ASSESSMENT 2

Lake Kate Sheppard:

An exemplar mahingā kai site?

GEO 402
Urban Development
Ada Zhang
Steve Carrick
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Lake Kate Sheppard is a man-made lake located in the East Burwood area of Christchurch. The basin of the lake was designed as a sediment trap for silt converted downstream from the Travis wetland catchment (Taylor & Blair, 2011). This lake was a spawning ground for inanga[1] and surveys in 2007 (Taylor & Blair, 2011) showed significant areas of inanga eggs in the shoreline. The seismic events of 2010 and 2011 had a considerable effect on the lake and surrounding area. Liquefaction and land movement caused severe damage to the local environment and severe damage to the residential areas to the west and east of the lake.

Environment Canterbury (ECan) commissioned a report (Taylor & Blair, 2011) to determine the effects on inanga spawning grounds on Christchurch City rivers. This report included Lake Kate Sheppard and identified that the inanga spawning ground within the lake had been severely damaged and restoration work was required. On 20 November 2013 a workshop was undertaken to develop an exemplar project that demonstrates how a mahingā kai project could be developed and what outcomes could be expected. This workshop was under the guidance of Te Rūnanga o Ngāi Tahu (TRONT), Ngāi Tūāhuriri, the Avon Otākaro Network and the Canterbury Waterways Research Centre. The authority for this was the Christchurch City Council's Natural Environment Recovery Programme for greater Christchurch with Project 17 status which is to "Act on the opportunities to restore and enhance Mahingā kai" with Ngāi Tahu (Ngā Papatipu Rūnanga and Te Rūnanga o Ngāi Tahu) as the lead agency. The objectives of this exemplar project are (Avon/Otākaro Network, 2014):

- To restore and re-develop a Mahingā 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, storm water treatment, land drainage, food production and active and passive recreation.
- To implement a Mahingā kai exemplar project that could be applied to other ecological and recreational reserves along the Avon River/Otākaro and Heathcote River/Opāwaho corridors from the city to the sea.
- To use Anzac Drive reserve as an exemplar Mahingā kai site.

The purpose of this essay is to discuss what factors may be affecting inanga spawning within Lake Kate Sheppard and to define a way forward for the restoration of the lake as an exemplar mahingā kai site.

[1] Whitebait (Galaxis maculatus)

The project leads for this are TRONT, Ngāi Tūāhuriri and the Avon/Otākaro Network, however, the restoration of waterways involves multiple stakeholders and Figure 1 shows the extent of these, some additional community groups and schools are also involved in this project.

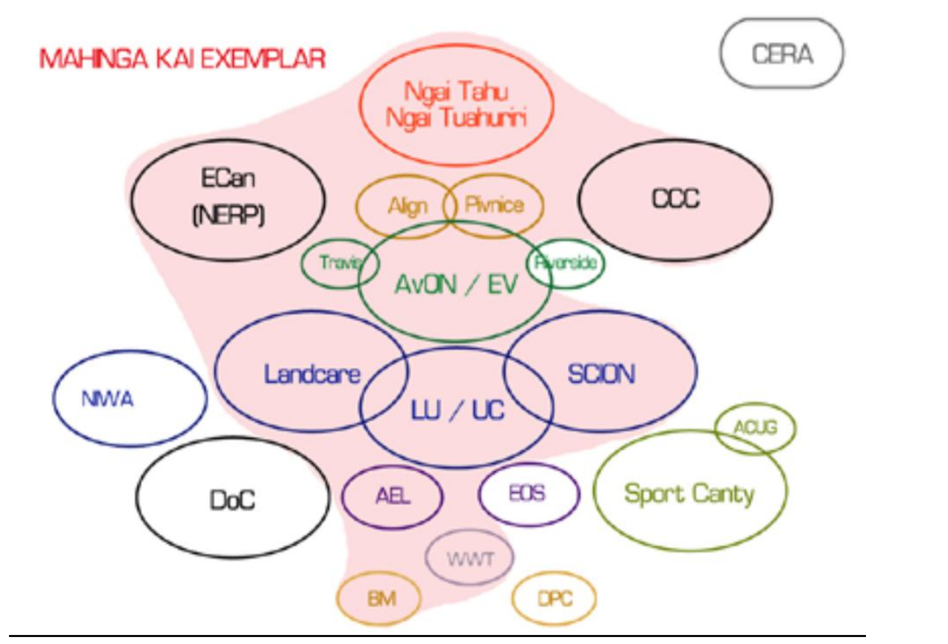

Fig 1. Stakeholders for Mahingā kai Project (Avon/Otakaro Network, 2014)

The methodologies used for this essay included on site visits, qualitative data comparisons, Māori methodologies, technical reports and personal communications with various individuals and organisations.

The project is directly related to Mahingā kai, and as such it is necessary to define it so as to understand the relationship it has within a waterways restoration project.

The term 'Mahingā Kai' was used in the Crown's Settlement Offer with Ngāi Tahu to refer generally to many of the cultural aspects of the redress package. Mahingā kai properly refers to Ngāi Tahu interests in traditional food and other natural resources and the places where those resources are obtained (Ngāi Tahu, 2014). This is clarified to a higher degree by Te Marino Lenihan (Avon/Otākaro Network, 2014) as follows:

- Mahingā kai is a key Ngāi Tahu value for earthquake recovery. It is an important aspect of the Ngāi Tahu Settlement Claim.

- Mahingā 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.
- Mahingā kai, meaning to mahi ngā kai (work the food), is a management concept, a way of thinking that involves and understands the simultaneous protection and use of resources. Ngāi Tahu approaches this from an integrated management model known as Ki Uta Ki Tai (from the mountains to the sea).
- Ngāi Tahu supports the metaphor of a plaited rope with the weaving of exotic and indigenous species, and of Pākehā and Ngāi Tahu traditions.
- Ngāi Tahu interprets mahingā kai 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 Mahingā kai as the physical food.

Within the Christchurch area there were multiple mahingā kai sites, Pā sites and residential villages which utilised the resources available (Tau, Goodall, Palmer & Tau, 1990). As previously stated mahingā kai is not just the food but the resources needed to survive, to support the gathering of food and to maintain the subsistence lifestyle that Māori had. The locations of these sites and resources are shown in Figure 2 and 3 respectively. Of relevance to the Lake Kate Sheppard area was a residential village, Oruapaeroa, which was located adjacent to the western side of Travis Wetlands. More significantly was Te Ihu Tai a major mahingā kai site located on the Sumner-New Brighton coastline, the owners being Ngāi Tūāhuriri from Kaiapo Pā. In 1956 this site was taken under the Public Works Act 1928 as part of the site for the Christchurch sewage scheme. It was considered so valuable to the owners that they would not accept payment as compensation for their loss. The only compensation acceptable to the local hapu was a similar area of land having similar characteristics to Te ihu Tai. Te Ihu Tai supported various types of fish and shellfish, tuna, kanakana, tuere, pātiki, waikoura, waikakahi and inanga[2] were some of the species which were gathered (Tau, et al, 1990). The restoration of Lake Kate Sheppard as an exemplar mahingā kai site has significant cultural implications for Ngāi Tahu and given the Red Zoning of large tracts of land along the Avon/Otākaro this may have future implications for the land use of some of these areas.

[2] Eel, lamprey, blind eel/hagfish, flounder, fresh water crayfish, freshwater mussels, and whitebait.

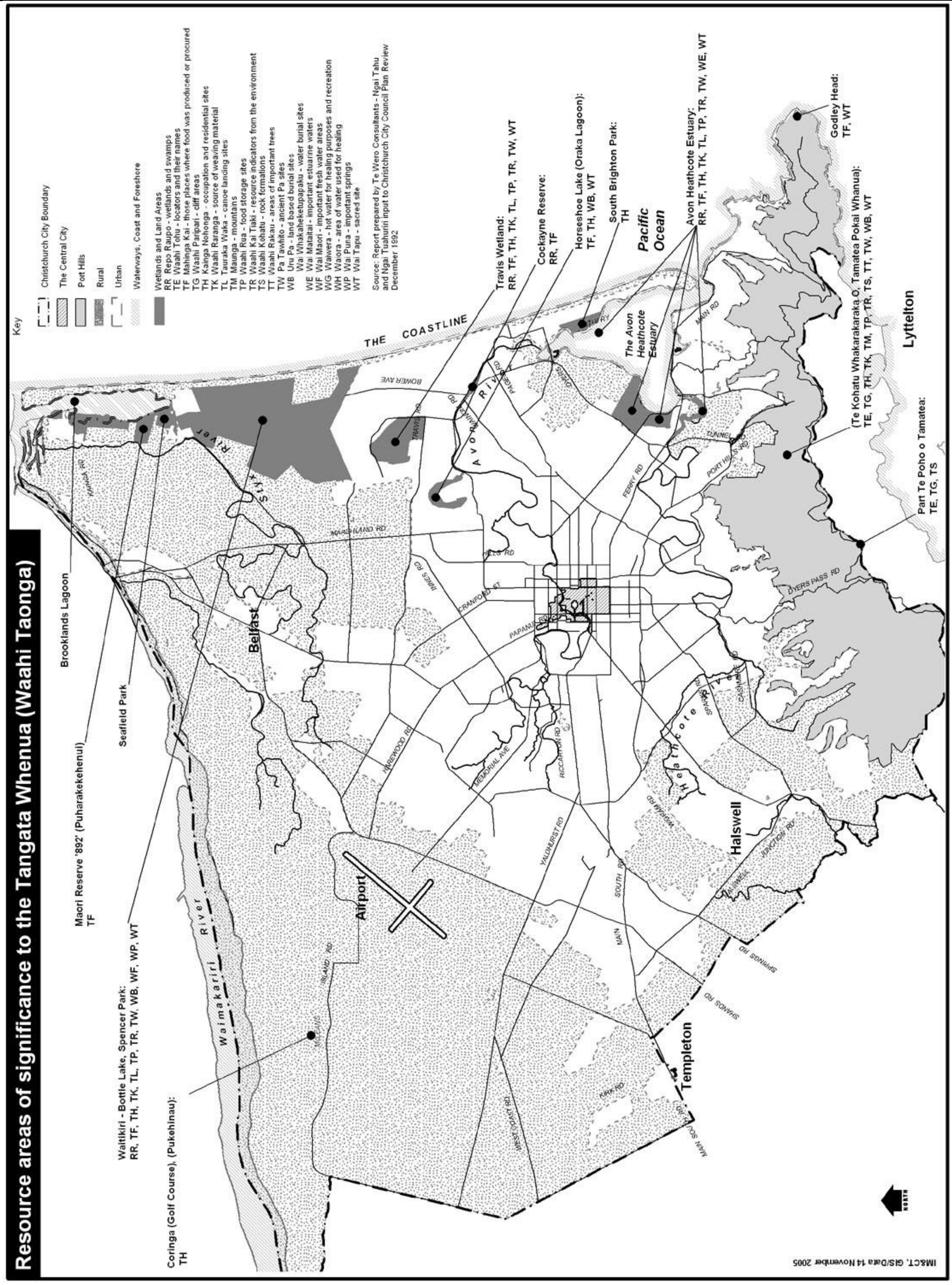

Fig 2. Resource areas of significance. (CCC, 2014)

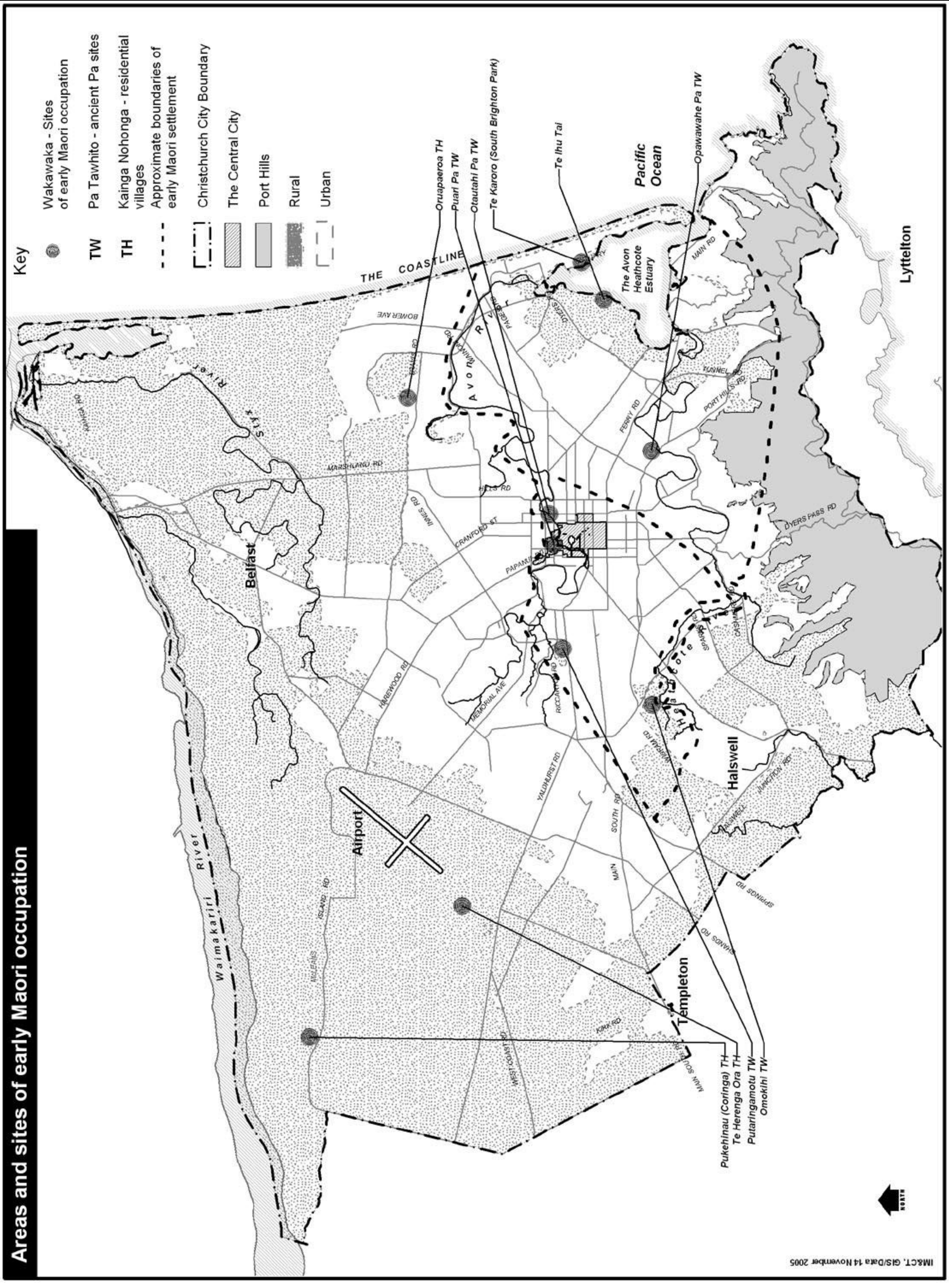

Fig 3. Areas and sites of early Māori occupation. (CCC, 2014)

The physical layout of Lake Kate Sheppard is shown in Figure 4 with key aspects annotated in the key. There is a linkage to community groups and schools utilising an "Outdoor Classroom" and learning panels at various locations. These learning panels would be completed by the major stakeholders and should be interactive to encourage use by school groups. An example of this could be to have moulds of a pūkeko footprint at the "Birds: of bush, Gardens & Waterways" so that rubbings could be taken and this reinforces learning in a positive, fun manner for younger school groups. Interactive lesson boards are being developed in consultation with Ngā Tahu for the walkway surrounding Lake Ellesmere/Te Waihora. These lesson boards may be a good guideline for this project, standardise data and minimise design and production costs.

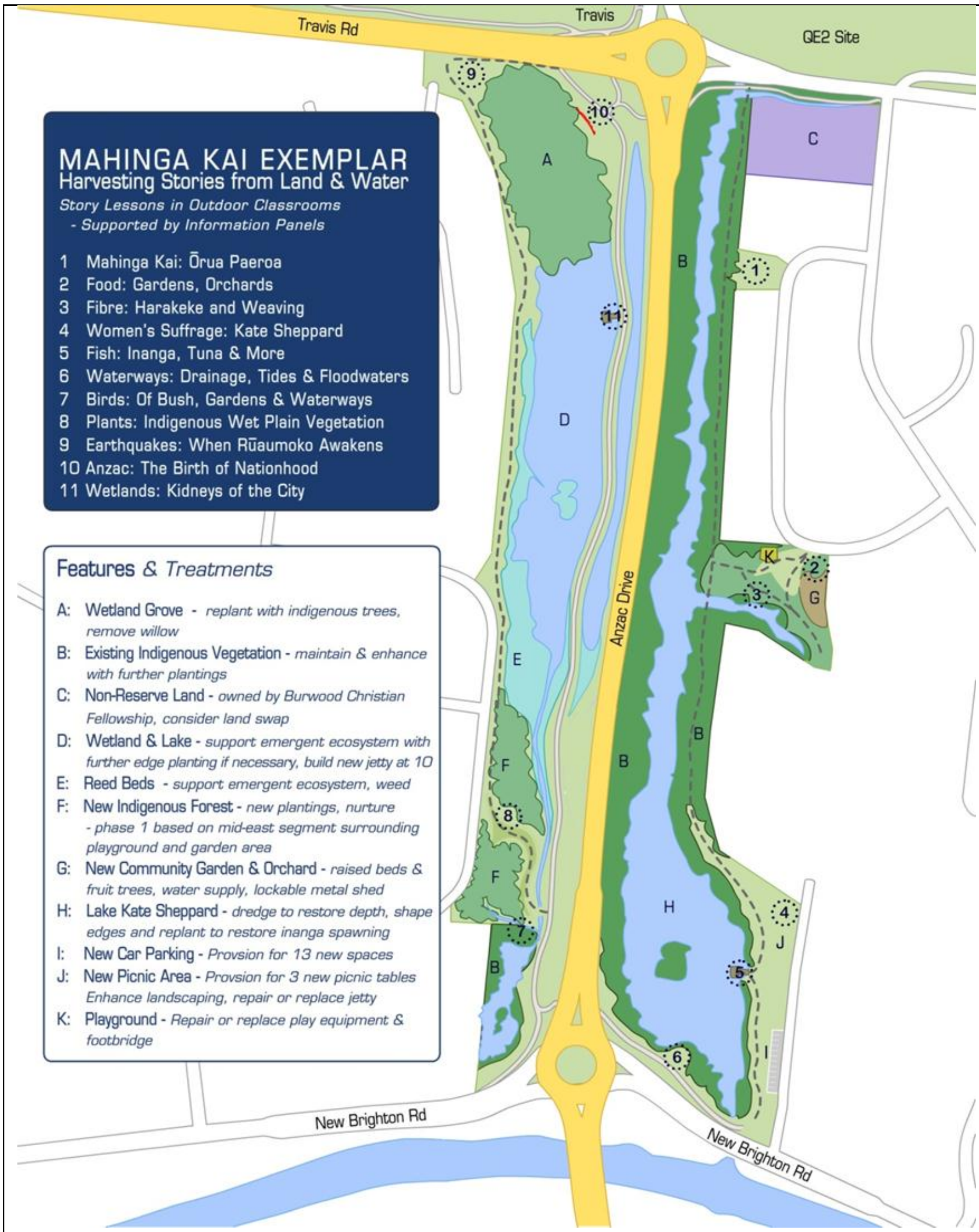

Fig 4. Site plan – Lake Kate Sheppard (Avon/Otākaro Network, 2014)

The Canterbury Earthquake Recovery Authority (CERA) has graded the residential areas to the west and east of Lake Kate Sheppard as Red Zone properties. Residential property which has been zoned red is so badly damaged by the earthquakes it is unlikely it can be rebuilt on for a prolonged period and properties within this zone are removed or demolished leaving vacant areas.

The criteria for defining areas as residential red zone are:

- there is significant and extensive area wide land damage;
- the success of engineering solutions may be uncertain in terms of design, its success and possible commencement, given the ongoing seismic activity; and
- any repair would be disruptive and protracted for landowners.

As this land will become vacant it should be included within the scoping of Lake Kate Sheppard as significant storm water runoff will flow from these areas towards the lake. The area to the west of Anzac Drive could be utilised as a storm water detention/treatment area to cater for stormwater run-off for the surrounding area and to take excess stormwater during peak flood levels from the Avon/Otākaro River. The CCC has installed a detention/treatment system to meet similar requirements at Wigram. This initiative will alleviate pressure on the Avon/Otākoro River and areas upstream, as well as reducing the effect of storm water runoff and peak river flow on Lake Kate Sheppard.

After the Canterbury earthquake in 2011, the Residential Red Zone (RRZ) area underwent a broad ground earth subsidence. From 2010 to post June 2011 airborne laser scanning (LiDAR) shows there was up to 1m drop in elevation on either side of the Lake Kate Sheppard, and a rise of up to a 1.5m in the residential area to the west of the area from the fill. Lake Kate Sheppard is a built wetland that offers an ecological corridor to the Travis wetland (Taylor & Blair, 2011). The original design concept for the lake was for excess peak flood water to transit through Lake Kate Sheppard into the Travis Wetlands which has the capacity to hold a large volume of water and then slowly release it back into the Avon/Otāaro. Unfortunately due to other priorities by the CCC regarding the Flockton Basin, we were unable to obtain up to date hydrological data for the lake and surrounding area. This is deemed vital to understand how the system actually works post the seismic events. There were multiple conflicting reports given as to how people thought the hydrology worked but on observation during a calm dry period and during a heavy rain event these theories were not evident.

It had been predicted that the lower ecological corridor would become the main habitat for inanga spawning with suitable vegetation and fish entrance (Taylor, 1996). Along with the riparian flora gradually growing to maturation, the minute habitat was considered much more suitable for inanga egg growth in April 2004 (Taylor, 2004). Inanga eggs were mostly found in the north of the wooden jetty on the lake with high egg densities (Taylor & Chapman, 2007). However, post-earthquake, there were no inanga eggs found in the damaged habitat. Furthermore, the location of inanga spawning that were largely buried by soil were marked in 2007. The riparian vegetation which was regarded as the most suitable for inanga disappeared in 2011. They were probably killed by soil as well (Taylor & Blair, 2011). Currently, it is found that the original bank level has buried by silt as displayed in Figure 5 and 6.

	
Fig 5. Eastern Bank of Lake Kate Sheppard	Fig 6. Western Bank of Lake Kate Sheppard

Potential stormwater runoff pollution

Stormwater refers to rainwater that cannot be absorbed by a hard, sealed and impermeable surface, such as roofs, roads, driveways, and footpaths. Therefore, it runs off the surface. This runoff water is named stormwater (Environmental Canterbury Regional Council, n.d). It is collected by a network of underground pipes via gutters. The drainage system of Christchurch is divided into waste water pipe network and storm water pipe network; wastewater is sent to Bromley for treatment, while stormwater is directly discharged into the nearest river. Most stormwater is untreated. It directly flows into streams, rivers, and finally estuaries and the sea. As mentioned earlier, the land level in Lake Kate Sheppard has settled since the earthquake. This causes stormwater runoff from the surrounding area to readily flow into the lake and is shown in Figure 7. The red arrows represent the stormwater runoff from residential area and the blue arrow represents the stormwater runoff from Anzac Drive and surrounding roadways.

Fig 7. Probable stormwater runoff flow direction.

Usually, stormwater carries a large number of contaminants which are collected on the road and grassland. These contaminants include littered solid rubbish, such as broken glass, cigarette butts, packing paper; and heavy metals from vehicles, roofs and roads. The adverse effects of stormwater runoff from roads containing oil, petrol and rubber particulates derived from vehicles is a significant issue for the water quality in waterways. With Anzac Drive being in such close proximity and being a major arterial route this is considered to be an issue. The data to capture the effect of this was unavailable and little research or monitoring of transport related by-product run off in waterways has been undertaken in Christchurch (CCC, 2013). The potential for heavy metals and contaminants entering into lake Kate Sheppard of this nature are considered high. Whilst the riparian zone between Anzac Drive and the lake may minimise the effect of these elements, the lake is being established as an exemplar mahingā kai site. As such the species inherent in the lake are deemed suitable for consumption. Toxicology testing and a water monitoring programme needs to be implemented to ascertain the effects of this on Lake Kate Sheppard.

In addition, since the earthquake in 2011, the local drainage network has suffered a decline in capacity during peak river levels due to ground drop (MAYORAL FLOOD TASKFORCE, 2014). This enhances the risk of flooding during a heavy rain. The discharge points of stormwater in the upstream of the Avon River are shown in Figure 8. It means that part pollutants will enter our streams, rivers and lakes due to rainfall. It also illustrates that there will be a massive flow rate merged into the Avon River. This further increases the risk of flooding due to the water level rise.

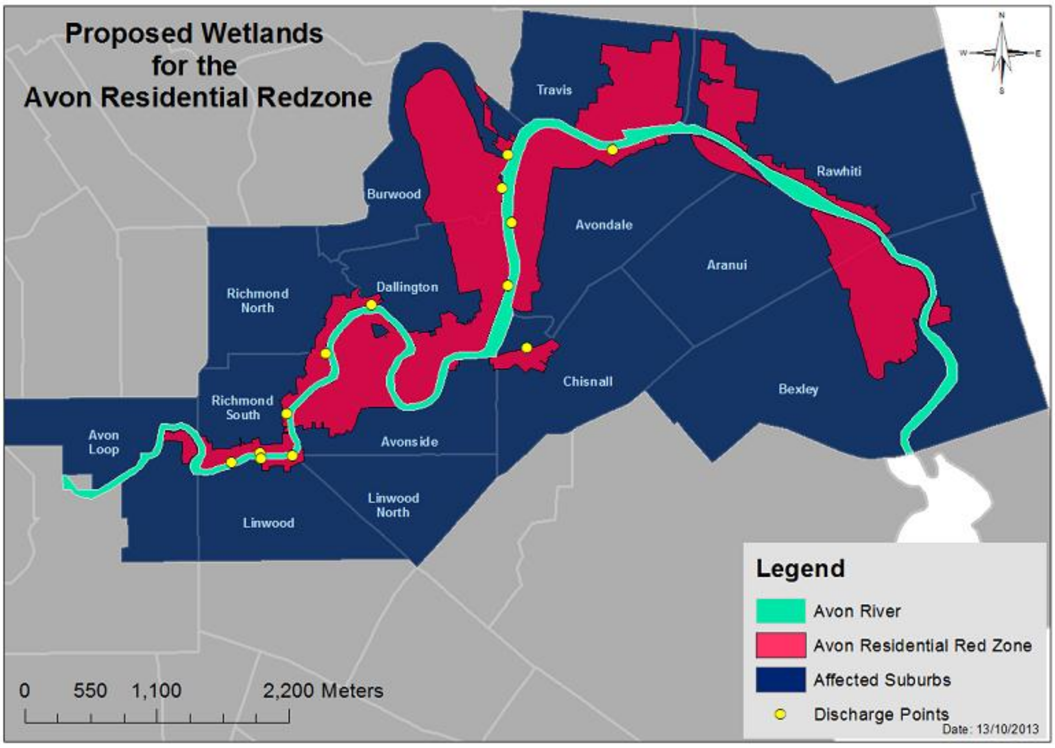

Fig. 8. Discharge points of stormwater on the Avon River. Source: (Toiata Apelu-Uili, Aimee Martin & Daniel Risi, 2013)

Lake Kate Sheppard was visited by the project team on 22 Mar 14 and 14 May 14. The first visit was on a warm sunny day after a prolonged dry spell with the second visit after a high rain event. Whilst lacking quantitative data for these events, the qualitative data showed significant comparisons which raised some concerns. The outflow of the lake to the river at the southern end of Lake Kate Sheppard is shown in Figure 9 – 12 from two perspectives, from the lake side and he river side and it is obvious to see the difference between a sunny and rainy day and the effect it has upon the lake. The differences include water flow rate, water flow velocity, turbidity/clarity, water quantity (water level). After the rain the water level increased sharply and this in turn increased turbidity levels. The quantity of stormwater discharged from any given rainfall events can depend on several factors such as storm size (duration and intensity), ground cover type and the degree of imperviousness, soil type (saturability) and Topography.

Fig 9 – 12. (Clockwise from top left). Outflow from lakeside, water is clear and low. Higher water as a result of rain and significant clarity issues. High volume of water exiting, increased flow rate. Low volume, slower flow rate.

Further evidence of the dramatic change in water levels is shown in Figure 13 from Aug 20112 where the water level significantly lower than in Mar 14. The vast difference in water levels inhibits the sustainability and resilience of shoreline plants surrounding the lake. A mild fluctuation in the lake water level could be catered for but not such dramatic changes as shown in Figures 9 – 13.

Fig 13. View of lake from south west corner shown lake level in Aug 2012. (Google.maps)

By comparing the pictures, a quantitative assessment can be made that the water colour has undergone changes and this has environmental impacts on the quality of the water for the spawning ground.

A further qualitative assessment by comparing aerial views of the lake from a pre-earthquake and post-earthquake perspective shows that the water quality and the physical makeup of the lake appear to have changed and this is shown in Figure 14. The water colour is different, green (pre-quake) and brown (post-quake) in the same area of the lake. The top picture shows the ledge in the inanga spawning habitat in 2007 and the lower picture shows the ledge has gone since the earthquake. The blue arrows indicate the shallow ledge along the bank on both sides of the lake. The reasons for the absence of the ledge in the later picture could be due to increased turbidity so that it cannot be seen, that the liquefaction silt has risen from the bottom of the lake and buried the shallow or that the land slump issues mentioned previously have affected the shelf and it has dropped into the lake bed. The reason for the change in colour is a complex issue and this could be related to a variety of issues such as water temperature, water flow, quantity, contaminants, phosphate and nitrogen levels and potential algae bloom issues.

Fig 14 Pre and post-earthquake aerial view of Lake Kate Sheppard showing different water colour and a shelf/ledge around the lake in the top view which is missing the bottom view.

The seismic events of 2010 and 2011 also had major effects on the structure of the banks and the shoreline plantings. The liquefaction not only placed significant amounts of silt through the plants but also damaged large areas of plants. A comparison of the shoreline for pre and post seismic events can be seen in Figures 15 and 16. Remedial action needs to be completed to replace/restore the shoreline planting to provide a suitable habitat for inanga to lay their eggs. This needs to cater for a mean water level and the plants chosen require some resilience for the fluctuating water level from high water events, tidal surges and flooding as well as low water events. Planting should also incorporate plants to reduce the impact of Canadian geese and the residue that they create as this can be prolific and further reduce water quality.

	
Fig 15. Shoreline pre earthquake	Fig 16. Shoreline post eartquake

An observation on the eastern side of the lake shows that the lack of flow within the lake in Mar

2014 created a buildup of surface matter which may not be conducive to healthy water (Figure 17).

Fig 17. Eastern side of lake with surface growth on 22 Mar 14.

A comparison of this location between Mar and May 2014 can be seen where there is no surface matter in Figure 18 and the brown sludge has gone. The surface matter has been flushed as a result of heavy rain. This requires to be monitored to rule out algae bloom and any potential negative elements.

Fig 18. High water level with surface scum flushed.

The effects of stormwater runoff are exaggerated by built up areas with significant hard standing and closed drainage systems. The water is unable to drain naturally into the soil and has specific directions/places to go and with saturation and high water levels can lead to flooding issues. When rain falls onto leas and gardens, it will soak into the ground because these surfaces are permeable, gardens, grass and stone pebble pathways fall into this category of permeable surface. This allows rainfall to soak into the soil, reducing the amount of water entering stormwater drains network. The consequence of this helps to reduce flooding, pollution and deposited sediment in streams and estuaries (Environmental Canterbury Regional Council, n.d). Effective management of stormwater can provide many ecological benefits such as protecting ecosystem health and conserving biodiversity. It can also provide economic benefits and the protection and enhancement of landscape and recreational values. Some examples of stormwater management are summarized as below:

Vegetated swales

Vegetated swales are areas which are used in place of curbs or paved gutters to transport stormwater runoff.

Rain gardens

Rain gardens which are shallow depressions, infiltrate and filter rain that falls on hard surfaces like roofs, roads, driveways, car parks and footpaths. This helps minimise excessive runoff as well as reducing stormwater contamination from these surfaces, for example from rubbish, leaves, heavy metals from vehicles and detergents.

Green roofs

Green roofs are vegetated roof covers, with vegetation such as grass or meadow plants, replacing shingles, tiles or other hard roofing materials. Green roofs retain some stormwater and delay runoff, so that less stormwater enters the drainage system. These roofing systems also help reduce contaminants such as zinc from roofing and leaf litter.

Permeable Paving

The water is allowed to drain through permeable paving. Types include pavers, Gobi blocks and turf blocks. These types of pavers reduce the amount of impermeable surfaces and can also help treat stormwater. Permeable pavers provide stormwater treatment by letting water filter through the pavers into the land where it’s filtered through the ground or collected in subsoil drains before flowing to streams and rivers.

The Mahinga Kai project has included willow zones, grass area, liquefaction mounds. These designs are really efficient to reduce the amount of stormwater runoff entered the lake and the effect of stormwater on water quality of the lake.

Stormwater detention/treatment basin

Stormwater detention basins are artificially constructed depressions that store water temporarily to attenuate flood flows and potentially improve water quality by settling out sediment. They gradually discharge floodwaters through an outlet control structure into the receiving waters downstream, or to a further downstream treatment system (such as a wetland), in the overall terrain. As such they can provide both water quantity and quality control with some limitations.

The requirements for a resilient inanga spawning site are shade, humidity, substrate, dependent on hydrology, dredging, water levels, and bank shaping. It also needs areas with low turbulence at spawning times. In addition, water depth is very important for the protection of adult fish from predators. Inanga prefer exotic grasses, and rushes rather than flaxes and yellow flag iris. Thus, it is recommended to remove as much silt as possible from the bottom of the lake, because it will take a long time scale to develop a humid micro-habitat while the vegetation grows through the silt over time. The reason is that inanga eggs were not found in sandy soil that lack of a humid micro-habitat, but the loam soils with a mixture of mineral and organic components is suitable for inanga spawning (Taylor & Blair, 2011). Another benefit from removal of silt is to deepen the basin which will provide a suitable habitat depth for adult inanga which are intended to lay eggs there. Remedial action on the shoreline includes replacing the flaxes, cabbage trees, soft sedges and grasses with new specimens due to many of the remaining flaxes and shrubs emerged some unhealthy symptoms caused by root ruin.

Conclusions

Lake Kate Sheppard has damage from the seismic events which impair its performance as an exemplar mahingā kai site at present. Whilst there are inanga, patiki and tuna in the lake, their condition and suitability for human consumption is uncertain due to potential water quality issues. The last inanga egg count was in 2011 and it is unknown if inanga have laid eggs in the lake since then. The problems faced within the environment stem from the changes and uncertainty of the hydrology for the lake and the connections between the lake, the Avon/Otākaro River and Travis Wetlands. All remedial action on the lake stems from knowing this so that a mean water level can be set to establish bank shaping and a suitable planting regime. Whilst there are concerns that future sea level rises will affect the Christchurch area, it is considered that this mean water level is set with current conditions.

There is the requirement to establish a robust water monitoring programme which includes testing for heavy metals and road run off. This is to ensure the water quantity and quality is set at the levels to enable inanga spawning. Toxicity monitoring requires to be done to ensure mahingā kai species are suitable for human consumption. The silt within the lake and on the shoreline requires to be mitigated so that future generations of inanga eggs are not covered and to further enhance water quality. There is the potential to utilize neighbouring Red Zone areas to augment the catchment, assist with stormwater runoff and negate invasive species. This may be by stormwater detention basins and extensive planting with trees and native plants to encourage other species to the area.

Recommendations

The priority to restore Lake Kate Sheppard as an exemplar mahingā site is to conduct a complete hydrological survey of the lake and the catchment areas which affect it and to establish a mean water level within the lake.

Further recommendations (in no specific order) are as follows:

- **Short term recommendations**
    - Remove silt and reshape bank from jetty to south end of lake
    - Replant this section, both in water and on the banks
    - Plant trees on island with "wet feet" to encourage breeding zone
    - Involve local community groups/schools to facilitate replanting
    - Assess and monitor water quality
    - Toxicology assessments of mahingā kai species
- **Longer term recommendations**
    - Mitigate/manage silt issues
    - Excess water to flow back into Travis wetlands and/or detention basin
    - Shape bank of lake to provide depth and shallow edge
    - Replant lake edge & surrounds
    - Install storm water zone detention/treatment basin
    - Make outdoor classroom information panels interactive
    - Barrier fence along Anzac Drive to capture rubbish

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