

Mahinga Kai Exemplar

Baseline Survey 2015

Prepared by

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List of Abbreviations

CCC	Christchurch City Council
DOC	Department of Conservation
ECan	Environment Canterbury
GIS	Geographical Information System
MfE	Ministry for the Environment
MKE	Mahinga Kai Exemplar
NZCPS	New Zealand Coastal Policy Statement
RMA	Resource Management Act 1991
UC	University of Canterbury

Contents

1. Scope.....	1
2. Mahinga Kai Exemplar project	1
3. Characteristics of the site.....	2
4. Management context.....	4
5. Methods.....	5
5.1 Review of existing information	5
5.2 Field survey methods	5
Broad scale habitat mapping.....	6
Data capture and processing	6
Vegetation classification	6
Fish surveys.....	7
Salinity measurements.....	7
6. Results.....	8
6.1 Data gaps	8
6.2 Te Ngahere - Vegetation.....	9
Vegetation pattern	9
Invasive species	9
Ngāi Tahu taonga species and notable trees	9
6.3 Ngā manu - Avifauna.....	11
6.4 Ngā ika - Fish species	13
Fish surveys.....	13
Inanga spawning sites.....	15
6.5 Ngā puna – Springs.....	16
6.6 Mātai arowai - Hydrology	16
6.7 Wai tai - Salinity	16
7. Discussion and recommendations	19
7.1 Study limitations.....	19
7.2 Vegetation succession and lag times.....	19
7.3 Salinity changes.....	19
7.4 Monitoring.....	20
7.5 Recommendations.....	20
9. References	22
Appendix 1 Vegetation types of the MKE	23

Appendix 2 Combined results from CCC water bird counts at Travis Wetland and Anzac Drive Reserve, 2011-2012. Data courtesy of CCC..... 24

Appendix 3 Combined results from CCC water bird counts at Travis Wetland and Anzac Drive Reserve, 2013-2015. Data courtesy of CCC..... 26

Appendix 4 Salinity and temperature ranges over a spring tide sequence in Anzac Creek..... 28

Appendix 5 Data collection protocols **Error! Bookmark not defined.**



Swamp nettle (*Urtica perconfusa*) at the Mahinga Kai Exemplar site. The site is a local stronghold for this threatened species

1. Scope

The key objectives of this investigation were

- To identify an initial snapshot of biodiversity in the Anzac Drive Reserve – with particular focus on mahinga kai and taonga species, indicators of indigenous natural restoration, earthquake recovery, and ecological threats.
- To provide baseline information to support the promotion of natural restoration and associated activities as components of the Mahinga Kai Exemplar project (MKE).

For an initial biodiversity stocktake to support the MKE, the discovery and compilation of existing information was the first priority, followed by limited field survey. However, conditions at Anzac Drive Reserve have changed significantly since the earthquakes in response to altered ground levels and inundation patterns. The focus of field surveys was therefore to establish whether existing ecological information remains relevant to the current context, and associated with this, to identify major information gaps for a description of site in its current condition. In practice this meant only a limited number of taxonomic groups were considered in field surveys, with focus on documenting the major habitat types present in the new post-quake landscape.

2. Mahinga Kai Exemplar project

Background

The Mahinga Kai Exemplar is a joint project between Te Rūnanga o Ngāi Tahu, Ngāi Tūāhuriri Rūnanga, and the Avon Ōtākaro Network (AvON), with the assistance of many other organisations including CCC, ECan, DOC, and the Waterways Centre for Freshwater Management. The approach being taken is to develop an exemplar project at a peri-urban site that demonstrates how mahinga kai projects could be developed elsewhere.

The objectives of the project are:

- To restore and re-develop a mahinga kai in greater Christchurch to include recognition of cultural and heritage values, and restoration and enhancement of ecosystems, natural habitat, biodiversity, inanga spawning, pathway connections, stormwater treatment, land drainage, food production and active and passive recreation.
- To implement a mahinga kai exemplar project that could then be applied to other ecological and recreational reserves along the Avon River/Ōtākaro and Heathcote River/Ōpāwaho corridors from the city to sea.
- To use Anzac Drive Reserve as an exemplar mahinga kai site.

In the post-earthquake context the project also addresses the Natural Environment Recovery Programme for Greater Christchurch Project 17. This project seeks to 'Act on opportunities to restore and enhance mahinga kai', with Ngāi Tahu (Ngā Papatipu Rūnanga and Te Rūnanga o Ngāi Tahu) identified as the lead agency.

Mahinga Kai

Mahinga kai is a key Ngāi Tahu value for earthquake recovery and is an important aspect of the Ngāi Tahu Settlement Claim¹. Mahinga kai is the concept that exemplifies the complex, interconnected cultural beliefs and practices of Ngāi Tahu in relation to the environment, describing not only the species gathered but the places and practices involved in doing so. It includes the direct and indirect use of resources for ceremonial, medicinal and sustenance purposes.

Mahinga kai, meaning to ‘mahi ngā kai’ (work the food), is a management concept and way of thinking that involves the simultaneous protection and sustainable use of resources. Ngāi Tahu approach this from an integrated management model known as Ki Uta Ki Tai (from the mountains to the sea). Consequently, the concept of mahinga kai is interpreted in its broadest sense to include food for body, mind and spirit. Education, learning (‘food for thought’) and spiritual sustenance are thus as much a part of mahinga kai as the physical food, and techniques for management of mahinga kai resources are an essential aspect of the concept in practice.

Mahinga kai management and its associations are important to local whānau, hapū and rūnanga. Protecting, rehabilitating, enhancing and maintaining mahinga kai sites and resources, and the ability of Ngāi Tahu to access these, is critical. This is particularly true for Ngāi Tūāhuriri who hold mana whenua over the MKE site. Cultural harvest of any of these resources will occur only when the condition of the resource is appropriate.

3. Characteristics of the site

The MKE site is situated at Anzac Drive Reserve to the north of the Avon River/Ōtākaro. The reserve covers an area of approximately 16ha and is oriented north-south in a rectangular shape either side of Anzac Drive (Figure 1). The reserve is predominantly a wetland that provides ecological connectivity between the Ōtākaro/Avon River and Travis Wetland.

Two significant waterways are present, located either side of the road. In this report these are referred to as Anzac Creek, to the west, and Lake Kate Sheppard, to the east. The underlying landform suggests that these are natural ponding areas. Both have a history of modification in connection with housing developments, stormwater and flooding protection provisions, and road alignments. Lake Kate Sheppard has been artificially manipulated to create a permanent lake. Anzac Creek is connected to both the Ōtākaro/Avon River and to Lake Kate Sheppard via culverts, and is not directly connected to Travis Wetland. Instead, Travis Wetland is connected to Lake Kate Sheppard via a diagonal box culvert aligned underneath the QEII Drive roundabout, and otherwise connected to the Ōtākaro/Avon River via Corsers Stream. The complex set of hydrological connections is now a feature of the waterways at the MKE site.

Another significant aspect of the reserve is its relationship to other waterways and adjacent lands. In addition to providing for ecological connectivity between freshwater bodies and the Avon-Heathcote Estuary/Ihutai, the land in this vicinity is a natural low spot for the ponding of surface waters. Due to its position in relation to the coast, it is also susceptible to coastal inundation events. In terms of adjacent lands, the reserve is now bordered by Residential Red Zone land on both eastern and western boundaries. This creates opportunities to improve land and waterscape connectivity in the area, and to reconsider the role of the reserve in light of earthquake changes and future sea level rise.

¹ see Ngāi Tahu Claims Settlement Act 1998.

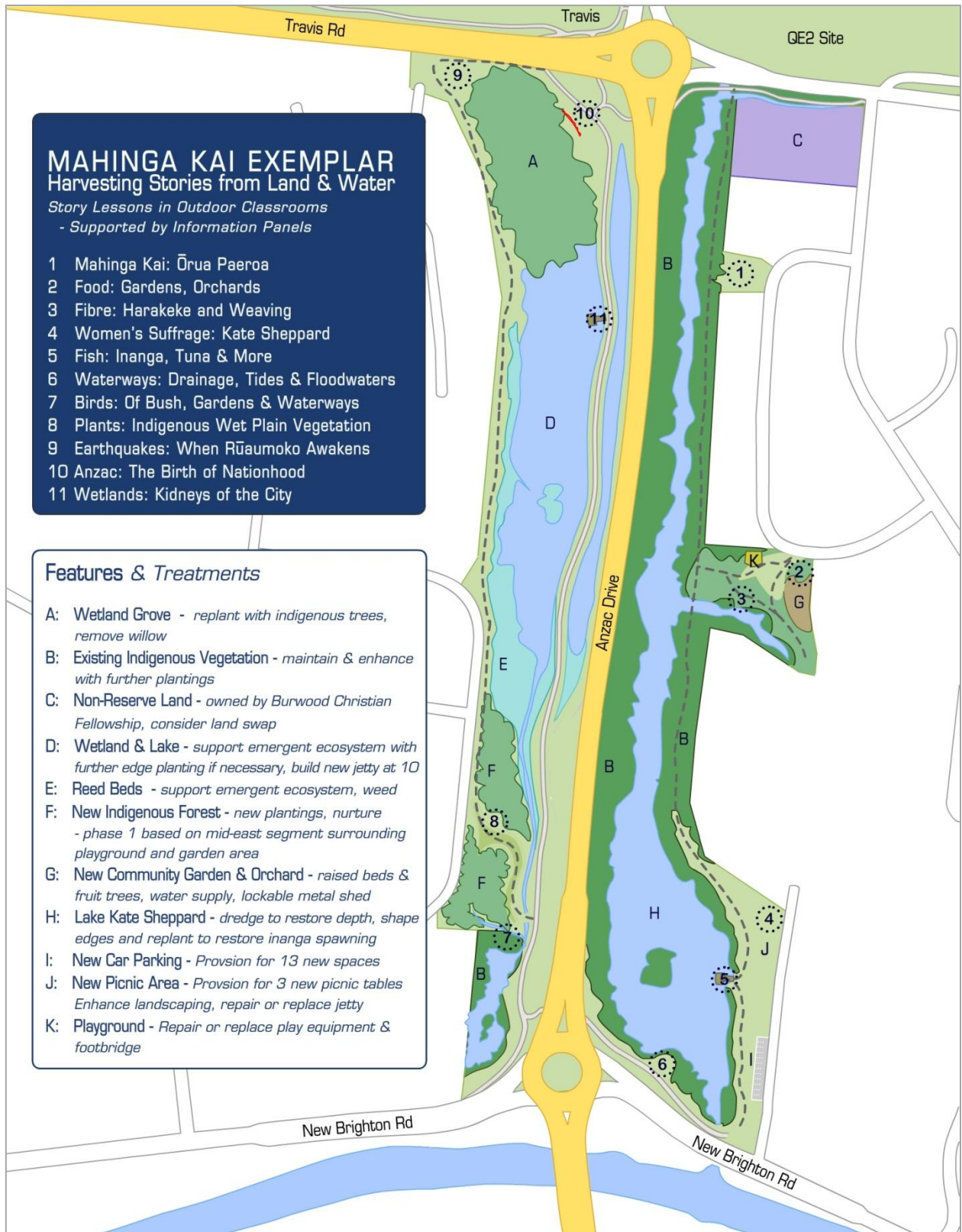


Figure 1. Mahinga Kai Exemplar site concept plan and map (March 2016 version). Source www.avon.org.nz

4. Management context

The MKE site is currently reserve land under CCC management. No specific management plan has been developed for the site to date. Management priorities are currently set under the Christchurch District Plan and CCC Parks and Reserves Bylaw 2008 in accordance with the Reserves Act 1977, Local Government Act 2002, and other relevant legislation. Day-to-day management is provided by the CCC Urban Parks Team (J. Skilton, pers. comm.). There are also additional aspects addressed by other teams within CCC in relation to waterway management and land drainage.

The wetland and floodplain habitats of the MKE site are of high ecological significance from several perspectives. At the national scale, wetlands are identified as priority areas for protection under the NZ Biodiversity Strategy 2000 and Resource Management Act 1991, and NZCPS 2010. Preservation of the natural character of wetlands and the coastal environment are among the matters of national importance identified under RMA s6a, as is the protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna under RMA s6c. The conservation of these environments is also specifically addressed in relevant NZCPS 2010 policies, including Policy 11 (Biodiversity) and Policy 13 (Preservation of Natural Character). The urgent need for action to protect wetlands and lowland forests is further highlighted in the Statement of National Priorities for Protecting Rare and Threatened Biodiversity on Private Land issued by DOC and MfE².

At the regional scale, the importance of Canterbury's floodplain and wetland habitats is also well recognised in both regional council documents and in the relevant DOC Conservation Management Strategy³. Other important planning documents include the Canterbury Biodiversity Strategy 2008⁴ and the Mahaanui Iwi Management Plan 2013⁵, both of which contain objectives that may be assisted by reserve management at the site.

In keeping with the national and regional context, CCC has identified the MKE site and other wetland, waterway, and riparian habitats as "Sites of Ecological Significance" in its recently notified Replacement Christchurch District Plan⁶. Several of the above documents also highlight cultural values which are significant at the site and additional information can be found in State of the Takiwā cultural values assessments conducted for the Avon-Heathcote Estuary/Ihutai catchment, and in the MKE Strategy and related documents.

² DOC & MfE (2007).

³ DOC (2014).

⁴ Available at <http://ecan.govt.nz/publications/Plans/BiodiversityStrategyFinalFeb08.pdf>

⁵ Available at <http://mkt.co.nz/mahaanui-iwi-management-plan/>

⁶ CCC (2015)

5. Methods

5.1 Review of existing information

Recent (post-quake) ecological information on the site was identified from the following literature:

- ECan (2015) Land and Water Regional Plan
- CCC (2015) Proposed Christchurch District Plan
- 2012 State of the Takiwā report (Lang et al., 2012)
- UC research on inanga spawning sites (Orchard & Hickford, 2016)
- UC student reports on Lake Kate Sheppard (water heights and some salinity data)
- Draft MKE Strategy (as at 29 February 2016)

Additional information on the site was acquired from the following sources:

- CCC water bird data for the combined unit of MKE site plus Travis Wetland
- eBird summary data for Travis Wetland
- NZ Birds online & NatureWatch NZ records
- LINZ Data Service
- NZ Freshwater Fish Database
- NIWA Environmental Information Browser

Personal communications with the following people provided further useful information:

- John Skilton (CCC) – reserve management
- Andrew Crossland, Kay Holder (CCC) – avifauna
- Paul Dickson, John Walters, Mike Bourke (CCC) – drainage & stormwater infrastructure
- Philip Grove, Helen Greenup (ECan) – vegetation & fish survey data
- Te Marino Lenihan – cultural landscape values
- Shelley McMurtrie (EOS Ecology) – aquatic ecology
- Mark Taylor (Aquatic Ecology Ltd) – aquatic ecology
- Sophie Allen (Working Waters Trust) – aquatic ecology
- Colin Meurk (Landcare Research) – plant ecology
- Ed Wilson (Wai Ora Landscapes) – pest plant species

5.2 Field survey methods

Field surveys were conducted for the following:

- habitat mapping based on vegetation patterns
- point data capture for invasive plants and other notable species not picked up in the above
- fish species occurrence
- salinity patterns

Field surveys conducted during 2015 as part of the UC Resilient Shorelines study also covered some sites within the MKE. These included inanga spawning site surveys and salinity measurements. Results from these surveys have been included here where relevant.

Broad scale habitat mapping

Field survey methods were based on broad scale habitat mapping recommendations in the National Estuary Monitoring Protocol (Robertson et al., 2002) following an approach similar to that used by ECan in the recent Canterbury coastal wetlands surveys with a focus on vegetation (Grove et al., 2012). At the date of this report only partial processing of the field data has been completed and a more complete description of broad scale habitat mapping procedures and results will follow in a future report.

In the design of field components particular attention was given to ensure consistency with the ECan surveys. These surveys did not include the MKE (P. Grove, pers. comm.) but covered a wide range of other coastal wetland sites in Canterbury. The nearest wetland included in that survey was Cockayne Reserve, which is the next prominent wetland area downstream from the MKE site in the Ōtākaro/Avon River catchment.

Mapping units were identified and described using an adaptation of the Atkinson (1985) system, based on the vegetation observed. Delineation of units was based on observed differences in dominant vegetation species. Boundaries between units were subjectively assigned in the field and recorded directly on field sheets. Percentage cover of the dominant species was estimated for each mapping unit as a using the procedures described by Grove et al. (2012).

The assessment was more difficult for habitat units comprised of a mosaic of patches of different vegetation. Although the relatively fine scale of the mapping units alleviated this in many cases, a subjective decision was required on the degree of subdivision of mapping units to capture finer detail. Threatened species, Ngāi Tahu taonga species, invasive species, and notable trees were recorded in the habitat units in which they occurred. In some cases the location of individual plants or small patches of interest was also recorded using a handheld GPS. Water bodies and areas devoid of vegetation were generally not mapped.

Data capture and processing

Following the field work component, mapped units were digitised in QGIS v2.8.7 (QGIS Development Team, 2015) using basemap imagery assisted by GPS waypoints to accurately delineate vegetation unit boundaries in the GIS. For complex vegetation mosaics, which are common at the MKE site, a follow-up field survey using the draft digitised map was required to accurately determine final boundary assignments and to promote consistency in the degree of lumping and splitting of units which shared many of the same species or were of patchy nature. In general, this approach generated a finer scale vegetation map than the majority of areas surveyed by Grove et al. (2012). This is appropriate given that the MKE site contains a relatively complex set of habitats that include several transition zones between the dominant plant communities. \

Vegetation classification

To produce an initial visualisation of vegetation patterns, a preliminary classification of the field data was conducted as a component of this study. Based on the field descriptions, mapped units were assigned to one of ten vegetation types based on the structural classes of Grove et al. (2012) that were considered to occur at the site. Mapped units were combined into a shapefile in GIS, processed to remove sliver polygons, and classified by vegetation type to produce a baseline map of vegetation patterns at the site. Further analysis to produce a hierarchical classification of vegetation types such as that developed for other Canterbury coastal wetland surveys will be conducted in the future. The creation of a metadata file to describe the classification process and associated shapefile attributes was outside of the scope of the present study but is also recommended.

Fish surveys

Two surveys were conducted using fish trapping techniques. Overnight sets were installed on 16 and 17 December 2015 when tides were suitable for evening installation followed by morning retrieval. The two survey locations were the eastern shore of Lake Kate Sheppard either side of the jetty, and the eastern shore of the upper Anzac Creek lake in the vicinity of the culverts connecting this water body with Lake Kate Sheppard (Figure 2).

In each survey two fyke nets and eight minnow traps were deployed oriented perpendicular to the shoreline at regular intervals with 20-30m spacings. Each net / trap was positioned to be fully submerged at low tide and was typically 5-10m from the low tide shoreline. All traps were baited with marmite and were retrieved the following morning.

Salinity measurements

Measurements of bottom and near-surface salinities (10 cm from the top of the water column) were taken on spring tides using a YSI 30 handheld conductivity/salinity/temperature meter. In these surveys the progression of the flood tide was followed upstream to establish the maximum upstream extent of saltwater intrusion following the methods of Richardson & Taylor (2002). Additional time series measurements were taken using Odyssey conductivity/temperature loggers deployed over approximately two week intervals. These loggers were secured on a concrete base with the probe positioned 10cm from the bottom to reduce the likelihood of sediment accumulating around and potentially blocking the probe.



Figure 2. Deploying a fyke net in the upper Anzac Creek catchment.

6. Results

6.1 Data gaps

From review of the existing information sources several major data gaps were identified (Table 1). Other information sources may exist but were not discovered within the time available.

Table 1. Data gaps relevant to restoration of ecological and cultural values at the MKE site.

Data gaps	Status
<i>Physical environment</i>	
Substrate	Existing databases are at broad scale relative to the site and largely reflect underlying landforms. Site-scale substrate information is difficult to derive from these sources and /or is unlikely to reflect the post-quake surfaces. Although no prior field surveys were identified from the MKE site, extensive sediment sampling has been conducted by UC, NIWA and others in the Avon-Heathcote Estuary/Ihutai that includes several post-quake studies.
Hydrology	Limited data has been collected by student projects at UC. A hydrodynamics model has been partially developed by a joint AvON / Engineers Without Borders project in Tuflow but remains uncalibrated. The site is generally not covered by other known hydrodynamic models developed for the Ōtākaro/Avon catchment (eg. NIWA Delft 3D model).
Salinity	Very little post-quake data exists with the exception of limited spring tide salinity data collected by UC.
Water quality	No data specific to the site was found.
<i>Biota</i>	
Vegetation	Very little post-quake data exists. The site was not covered in ECan coastal wetland surveys and was also outside of the scope of earlier CCC CREAS surveys.
Fish	Existing records are limited to a small survey for adult inanga conducted by ECan staff.
Birds	There is existing CCC data from waterbird counts but only a few casual observations were found for other bird species (eg. woodland birds).
Invertebrates	Few existing records.
<i>Cultural values</i>	
Mahinga kai values, wāhi tapu, wāhi taonga	Background information on mahinga kai and other cultural values at the site is found in the MKE Strategic Plan. The MKE site was not included in the 2012 State of the Takiwā assessment although some of the monitoring site locations are nearby, including Ōruapaeroa/Travis Wetland and at Owles Terrace on the Ōtākaro/Avon River. No other cultural values assessments specific to the site were found.

6.2 Te Ngahere - Vegetation

Vegetation pattern

In total, a little over 9 ha of floodplain and riparian habitats were mapped in this study. Additional habitats not mapped include submerged aquatic plant communities, and habitats not defined by vegetation (eg benthic communities) at the site. The most extensive vegetation type in terms of structural class was treeland (31.3%) which typically contains a mix of lowland and coastal species such as Ngāio (*Myoporum laetum*) and Tī kouka (*Cordyline australis*). Extents of the other types mapped were wīwī rushland (18.5%), grassland (15.5%) harakeke flaxland (10.8%), sedgeland (6.8%), shrubland (6.2%), reedland (2.5%), tussockland (0.7%), and other areas of sparse vegetation (5.2%).

Indigenous species were dominant over 78% of the area mapped. The exceptions were grassland and sparsely vegetated areas which are dominated by exotics, and relatively small patches of exotic treeland (1.7%) largely related to shared boundaries with residential properties in the past. Recent restoration plantings were mapped as shrubland in this study although they contain a mixture of species from rushes and sedges to shrub and forest species. A baseline map of the vegetation types present (Appendix 1) provides a resource for monitoring future change in the extent and spatial pattern of these habitats.

Invasive species

Infestations of selected invasive plants were recorded (Figure 3) with a focus on species for which immediate control measures were considered warranted. Other pest plant species are also present including yellow-flag iris (*Iris pseudacorus*) which currently occurs in relatively low densities in several parts of the site and is subject to periodic control (J. Skilton, pers. comm.).

Ngāi Tahu taonga species and notable trees

Ngāi Tahu taonga species are prominent at the site with extensive stands of wīwī rushland present, comprising mostly of *Juncus edgariae*, *J. pallidus*, and *J. sarophorus*. The exotic *J. effusus* was also observed in some areas though never in high densities. Harakeke (*Phormium tenax*) is also common, occurring both in extensive stands and as an associate in communities dominated by other species. Ngāio (*Myoporum laetum*) and Tī kouka (*Cordyline australis*) are also common at the site.

Other taonga species present include raupō (*Typha orientalis*) reedland which is largely limited to two patches located near the head of Lake Kate Sheppard and in a swale area adjacent to Anzac Drive. Koromiko (*Hebe salicifolia*) is present as is the Banks Peninsula endemic *H. strictissima* which appears to have been used extensively in the past in areas of landscaping such as in the vicinity of the Anzac Bridge. Other Ngāi Tahu taonga species observed include karamū (particularly *Coprosma robusta*), kōwhai (*Sophora microphylla*), pokākā (*Elaeocarpus hookerianus*), tarata (*Pittosporum eugenioides*), kōhūtū (*Pittosporum tenuifolium*), kāpuka (*Griselinia littoralis*), māpou (*Myrsine australis*), mānuka (*Leptospermum scoparium*), wī (*Poa cita*), toetoe (*Cortaderia richardii*), tōtara (*Podocarpus totara*), and kahikatea (*Dacrycarpus dacrydioides*).

In addition to the broad scale mapping, point data was captured for the lowland podocarps kahikatea (*Dacrycarpus dacrydioides*) and tōtara (*Podocarpus totara*) which were observed in several parts of the site (Figure 3). These records are not expected to be comprehensive as many of the trees were small and others may be present, but provide an initial set for monitoring. Some mortality of these species was noted at locations close to waterway margins. Across the site these trees are generally well spaced consistent with being planted in previous restoration or landscaping projects. There are also other canopy forming species present such as lowland ribbonwood / manutu (*Plagianthus regius*) and narrow-leaved lacebark / narrow-leaved houhere (*Hoheria angustifolia*). The five large oak trees near Anzac Creek were also noted.



Figure 3. Maps of two threatened species and three notable tree species from observations at the MKE site in December 2015 (left) and areas noted for control of pest plant species (right).

Threatened species

Substantial populations of two threatened species⁷ are present at the MKE; shrubby tororaro (*Muehlenbeckia astonii*) [Nationally Endangered] and swamp nettle (*Urtica perconfusa*) [Declining] (Figure 3). A small number of gossamer grass (*Anemanthele lessoniana*) [Nationally Vulnerable] are also present in boundary plantings along the eastern side in addition to *Hebe strictissima* [Naturally Uncommon] as mentioned above.

Several parts of the MKE site appear to be swamp nettle strongholds and there are more individual plants present than recorded in the point data presented here. Locations of particular note are along the eastern shore of Lake Kate Sheppard where several plants were found growing in association with harakeke and wīwī clumps, and at the small riparian wetland adjacent to the Anzac Bridge. The latter is a well protected area where swamp nettle is growing cryptically, being typically entwined in other vegetation.

⁷ see de Lange et al. (2012) for the latest NZ threat classification and DOC (2014) for information on threatened species in Canterbury.

Restoration plantings

During vegetation surveys high mortalities of restoration plantings were noted in some areas. These were investigated further on spring tides to ascertain a potential relationship with water levels (Figure 4). The results indicated that periodic inundation was occurring and in conjunction with measured salinities likely accounts for these observations. Not all species were affected, and the observed differences provide useful information for future restoration initiatives that would be beneficial to capture. A monitoring programme for planted areas is recommended, especially since peak tidal water levels and the extent of ponding areas following rainfall are difficult to ascertain in many parts of the MKE site. An adaptive approach informed by monitoring may assist to identify appropriate strategies.



Figure 4. A restoration area adjacent to Anzac Creek showing the recent tidal water level in relation to the area of planting.

6.3 Ngā manu - Avifauna

Few bird observations specific to the MKE could be found. However, large numbers of water birds are frequently observed at the site and CCC has a long term record of bird counts in the area from regular surveys (A. Crossland, pers. comm.). The most relevant dataset is a combined record of water birds from Travis Wetland and Anzac Drive Reserve. These data include observations of 46 bird species, including several introduced species such as Canada Goose which may be present in high numbers. Excerpts from the CCC dataset are presented in Appendix 2 (2009-2011) and Appendix 3 (2012-2015).

Records in the eBird database are not specific to the MKE. These records are compiled against discrete places to generate checklists and other summaries. Travis Wetland is the closest place to the MKE in the eBird system for which 59 bird species have recorded. These eBird observations also indicate that Travis Wetland is one of the top birding locations in the region. It is ranked 2nd highest for the number of species recorded at eBird localities over all years (Figure 5a), and was the site with the most species recorded over the past 12 months (Figure 5b).

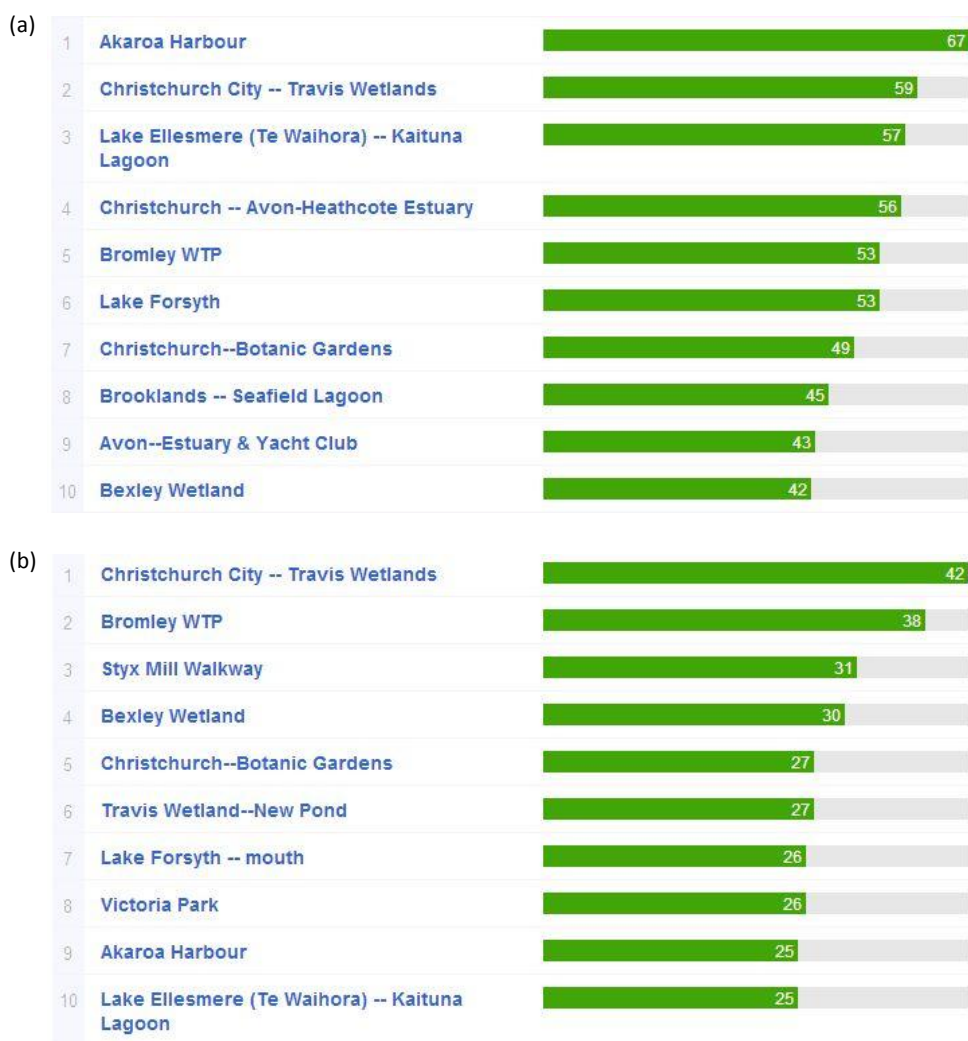


Figure 5. eBird records showing the number of species observed at birding locations in Canterbury. Each location is defined by a polygon in the eBird system. (a) all records. (b) 2015 records.

Although a relatively new development, the NatureWatch NZ database was also reviewed for bird species records. This was achieved by creating a new place, “Mahinga Kai Exemplar” in the underlying database, defined by a polygon. NatureWatch NZ functionality includes the ability to generate species lists from observations present in the database that occur in the place, and filter these by taxonomic groups. This analysis shows that 11 bird species have been recorded in the NatureWatch NZ database to date within the MKE site boundaries. This tool can be used in the future to support targeted monitoring and educational activities at the MKE, which could include bird counts along with other taxa.

As part of this project, an example resource for conducting bird counts at standard locations within the MKE was also created using NatureWatch NZ. This includes a “MKE Birds” project within NatureWatch NZ which contains custom data fields for bird count observations at the MKE, and an accompanying map resource. Field sheets can also be generated using the CSV file tools available in NatureWatch NZ, if desired. Similarly, other taxa can also be targeted and recorded in NatureWatch NZ, along with casual observations of any species.

Figure 6 shows a screenshot of all species recorded within the MKE place in NatureWatch NZ to date displayed in the map view, and the Species Guide function in the grid view. Full details of each observation can be accessed by clicking the map pins, and links to further information on each species is available through hyperlinks embedded in the observations and the Species Guide. These features create an excellent educational resource centred on the set observations present in the MKE place, and these can be added to by participants in experiential and educational programmes.

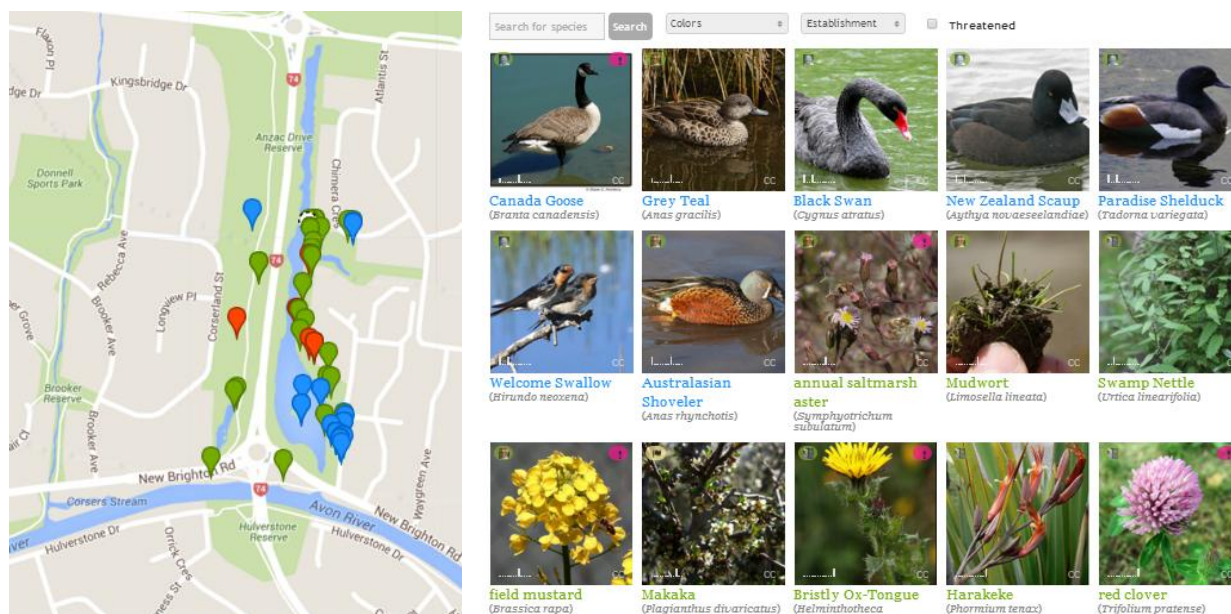


Figure 6. Screenshots of data and resources generated from the MKE place in NatureWatch NZ. Left - map view of observations occurring within the place boundaries. Right - grid view of the Species Guide generated from observations occurring within the place boundaries.

6.4 Ngā ika - Fish species

Fish surveys

One existing record of a fish survey at the MKE site was discovered. This was a recent survey by ECan with a focus on adult inanga (*Galaxias maculatus*) (H. Greenup, pers. comm.).

The key results were:

- 10 minnow traps were deployed in Lake Kate Sheppard on 17/02/2015 and inanga were caught in four of these
- Total catch of over 200 adult inanga

Results from the trapping surveys conducted 16-17 December 2015 also indicated that Lake Kate Sheppard supports a sizeable adult inanga population. Inanga can also be regularly seen from the jetty and the footbridge near Matariki gardens, as well as at other locations along the shorelines on occasion. In contrast, no inanga were caught in the minnow traps set in upper Anzac Creek. For comparison, the total number caught in Lake Kate Sheppard using the same number of traps for the same duration was 59.

Tuna / shortfin eels (*Anguilla australis*) are also abundant in the lake and up to 12 were caught in the fyke nets (Figure 7) with the largest individual measuring 65cm in length. Smaller tuna, up to 40cm in length, were also caught in the minnow traps. Tuna can also be regularly seen along the shorelines, and were frequently observed in the vicinity of the culverts connecting Lake Kate Sheppard with Anzac Creek. Common Bully (*Gobiomorphus cotidianus*) were also caught in both locations (Table 2).

Table 2. Fish survey results.

Fyke nets	<i>Anguilla australis</i>	<i>Galaxias maculatus</i>	<i>Gobiomorphus cotidianus</i>
Lake Kate Sheppard	15	0	0
Anzac Creek	5	0	0

Minnow traps	<i>Anguilla australis</i>	<i>Galaxias maculatus</i>	<i>Gobiomorphus cotidianus</i>
Lake Kate Sheppard	33	59	13
Anzac Creek	5	0	1



Figure 7. Sophie Allen assists with a haul of tuna from a fyke net at Lake Kate Sheppard.

Inanga spawning sites

Data from UC inanga spawning site surveys conducted over the 2015 season (Orchard & Hickford, 2016) are presented in Figure 8. These studies showed that Lake Kate Sheppard is an important post-quake spawning site. Spawning was found to occur within the same section of shoreline during all four months of the survey programme (Figure 9). The total egg production was also consistently high. No spawning was found on the western shores of Lake Kate Sheppard where spawning had previously occurred prior to the quakes. On this shoreline conditions have changed markedly since the earthquakes in response to lower ground levels, liquefaction effects, and other disturbances that have affected the composition of riparian vegetation.



Figure 8. Maximum monthly area of occupation (m^2) recorded at Lake Kate Sheppard and Anzac Creek during surveys conducted by the UC in the 2015 spawning season.

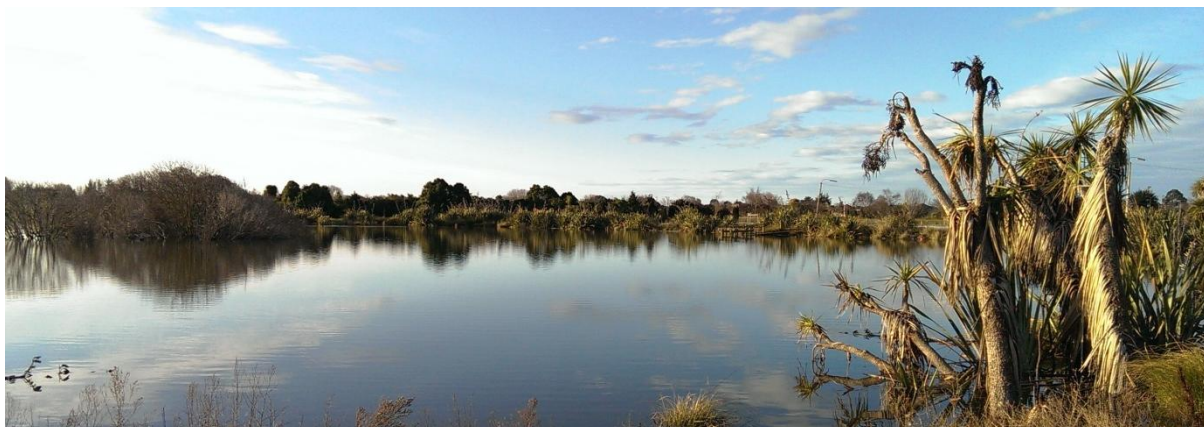


Figure 9. View of Lake Kate Sheppard. Inanga spawning occurs along the far shoreline as seen in this image.

6.5 Ngā puna – Springs

Two springs were discovered during the fieldwork components of this project (Figure 10). Both had appreciable base flows over all months of the 2015 summer indicating that they are not ephemeral. However neither spring is recorded in the ECan records. The possibility that the Barkers Lane ‘spring’ may be the result of a leak from CCC water supply infrastructure was discussed with staff and considered to be unlikely (M. Bourke, pers. comm.).

These springs are notable features of the site, each giving rise to small waterways with associated riparian wetlands. Specific policies for springs are found in the Mahaanui Iwi Management Plan 2013 (Jolly & Ngā Papatipu Rūnanga Working Group, 2013) and other Ngāi Tahu documents. In addition to their ecological value they present an important opportunity for the restoration of cultural values at the site. A focus on these sites could be developed to provide examples of springs management from a tikanga Māori perspective.

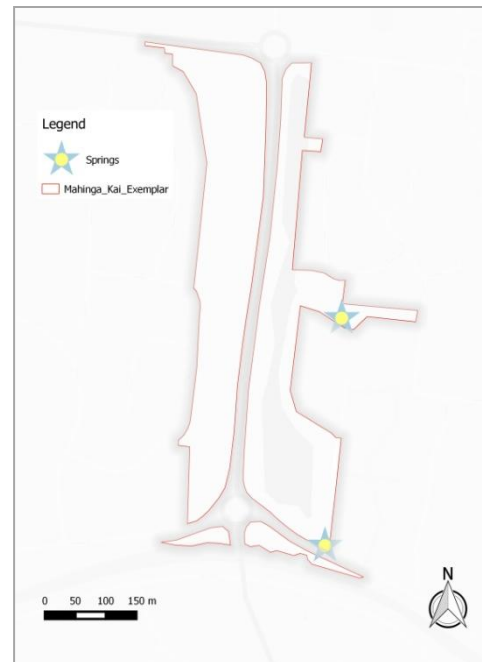


Figure 10. Location of pūna (springs) at the MKE site.

6.6 Mātai arowai - Hydrology

Hydrological aspects of the Lake Kate Sheppard and Anzac Creek waterways were beyond the scope of this project. They are generally complex and heavily modified by a range of man-made structures designed to provide for drainage and a degree of circulation. The system was devised in conjunction with the alteration of the Lake Kate Sheppard inlet / outlet structure to hold back water and thus create a lake (J. Walter, pers. comm.). This purposefully created an impediment to drainage which has effects on the waterways further upstream in the system, especially in terms of water levels under different rainfall and flow scenarios both with the MKE waterway system and the adjacent connected waterways. The latter include the Ōtākaro/Avon River, Travis Wetland via a diagonal culvert beneath the QEII Drive roundabout, and a drain in the north-east corner of the site which is a discharge point for the CCC stormwater network in the area.

Water levels in the system have changed in response to earthquake-related ground level effects (P. Dickson, pers. comm.). Earthquake effects are also likely to have changed salinity patterns in the area, and any further modification to drainage infrastructure has the potential to cause further change. These are complex topics and yet are a key matter for the MKE project due to the strong influence of these factors on indigenous biodiversity and the success of ecological restoration initiatives. Further work on the hydrology and salinity patterns present and likely changes is therefore recommended.

6.7 Wai tai - Salinity

Comprehensive salinity measurements were beyond the scope of this study. However some preliminary field measurements were taken and additional data provided by UC from a current salinity study in the Ōtākaro/Avon River mainstem that has included some field measurements within the MKE site and nearby.

Some of the key findings were:

- Peak salinity varies markedly month to month and tide to tide, even of tides of similar tidal heights as predicted on tide charts.

- Saline water frequently reaches the far end of both Lake Kate Sheppard and Anzac Creek. Salinities as high as 2.1 ppt were also measured in the south-east corner of Travis Wetland and saline water regularly enters Travis Wetland at the Corsers Stream culvert on spring tides.
- The maximum salinity recorded at Lake Kate Sheppard was 19.0 ppt at the inlet structure on 13 June 2015. On this same tide salinity at the jetty reached 14.5 ppt.
- Salinity measurements demonstrate that the upper Anzac Creek water body is poorly flushed (see below for further discussion).

It is important to note that these are very preliminary observations that were biased towards detection of peak salinity levels at spring high tides. The data available relates to only two positions in the water column and a limited number of sites, dates, weather and antecedent conditions all of which strongly influence salinity effects on different parts of the site.

A typical salinity pattern at high tide is shown in Figure 11 as measured on the spring tide of 19 April 2015. On this tide the predicted tidal height at the port of Lyttelton was 2.6m above chart datum. The maximum salinity record at the Lake Kate Sheppard inlet structure was 8.0 ppt.



Figure 11. Peak tide salinity measurements taken on 19 April 2015 at two positions in the water column. For each pair of measurements top salinity (10cm from the surface) is displayed in the left-hand box and bottom salinity in right-hand box.

Results from the upper Anzac Creek water body are of particular interest. Brackish conditions were typically measured here using hand-held meters and appeared to change little irrespective of the tide.

A data logger deployed over a 3 week period in January 2016 confirmed that salinity levels are relatively static for considerable periods (see Appendix 4). Additional field observations include the presence of anoxic sediments which are a notable contrast from Lake Kate Sheppard which has a relatively sandy lake bed substrate.

Further investigation into the flushing regime, substrate types, water and sediment quality would be warranted in this waterway. In conjunction with the large numbers of water birds present, a poor flushing regime is likely to exacerbate local water quality issues that bear a direct relationship to the suitability of resources for harvest.

The upper Anzac Creek water body is therefore considered to be a priority area to investigate for a potential intervention to assist earthquake recovery and the restoration of mahinga kai. Potential impediments to flushing include the existence of perched culverts beneath Anzac Drive. Associated with this, there may be opportunities to improve mahinga kai values through development of a design solution that better integrates drainage requirements with ecology and cultural values.

7. Discussion and recommendations

7.1 Study limitations

The scope of this study was limited to only a few aspects of the site's ecology and much more could be learned. Although fieldwork for the vegetation survey was prioritised as a key task, only a preliminary analysis of the resulting data was conducted in order to create an initial vegetation map. A more comprehensive analysis to develop a vegetation database for the site will be completed in the future and there are many other biogeographical patterns of interest.

More generally, the focus of the study was oriented towards the biodiversity components. However the nature and dynamics of the abiotic components at the site is also important. Many of these are strong drivers of biodiversity and biodiversity change. Other potentially important topics not addressed in this study include water quality and food safety aspects which are relevant to mahinga kai.

Quantification of the resources available for wild harvest using metrics such as abundance or biomass was also not a component of this study. The wider cultural health of the site provides important context for mahinga kai and was also not addressed in this study. However the results presented here may provide useful information for considering the design of a cultural health assessment in the future.

7.2 Vegetation succession and lag times

Since the Canterbury earthquakes, significant changes have been recorded in bed level and hydrology in and around the Avon-Heathcote Estuary/Ihutai (Measures et al., 2011). Vegetation changes have also been recorded that are, at least in part, associated with these effects (eg. Cochran et al., 2014). Vegetation changes may be ongoing since a lag time can be expected for plant communities to fully adjust towards a new relatively stable state in response in response to such changes. A continuing sequence of dynamic change can also be expected should the system experience additional changes. At the MKE site, local experts familiar with the area consider that earthquake-related ecological changes are as yet unlikely to have attained a stable end-point (A. Crossman, P. Grove pers. comm.).

Establishing baseline measurements and conducting repeat surveys at regular intervals would be useful to detect further change and may provide essential information for restoration planning, such as by helping to ensure investments are effective in delivering desired outcomes. For some parts of the site, plant colonisation and succession patterns driven by natural processes may result in a desirable flora without significant investment being required. Because of the strong influence of salinity on plant community structure decisions regarding the future manipulation of tidal waters is an important additional factor to address. This would ideally occur prior to considering the need for plant restoration activities in parts of the site that may be affected.

7.3 Salinity changes

In relation to the above discussion, only a basic understanding of the salinity regime at the site is currently known. Observations over a number of years have confirmed a general pattern of higher freshwater in-flows and associated ponding areas over winter (A. Crossman, pers. comm.). These are likely to cause significant spatio-temporal salinity fluctuations with both macro and micro-scale effects between seasons. The salinity data presented in this report should be interpreted with this in mind and further salinity measurements at other times of the year are recommended to assist the further identification of patterns. These effects add complexity to the understanding of plant community changes, lag times, and estimation of future change.

Salinity aspects at the site are likely to be subject to at least two sources of further change. These are:

- Reconfiguration of the stopbank system in the lower Ōtākaro/Avon River and/or alteration of drainage system. This system currently restricts the entry of tidal waters to the site through an engineered inlet/outlet structure at Lake Kate Sheppard. However the wider stop-banking system also affects the inland extent of salt water intrusion and associated mixed regime within the Ōtākaro/Avon River mainstem further downstream, thus affecting the composition of tidal waters that reach the site.
- Sea level rise associated with climate change.

These factors are related since sea level rise considerations are likely to influence decisions on drainage and the role of engineered structures in the area (eg. flap-gates and stop-banks). Understanding the potential impacts of each on the hydrological and salinity regime at the MKE site is a particularly relevant consideration for restoration ecology from a holistic perspective.

7.4 Monitoring

Monitoring activities perform several essential roles in support of restoration initiatives. These include detecting ongoing and potential unanticipated changes that may affect management objectives, and to measure progress towards specific targets to determine whether current management actions are effective. Monitoring programmes can also create experiential and participatory opportunities that can increase the level of engagement between project champions and the wider community.

7.5 Recommendations

The following recommendations address information gaps and aspects of site ecology and biogeography that have been noted during this study.

To address information gaps:

- Develop a baseline vegetation database from the field survey data reported here using methods similar to Grove et al. (2012). This involves classification of the raw data into a hierarchical database linked to shapefiles and documentation of an accompanying metadata file. This arrangement allows vegetation analyses at a range of scales to support design of restoration and monitoring programme and will facilitate inclusion of the MKE in future iterations of the Canterbury coastal wetland surveys.
- Monitor plant growth / survival of restoration plantings, and collect additional data on other taxonomic groups of interest (eg. invertebrates, woodland bird species). Citizen science approaches using NatureWatch NZ could be usefully employed although some additional survey effort would likely be required to establish reliable baselines.
- Collect further data salinity patterns and water levels at the site at different times of the year to enable a better understanding of seasonal variation. Baseline data on the substrates present and soil salinity levels, may also be of interest.
- Conduct water quality and sediment quality sampling. These topics are a key potential concerns for site management and are especially relevant to the condition of mahinga kai resources eg. suitability for harvesting.
- Conduct a cultural baseline monitoring for additional aspects important to mahinga kai. This assessment could be informed by results from many of the above information needs, for example through use of a modular methodology such as State of the Takiwā, whilst also including more specific detail on the cultural context and condition of values important to

manawhenua. Wetland condition monitoring protocols such as those presented in Clarkson et al. (2003) could also be a useful component.

To address current threats and management opportunities observed at the site

- Initiate control measures for areas of establishing grey willow as a priority, and develop management strategies for other invasive species likely to pose a risk to mahinga kai values at the site.
- Consider a riparian restoration project targeting denuded areas on the shoreline. These are small in extent but are heavily used as roosted areas by waterfowl and likely contribute disproportionately to eutrophication issues. By prioritising the restoration of these areas with suitable riparian species, favoured roosting areas for introduced waterfowl will likely shift towards other nearby short grassland sites. This will increase the separation between concentrated pollution sources and water bodies, improving the ability of the land to intercept run-off and assimilate nutrients at the whole site scale.
- Investigate the potential fish passage issue in relation to the waterways of Anzac Creek. This is a considerable area of waterways that could support a sizeable adult inanga population but does not appear to do so.
- Investigate and monitor the condition of the upper Anzac Creek water body. This area currently appears to have very little flushing and is characterised by anoxic sediments and degraded riparian margins.
- Provide for the protection of inanga spawning sites at the MKE, including by ensuring they are adequately addressed in relevant statutory and non-statutory plans⁸.
- Consider a strategy for long term protection of the two notable pūna (springs) present on the site, with the potential for creation of 'springs reserves' or similar, and associated awareness raising activities.
- Develop a restoration plan for the site to identify appropriate restoration objectives, relate these to the current baseline conditions, and identify suitable criteria for monitoring progress. This could include some of the above recommendations and an implementation programme for progressing priority objectives.
- Develop and implement a monitoring programme to support the above.

8. Acknowledgements

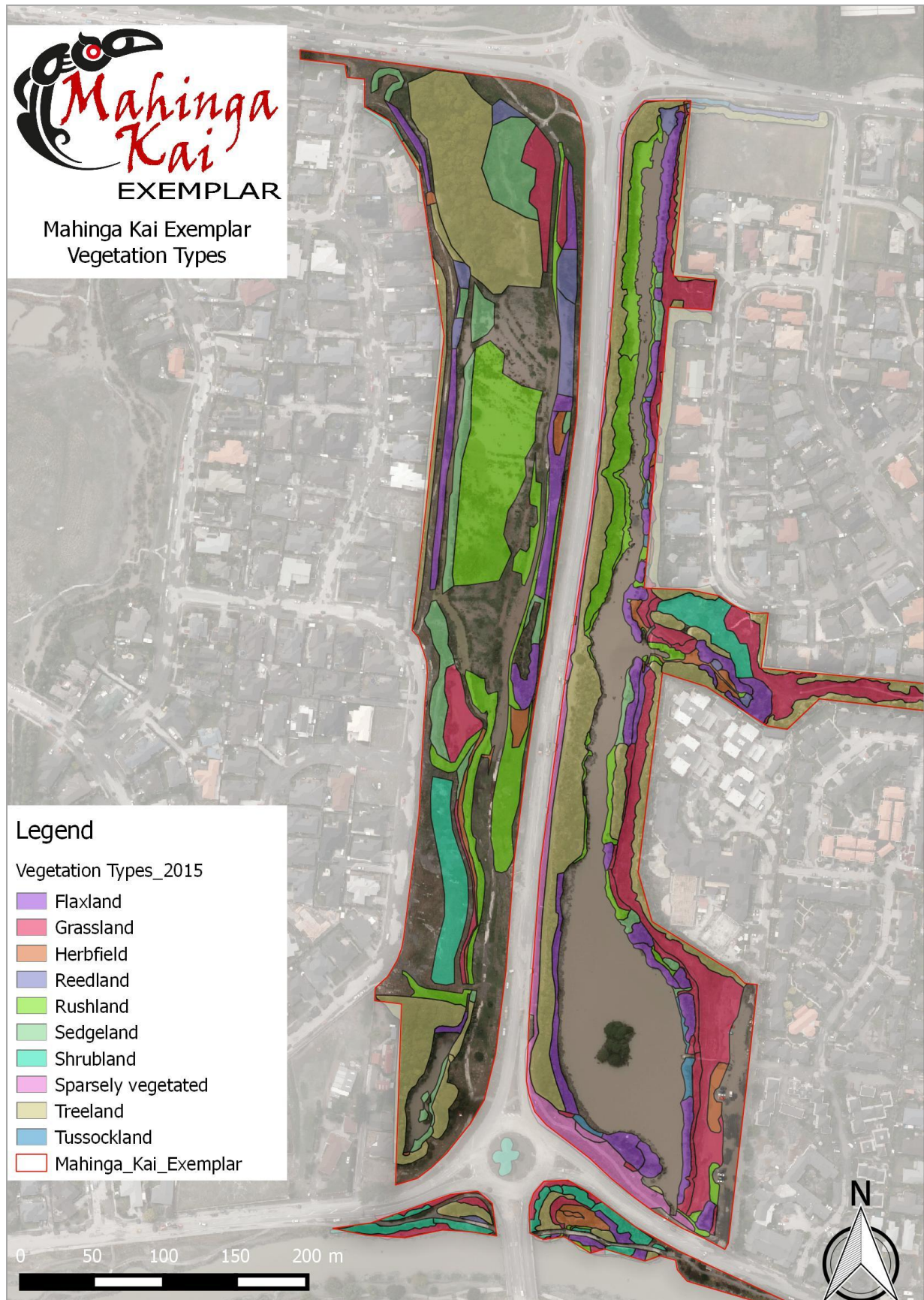
Access to CCC bird survey data is gratefully acknowledged, as is the input from many people who assisted with the compilation of information on the MKE site. Thanks also to Sophie Allen, Judith Rikmanspoel, and Tess Carney for assistance with field surveys and to the staff at the UC Waterways Centre for Freshwater Research for additional support.

⁸ see Orchard (2016).

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Appendix 1 Vegetation types of the MKE



Appendix 2 Combined results from CCC water bird counts at Travis Wetland and Anzac Drive Reserve, 2011-2012. Data courtesy of CCC.

	2011-01-17	2011-03-13	2011-06-26	2011-12-05	2011-12-14	2012-01-29	2012-03-05	2012-03-28	2012-04-29	2012-05-28	2012-06-24	2012-07-10	2012-07-22	2012-08-09	2012-09-24	2012-10-21	2012-12-07	2012-12-20
Black Cormorant	1	3	3		4		5	4	6	8	3		2	2	1	5	2	4
Pied Cormorant	0	0						0	0	0	0		0	0	0	0	1	0
Little Cormorant	0	1						4	1	3	1		0	1	1	5	5	8
Little Black Cormorant	0	0			2			17	0	0	0		0	0	0	0	0	0
Spotted Shag	0	0						0	0	0	0		0	0	0	0	0	0
White-faced Heron	0	4						3	4	1	0	2	0	0	1	7	1	3
White Heron	0	0						0	1	0	0		0	0	0	0	0	0
Cattle Egret	0	0						0	0	1	0		0	0	0	0	0	0
Australasian Bittern	0	0						0	0	0	0		0	0	0	0	0	0
Royal Spoonbill	0	0						0	0	0	0		0	0	0	0	0	0
Glossy Ibis	0	0	1					1	1	1	1		1	1	0	0	0	0
Mute Swan	0	0						0	0	0	0							
Black Swan	2	24			13	12	10	17	21	24	25	15	17	29	38	39	25	10
Canada Goose	156	247			377	442	783	470	771	817	713	712	893	595	511	449	249	169
Feral (greylag) Goose	0	0			0	1	1	3	1	1	3	2	0	3	2	2	1	0
Cape Barren Goose	0	0			0			0	0	0	0		0	0	0	0	0	0
Paradise Shelduck	168	144			115	133	123	168	179	168	247	75	114	153	115	132	128	162
Mallard/Grey Duck	n.c.	239						132	150	91	193		130	247	135	105	102	88
Grey Duck	n.c.	0						0	0	0	0		0	0	0	0	0	1
Grey Teal	n.c.	295						66	202	213	282		226	144	97	131	87	38
Brown Teal	1+	0						0	0	0	2		0	1	2	0	0	0
New Zealand Shoveler	n.c.	164						22	36	52	70		57	129	41	21	25	14
NZ Scaup	n.c.	38						15	24	62	12		19	33	27	37	40	33
Australasian Harrier	4	0	2					2	2	3	2	2	3	4	5	2	2	3
New Zealand Falcon	0	0						0	0	0	0		0	1	0	0	0	0

Marsh Crake	0	0					0	0	0	0		0	0	0	0	0	0	
Spotless Crake	0	0					0	0	0	0		0	0	0	0	0	0	
Pukeko	n.c.	183	254				247	303	274	319		303	298	230	215	227	130	
Australasian Coot	0	0					0	0	0	0		0	1	0	1	1	0	
Variable Oystercatcher SIPO	0	0					0	0	0	0		0	0	0	0	1*	0	
Spur-winged Plover	37	14	40	33		54	56	17	44	57	67		52	46	57	39	56	43
Banded Dotterel	0	0		1				0	0	0	0		0	0	1	2	0	0
Black-fronted Dotterel	0	0	1					1	1	1	1		1	0	0	0	0	1
Bar-tailed Godwit	0	0						0	0	0	0		0	0	0	0	0	0
Pectoral Sandpiper	0	0						0	0	0	0		0	0	0	0	0	0
Pied Stilt	12	2	34	63		42	34	2	24	14	12		25	104	114	93	49	137
Black Stilt	0	0						0	0	0	0		0	0	0	0	0	0
Black-backed Gull	0	13						6	18	10	15		11	11	13	11	8	9
Red-billed Gull	0	13						1	0	0	1		1	0	0	0	0	0
Black-billed Gull	0	8						0	0	1	0		1	0	0	0	0	0
Caspian Tern	0	0						0	0	0	0		0	0	0	0	0	0
Whiskered Tern	0	0						0	0	0	0		0	0	0	0	0	0
Black-fronted Tern	0	0						0	0	0	3		1	0	1	0	0	0
NZ Kingfisher	1	2						20	4	2	2		0	32	8	6	4	2
Welcome Swallow	0	0																
TOTAL	381	1394	335	97	511	684	1012	1218	1793	1806	1976	810	1859	1837	1402	1302	1013	855

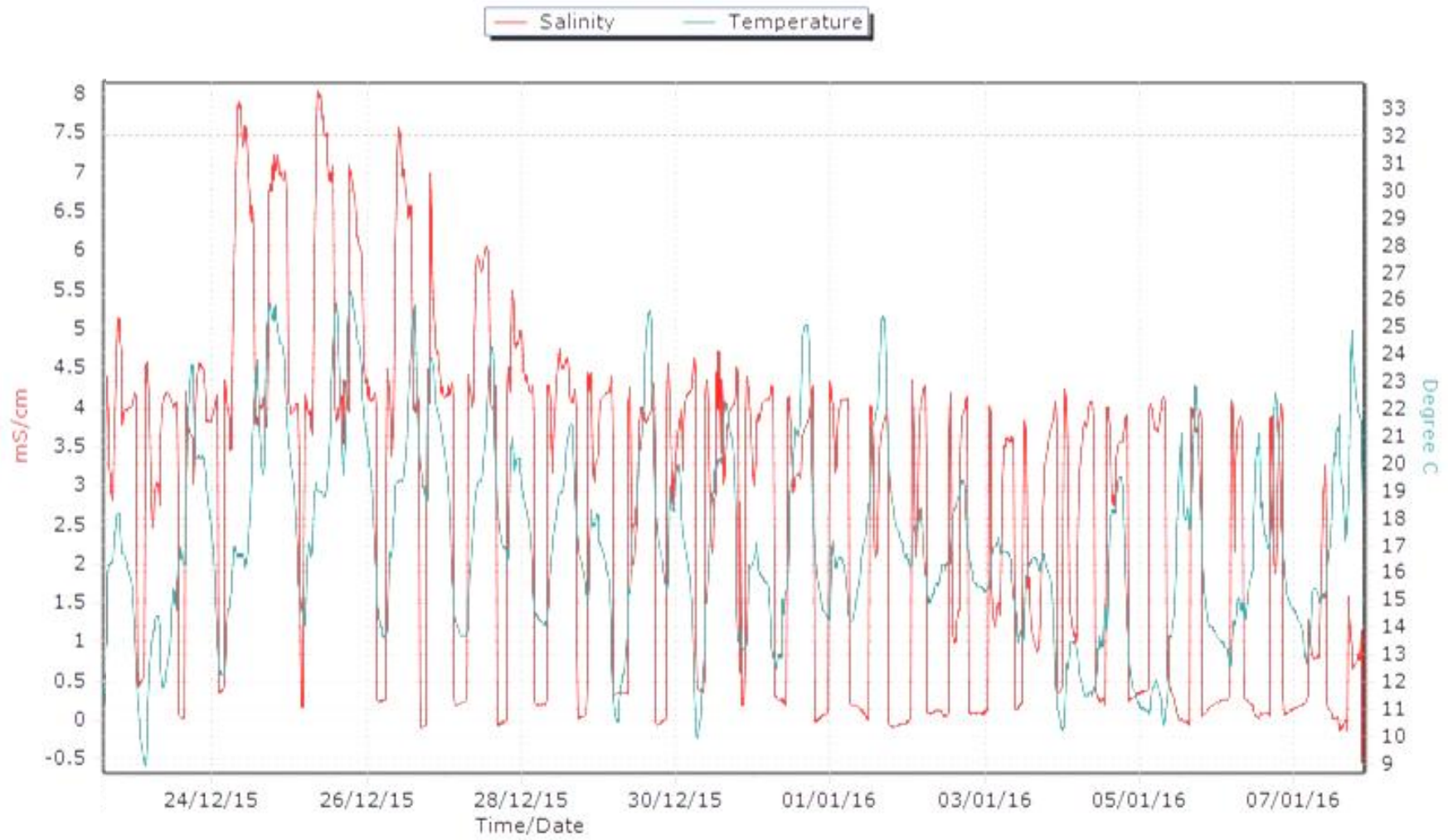
Appendix 3 Combined results from CCC water bird counts at Travis Wetland and Anzac Drive Reserve, 2013-2015. Data courtesy of CCC.

	2013-01-24	2013-02-20	2013-06-17	2013-06-18	2013-08-15	2013-12-10	2014-01-06	2014-02-27	2014-05-19	2014-06-12	2014-06-24	2014-08-04	2014-12-04	2015-02-11	2015-04-20	2015-06-23	2015-09-30
Black Cormorant	7				2		2	5	4	6		1	7	3	2	1	
Pied Cormorant	1				1		0		0				1		0		
Little Cormorant	1				2		6		1			3	6	1	2		
Little Black Cormorant	2					1	0		0			5	7		1		
Spotted Shag	0						0		0				0		0		
White-faced Heron	3					1	6		1				8		0		
White Heron	0						0		0				0		0		
Cattle Egret	0						0		0				0		0		
Australasian Bittern	0						0		n.c.				2		0		
Royal Spoonbill	2						0		0				3		0		
Glossy Ibis	0	1						1		1	1			0	1	1	
Mute Swan					0		0		0				0		0		
Black Swan	17	10			13	8		22		20			10	18	8	28	12
Canada Goose	424	237			540	339		355		404			151	419	1121	863	385
Feral (greylag) Goose	2	1			1	0		0		0	1		1	0	1	2	
Cape Barren Goose	0						0		0				0		0		
Paradise Shelduck	222	194			75	229		184		n.c.	83		82	360	148	149	39
Mallard/Grey Duck	88						133		n.c.				117		109		
Grey Duck	1	2						0		n.c.				0		0	
Grey Teal	108	176						156	430	n.c.				44		108	
Brown Teal	0			1			0		n.c.				0		0		
New Zealand Shoveler	18						86		n.c.				59		131		
NZ Scaup	17	1						16		n.c.				23		105	
Australasian Harrier	3						3	2	3				3		5	2	
New Zealand Falcon	0						1		0				0		0		

Marsh Crane	0						1		n.c.				1		0		
Spotless Crane	0						0		0				1		0		
Pukeko	111	121	173+	202				140		345				111		269	
Australasian Coot	0					2	1		2				3		1		
Variable Oystercatcher	0						0		0		2		0		0		
SIPO	0	0						0		1	1		1	0		3	
Spur-winged Plover	27	35						31		51	43		36	26		30	
Banded Dotterel	0						0		0			1	0		0		
Black-fronted Dotterel	0						0		0				0		0		
Bar-tailed Godwit	0						0		0				0		0		
Pectoral Sandpiper	0						0		0			1	0		0		
Pied Stilt	38	36						10		38	15		19	15		32	64
Black Stilt								0		0				0		0	
Black-backed Gull	5						1		n.c.				3		19		
Red-billed Gull	0						0		n.c.				0		0		
Black-billed Gull	0						0		n.c.				0		2		
Caspian Tern	0						0		0				0		0		
Whiskered Tern	0						0		0				0		0		
Black-fronted Tern	0						0		0				0		0		
NZ Kingfisher	0						0		2				3		1		
Welcome Swallow							1		n.c.				30		21		
TOTAL	1124	944	0	202	630	581	4	1156	437	873	150	2	311	1270	1283	1884	503

Appendix 4 Salinity and temperature ranges over a spring tide sequence in Anzac Creek.

(a) Anzac Creek inlet



(b) Upper lake near top culvert

