KIA MOURIORA TE KAIWHARAWHARA

A COLLABORATION LED BY ZEALANDIA

WPI

Characterizing the Health of the Kaiwharawhara Catchment

7 March 2025

Grant Kortfelt | Thomas O'Leary | Ben Petrich | John Sirois

Dr. Nate Rigler | Professor Ingrid Shockey | Professor Robert Kinicki

Image Credit: Rob Suisted

Characterizing the Health of the Kaiwharawhara Catchment

An Interactive Qualifying Project submitted to the faculty of WORCESTER POLYTECHNIC INSTITUTE in partial fulfillment of the requirements for the degree of Bachelor of Science

By:

Grant Kortfelt

Thomas O'Leary

Ben Petrich

John Sirois

Submitted to:

Professor Ingrid Shockey

Professor Robert Kinicki

Dr. Nate Rigler

Jo Ledington

Terese McLeod

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Abstract

The Kaiwharawhara Stream in Wellington, Aotearoa New Zealand faces ongoing pollution and neglect. Restoring the area's health requires an increase in public and government knowledge and support. We partnered with Kia Mouriora te Kaiwharawhara and Zealandia Te Māra a Tāne to develop a framework to collate, interrogate, monitor, and report data relating to the stream. To achieve this goal, our team used site assessments, archival research, and interviews to develop an interactive dashboard to tell the story of the catchment through historical photographs, records of species relocations, and relevant events. User testing results helped us provide our partners with recommendations to continue dashboard development and implement additional water quality monitoring within the stream.

Executive Summary

In Aotearoa New Zealand's capital city of Wellington, local government and infrastructure agencies have funneled over 90% of the streams through pipes to prevent flooding and the erosion of inhabited land. While this protects the built environment, the reduction of freshwater pathways threatens the health of local ecosystems. The Kaiwharawhara Stream is one of the only non-piped streams that flow through Wellington City mostly above ground. Consequently, environmentalists and conservation groups recognize the stream as valuable for supporting biodiversity, and many native species depend on it for survival. Furthermore, the stream is culturally important to local *iwi* (Māori tribes) through the sentiment of *Te Mana o te Wai*. Despite its recognized importance, the Kaiwharawhara faces contamination from years of dumping, sewage leaks, and neglect.

To address catchment health issues, Zealandia Te Māra a Tāne (Zealandia) leads the Kia Mouriora te Kaiwharawhara initiative in partnership with *mana whenua* Taranaki Whānui ki te Upoko o te Ika. Zealandia is the world's first completely fenced ecosanctuary, renowned for nurturing wildlife in a pest-free space. Because the stream originates within the sanctuary, Zealandia has a stake in the initiative. Their staff, alongside Kia Mouriora te Kaiwharawhara volunteers strive to restore the health of the stream (*Te awa*), improve the native flora and fauna (*Te ngahere*), and support the overall wellbeing of the community (*Te tangata*). The scope of our project included creating an online dashboard to communicate catchment health data and initiative progress to increase community awareness and involvement.

Background

A review of available literature suggests that conveying both quantitative and qualitative information is a crucial aspect of science communication between research entities and the public. Best practices for conveying numerical information for more general use include summarizing findings, drawing attention to important metrics, and maintaining simplicity (National Academies of Sciences et al., 2017). A study at MIT found that thinking in terms of heuristics, or mental shortcuts to facilitate understanding, were effective for promoting comprehension (Setlur et al., 2023). Examples of heuristics include graphic simplification, iconography, and psychological associations such as the construction of parallels to past user experience and the application of common relationships. Qualitative data helps to inform and contextualize metrics and produce a stronger interactive connection with the audience (Alhamadi et al., 2022). These tools effectively engage users and efficiently share important information.

Expressive science communication can facilitate the ease and quality of its analysis and ultimately enable initiative or policy partners and stakeholders to conduct well-informed action. Platforms such as interactive online dashboards allow multiple users to visualize and share information quickly and effectively. Consistently updating these platforms can provide a medium to identify patterns, gain insights, and draw conclusions (Ustun, 2024). In recent years, online dashboards have become a common method of informing the public about important topics using understandable language and graphics. Best practices in dashboard design provide creative and engaging charts, images, and explanations in an intuitive format. Color schemes support the displayed data through cognitive associations and potent contrast.

In terms of the Kaiwharawhara initiative, a platform hosting a map with data overlay alongside charts to display data over time can

Executive Summary

serve as an accessible hub to communicate environmental health, water quality, and biodiversity. In addition, many local residents share a cultural connection with the Kaiwharawhara, which means that integrating qualitative historical data with scientific data can strengthen community bonds and spark public involvement around the initiative.

Approach

To achieve our goal, we identified three objectives:

1. Compile and organize the Kaiwharawhara catchment's existing data trends and gaps in current knowledge.
2. Design a dashboard to consolidate and visualize available data.
3. Revise and implement the dashboard based on user feedback.

These objectives informed our methodology, which consisted of site visits in the catchment area, database exploration, design-related interviews, and dashboard design. The site visits provided us with a personal snapshot of the catchment area and an overview of important locations. Exploration of Zealandia's catchment archive and other available data sources yielded metrics to populate our dashboard, which we designed according to the recommendations of specific users. We then reviewed the dashboard with our project partner and surveyed our student and professional cohort to address perceptions related to the dashboard design and level of engagement.

Design & Results

Our approach yielded key findings that informed the design of our dashboard. During our site assessments of the Kaiwharawhara catchment, our project partner Dr. Nate Rigler (Kia Mouriora te Kaiwharawhara Project Lead at Zealandia) discussed the importance of the catchment's flora and fauna on the biological health of the area as well as its impact on community wellbeing. We observed *toitoi* (common bully) and *banded kōkopu* in the Te Māhanga headwater at Zealandia, and *tuna* (freshwater eels) throughout the catchment. *Harakeke* (New Zealand flax) also thrives in the region. Both *tuna* and *harakeke* represent species of historical cultural importance to local *iwi*. *Tuna* were once a food source for Māori within the catchment before eel populations declined and water contamination increased, while *harakeke* continues to be a primary weaving material for traditional items such as *kete* (baskets) and *tīpare* (headbands).

Ongoing contamination of the Kaiwharawhara Stream is primarily the result of the stream picking up leachate as it runs through two decommissioned landfills below Appleton and Ian Galloway Parks. The water mobilizes contaminants such as heavy metals which travel downstream towards the harbor (see Figure 0.1). Sewage leaks at Ōtari-Wilton's Bush and Trelissick Park have also contaminated the water with E. Coli and other pollutants. At the estuary, trash collects in the water and surrounding vegetation due to dumping and upstream debris mobilization.

Figure 0.1: Rust-colored contamination of the Kaiwharawhara immediately downstream of Ian Galloway Park.

Executive Summary

These site assessments, which familiarized our team with relevant areas of the catchment, highlighted the importance of connecting qualitative and quantitative data geospatially. Characterizing the Kaiwharawhara catchment and its interaction with the watershed, the surrounding forest, and the community requires engaging and user-friendly data representation. While our intended dashboard users may be familiar with some locations along the stream, the use of documented pin markers along with historical and quantitative information can also tell the story of the Kaiwharawhara in real time and emphasize the extent of the area's mistreatment. Interviews with six prospective dashboard users guided our platform development. The key recommendations from these interviews were to display flora and fauna species data within the catchment, provide a record of species translocations, and display a mix of quantitative and qualitative data to better engage with public users. Additionally, these interviews informed the layout of the dashboard and supported the team's decision to feature a map of the catchment area and locational pins highlighting key locations.

Team members Thomas O'Leary and Grant Kortfelt used previous experience, design interviews, and personal preferences to make two key design decisions when constructing the dashboard. First, they elected to code the dashboard from scratch using HTML, JavaScript, and CSS rather than building the website with a designer such as Wix. This provided increased flexibility in the layout and coding of the dashboard but required more time to complete. They also decided to host the dashboard on a WPI domain (found here) since the platform cannot integrate into the framework of the current Zealandia website.

To populate the dashboard, we explored the Kia Mouriora te Kaiwharawhara catchment archive on SharePoint. Based on recommendations from our pre-development interviews and internal discussions, we pulled data on historical catchment events, species relocations, and pest relocations. This research provided us with qualitative and quantitative catchment data but ultimately highlighted the need for additional data collection to properly characterize the wellbeing of the region.

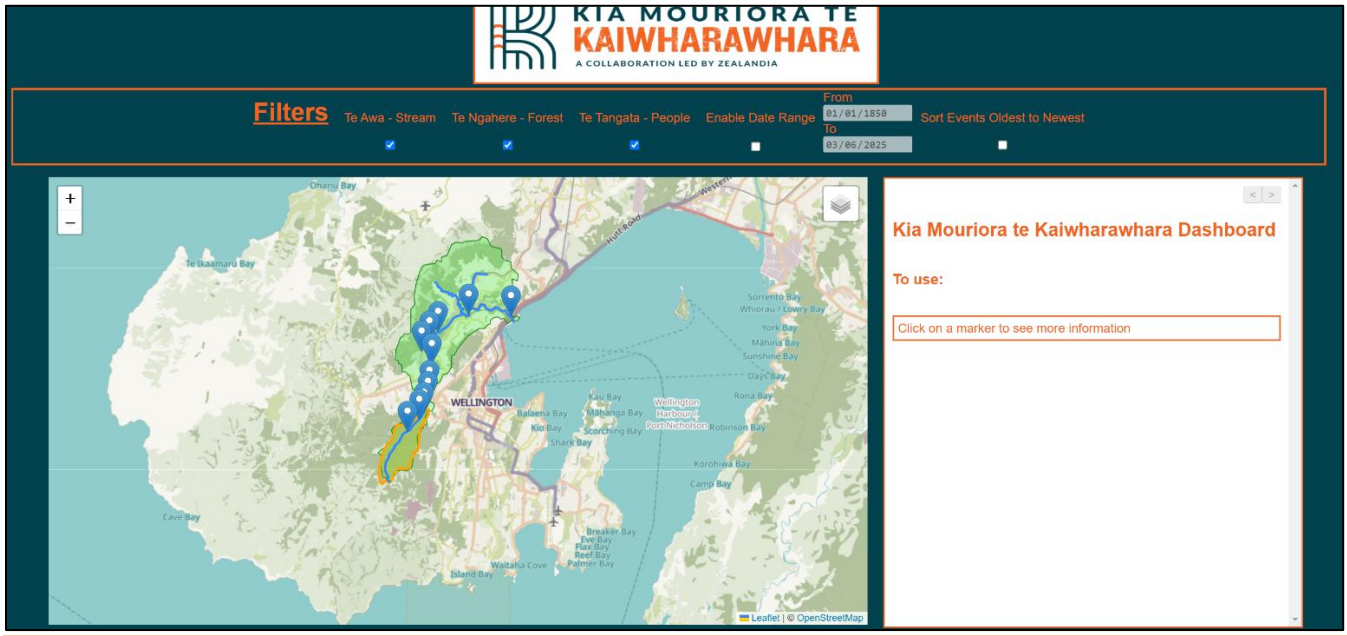

Figure 0.2: Dashboard layout depicting a map of the catchment, locational pins, and historical photographs.

Executive Summary

The dashboard layout allows users to view a map of the catchment area while reading data on the right (see Figure 0.2). Locational markers, polygon overlays, and map types characterize the map window and are toggleable. We presented qualitative data through a historical lens, tying photographs and events in catchment history to specific locations and dates. Quantitative data regarding species relocations appear in the right window. We stored this data in an Excel spreadsheet for future data addition and applied a JSON conversion script to upload it to the dashboard. We presented our project work to the Kia Mouriora te Kaiwharawhara community group at the 20th Community Hui on 19 February 2025. The community at large expressed enthusiasm for our project directive and the design of our dashboard.

We also conducted a brief design review with our project partner, in which Dr. Rigler edited the content and wording on the dashboard and approved the platform for user testing. This testing sought to identify which design criteria were most important for future revision. User feedback from our student and professional cohort revealed that visual appeal received the lowest overall score of the four design criteria that we assessed (see Figure 0.3).

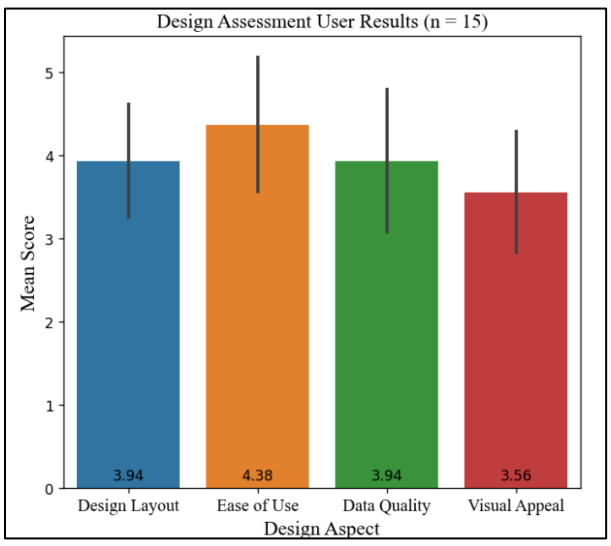

Figure 0.3: Graph depicting our user testing results.

This feedback informed our recommendations for further dashboard development.

Recommendations

Based on our key findings, we developed two recommendations to aid the Kia Mouriora te Kaiwharawhara initiative in enhancing their public data display and reviewed them with our project partner.

Recommendation 1: Develop low-cost, durable, and accurate wireless sensor networks to conduct additional water quality monitoring within the Kaiwharawhara Stream and provide actionable data over time. Collaborate with citizen science demographics (Victoria University students, engineers, project teams, etc.), community volunteers, and potentially Greater Wellington Regional Council (GWRC) for development and implementation.

Recommendation 2: Employ additional technical personnel or a university student team to continue development of dashboard components, display capabilities, visualizations, website complexity, data storage, and integration with Zealandia's new upcoming website.

Conclusion

The project team created a dashboard that can host records of historical context and ongoing environmental interventions along the Kaiwharawhara catchment. It serves as a buildable resource for Kia Mouriora te Kaiwharawhara partners and stakeholders, and local interest groups, to visually present critical sites along the stream and its bioregion. We hope our dashboard acts as a central resource for effective visualization and communication of catchment restoration efforts moving forward.

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- Our project advisors, Professor Robert Kinicki and Professor Ingrid Shockey of Worcester Polytechnic Institute, for their continuous support throughout the project.
- Our project partner, Dr. Nate Rigler, for his unwavering support and involved oversight.
- Jo Ledington, and Terese McLeod for their guidance and encouragement throughout the term.
- The Zealandia staff for their hospitality throughout the duration of the project.
- Our interviewees, who made time to discuss our project and provide input on our dashboard design.
- Our survey participants, who took the time to review our dashboard and provide meaningful feedback.

Meet the Team

Grant Kortfelt

Hey everyone! My name is Grant Kortfelt and I am from Montville, Connecticut. I am a junior at WPI studying Computer Science, Data Science, and Cybersecurity. I have loved being a part of this project. It was great spending time at Zealandia and working throughout the catchment. It was awesome talking with and working with many welcoming people about our work! The lessons I learned from this partnership will stay with me long into my future work endeavors and experiences.

Thomas O'Leary

What's on! My name is Thomas O'Leary, and I am from Millbury, Massachusetts. I am a junior at WPI studying Computer Science and Artificial Intelligence through the BS/MS program. Spending each day at Zealandia was amazing, and I loved being surrounded by nature every single day. Our partners' incredible passion for conservation was infectious. I think I've gained a new appreciation for nature from this project.

Benjamin Petrich

Hello! My name is Ben Petrich and I'm from Ithaca, New York. As a third-year WPI student majoring in Biomedical Engineering, I have greatly enjoyed working on this project. Exploring Zealandia and contributing to the team efforts has been an unforgettable experience. Seeing firsthand the dedication of our partners and the impact of our work has been truly inspiring. I greatly appreciate the opportunity to learn in such a positive and dedicated environment.

John Sirois

What's up! My name is John Sirois. I'm a junior studying Mechanical Engineering from New Jersey. Working in the catchment has given me an appreciation of New Zealand's cultural values in a hands-on environment. I will always be grateful for the knowledge, skills, confidence, and experience I have taken away from this project! I look forward to applying the lessons I have learned here throughout the rest of my academic and professional career.

Table of Contents

Table of Figures

Table of Tables

Chapter 1: Introduction

Water quality in the built environment is susceptible to aging infrastructure, negligence, and limitations in protective planning initiatives. Aotearoa New Zealand faces additional complications with monitoring its fragile ecosystem due to seismic activity and unstable terrain. These risk factors have led to toxic runoff from sources such as decommissioned landfills, which in turn impact water supply, adjacent communities, and local ecosystems. In the capital city of Wellington, local government and infrastructure agencies have funneled over 90% of the streams through pipes to prevent flooding and the erosion of inhabited land. While this protects the built environment, the reduction of freshwater pathways threatens the health of the ecosystem. The Kaiwharawhara Stream is one of the only non-piped streams that flow through Wellington City mostly above ground. Consequently, environmentalists and conservation groups recognize the stream as valuable for supporting biodiversity, and many native species depend on it for survival.

Part of the Kaiwharawhara catchment area lies within Zealandia Te Māra a Tāne (Zealandia), the world's first completely fenced ecosanctuary, renowned for nurturing native wildlife in a pest-free space. However, the stream's water quality through this zone is poor. Even further downstream, two decommissioned landfills and multiple sewage leaks contaminate the Kaiwharawhara with toxic runoff, compromising the stream's health and threatening the surrounding landscape (Whaitua Te Whanganui-a-Tara Committee, 2021). To monitor and address this issue, Zealandia leads the Kia Mouriora te Kaiwharawhara Sanctuary to Sea initiative in partnership with *mana whenua* Taranaki Whānui ki te Upoko o te Ika. Their initiative strives to restore the health of the stream (*Te awa*), improve the native flora and fauna (*Te ngahere*), and support the overall wellbeing of the community (*Te tangata*) (Zealandia, 2018). Purifying the Kaiwharawhara is a cornerstone of Zealandia's overall conservation efforts, as the waterway already promotes species development and wellbeing throughout the bioregion.

A comprehensive platform displaying the Kaiwharawhara Stream's status could enable Zealandia and its partners to better address water quality issues with actionable steps. In recent years, researchers and territorial authorities have already collected considerable data from the catchment area (Personal Communication: Nate Rigler, 11 November 2024). However, there has not been an opportunity to consolidate information on the waterway's health. Furthermore, access to easily visualized, quantifiable, and comparable ecological health data is critical for informing public

communications. Thus, the goal of this project was to partner with Zealandia Te Māra a Tāne and Kia Mouriora te Kaiwharawhara Sanctuary to Sea to develop a framework to collate, interrogate, monitor, and report data about the Kaiwharawhara catchment. To achieve this goal, our team outlined three objectives: 1. Compile and organize the Kaiwharawhara catchment's existing data trends and gaps in current knowledge; 2. Design a dashboard to consolidate and visualize available data; 3. Revise and implement the dashboard based on user feedback.

We designed the dashboard to display a map of the catchment area with selectable overlay polygons and locational markers containing historical data. We also created a user testing survey; respondents concluded that this dashboard's layout was intuitive and felt as though they learned more about the catchment from its use. Our findings from the construction and design of this dashboard suggested a potential lack of actionable quantitative data relating to catchment health. Therefore, our team recommended both the implementation of additional water quality monitoring and further development of our visual platform to display this data. Though further iteration will be necessary, we hope that our work provides the Kia Mouriora te Kaiwharawhara initiative with an elementary platform for effective visualization and publication of catchment progress, inspiring further community involvement with restoration efforts in the region.

Chapter 2: Exploration of Context

This chapter details both physical landmarks and the historical background of the project. We identify key partners and interest groups working in the catchment and highlight approaches that can inform data consolidation, visualization, and characterization for Kia Mouriora te Kaiwharawhara.

Partners in ecosystem management

Poor water quality affects ecosystem species diversity, the health of communities, and the cultural identities of those who live in and share a watershed. Building a network that can share and optimize data offers collaboration opportunities across agencies and interest groups to address critical resources. Within Aotearoa New Zealand, ecological health bears high cultural importance, and partnered collaboration addressing water quality issues provides a cultural touchstone that fosters social unity (see Figure 2.1). Additionally, ecological restoration is an important facet of long-term communion between humanity and the natural world.

Figure 2.1: The project team volunteering to clean up the Kaiwharawhara estuary.

Internationally, decommissioned landfills have continued to contaminate freshwater sources. A study in Gaeiras, Portugal discovered that flowing water sources such as rivers and stormwater runoff regularly pick up and deposit landfill contaminants downstream (Ramalho et al., 2013). Chronic problems regarding water quality and contamination are at the forefront of Aotearoa New Zealand's public concern (Heagney, 2024). Building research collaborations and promoting science communication can grow public awareness and support steps toward resolution of water quality issues.

In Aotearoa New Zealand, cultural identity stemming from Māori values places paramount importance on the preservation of the personal connection between social wellbeing and the natural

world (Lockhart et al., 2019). Natural water sources are an integral part of the country's identity, a sentiment described as *Te Mana o te Wai* (*Clause 1.3*, 2022). Residents and conservationists invested in ecosystem rights and water quality need consolidated ecological health data that can inform policy decisions for remediation.

The Kia Mouriora te Kaiwharawhara initiative has a 100-year vision for restoring the health of the Kaiwharawhara catchment (Zealandia, 2018). The scope of the catchment initiative is extensive, involving many partners and stakeholders sharing the effort to act and build momentum for more careful oversight. Zealandia and its staff reside at one of two headwaters of the Kaiwharawhara Stream. Their ecosanctuary falls within the water catchment area, and the Te Māhanga branch of the Kaiwharawhara runs through its protected land (see Figure 2.2). Poor water quality has consequences for this sensitive and biodiverse ecosystem. The organization's mission to restore the sanctuary to pre-colonial Aotearoa prioritizes regional watershed concerns.

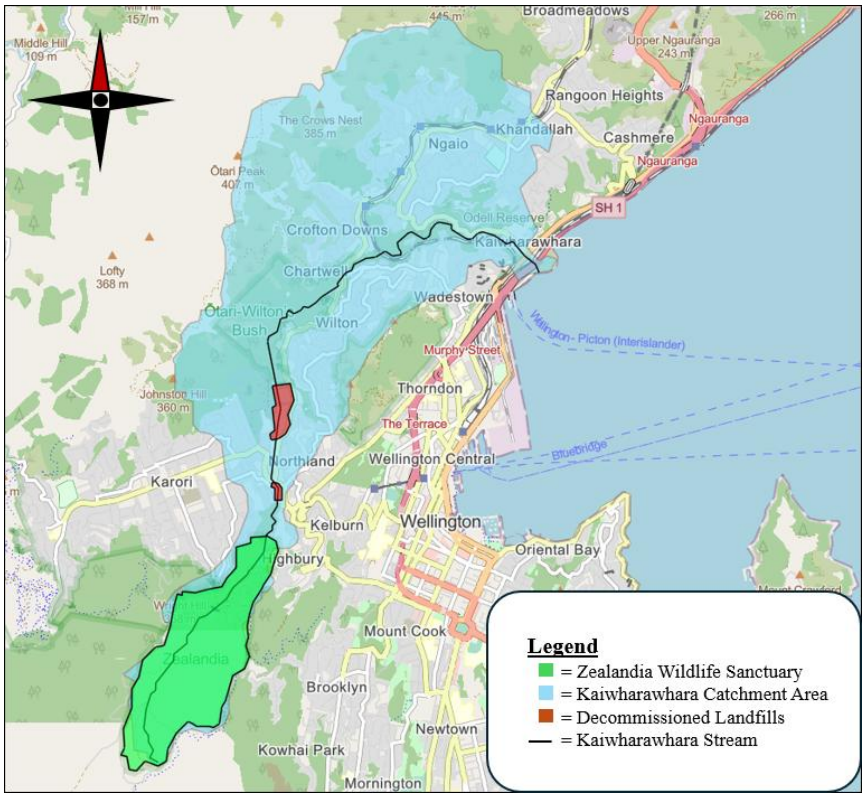

Figure 2.2: Map of the greater Wellington City, highlighting the location of Zealandia ecosanctuary, the Kaiwharawhara catchment area, and the decommissioned landfills over which the Te Māhanga branch of the Kaiwharawhara Stream flows (map credit: OpenStreetMap, modified by Grant Kortfelt using ArcGIS).

Apart from Zealandia, there are numerous other stakeholder groups that strive to improve the ecological health of the Kaiwharawhara catchment. Three governmental agencies have an interest in the project: the national agency Department of Conservation (DOC) and the territorial agencies Greater Wellington Regional Council (GWRC) and Wellington City Council (WCC). In addition, Morphum Environmental Ltd. is an environmental engineering consulting company with expertise in catchment planning, water engineering, and sustainability that supports the initiative (*New Zealand Engineering*,

Science, Geospatial & Sustainability Consultants, n.d.). Furthermore, Kia Mouriora te Kaiwharawhara is now working in collaboration with Victoria University Wellington (VUW), GHD environmental engineering firm, and CentrePort (Personal Communication: Nate Rigler, 19 December 2024). These groups are directly involved in the health of the Kaiwharawhara Stream and the water quality within the catchment, concerned with its impact on both natural and urban spaces (Zealandia, 2018). Ōtari-Wilton's Bush Trust and the Trelissick Park Group are examples of smaller-scale interest groups. Finally, the *iwi* (Māori tribe) local to the Wellington Harbor area have valued the cultural and bio-heritage significance of the Kaiwharawhara since their southern migration from Taranaki in the early 1800s. Healthy collaboration and communication between these groups are essential for achieving the best possible outcomes for the initiative.

Ecological health monitoring for decision-making

The Kaiwharawhara catchment area lies to the west of Wellington CBD (Central Business District) and its un-piped tributaries form the only stream in the city that flows freely into Wellington Harbor (see Figure 2.3).

Figure 2.3: Wellington City and Wellington Harbor pictured from the top of the Wellington Cable Car.

Exploration of Context

Many diadromous fish species rely on both the freshwater stream and saltwater harbor for their reproductive cycle (Personal Communication: Nate Rigler 11 November 2024). The catchment area also includes several known contamination sources, including sewage leaks and two decommissioned landfills below Appleton Park and Ian Galloway Park (Personal Communication: Nate Rigler, 11 November 2024). Minor scrapes or cuts from the local sports field at Ian Galloway Park often lead to infection. Leachate in water runoff from the contamination sources pollutes the Kaiwharawhara Stream as it collects and mobilizes the contaminants. Interaction with the water itself, which was once harmless to swimmers (see Figure 2.4), now presents the risk of toxic exposure (see Figure 2.5).

Figure 2.5: St. John's pool, once a popular swimming hole in the Te Māhanga branch of the Kaiwharawhara Stream before Northland School opened their own swimming pool in 1937 (image credit: Living Heritage – Northland School, n.d.).

Figure 2.4: The remains of St. John's pool today. Contamination of the Kaiwharawhara Stream now prevents swimming.

In recent decades, routine ecological health monitoring has been a positive contribution, as experts realize regular collection and processing of data holds high importance (Burt et al., 2014). Long-term data patterns, trends and cycles, and documented infrequent events enable scientists to develop mitigation and adaptation strategies (Burt et al., 2014). The parameters and indices to determine water quality generally include physicochemical properties, hydro-morphological status, biological composition, and chemical composition (Madrid & Zayas, 2007). Knowing and monitoring the key parameters to assess the overall water quality is one feasible and efficient scheme to gauge health (Bhardwaj et al., 2018). Other quantifiable ecological components that measure wellbeing include the abundance and balance of nutrients, number of invasive species, abutting land use, regional land cover, and human activity (Mamun & An, 2022). Quantifiable and communicable ecological health data is crucial for providing stakeholders and experts with information to make informed decisions.

Visualizing data for science communication

Moving quantifiable data points into actionable policy is a lesson in science communication. Without consolidation and visualization, there are limitations regarding the application of collected data (Personal Communication: Nate Rigler, 22 January 2025). While the Kia Mouriora te Kaiwharawhara initiative has information about the catchment, there is an opportunity to improve the interaction of scientists, researchers, and the public with these metrics.

Conveying quantitative information is a crucial aspect of science communication between research entities and the public. Numerical data can be difficult for people to grasp, therefore it requires proper display characteristics and an understanding of how people process and commonly misunderstand information (National Academies of Sciences et al., 2017). Literature suggests that the best practices for conveying numerical information for more general use include summarizing findings, drawing attention to important metrics, and maintaining simplicity (National Academies of Sciences et al., 2017). A study at MIT found heuristics—mental shortcuts to facilitate understanding—effective for promoting comprehension (Setlur et al., 2023). Some examples of heuristics are graphic simplification, iconography, and psychological associations such as constructing parallels to users' past experience and applying common relationships. These tools are imperative for engaging users and conveying important information.

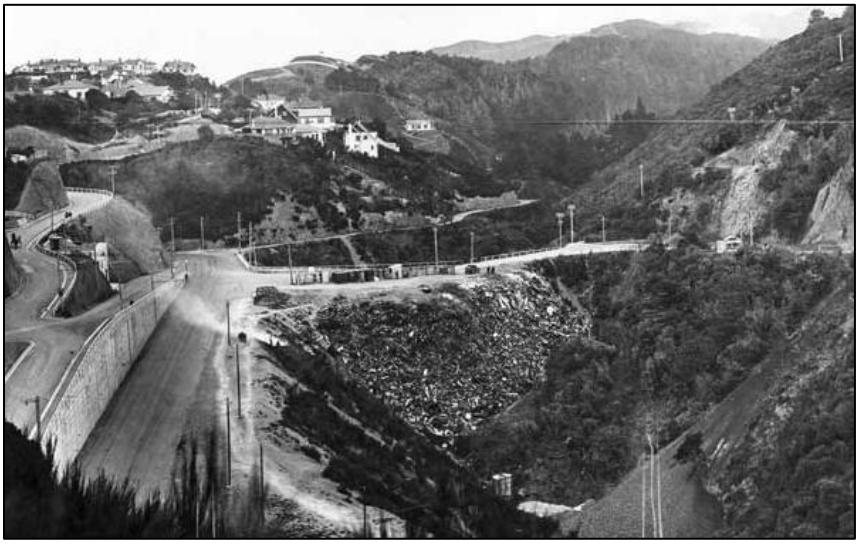

Figure 2.6: Qualitative historical storytelling through photography, depicting the Appleton Park valley in 1935. Today, this decommissioned landfill resides under flat terrain while the Te Māhanga branch of the Kaiwharawhara Stream continues to run directly through the area (image credit: Edward Thomas Robson, 1935).

Communication of qualitative data is equally important for general engagement and public literacy. Qualitative storytelling is an effective tool for maintaining accessibility and understanding (see Figure 2.6), and researchers working in data communication must carefully consider what to convey and how to best grasp an audience's interest (Alhamadi et al., 2022). Qualitative data helps to

inform and contextualize quantitative analysis while producing a stronger interactive connection with the audience.

Expressive science communication can facilitate the ease and quality of its analysis and ultimately enable initiative or policy partners and stakeholders to conduct well-informed communication and action. There are many approaches for developing a platform for amplifying and communicating findings, but a dynamic online dashboard format can enable multiple users to visualize and share information quickly and effectively. A consistently updated dashboard can serve as a source and archive that provides methods for identifying patterns, gaining insights, or drawing conclusions (Ustun, 2024).In recent years, online dashboards have become a relatively common method of informing the public about important topics using understandable language and graphics. Some popular examples of successful dashboards include Johns Hopkins' COVID-19, OEC World, and Hudson River Park water quality monitoring (*COVID-19 Map*, n.d.; *Monitoring Our River's Improving Health*, n.d.; *The Observatory of Economic Complexity*, n.d.). These three dashboards provide creative and engaging charts, images, and explanations. Figure 2.7 depicts an intuitive layout for displaying combined sewer overflow (CSO) risk over time by the Hudson River Park. The graphics are simple and effectively convey the data. The color scheme supports the data through cognitive associations and potent contrast. In fields such as nature conservation which envision long-term goals, common data display methods such as histograms and scatter plots do not always portray the same urgency as specialized graphs.

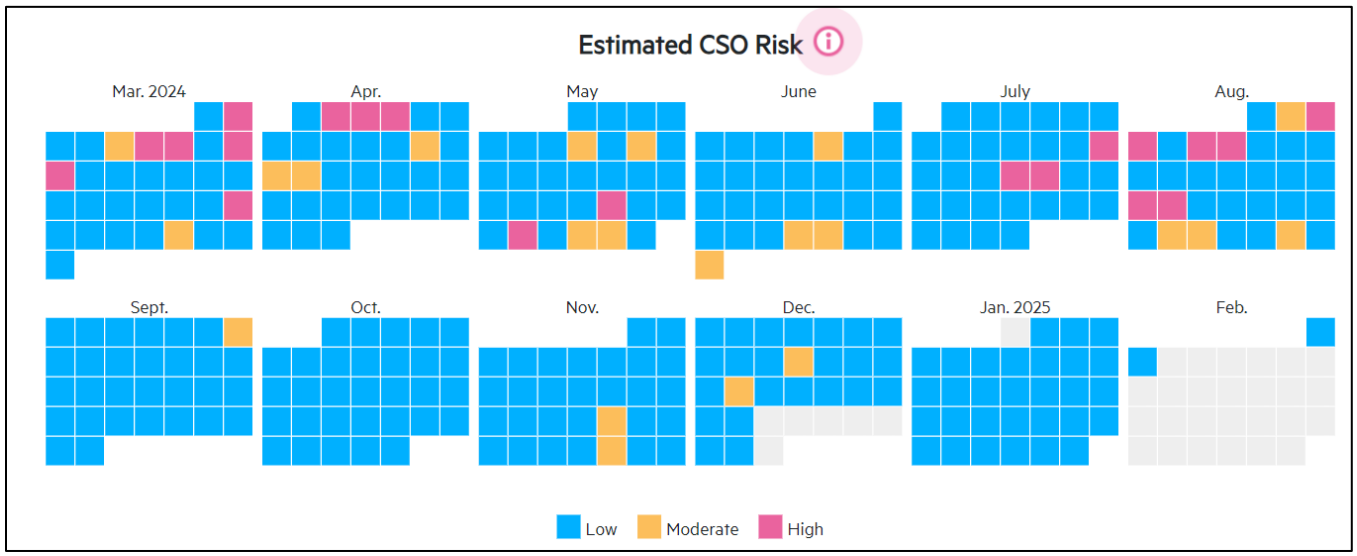

Figure 2.7: An example of a creative water quality data display using Hudson River Park's daily combined sewer overflow (CSO) risk, accessed 2 February 2025. A pulsing 'info' icon provides context for the graph (image credit: Monitoring Our River's Improving Health, n.d.).

In terms of the Kaiwharawhara initiative, a platform hosting a map with data overlay, as well as charts to display quantitative scientific data over time, could serve as an easily accessible hub to communicate environmental health, water quality, and biodiversity. In addition, many local residents and interested volunteers share a cultural connection with the Kaiwharawhara (see Figure 2.8). Therefore, integrating qualitative historical data with scientific data can strengthen community bonds and spark public involvement around the initiative.

Figure 2.8: The Kaiwharawhara catchment at Zealandia(image credit: Rob Suisted).

Critical findings to inform upcoming work

A review of key literature revealed three points that informed our study going forward. Wellington Region is a culturally rich area with many citizens supporting ecological restoration, specifically within the Kaiwharawhara watershed (see Figure 2.9). Collected data that measure and characterize catchment health are essential tools for ecological analysis and cultural interaction.

However, widespread communication of data emerging from these research efforts is critical to catalyze action. Dashboards are one example of a useful platform for visualizing data and fostering awareness and communication within local communities.

Figure 2.9: Our team posing with our project partner Dr. Nate Rigler.

Chapter 3: Approach

The goal of this project was to partner with Zealandia Te Māra a Tāne and Kia Mouriora te Kaiwharawhara to develop a framework to collate, interrogate, monitor, and report data about the Kaiwharawhara catchment. We identified three objectives to achieve this goal:

1. Compile and organize the Kaiwharawhara catchment's existing data trends and gaps in current knowledge.
2. Design a dashboard to consolidate and visualize available data.
3. Revise and implement the dashboard based on user feedback.

This chapter details our various methodologies and strategies to meet our objectives and achieve the project goal. Figure 3.1 summarizes our approach to completing the components of this project.

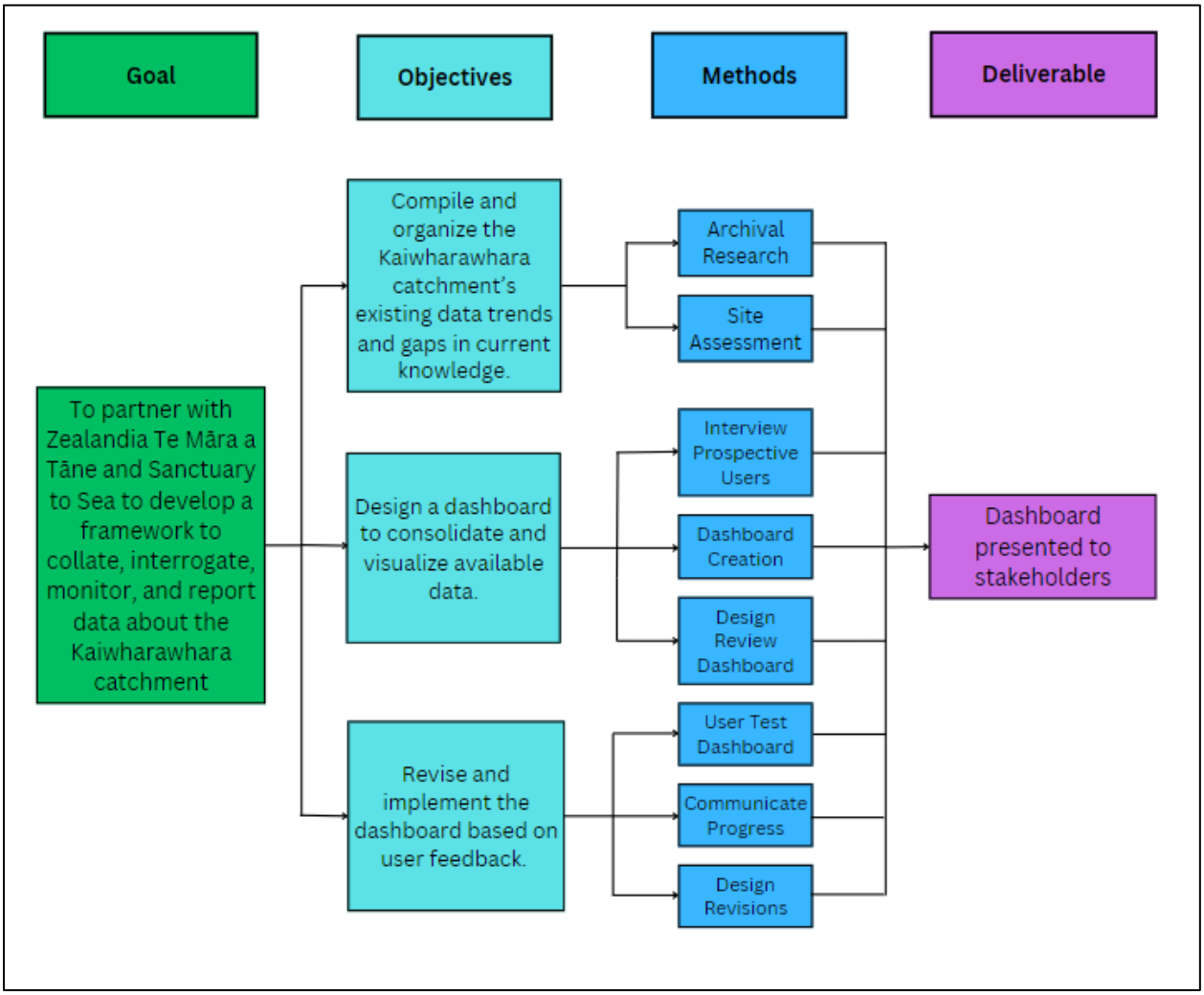

Figure 3.1: Methods diagram depicting goal, objectives, methods, and deliverable.

Compile and organize existing data trends and gaps in research

Conduct a site assessment

During the first week in Wellington, our project partner Dr. Nate Rigler (Kia Mouriora te Kaiwharawhara Project Lead at Zealandia) led onsite inspections of the Kaiwharawhara catchment (see Figure 3.2). These tours helped orient us within the catchment area, provided opportunities for a discussion of notable features and critical locations, and informed the design of our dashboard. Our team photographed important points of interest and recorded field notes for internal reference.

Figure 3.2: The team's site visit in the Kaiwharawhara catchment at Zealandia.

Collate the Kaiwharawhara catchment archives

Zealandia's online archive contains various reports, surveys, and studies of the Kaiwharawhara catchment. However, the lack of data cohesion hinders any analysis and prioritization of catchment issues. To collate the usable and actionable data, we created an Excel spreadsheet for tagging datasets

and logged them based on Kia Mouriora te Kaiwharawhara objectives, data source, date range, data type, and accessibility. We consolidated data from Zealandia's SharePoint archive and public communications, Greater Wellington Regional Council, Wellington City Council, and various local news articles. This effort provided our team and Kia Mouriora te Kaiwharawhara with a foundation for populating a dashboard platform and confirming critical domains of catchment research.

Design a dashboard to consolidate and visualize available data

Interviews with prospective users

The dashboard's main purpose is to inform the public about the progress of the Kia Mouriora te Kaiwharawhara initiative and, as a result, to increase community engagement. Before and during development, we conducted brief, informal discussions with six Kaiwharawhara catchment experts to gauge their content preferences and boundaries (see Appendix A for the consent form and Appendix B for interview discussion points). Table 3.1 lists the interviewees and their titles.

Table 3.1: List of prospective dashboard user interviewees, their relevance to the initiative, and the date of the interview.

Interviewee	**Title**	**Date**
Dr. Nate Rigler	*Kia Mouriora te Kaiwharawhara Sanctuary to Sea Project Lead*	23 January 2025
Anne Tuffin	*Trelissick Park Group Lead*	24 January 2025
Steve Cosgrove	*Network Communications Academic & Zealandia Volunteer*	4 February 2025
Dr. Andrew Rees	*VUW Environmental Sciences Lecturer*	5 February 2025
Dr. Kevin Norton	*VUW Geology Lecturer*	5 February 2025
Justin Gulino	*Former Zealandia Intern (Catchment StoryMap Development) & PhD Student at VUW*	14 February 2025

Platform design for data visualization

To consolidate, organize, and display the Kaiwharawhara data, team members Thomas O'Leary and Grant Kortfelt constructed a dashboard for data visualization (see Chapter 4 for design information). Concurrently, our team developed a user manual (see Appendix C) to inform future operation and enhancements for the dashboard.

Dashboard feedback and design implementation

Present project work to the partners and stakeholders

We presented the prototype dashboard to the Kia Mouriora te Kaiwharawhara strategy group for feedback at their 20th Community Hui on 19 February 2025. Following the presentation, we conversed with various stakeholders who provided feedback and insight into the dashboard's design.

Design review

Our team conducted design reviews with our project partner to ensure he approved of the direction our dashboard was heading. The initial design review confirmed that the features and graphics we implemented reflected his expectations. The second design review was more in-depth, confirming the validity of the dashboard's information before it became publicly available.

User testing

Following the design review, our team looked to conduct dashboard user testing by surveying Kia Mouriora te Kaiwharawhara stakeholders, initiative volunteers, and VUW students. We sought to develop a survey in Qualtrics to route users to the online dashboard hosted on the WPI domain. We wanted users to rate their familiarity with dashboards and the Kaiwharawhara catchment area, then explore the dashboard's features and functionality before reporting their design impressions and areas for improvement. We targeted Likert-scale questions as well as open responses (see Appendix D) to assess the dashboard's design and coded the feedback to identify the most important revisions to make. Users responded both before and after dashboard use in the same survey so that we could gauge its effectiveness in learning about the Kaiwharawhara catchment.

Construction of recommendations

Based on user testing feedback alongside team discussion, we constructed a list of recommendations for the Kia Mouriora te Kaiwharawhara initiative to inform future dashboard development. We presented these recommendations to our project partner Dr. Nate Rigler for review and approval.

Chapter 4: Results

This chapter outlines our project results in order of our methodology. It includes our site assessment, data collation, interviews with prospective dashboard users, and sample surveying. We discuss the most pertinent findings at the end of the chapter.

Compile and organize existing data trends and gaps in research

To create a dashboard that can best support action in the region, we first ensured that current site conditions and regional impacts confirmed the existing data.

Site assessment

With our partner Dr. Nate Rigler, we explored the Zealandia sanctuary and the surrounding Kaiwharawhara catchment area to inform our work. We explored the importance of the catchment's flora and fauna on the biological health of the area as well as its impact on the community's wellbeing. Within the headwater and reservoir of Zealandia, fish species such as *toitoi* (common bully) and *banded kōkopu* rely on the waters as part of their natural habitat. Throughout the stream, we also observed *tuna* (freshwater eels), a protected species in the catchment due to their dwindling populations because of human activity and freshwater contamination. These protections prevent hunting in the region but also impact practices that support local Māori cultural identity.

Culturally significant plants also flourish within the catchment area, including *harakeke* (common New Zealand flax) which is the primary *raranga* (weaving) material. Māori use *harakeke* to weave items such as *kete*, or baskets, and *tīpare*, or headbands (see Figures 4.1 and 4.2). Traditional Māori worldviews foster a strong connection to the natural environment, and the *iwi* have used ecological resources for a multitude of purposes over many years.

Figure 4.1: A Hawaiian technique we used to weave harakeke into a headband.

Results

Figure 4.2: Harakeke weave.

In our assessment of the larger catchment area, we observed the systemic concerns that have infiltrated the entire ecosystem. Our team noted heavy metal contamination within the Kaiwharawhara waters exiting the Ian Galloway Park landfill (see Figure 4.3). Illegal dumping and water runoff also pollute the stream. Major sewage leak locations, a result of old and crumbling infrastructure, exist in both Otari-Wilton's Bush and Trelissick Park (see Figure 4.4). The GWRC monitors Kaiwharawhara Stream water quality at Ngaio Gorge in Trelissick Park, but the sole sensor is too far downstream of the main contamination sources to produce actionable data (see Figure 4.5). Based on information from our partner, many of the concentrated upstream contaminants dilute before reaching the water quality sensor. Therefore, the recorded data does not accurately depict the severity of the problem or the primary sources of contamination.

Figure 4.3: Rust-colored contamination of the Kaiwharawhara Stream immediately downstream of Ian Galloway Park

Figure 4.5: Leaking sewage pipe in Trelissick Park.

Figure 4.4: GWRC water quality monitor at Ngaio Gorge in Trelissick Park.

The Kaiwharawhara estuary acts as both a dumping ground and a funnel for trash and debris to accumulate in and around the stream. In addition, a nearby sewage pipe has a history of leaking raw sewage into the water. Furthermore, the estuary's saltwater ridge, which is an important spawning location for fish species such as *inanga* (or whitebait) lacks proper vegetative growth along its border. While Kia Mouriora te Kaiwharawhara has been working to restore some native vegetation and provide ample spawning habitat, the estuary's tidal conditions make it difficult for the plants to take root and survive along the river's edge.

These site assessments, which familiarized our team with relevant areas of the catchment, highlighted the importance of connecting qualitative and quantitative data geospatially. Characterizing the Kaiwharawhara catchment and its interaction with the watershed, the surrounding forest, and the community requires engaging and user-friendly data representation. While our intended dashboard users may be familiar with some locations along the stream, the use of documented pin markers along with historical and quantitative information can also tell the story of the Kaiwharawhara in real time and emphasize the extent of the area's mistreatment.

Leveraging the Kaiwharawhara catchment archives

From the Kia Mouriora te Kaiwharawhara catchment archive and other data sources, we collated historical photographs, locational information, species relocations, and pest removals into an Excel spreadsheet. We collected historical photos of important catchment locations and constructed written overviews of each location we toured during our site visits. Our Zealandia translocation records included the addition of species such as *toitoi*, *kākahi* (freshwater mussels), *pua o te Rēinga* (wood rose), and *pirita* (mistletoe). We also included records of brown trout removal from Roto Māhanga (Zealandia's upper reservoir) and Eurasian perch removal from Roto Kawau (Zealandia's lower reservoir). Lastly, we added a brief record of *pepeketua* (Hamilton's frog) release from their boxed enclosures within Zealandia. We provided Kia Mouriora te Kaiwharawhara with access to this Excel spreadsheet for future data addition (our manual for adding data to this spreadsheet is in Appendix E). Collation of this data produced a foundation for dashboard population but also highlighted the potential for further work. We discuss our recommendations for additional data collection and consolidation in Chapter 5.

Design a dashboard to consolidate and visualize available data

Determining the Web stack

To build a website, programmers either utilize a website construction service (such as Wix) or create a platform from scratch. While website construction services are quick and efficient, they are not customizable from a code level. On the other hand, building a website is more time-intensive and requires significant coding experience, but provides increased freedom to the designers. Team members Grant Kortfelt and Thomas O'Leary are both majoring in computer science, and Thomas possessed extensive experience with web design. They preferred the increased flexibility and workload of coding the platform rather than the limitations of a website builder. Thus, they decided to build the entire dashboard from the ground-up. They designed the platform with the standard trio of website programming languages – JavaScript, HTML, and CSS. For cooperation, the two used GitHub (repository found at https://github.com/thomasjoleary/ZealandiaDashboard).

Interviews with prospective users

We held our first discussion on dashboard development with our partner Dr. Nate Rigler. His priority is public outreach, focusing on increasing local involvement in the Kia Mouriora te Kaiwharawhara initiative. His primary suggestion was to make the dashboard as intuitive as possible,

appealing to anyone seeking involvement in restoration. He supported our idea to overlay dashboard data onto an interactive map and maintain information on past progress and future plans (see Appendix F).

Trelissick Park Group Chair Anne Tuffin mentioned that restoration is a long-term project, and results are never instantaneous. In hopes of sparking local interest in the initiative, she recommended we find data sources on plant and animal species within the catchment to showcase native population growth and pest trapping efforts (see Appendix G).

Zealandia volunteer and academic Steve Cosgrove recommended that our dashboard display a mix of quantitative and qualitative data. This could help to balance the dashboard's usability for those with a technical background as well as those interested in the catchment without scientific expertise. Additionally, he suggested that we identify gaps in current data to help inform future research opportunities or available funding (see Appendix H).

Our meeting with Dr. Andrew Rees and Dr. Kevin Norton yielded soil, heavy metal, and microplastic data from within the catchment. However, these metrics are currently unreliable due to the varied procedures and the sampling population that conducted them. Additionally, during the meeting, Dr. Rees suggested that we add an input feature for the dashboard's storage functionality so researchers may contribute data. This will ensure the product stays up to date after our project (see Appendix I).

Meeting with Justin Gulino, we received dashboard recommendations to add species spread graphics over time and to display the extent of native and non-native species within different areas of the catchment. He also proposed the display of different types of habitats and land cover as overlays or map layers (see Appendix J).

These interviews were instrumental in our dashboard design process, shaping dashboard construction and informing recommendations for future work. With the feedback we received, we prioritized these user perspectives and their recommended features.

Designing the website layout

Our dashboard layout allows users to view a map of the catchment area while reading data on the right. We placed options that interact with the map content above the map so that they are easy to notice, since users typically read from left to right and from top to bottom.

Results

Preliminary interviews about the design of the dashboard informed the development. We looked to create a dashboard that would present information in an intuitive format, show a mix of qualitative and quantitative data, and allow for people interested in the catchment to contribute to it.

For qualitative data, we decided to present historical events which affected and may still affect the catchment's health. The team tied these events to the date on which they occurred and placed locational markers on the map. We added images to the explanation of these events wherever possible (see Figure 4.6).

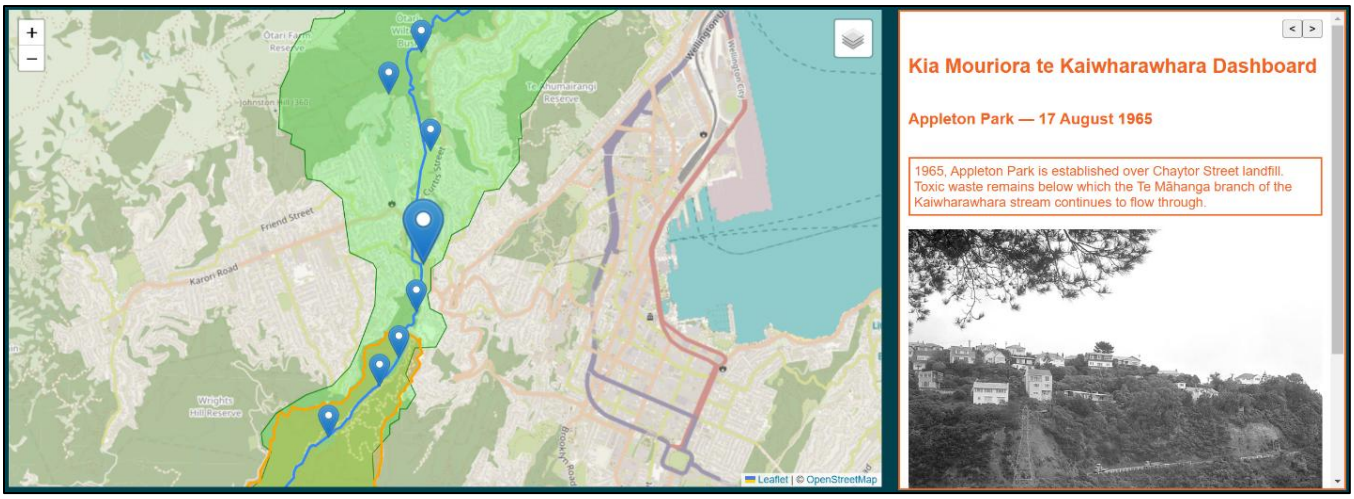

Figure 4.6: A snapshot of historical data on the Kia Mouriora te Kaiwharawhara dashboard.

To display quantitative data, we coded the basic functionality to present data over time in a graphical format. We planned to depict primarily water quality data and species counts in this format, but we prioritized other aspects of the dashboard and their functionality due to time constraints. We also planned to provide other quantitative metrics, but Kia Mouriora te Kaiwharawhara often lacked consistent and reliable data volumes to sufficiently display them. Therefore, the main quantitative metrics that we displayed on the dashboard were written records of species relocations. We recommend the addition of quantitative displays, as Chapter 5 discusses in detail.

Designing the visuals

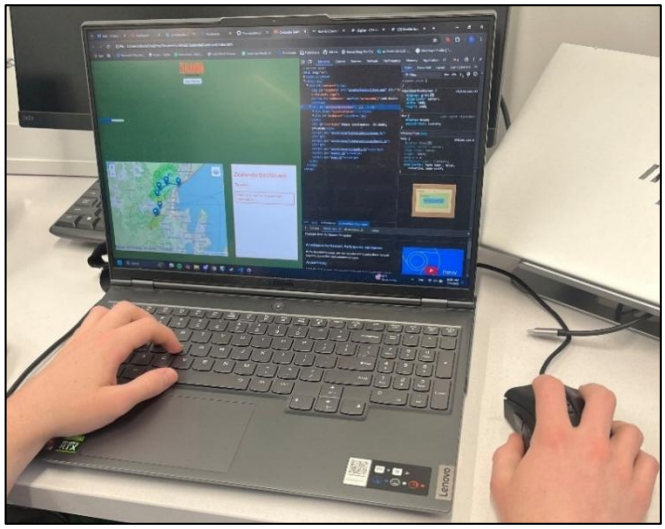

Figure 4.7: The Inspect tool enables sizing of different elements on the dashboard page.

The team selected the colors of the website to match the color scheme of the Kia Mouriora te Kaiwharawhara initiative. When we used alternate colors, we matched the Zealandia color scheme, developing both schemes directly from their website and logos. We made this design choice to simplify the later addition of the dashboard to their website. Our team used CSS to control the appearance of elements on the dashboard and their sizes (see Figure 4.7). For an explanation of the elements on the dashboard, see Appendix C.

We used the JavaScript library Leaflet to add the map functionality to our dashboard (*Leaflet — an Open-Source JavaScript Library for Interactive Maps*, n.d.). Leaflet pairs with the open-source OpenStreetMap (OSM) (*OpenStreetMap*, n.d.). The team procured background map layers from OSM, which facilitated the use of their open-source maps with attribution. Leaflet enabled us to restrict the map region to Wellington City and made it easy to add overlays and markers on top of the map.

The team manually plotted regions as overlays on the OSM map, like Zealandia and the Kaiwharawhara catchment. We developed a tool to convert these OSM polygons to GeoJSON polygons, which facilitated integration with Leaflet. On the dashboard map, we used Leaflet's default icon for the blue markers on the map.

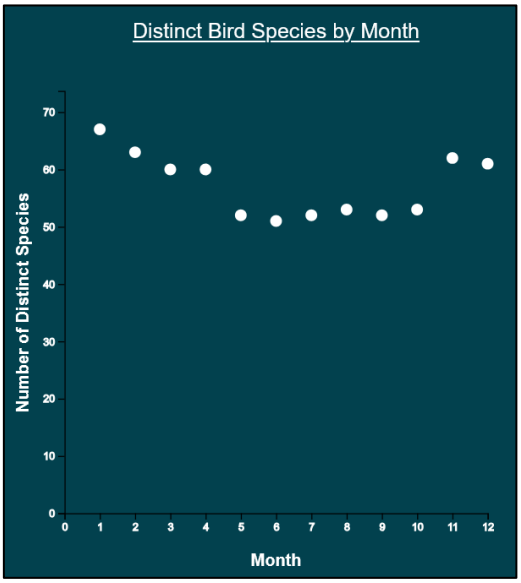

Figure 4.8: Prototype graph developed with d3.js.

To create charts and graphs, we preferred a JavaScript library that was heavily customizable. We chose d3.js because it is industry-standard and gives the user complete freedom over the design of their visuals. We decided to primarily create data-over-time graphs because they are well-suited to demonstrate a variety of metrics. Figure 4.8 illustrates one of

our prototype graphs. Due to time constraints, the team did not implement these quantitative graphs onto the final dashboard.

Our design tied events on the dashboard to locations in the form of markers. Selecting these markers doubles their size for clarity and presents the associated information in the right-side panel. If a user ties multiple events to a single marker, they can click through them in chronological order using the left and right arrows. The user can filter the events by date and by which dimension(s) of the Kia Mouriora te Kaiwharawhara initiative they affect (see Figure 4.9).

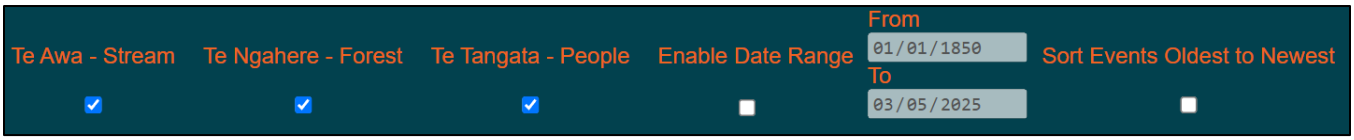

Figure 4.9: A snapshot of the dashboard's filter options.

Populating the dashboard with informative pins

We intended to develop a database to facilitate easy addition and storage of data, but due to time constraints, we prioritized dashboard functionality. Thus, our process for adding data points to the dashboard map was to manually write text in lines of code. To expedite this process of data entry and provide the opportunity for future addition of data without the development of a database, Grant wrote a Python script to convert our tagging spreadsheet Excel data into a JSON file. This conversion script allowed for dashboard population without editing the website's code. Ease of use was a major priority in dashboard design, as we hoped the Kia Mouriora te Kaiwharawhara initiative could update the platform as ecological restoration progressed. We focused on adding qualitative data points, specifically information relating to our site visit locations and Zealandia's species translocation efforts. The locational pins we implemented highlight key places such as Zealandia ecosanctuary, Appleton Park, Ian Galloway Park, Ōtari-Wilton's Bush, Trelissick Park, and the Kaiwharawhara Estuary. The data we chose to display under each of these pins includes locational overviews, historical events, and relocations of species such as *toitoi*, *kākahi*, and *pirita*. We have included the user guide for future Excel spreadsheet data entry in Appendix E.

Choosing a website host

Because we did not use a website building service to create the dashboard, we needed a method to host the site on the internet. Initially, we wanted to display the dashboard on the Kia Mouriora te

Kaiwharawhara page on Zealandia's website. However, after meeting with Zealandia's IT lead (see Appendix K), we learned that their website uses a building and hosting service which would not allow us to insert a JavaScript program onto the page. Therefore, our options were either to host a website with the Kia Mouriora te Kaiwharawhara budget or host the dashboard on a WPI server with free access. The downside of using a WPI server is the slightly slower network speeds, but we believe that this temporary sacrifice is milder than the cost of hosting a website in New Zealand. We collaborated with our university's Academic Technology Center and IT department to deploy our dashboard to a WPI subdomain (https://kmks2sdashboard.wpi.edu/). We utilized Gitlab and a continuous integration/continuous delivery pipeline to continually update the website as we made changes to the code for the dashboard.

Dashboard feedback and design implementation

Present project work to the partners and stakeholders

We presented our prototype dashboard deliverable at the 20th Kia Mouriora te Kaiwharawhara Community Hui on 19 February 2025 (see Figure 4.10). After the presentation, we fielded ten minutes of comments and questions from the audience of roughly forty stakeholders. During this session, we received a suggestion to add the graphing functionality to display multiple metrics on the same chart. Since we were unable to add full quantitative graphing functionality to the dashboard within our project timeframe, this suggestion lent itself to our qualitative tagging display system and future recommendations. The largest concern of the community was the continuation of dashboard development after our departure. Since our work timeframe was too short to integrate all website development suggestions, we have detailed several recommendations for future work in Chapter 5.

Figure 4.10: Presenting the prototype of the dashboard at the 20th Community Hui.

Design review

Our preliminary dashboard review for assessment of the prototype yielded three main recommendations from our project partner. First, Dr. Rigler required that the dashboard state specific gaps in data, since dashboard users may not differentiate between an omission of available data and the lack of information. Additionally, he opined that a Māori perspective of catchment history will differ from a Western viewpoint. Therefore, our team should recommend networking with Taranaki Whānui ki te Upoko o te Ika to provide additional Kaiwharawhara historical data for our platform. Lastly, Dr. Rigler required us to submit the dashboard to him for a complete review of the published content (see Appendix L).

Our second review involved the dashboard in its completed form. Dr. Rigler conducted his assessment of the content, providing suggestions for several small changes in styling and editing the 34 descriptive paragraphs across our 11 locational pins. He then approved the dashboard for publication and user testing.

User testing

Finally, we conducted brief user testing with a survey to assess dashboard design and identify the most important revisionary areas. We modified our approach to user testing that we outlined in Chapter 3 to compensate for our shrinking timeframe due to the dashboard construction overshooting our targeted deadline for completion. We surveyed a sample of our professional and student cohort in a sample of convenience, using Likert-scale questions to assess different aspects of dashboard design. These questions asked users to rate their experience with dashboard navigation and Kaiwharawhara catchment issues both before and after viewing our dashboard. Furthermore, our post survey asked the users to rate the quality of four different aspects of the dashboard (design layout, ease of use/intuitiveness, quality of presented data, and visual appeal) and provide any additional suggestions. We determined these design aspects to be most important from our expert interviews. We constructed this survey using Google Forms, since we possessed more experience with this platform than with Qualtrics. We posed the Likert-scale questions on a range from 1 to 5, or poor to excellent. A copy of the survey is present in Appendix D.

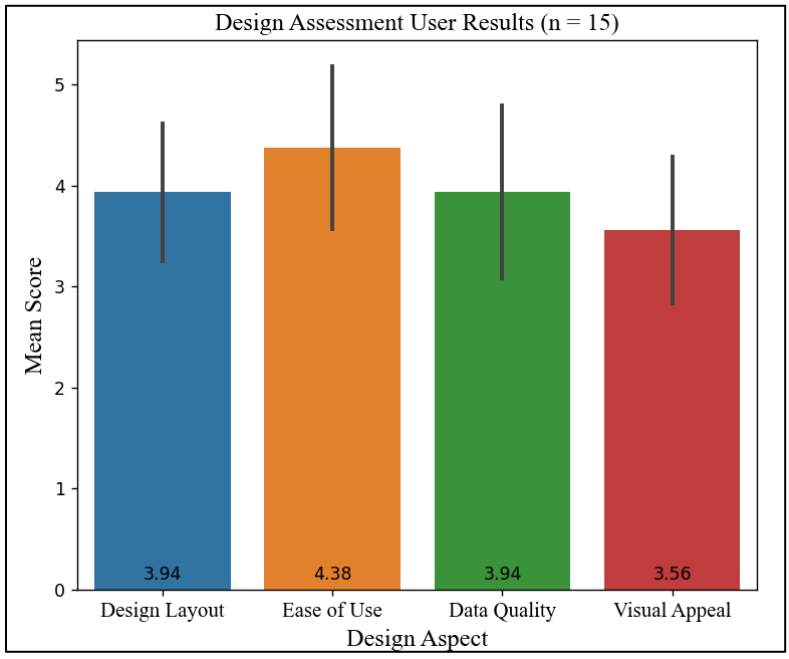

Figure 4.11: Graphs of our user testing results. The colored bars represent score averages from responses with the standard deviation represented with a thin black bar.

Analysis of the survey submission data, provided by 15 participants, revealed that visual appeal was the design feature in the greatest need of further development. Though not statistically significant, the average user score for visual appeal was 3.56, the lowest of the four design categories (see Figure 4.11). Therefore, these results suggest that visual appeal is the most critical dashboard characteristic to improve via a future revision of the platform, though developers should conduct additional testing. These results helped to shape our recommendation for additional dashboard development, which we discuss in Chapter 5.

Notably, we found that participants rated the dashboard's ease of use the highest at an average of 4.38. When we surveyed the user familiarity with the catchment area before and after dashboard testing, we saw that 87% of users had an increased familiarity, with 27% of users reporting a 3-point rating increase. Again, due to the small sample size, we cannot put full confidence in our findings from the data. However, these metrics seem to highlight the success of the dashboard design and content.

Construction of recommendations

Based on the results of our user testing, we decided that visual appeal was the primary area to focus on for dashboard revision. We also concluded that an increase in catchment data would benefit the Kia Mouriora te Kaiwharawhara initiative and its efforts for catchment restoration. We detail these recommendations in Chapter 5.

Discussion of results

Our research confirmed the clear need for high quality monitoring and communication about interventions in the Kaiwharawhara. The area of impact presented considerable environmental toxins and ongoing contamination of the surrounding ecosystem. Our site visit highlighted the extent of problems relating to the water, the forest, and the people. While other individuals have completed projects for the initiative, there has been no scheme to effectively archive or share efforts in a manner that would inspire meaningful collaboration between scientists and citizens. When we analyzed the catchment data, we discovered that it contained many individual studies with limited long-term data collection capabilities. Thus, we recognized the difficulty in drawing conclusions from single reports as there was rarely consistent, longitudinal testing.

The feedback we received from prospective user interviews indicated that the dashboard must be multi-faceted and adaptable for users. It must provide qualitative data, such as a historical catchment timeline, and quantitative data like species relocation records. Importantly, we realized the importance of the dashboard acting as a form of public communication, it should be both simple and intuitive. These insights were crucial in guiding our dashboard design process. Early testing and feedback helped us narrow our focus, as well as highlight items for inclusion in later development stages. Based on these results, we constructed two major recommendations for the Kia Mouriora te Kaiwharawhara initiative regarding continued work on this project.

Chapter 5: Recommendations and Conclusion

This section provides our recommendations for Zealandia Te Māra a Tāne and Kia Mouriora te Kaiwharawhara regarding dashboard improvement and additional research.

Recommendation 1: Implement consistent water quality monitoring

Justification

The team's efforts looking through the available data within Zealandia's archive and on public pages, alongside dashboard development, suggested a lack of accurate, actionable, and long-term quantitative data. Presenting the contaminated state of the catchment area continues to be a source of difficulty for the Kia Mouriora te Kaiwharawhara initiative. This limits the opportunities to rally policymakers in the Greater Wellington Regional Council and other governing bodies. Water quality data is the primary quantitative focus within the Kaiwharawhara catchment area. Unfortunately, the single data collection site at Ngaio Gorge in Trelissick Park is largely ineffective due to its presence far downstream of the major contamination sources. Consistent water quality monitoring at multiple locations further upstream can reveal changes, trends, and sources of contamination that may produce evidence of neglect and pollution. Specifically, water quality monitoring of pH, heavy metal contamination (or conductivity), E. Coli, and dissolved oxygen levels directly above and below the Appleton Park and Ian Galloway landfills would provide Kia Mouriora te Kaiwharawhara with quantitative evidence of the ongoing contamination of the Kaiwharawhara Stream (*Chapter 5 Water Quality Conditions | Monitoring & Assessment | US EPA*, n.d.).

Audience

The target organization for implementation is the Kia Mouriora te Kaiwharawhara initiative in potential collaboration with GWRC, Zealandia volunteers, and citizen science demographics such as engineering students, local experts, and technologically experienced individuals. GWRC monitors the current water quality sensor at Ngaio Gorge. Zealandia volunteers and citizen science stakeholders contribute input and resources for the development of water quality monitoring sensors as well as non-invasive, environmentally friendly, weather-proof, and pest-proof sensor housings for proper electronic protection.

Cost and Implementation

Recent developments in wireless sensor networks and water quality monitoring have drastically reduced sensor costs. Arduino programming boards are cost-effective and are compatible with wireless sensors and Wi-Fi transmitters (Shaimaa et al., 2018). Software code and network assembly are relatively simple and open-source manuals detailing the complete process are publicly available. Figure 5.1 below depicts an open-source air quality sensor whose design simplicity may be comparable to open-source water quality monitoring sensors.

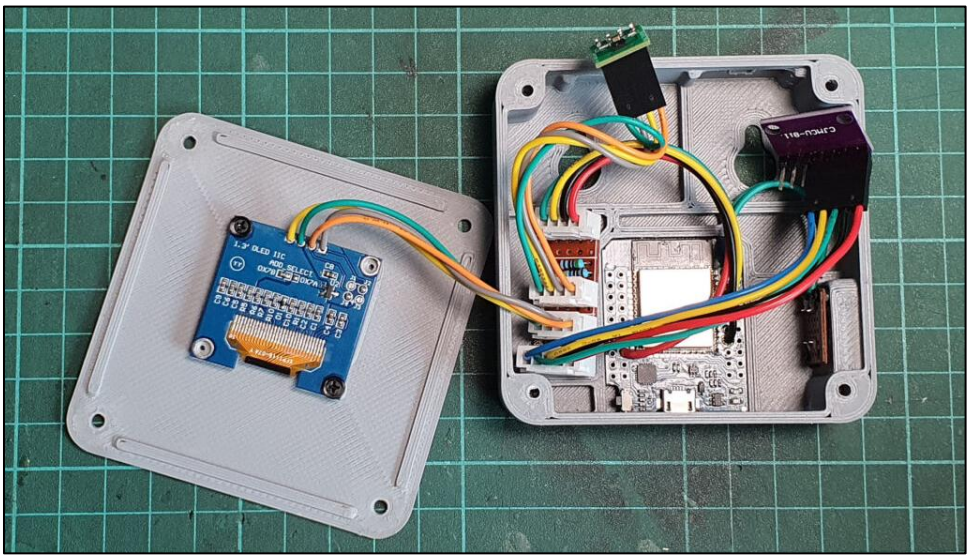

Figure 5.1: DIY module for measuring air quality using the ESP32 Mini module (image credit: simplymaker, 2024).

Involving additional personnel in the implementation of data collection will take time and incur material development and hiring costs. Considerations regarding land rights and monitoring permissions will also require approval from local *iwi*.

Timeline

Based on limited personnel, necessary technical expertise, and extended data collection, the team expects the initial implementation of this recommendation to take roughly one to two years. We foresee the involvement of various public stakeholders and technical experts willing to assist with the project to occur within the first year, should Kia Mouriora te Kaiwharawhara secure internal or donor funding. Sensor development and initial implementation will occur by the end of year two, and data collection will follow in perpetuity.

Recommendation 2: Conduct further technical development of the Kia Mouriora te Kaiwharawhara dashboard

Justification

Our dashboard is an elementary platform that we designed for data presentation and catchment storytelling rather than as a finalized page. Further development of maps, graphs, and storyboards will expand the scope of the dashboard and its communication of information. Additionally, the construction of a database to store quantitative data would facilitate future data addition and a broader scope of visualization. Currently, an Excel spreadsheet and a conversion script hardcode the data onto the dashboard website. The use of a database would facilitate increased partnership between Kia Mouriora te Kaiwharawhara stakeholders, citizen science demographics, and Taranaki Whānui ki te Upoko o te Ika by allowing for easy addition of collected and collated data and providing a foundation for analysis.

Audience

The target audience for implementation of this recommendation is the Kia Mouriora te Kaiwharawhara initiative. A technical programmer should further develop the dashboard's features and visual design.

Implementation and Cost

We recommend that 2-3 individuals with experience in JavaScript, CSS and HTML coding languages, basic website design, and data visualization continue this project. These individuals may be technical experts that the Kia Mouriora te Kaiwharawhara initiative hires for this work, or a computer science Major Qualifying Project (MQP) team from Worcester Polytechnic Institute who continue this work as part of their graduation requirements. Those who continue the project work should focus on implementing additional quantitative graphing functionality and data displays. Additionally, development of a database is necessary for intuitive data addition, consolidation, and storage. Further, we recommend a visual overhaul to the website layout and additions to the dashboard's current data to fill in gaps. The fact that visual appeal was the lowest rated design aspect in our user testing indicates a visual overhaul is especially needed.

Lastly, we recommend that Zealandia or the Kia Mouriora te Kaiwharawhara initiative either add the dashboard to an existing website (such as the updated Zealandia homepage) or purchase a separate

domain to host the dashboard at an annual domain renewal fee and a monthly hosting fee. Hiring fees for additional personnel will also contribute to the cost of implementation, unless a WPI MQP team or volunteer can continue the project.

Timeline

Due to the technical requirements to continue dashboard development, our team anticipates a recommendation timetable of 4-8 months. The successor will use the first two weeks to familiarize themselves with the dashboard code and its operation. They will spend the remaining time developing additional visuals, streamlining the layout, constructing a database, inputting more quantitative data, and integrating the dashboard with an external domain or a refurbished Zealandia website.

Conclusion

Guided by our partner Dr. Rigler, our team prototyped a dashboard (found here) that can host records of historical context and ongoing environmental interventions along the Kaiwharawhara catchment (see Figure 5.2). It serves as a dynamic resource for Zealandia partners and local interest groups about critical sites along the stream and its bioregion. The dashboard highlights the need for our primary recommendation for further water quality monitoring within the catchment area, especially through the process of adding and monitoring more testing sites. Community members expressed enthusiasm for the platform and they believe it would accelerate cooperation in restoration efforts.

Figure 5.2: The team shadowed on the Roto Māhanga dam.

We deeply appreciated the opportunity to learn from and work with Dr. Nate Rigler, Zealandia Te Māra a Tāne, and Kia Mouriora te Kaiwharawhara, and we thank them for all their extensive help during this project. We hope our dashboard acts as a central resource for effective visualization and communication of catchment restoration efforts moving forward.

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Appendix A:

Consent Form for Prospective Dashboard User Interviews

Project Introduction: We are a team of university students working with Zealandia Te Māra a Tāne and Kia Mouriora te Kaiwharawhara to develop an online dashboard for characterizing the environmental health of the Kaiwharawhara catchment.

Procedure for this test session: Your participation in this research is voluntary. We will discuss with you the creation and design of our dashboard to identify any important inclusions. During this discussion, one of our team members will take notes, but we will not record any conversation. When sharing your opinions, you may decline to comment on any questions that you do not wish to answer.

Purpose of this test: Your feedback will help us design the layout and content of the dashboard.

Confidentiality: We will not publish any details about your identity in this project without your permission. However, if you wish to share any details about yourself in publication (i.e. name, university/employer, position, etc.), please share below:

_____

_____

Thank you for your time!

Appendix B:

Interview Questions for Prospective Dashboard Users

After acquiring verbal consent to include their responses in our work, we held informal discussions with prospective dashboard users. Here is the list of questions we asked:

B.1 If you are willing to share this information, what is your job title and how long have you served in this role?

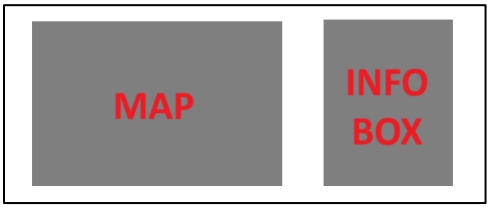
B.2 What data do you want to see on the dashboard?

B.3 What types of visuals do you want to see on the dashboard (e.g. maps, charts, graphs over time, etc.)?

B.4 How would you use the dashboard?

B.5 What other roles could a dashboard serve (e.g. historical timeline, species list, etc.)?

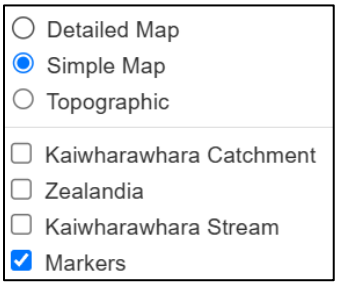
Appendix C: Dashboard User Manual



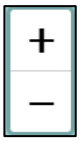
The basic layout of the dashboard has an interactive map of the Kaiwharawhara catchment on the left, and a box for displaying information on the right. They are referred to as the map and the info box, respectively. To navigate the map, simply click and drag it to pan around.

This is a marker on the map. Clicking on one of these will load up information about the respective area in the info box.

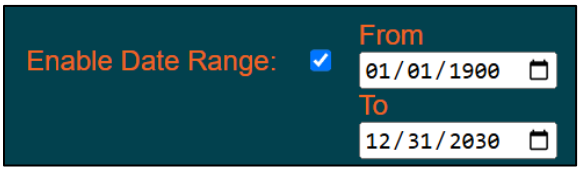
The layers icon, located on the top right of the map, will allow a user to switch between our three map displays, simple, detailed, and topographic, as well as to enable and disable different overlays that add context to the data shown on the map.



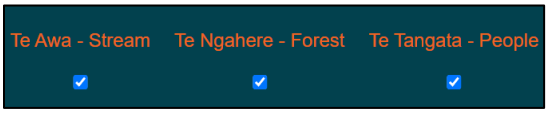
This is the menu shown when the layers icon is clicked. Users can select different map displays from the first three options. Only one map display can be active at once. Users can use the following choices to enable and disable overlays. Overlays can be enabled and disabled in any combination or order.



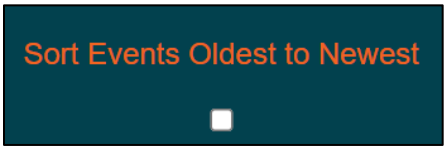
These are the zoom in and zoom out buttons. Clicking the + will zoom in on the map, while clicking the – will zoom out on the map. The user can also scroll up on the map to zoom in or scroll down to zoom out.



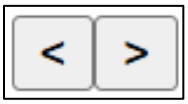
If you're only looking for events that occurred at a certain time, you can enable the date range option. Then, simply choose your starting date and ending date. All events shown by the dashboard will now be contained within that range.



If you would like to narrow down the events shown by the dashboard by what aspect of the initiative's strategy plan they affect, you can do so with these filters. An event will only be shown if it has at least one tag that is currently checked.



If you would like to view events in chronological order from the oldest to most recent, you can check this option. By default, events are displayed in order from the most recent to the oldest.



These buttons are used to click through multiple events on the same marker. Some markers will only have one event. If there are no more events to click to, the respective button will be grayed out.

Appendix D: Survey for Public User Dashboard Testing

Here is a copy of the Kia Mouriora te Kaiwharawhara Dashboard Review questionnaire in Google Forms that we used to evaluate the dashboard's public navigation and features. We did not collect the names, emails, or other personal information of survey participants.

1/5

Kia Mouriora te Kaiwharawhara Dashboard Review

Project Introduction: We are a team of American university students working with Zealandia Te Māra a Tāne and Kia Mouriora te Kaiwharawhara to develop an online dashboard for characterizing the environmental health of the Kaiwharawhara catchment area.

Procedure for this test: Your participation in this research is voluntary. We will ask you to interact with our dashboard and then share your opinions on the experience. When sharing your opinions, you may skip any questions that you do not wish to answer. The entire process should take only ten minutes of your time.

Purpose of this test: Your feedback will help us to evaluate the dashboard's functionality and design. We hope to provide recommendations for future revision based on this feedback.

Confidentiality: When completing this survey, your participation will remain anonymous. Should we choose to include any of your specific responses in our final report, they will be stripped of all identifiable information before project submission.

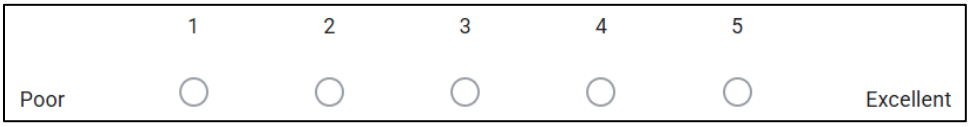
On the next page, you will be prompted to answer two pre-navigation questions before following a link to the dashboard. Please spend a few minutes exploring this platform, then answer the post-navigation and dashboard design questions. Click "Next" when you are ready to proceed.

2/5

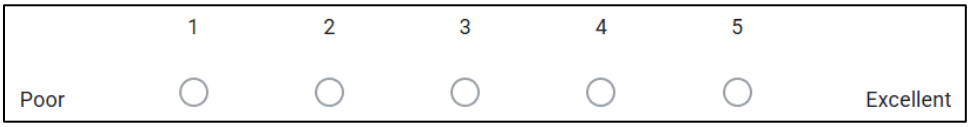
Pre-Navigation Questions:

These questions seek to evaluate your level of experience with dashboard navigation and the environmental history that our dashboard seeks to display before navigating the platform.

K.1 How would you rate your level of experience navigating technical platforms like a dashboard?



K.2 How would you rate your familiarity with the Kaiwharawhara catchment area and its state of health?



3/5

Kia Mouriora te Kaiwharawhara Sanctuary to Sea Interactive Dashboard

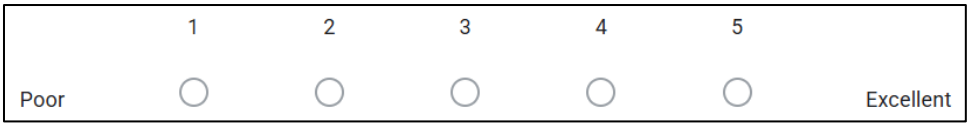
Follow this link to our developed dashboard and spend a few minutes exploring the dashboard and familiarizing yourself with its features, including the visuals and overall design. Then, answer the questions on the following page.

4/5

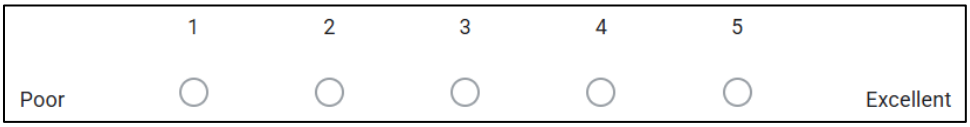
Post-Navigation Survey Questions

These questions seek to evaluate your level of experience with dashboard navigation and the environmental history that our dashboard seeks to display after navigating the platform.

K.3 How would you rate your level of experience navigating technical platforms like a dashboard after interacting with our platform?



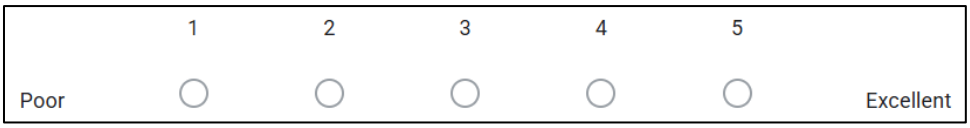
K.4 How would you rate your familiarity with the Kaiwharawhara catchment area and its state of health after interacting with our dashboard?



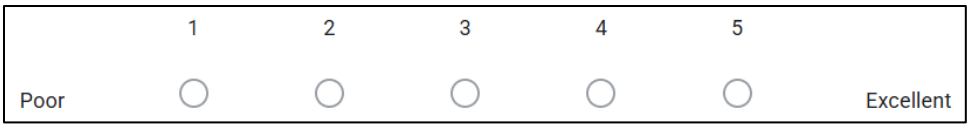
Dashboard Interactivity Questions

These questions seek to assess which aspects of the dashboard would benefit the most from future revisions.

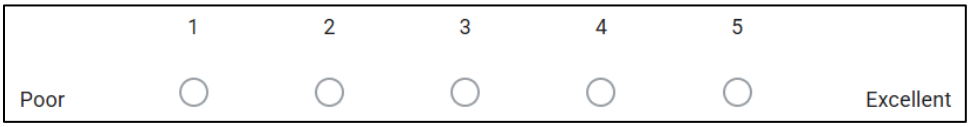
K.5 How would you rate the layout and design of the dashboard page?



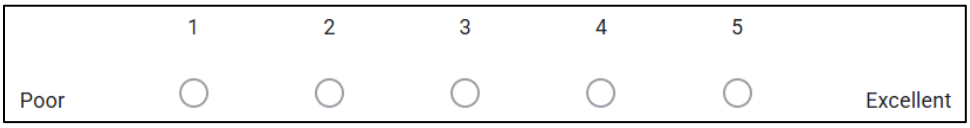
K.6 How would you rate the ease of navigation and intuitive usability when exploring the dashboard's features and presented data?



K.7 How would you rate the quality of the presented data in terms of how informative and effective it is?



K.8 How would you rate the overall visual appeal of the dashboard and its features?



K.9 Are there any other features of the dashboard that future revisions should address, or any additional features or metrics that should be added?

K.10 Are there additional comments that you have regarding the dashboard?

5/5

Thank you for taking the time to fill out this survey. We greatly appreciate your feedback as it will help us to provide recommendations for future revision of this platform.

Appendix E: Data Entry User Manual

Data entry occurs in an Excel spreadsheet. There are columns for each event field. This appendix describes each column (stylized in **bold**) and how data should be entered into it.

***Te Awa* - The Stream**	If the event is relevant to the stream, type ‘x’, otherwise leave it blank.
***Te Ngahere* - The Forest**	If the event is relevant to the forest, type ‘x’, otherwise leave it blank.
***Te Tangata* - The People**	If the event is relevant to the people, type ‘x’, otherwise leave it blank.
Place Name	Place name.
Latitude	Place latitude (in decimal degrees, i.e. 21.94849°).
Longitude	Place longitude (in decimal degrees).
Place Description	Place description.

Please note: In the dashboard, every location only has one description. If another instance of the location is in the Excel sheet, please use the same description)

Year	Year
Month	Note: if there is no month associated with a location, type in 'null'
Day	Note: if there is no day associated with a location, type in 'null'
displayDate?	If the date should be displayed with the event, please type in 'yes'. Otherwise, please type in 'no'.
Event Details	Event description.
Image Link	This is the link to the image’s location in the file system.
Relevant Citations	Any relevant citations can be placed here.

Appendix F: Meeting Minutes for Prospective User Interview: Dr. Nate Rigler

Interview Participant: Dr. Nate Rigler

Attendees: Grant Kortfelt, Thomas O'Leary, Ben Petrich, John Sirois, Dr. Nate Rigler

Date: 23 January 2025

Background:

- Nate is the Kia Mouriora te Kaiwharawhara Project Lead at Zealandia Wildlife Sanctuary
- Nate was curious to hear the types of displays and overall layout we might be able to accomplish

Recommendations

- The dashboard platform should be simple and intuitive to appeal to the broadest audience of potential users
- A map with POIs and notes marked, alongside charts with data and records of different inquiries and initiatives could be very helpful

Appendix G: Meeting Minutes for Prospective User Interview: Anne Tuffin

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Interview Participant: Anne Tuffin

Attendees: Grant Kortfelt, Thomas O'Leary, Ben Petrich, John Sirois, Dr. Nate Rigler, Anne Tuffin

Date: 24 January 2025

Background:

- Anne Tuffin is the Trelissick Park Group lead
    - The Trelissick Park Group is a volunteer organization that helps restore Trelissick Park by planting native flora and removing invasive species
- We discussed our project
    - A platform for visualization of data and the catchment at large has been a targeted project of Anne's for years

Recommendations:

- Incorporate species data for both native and non-native flora and fauna
    - Plant species, fish species, trees, birds, bugs, etc. within the catchment area

Appendix H: Meeting Minutes for Prospective User Interview: Steve Cosgrove

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Interview Participant: Steve Cosgrove

Attendees: Grant Kortfelt, Thomas O'Leary, Ben Petrich, John Sirois, Steve Cosgrove, Dr. Nate Rigler

Date: 4 February 2025

Background:

- Steve Cosgrove is a PhD candidate in Network Communications at VUW
- Long-time volunteer at Zealandia
- Gave verbal consent to publish his name and potential quotations in our report

Our project discussion:

- GWRC water quality sensor at Ngaio Gorge in Trelissick Park
- Independent one-time water quality tests
- Species datasets from eBird

Landfill discussion:

- There is a landfill (decommissioned in 1971) in Houghton Bay valley similar to the landfills under Appleton Park and Ian Galloway Park

What we hope for the dashboard:

- It will show:
    - How severe the catchment contamination problem has become
    - Where there are gaps in current data
- We plan to graph data as a trend over time
- We are looking to display location-associated data on a map

Project impetus (Dr. Nate Rigler):

- Many groups of people are asking for data on the Kaiwharawhara catchment
    - We are looking to make it more accessible, digestible, and understandable

Notes and recommendations:

- The primary benefit of a dashboard is to increase exposure to the problem and demonstrate to officials (and others) that change is worth investing time and money into
- Steve recommended that we identify gaps in the current data
    - This reflects the opinions of Jo Ledington
    - Identify where additional data collection is most needed and what types of metrics should be explored
- Steve recommended that we demonstrate that aspects of catchment health are trending in the right direction (frame in a positive light where possible)
    - Potential to increase exposure and support for the project
- This project may be continued after we have completed our work in Wellington
    - We should ensure that all documentation and comments are accurate and correct
- Initiatives such as the Nelson Project sought to involve schools in catchment restoration efforts
    - Has some interesting visuals but is not publicly available
- Look into and collate information regarding the formation/history and activities of the Trelissick Park Group, and compare to the GWRC/government responses to catchment issues and collection of data
- Water quality monitoring sensors have reduced in price significantly over the last few decades
    - Researchers will determine the metrics to test while engineers will design the sensors to carry out this task
    - Our team could determine which water quality metrics have the strongest association with overall water health
- Nate mentioned community members and the common pitfall of assuming that the problem is about information

Website recommendations:

- Nate mentioned a balance of qualitative and quantitative data
    - Historical memory of the area
    - Landfills and swimming holes
    - Historical markers of changes and declining water health
- Nate mentioned that Zealandia often “tells too good of a story” by greenwashing some of the other issues
    - Some of the achievements of Zealandia (i.e. bird population recoveries) are used to depict the region’s accomplishments, while there are other areas of ecological health that are suffering or continuing to decline
- Nate mentioned that “numbers are numbers but they don’t really tell a story out of context”
    - A timeline of data with a slider through the years could help depict history
- Balance quantitative data/evidence with qualitative storytelling to create a compelling and engaging dashboard
    - A story-map-type historical view
    - Data and graphs
    - Can depict the restoration of certain areas and the decline of others

    - The story of the dashboard could juxtapose the increasing health of the bush and birds and the declining health of the water
    - Balance anecdotes and evidence to engage with both the public and the governing organizations (persuasive storytelling versus actionable data) – “the plural of anecdotes is not evidence” (Nate)
- Steve mentioned implementing “a flexible method of adding data”

Appendix I: Meeting Minutes for Prospective User Interview: Dr. Andrew Rees and Dr. Kevin Norton

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Interview Participants: Dr. Kevin Norton, Dr. Andrew Rees

Attendees: Grant Kortfelt, Thomas O'Leary, Ben Petrich, John Sirois, Dr. Kevin Norton, Dr. Andrew Rees, Dr. Nate Rigler

Date: 5 February 2025

Victoria University Wellington has run multiple projects in the catchment area

- Some have worked while others have not
- One project utilized LIDAR data to find the landslide susceptibility
    - There was a systemic error in the dataset
- Ian Galloway Park nutrient project

Ecology class projects:

- Dr. Kevin Norton and Dr. Andrew Rees recently implemented soil testing field work as part of a class they teach on environmental health at VUW
- Heavy Metal Heads team
    - Water data
    - Macroinvertebrate community index
- Trash Talkers team
    - Soil data (plasma torch broke during testing)
    - First set went really well
- Microplastics team
    - Found an abundance of microplastics
    - Same microplastics everywhere

History of the catchment:

- Metal mining and gold extraction used to take place in the area
    - Heavy metal remnants still impact the catchment soil
- There is cadmium in Zealandia

Our project:

- We are designing a dashboard to visualize the catchment area
- Site recommendations
    - Rank the most important spots to test water quality and soil content

- We showed both attendees the current dashboard prototype
- Could we define good health and bad health and depict this on the platform?
- Could implement a health score using colors and simple graphics
- LAWA website has some good graphics

Interest in University studies:

- Microplastic data
    - Students have the tools to measure with spot sampling
- Fish passages and fish ladders

Invertebrate baselines:

- Compare the tested site to low-impact site metrics
- The GWRC site has the longest-running data
    - Could determine baselines from this
- Nate mentioned that an important water quality metric is E. Coli

Recommendations:

- Standardize the input of Excel/CSV files for easy addition of data to the dashboard
- Invertebrate data could be helpful
    - Providing a catchment health measurement based on invertebrate populations
- Provide access to a spreadsheet for data entry after development of the dashboard
- Present the user guide for uploading data
- Look into independent researchers' site analysis for water testing
- Break data down into qualitative markers (smiley face, sad face, etc.)
- eDNA potential
    - Wilder Lab may have designed a health score framework based on eDNA
- Microplastics, heavy metals, landfills, sewage leak locations, E. Coli measurements
- Check out the LAWA website
- Nate mentioned that weaving and weaving materials could become a cultural replacement for placing plastic flowers on graves

Appendix J: Meeting Minutes for Prospective User Interview: Justin Gulino

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Interview Participant: Justin Gulino

Attendees: Grant Kortfelt, Thomas O'Leary, Ben Petrich, John Sirois, Justin Gulino, Dr. Nate Rigler

Date: 14 February 2025

Justin's background:

- Attended George Washington University in DC
- Came to Wellington in 2020 right before quarantine
- Two semesters at Victoria University (2020 – 2021) then four months interning at Zealandia

Discussion of citizen science in the catchment:

- There is available bird data but not a lot of catchment data relating to other species
    - Data collection is largely driven by volunteer efforts, and birdwatching is the most popular species tracking activity
- Data from eBird is best starting around 2005 or 2010

Recommendations for the dashboard:

- A dashboard can drive community efforts to help better the catchment area by increasing exposure
    - Nate Rigler: in reference to driving community efforts, the people already know many of the problems, so we do not need to reiterate too much
- A dashboard can display the extent of native and non-native species in an area
- Maybe we can show species spread through the region as a timeline (bird expansion ranges)
    - Nate Rigler: kākā are a good example, but many bird species expand through affluent neighborhoods with more bush so widespread community exposure is not always represented
    - There are fewer native birds in poorer areas (environmental racism)
    - Data from the 2018 New Zealand Census has depravation scores of Wellington neighborhoods (TA Census Block 47)
- Nate Rigler: the background map (OpenStreetMap Standard) is very noisy
    - The suburb names are good, but there is some extraneous information that is crowding the view and may not be necessary (small complaint regarding visual appeal)
    - We can add other OSM background maps to the dashboard, allowing the user to toggle between them
- We can overlay habitat areas and land cover types

    - LAWA or Manaaki Whenua will have this data
- We can overlay population densities of people in the region
    - To find these polygons, we can go on the SharePoint and go to Restoration Projects / GIS

Appendix K: Meeting Minutes: Zealandia Website Admin

Interview Participant: Zealandia Website Admin

Attendees: Grant Kortfelt, Thomas O'Leary, Dr. Nate Rigler, Zealandia Website Admin

Date: 28 January 2025

Questions to address:

- How is the website hosted?
- How does the database work?
- How could a dashboard be integrated into the website?
    - Database access or authentication system?

Notes:

- Zealandia website is on the free version of DNN (dotnetnuke)
- Generally, they use HTML richtext but there are Javascript widgets
- We can roll back modules but not pages
- We can add button modules

Appendix L: Preliminary Design Review Notes

We conducted a preliminary design review of the dashboard with our partner, Nate Rigler. Below are our notes from the design review.

- From a public standpoint, omitting data and lacking data appear the same on a dashboard
    - We need to provide notes mentioning specific absences of data to deliberately show it is lacking and not deliberately omitted
- Regarding dashboard recommendations, we should request someone to contract or network with Taranaki Whānui ki te Upoko o te Ika to find and add historical records from before 1897 (when our data starts)
    - From a Māori perspective, the history of the area encompasses a wider range of things and is not always reflected by Western scientific interpretations
    - Taranaki Whānui ki te Upoko o te Ika will have qualitative additions that extend back much farther than the data we have integrated into the dashboard
- We could add some of our recommendations onto the dashboard itself
    - This project is a long-term undertaking (at least a 1-year project) that we have worked on for just 7 weeks
- John brought up the recommendation to provide date/year options in a dropdown rather than a complete date range.
    - This would help the dashboard remain simple and intuitive since most public users would be navigating the dashboard to learn and would not know what data or date ranges to target
    - Restricting the date selection to timespans where data is available would benefit the dashboard's interactivity
- Thomas stated that as more data populates the dashboard, years will likely become cluttered and thus a date range is more ideal
- Date range discussions were deemed not a large concern.
    - We should focus on populating the dashboard with what we have before trying to make small changes or improve the aesthetics.
- Note: Currently, the pin must be reselected after a date range is inputted or the notes do not update. This could be a consideration for user interactivity
- Additional locations we highlight should include the Ōtari-Wilton slip (large landslide) that occurred recently.
- Focusing on the qualitative data is sufficient with our time constraints.
- Nate needs to review the accuracy of the dashboard once we have a complete and populated prototype.
- Some of the geotagged data for species relocation is private
    - We should provide general locations, dates, and the *iwi* that provided the species
- We do not have enough time to conduct user testing with KMK stakeholders
- Nate mentioned a retired software engineer who may be interested in viewing and providing additional development for the dashboard
- Additional dashboard feature: implement a timeline at the bottom of the dashboard that is scrollable with buttons to select the next marker