Te Mana o Taiari salinity monitoring

Shane Orchard

Prepared for

Department of Conservation
June 2022

Cover photograph:
Lake Waipōuri.
Photo: S. Orchard

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Report WL22062 for Department of Conservation

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PART 1 PARTICIPATORY SALINITY MONITORING

Background

Ngā Awa river restoration programme

Te Mana o Taiari is a project within the national Ngā Awa programme established by the Department of Conservation (DOC). It is applying a collaborative ki uta ki tai (mountains-to-sea) approach to restore river environments through the identification, planning and implementation of new co-management models with tangata whenua and other stakeholders (Department of Conservation 2021).

National objectives for the Ngā Awa programme include:

- improving the condition, biodiversity and the ecological processes of the rivers
- protecting the threatened species that are present
- increasing the ability of each river to cope with climate change

The national programme consists of 14 priority river catchments. Within each of the Ngā Awa catchments the national objectives are being refined and contextualised by the project partners with the support of technical advice on key issues.

Te Mana o Taiari

The Taiari catchment was chosen for the Ngā Awa programme in Otago following a site selection process that considered:

- the headwaters were in a natural condition
- sections of the catchment nearer the coast (lowland areas) were in good conditions
- important ecosystems were present and/or taoka species
- catchments have some factors that could be fixed or improved

Te Mana o Taiari is now in its early stages of development. Initial work between DOC, Ōtākou Runaka, Kati Huirapa Runaka ki Puketeraki and Otago Regional Council has identified the need for Matatū ki te Taiao - a climate resilience strategy - as a key overarching component. Within the context of Ngā Awa river restoration it will help to identify and contextualise climate change impacts and prioritise restoration needs in the catchment.

Salinity monitoring framework

Overview

The lower Taiari is characterised by extensive lowland wetlands and floodplains many of which are strongly tidal despite being located many kilometres from the open ocean. To support Ngā programme objectives in the lower catchment a salinity monitoring project is being developed. Salinity information is useful for a range of resource management applications including the assessment of estuarine environment types and to investigate the tolerances and sensitivities of characteristic species. An understanding of the spatial extent of different salinity zones within the catchment also provides a useful baseline measure for the evaluation of future conditions and their potential impacts on the environment types and resources that are currently present. In this regard, salinity measurements will help to inform resilience to sea-level rise considerations within Te Mana o Taiari Matatū ki te Taiao . For example, they will help to address the topic of salt water intrusion into coastal freshwater systems with rising sea-levels.

The salinity monitoring project is also designed around training and participation opportunities for local community members and conservation field staff involved in Te Mana o Taiari. In this way it can support skills and capacity-building in aspects of environmental monitoring that are important to cultural objectives such as guardianship and kaitiakitaka. A participatory dimension also facilitates the upscaling of data collection efforts as a form of citizen science and may help to raise the awareness of climate change and its specific challenges in the catchment.

These aspects are being supported through training workshops and the development of resources to enable a variety of community groups to participate in salinity monitoring activities. Initial participants including hāpu members and kaimahi engaged in the Te Nukuroa o Matamata project.

Components of the salinity monitoring project include a set of baseline surveys that will help to characterise the waterway network and inform the selection of sites for longer-term monitoring using data loggers (Figure 1). Initial site selection has been directed by local knowledge of the waterway channel network and access considerations. Over time this will be extended to a greater number of waterways and aquatic environment types. A selection of features of particular interest including salinity limits, mixing zones, springs and groundwater inputs may also be monitored over longer time frames (e.g., 5-yearly re-surveys).

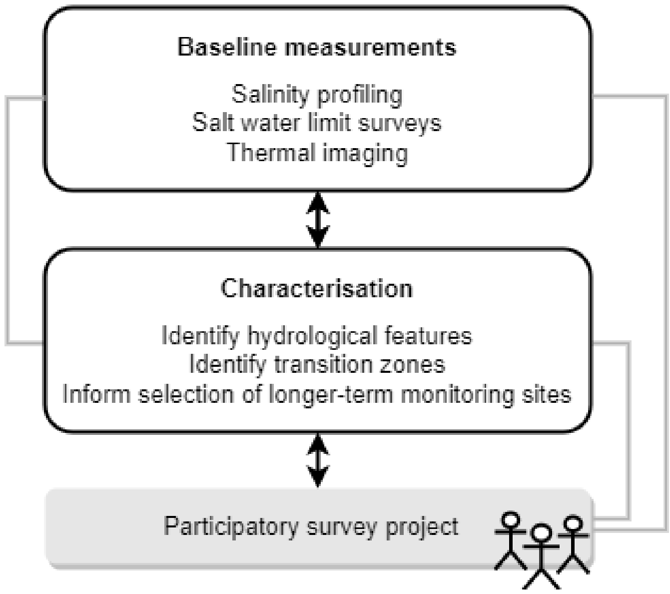

Figure 1 Participatory salinity monitoring model.

Monitoring activities

Baseline surveys

- **Salinity profiling surveys**
  These surveys use hand-held meters deployed from the bank or small boats such as kayaks. The objective is to assess salinity ranges and peak values across the waterway channel network at selected times of interest such as during spring high tides.
- **Thermal imaging**
  These surveys use a drone-based sensor to detect changes in water temperature. This will complement the salinity profiling surveys by helping to detect freshwater inputs (e.g., springs). Where these are detected additional profiling surveys are deployed to further characterise the extent and strength of the influence. One example was surveyed in the pilot study in Titiri Creek – see Section 2 for details.
- **Salt water limit surveys**
  These surveys use the salinity profiling method to iteratively zero-in on the upstream limit of salt water intrusion in individual waterway channels. Since this limit will vary on different combinations of tidal height and river flows, a standardised set of conditions are targeted with the general objective of establishing the furthest upstream position of this limit. For this purpose the conditions of most interest are the combination of spring high tides and low river flows.

Longer-term monitoring

- **Logger deployments**
  These surveys use arrays of salinity and water height loggers deployed over a full lunar tidal cycle (or longer) at selected monitoring sites. For each deployment period a suite of loggers will be deployed in a logical array to obtain concurrent data at locations and scales of interest across and within the wider catchment.

PART 2 PILOT STUDY

Overview

A pilot study was completed to gain an initial impression of salt water limits and inform the initial round of salinity logger deployments with Te Nukuroa o Matamata. The scope of the pilot study was limited to an initial characterisation of salinity conditions in five study areas (Figure 2). Each study area was centred around a discrete waterway channel although these differed considerably in their size and also included a portion of Lake Waipori /Waipōuri, an embayment in Lake Waihola /Waihora, and other confluence areas. [Note that alternative names are in common usage – locally preferred names are used hereafter]. Each study area was surveyed either once or twice to establish a picture of the salinity conditions on a spring high tide. The location of the salt water limit was estimated for four of the study areas which are inflowing freshwater waterways. The remaining study area (Titiri Creek) is an estuarine channel that connects Lake Waihora with the lower Waipōuri River, and is one of several outlet channels (Figure 2)

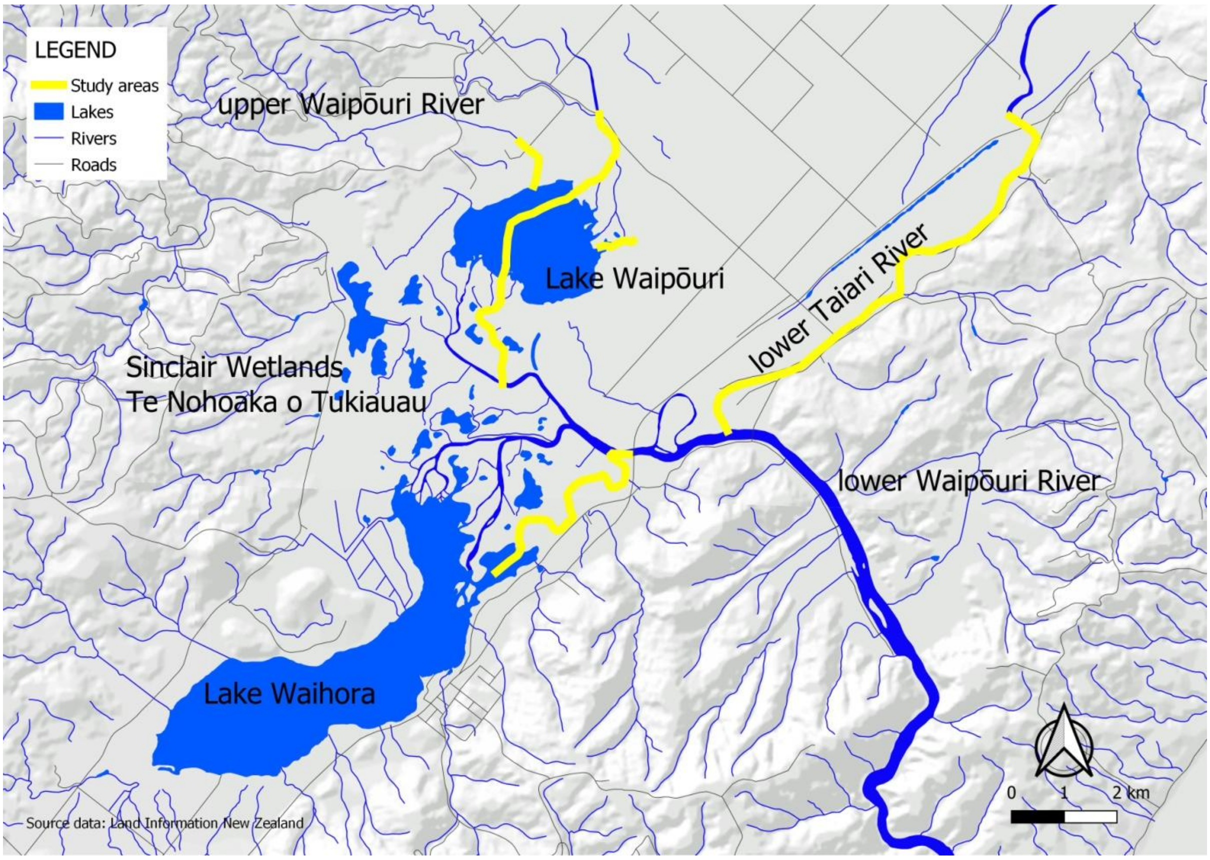

Figure 2 Location of the study areas selected for the salinity pilot study.

Methodology

Study sites and dates

Study sites were chosen on the basis of their tidal characteristics, feedback from project partners and accessibility as assessed in preliminary site visits.

Access logistics were assessed for several parts of the lower catchment upstream of the Taiari – Waipōuri confluence and water level height fluctuations used an initial guide of tidal extent based on visual observations completed at high tide. Surveys were then planned to coincide with spring high tide events in settled weather conditions, although some storm measurements were also made at bank-based locations. This scoping process resulted in two survey periods being chosen, the first in early February and the second in mid April.

Spring high tide heights as predicted for Green Island were 2.1 m in the February surveys (Table 1), and slightly lower in the April survey period (Table 2) during which the weather was more unsettled. Fortunately, a calm day on 17 April allowed for an extensive kayak-based survey of the Lake Waipōuri waterways and the maximum salinity values observed at most of the monitoring sites were recorded in that survey.

Table 1 Tidal height data for surveys in early February 2022 (Source: LINZ).

Date	Time	High tide height* (m)	Survey locations
1 Feb	0337	2.1	Taiari mainstem
1 Feb	1556	2.0	
2 Feb	0521	2.1	Taiari mainstem, Titiri Creek
2 Feb	1648	2.0	
4 Feb	0611	2.1	Titiri Creek
4 Feb	1633	2.0	

* predicted tide levels above Chart Datum at Green Island (Lat. 45° 57' S Long. 170° 23' E). Source: LINZ.

Table 2 Tidal height data for surveys in April 2022 (Source: LINZ).

Date	Time	High tide height* (m)	Survey locations
15 Apr	0337	1.9	Contour Channel, Lake Waipōuri, outlet channels
15 Apr	1556	1.9	
16 Apr	0212	1.9	Lee Creek, Contour channel, Meggat Burn
16 Apr	1429	2.0	
17 Apr	0255	2.0	Contour Channel, Lake Waipōuri, Meggat Burn
17 Apr	1515	2.0	

* predicted tide levels above Chart Datum at Green Island (Lat. 45° 57' S Long. 170° 23' E). Source: LINZ.

River flows were low across the catchment in both of the survey periods. For example, at Otago Regional Council's Taiari River monitoring site at Outram, the flow was around 3.5 cumecs in the February surveys, and around 4.5 cumecs in the April surveys despite a period of rain with elevated flows having occurred in the intervening period (Figure 3).

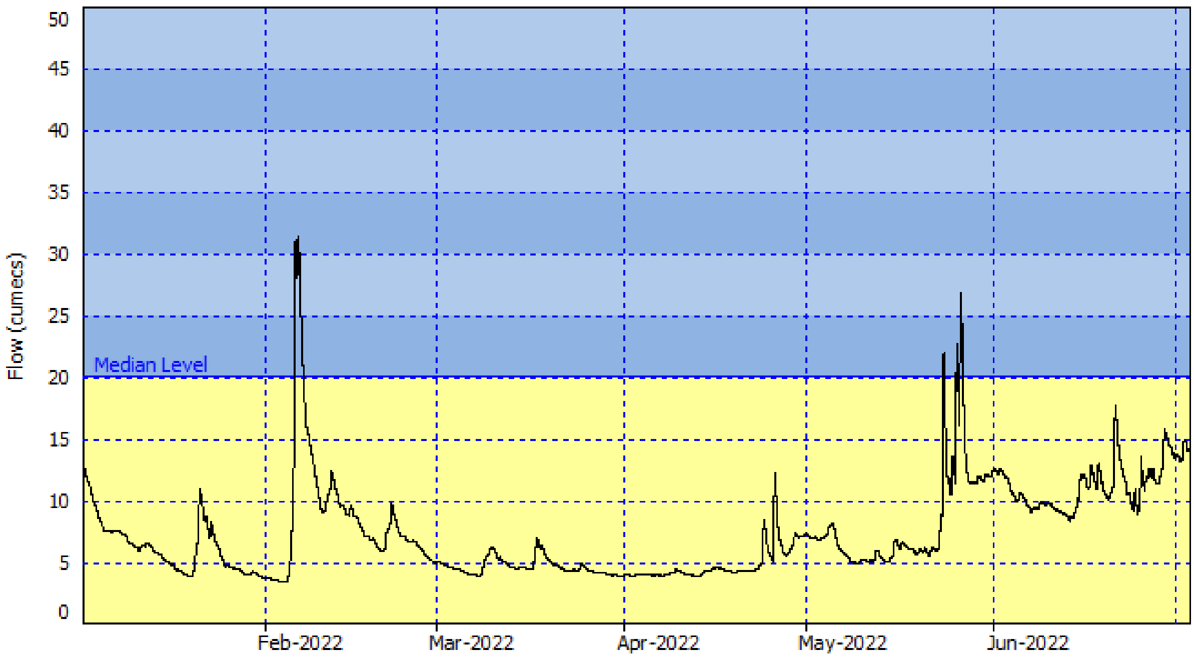

Figure 3 River flows in the Taiari River at Outram. Source: Otago Regional Council.

Taiari mainstem

Surveys were completed on 1 and 2 February 2020. In the 1 February survey the main objective was to estimate the position of the salt water limit. Six monitoring stations were established over a survey reach length of ~4 km, all accessible from the road on the true left bank. In the 2 February survey the main objective was to establish the peak value at the Henley bridge (on Henley Berwick Road) using repeat measurements taken every few minutes on the incoming tide at three positions across the channel.

Titiri Creek

A profiling survey was completed in Titiri Creek on 4 February 2020 following preliminary site visits in the days prior. This survey used a kayak to obtain measures on the incoming tide beginning from the Waipōuri mainstem downstream from the Titiri Creek confluence and continuing upstream via the Titiri Creek channel to Lake Waihora. The survey was timed to capture top of the tide measurements in the vicinity of the Titiri Creek footbridge. Because the upstream section of this waterway ends at Lake Waihora which has saline conditions, identifying the salt water limit was not a component of this survey. Instead its focus was on establishing the salinity characteristics of the channel in relation to a groundwater source that was discovered in the preliminary survey.

Lake Waipōuri waterways

The remaining study areas are associated with Lake Waipōuri and include both inflowing and outflowing channels. It is important to note that there are also several unsurveyed waterways present in this area and the channel network is further nuanced by emphemeral flow paths that are active at higher water levels.

In the lake outflow area there are two major channels draining the lake to seaward. These channels meet ~ 1.5 km downstream from the lake to become the lower Waipōuri River. The smaller (eastern) channel was included in the survey and the confluence point with the western channel marked the downstream limit of the survey area (Figure 2). The three largest inflowing waterways (Contour Channel / upper Waipōuri River, Lee Creek, Meggat Burn) were also included in these surveys.

Survey methods

For each survey area a series of monitoring sites was established along the reach using a desktop GIS or from GPS points captured in the field. Each survey began before the time of high tide as estimated from the predicted tide levels for Green Island and consideration of the time delay for tidal propagation inland in the Taiari system. Measurements were taken periodically at each monitoring site using a hand-held meter (YSI Model 30, YSI Inc., USA) with the probe positioned at the bottom and 10 cm from the top of the water column. Depending on the study site the probe was deployed from a kayak, the river bank, or a bridge across the channel.

Some of the surveys focused on measuring the upstream limit of salt water on the top of the tide if its general vicinity had been established prior. Other surveys focused on capturing a longitudinal salinity profile along the length of a selected channel. This can help build up a picture of the salinity environment and potential location of the salt water limit.

A common feature of all surveys is that the maximum salinity value for the tide being measured can be established at only a single location. This location must be either predetermined as part of a survey strategy involving repeat measurements at that site, or worked out on-the-fly using clues such as water level changes and current patterns to assess the timing of the top of the tide.

In some locations (e.g., Lee Creek) the occurrence of deeper pools create additionally opportunities to sample peak salinity values after the top of the tide where a layer of higher density saline water remains relatively undisturbed for a period of time on the outgoing tide. Such pools have the potential to retain salinity values that reflect inputs from a previous tide that may have occurred during the night or day before (and potentially even greater periods of time).

Results and discussion

Taiari mainstem

In the 1 February survey each monitoring site was measured three times, initially on the incoming tide (Table 3). The top of the tide, as assessed using observations of the current reversal pattern, occurred in the vicinity of site 4 at 1810 and the measurement taken at that time is close to the peak salinity value experienced at that location. All other measurements underestimate the peak salinity value due to having been captured either before or after the top of tide (Table 3). At site 5, for example, the measured salinity was never greater than the background level of 0.1 ppt for this waterway, but the tidal salt water limit was thought to have been close to this position on the top of the tide (Figure 4). On larger spring tides it is likely that the salt water limit could be a little further upstream in the vicinity of the SH1 bridge based on these observations.

In the 2 February survey the main objective was to establish the peak value at the Henley bridge (Table 4). Sampling from the bridge also allowed all of the channel to be accessed to check for deeper areas that would be likely to have higher salinity values. However, the bottom salinity value was similar between the three monitoring sites (left, centre, right) consistent with a relatively even depth across channel (Table 4). At the top of the tide a slightly higher value was attained on the left and right in comparison to the channel centre and there was a small delay in the timing of this peak as well.

These observations are the result of eddy effects after the current direction had turned in the centre of the channel.

The combination of the two surveys resulted in representative 'peak' values being captured at two of the monitoring locations. The peak values recorded on 2 February for Henley bridge were noticeably higher than recorded in the previous survey on 1 February which captured top of tide measurements further upstream. In that survey the highest measurements taken at the Henley bridge (site 1 in Table 3) were recorded around 20 minutes later after the tide had turned. Repeat measurements at Henley bridge on 2 February showed that salinity readings climbed steadily on the incoming tide before declining rapidly after the top of the tide, consistent with the 1 February observations.

Table 3. Maximum bottom salinity recorded at six monitoring sites in the lower Taiari mainstem on 1 February.

Site	Time	NZTM coordinates		Salinity	Temp
		X	Y	(ppt)	(°C)
1	1832	1382787	4907089	6.4	19.9
2	1838	1381050	4904770	6.2	19.6
3	1844	1380688	4904471	0.7	20.8
4	1810	1381983	4905567	0.7*	20.7
5	1815	1382861	4906829	0.1	21.1
6	1820	1382787	4907089	0.1	21.2

* close to estimated peak value for this tide based on observed current patterns

Table 4. Maximum top and bottom salinity recorded at the Henley bridge in the lower Taiari on 2 February 2022. For this survey the three monitoring points were measured every few minutes on the incoming tide. Salinity values shown are the maximum recorded for this tide.

Site	Time	NZTM coordinates		Salinity (ppt)		Temp (°C)	
		X	Y	Top	Bottom	Top	Bottom
Left	1847	1380307	4904247	2.4	11.2	18.9	19.6
Centre	1838	1380318	4904229	2.3	10.7	18.7	19.6
Right	1847	1380326	4904210	2.3	11.1	18.9	19.6

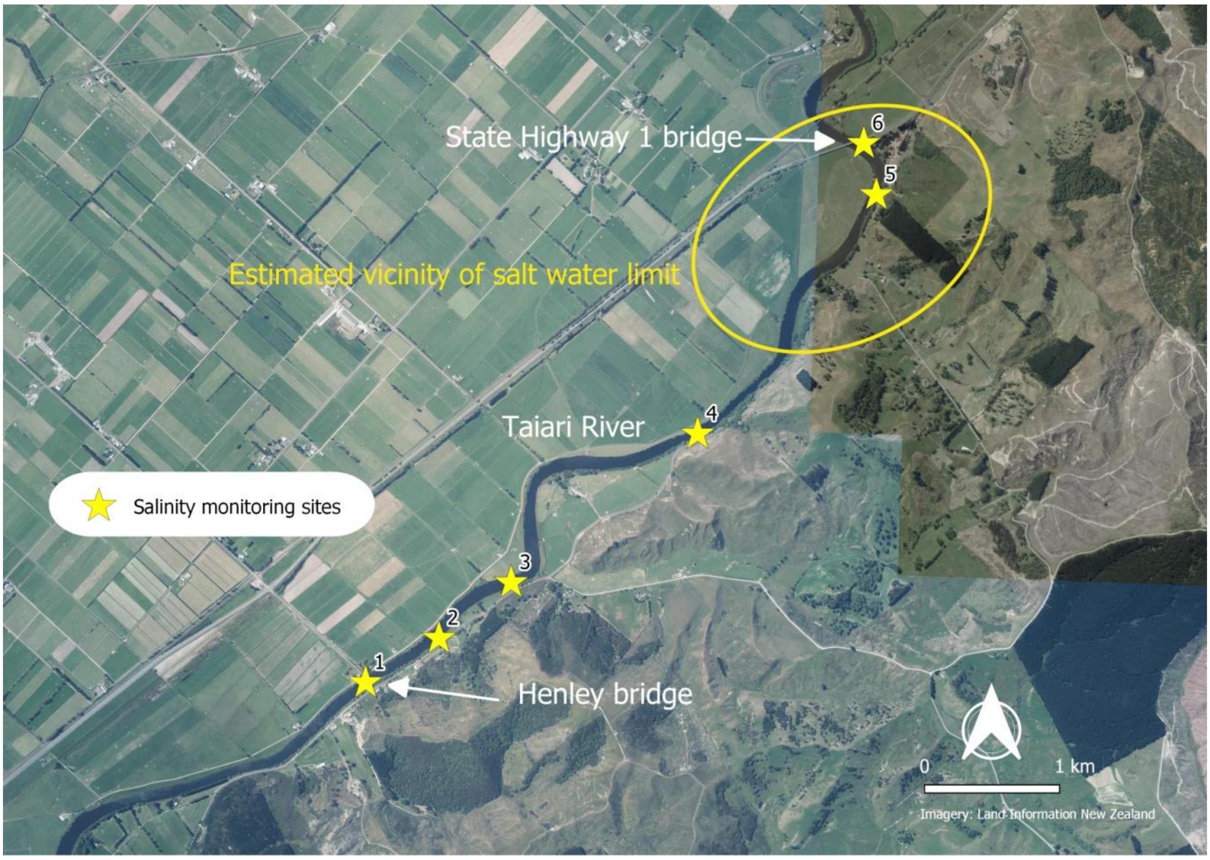

Figure 4 Location of salinity monitoring sites used in surveys of the lower Taiari mainstem on 1 and 2 February 2022. This is an example of a large survey area that was surveyed with the objective of narrowing down the vicinity of the salt water at the top of the tide.

Titiri Creek

The 4 February survey of Titiri Creek covered the reach between the Waipōuri River confluence and Lake Waihora, which is essentially all of this tidal channel. In this case the survey was timed so that peak values would be recorded in the vicinity of the Titiri Creek footbridge which is located in the middle of the survey reach (Figure 5). As with the Taiari mainstem surveys the peak values were only recorded at the locations coinciding with the timing of the top of the tide, but the presence of relatively saline water upstream in Lake Waihora also meant that the salinity values did not fall as rapidly as seen in the Taiari after the tide had turned.

A notable feature of this study area involves the influence of a groundwater source that was detected in the preliminary survey on 2 February in the area around the Titiri Creek footbridge. These observations showed a reversal of the typical vertical stratification pattern where the more dense saline water will sit on the bottom. Results from the 4 February survey also showed this effect with the bottom salinity being *lower* than at the top of the water column at two of the monitoring sites (Table 5). This suggests that the groundwater source is located on the stream bed and probably involves a cluster of springs in this area. This groundwater source also appears to affect salinity values further upstream for several hundred metres resulting in an area of lower peak salinity values in comparison to higher values recorded both upstream and downstream (Figure 5). Although the configuration of the springs involved requires further work to establish, these initial results suggest that an appreciable volume of groundwater is entering the tidal system in this area.

Table 5 Maximum top and bottom salinity recorded at 20 monitoring sites in the Titiri Creek area on 4 February 2022. The shaded sites (located in the vicinity of the Titiri Creek footbridge) show a reversal of the typical vertical stratification pattern as seen elsewhere that indicate groundwater inputs to channel.

Site	Time	NZTM coordinates		Salinity (ppt)		Temp (°C)	
		X	Y	Top	Bottom	Top	Bottom
1†	910	1377639	4902657	17.1	17.6	19	19
2†	930	1377446	4902609	17.3	17.6	19	19
3†	950	1377351	4902590	16.4	17.1	19	19
4	1000	1377532	4902499	17.3	17.5	18.8	18.8
5	1018	1377611	4902277	13.3	16.8	18.9	19
6	1025	1377439	4902161	12.1	15.4	19.1	19.2
7	1030	1377306	4902311	7.8	12.4	19.2	19.5
8	1025	1377051	4902239	7.2	10.5	19.4	19.5
9	1040	1376860	4902053	6.7	7.8*	19.6	19.7
10	1045	1376908	4901849	6.7	6.6*	19.7	19.7
11	1050	1376925	4901708	6.6	6.5	19.6	19.7
12	1055	1376725	4901572	5.6	6.4	19.4	19.7
13	1100	1376606	4901693	4.5	5.9	18.3	19.6
14	1158	1376423	4901698	5.2	5.3	18.6	18.6
15	1110	1376270	4901654	5.5	5.5	18.7	18.7
16	1115	1376248	4901514	5.6	5.6	18.9	18.9
17	1120	1376265	4901379	5.4	6	18.8	19.4
18	1124	1376207	4901259	4.7	7.7	18.3	20.3
19	1138	1376114	4901158	4.7	10	18.3	20.6
20	1133	1375976	4901020	4.3	9.5	18.2	19.7

† these sites were sampled at three positions across the channel and the maximum values shown here. All other sites were sampled at a single position in the centre of the channel
* close to estimated peak value for this tide based on observed current patterns

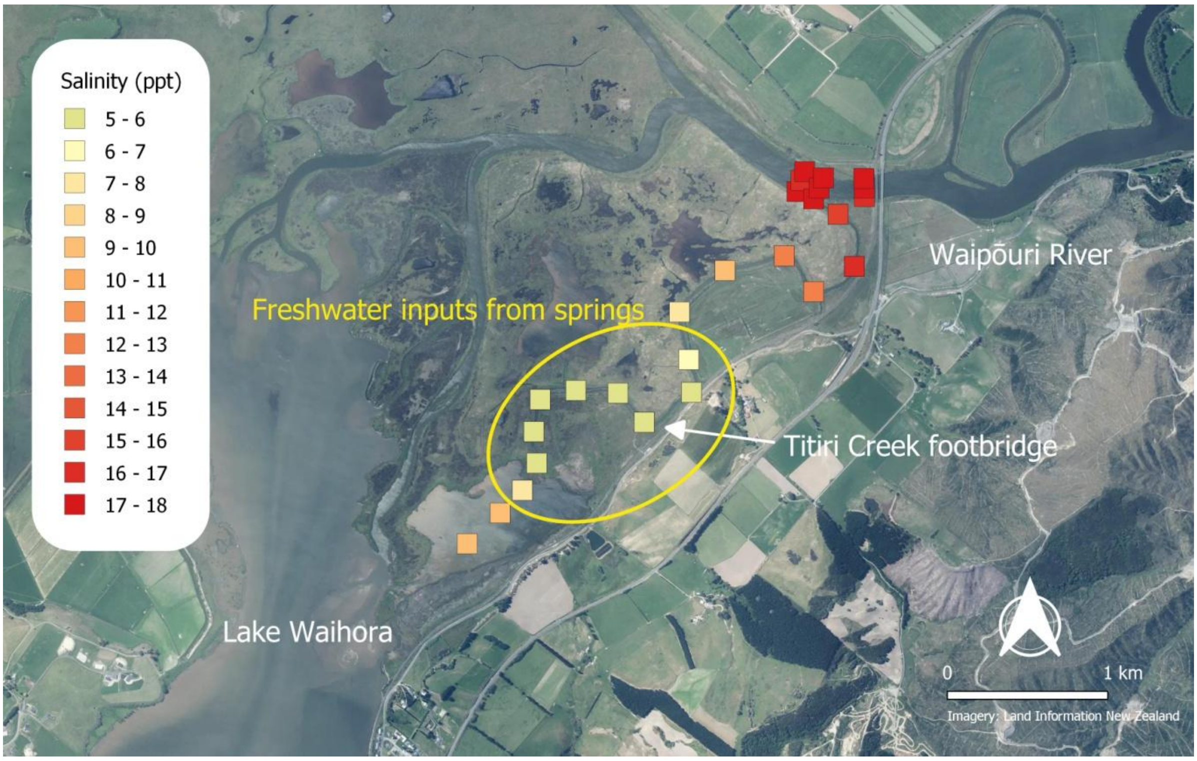

Figure 5 Maximum bottom salinity values recorded during a salinity profiling survey of Titiri Creek on 4 February 2022. Freshwater inputs from springs were detected in the vicinity of the Titiri Creek footbridge.

Lake Waipōuri waterways

Several visits to Contour Channel at its confluence with the upper Waipōuri River established that the salt water limit lies in this vicinity with a combination of spring high tides and low river flows. However, only low salinity values (< 1ppt) were recorded between the confluence and Lake Waipōuri. The lake acts as a mixing basin that regulates the reach of the tide further upstream. A survey on 15 April showed that the salt water had spread out across the bottom of the lake and only just reached the northern shoreline that day. A strong south-west wind on 16 April had the effect pushing more saline water across the lake from the south which was detected as higher salinity values in the northern inflowing waterways and with less vertical stratification in the water column. This effect had reduced by the following day with the vertical stratification becoming re-established in Lake Waipōuri.

Waipōuri River

A kayak-based survey on 17 April generally recorded higher salinity values than observed in a similar survey on 15 April at many of the same monitoring points (Table 6). These higher values were expected due to the 17 April tide being a bigger spring tide (Table 2). The estimated timing of the top of the tide was observed in the eastern outlet channel approximately 100 m from the lake during the 15 April survey (Table 6a). For the 17 April survey it was observed at the entrance to this outlet channel on the southern shoreline of the lake (Table 6b). All other measurements in Table 6 therefore underestimate the peak salinity values to an unknown degree. However, the overall trend was consistent between surveys and involves incoming tidal waters with a bottom salinity of 5 ppt or higher flooding into Lake Waipōuri from the south. A salinity front then spreads across the lake in a northerly direction generally following the alignment of shallow channel network that characterises the lake. A visual representation of observed maximum values from combined survey results is shown in Figure 6.

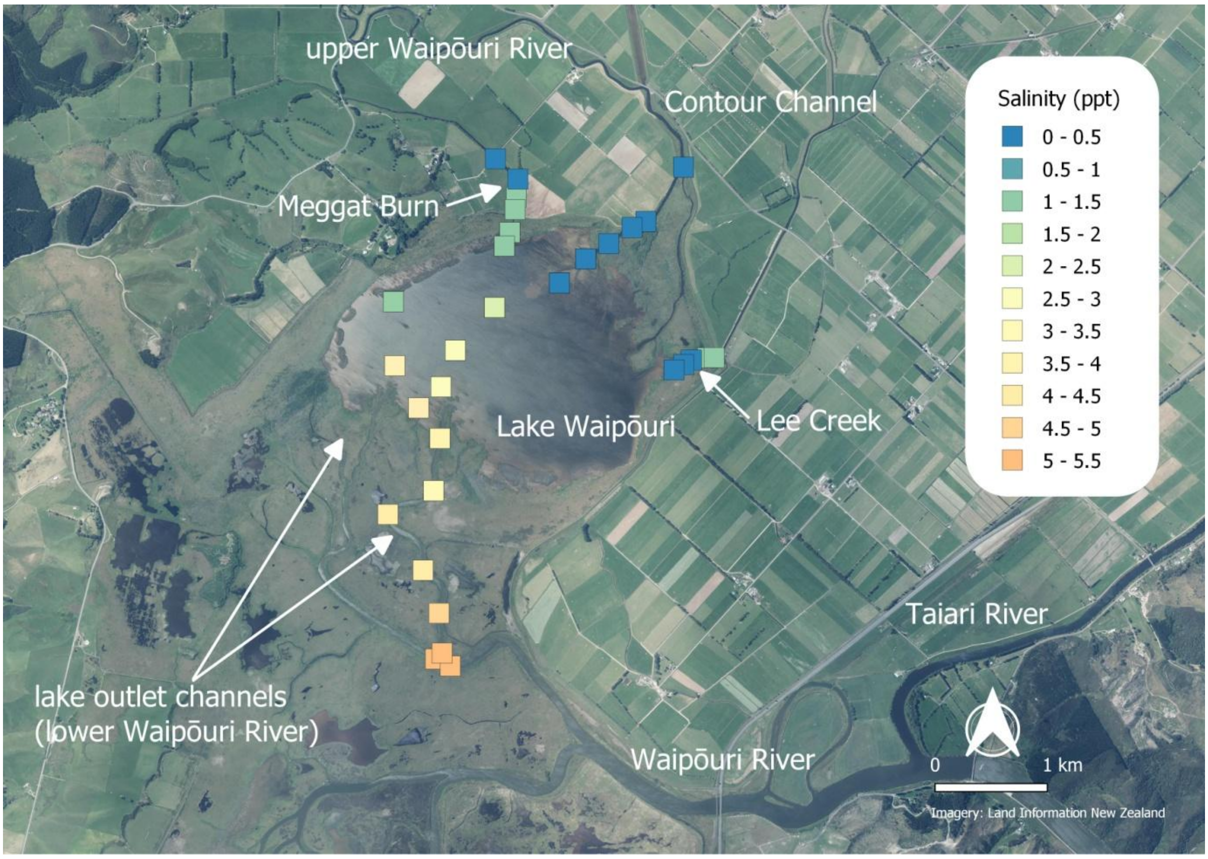

Figure 6 Maximum bottom salinity values recorded during salinity profiling surveys of inflowing waterways and the eastern outlet channel of Lake Waipōuri during the period 15-17 April 2022.

Table 6 Contour Channel and Lake Waipōuri surveys.
(a) Maximum top and bottom salinity recorded at 13 monitoring sites in Contour Channel and Lake Waipōuri on 17 April 2022.

Site	Time	NZTM coordinates X	NZTM coordinates Y	Salinity (ppt) Top	Salinity (ppt) Bottom	Temp (°C) Top	Temp (°C) Bottom	Location
1	1528	1304183	4831483	0.0	0.0	14.7	14.7	Contour Channel
2	1535	1377125	4906220	0.0	0.0	14.4	14.1	Contour Channel
3	1540	1377039	4906179	0.0	0.0	14.5	14.7	Contour Channel
4	1545	1376899	4906075	0.0	0.0	14.5	14.7	Contour Channel
5	1550	1376759	4905975	0.0	0.0	16.4	14.8	Contour Channel
6	1555	1376602	4905821	0.0	0.0	15.4	15.5	Lake Waipōuri
7	1724	1376205	4905655	0.5	2.4	14.7	13.7	Lake Waipōuri
8	1715	1375972	4905381	2.0	2.8	14.0	13.4	Lake Waipōuri
9	1623	1375891	4905152	3.0	3.0	13.1	13.1	Lake outlet
10	1630	1375896	4904834	3.1	3.6*	13.1	13.1	E outlet channel
11	1636	1375869	4904509	3.5	3.5	13.2	13.2	E outlet channel
12	1642	1375591	4904352	4.1	4.1	13.2	13.2	E outlet channel
13	1650	1375821	4904016	4.4	4.5	13.3	13.3	E outlet channel
14	1655	1375929	4903754	4.7	4.8	13.3	13.4	E outlet channel
15	1705	1375958	4903508	4.9	5.1	13.4	13.4	E outlet channel
16	1659	1375917	4903470	4.9	5.1	13.4	13.4	W outlet channel
17	1702	1376011	4903430	4.9	5.1	13.4	13.4	lower Waipōuri River

* close to estimated peak value for this tide based on observed current patterns

(b) Maximum top and bottom salinity recorded at 13 monitoring sites in Contour Channel and Lake Waipōuri on 17 April 2022.

Site	Time	NZTM coordinates X	NZTM coordinates Y	Salinity (ppt) Top	Salinity (ppt) Bottom	Temp (°C) Top	Temp (°C) Bottom	Location
1	0545	1377109	4907016	0.0	0.1	11.5	11.5	Contour Channel
2	0550	1304183	4831483	0.1	0.1	11.5	11.5	Contour Channel
3	0555	1377345	4906564	0.2	0.2	11.5	11.5	Contour Channel
4	0600	1377125	4906220	0.4	0.4	11.5	11.5	Contour Channel
5	0605	1376759	4905975	0.4	0.7	11.3	11.4	Contour Channel
6	0610	1376602	4905821	0.4	1.0	11.1	11.3	Lake Waipōuri
7	0615	1376205	4905655	1.3	1.4	11.5	12.2	Lake Waipōuri
8	0620	1375972	4905381	1.9	4.5*	11.8	12.4	Lake Waipōuri
9	0625	1375891	4905152	3.8	5.0*	11.8	12.5	Lake outlet
10	0631	1375896	4904834	4.0	4.3	11.9	12.1	Lake outlet
11	0642	1375757	4905017	3.3	3.6	11.6	12.3	Lake Waipōuri
12	0647	1375600	4905272	1.7	3.3	11.4	12.3	Lake Waipōuri
13	0702	1375577	4905668	0.7	1.2	11.5	11.5	Lake Waipōuri

* close to estimated peak value for this tide based on observed current patterns

The eastern and western outlet channels were sampled above their confluence and 100 m downstream of their confluence on 15 April on the outgoing tide. Similar salinity values were recorded at the bottom of surface of each channel (Table 6a). This suggests that conditions in the western channel are likely to be similar to the east through to its outlet at Lake Waipōuri.

Both channels have a sinuous character, generally incised banks and dense riparian vegetation, with water depths over 2 m at high tide. Canopy species include harakeke (*Phormium tenax*), te kouka (*Cordyline australis*), toetoe (*Austroderia* spp.), tall fescue (*Schedonorus arundinaceus*), raupō (*Thypha orientalis*), and sedges (*Carex* spp.) along with invasive willow (*Salix* spp.) and reed sweetgrass (*Glyceria maxima*). At the lake outlet these channels form adjacent delta features on the southern shoreline that contain many small islands and channel features on the southern lake shoreline (Figure 7).

Figure 7 Calm conditions in the eastern outlet channel of Lake Waipōuri on the high tide of 15 April 2022.

Lee Creek

A bank-based survey of Lee Creek in windy conditions on 16 April found the highest salinity values in a deep pool in front of the floodgate structure. This is consistent with higher salinity water having been trapped in the bottom of the pool (Table 7). This location is also the effective salt water limit in this waterway as expected due to the presence of the control gates. Lower salinity values were recorded downstream of this position during the 16 April survey even at the top of the tide. This suggests that the previous night's high tide may have been responsible for the observed salinity values at the upstream limit, and the time of this tide coinciding with the period of strongest south-west wind which would have influenced the degree of mixing and movement of tidal water across Lake Waipōuri towards the Lee Creek confluence (Figure 8).

Table 7 Maximum top and bottom salinity recorded in the lower section of Lee Creek on 16 April 2022.

Site	Time	NZTM coordinates		Salinity (uS)		Temp (°C)	
		X	Y	Top	Bottom	Top	Bottom
1	1802	1377578	4905394	968	1431*	14.1	13.8
2	1728	1377537	4905391	1058	1227	14.1	14.0
3	1731	1377496	4905401	797	1018	14.4	13.9
4	1734	1377474	4905400	618	610	14.2	14.1
5	1737	1377437	4905374	560	536	14.2	14.1
6	1740	1377391	4905344	552	560	14.2	14.0
7	1746	1377332	4905309	548	556	14.2	14.1

* close to estimated peak value for this tide based on observed current and channel depth patterns

Figure 8 Lee Creek. (a) Monitoring site in the lower section with Lake Waipōuri visible downstream. (b) Channelised section upstream of Henley Berwick Road.

Meggat Burn

A brief survey of Meggat Burn was undertaken on the return leg of the 17 April kayak-based survey. Although the first measurements were taken approximately 1 hour after the top of the tide, the confluence area has several localised deep spots that can trap saline water similar to the Lee Creek example discussed above (Figure 9). Despite being less than peak values the measurements are useful for narrowing down the vicinity of the salt water limit in this waterway. It is likely to be located near the bridge on a farm track approximately 500 m upstream from the lake (Site 6 in Table 8) which was slightly above the salt water limit that was observed (Table 8).

Table 8 Maximum top and bottom salinity recorded at six monitoring sites in Meggat Burn on 17 April 2022. As this survey commenced approximately 1 hour after the top of the tide it did not capture peak salinity values from this tide.

Site	Time	NZTM coordinates		Salinity (uS)		Temp (°C)	
		X	Y	Top	Bottom	Top	Bottom
1	0718	1376252	4906036	1202	1778	11.3	11.9
2	0742	1376315	4906341	270	1120	10.7	11.6
3	0738	1376310	4906265	433	1020	10.6	11.4
4	0734	1376283	4906122	871	922	11.1	11.3
5	0730	1376178	4906573	107	145	10.4	10.5
6	0726	1376321	4906453	89	89	10.1	10.1

Figure 9 Meggat Burn. (a) confluence with lake Waipōuri. (b) Royal Spoonbills / Kōtuku ngutupapa (*Platalea regia*) roosting on the confluence islands.

References

Department of Conservation. (2021). *Ngā Awa programme engagement report 2020/2021*. Department of Conservation.