more values share benefits and there were fewer losers. Clearly any such changes would need to be accompanied by a review of how the costs of management were shared amongst these parties, and in all of this an economic sense would need to be linked to an 'objective function' for the lake and its environs.

## 5. Where to from here for Te Waihora/Lake Ellesmere?

The modelling undertaken for the 2009 symposium served useful purposes. First, it was possible to model the lake level management regime with a high degree of success. Second, it was possible to include a wide range of values that respond to the management regime, but not all of the key values could be included and more work may be needed in this context. Given these two successes it was then possible to consider a range of potential future lake level management scenarios and demonstrate the 'winners' and 'losers' from such changes.  These scenarios helped to focus debate around some key issues and to clarify some potential ways forward, e.g.:

- higher lake opening trigger levels come with a variety of costs but few obvious gains;
- a higher average lake level can be achieved without raising the trigger level, but by incorporating other decision criteria;
- targeted openings around September and/or October have potentially great benefits for fisheries management; and,
- each of the former needs to be associated with a reconsideration of who pays the cost of management.

All of these considerations need further debate, but this debate is now clearly much better informed by the modelling and by discussions which occurred at the symposium and which have been reported in Section 4 above. Finally, it is clear that the lake's future is tied to much more than the lake level management regime. Riparian (willow control, stream edge planting, and stream side fencing) management is clearly necessary now and has started, albeit in a very limited way. More fundamentally the catchment as a whole needs careful management within defined emissions targets, especially associated with nitrogen and phosphorus, and with regard to water quantity in the multiple mainly spring fed tributaries, and linked to questions around management of groundwater and potential major new inputs from proposed large scale irrigation development in the Central Plains area. All-in-all these are huge challenges and a suggestion for the next symposium in 2011 was to broaden the discussion to total catchment management – such will indeed be a challenge.

**REFERENCES:**


Bray, W.B. 1875: Report and plan relating to the drainage of Lake Ellesmere. Report to the Secretary for Public Works, Wellington.

Hughey, K.F.D., Taylor, K.J.W. (eds). 2009. Te Waihora/Lake Ellesmere: State of the Lake and Future Management. EOS Ecology, Christchurch. 150pp.

Morris and Wilson Consulting Engineers Ltd, 1980: Stabilisation of Lake Ellesmere. Preliminary report to the North Canterbury Catchment Board, Christchurch.


**LIST OF APPENDICES**

APPENDIX 1:
SYMPOSIUM PROGRAMME

APPENDIX 2:
UPDATES ON RESEARCH/MANAGEMENT QUESTIONS PRESENTED AT THE 2009 LIVING LAKE SYMPOSIUM

APPENDIX 3:
RAFFENSPERGER, J.F. INTRODUCING PLOVER 2K: PLANNING OPENINGS AND VALUES FOR ELLESMERE'S RESILIENCE

APPENDIX 4:
'EXPERT' RESPONSES TO THE LAKE OPENING MODEL

**APPENDIX 1: Symposium programme**

waihora ellesmere trust

## "Living Lake Symposium 2: Future sustainable management pathways for Te Waihora/Lake Ellesmere" – 2009

**Tuesday 3rd November:**

Bus trip

- 5.30pm - 8pm focused on highlighting issues to be discussed/ Barbeque dinner 8pm

**Wednesday 4th November: Stewart Lecture Room, Lincoln University**

| | | |
|---|---|---|
| **Registration/coffee:** | | 08.30 am |
| Welcomes: | | |
| o Powhiri | Ngāi Tahu | 09.00 am |
| o Welcome | WET/Bryan/Ken | 09.15 am |
| Updates since 2007: detailed: 15-20 min each | | |
| o Water balance model | Graeme Horrell, NIWA | 09.30 am |
| o Lake opening engineering | Ross Vesey, ECan | 09.50 am |
| Questions/discussion/implications: | | 10.10 am |
| **Morning Tea** | **NIWA sponsored** | **10.30 am** |
| Updates since 2007: brief: 5-10min each | | |
| o Water quality | Shirley Hayward, Dairy NZ | 10.50 am |
| o Salinity modelling | Bob Spigel, ECan | 11.00 am |
| o Macrophytes | Don Jellyman, NIWA | 11.10 am |
| o Willow control | Philip Grove, ECan | 11.20 am |
| Questions/discussion/implications: | | 11.30 am |
| Scenarios - review/recap 07: | Ken Hughey/Ken Taylor | 11.40 am |
| ➢ Improved; Enhanced; Strong – how it relates to the modelling to be presented | | |
| Questions/discussion/implications: | | 12.00 pm |
| **Lunch** | | **12.15 pm** |

The sustainable management lake model: John Raffensperger, UoC 1.00 pm
Questions/discussion/implications: 1.20 pm

Components of the Model – expert verification * 5 mins 1.30 pm

- Birds/duck shooting Ken Hughey, Lincoln Uni
- Farming TBA
- Fish Don Jellyman, NIWA
- Ngāi Tahu values Jason Arnold, Ngāi Tahu
- Native vegetation Trevor Partridge, CCC

Questions/discussion/implications: 2.00 pm

Thoughts for the future – moving forward with uncertainty:

- Insights from the science/model Ken H/Ken T 2.15 pm
- Insights from the management Bryan Jenkins 2.25 pm
- Insights from the community Kelvin Coe, Mayor SDC 2.35 pm
- Insights from Ngāi Tahu Jason Arnold 2.55 pm

**Afternoon Tea NIWA sponsored 3.15 pm**

Developing future pathways:
– breakout groups – examine scenarios in light of lake level mgt options 3.30 pm
- report back and overall discussion 4.30 pm

**Drinks and dinner at Lincoln University 5.00 pm**

Evaluation of the overall sustainable pathways approach and a recommended way forward :

- Evaluation panel (B Jenkins, KH, KT, K Coe, NGĀI TAHU, DOC) 6.30 pm
- DISCUSSION – open session to clarify and see if roughly right 6.50 pm
- Break out groups – how to make the system work, including not just the opening and closing but all the other bits and pieces (e.g., riparian work) 7.00 pm
- Report back and take home messages 7.45 pm
- Overall discussion and wrap up 8.15 pm
- FINISH 8.30 PM