Using Data Visualisation to Communicate the Sources of Plastic Pollutants in Port Phillip Bay

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We acknowledge the Kulin Nation as the traditional and continuing custodians of the land and waterways on which this research was conducted.

Abstract

Plastic pollution is a complex problem. The chemical properties of plastic make it a threat to marine biodiversity when it is improperly disposed of. This project assists the Port Phillip EcoCentre, which has been conducting litter audits across streets, beaches, and rivers in order to determine levels of plastic pollution in Port Phillip Bay's catchment area. This project compiled litter audit, human, and environmental data into a Geographic Information Systems map to visualise the data, facilitate its analysis, and enable communication with the public and government. The visualisation was analysed for correlations between pollution levels and factors which will impact waste management policies and source reduction plans on the local and state level.

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Executive Summary

The goal of this project was to use Geographic Information Systems (GIS) mapping to visualise plastic pollution data and communicate the sources of plastic pollutants entering Port Phillip Bay. This was accomplished by conducting a case study on GIS mapping softwares, gathering human and environmental data relevant to plastic pollution and the geospatial regions surrounding the bay, and using the GIS map to identify sources of plastic pollutants.

Plastic is a man made material that has become ingrained in the fabric of society. “We are producing increasing amounts of plastic because it’s such a marvellous material, [but] the qualities that make it so great also make it an absolute nightmare in the environment once it gets displaced” (Annette Finger, personal communication, 21 November, 2018). When plastic is improperly disposed of, it becomes a threat to marine environments. Approximately 92% of marine debris is plastic, and plastic pollutants affect at least 693 species worldwide including “all known species of sea turtles, 54% of all species of marine mammal, and 56% of all species of seabird" (Gall & Thomson, 2015).

One ecosystem affected by plastic pollutants is Port Phillip Bay in Victoria, Australia. Port Phillip Bay contains more endemic species than the Great Barrier Reef, and is an important body of water for the fishing industry, as well as maintaining biodiversity (*Baykeepers*, 2017). The Port Phillip EcoCentre has been collecting data on plastic pollution in Port Phillip Bay since 2012. This data has been collected using street, beach, and river litter audits. Street litter audits categorise litter into 51 distinct categories, collect litter within three zones, and across six different street usages. Beach litter audits examine litter items that fall within nine quadrats, which are distributed across well established beach litter audit sites. River litter audits are conducted in the Yarra and Maribyrnong rivers and utilise a manta net to collect a sample from the top of the water column. By gathering data from streets, beaches, and rivers, the EcoCentre hopes to understand how pollutants from within the catchment area make their way into

Port Phillip Bay.

The plastic pollution data along with supplemental data was combined into a map visualisation. A case study on relevant GIS mapping softwares was used to establish Tableau as the software that best fit the EcoCentre's needs. Interviews with experts in the field of plastic pollution as well as waste management educators from local councils were conducted to obtain information on people's views on the sources of plastic pollutants. The interview data as well as discussion with EcoCentre staff was used to select rainfall, wind, sunlight, temperature, hotels, sporting grounds, markets, and wastewater treatment facilities as possible transporters and sources of plastic pollutants. This data was collected and displayed on the data visualisation. Sources of plastic pollutants were determined by visually comparing the supplementary data and the levels of plastic pollution over time and location.

Sunlight and temperature were found to affect the levels of plastic pollution in street litter audits. Wind and tides were found to affect the levels of plastic pollution in beach litter audits. Sunlight, rainfall, and wind were found to affect levels of plastic pollution in the Yarra and Maribyrnong rivers. The most commonly found items across all the audits were cigarette butts, soft plastic fragments, hard plastic fragments, and polystyrene beads. Due to the fact that many of the audits sites were relatively new, it was difficult to find concrete trends between levels of plastic pollution and supplementary factors. Continuing to collect data at these audit locations will allow future studies to make more definitive conclusions. This data visualisation tool will serve as the foundation for future research projects conducted by the EcoCentre to inform source reduction plans and waste management policies at the local and state level.

Introduction

Beginning at 2 million metric tonnes in 1950 and increasing to over 400 million metric tonnes in 2015, plastic production has grown faster than most other industrial materials (University of Georgia, 2017). Globally, plastic pollution has been an issue of increasing concern. The Ellen MacArthur foundation conducted a study that estimated 8 million tonnes of plastics enter the ocean each year (Ellen MacArthur Foundation, 2016). They equate this to "dumping the contents of one garbage truck into the ocean per minute and, if no action is taken, this will increase to two per minute by 2030 and four per minute by 2050" (Ellen MacArthur Foundation, 2016). Plastic pollutants in the ocean have widespread negative effects on humans, the environment, and marine organisms.

Plastic pollution is a complex social, environmental, and economic problem with no easy solution (United Nations Environment Programme, 2016). The physical properties of plastic make it ideal for mass consumerism and the health industry. "Single-use plastic products that prevent the spread of infection are crucial in the medical industry. Instruments such as syringes, applicators, drug tests, bandages, and wraps are often made to be disposable" (Plastics Industry Association, 2018). While single-use plastics are necessary for some industries, in many cases single-use plastics are used solely for convenience. Plastic products are often found littered on the side of the road, in nature, and in the ocean (Charko et al., 2018). One famous example of the extent of plastic pollution is the Great Pacific Garbage Patch, a floating patch of pollutants between Hawaii and California that was discovered by Charles Moore (The Ocean Cleanup, 2018). It is estimated that there are 1.8 trillion pieces of plastic in the Great Pacific Garbage Patch alone (The Ocean Cleanup, 2018).

Figure 1. Aerial view of the Great Pacific Garbage Patch (Rothert, 2018)

Plastic pollutants in the ocean has large negative impacts on marine environments such as Port Phillip Bay. Port Phillip Bay (referred to as "the bay" in following passages) is an inland embayment located in Victoria, Australia with a large catchment area and small estuary. All of the plastic waste improperly disposed of by the 3 million people within the 10,000 square kilometre catchment area, ultimately travels into the bay. Since the bay's opening into Bass Strait is only 3.2 kilometres wide, it is difficult for pollutants to escape. Ultimately, this means that the bay is at high risk of becoming contaminated and contaminants are unlikely to leave the bay by natural means. An estimated 828 million pieces of litter enter the bay each year through the Yarra and Maribyrnong rivers (Charko et al., 2018). These plastic pollutants negatively affect the diverse ecosystem residing in the bay. Organisations can have a profound impact on the health of marine wildlife in Port Phillip Bay by monitoring and controlling the levels of plastic pollution in the catchment area.

Lead by the Port Phillip EcoCentre (referred to as "the EcoCentre" in following passages), the Clean Bay Blueprint project is an ongoing effort to quantify microplastics and other plastic pollutants in Port Phillip Bay (Port Phillip EcoCentre, 2017). The EcoCentre is a not-for-profit organisation whose mission is "to build relationships to

inspire, educate and demonstrate sustainable environmental practice and reconnect people to the natural world" (Port Phillip EcoCentre, 2017). Since 2012, the EcoCentre has been gathering pollution data using street, beach, and river litter audits (Charko et al., 2018). The EcoCentre aims to demonstrate the levels of plastic pollution in Port Phillip Bay's catchment area in order to reconnect the community to pressing environmental issues and inform government policy. Similar organisations, such as the Victoria Litter Action Alliance, Tangaroa Blue, and the 5 Gyres Institute, have been collecting plastic pollution data in other areas of Australia.

This project aimed to support the Port Phillip EcoCentre in their mission by providing research into the sources of plastic pollutants entering Port Phillip Bay and the infrastructure to use Geographic Information Systems mapping (referred to as "GIS mapping" in the following passages) in future research efforts. A case study was presented to the EcoCentre ranking and comparing different GIS mapping tools, so they were able to select the best tool for their needs. Using this tool, the team created a system that allows the EcoCentre to analyse plastic pollution data and continue to do this after our project has ended. Information about local waste management regulations, plastic mitigation efforts, and current research efforts came from interviews with local council representatives and experts in the field of plastic pollution. Ultimately, our goal was to produce a data visualisation that will support the EcoCentre's current and future efforts to discover and communicate correlations between levels of plastic pollution in Port Phillip Bay and potential causal factors.

Background

Plastics

Plastic shopping bags take 20 to 1,000 years to decompose because of their chemical properties (ABC, 2018). Plastic is "a synthetic material made from a wide range of organic polymers... that can be moulded into shape while soft and then set into a rigid or slightly elastic form" (Oxford University Press, 2018). Polymers are chemicals made of repeating units, known as monomers. The polymers that make up plastics are derived from oil and natural gas and contain chemical additives to enhance their properties. Most polymers are hydrocarbons, meaning they are composed of carbon and hydrogen (American Chemistry Council, 2018). In these hydrocarbons, each carbon atom has four covalent bonds giving it a full octet, which make these bonds difficult to break (BCcampus, 2018). The chemical additives that are added to plastics enhance these properties by manipulating the molecular structure of the compound (American Chemistry Council, 2018). As a result of these chemical properties and additives, plastics do not readily decompose. These qualities make plastic pollutants harmful to the environment.

Microplastics

Microplastics are small plastics less than five millimetres in size (Charko et al., 2018). There are two categories of microplastics: primary and secondary. Primary microplastics are plastics that are created at this size intentionally and are used in various aspects of everyday life. Secondary microplastics are created through the degradation of plastic over time.

Primary microplastics are typically manufactured for use in other products. The main source of primary microplastics is plastic resin pellets, also known as nurdles (United Nations Environment Programme, 2016). A nurdle, as shown in the figure below, is a small plastic pellet typically two to three millimetres in diametre, that is used to make a wide range of plastic items (Maillard et al., 2013). The most common way that pollution levels

are impacted by industry is through the escape of nurdles at various stages of the plastic production process (Beaman et al., 2016). Another example of a primary microplastic is a microbead, which is used as an abrasive agent in a wide range of personal care and cosmetic products (United Nations Environment Programme, 2016). One example of this is small beads found in face exfoliants. Wastewater treatment plants often do not have equipment that is able to filter out these microbeads which results in the microbeads being discharged into a local body of water (Beaman et al., 2016).

Figure 2. Nurdles collected on a beach bordering Port Phillip Bay.

Secondary microplastics are created through degradation. While plastic pollutants are floating on top of the water they are exposed to a weathering process. Microplastics are formed from the "fragmentation of larger items through a combination of physical,

chemical and biological processes" (United Nations Environment Programme, 2016). Degradation of plastics has been a research topic for hundreds of different agencies in over 60 countries worldwide (plastic pollution coalition, 2018). Rates of degradation among different types of plastic debris vary, but most plastics persist in the aquatic environment for hundreds of years (Beaman et al., 2016). Photodegradation is caused by the absorption of photons by molecules in plastic, which breaks bonds within the polymer (Pollution Solutions, 2015). Photons are found in ultraviolet (UV) light, a key component in sunlight (Pollution Solutions, 2015). UV light from the sun causes oxygen molecules to be absorbed into the plastic through oxidation (Pollution Solutions, 2015). As more oxygen molecules are absorbed into the plastic, they react with the polymers ultimately weakening them. This makes the plastic more brittle and easier to break when it is stepped on or run over by a car (Pollution Solutions, 2015).

Quantifying the amount of microplastics present in the marine environment is difficult because most plastics have a higher specific gravity than water (Beaman et al., 2016). As a result, most plastics sink and are out of the range of human sight, making it difficult to determine the total number of plastic pollutants in the ocean (United Nations Environment Programme, 2016). One study found that there are 2.73 pieces of microplastics in the ocean per zooplankton (Collignon, Hecq, Galgani, Collard, & Goffart, 2014). A different study, conducted by 5 Gyres Institute, estimated that 5.25 trillion plastic particles are floating in the marine environment (Eriksen et al., 2014). This estimate is based on various trawls done at the surface of the ocean and visual surveys of large plastic debris. A trawl is a pollutant collection method consisting of a net that is pulled behind a boat that catches floating particles (Food and Agriculture organisation of the United Nations, 2018). In the conclusion of the 5 Gyres Institute report, the researchers state that they believe their result to be an underestimate as they only collected plastics that were found on the surface, and then extrapolated their data using the vertical distribution equation to encompass plastics in all depths and areas of the ocean

(Eriksen et al., 2014). 5 Gyres Institute has furthered their studies by creating a program known as "TrawlShare" which enables citizen scientists, which are a subset of amateur scientists, from around the world to perform trawls in their respective regions (5 Gyres, 2018). The platform that 5 Gyres Institute has created enables accurate collection of data using citizen science and also enables people to contribute to a robust global dataset of trawling data. The results of these manta trawls are used to update 5 Gyre Institute's global estimate of levels of marine plastic pollution.

Effects of Plastic Pollution on Marine Organisms

The chemical composition of plastic causes the adsorption of toxins that are harmful to marine organisms. Persistent organic pollutants (POPs) are one example of toxic chemicals that last for years in the environment due to their low water solubility. POPs are man made chemicals that primarily come from pesticides and industrial chemicals. POPs are lipophilic, meaning they are attracted to the fatty tissue of living organisms (United Nations Environment Programme, 2018b). POPs can affect organisms in various ways, such as damaging organ systems or causing cancer (United Nations Environment Programme, 2018b). Plastics can act as "a 'sponge' to remove and concentrate contaminants from the water column. If an animal, such as a fish, bird or marine mammal, ingests plastic particles then there is the potential for transfer of these adsorbed chemicals into the tissue" (United Nations Environment Programme, 2016). The result of a study on the sorption of POPs implies that some plastics pose greater risks to marine wildlife than others due to higher concentrations of hazardous chemicals (CM, E, BT, & S, 2013).

Due to the small size of microplastics, organisms can confuse them for food and accidentally consume plastics. When marine organisms consume plastic they are ingesting both the plastic itself and the toxins that have been adsorbed (Lockwood, 2012). When plastics are consumed, chemicals are absorbed off the plastic and into the bloodstream and tissues of the organism. It has been found that fish who consume plastics are more likely to

have tumor or liver problems (Maillard et al., 2013), (Barclay, 2013). Through bioaccumulation, these chemicals travel up the food chain and eventually reach humans (Michigan Department of Community Health, 2018). Due to the inability of plastics to degrade and the potential for plastics to absorb harmful chemicals, the improper disposal of plastic items poses a great threat to marine ecosystems and human health. The images below show a few of the effects that plastics have on organisms.

Figure 3. (left) Seabird found dead on beach with stomach full of plastic (Estrada, 2017). (right) 800g of plastic found in Minke whale that washed up dead on a beach in Normandy (BBC, 2016).

Approximately 92% of marine debris is plastic and plastic pollution affects at least 693 species worldwide including "all known species of sea turtles, 54% of all species of marine mammal, and 56% of all species of seabird" (Gall & Thomson, 2015). Of the species that are affected, 17% are on the International Union for Conservation of Nature's Red List for being threatened, vulnerable, endangered, or critically endangered (Gall & Thomson, 2015). Since plastics are not digestible, and can not be excreted, once ingested they remain in the organisms stomach and shrink the effective size of the organisms stomach. The ingestion of plastic by marine animals has the potential to cause significant biological problems by blocking gastric enzyme secretion, diminishing feeding stimulus, reducing energy levels, lowering steroid hormone levels, delaying ovulation, causing reproductive failure, and can even result in death (Gall & Thomson, 2015). Even if plastic pollutants are not ingested, marine organisms can get entangled in items such as plastic rings or bags. For these reasons, plastic pollutants in marine environments pose a great threat to the health of marine ecosystems.

It is only within the last decade that people have begun to realise microplastic pollution is a problem (United Nations Environment Programme, 2016). Most of the research that exists focuses on the effects that microplastics have on marine organisms and, in many cases, the research done focuses on specific species. A study by Gall and Thompson attempts to quantify the current state of research on the effects that plastics have on marine organisms (Gall & Thomson, 2015). They found that there are 340 original publications reporting the encounters between organisms and marine debris (Gall & Thomson, 2015). However, research is lacking when it comes to quantifying the amount of microplastics present in the marine environment (Fraunhofer-Institute for Environmental, Safety, and Energy Technology UMSICHT, 2015).

Prevalence of Plastics

Plastic consumerism gained popularity following World War II, when the large production capacity of the United States pivoted towards the mass consumer market (Knight, 2014). As a result, the global production of plastics rose from 2 million metric tons in 1950 to 400 million metric tons of plastic in the year 2015 (University of Georgia, 2017). This increase in plastic production has resulted in the creation of 8.3 billion metric tons of plastic (University of Georgia, 2017).

Plastic revolutionised society by greatly impacting the packaging industry (Hall, Berry, Rintoul, & Hoogenboom, 2015). Most packaging products are single-use plastics. Single-use plastics are meant to be used once and then disposed of. Some examples of single-use plastics include grocery store bags, water bottles, straws, plastic packaging, and disposable cups. Today it is socially acceptable to use single-use plastic items rather than using reusable items.

> When we buy our groceries our snacks come within a plastic wrapped box with plastic wrapped individual granola bars or chips. Our baked goods come in new plastic containers. This practice is not just applied to unhealthy 'processed'

> food but every aspect of our lives. When we buy fruit and vegetables we place apples or lettuce in thin plastic bags. Even worse we place pre-peeled and sliced apples, oranges, or carrots in a plastic container (McDermott, 2016).

Grocery stores try to mitigate the effects of single-use plastic bags by collecting and recycling them. However, it is estimated that 4 trillion plastic bags are used annually worldwide, and that only 1% of these are returned for recycling (Earth Day Network, 2018). Along these same lines, humans buy approximately 1 million plastic bottles per minute and, in Australia, only about 11.8% of these plastic bottles are recycled (O'Farrell & Australian Government: Department of the Environment, 2018). This shows that current efforts to enforce recycling practices are ineffective against today's single-use consumer culture. The most commonly found pollutants in the ocean are plastic bottles and plastic bags, both of which are single-use plastics. However, clothing, lighters, polystyrene, containers, and plastic shoes which are intended for multiple uses are also found in large quantities in the ocean (Guern, 2018). This "multitude of plastic pollution is not just attributed to the odd ignorant man directly dropping a plastic cup into the river but has everything to do with the overconsumption of single-use plastics" (McDermott, 2016).

While plastics are typically recyclable, many user items containing plastics are not. One example of this is single-use coffee cups, which are not easily recyclable due to their polyethylene lining. The polyethylene lining prohibits the coffee from soaking through the paper cup, but results in only 1% of coffee cups being recycled properly (Gabbatiss, 2018). Another item that is frequently littered and contains plastic is a cigarette. The filter in a cigarette is comprised of thousands of plastic particles (Hamblin, 2017). Both single-use coffee cups and cigarettes are frequently used in everyday life and can not be easily recycled.

Journey of Plastic Pollutants

According to Jenna Jambeck, a researcher at the University of Georgia, 80% of plastic pollutants originate on land (University of Georgia, 2017). Pollutants can be littered either intentionally or unintentionally. When a user intentionally pollutes an area with a pollutant, this is considered intentional littering. Unintentional litter is originally disposed of properly, but due to unforeseen factors ends up as litter. Plastic pollutants can enter local waterways through unintentional littering which can be due to improper waste management (Beaman et al., 2016). This includes plastics falling out of overflowing litter bins or garbage trucks. Improper waste management and unintentional litter are especially a problem after large public gatherings because disposal systems may not be equipped to handle such large volumes of plastics. Volumes beyond system capacity result in overflows that allow wind and wildlife to carry them into local waterways (Beaman et al., 2016).

Neil Blake of the Port Phillip EcoCentre has coined the term, "Streets to Bay" to describe the transport of litter from local streets to bodies of water. When items are littered on streets in urban suburbs, they ultimately travel to the nearest body of water. Heavy rainfalls and strong winds can cause littered items to move from sidewalks to storm drains and ultimately into Port Phillip Bay through stormwater drains. Neil Blake states that:

> many people aren't aware that stormwater drains connect the streets to the bay. If you can't see a bay or a creek many people just wouldn't understand that connection... the idea is that choices people make no matter where they live will have a direct impact on the bay even if they don't know it (Neil Blake, personal communication, 12 November, 2018).

State of Current Research

Ultimately, all of the pollutants that are littered on land, may end up in the ocean. One study conducted in Tasmania, Australia focused on researching the sources of marine

litter. This study tested three hypothesis on the sources of marine litter: (1) direct deposition by beachgoers, (2) transport from surrounding areas via storm water drains and coastal runoff, and (3) onshore transport from the marine system (Willis, Hardesty, Kriwoken, & Wilcox, 2017). Ultimately, they found that most marine litter is deposited locally and that "local interventions are likely to be the most effective in reducing land-based inputs into the ocean" (Willis et al., 2017). One major conclusion from the study was that there were:

> greater amounts of debris on shores with a greater number of stormwater drain outflows within a 5 km radius, even when we controlled for local population density. The greater number of stormwater drains, the higher probability that litter will exit a drain and be deposited on the shore (Willis et al., 2017).

The research done to understand why pollutants are so commonly found in nature is sparse (Eriksen et al., 2013). A group of researchers concluded that the "focus has been primarily on the symptoms (the animals or environments harmed by the litter) rather than the causes (how the litter enters the environment, and plastic use in society)" (Pahl, Wyles, & Thompson, 2017). The United Nations Environmental Programme (UNEP) is the leading global environmental authority, with the primary objective of establishing the global environmental agenda (United Nations Environment Programme, 2018a). Their publication, Marine Plastic Debris and Microplastics: Global lessons and research to inspire action and guide policy change, compiles leading global data to generate consensus between key organisations, with the goal of guiding policy change to generate positive outcomes. One conclusion that this report draws is that until the extent of plastic pollution is more widely understood, policy makers should take precautions to limit the widespread use of plastics (United Nations Environment Programme, 2016). According to UNEP, “there is a sufficient body of knowledge to argue convincingly of the need to invoke the precautionary approach in reducing the input of plastics into the ocean and minimising the risk” (United Nations Environment Programme, 2016). Despite the significant studies

that have already been conducted, more research is required to better understand the scope of plastic litter in marine environments so that different organisations can appropriately address the problem of plastic pollution.

As part of the effort to better understand the extent of plastic pollution, the Port Phillip EcoCentre has been collecting data on plastic pollution across beaches, streets, and rivers within Victoria since 2012 (Maillard et al., 2013). Citizen science has been an invaluable tool in collecting data through street, beach, and river litter audits (Charko et al., 2018). This data has been used to draw the conclusion that plastic pollutants are prevalent in Port Phillip Bay.

Port Phillip Bay

Port Phillip Bay is a 2,000 square kilometre large marine embayment south of Melbourne (State Government of Victoria, 2013). Since the bay is almost entirely surrounded by land, its catchment area is estimated at 10,000 square kilometres. In June 2015, there were an estimated 4.53 million people living in the Greater Melbourne area and approximately 3 million of those live and work in Port Phillip Bay catchment area (Australian Bureau of Statistics, 2015), (Harris et al., 1996). Because of the large population within the catchment area, the bay is exposed to a high volume of plastic pollutants. As shown in the figure below, the mouth of Port Phillip Bay is a 3.2 kilometre wide opening laterally stretching from Point Nepean to Point Lonsdale. Due to this small opening, the majority of pollutants that are introduced into the bay are unlikely to escape through the Bass Strait, making Port Phillip Bay highly susceptible to lingering plastic pollution.

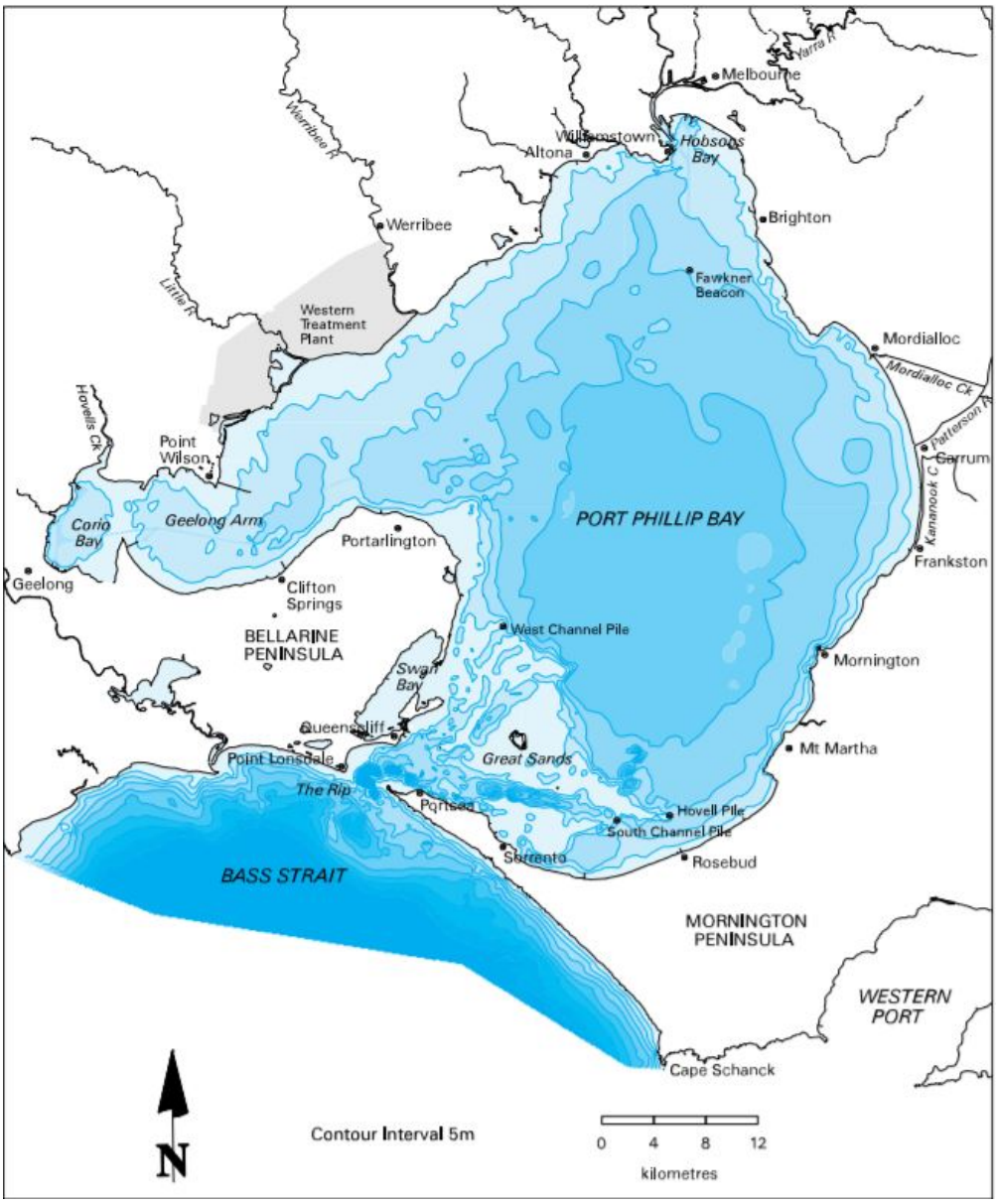

Figure 4. Locality map of Port Phillip Bay (Harris et al., 1996)

In order to fully understand how society contributes to marine plastic pollution in Port Phillip Bay, it is necessary to identify which regions the pollutants may be coming from and details regarding the catchment area. The Greater Melbourne and Greater Geelong areas landlock Port Phillip Bay and comprise the majority of the bay's catchment area. These areas have a higher population density than the rest of Victoria and are likely sources of plastic pollutants because having more people in an area creates the potential for more pollutants to be introduced into the environment. In 2015, the average population

density in Victoria was 26 people per square kilometre, while the population density in Greater Melbourne was 450 people per square kilometre (Australian Bureau of Statistics, 2015). This urbanisation occurs predominantly along the lower Yarra River, Maribyrnong River, Moonee Ponds, and Merri Creeks (Harris et al., 1996). There are many local government areas (also commonly known as councils) within Port Phillip Bay catchment area, and waste management policy and regulations can diverge significantly from council to council. It is possible that these differences in policy are another source of variation in levels of plastic pollution. These waste management policies, and how well they are maintained, can have a large impact on the prevalence of plastic pollutants in that area. As such, the relationship between levels of plastic pollution and waste management policy has been analysed throughout this project.

In order to understand where the pollutants originate, it is important to understand the geography of the bay's catchment area. The catchment area is comprised of 21 natural drainage basins, eight of which directly feed into the bay. Melbourne Water's Healthy Waterways Strategy divides Port Phillip Bay catchment area into five major areas of focus, one of which is the Yarra catchment (Melbourne Water, 2018). Seven drainage basins contribute runoff to the Yarra catchment (Harris et al., 1996). This makes the Yarra River a major contributor to water inflow into the bay and an area of focus for pollution research. The EcoCentre estimates that 828 million pollutants flow into Port Phillip Bay each year from the Yarra and Maribyrnong rivers (Charko et al., 2018).

It is approximated that 10,000 marine species are living in Port Phillip Bay. In addition to supporting stable communities of local species, the bay also supports a number of species that move into and out of the bay (State Government of Victoria, 2013). Benthic species remain native to the bay and form the basis for important commercial and recreational fisheries (State Government of Victoria, 2013). Many of the benthic and mollusk species found in the bay are a large part of the local fishing industry. In order to ensure the health and well-being of consumers and to protect local fishing, it is imperative

that the bay remains free from pollutants as much as possible. Port Phillip Bay has more endemic species than the Great Barrier Reef, therefore, the preservation of its natural state should be made a priority (*Baykeepers*, 2017).

Port Phillip EcoCentre

One of the many organisations that works to protect Port Phillip Bay is the Port Phillip EcoCentre located in St. Kilda. Their mission is "to build relationships to inspire, educate and demonstrate sustainable environmental practice and reconnect people to the natural world" as well as to "spread awareness of the environmental issues through educational programs directed towards the public and to address these issues by involving the community to take action" (Port Phillip EcoCentre, 2018). One way they meet their mission is through the Clean Bay Blueprint project.

The Clean Bay Blueprint project began as the LitterHotspots program in 2015, and will continue into 2020. This project aims to keep Port Phillip Bay clean and free of plastic pollutants (Port Phillip EcoCentre, 2017). The Clean Bay Blueprint project is spearheaded by Neil Blake, Port Phillip Baykeeper, and Fam Charko, a marine biologist working at the EcoCentre (Port Phillip EcoCentre, 2018). This project team collaborated with Mr. Blake and Ms. Charko on the Clean Bay Blueprint project.

A major part of the Clean Bay Blueprint project is to monitor plastic pollution levels. The Clean Bay Blueprint project is important for many reasons, one being that plastic is not currently a pollutant that the Government of Victoria monitors in their assessment of the water quality for the Yarra and Maribyrnong Rivers or for Port Phillip Bay. Methods of monitoring levels of plastic pollution that the EcoCentre employs include street, beach, and river litter audits (Port Phillip EcoCentre, 2017). This project will use plastic pollution data from these sources. Beach and street litter audits were created and designed as part of previous Interactive Qualifying Projects (IQP) with Worcester Polytechnic Institute (WPI). The project titled *A Citizen Science Platform for Long-Term*

Monitoring of Microplastic Pollution in Port Phillip Bay, that took place in May of 2017, created procedures for the use of citizen science in performing beach litter audits (Bayas, M., Ford, & Lawes, 2017). The project titled *From Streets to Sea: Evaluating Citizen Science Programs with the Port Phillip EcoCentre*, that took place in December of 2017, created a rubric to evaluate the citizen science programs that the EcoCentre runs. The group used this rubric as a guideline to improve beach litter audits as well as develop street litter audits (Bergstrom, Duquette, Healey, & Sorenson, 2017). River litter audits are performed at the head of Port Phillip Bay and along the Yarra and Maribyrnong rivers by EcoCentre scientists in collaboration with the Yarra Riverkeepers Association.

Project Statement

The EcoCentre began their research on microplastics in Port Phillip Bay in late 2012 following the discovery of an abundance of nurdles at Middle Park Beach (Maillard et al., 2013). Since then, the EcoCentre's Clean Bay Blueprint project research has focused on quantifying levels of microplastic pollution through street, beach, and river litter audits. A crucial research gap that exists is determining the source of these microplastics. This project aims to fill this gap by using data visualisation to determine the sources of plastic pollutants entering Port Phillip Bay. GIS mapping will be used to visualise the data to find correlations between human and environmental factors and levels of plastic pollution.

The goal of this project is to use GIS mapping to visualise, analyse, and communicate sources of plastic pollutants entering Port Phillip Bay. The project has three objectives: (1) conduct a case study on GIS mapping tools, (2) gather human and environmental data relevant to plastic pollution and the geospatial regions surrounding the bay, and (3) use GIS mapping to identify sources and causes of plastic pollution.

Methods

Project Goals

The goal of this project is to find the sources of plastic pollutants entering Port Phillip Bay. We identified three objectives in order to accomplish this goal. First, we conducted a case study on different GIS mapping tools. Second, we collected information about plastic pollutants in Port Phillip Bay catchment area through interviews, observations, and the collection of supplementary data. This consisted of interviews with council representatives and experts in the field and also conducting, categorising, and analysing street, beach, and river litter audits. Finally, we used GIS mapping to visualise the geospatial and chronological relationship between plastic pollution and supplementary datasets in order to identify the correlations and causations of plastic pollutants entering Port Phillip Bay.

Case Study of GIS Mapping Softwares

GIS Mapping Rubric. In order to accommodate the EcoCentre's efforts to understand the levels of plastic pollution, the EcoCentre desired a GIS mapping tool to visualise the street, beach, and river litter audit data. The purpose of this tool is to aid them in identifying relationships between plastic pollution and other variables. It was important to thoroughly investigate a wide variety of commercially available tools so we could present options to best meet the EcoCentre's needs. The selection process began with researching eight GIS mapping tools and evaluating each tool based on important criteria using a rubric we created.

To complete the rubrics, we had each member of the team download a tool, use it, and attempt to add our data to it. This was the baseline for how far to go with each of the tools for ranking. Afterwards, we also had a different member of the team use the same tool so we could get a more standardised ranking. The criteria used to rank the tools were cost, ease of download, usability, customisability, and quality. The GIS mapping case study

contains a rubric for all eight tools, and can be found in Appendix A.

After the GIS rubrics were completed, we used an analysis matrix to display the rankings in a more concise way. This involved displaying the qualitative data in a quantitative manner, which allowed for a more objective comparison of the various tools. This quantification occurred using coloured labels corresponding to how well the tool meets the needs of a specific category. For example, if a tool's user interface was extremely intuitive and easy to use, the cell in the analysis matrix describing its characteristics was coloured green. In contrast, a tool with a poor user interface may have a cell coloured yellow or red. In this way, a user can glance briefly at the analysis matrix to understand which tool may be best suited for their use. The GIS mapping case study contains the analysis matrix and can be found in Appendix A. The analysis matrix was used to identify which software package was the best for the EcoCentre to use. Ultimately, Tableau was selected because of its easy user interface, available features, and high quality output.

After selecting a GIS tool, we created a *Introduction to GIS Mapping with Tableau* document which can be found in Appendix B. This document explains everything from formatting data, to downloading Tableau, and to creating complex graphs. It also covers how to edit the existing visualisations that were created. This way the EcoCentre can continue with our project after we leave.

Gathering Relevant Data

Selecting Pollution Datasets. The EcoCentre and their volunteers have been collecting street, beach, and river litter data since 2012 (Charko et al., 2018). The team used all of this pollution data in the visualisation. The street litter audit data was collected by EcoCentre staff, volunteers, and Scouts Victoria using the collection methods found in Appendix C. The beach litter audit data was collected by volunteers using the collection methods found in Appendix D. Both the street and the beach litter audit collection methods were designed by the EcoCentre. The trawling data was collected by

the EcoCentre in conjunction with the Yarra Riverkeepers Association.

After gathering the data sheets from the audits, the team formatted the data so it could be inputted into the GIS mapping tool, Tableau. This process involved finding latitude and longitude coordinates for each of the audit sites and storing them within the data sheet.

Selecting Supplementary Datasets. For supplementary datasets, the team identified potential human and environmental sources of plastic pollutants. These potential sources were identified by researching other organisations' opinions on the sources of plastic pollutants as well as through interviews conducted with experts in the field. The sources the team identified can be found in the table below. For all the locations, Google Maps was used to determine the latitude and longitude.

Supplementary Data	Significance	Methodology
Human		
Sporting Events: Locations and Frequency	We wanted to visualise the locations and dates of sporting grounds that host large events to try and correlate these with increases in levels of plastic pollution.	When selecting sporting events, major sporting events were chosen and recorded along with the date the sporting event occurred. A major event was defined as one that is internationally famous, appeared in multiple news stories, or occurred at a large venue. In order to also represent local clubs' sporting events, the grounds at which these local clubs play were also recorded. Most of the sporting grounds were found through council websites. When councils did not list sporting grounds, Google Maps was used to find sporting venues by searching for cricket ovals, tennis courts, and other common sports fields.

Markets: Locations and Frequency	Markets tend to attract crowds of people which could be contributing to high levels of plastic pollution. We wanted to visualise the locations of these events and try to correlate the dates on which they occur with spikes in levels of plastic pollution.	The Melbourne Farmers Markets website lists all the farmers markets in the Greater Melbourne area. The markets that took place in large venues or are tourist destinations, such as the Queen Victoria Market and Dandenong Market were chosen. Additionally, smaller markets that were located close to the rivers or bay were chosen. Once the markets were chosen, the days of the week that these markets had operated between 2013 and 2018 were found and recorded in the spreadsheet.
Waste Water Discharge Locations	Filters at waste water discharge plants are not fine enough to capture microplastics. It is possible that microplastics escape into bodies of water via wastewater discharge locations. This suggests that beach litter audits conducted near wastewater discharge locations may reflect larger quantities of microplastics.	Melbourne Water's website was used to determine the location of the two wastewater treatment plants and where both of these plants discharge.

Hotels and Large Apartment Buildings	Hotels are important because they have a high population density. We can look at this from two perspectives, (1) how tourists/travellers treat the land around Melbourne, and (2) how high density population areas influence levels of plastic pollution. Travellers may lack certain amenities that they enjoy at home, resulting in the use of more single-use plastics.	Travel websites were used to find hotels located within the same council as street and beach litter audit locations. Hotels with more than one hundred rooms were classified as potential locations for high levels of plastic pollution and included those in our data sheet.
Environmental		
Wind, Rainfall, Sunlight, and Temperature	Wind can knock rubbish out of bins and transport it along the streets and into the water. Rainfall can move rubbish from streets to stormwater drains. Sunlight and temperature can affect the number of people who spend their day outside. All of these factors could lead to increases in levels of pollution.	Data on wind, rainfall, sunlight, and temperature were obtained from the Australian Bureau of Meteorology. We searched for monthly weather and climate data and then found the closest (within twenty kilometre) weather station to each audit site. The mean 3 PM wind speed, total rainfall, mean daily hours of sunlight, and mean maximum temperature for each month averaged over previous years at the station closest to each audit site were recorded.
Other		
Council Boundaries	Different councils could have different legislative regulations that can affect levels of plastic pollution.	The councils that are within Port Phillip Bay catchment area were chosen to be shown on our visualisation. Tableau has the ability to show council boundaries, so no external data source was required.

Observations.

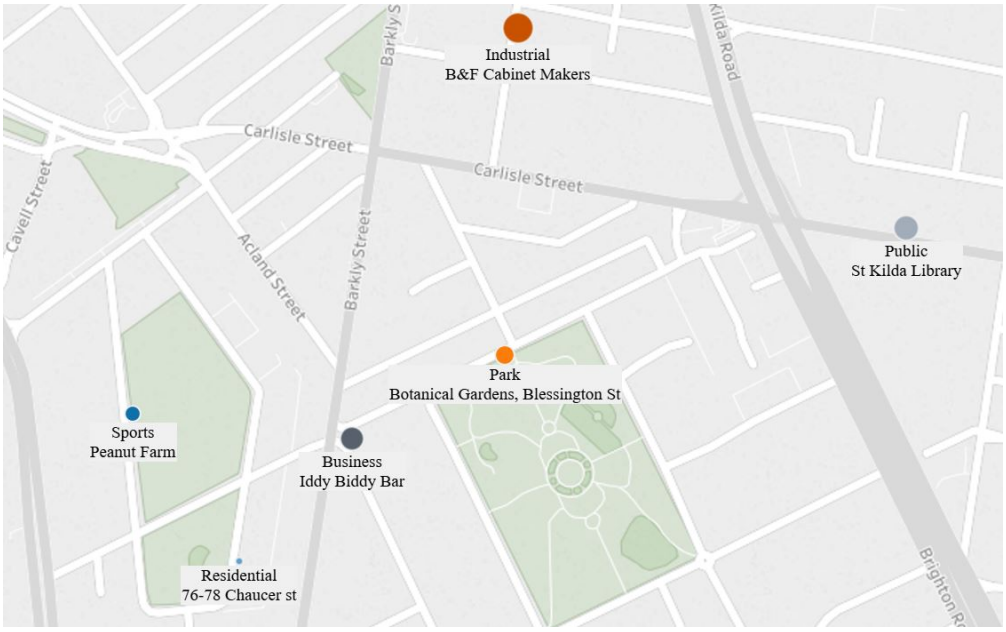

Figure 5. Location of the Team's Street Litter Audits

Observations of the Greater Melbourne area were used to determine potential sources of plastic pollutants. The team created an observation rubric that aims to show an overview of the auditing site in terms of waste management facilities and most common pollutants found. Observations were conducted at one site for each of the six street usage types. These six street usage types are business, industrial, parks, public, residential, and sporting grounds. The audit sites chosen for each usage were Iddy Biddy Bar, B & F Cabinet Makers, St. Kilda Botanical Gardens along Blessington Street, St. Kilda Library, 76-78 Chaucer Street, and Peanut Farm, respectively. While at these sites, the team looked for visual signs of plastic pollutants and also performed street litter audits following the EcoCentre's street litter auditing procedures. These sites were chosen due to their proximity to the EcoCentre. The team's observation rubric can be found in Appendix E. The completed rubric and audit sheet for each of the six audits that were conducted can be found in Appendices F, G, H, I, J, K, L, M, N, O, P, and Q.

Interviews. Interviews were conducted with council and non-profit representatives as well as experts in the field of plastic pollution research. Before any

interview, both in person or electronically, the team gave the interviewee a statement of consent to be interviewed, which can be found in Appendix R.

Council and non-profit representatives were interviewed to determine the waste management practices that exist in their councils, their awareness of plastic pollution, and their awareness of current efforts to reduce levels of plastic pollution. The council representatives that we interviewed were chosen based on discussions with the EcoCentre staff and Jessica Hand, an employee at the Metropolitan Waste and Resource Recovery Group. One of the factors in selecting council representatives is the proximity of councils to the Yarra and Maribyrnong rivers. Due to the bay's large catchment area, it was not feasible to interview all councils that reside within the catchment area. Council representatives with whom the team was unable to conduct in person interviews with were asked to complete an online form with the interview questions. For a list of interview questions for council and non-profit representatives see Appendix S and for a list of council and non-profit representatives that were interviewed see Appendix T.

Experts in the field include scientists researching plastic pollution as well as people who work for organisations that explore ways to reduce levels of plastic pollution. Since experts may have insight into the sources and causes of plastic pollutants that the project team does not, experts were interviewed about how they address high levels of plastic pollution in their work as well as what they think are potential sources of plastic pollutants. A full list of interview questions for experts in the field can be found in Appendix U and a list of experts in the field that were interviewed can be found in Appendix V.

Using GIS Mapping to Identify Sources of Plastic Pollutants

Creation of the Visualisation. Before the interactive visualisation could be completed, some technical processes needed to be completed. Tableau can only accept data when formatted in a particular way. Currently, the EcoCentre records data from beach and street litter audits on physical pieces of paper. The collected data was transferred to a

spreadsheet that Tableau would be able to interpret. For a more detailed process see Appendix B. The visualisation will need to be simple enough for future EcoCentre staff to continue collecting and viewing data, and any correlations or trends in data will need to be easily recognised by viewers. The EcoCentre may share the visualisation with government representatives, volunteers, or other non-profit groups. An iterative design process was used to tailor the visual and interactive aspects of the design. EcoCentre staff were encouraged to provide feedback throughout the iterative design process, so that the tool would be ideal for their needs.

Conducting Analysis with the Visualisation. The visualisation is intended to be a standalone tool for understanding plastic pollution within the catchment area of the bay. As a result, correlations between levels of plastic pollution and other variables were determined simply by looking at the visualisation. The visualisation testing website can be found at `https://sjcomeau43543.github.io/clean_bay_blueprint/`. The primary method for finding relationships involves looking at varying levels of plastic pollution, as well as composition of plastic pollution samples, over time. The date filtering option in the upper right corner of the visualisation is used to see variations in the plastic pollution data and supplementary data with time as the independent variable.

Results / Discussion

Interview Results

The team conducted interviews with waste management educators from councils located within Port Phillip Bay's catchment area as well as with experts in the field of plastic pollution. The council representatives that the team interviewed were Nick Dunstan of the City of Port Phillip Council, Emily Richards of the City of Port Phillip Council, Shaun Young of Hobsons Bay City Council, April Williams of City of Monash Council, and Kirsty Richards of the City of Yarra Council. The experts in the field of plastic pollution that the team interviewed were Randall Lee of the Environmental Protection Authority (EPA) Victoria, Peter Kennedy of Scouts Victoria, Neil Blake of the Port Phillip EcoCentre, Fam Charko of the Port Phillip EcoCentre, and Jodi Jones of Tangaroa Blue. The team also interviewed Annette Finger of Boomerang Alliance, a non-profit organisation that focuses on waste management and helping communities move towards zero waste. Interview transcripts can be found in Appendices W, X, Y, Z, AA, AB, AC, AD, AE, and AF.

From the council interviews, the team gained insight into the perception of the prevalence of plastic pollution within councils in Victoria. When asked how serious of a problem plastic pollution is on a scale from 1 (not a problem) to 10 (immediate solution is required), all council representatives ranked the severity of plastic pollution levels as an 8 or higher. April Williams said:

> I think [plastic pollution] is probably one of the worst types of pollution since it doesn't break down or, if it does, then it goes into microplastics which are very harmful. We as a society have a very consumerist tendency. A lot of what they buy is crap and junk. The top level of the waste hierarchy is avoiding waste and we don't talk about it a lot because council thinks it's too much of a societal issue and nobody wants to tell people how they need to live their lives April

Williams, personal communication, 13 November, 2018.

Emily Newton said that she thinks plastic pollution is "pretty serious, I think given the recent news articles... it's a huge scale problem and I don't think people are aware of it yet. The reason I started working in waste management is because of plastic pollution" Emily Newton, personal communication, 9 November, 2018. From the interviews with councils, it was found that increasing general awareness of the problem of plastic pollution is important because a solution can not be found if people do not know it is a problem.

Different councils have different plastic usage regulations, which may affect the prevalence of plastic pollutants within council boundaries. Many of the council representatives were in support of plastic use bans. The City of Port Phillip requires that event holders "have a meaningful commitment to minimising their impact on the environment" and discourages single-use plastics from being used at public events and, in the future, a regulation may be coming that prevents disposable plastics from being used at public events Nick Dunstan and Emily Newton, personal communication, 9 November, 2018. Hobsons Bay City Council supports and advocates for the ban of single-use plastics in legislation as well as hosts anti-litter campaigns in the summer Shaun Young, personal communication, 13 November, 2018. City of Monash Council has a regulation prohibiting the use of single-use plastics or balloons during events that take place on public lands. Additionally, they are working with staff members, caterers, and cafes that operate on council lands to move away from soft plastics. If the council are successful at removing soft plastics from their own practices, the City of Monash Council plans on providing the public with recommendations on how to make similar changes April Williams, personal communication, 13 November, 2018. City of Yarra Council encourages traders to move away from single-use plastics and supports a ban of plastic straws and balloons. They are also working with companies who are developing new methods of recycling within Australia Kirsty Richards, personal communication, 14 November, 2018. All the council representatives that were interviewed spoke about the plastic bag ban in Victoria that will

come into effect in late 2019. The Andrews Labor Government of Victoria will sign this ban which will prohibit single-use plastic shopping bags that are less than 35 microns thick (Minister for Energy, Environment and Climate Change, 2018).

In addition to plastic use regulations, waste management practices differ between councils. All the councils that were interviewed offered curbside pickup of rubbish and recycling bins for residences. The City of Port Phillip Council and the City of Yarra Council also offer this service to businesses Nick Dunstan and Emily Newton, personal communication, 9 November, 2018 Kirsty Richards, personal communication, 14 November, 2018. Monash City Council provides curbside rubbish pickup for businesses, and charges extra for recycling pickup April Williams, personal communication, 13 November, 2108. All councils offer public rubbish bins and increase the frequency of collection during summer and large events. The City of Port Phillip Council is trialing solar compactor bins that will compact rubbish so that bins do not need to be emptied as frequently. Additionally, these bins are equipped with sensors that send a signal with GPS coordinates to the collection staff when the bin is getting close to full. In this way, the City of Port Phillip Council hopes to avoid overflowing bins Nick Dunstan and Emily Newton, personal communication, 9 November, 2018. The City of Yarra Council is taking a different approach by performing Blitz's. During a Blitz, the in-house crew goes to a specific area in the council to clean it thoroughly. The following week they will do this with a different area. This idea stemmed from the concept that the cleaner an area starts out, the cleaner it will continue to be Kirsty Richards, personal communication, 14 November, 2018. Similarly, all the councils perform street sweeping at regular intervals. Areas that have more traffic, such as busy retail areas, are swept more frequently. In addition to street sweeping, the City of Port Phillip's in-house crew performs mechanical beach cleanings where a machine combs the top few centimetres of the sand for plastics as well as manual hand picking of litter at the tide lines. Both of these occur daily Nick Dunstan and Emily Newton, personal communication, 9 November, 2018. The City of Monash Council

performs footpath and lane-way sweeping in addition to their street sweeping April Williams, personal communication, 13 November, 2108.

Many council representatives thought cigarette butts, littering, drink containers, straws, and plastic bags were the most common causes of high levels of plastic pollution. The graph below demonstrates the overall opinion on what is causing the abundance of plastic pollution.

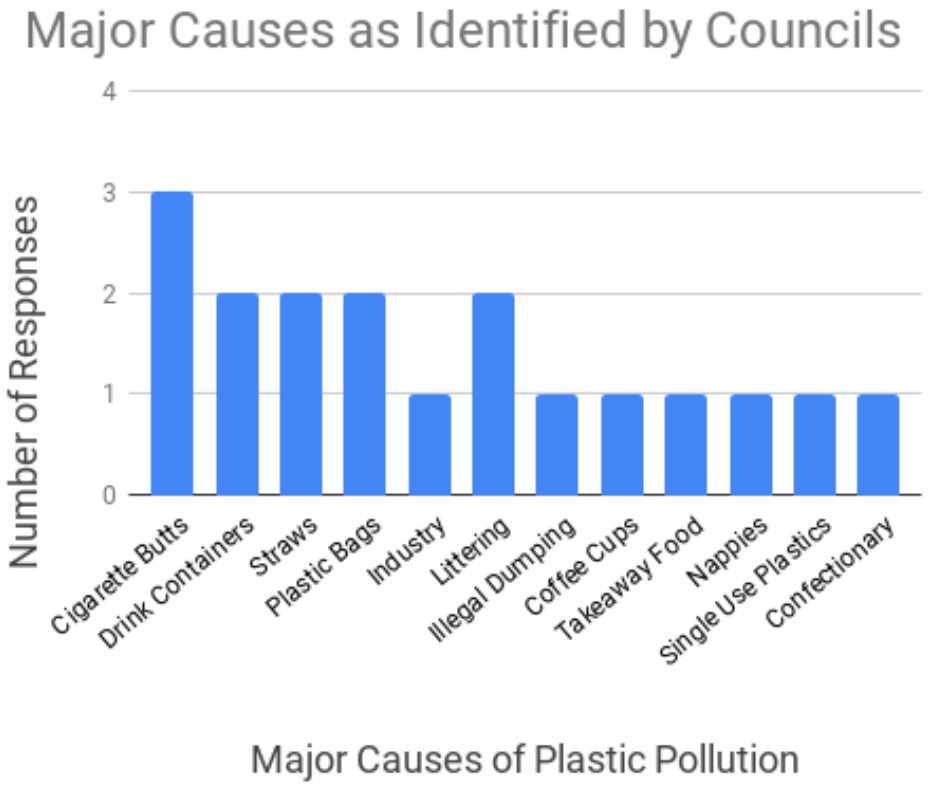

Figure 6. Waste management educators view on major causes of plastic pollution

While the council representatives are aware, many of them stated that educating the public is a major barrier to reducing plastic litter as shown in the following quote from Kirsty Richards.

> I am aware that there is heaps of [plastic pollution] in the sea and that [plastic pollution is] in the Yarra. The Yarra runs through the suburbs and I'm trying

> to make people aware that if it's in the gutter it goes into the Yarra and then into the sea. It opens people's world to understand the concept of how far the effect of what they do does Kirsty Richards, personal communication, 14 November, 2018.

Similarly, Fam Charko of the Port Phillip EcoCentre stated that she thinks a major cause of plastic pollution is "lack of understanding by consumers on what plastic does, what kind of material it is, and what kind of effect it has on the environment. There are a lot of people who throw plastic in the bin and they don't see it anymore so they think it goes away" (Fam Charko, personal communication, 22 November, 2018).

From interviews with experts in the field of plastic pollution the team gained insight into what experts thought the major sources and causes of plastic pollutants in Port Phillip Bay are, as well as which human and environmental factors they think contribute to levels of plastic pollution. This information gave the team things to look for when analysing the data and the visualisation as well as information on what data should be included in the visualisation.

Randall Lee of EPA Victoria identified packaging as a major cause of plastic pollution. He reasons that this is because:

> we throw that stuff away and there is a more fundamental issue that we don't value the resource that plastic is and that we don't reuse it we just throw it away. If some packaging or nurdles escape we don't go and clean them up because we just think we can go and get some more (Randall Lee, personal communication, 12 November, 2018).

He identified stormwater drains as a major source of plastic pollutants as drains serve as a transportation mechanism for plastics from streets into the bay (Randall Lee, personal communication, 12 November, 2018). For human and environmental factors, Randall Lee listed illegal dumping, socioeconomic factors, wind, and improperly managed

landfills (Randall Lee, personal communication, 12 November, 2018). He also mentioned that work is beginning to be done in the Mediterranean Sea to determine the ratio of microplastics found in the stomach of plankton. This is important because it uses a method other than extrapolating data from the surface of the ocean to quantify microplastics. It also illustrates that microplastics have infultrated the most basic component of the marine food chain.

Peter Kennedy of Scouts Victoria identified littering, bad habits, inadequate storage facilities, and people's inability to care for the environment as major causes of plastic pollution (Peter Kennedy, personal communication, 12 November, 2018). For sources of plastic pollutants, he said that the street litter audit data he has collected thus far shows commercial retail areas, such as supermarkets, as well as sporting fields to be major sources of plastic pollutants (Peter Kennedy, personal communication, 12 November, 2018). When asked to list environmental and human factors that he thought contributed to levels of plastic pollution, Peter Kennedy responded "I am not sure there is environmental or human factors. There are those people who litter and those who don't, I'm not sure that changes or is circumstantial" (Peter Kennedy, personal communication, 12 November, 2018). Peter Kennedy and Scouts Victoria will continue collecting street litter audit data for the EcoCentre. Because of this, after the interview the team spoke with Peter Kennedy about how this new data will need to be formatted in order for the EcoCentre to include it in future visualisations. This information is formatted into a document titled *Introduction to GIS Mapping with Tableau*. This document can be found in Appendix B.

Neil Blake of the Port Phillip EcoCentre identified inadequate or irresponsible disposal as a major cause of plastic pollution (Neil Blake, personal communication, 12 November, 2018). He thinks that sporting events, industrial precincts, retail precincts, recent winds and people's belief that councils will pick up their litter are major sources of plastic pollutants (Neil Blake, personal communication, 12 November, 2018). Neil Blake also mentioned that single-use food and drink containers are a major contributor as "when

people are on the move, they often leave a trail behind them" (Neil Blake, personal communication, 12 November, 2018). Neil Blake would like the team to include sporting events in the visualisation as he thinks there is cultural acceptance of litter after sporting events. For example during a marathon, runners grab plastic cups of water from the water station, throw them on the ground when they are finished drinking, and then continue running. Similarly, during spectator sports many people leave their food and drink litter under their seat as they think someone else will clean it up (Neil Blake, personal communication, 12 November, 2018).

Fam Charko of the Port Phillip EcoCentre identified over consumption as the major cause of plastic pollution because "the more plastic gets consumed, the more it gets into the environment" (Fam Charko, personal communication, 22 November, 2018). She thinks that this over consumption stems from a lack of understanding by consumers "on what plastic does, what kind of material it is and what kind of effect it has on the environment" (Fam Charko, personal communication, 22 November, 2018). Fam Charko thinks that it is very hard to pinpoint a source of plastic pollutants since they are different for every location. However, she thinks that the suburbs of metropolitan Melbourne and the users of plastic there are likely the sources of plastic pollutants in Port Phillip Bay (Fam Charko, personal communication, 22 November, 2018). When asked about human and environmental factors that may contribute to levels of plastic pollution she told the team she thinks the weather is an important factor. For example, on a nice sunny day more people go outside and they get takeaway or they bring picnics all of which include plastic (Fam Charko, personal communication, 22 November, 2018).

Jodi Jones of Tangaroa Blue Foundation was unable to meet with the team in person, however she did respond to a survey that contained the team's interview questions. Tangaroa Blue Foundation thinks the major source of plastic pollutants is single-use plastics (Tangaroa Blue Foundation, personal communication, 12 November, 2018). They think that humans are responsible for the manufacture of plastics and the release of it into

the environment (Tangaroa Blue Foundation, personal communication, 12 November, 2018). The release of plastic pollutants into the environment is due to humans making bad decisions, but the nature of these bad decisions differ between spaces, places, organisations, industries and processes (Tangaroa Blue Foundation, personal communication, 12 November, 2018).

During the interview with Annette Finger of the Boomerang Alliance the team asked her the same questions as the council representatives. This was done because Annette's primary role is to campaign for Victoria to implement waste policy changes and the team wanted to see if her opinions on plastic pollution were similar to those of the council representatives or if they were different. She thinks that overall councils in Victoria are doing a better job at preventing high levels of plastic pollution than councils in other states of Australia. However, she did express concern about the lack of recycling facilities. She thinks councils are doing a very good job at collecting recycling, however, since China has refused to accept any more of Australia's recycling the councils have nothing to do with the recycling they collect. Annette recommends that councils adopt a container deposit scheme (Annette Finger, personal communication, 21 November, 2018). When asked about the plastic use regulations that Victoria has in place, Annette mentioned the plastic bag ban that all the councils mentioned. She added that she thinks councils should be implementing more plastic use regulations and specifying the wording of these regulations so as to avoid loopholes (Annette Finger, personal communication, 21 November, 2018). Overall, Annette thinks that plastic pollution is a global issue, on par with climate change as:

> chemistry is a marvellous thing but we created these long-chained polymers that nature largely has no idea what to do with. Because these don't exist in nature, nature has no idea how to incorporate them into their circle of life. We are producing increasing amounts of plastic because it's such a marvellous material. The qualities that make it so great also make it an absolute nightmare in the environment once it gets displaced (Annette Finger, personal

communication, 21 November, 2018).

Each of the experts had differing views on the sources of plastic pollutants as can be shown in the two figures below. The most common responses for causes of plastic pollution were mismanagement of waste, littering, and a lack of understanding of the resource that plastic is. The most common responses for sources of plastic pollutants were wind and industry.

Figure 7. (left) Experts view on causes of plastic pollution. (right) Experts view on the sources of plastic pollutants

Visualisation

To fully understand fluctuating levels of plastic pollution within Port Phillip Bay catchment area, the team created a GIS map to visualise data that has been previously collected by the EcoCentre. The team used an iterative design process using feedback from the EcoCentre to ensure that the visualisation caters to the intended audience.

The team researched similar works that other organisations have created using GIS mapping. The map below was created using ArcGIS and reflects the quantity of plastic pollutants in the world's oceans (*Estimate of Plastic Pollution in the World's Oceans*, 2018). It was interesting to see that the design utilises points rather than geospatial shapes to represent locations of pollutants in oceans.

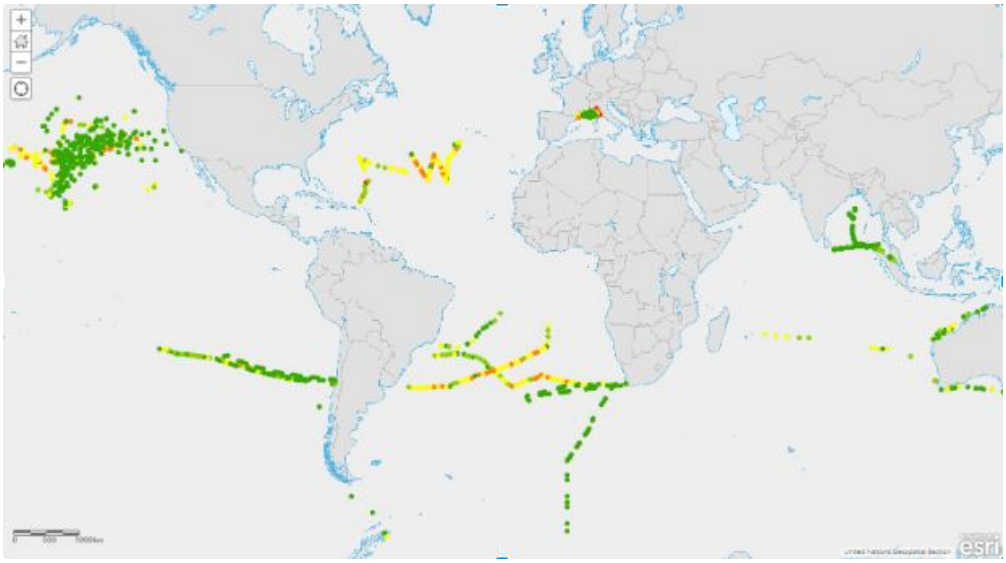

Figure 8. ArcGIS Visualisation of Pollution Levels in Ocean

The team was especially interested in the visualisation below, because of its relevance to the project. The visualisation below shows levels of plastic pollution along the bay's coastline, and utilises geospatial data as well as charts. The use of charts enables the viewer to see a breakdown of individual points, which provides useful detail to accompany the map.

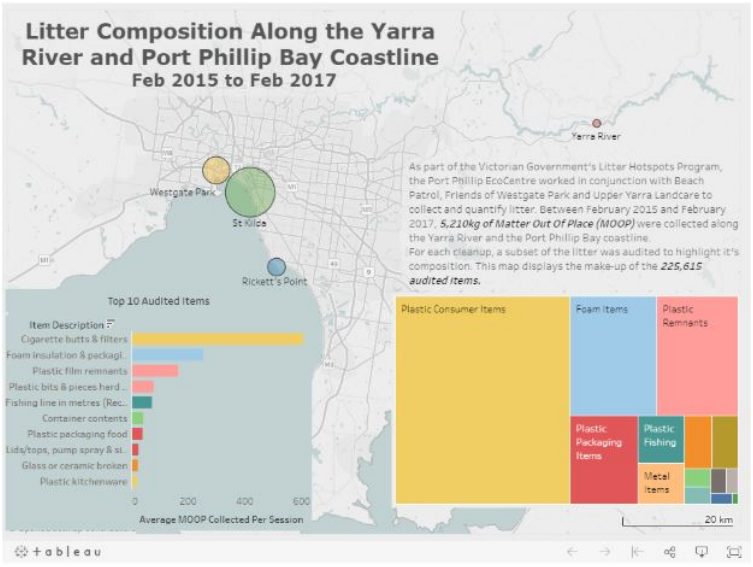

Figure 9. Tableau Visualisation of Pollution Levels on Port Phillip Bay Coast (Tregillis, 2017)

The team considered the benefits of each of the visualisations, and created the following initial design.

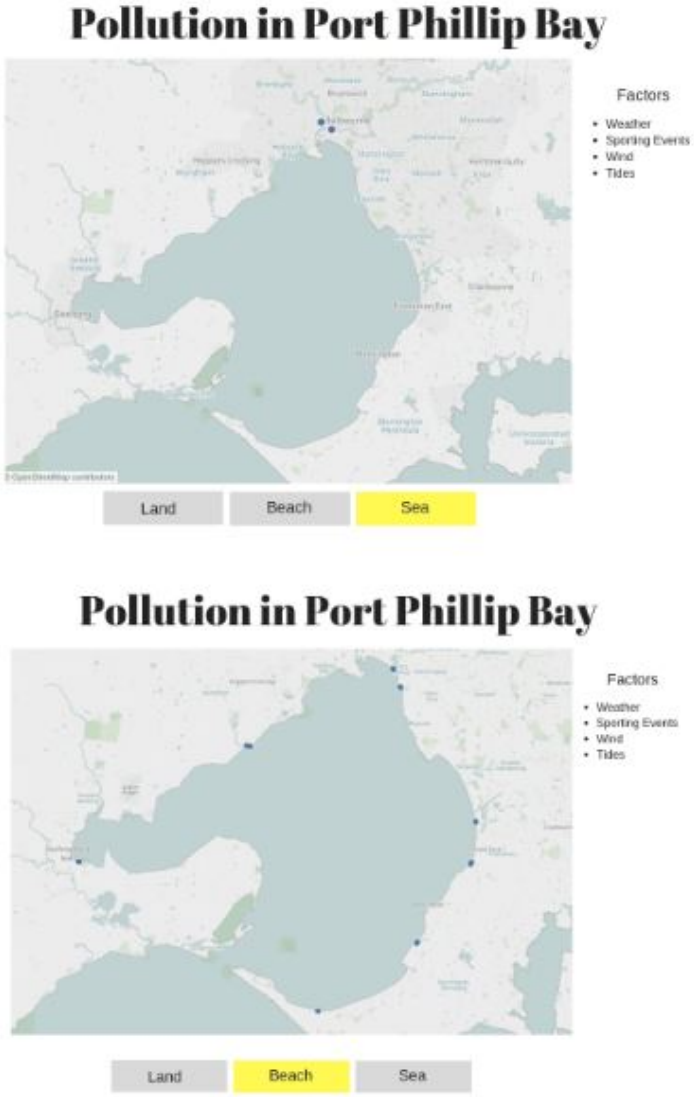

Figure 10. Iteration One

The goal for the first iteration was to represent the layout of the GIS map in relation to the supplementary and pollution datasets the team had selected. The first iteration contains two different selector areas: one for pollution data located at the bottom and one for factor data to the right of the map. This feature enables the user to select what supplementary and pollution data is currently visible on the map. This visualisation uses the bullet point method of representing the levels of plastic pollution. The second

iteration came shortly after the first and appears below.

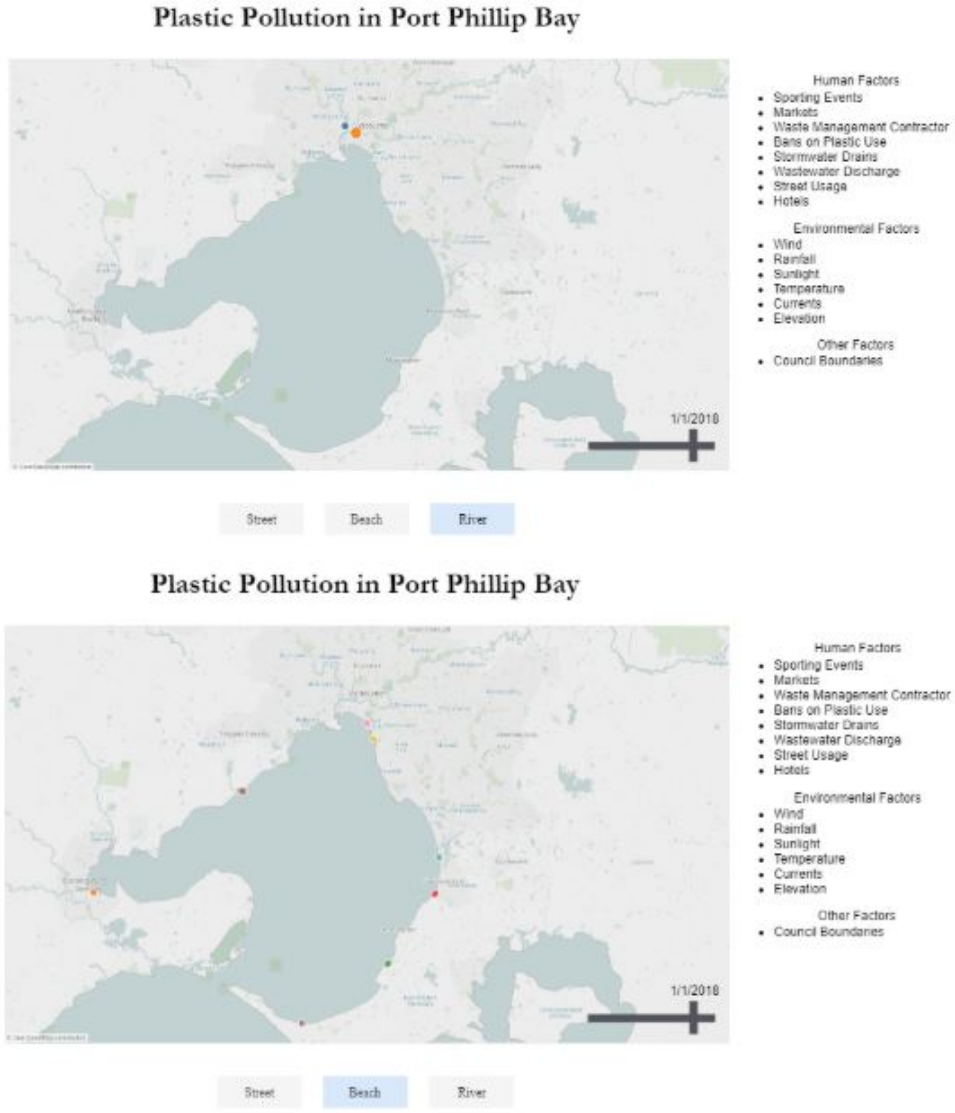

Figure 11. Iteration Two

This iteration includes a variety of changes, such as adding all of the supplementary data, changing the colour scheme, adding a date selector, and changing some wording of the button labels. For the third iteration the team decided to try something completely different so as to test other styles and see which was ultimately the most pleasing to the viewer.

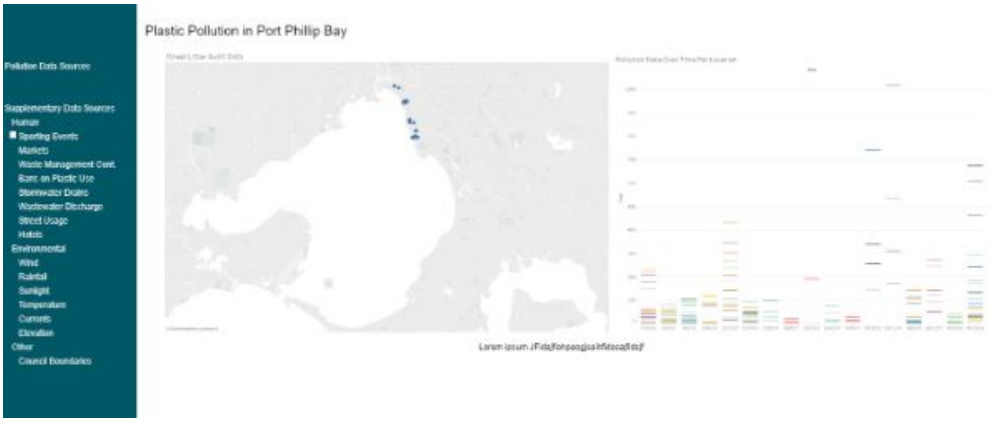

Figure 12. Iteration Three

For this iteration, the team consulted a professional in the field of website development, Elizabeth Gallagher. By consulting a professional, the team hoped to receive critical feedback on some concepts they may have been overlooking. This inspired the team to change the visualisation to the following.

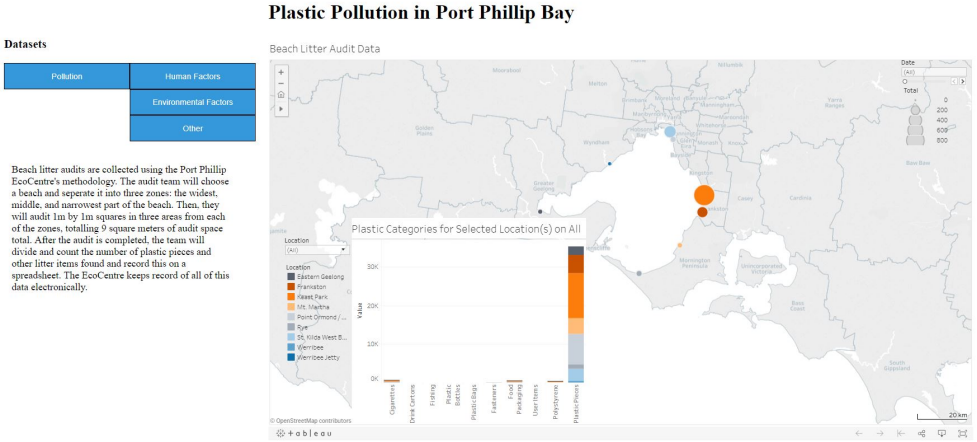

Figure 13. Iteration Four

In this visualisation a lot of things changed. Firstly, the menus on the side became drop down menus which allow the user to select both a pollution data set and a supplementary data set. When no supplementary data set is selected, the chart displayed shows a GIS map overlaid with a chart representing the break down of plastic pollutants found in all audits. Since there are many more colours on these maps, the team decided to do in depth research on how to design for people with colour blindness. This led to the use

of a variety of shades of blues and oranges throughout our visualisation since monochrome and complementary colours are easy for people with colour blindness to distinguish (Collinge, 2017).

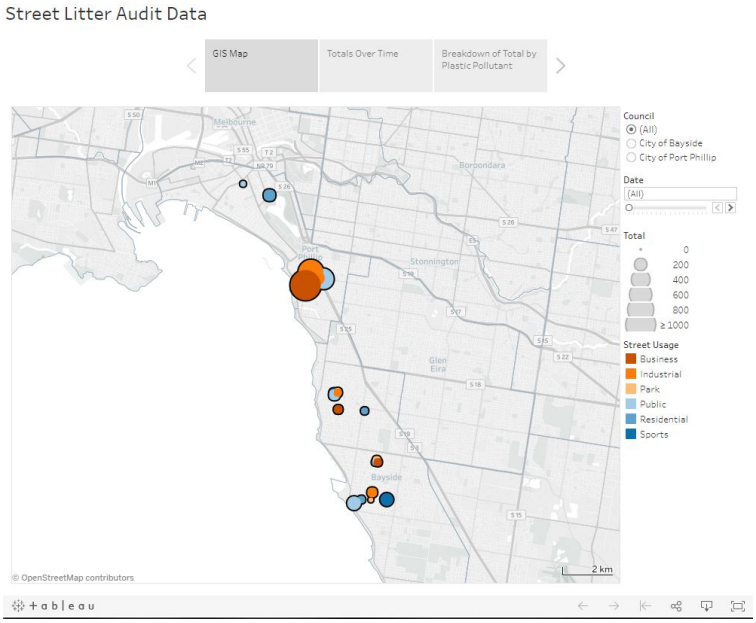

Figure 14. Final Street Litter Audit Design

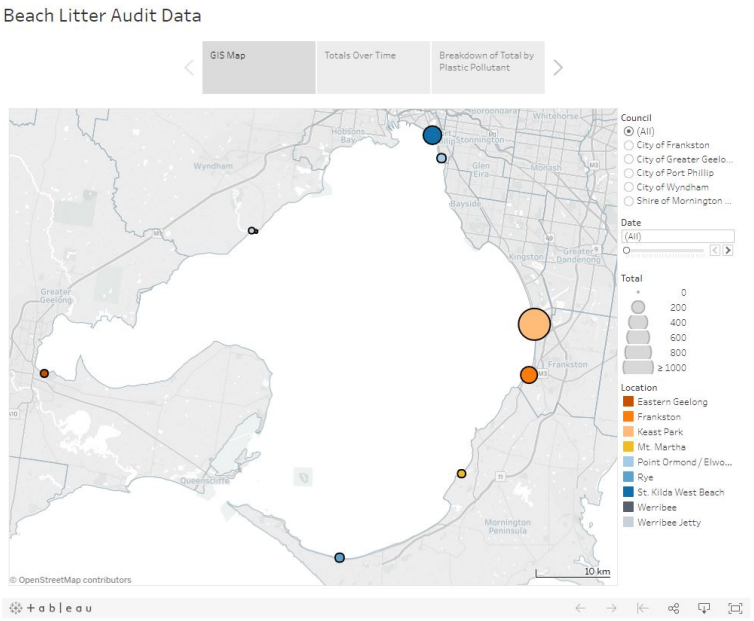

Figure 15. Final Beach Litter Audit Design

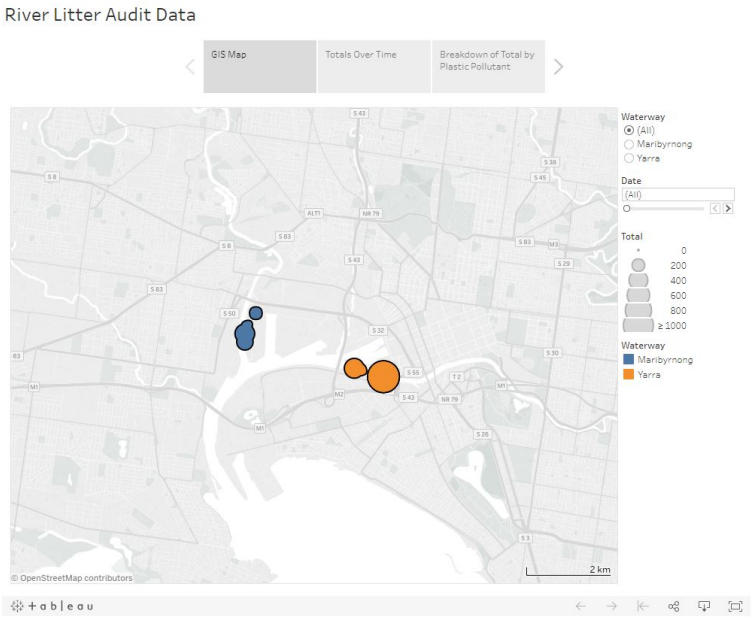

Figure 16. Final River Litter Audit Design

After discussions with the EcoCentre's marketing employee, Josh Solomonz, and the professional web developer, Elizabeth Gallagher, the team finalised the visualisation to look like it does above. The latitude and longitude values were removed from the tooltips, since they are not useful to the user. The council and location of the audit are in the tooltip and, if applicable, the street address and business name is also in the tool tip. There is now the ability to filter based on the council which will help the EcoCentre inform council waste management policy. The halo around the points makes it easier for viewers to distinguish between the audits and the supplementary data. The colour scheme was changed to not include greys so that the points are easier to see on the background map. Streets and land cover were added onto the background map since it would help the user see the areas that surround the audit site.

The EcoCentre plans to post the team's visualisations to their website. The design was modified to flow from top to bottom so the page was not too busy. The team only posted the three litter audit visualisations since it keeps clutter and maintenance to a minimum for the EcoCentre. All of the finalised visualisations can be found at `https://sjcomeau43543.github.io/clean_bay_blueprint/`

Street, Beach, and River Litter Audit Data Analysis Results

Using a combination of the visualisation, supplementary charts, and hands on experience, the street, beach, and river litter audit data was analysed. The goal of this was to try to determine the source of plastic pollutants in each of the areas separately from the others. For all the street, beach, and river litter audits each of the collected supplementary data sources were used to try and identify correlations. If no correlations were found, this analysis was not mentioned. The analysis discusses the areas where correlations were found. For street litter audits correlations were found between levels of plastic pollution and street usage, temperature, and sunlight. For beach litter audits correlations were found between levels of plastic pollution and wind, temperature, seasons, and tides. For river litter audits correlations were found between levels of plastic pollution and sunlight, rainfall, wind, hotels, and sporting grounds.

Street Litter Audit Data Analysis Results

At the beginning of the project, the team conducted street litter audits in order to fully understand the auditing process, and to collect consistent data for easy comparison of the six street usage types. The team did one street litter audit for each type of street usage. These street usages include (1) Business / Retail, which is a privately owned business or retail store, (2) Industrial, which is a business that constructs a product, (3) Park, which includes public parks or green space, (4) Public, which includes town buildings such as libraries or town halls, typically which host events five or six days in a week, (5) Residential, and (6) Recreation / Sports, which are grounds for sporting matches. The locations for the street litter audits were selected based on proximity to the EcoCentre and Neil Blake's knowledge of sites that he had visited previously. These sites were as follows:

Business / Retail	Iddy Biddy Bar
Industrial	B&F Cabinet Makers
Park	St Kilda Botanical Gardens, Blessington St
Public	St Kilda Library
Residential	76-78 Chaucer St

Recreation / Sports	Peanut Farm

The fact that street litter audits were conducted by the same people on the same day allowed for some assumptions about the data to be made. Despite the street litter audit methodology being well documented, there are still instances that can cause variation in the data. For example, the number of items collected can vary greatly depending on the amount of time and effort applied by the auditors. Because the same group of people conducted these six audits, it can be assumed that they applied the same amount of effort and searched with the same level of care. This implies that all data collected is representative of the audited location at that day and time and is not influenced by human factors. The team chose to conduct audits the day before street sweeping was scheduled in St. Kilda in order to collect the maximum amount of litter at audit locations.

However, these street litter audits do have some potential flaws. For example, the same one to two people searched the same zone for each of the six audits. This potentially exposes bias within the group; however, the team felt that this bias would affect the data less in comparison to two different groups conducting the audits. To mitigate this bias, the team had a training session with Neil Blake before the audits and learned the standardised way to conduct the audits. The last potential flaw is that the team only got to collect this data for one of each street usage type. These could all be outlier audits, and the team would not have the ability to know with only the team's data. To mitigate this potential flaw, the data collected by the team was compared with the data collected by other groups.

The categories for items found in the street litter audits are plastic bags, fishing, glass, plastic bottles, food packaging, cigarette butts, medical/cosmetic, rubber / elastic, drink cartons, plastic fragments, fasteners, polystyrene and other. In the chart below, for each street usage type the total of each of these categories was graphed.

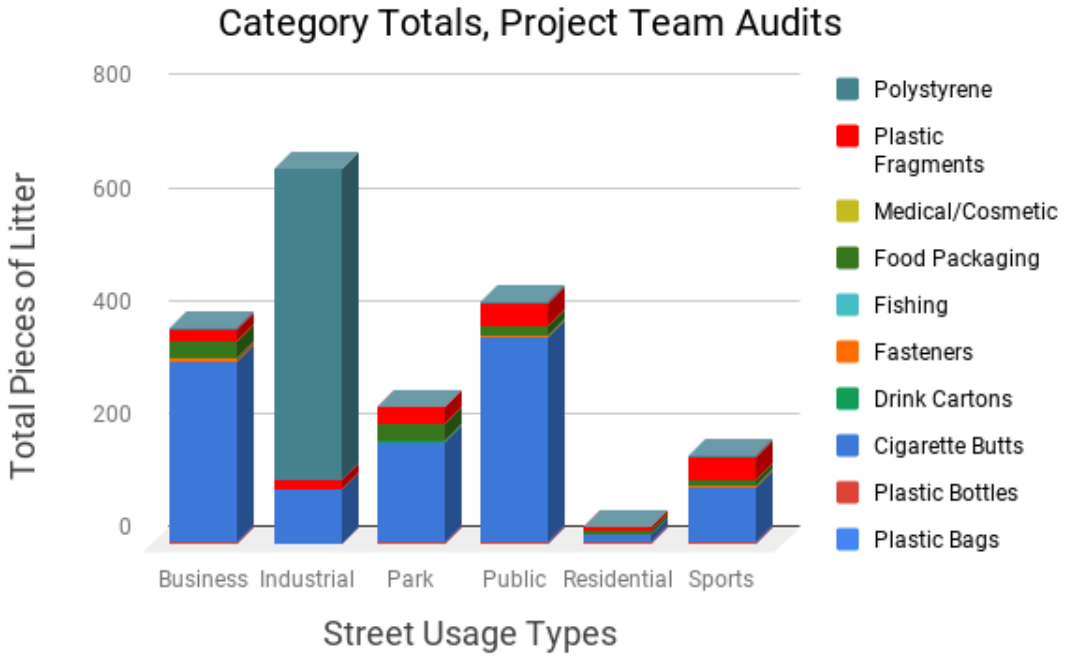

Figure 17. Project Team Street Audit Results, Category Totals

Cigarette butts were found consistently in every street usage type. The team found the most cigarette butts in front of public and business properties, which are both areas, in this scenario, that had trash bins readily available and not overflowing. In the case of the business area, there were six trash bins and two recycling bins. In front of the public property, there was a tram stop and a cafe. There were also many small areas in which a person could hide their cigarette butt. A lot of the cigarette butts within this area were out of reach of the auditors. The image below shows the areas that were missed during the street litter audit.

Figure 18. Picture from Team's street litter audits of St Kilda Library

Another standout item from the audits is the number of polystyrene beads within the industrial area. One thing to note is that the data was only collected between the public sidewalk and the road. The image below shows the area that was missed during this process.

Figure 19. Picture from Team's street litter audits of B&F Cabinet Makers Lawn

This industrial business had a large front yard in which a lot of pollutants could be seen, but these were not collected as they were on private property. One thing that stood

out about this area was that it was very difficult to find all the polystyrene within the grass area. The image below shows the levels of pollution in front of the industrial area based on the zone it was found in.

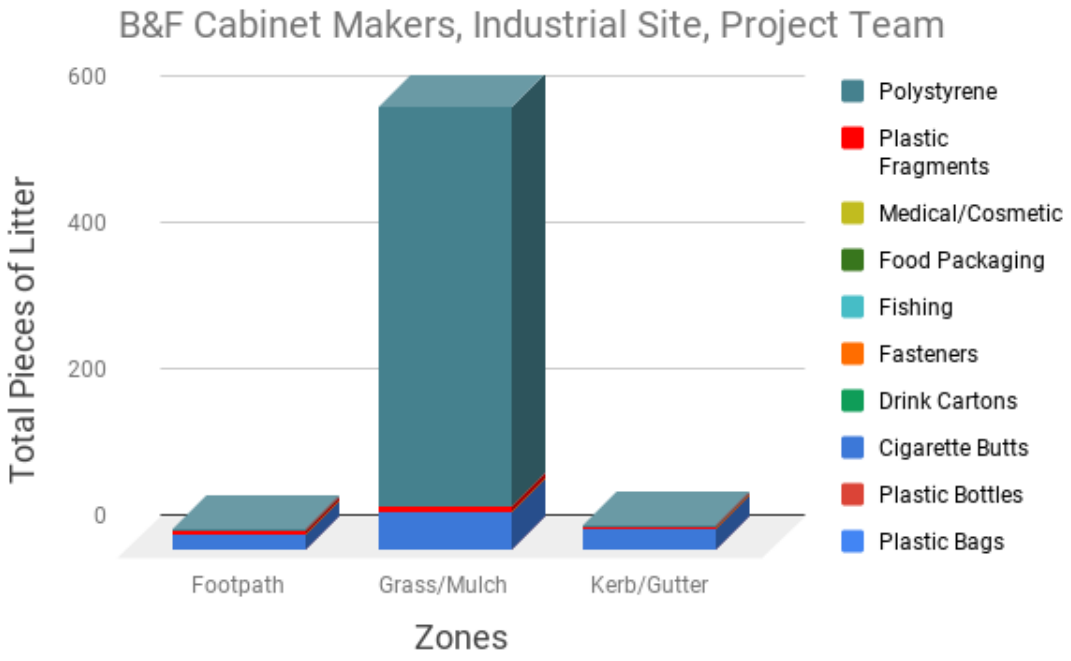

Figure 20. B&F Cabinet Makers Audit Data by Zone

As can be seen in the graph above, the polystyrene beads are most prevalent in the grass/mulch in front of the industrial area. The other two zones did not have nearly as many pollutants. This could be due to the fact that street sweeping occurs in the footpath and kerb/gutter zones, but not in the grass/mulch zone. Additionally, the grass is compact and thus a stronger force is required to move smaller items than if these same items were on concrete. If items do leave the grass/mulch, what conditions cause them to do so? One potential is lawn mowing tendencies. The lawn mowing machines may kick up polystyrene beads as the grass is cut and blow the beads around. They may also chop the polystyrene into smaller pieces. The team thinks that industrial zones had high levels of polystyrene beads because of all the packaging and deliveries that they receive. Most of these beads were found near the trash bins in the grass. This could be because when workers throw out the packaging, the beads may fall on the ground around of the bin. There was also a

stormwater drain right next to the site location, which leads the team to believe that if these polystyrene beads get blown around, then industrial sites may be a large contributor to the number of polystyrene beads in the ocean.

Overall, the most commonly found pollutants were cigarette butts, polystyrene beads, hard plastic fragments greater than 5 millimetres and soft plastic fragments greater than 5 millimetres. Polystyrene beads are most prevalent in the industrial area. Another observation is the consistent prevalence of cigarette butts. Confectionery wraps and plastic fragments are less apparent in the street litter audits. However, these findings could be misrepresented based on the locations the team chose.

The data the team collected must be combined with other audit data to understand the full picture and ensure that the team's data were not outliers. The data collected by Scouts Victoria was used in conjunction with the data the team collected. When combining the Scouts Victoria data and the team's audit data, the team took care to ensure that this was done fairly and consistently in order to eliminate any bias. For each street usage, multiple locations from each street usage category were selected in order to ensure that any one particular location is not an outlier and that the each street usage category is properly represented. The following locations from the Scouts Victoria data were selected to be averaged with the team's data.

Business / Retail	Woolworths, Church St	Woolworths, Church St
Industrial	46 Middle Crescent	46 Middle Crescent
Park	Wilson Reserve, Middle Crescent	Wilson Reserve, Middle Crescent
Public	Sol Green Community Center	Rec Center, Outer Crescent
Residential	4A Bright St, Brighton East	4A Bright St, Brighton East
Recreation / Sports	Wilson Reserve, Outer Crescent	Wilson Reserve, Outer Crescent

These locations were selected because they vary in auditor and location. The team was hoping to get more variety in location sites originally, but since the project is still in

the beginning stages there is not a wide variety of audit locations. However, these twelve audits provided the information shown in the chart below.

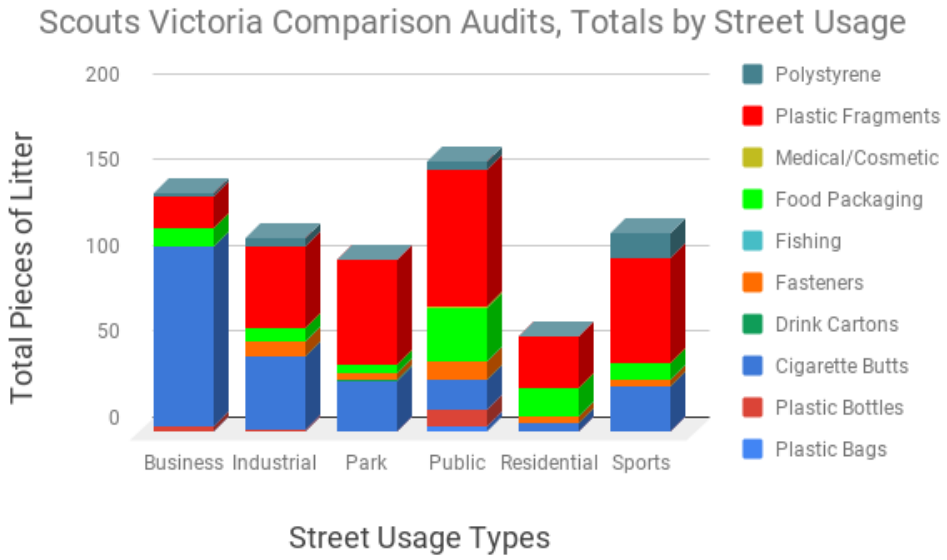

Figure 21. Scouts Victoria Data per Street Usage

As can be seen in the chart above, Scouts Victoria found that public locations have a larger quantity of litter items than the other street usage types. Within the public street usage type, plastic fragments, food packaging, and cigarette butts tend to be the most prevalent items. Industrial sites and businesses tend to experience more littering from cigarette butts than the other street usage types. It appears that residential areas do not experience as much litter as the other street usage types. Within residential areas, plastic fragments and food packaging tend to be seen the most. The updated chart of the total for each pollutant category is below. This chart shows the team's data averaged with the chosen Scouts Victoria data.

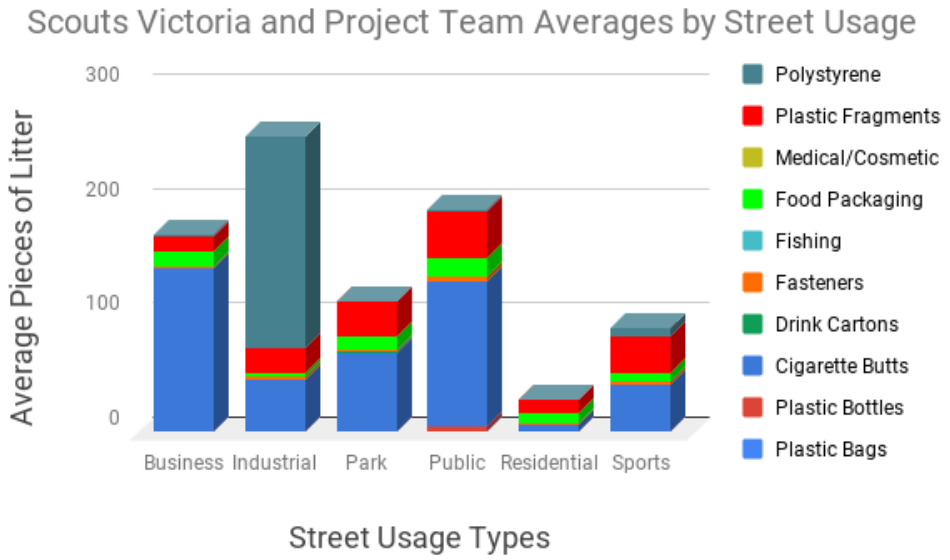

Figure 22. Averaged Team and Scouts Victoria Data per Street Usage

For street usage, the pollutants of the team's data was averaged with Scouts Victoria data. Industrial sites on average were the highest area of plastic pollutants. Residential remained low in litter. Sports and business levels raised. One main difference between the team's data and the Scouts Victoria's data is that the team collected more plastic fragments overall than Scouts Victoria did. Another main difference that can not be seen in the chart is the number of polystyrene pieces that were found at industrial sites. It may be that the auditing methods varied between groups as the team found 552 pieces, and Scouts Victoria found 4 and 1 at their two industrial sites. Similarly, the team's cigarette butt counts were on average 12 times higher than the Scouts Victoria cigarette butt counts.

Overall, it is clear that cigarette butts, polystyrene, and plastic fragments are the main contributors to the level of plastic pollution in street litter audit data. Although there were readily available trash bins at each of the locations that the team surveyed, the quantity of plastic pollutants found in that area was high.

Street litter auditing includes collecting all pollutants, not just plastic, that are found at an audit zone. From street litter audit data it was found that 81.68% of the audit was plastic pollutants. The remaining 18.32% is glass, rubber, metal, and other. This

shows the prevalence of plastic pollutants in street litter audit locations in comparison to other pollutants such as glass or rubber.

All six of the street usage types had their highest total number of pieces of plastic found in October or November. This could be because spring is ending and it is turning into summer, so the weather is getting warmer. When the weather is warmer, people may tend to spend more time outside which creates the potential for higher levels of pollution.

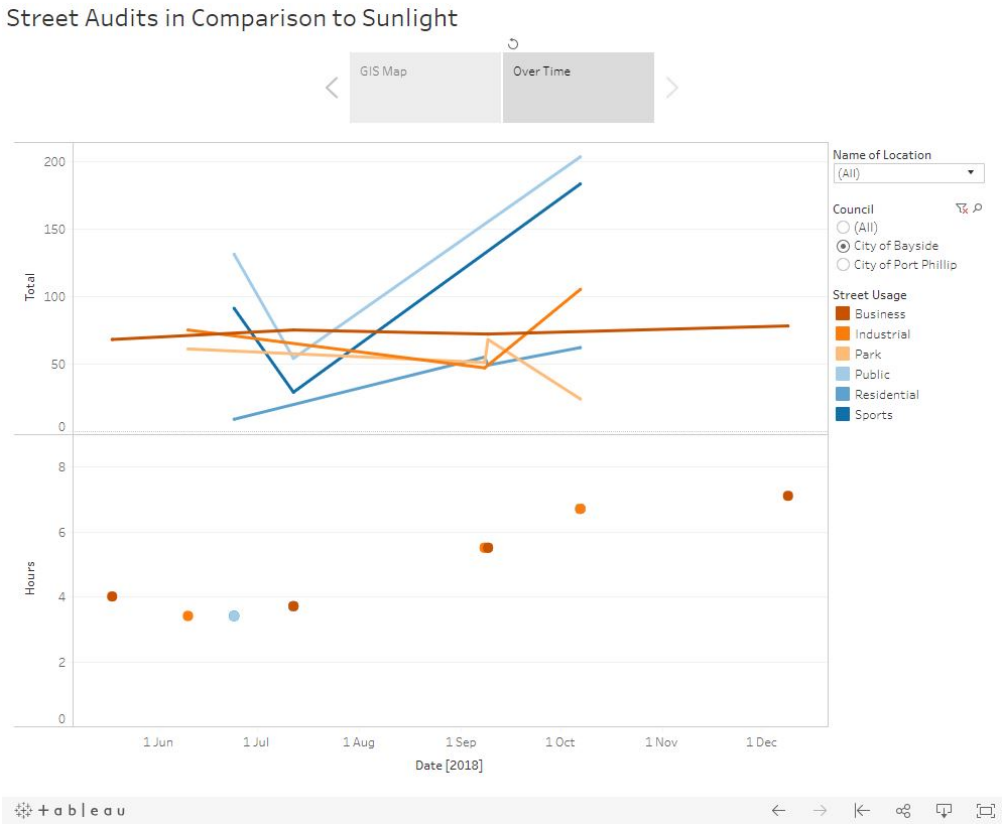

Figure 23. Street Litter Audits in Comparison to Sunlight

The graph above shows sunlight and levels of plastic pollution over time. Spikes of the total level of plastic pollution occur when the sunlight increases. Similar trends occur in the graph of sunlight and plastic pollution over time. Based on these observations, the team concluded that there is a correlation between the hours of sunlight in a day and the amount of plastic pollutants found at street litter audit locations, as well as temperature and levels of plastic pollution.

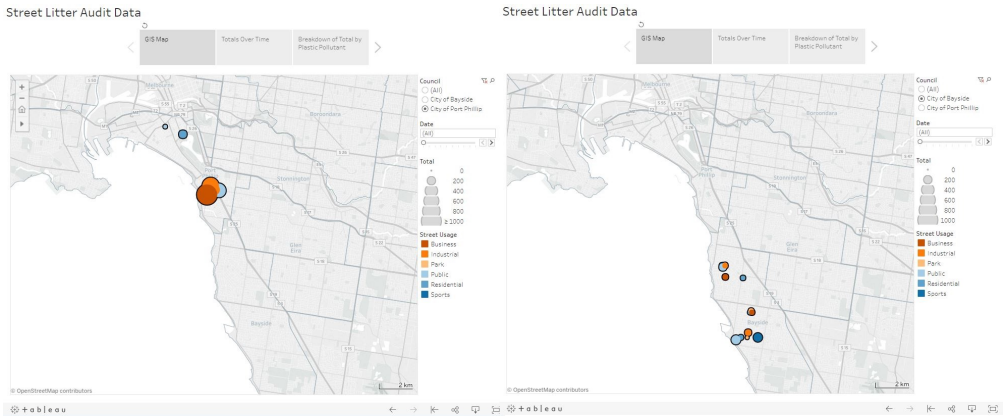

Figure 24. Street Litter Audits City of Port Phillip (left) Compared to City of Bayside (right)

The visualisation above shows that overall the City of Port Phillip street litter audits reflect higher levels of plastic pollution than the City of Bayside. By averaging all the sites of the same street usage and choosing the top three most littered street usages, the team recommends that the City of Bayside prioritise their sustainability efforts on sports fields, businesses, and parks. The City of Port Phillip, on the other hand, should prioritise industrial, business, and public sites. This illustrates the concept that each council has different street usage types that contribute to higher levels of plastic pollution and waste management efforts should be customised to fill the needs of each individual council.

Beach Litter Audit Data Analysis Results

The team conducted one beach litter audit in order to understand the beach litter audit method. The data discussed in this section is pre-existing EcoCentre data that has been collected at nine different beach litter audit locations beginning in 2017. First, the nine beaches were compared to see if any audit locations stood out from the rest. The chart below shows the average levels of plastic pollution found at the beaches that were audited.

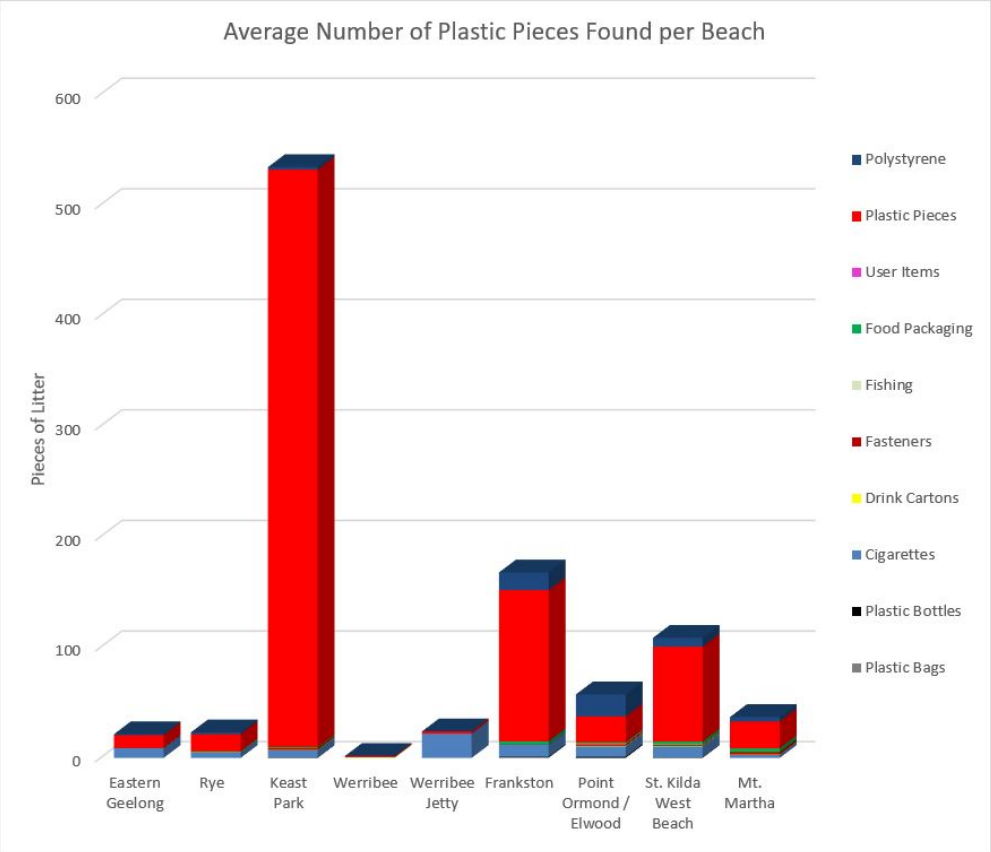

Figure 25. The average number of plastic pieces found per beach.

Plastic fragments are the most prevalent item found during audits on the beaches. The beach litter audit data shows that 99.16% of pollutants found during the audits are plastic. The team noticed that larger items such as bottles or plastic bags were often found in the park area surrounding the beach and are less commonly found in the audited areas of the beach. To further understand the distribution of plastic pollutants on beaches, the data was broken down into rows of quadrats (top, middle, or lower) to see which region of the beach contained the most amount of plastic pollutants.

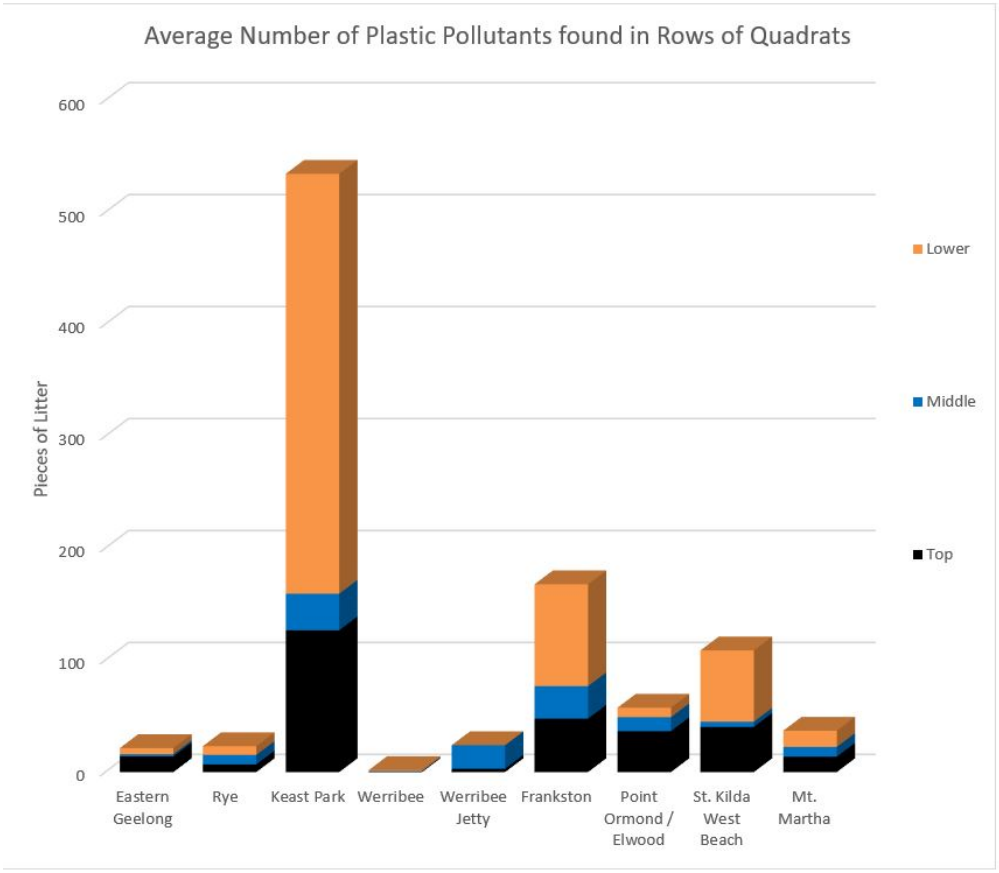

Figure 26. The average number of plastic pieces found per row of quadrat per beach.

The chart shows that larger quantities of plastic pollutants are found in the lower and top sections of the beach. In order to understand why this might be, the team considered the different mechanisms by which plastic pollutants are transported onto beaches. Littered items can be transported to beach litter audit sites by environmental factors such as wind and rain from nearby streets or walkways. Litter can also originate on beaches as a result of intentional or unintentional littering that occurs by beach goers. Litter generated on streets or by beach goers is likely to be found in the middle or upper sections of the beach. It is likely that factors such as sunlight and temperature are correlated to spikes in levels of pollution due to an increase in beach goers, as people are likely to spend time on or near the beach when the weather is nice. Generally speaking, items found along the tide line are representative of items that are currently in the bay, and have been washed onto the beach during the last tide cycle (Neil Blake, personal

communication, 12 November, 2018). As can be seen in the chart above, the low tide area typically had the most plastic pollutants in it. This could be from the larger plastic items that entered the bay, became degraded, and then were washed up onto the beach from the tide. For this reason, data from the lower section of the beach can lead to conclusions about prevailing tides in the bay.

Within each beach litter audit site, the distribution of items may not appear equally across all quadrats. Local currents or wave patterns can greatly influence the data collected during beach litter audits, particularly for the lowest quadrat within each transect. One example of this is the St. Kilda West Beach, where the most objects tend to be found in the lowest quadrat of the widest section of the beach. Two images of the St. Kilda West Beach are shown below. The image on the left is a Google Maps screenshot showing the beach as it exists today, with orange arrows representing the tendency of pollutants to wash towards the widest section of the beach. The nine quadrats are represented by blue circles. The image on the right shows a Tableau map displaying the average levels of pollution seen on St. Kilda West Beach, with the colours yellow, blue, and red representing the narrow, middle, and wide transects, respectively. The size of the circles corresponds to the amount of littered items found there on average.

Figure 27. Left: Google Maps image of St. Kilda West Beach, Right: Tableau Visualisation of St. Kilda West Beach

Within the St. Kilda West Beach, the proportion of littered items increases or

remains the same across the narrow, middle, and widest transects, respectively. This is true across transects at the top, middle, and lower levels of the beach. While this claim cannot be made for all nine beach litter audit locations, it is clear that tidal forces can have an influence on plastic pollution data collected through the EcoCentre's beach litter audit method. In this way, data collected by the Port Phillip EcoCentre supports the conclusion that tidal forces deposit litter at the widest section of the St. Kilda West Beach.

In addition to evaluating which items are most likely to be found at different audit sites, it may be interesting to note temporal correlations to levels of plastic pollution. The graph below shows line plots for the total number of pollutants found for each beach litter audit site over time.

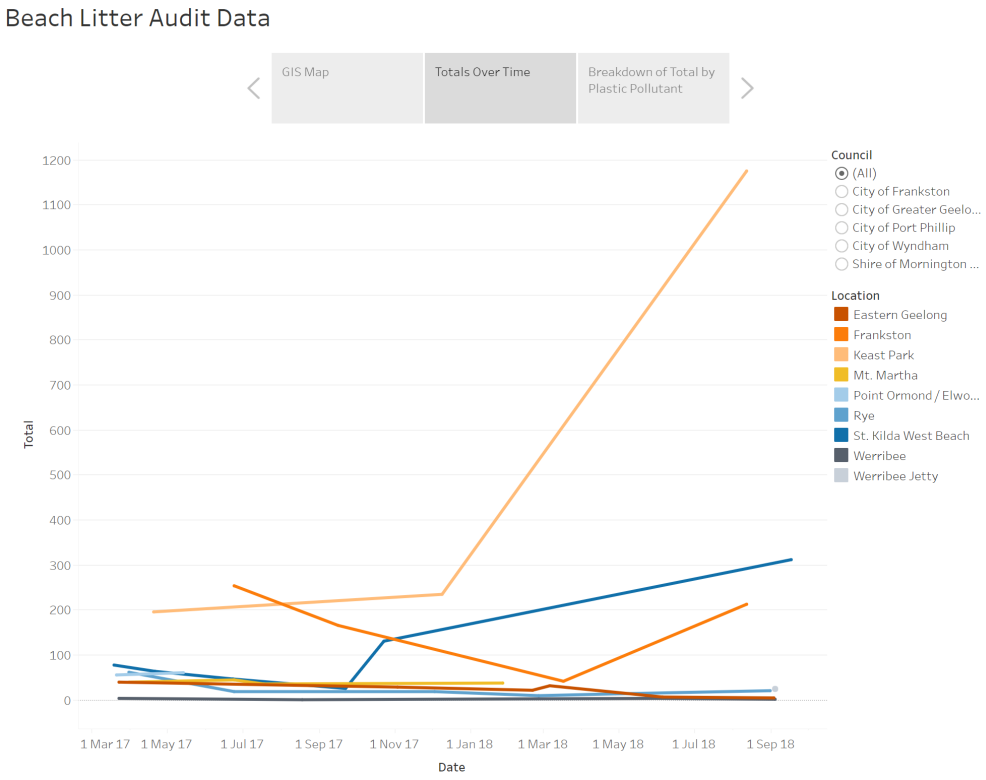

Figure 28. Beach Litter Audits Over Time

The graph shows that some audit sites such as Eastern Geelong, Mt. Martha, Rye, and Werribee show little or no variation over time. However, other audit sites such as Frankston, St. Kilda West Beach, and Keast Park show large temporal variations. It

appears that audits conducted in the months of August and September showed increased levels of pollution compared to average values for the site. This time of year is the transition from the winter to spring. These increased levels of pollution may be outliers caused by other factors, or may be tied to the seasonal transition. More data collection may be able to validate this observation. When examining data from the different beach litter audit sites, it is important to consider that the beach litter audit sites differ greatly. The chart below gives the average quantity of pollutants found at each audit site, as well as the standard deviation for each site.

Audit Site	St. Kilda West Beach	Rye	Mt. Martha	Werribee	Werribee Jetty	Point Ormond / Elwood	Keast Park	Frankston	Eastern Geelong
ST DEV	105.3	19.0	3.9	1.5	N/A	3.5	554.3	91.8	14.0
AVERAGE	108.7	23.2	38.8	1.8	24.0	57.5	534.3	167.8	21.5

Figure 29. Table of beach litter audit Site Statistics

It is clear that in some instances, litter levels fluctuate greatly from audit to audit. In the case of Keast Park, the standard deviation is greater than the average number of items collected. While beaches such as Frankston, St. Kilda West Beach, and Keast Park experience high levels of pollution, other beaches such as Werribee and Eastern Geelong experience very little pollution.

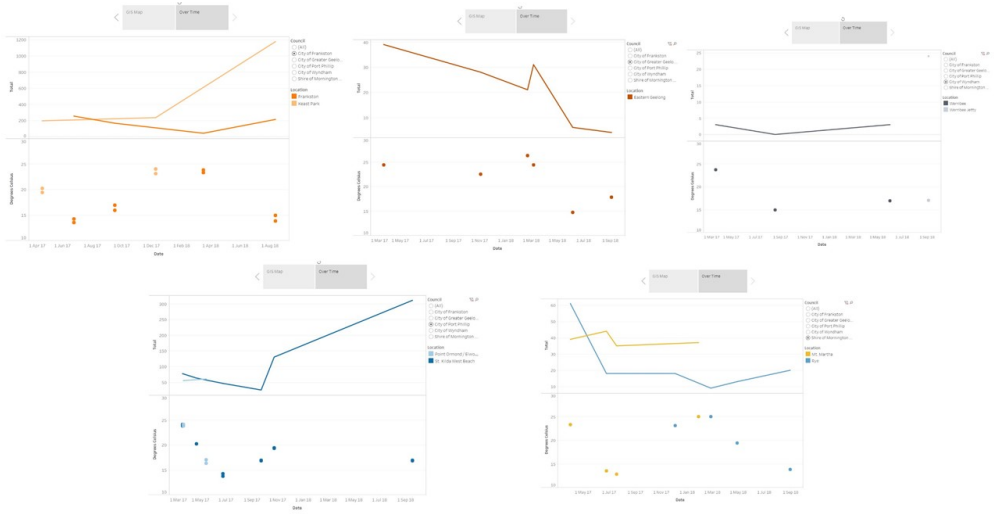

Figure 30. Beach Litter Audits in Comparison to Temperature

As seen in the figures above, the shapes of the graphs for Eastern Geelong, Werribee, and St. Kilda West Beach are very similar to their respective temperature graphs. However, the graphs of Keast Park, Frankston, Mt. Martha, and Rye show an inverse relationship between temperature and levels of plastic pollution. This illustrates that temperature influences levels of plastic pollution. Due to the fact that half of the audit sites showed a direct correlation and half of the sites showed an inverse correlation, more data is necessary to determine if any of these audits are outliers and to determine how temperature affects levels of plastic pollution on beaches.

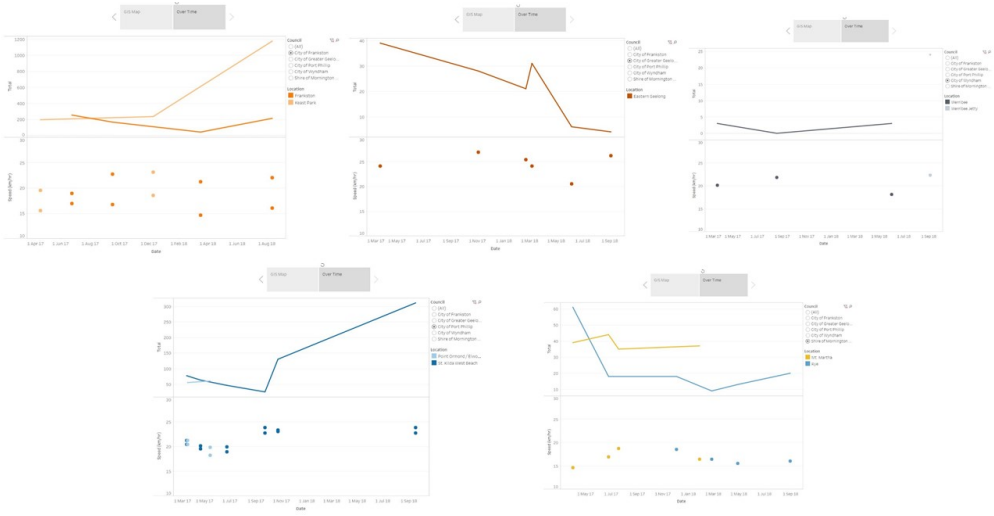

Figure 31. Beach Litter Audits in Comparison to Wind

When levels of plastic pollution from beach litter audits were compared to wind speeds, an inverse relationship was discovered. This means that as wind speeds increase, levels of plastic pollution decrease and vice versa. It is possible that this is because strong winds near the audit site blow plastic pollutants away from the audit site. Since the majority of items found in beach litter audits are microplastics, it may be the case that strong winds are blowing large litter items into the bay. These items then experience degradation and wash up on the beach at beach litter audit sites some time after they were transferred to the bay.

Overall, it is difficult to identify trends in beach litter audit data. Beach litter audit data collected by the EcoCentre only dates back to early 2017. Since then, audits have only been occurring every few months. The low frequency of audits makes it difficult to determine what "normal" beach conditions are, and which variables are influencing results. Additionally, each beach site, as well as quadrats within the beach sites, differ greatly due to the human and environmental factors associated with their surroundings. For this reason, it is difficult to see the same or even similar trends between beach litter audit sites.

River Litter Audit Data Analysis Results

Although the team did not have the opportunity to participate in a river trawl, they did have the opportunity to participate in multiple river litter audit categorisation sessions with samples collected by the EcoCentre and Yarra Riverkeepers Association. These involved separating the plastic pollutants, such as microplastics, from organic material that was captured in the manta net. The river litter audit categorisations involved precise work to ensure that no microplastics were missed when organising the sample. The volunteers must have a training session with Fam Charko, the expert in analysing trawl samples. In this way, each volunteer analyses samples and records findings using the same process to ensure the results are standardised.

To analyse the data, the first thing the team looked at were levels of plastic pollution in the Yarra and Maribyrnong rivers over time which is shown in the following figure.

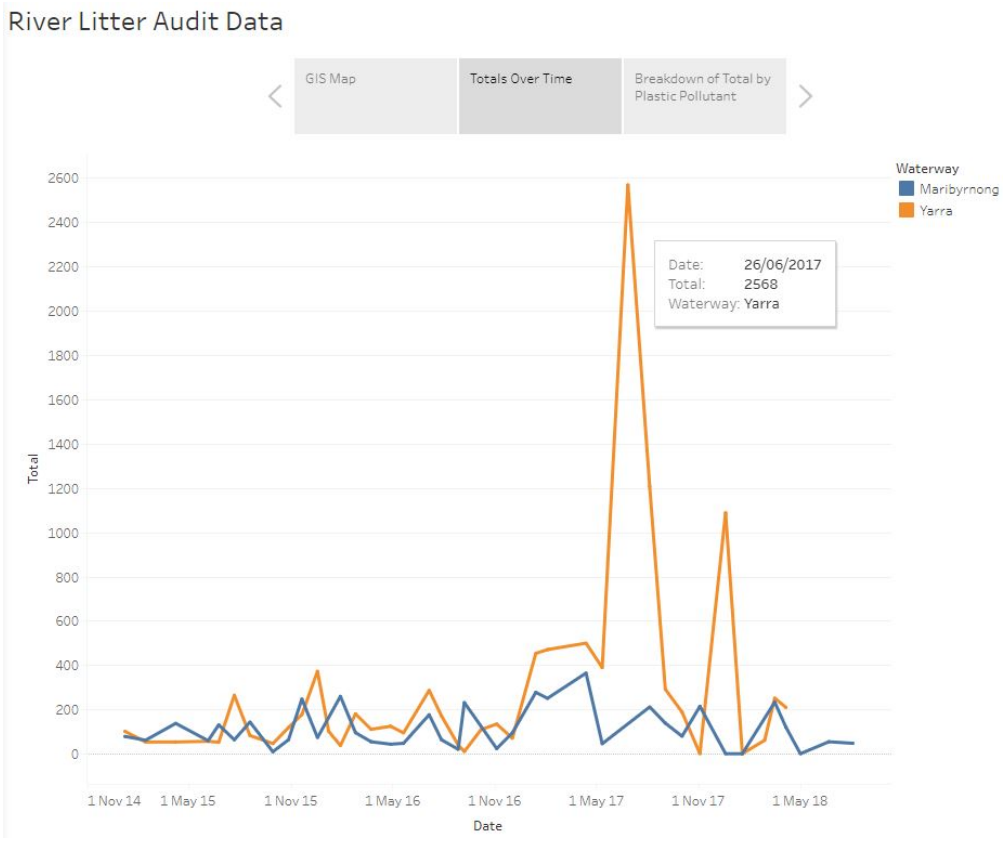

Figure 32. River Litter Audits Over Time

This chart shows the river litter audit totals over time. There are large spikes in the Yarra River in June and December of 2017. Typically, the Maribyrnong levels do not spike as much as the Yarra. However, there is a spike in the Maribyrnong during a trawl on 26 June 2017. In order to see the most common item found during that trawl, the Tableau visualisation was used to look at the breakdown of plastic pollutants during that audit. This visualisation is shown below.

Figure 33. Yarra Breakdown for 26 June 2017

The chart above shows the breakdown of plastic pollutants in the Yarra River on the date the spike occurred. The most common item found during this river litter audit was hard plastic fragments followed by polystyrene beads. In the months leading up to the spike, there are also relatively high levels of plastic pollutants in both rivers. The beginning of the spike occurred in January of 2017, which is summertime. One important thing to note is that the hard plastics levels may be increasing due to the faster rate of photodegradation since in the summer there is more UV light from the sun than in the winter (Australian Government Bureau of Meteorology, 2018).

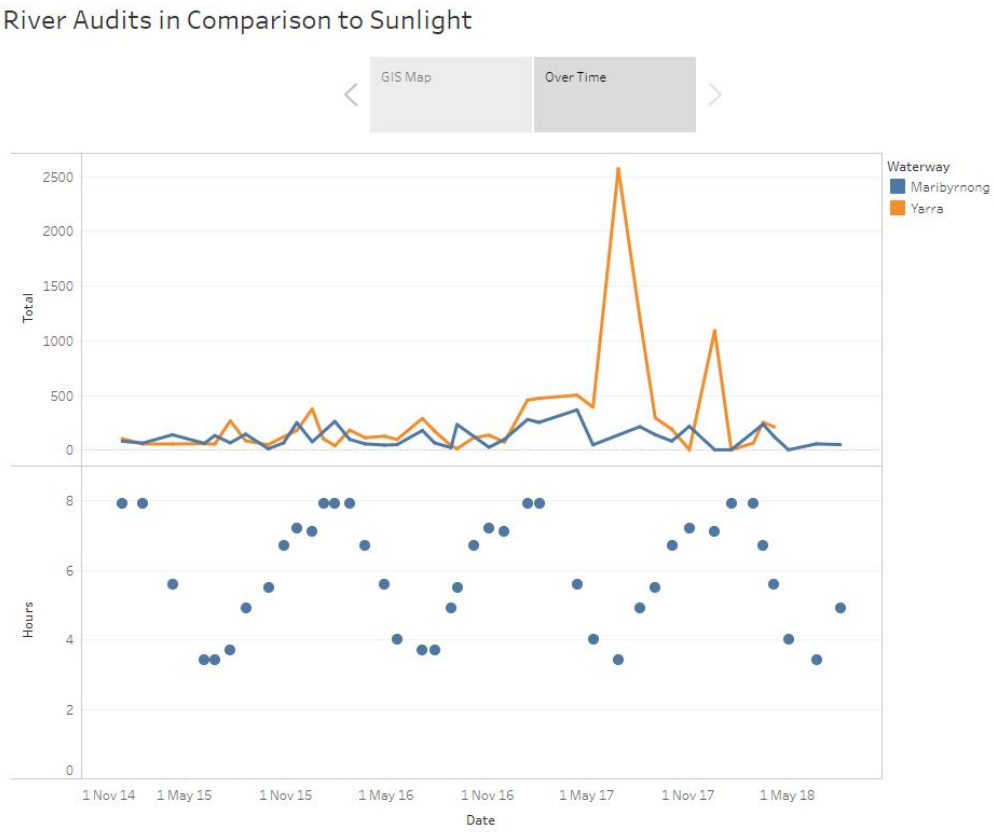

Figure 34. River Litter Audits Compared to Sunshine

The graph above shows a spike in average hours of sunlight per day right before a large spike in plastic pollutants occurs in both of the rivers (January 2017- June 2017). The main pollutant during these river litter audits is hard plastics which made up 58.8% of the Maribyrnong litter audits and 66.6% of the Yarra litter audits.

Since hard plastics made up more than half of the river litter audits during this time period, potential sources of these were determined. This was done by observing the months leading up to the beginning of the spike as large plastic pollutants that entered the river before this spike would take time to degrade into microplastics that the manta net can collect. An increase in millimetres of rainfall occurred in July of 2016 which could mean the stormwater drains were filled with water and carried plastic pollutants into the river. This is shown in the image below.

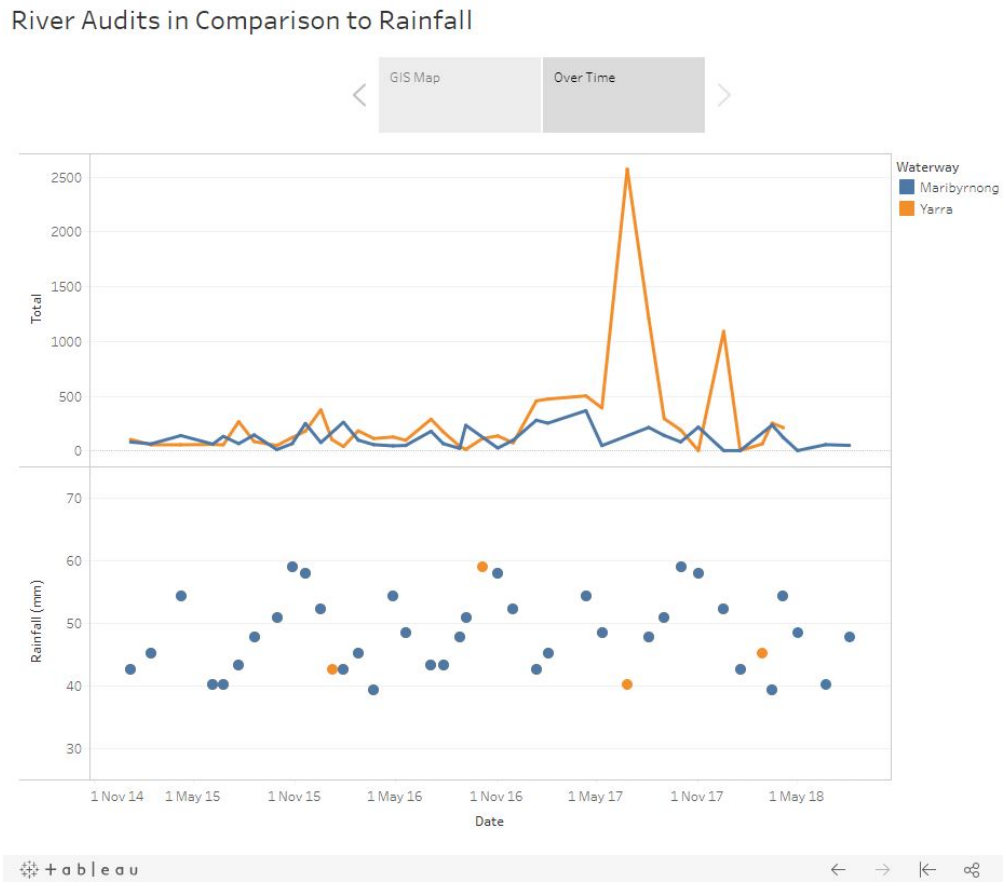

Figure 35. River Litter Audits Compared to Rainfall

Similarly, the chart above shows that the second spike in levels of plastic pollution in the Yarra River follows a spike in rainfall that occurred in September of 2017. This led to the conclusion that rainfall could be a potential transporter of plastic pollutants into the rivers and that the source of plastic pollutants is the litter that ends up in stormwater drains.

Polystyrene beads make up 11.75% of the Maribyrnong litter audit and 23.4% of the Yarra litter audit in the time frame leading up to the spike in levels of pollution. Polystyrene packaging and cups readily break down into polystyrene beads (Korpella, 2017). From the street litter audit results, it was determined that polystyrene beads are typically found at industrial sites, business, and public street usage types. Bourke Street, Collins Street, and Harbour Esplanade all end along the river next to the audit locations and have a large quantity of businesses and public areas along them. There is also

extensive manufacturing, retail, and hospitality precincts along the banks of the Yarra River (Charko et al., 2018). Due to the fact that wind showed high speeds before the spike in the level of pollution, these business, industry, and public sites could be a source of polystyrene pollutants in the Yarra River.

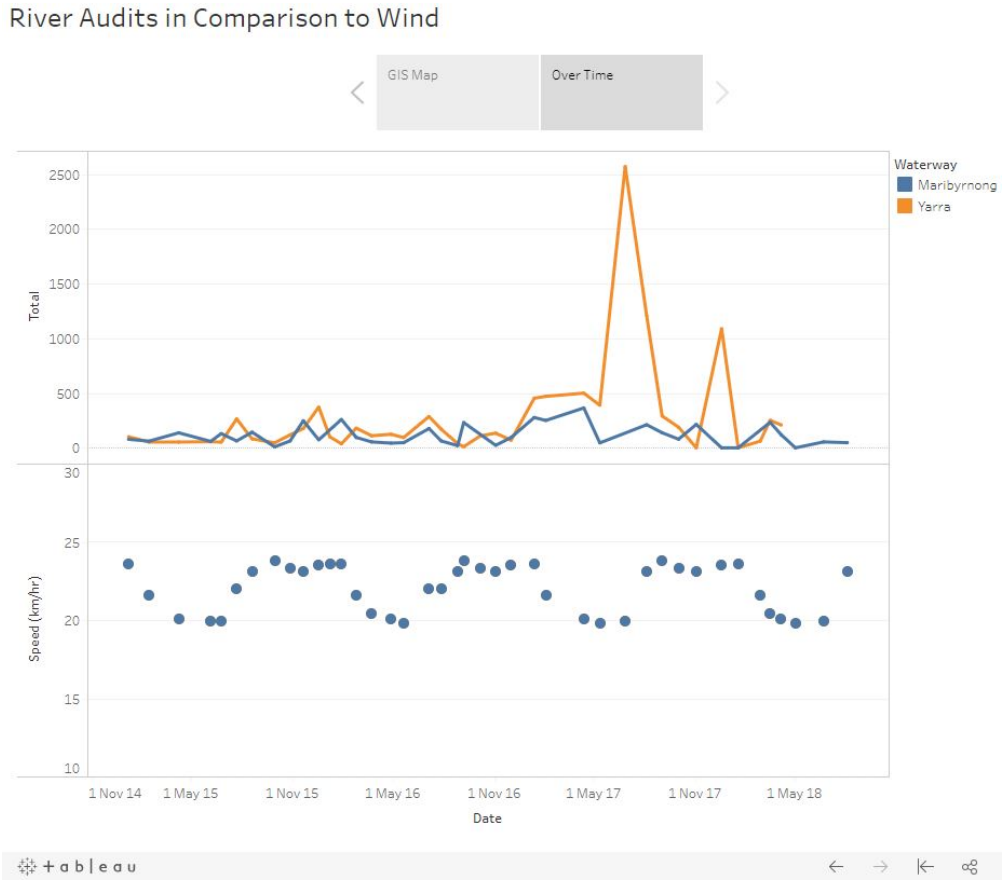

Figure 36. River Litter Audits Compared to Wind

The chart below shows hard plastics, polystyrene, and soft plastics as the most common categories in both rivers.

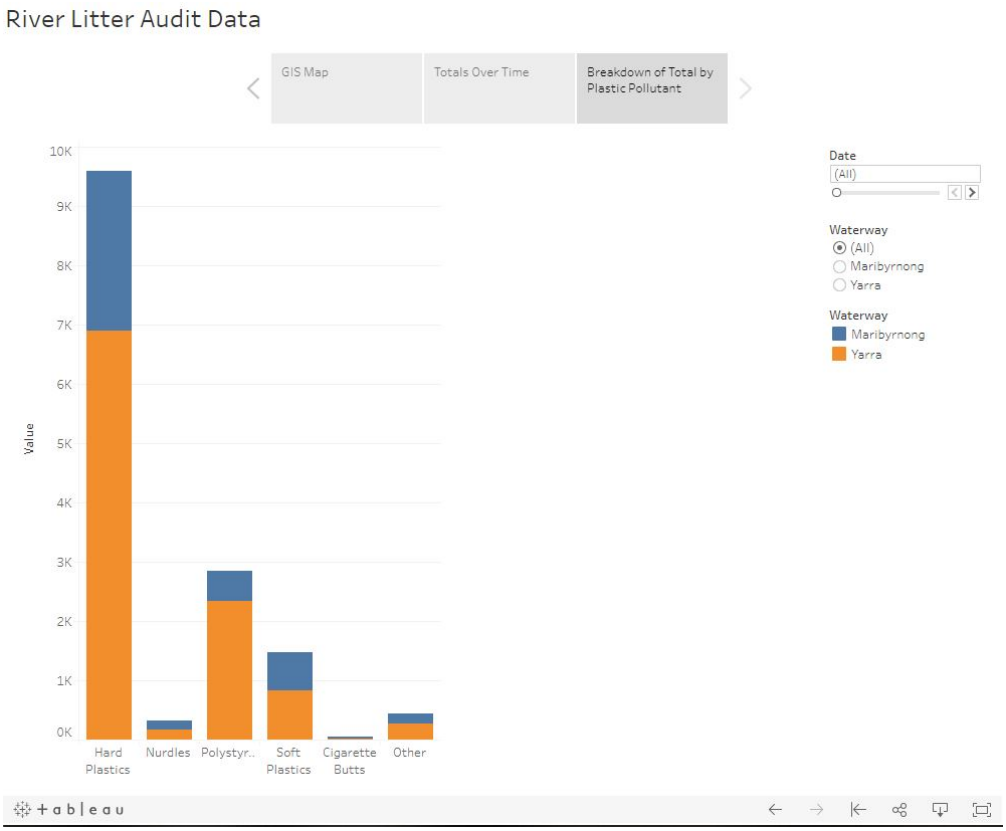

Figure 37. Breakdown of Plastic Pollutants for Both Rivers

The Yarra had approximately double the amount of polystyrene that the Maribyrnong had. With river litter audits it is important to consider that 77.8% of pollutants found are microplastics. This means river litter audits are either missing the large plastic pollutants due to the size of the net, or large pollutants are not present in the river as they are caught by litter traps. It is unknown how long it takes microplastics to form from large plastic pollutants. Eventually, however, the pollutants reach the bay as either a large pollutant or a small plastic piece. Styrofoam, once it has broken into beads, does not break down into smaller beads when it is exposed to weathering, but rather forms a yellow filament along the outer layer (Gregory & Andrady, 2003). Due to this, we are unable to tell how long the polystyrene beads have been in the water from the river litter audit data, however an identifier could be added to keep track of this so the analyst would know how long that polystyrene bead has been in the water.

The proximity to the river and the size of event or business were used to find the

potential sources of large plastic pollutants in the rivers.

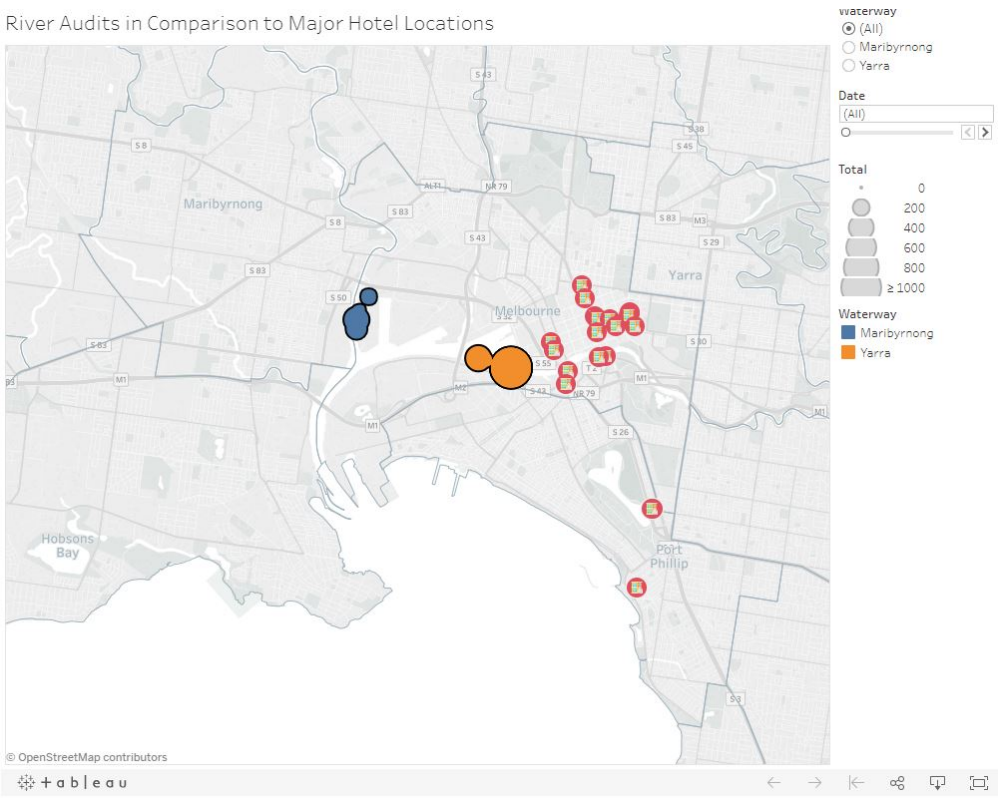

Figure 38. River Litter Audits Compared to Hotels

The large number of hotels along the Yarra River could be a source of plastic pollutants in the Yarra River. This could be one of the reasons for the spike in levels of plastic pollution in the Yarra River in the fall months. Tourists came and stayed in hotels during the summer and the resulting plastic pollutants would take time to degrade into small enough fragments that the manta net is able to pick up. The hotels directly on the Yarra River near the audit site are Crown Towers, Langham, and Quay West Suites. Similarly, sporting events that are located directly on the Yarra River can be seen below. The two main events that occur directly next to the river are the Australian Open and Rugby League World Cup, and as we can see in the figure below, there are multiple other events and sporting grounds along both rivers.

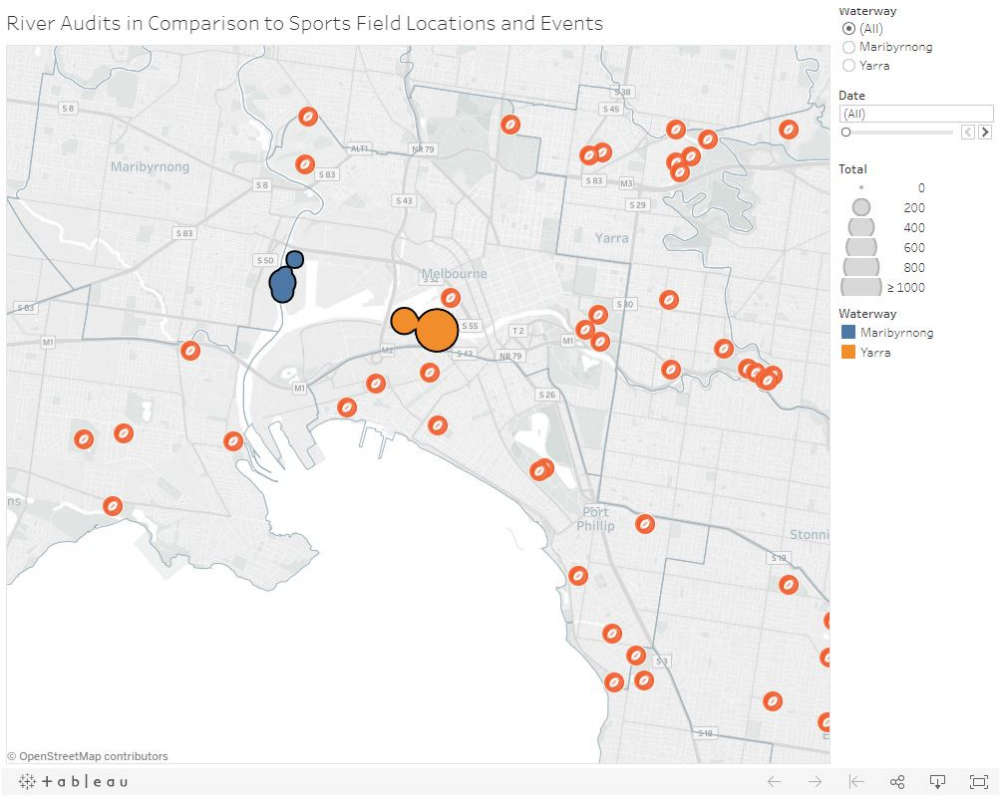

Figure 39. River Litter Audits Compared to Sports

Ultimately, to find the sources of plastic pollutants in the rivers, more street litter audits along the rivers would help draw concrete conclusions as to what businesses or events could be contributing to the levels of pollution.

Conclusion

Who Litters and Why. According to the Victoria Litter Action Alliance (VLAA), the littering rate in the state of Victoria is 35% meaning that 35% of people do not dispose of their waste in public waste bins (Victorian Litter Action Alliance, 2014a). Considering that there are 4.82 million people living in the Greater Melbourne area (Population Australia, 2018), this means that 1.7 million residents may be liable to litter. In addition to residents, each year Victoria receives 50.9 million visitors, 30.9 million of which visit Melbourne alone (Victoria State Government, 2018). Larger numbers of people impose a higher chance that there are litterers in crowds, which could be one reason that frequently visited areas, such as shopping centres, sports fields, and public spaces have high pollution levels. The VLAA also states that "young people are more likely to litter when they are in a group" (Victorian Litter Action Alliance, 2014b). Typically after school hours, groups of young people can be found in the high traffic areas previously mentioned, which could be another reason why these are highly polluted.

There are many factors that affect whether people litter or not, a few of which include type of item, type of place, cleanliness of location, and what others are doing. Type of item includes things such as is the litter small, or large, or is the area or item clean or messy. People are most likely to litter cigarette butts because they consider them to be "only small" (State of NSW and Environment Protection Authority, 2013). There are also some locations where people are more likely to litter. For example, people are more likely to litter when getting onto transport systems or in other places where they think they are not likely to be seen littering (State of NSW and Environment Protection Authority, 2013). Similarly, people are less likely to litter in places that are already clean (State of NSW and Environment Protection Authority, 2013). What other people are doing plays a large role in littering, if people see other people littering then they are more likely to litter as well since they think it is socially acceptable. They are also more likely to litter in places such as movie theatres or sports stadiums as they think that it is someone else's job to clean it

up (State of NSW and Environment Protection Authority, 2013). These factors mean that the same person will have different littering habits with the same item in different situations. For example, the same person "may walk 300 metres to put a plastic cup in a bin at a park but litter the same item under the seat at a football stadium" (State of NSW and Environment Protection Authority, 2013).

Sources and Transport of Plastic Pollutants. Plastic pollution is a complex problem because it involves understanding how people live their lives. Plastic usage is so ingrained in the fabric of society that it is nearly impossible to identify a single source of plastic pollutants. To attempt to find the sources, the team focused on the most commonly found items such as cigarette butts, soft plastic fragments, hard plastic fragments, and polystyrene beads. This project not only focused on types of pollutants, but also where they are littered and how these items move. All pollutants within the catchment area will ultimately travel into the bay. Understanding variables that contribute to the motion of plastic can be just as valuable as understanding sources of plastic pollutants.

Streets can be a major source of plastic pollutants entering the bay if street litter is improperly managed. Plastic pollutants made up 75% of all the pollutants that were collected during street litter audits. Cigarette butts, plastic fragments, and food packaging were the most commonly found items. They were mostly found in high traffic areas, such as businesses and public buildings. Public bins were present at all the locations where the team conducted street litter audits, and none were overflowing. Increases in temperature and sunlight were found to correlate to increases in plastic pollution levels. This could be because more people go outside when it is warmer and this creates a higher potential for litter.

Using the beach litter audit data that has been collected, it is possible to make conclusions about what factors may contribute to plastic pollution levels on beaches. It is clear that in the lower beach zones, the levels of plastic fragments found are generally representative of the prevailing tide conditions. For example, at St. Kilda West Beach the

majority of plastic pollutants are found in the widest part of the beach due to tidal factors in the area. Furthermore, environmental factors such as wind have an influence on the levels of plastic pollution observed at audit sites. The wind and pollution graphs were out of phase, as an increase in wind led to a decrease in levels of plastic pollution and vice versa. This may be because the wind blew the plastic off of the beaches and into the bay. Following the decrease in levels of plastic pollution, a spike in wind occurred, likely when the items that were blown into the bay had degraded and appeared on the shore as plastic fragments.

The Yarra and Maribyrnong rivers are one of the major sources of plastic pollutants in Port Phillip Bay (Charko et al., 2018). In the rivers, the main plastic pollutants collected during river litter audits were hard plastic fragments and polystyrene beads. More plastic pollutants were found in the Yarra River than in the Maribyrnong River. Wind, rain, and sunlight levels all correlate to fluctuations in levels of plastic pollution in the rivers. Wind and rain transport plastic pollutants from stormwater drains and streets to the Yarra and Maribyrnong rivers. Sunlight correlated to an increase in levels of microplastic pollution. Faster rates of degradation associated with longer periods of higher UV indices could cause larger plastic pollutants to degrade more quickly into microplastics, which are collected in the river trawling samples. Potential contributors to large plastic pollutants are sporting grounds and hotels, since they are concentrated near the Yarra river litter audit site. However, without street litter audits along the river near these sporting grounds and hotels, a conclusion can not be made as to whether these sites are directly causing changes in levels of plastic pollution.

Recommendations for Future Study

In order to be able to make more concrete conclusions in the future, the team has some recommendations for future data collection. The EcoCentre should continue to collect data using the existing audit methods, which will allow more trends and correlations

between levels of plastic pollution and supplemental data to become apparent. Similarly, maintaining consistency in audit location is important. The beach and river litter audit sites have done well with this, but this should be extended to the street litter audit sites in order to allow more temporal trends to be identified. Currently, the street litter audits primarily occur in the City of Port Phillip and the City of Bayside. Expanding the street litter audits to encompass the entire bay would allow for a more complete understanding of the levels of plastic pollution in the entire catchment area. This could be done by continuing to recruit and train more scouts groups in other councils within Port Phillip Bay catchment area. Street litter audits should also be conducted around the Yarra and Maribyrnong rivers. Data from these street litter audits would provide further justification for the Streets to Bay concept. Another recommendation is to increase the number of street litter audits for each street usage type. This will allow more data to be collected about the correlation between street usage type and level of plastic pollution. If more data is collected, the data may show that one street usage type has more plastic pollutants than others. If this is the case, local councils can revise waste management policies and work with businesses in that street usage type to reduce the levels of plastic pollution. Currently, recommendations as to which street usage types are most problematic should be made on a council by council basis since there were noticeable differences between City of Port Phillip and City of Bayside. It would also be interesting to conduct street litter audits before and after large sporting events and markets. This data would help to identify how significantly attendees at large sporting events and markets contribute to levels of plastic pollution. If it is found that they are large contributors, waste management policies for the events can be revised so as to reduce the levels of plastic pollution.

Recommendations for Society

Overall, plastic usage is tightly woven into the fabric of society. This makes identifying a single source of plastic pollutants quite difficult. Cigarette butts, soft plastic

fragments, hard plastic fragments, and polystyrene beads were the most commonly found items across all the litter audits that the EcoCentre has conducted. Cigarette butts, as well as most of the soft plastic fragments, and polystyrene beads that were found originated from single-use plastics. Single-use plastics can be removed from everyday life through conscious effort and behavioural change. A radical societal movement away from single-use plastics will be required in order to reduce levels of plastic pollution in Port Phillip Bay, and similar environments globally. Ways that individuals, business owners and councils can address the issue and reduce levels of plastic pollution are discussed in the following passages.

As an individual, there are many things that can be done to reduce levels of plastic pollution. Single-use plastics are commonly used in everyday life; however, they are largely unnecessary. There are numerous alternatives to single-use plastics such as reusable water bottles, avoiding straws and plastic utensils, and avoiding face exfoliants that contain microplastics. If you do still use single-use plastics, be sure to properly dispose of them by putting them in the correct recycling bin. Only dispose of single-use plastics in bins that are not overflowing as things put in overflowing bins have the potential to get knocked out of the bin or blown out by the wind. The carelessness of people and their lack of desire to find a bin contributes to the levels of plastic pollution. Additionally, people may feel more inclined to litter when they are in large groups due to peer pressure. Individuals also need to be educated about the effects that plastic pollutants have on Port Phillip Bay, as well as the numerous pathways for plastic pollutants to enter the bay. If everyone knew the massive effect they have on marine organisms and the food chain, they may change the way they look at littering and care more about recycling and properly disposing of their waste.

Looking at the issue from a business perspective, industry, public, and business street usages consistently have higher levels of plastic pollution than other street usages. For example, the business street usage had the highest number of cigarette butts, whereas industrial street usages had high quantities of polystyrene beads. Some of these issues can

be resolved by having stricter waste management practices on property or regulations set by councils. One way businesses can reduce their plastic use is by having staff use KeepCups in order to avoid disposable coffee cups. KeepCups are reusable cups that can be purchased and refilled at cafes in Melbourne, oftentimes for a discounted rate. KeepCup tracks how many people buy these and calculates how many plastic cups are being saved. In 2018 alone, 2,554,662 disposable coffee cups were removed from circulation in Australia through the use of KeepCups (KeepCup, 2018). Similarly, by using reusable cups at a two day coffee festival, 18,530 single-use cups were saved from the landfill. Business owners should also be educated on plastic pollution and the effects of it so that they can make informed decisions on how to maintain a clean store front. One additional way that businesses can reduce levels of plastic pollution is by not creating products with plastic in them where possible. For example, cigarettes have plastic in their filter, but a filter is not required for the cigarette to burn nicotine. The filter just provides more holes through which the smoke can filter. Furthermore, there is research being done at Ohio State University that shows filters in cigarettes are actually worse for human health since they cause smokers to take bigger breaths of smoke resulting in more smoke reaching smoker's lungs (Hamblin, 2017).

At the council level, the main goal should be to educate the community about the prevalence of plastic in the area and how it affects ecosystems. Increasing awareness about the effect that plastic consumption has on the environment is the key to getting the public to change their habits and reduce their use of plastic. Education campaigns should encourage the public and businesses to become more sustainable and switch to reusable containers instead of single-use plastics. One example of a successful education campaign was in the United Kingdom, specifically Edinburgh and London. This campaign divided each bin in half and asked a simple opinion based question. Whichever half of the bin that people placed their litter in served as their vote towards the question. On one particularly busy street in London, cigarette butt litter was reduced by 8% during the campaign (Zero Waste Scotland, 2018). Another step councils can make towards reducing levels of plastic

pollution is providing more opportunities for kerbside pickup, both recycling and rubbish at businesses and residences. Additionally, if there were methods in place to sense when a waste bin was almost full, similar to those that the City of Port Phillip is testing, bins can be emptied before they become full, and more bins can be added to areas that have higher volumes of litter than the current bins can handle.

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21

ABC. (2018). *No bag, thanks!* Retrieved from http://www.abc.net.au/science/features/bags/default.htm (This is an article from ABC about plastic bags. This article discusses the impacts that plastic bags have on the environment as well as how long they take to decompose. It also discusses the production of plastic bags, the management of plastic bag usage, recycling of plastic bags, reuse of plastic bags, and alternatives to plastic bags.)

18

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18

Australian Bureau of Statistics. (2015). *Regional population growth, australia, 2014-15.* Retrieved from http://www.abs.gov.au/ausstats/abs@.nsf/Previousproducts/3218.0Main%20FeatureS252014-15 (This is a web page published by the Australian Bureau of Statistics showing population data from 2014 to 2015. It talks about the population growth, change and density in various regions. The source provides plenty

of text, charts, and maps to display content. While this data is relatively outdated, it is still useful to build background knowledge of the area, keeping in mind that specific numbers and distributions may have changed.)

27, 29

Australian Government Bureau of Meteorology. (2018). *Ultraviolet (uv) / ozone frequently asked questions.* Retrieved from `http://www.bom.gov.au/uv/faq.shtml` (The Australian Government Bureau of Meteorology department answers questions about UV radiation and the ozone layer. It talks about information such as what ultraviolet is and how harmful the rays are as well as what affects UV levels and when they are strongest. There is also information on what the ozone layer is and what is depleting it.)

74

Barclay, E. (2013, December 13). *How plastic in the ocean is contaminating your seafood.* Retrieved from `https://www.npr.org/sections/thesalt/2013/12/12/250438904/how-plastic-in-the-ocean-is-contaminating-your-seafood` (This is an article that speaks about chemicals in the ocean that are ingested by fish. Aside from mercury, there are many other chemicals that fish absorb. Chemicals dumped in the ocean are directly ingested by fish, some chemicals are absorbed through plastic debris that the fish ingest. Scientists have known for years that chemicals absorbed by smaller fish are in turn ingested by predators that eat the smaller fish. Plastics are a sponge for chemicals and when ingested by fish these chemicals are transferred into their bloodstream or tissue. Fish who consume a lot of plastic are also more likely to have tumor and liver problems.)

22

Bayas, A., M., B., Ford, C., & Lawes, J. (2017). *A citizen science platform for long-term monitoring of microplastic pollution in port phillip bay* (Tech. Rep.). Worcester Polytechnic Institute. (This is the report of a previous IQP titled A Citizen Science

Platform for Long-Term Monitoring of Microplastic Pollution in Port Phillip Bay. This IQP took place during D term of 2017, and had the same sponsor as our project does, the Port Phillip EcoCentre. This project updated the beach litter audit methods that Port Phillip Baykeeper had created in order to allow citizen scientists to perform these audits. The use of citizen science allows for a greater number of audits to occur. However, care must be taken to ensure that the data collected by citizen scientists is all of the same quality and is still accurate.)

31

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13, 30

BBC. (2016, November 23). *The animals that are being harmed by plastic bags.* Retrieved from `http://www.bbc.co.uk/newsbeat/article/38063952/the-animals-that-are-being-harmed-by-plastic-bags` (This report talks about marine animals being harmed by plastic bags, the number found per metre in the UK and the fact that the number has been dropping over the years. When organisms eat plastic bags, the bags persist in the organism's stomach which can lead to disease, starvation, or death. Researchers looked at sea birds from the Netherlands and discovered 96% of them had plastic in their stomach. Turtles, whales and albatross

often mistake plastic bags for food and eat them.)

9, 22

BCcampus. (2018). *Hydrocarbons.* Retrieved from `https://opentextbc.ca/chemistry/chapter/20-1-hydrocarbons/` (This is a page from a university in British Columbia's website about hydrocarbons. Hydrocarbons are compounds made of only carbon and hydrogen. This article talks about the different kinds of hydrocarbons, the structures of hydrocarbons, and the bonding of hydrocarbons. Most plastics are hydrocarbons, so the properties of hydrocarbons are similar to those of plastics.)

18

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19, 20, 25

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methods. They used citizen science to allow for more audits to occur. They created a rubric to analyse their audit methods and ensure that the data that the citizen scientists collected was still accurate and all of the same quality. Our team also spoke to this project team at the beginning of the term and they gave us advice and guidance about our sponsor and our project.)

31

Charko, F., Blake, N., Kowalczyk, N., Johnstone, C., Seymore, A., & Quek, Y. (2018). *Microplastics in the maribyrnong and yarra rivers, melbourne, australia* (Tech. Rep.). Port Phillip EcoCentre. (This is the report published by the Port Phillip EcoCentre in May 2018 on their trawling data, which was collected from January 2015 to June 2017. The trawling and corresponding data collection was completed as a study under the "Turn off the Tap" project. In July 2017, the Victorian Government granted the Port Phillip EcoCentre funding for an additional three years of research under the project title, "Clean Bay Blueprint". The report outlines the methods, results, and analysis of the data collected during these monthly trawls. The analysis of the data primarily focuses on the comparison of the data collected for the two rivers, and notes fluctuations in certain plastic litter throughout the year. The report postulates causal factors for pollution variation: industrial usage, population density along the rivers, and local sporting events. The report concludes that further data should be collected in order to better understand pollution variation, and that further interpretation of the data may yield causal factors for pollution. The data analysis for this report was performed by Christopher Johnstone.)

15, 16, 17, 18, 27, 29, 33, 77, 83

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organic pollutants in San Diego Bay United States. It also talks about how various materials have higher concentrations among plastic types and locations.)

21

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20

Collinge, R. (2017, January 17). *How to design for colour blindness.* Retrieved from `https://usabilla.com/blog/how-to-design-for-colour-blindness/` (This website by Collinge makes suggestions on how to design websites for colour blindness. It states the most common colour blindness is between red/green colours. It suggests using colour and symbols to represent things and also to avoid bad colour combos such as green/brown, blue/purple, green/yellow etc.)

53

Earth Day Network. (2018). *Fact sheet: Single-use plastics.* Retrieved from `https://www.earthday.org/2018/03/29/fact-sheet-single-use-plastics/` (This source provides nine facts about how large the problem of single-use plastics are and how most people contribute to the problem. Plastic pollution is a growing problem and trillions of pieces of plastic pollute land and harm wildlife today. The

nine facts listed in this source are good starting points for further research, as the article gives links to the sources of these facts.)

24

Ellen MacArthur Foundation. (2016, January 19). *The new plastics economy: Rethinking the future of plastics.* Retrieved from https://www.ellenmacarthurfoundation.org/publications/the-new-plastics-economy-rethinking-the-future-of-plastics (This is an initiative to head in the direction of recyclable plastics and less plastics overall. The initiative is led by the Ellen MacArthur Foundation. It focuses on five building blocks to create a design for the system. These building blocks include: dialogue mechanism, global plastics protocol, innovation moonshots, evidence base, and stakeholder engagement.)

15

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20, 21

Eriksen, M., Maximenko, N., Thiel, M., Cummins, A., Lattin, G., Wilson, S., ... Rifman, S. (2013). Plastic pollution in the south pacific subtropical gyre. *Marine Pollution Bulletin*, 71-76. (This source discusses how gyres are formed and how these pollutants build up from land and sea sources. Gyres are large islands of marine pollutants. This source states that plastic pollution enters the marine environment via rivers, beaches, maritime activities and illegal dumping at sea. It states that there is not much conclusive data on the sources of plastic pollution which creates a problem when modelling.)

26

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48

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in humans and marine organisms alike. POPs make their way up the food chain through bioaccumulation and can get all the way to humans. The best way to avoid this problem is to just not buy single-use plastics and reuse as often as you can.)

9, 22

Food and Agriculture organisation of the United Nations. (2018). *Trawls.* Retrieved from `http://www.fao.org/fishery/geartype/103/en` (This is a part of the Fisheries and Aquaculture Department's website that discusses different types of fishing gear. The specific page that was relevant to our paper was the page that discussed what trawling was. We used this to make sure we had accurate background knowledge on the process of trawling since that is how a lot of the data we will be looking at is going to be collected.)

20

Fraunhofer-Institute for Environmental, Safety, and Energy Technology UMSICHT. (2015). *Fraunhofer umsicht takes position topic: Microplastics* (Tech. Rep.). Fraunhofer UMSICHT. (This is a position paper about microplastics written by a university. They believe there is a strong need to do more research on microplastics because they are becoming increasingly popular and showing up throughout the food chain. The problem requires an early development of sustainable solutions. The impact of physical and chemical factors break down plastics and research on this in aquatic environments is just beginning. These studies on microplastics should include fresh and salt water as well as in drinking water and regard the whole system so more than just rivers and seas. In the future, new materials need to be developed that are biodegradable to reduce this problem. The UNEP estimates there are 100 million tonnes of plastic waste in the oceans and 6 million tons are added annually. There also needs to be more research done of methods of removing microplastics from the water.)

23

Gabbatiss, J. (2018, January 5). *Disposable coffee cups: How big a problem are they for the environment?* Retrieved from `https://www.independent.co.uk/environment/disposable-coffee-cups-how-big-problem-environment-landfill-recycling-incinerate-export-rubbish-a8142381.html` (This article discusses the misconceptions surrounding recycling. It discusses the differences in different companies and how the coffee cups are produced. Some are recyclable, however, often times they are not or are not recycled due to ignorance. Since coffee cups are lined with polyethylene they can not be recycled at standard recycling plants and must be taken to special areas.)

24

Gall, S., & Thomson, R. (2015). The impact of debris on marine life. *Marine Pollution Bulletin*, 170-179. (This is a journal article from the Marine Pollution Bulletin. This article is a literature review about the current research that has been done on the effects that marine debris has on organisms. This article allowed us to determine the state of current research. Additionally, it included some up to date statistics about the number of species that are affected by marine debris.)

13, 22, 23

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78

Guern, C. (2018, March). *When the mermaids cry: The great plastic tide.* Retrieved from

http://plastic-pollution.org/ (This is an article on plasticpollution.org. This article talks about plastic pollution and the most commonly found pollutants. It also discusses the scope of the problem of plastic pollution and how 80% of plastic pollution comes from land based sources.)

24

Hall, N., Berry, L., Rintoul, L., & Hoogenboom, M. (2015). Microplastic ingestion by scleractinian corals. *Marine Biology*, 725-732. (This is a newspaper article from the Guardian about the impacts that throwaway culture has had on the environment. The main thing this article talks about is plastic packaging. Plastic packaging is meant to only be used once and then discarded. The problem with this is that there is now a surplus of plastic packaging waste.)

23

Hamblin, J. (2017, July 14). *If my friend smokes sometimes, should the cigarettes have filters?* Retrieved from https://www.theatlantic.com/health/archive/2017/07/cigarette-filters/533379/ (A health article was written about how smoking cigarettes with filters is more dangerous than smoking them without. It was said that filters decrease the amount of tar inhaled per breath, when in reality, most levels of tar inhaled unless it is high has very little affect on getting lung cancer. One reason people prefer filters is so the end of the cigarette does not get all wet and dissolve in saliva. The filters are creating a smoother hit which in turn makes the user more willing to take bigger hits and hold them in longer, making the user want to keep smoking more and increasing their chance of getting lung cancer.)

24, 86

Harris, G., Batley, G., Jernakoff, P., Newell, B., Fox, D., Molloy, R., ... Skyring, G. (1996, June). *Port phillip bay environmental study.* Retrieved from https://publications.csiro.au/rpr/pub?pid=procite:1e941c7a-3303-4b90-ba69-ecad2a810020 (This report was created by CSIRO, a

federal organisation responsible for scientific research. This environmental study was conducted from 1992 to 1996, and constituted 47 research tasks that were contracted out to 30 different organisations. The report gives an overview of all of the research tasks, compiled into primary topic areas such as nutrients, toxicants, and the ecology of the bay. This source has plenty of statistics, and while dated, provides some background on past research that has been conducted in the bay.)

9, 27, 28, 29

KeepCup. (2018). *Track your usage. contribute to a global movement.* Retrieved from `https://reusehq.keepcup.com/` (This is the website for the KeepCups and it talks about what they are as well as statistics about them. The website also has tips about how to be more sustainable and environmentally friendly. It says how many KeepCups are produced annually and how many plastic cups you save by using one KeepCup. There is a chart to show how many disposable cups are removed from circulation of a few countries. There are example success stories to show how big of an impact these cups can have on businesses and what they are doing to incorporate them and sustainability in general.)

86

Knight, L. (2014, May 17). *A brief history of plastics, natural and synthetic.* Retrieved from `https://www.bbc.com/news/magazine-27442625` (This is an article from BBC about the history of plastics. This source was used to define plastics as well as define the technical terms used in this definition. This source also discussed the boom of the plastic industry that occurred during World War II and how the plastic industry switched their focus to mass consumerism after the war.)

23

Korpella, R. (2017, April 25). *Is styrofoam biodegradable?* Retrieved from `https://sciencing.com/styrofoam-biodegradable-22340.html` (This article discusses the chemical properties of styrofoam and polystyrene beads. One major

point it makes is that polystyrene takes a long time to break down in the environment and is not biodegradable. Another important point was that styrofoam breaks down very easily into smaller beads.)

76

Lockwood, D. (2012, August 22). *Ocean plastics soak up pollutants.* Retrieved from `https://cen.acs.org/articles/90/web/2012/08/Ocean-Plastics-Soak-Pollutants.html` (Plastic debris in the ocean can absorb organic pollutants for months in the ocean. When fish eat plastic, they are ingesting the particle as well as the chemicals in it. Scientists measured concentrations of different organic pollutants for a year.)

21

Maillard, K., Sgardelis, P., Ng, Y., Kearney, Y., Franchi, E., Charko, F., & Blake, N. (2013, October). *Nurdle soup?* Retrieved from `http://www.ecocentre.com/sites/ecocentre.com/files/neil/Nurdle%20Soup%20booklet.pdf` (This is a report written by the Port Phillip EcoCentre after a school group found a large amount of nurdles during a beach litter audit. Nurdles are the small plastic pellets that form the base of many industrial plastics. They are typically between 2 and 3 millimetres in size and are thus categorized as microplastics. Due to their small size they are easily transported by wind and water. This preliminary discovery of nurdles on beaches in Port Phillip Bay prompted the EcoCentre to investigate the prevalence of microplastics in Port Phillip Bay. Two methods of data collection were used in this report: close visual inspection of beaches, and boat trawls in the Bay as well as in the Yarra and Maribyrnong rivers. The report outlines the methods that were used to collect both of these categories of data. The data for the number of nurdles found at specific beach locations during beach litter audits and trawling data for the Yarra and Maribyrnong rivers is broken down by type of plastic is included in this report.)

18, 22, 27, 31

McDermott, K. (2016). *Plastic pollution and the global throwaway culture: Environmental injustices of single-use plastic* (Tech. Rep.). Salve Regina University. (This is a study from Salve Regina University in Rhode Island, United States about the environmental injustices of single-use plastics. 80% of the plastics that enter the ocean each year are single-use plastics. This study talks about the injustices these single-use plastics impose on marine life, and humans. It also discusses how removing this plastic pollution from the ocean is not feasible since the pollution is so widely scattered throughout the ocean. This article says that the best way to deal with the plastic pollution is to change our habits so that more pollution does not end up in the ocean.)

24

Melbourne Water. (2018). *Understanding the yarra.* Retrieved from `https://s3.ap-southeast-2.amazonaws.com/hdp.au.prod.app.mw-yoursay.files/5515/1140/5968/Fact_Sheet_-_Understanding_the_Yarra.pdf` (This website is the homepage for the Melbourne Water organisation, a statutory authority owned by the Victorian Government. Their goal is to manage and protect Melbourne's major water resources. The organisation gathers rainfall data at over 200 collection sites in the Melbourne area, and the data is updated to provide daily results. This data collection enables Melbourne Water to provide other information about total water in the Port Phillip Bay catchment area. This website may be cited further to identify specific pages in which relevant information was collected.)

29

Michigan Department of Community Health. (2018). *Bioaccumulative persistent chemicals.* Retrieved from `https://www.michigan.gov/documents/mdch/Bioaccumulative__Persistent_Chemicals_FINAL_354016_7.pdf` (Bioaccumulation is the chemical buildup within fish which is then passed along throughout the food chain. As chemicals end up in water, they are ingested by

smaller fish which are then eaten by bigger fish who ultimately get these chemicals passed onto them. These chemicals that are ingested are persistent chemicals meaning they are stable and don't break down over time.)

22

Minister for Energy, Environment and Climate Change. (2018, June 27). *Victoria says no to plastic waste.* Retrieved from https://www.premier.vic.gov.au/victoria-says-no-to-plastic-waste/ (This article is about the plastic bag ban that the Andrews Labor Government of Victoria plans on implementing in 2019. This ban will include all plastic shopping bags that are less than 35 microns in thickness. This ban will be implemented due to the overwhelming public support for such a ban.)

42

O'Farrell, K., & Australian Government: Department of the Environment. (2018). *2016-17 australian plastics recycling survey* (Tech. Rep.). Envisage Works, Sustainable Resource Use. (This is a survey of recycling in Australia that was conducted by the Department of Environment and Energy. This source provided us with statistics on recycling in Australia. It talks about the amount of plastics consumed in Australia in 2016-17. It also talks about the amount recycled, the national recycling rate and how many plastics were reprocessed.)

24

Oxford University Press. (2018). *plastic.* Retrieved from https://en.oxforddictionaries.com/definition/plastic (This is Oxford Dictionary's definition of plastic. We used this source to define plastic in a way that is easy the general public to understand.)

18

Pahl, S., Wyles, K. J., & Thompson, R. C. (2017, October). *Channelling passion for the ocean towards plastic pollution* (Tech. Rep.). Nature Human Behaviour. (This

research report focuses on studying the difference between the symptoms of plastic pollution and the sources of plastic pollution. It discusses the methodologies for promoting a cleaner ocean and the reasons they do or don't work to address the underlying cause. For example, they discuss emotional social media images of animals being hurt by plastic pollutants. How this may be effective, they discuss that it doesn't address the broader society systems and habits that coincide with plastic use. In one section they discuss the role of behavioural science and how humans need to accept the responsibility for the plastic pollution before they will feel motivated to change their underlying values. Finally, they discuss the important role of NGO campaigns and research that is being conducted on recent bans in different countries: such as the microbead and plastic bag bans.)

26

plastic pollution coalition. (2018). *Plastic pollution coalition.* Retrieved from `https://www.plasticpollutioncoalition.org/the-coalition/` (This is the Plastic Pollution Coalition's website. The Plastic Pollution Coalition is a global alliance of businesses, individuals, and countries that are all working towards a plastic free ocean. They have quite a few research articles that allowed us to determine how many agencies were doing research on plastic pollution.)

20

Plastics Industry Association. (2018). *The purpose of single-use plastics.* Retrieved from `http://www.thisisplastics.com/environment/the-purpose-of-single-use-plastics/` (This is an article from the Plastics Industry Association's website about single-use plastics. This article talks about the benefits of single-use plastics and why they were introduced into society. It discusses which single-use plastics are necessary, such as those in the medical industry. The article then talks about the importance of properly disposing of single-use plastics.)

15

Pollution Solutions. (2015, August 19). *What is plastic photodegradation.* Retrieved from https://www.pollutionsolutions-online.com/news/waste-management/21/breaking-news/what-is-plastic-photodegradation/35801 (This is an article from Pollution Solutions that explains photodegradation. The durability of plastics is one of its most desirable properties, however this means that plastics do not easily degrade in the environment. One of the ways that plastics do degrade is through photodegradation. Photodegradation occurs when the UV radiation of the sun oxidizes the plastics. This oxidation makes the plastics more brittle and make them easier to break into smaller and smaller pieces.)

20

Population Australia. (2018). *Melbourne population 2018.* Retrieved from http://www.population.net.au/melbourne-population/ (This article by Population Australia discusses the current population in Melbourne. The population has been growing consistently ranging between 1.67% and 6.6%. Melbourne's population density is 453 per square kilometre. This article also discusses the demographics of the people who live in Melbourne.)

81

Port Phillip EcoCentre. (2017). *Clean bay blueprint.* Retrieved from http://www.ecocentre.com/cleanbayblueprint (This is the section of the Port Phillip EcoCentre's website that discusses the Clean Bay Blue Blueprint Initiative. The Initiative began in 2017 and will continue until 2020. Part of this Initiative is the collection of data on the prevalence of plastic pollution entering Port Phillip Bay from the Yarra and Maribyrnong rivers. This data is most of the data that our project will be analysing.)

16, 17, 30

Port Phillip EcoCentre. (2018). *Welcome to the port phillip ecocentre!* Retrieved from http://www.ecocentre.com/ (This is the Port Phillip EcoCentre's website. We

used it in our project to learn more about our sponsor, the Port Phillip EcoCentre, and what they stand for.)

30

Rothert, G. (2018). *The great pacific garbage patch.* Retrieved from http://georgerothert.com/the-great-pacific-garbage-patch/ (George Rothert was the scientist who discovered the Great Pacific Garbage Patch. He posts pictures and notes about it on his website.)

9, 16

State Government of Victoria. (2013). *Bay and catchments.* Retrieved from https://yarraandbay.vic.gov.au/assets/bay-and-catchments (Report card for the water in Port Phillip Bay from 1 July 2016 to 30 June 2017 based on nutrients, water clarity, dissolved oxygen, salinity, pH, metals and algae. Water quality declined over the year in the Yarra and Port Phillip Bay but improved in the Maribyrnong. Annual rainfall has been decreasing since the 1970s. Since 2000 there has been an overall increase in water quality in the Port Phillip Bay. This is due to the fact that less rainfall means the amount of urban and rural runoff decreases. Water quality improved in Maribyrnong after wet conditions due to returned flows to waterways in upper catchments that had reduced to isolated pools or dried river beds. The Yarra is the only catchment to show a decline in water quality due to increased runoff to tributaries in rural areas of the mid and upper catchment. Controlled releases of water proved helpful to water quality because they flush out sediment and simulate breeding of fish. The government, authorities, and community implemented some initiatives to improve waterway health.)

27, 29

State of NSW and Environment Protection Authority. (2013). *Nsw litter prevention kit.* Retrieved from https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/litter/130800-lpk-things-know.pdf?la=en&hash=

76823424DF0ADA527C28068FEF938723F10725EC (This source is from the EPA of New South Wales and describes a Litter Prevention Kit. This source talks about littering and the laws that are in place in New South Wales that deal with littering. It also discusses the factors that affect whether people litter or not and why some areas have more litter than others.)

81, 82

The Ocean Cleanup. (2018). *The great pacific garbage patch.* Retrieved from https://www.theoceancleanup.com/great-pacific-garbage-patch/ (This is a page on the Ocean Cleanup's website about the Great Pacific Garbage Patch. The Ocean Cleanup is a nonprofit organisation that is trying to use technology to rid the oceans of plastic pollution. The Great Pacific Garbage patch is a famous example of ocean pollution. It is the largest accumulation of ocean pollution and is located between Hawaii and California. The Great Pacific Garbage Patch is estimated to be twice the size of Texas.)

15

Tregillis, B. (2017, May 13). *Litter composition along the yarra river and port phillip bay coastline.* Retrieved from https://public.tableau.com/views/MOOP2/Dashboard1?:embed=y&:display_count=yes (A Tableau visualisation showing plastic pollution levels along Port Phillip Bay's coastline and the Yarra River. A breakdown of plastic pollutants per audit source is shown as well as category breakdown of these plastic pollutants.)

9, 49

United Nations Environment Programme. (2016). *Marine plastic debris and microplastics: Global lessons and research to inspire action and guide policy change.* Retrieved from https://wedocs.unep.org/handle/20.500.11822/7720 (This is the United Nations Environmental Programme's (UNEP) report on plastic debris and microplastics. This report provides valuable background information about

microplastics and how to guide policy change. Recognizing the issue of plastic waste in the marine environment happened recently and research on it is still in the beginning stages. Plastic waste is a complex problem that can be represented by a three legged stool. There are social, economic and environmental facets to this problem and solutions must satisfy all the legs of the stool in order for them to stand the tests of time. This paper discusses how to balance the social, economic and environmental factors when conducting research on microplastics in the marine environment.)

15, 18, 19, 20, 21, 23, 26

United Nations Environment Programme. (2018a). *About un environment.* Retrieved from `https://www.unenvironment.org/about-un-environment` (This is the website for the United Nations Environmental Programme. It contains information about the program and how they are the leading global environmental authority and that they serve as an authoritative advocate for global environment. The website has many topics they talk about such as oceans and seas. This program also promotes the protection and sustainable management of marine and coastal environments in the world.)

26

United Nations Environment Programme. (2018b). *Persistent organic pollutants (pops) and pesticides.* Retrieved from `http://www.cep.unep.org/publications-and-resources/marine-and-coastal-issues-links/persistent-organic-pollutants-pops-and-pesticides` (POPs are toxic chemicals that last in the environment for years and circulate all around the world. They accumulate in the fatty tissue of living animals and human beings because they are lipophilic. In fatty tissue, the levels can be magnified up to 70,000 times the normal amount. There has been research done on POPs that focused on twelve, which is referred to as the dirty dozen. They can negatively affect the health

of humans and animals in many ways. Monitoring POPs varies from country to country but they are banned in some countries.)

21

University of Georgia. (2017, July 19). *More than 8.3 billion tons of plastics made: Most has now been discarded.* Retrieved from https://www.sciencedaily.com/releases/2017/07/170719140939.htm (This is a news article that was based on research done by the University of Georgia. This article provides statistics that illustrate the magnitude of plastic pollution. For example, from the time that plastic production began in the 1950s until 2015, 8.3 billion metric tons of plastic have been created. Of that 8.3 billion metric tons, 6.3 billion tons are now waste. It is estimated that 8 million metric tons of plastics entered the ocean in 2010 alone. The majority of these plastics came from packaging which is meant to be used once and discarded. The article insinuates that the majority of plastic pollutants are single-use products.)

15, 23, 25

Victoria State Government. (2018). *Victoria's visitor economy.* Retrieved from http://www.business.vic.gov.au/__data/assets/pdf_file/0018/1734210/Victorian_Tourism_Performance_Overview_year_ending_June_2018.PDF (This infographic by the Victoria State Government breaks down the visitor economic impacts on Victoria. There were 80.6 million visitors who spent $27.3 billion. It then breaks down Victoria into regional areas and shows how much is spent in each area.)

81

Victorian Litter Action Alliance. (2014a). *Litter statistics fact sheet.* Retrieved from https://www.litter.vic.gov.au/litter-resources/research-and-resources (The Victorian Litter Action Alliance (VLAA) is the primary organisation for litter management and prevention in Victoria. This website provides information on the VLAA research and resources download page. The publication most important to this

project is the Victorian Litter Alliance Fact Sheet, which displays a variety of quantitative and qualitative information about litter disposal within Victoria, Australia. The document first outlines methods and reason people litter, and then shows statistics that have been collected from a variety of local sources. Over 4,000 litter traps prevent litter from entering the stormwater system, and are maintained by the Victorian local councils. It has been observed that littering in malls decreased from 2009 to 2010 by 2%, but littering in public parks increased by 15% in that same span of time. The total cost of litter and street sweeping maintenance is over $78 million, but it is unclear as to whether the cost of "litter" is for litter removal or not. The fact sheet serves as an example of current quantitative measurement tools that are currently in place to document litter levels, and also serves to show that litter is a prevalent problem within Victoria. One of the most important statistics is that 95% of resources are devoted to litter maintenance, and only 5% are devoted to litter prevention. This means that the relevant stakeholders must dedicate the vast majority of their resources to short term goals rather than long term goals.)
81

Victorian Litter Action Alliance. (2014b). *Litter statistics fact sheet.* Retrieved from `https://www.litter.vic.gov.au/litter-resources/research-and-resources` (The Victorian Litter Action Alliance posted this article about the littering behaviour of humans. It discusses who litters and concluded about some qualities of people that stereotype them as more likely to litter. It also discusses why people litter and sums it down to be: unaware, carelessness, convenience, and premeditated.)
81

Willis, K., Hardesty, B., Kriwoken, L., & Wilcox, C. (2017, March 10). *Differentiating littering, urban runoff and marine transport as sources of marine debris in coastal and estuarine environments* (Tech. Rep.). Scientific Reports. (This was a study conducted in Tasmania, Australia researching the sources of marine debris. They explored three

hypothesis: direct deposition by beachgoers, transport from surrounding areas, and onshore transport from the marine system. To study this they conducted 224 surveys at 67 sites along the open coast in Tasmania. The results suggested that most marine debris is deposited locally onto beaches and that is the main reason most litter is not reflected in the statistics of the amount of pollution in the marine environment.)

26

Zero Waste Scotland. (2018). *7 top litter prevention campaigns from around the world.* Retrieved from `https://www.zerowastescotland.org.uk/litter-flytipping/top-campaigns`

(This article is about seven of the best litter prevention campaigns around the world. These campaigns range from voting on a mindless topic, to helping donate to charity, to having pride in your community. Some of the campaigns provided statistics that show noticeable improvements on litter in the area and the fact that people realised these campaigns were about litter prevention and still were happy to get involved in them. The name of the campaign is important because if it is memorable and easily connected to the lives of people, then they will be more likely to take part in it and help out their community.)

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Appendix A: GIS Mapping Case Study

GIS Mapping Case Study

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11 October 2018

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Appendix A.8: Simple GIS Rubric

Introduction

Graphical Information Systems (GIS) Mapping is a mapping technique that relies on geospatial data and displays it in a map. GIS mapping can be a powerful tool for viewing and analysing the relationships between locations and data points. These data points could be related to anything. Specifically for this project, we will be using GIS mapping to correlate trends between plastic pollution and other factors. These factors will include environmental factors such as weather patterns and elevation levels and they will also include human factors such as sporting event schedules, different business locations and land use policy.

To identify an appropriate tool for comparing plastic pollution data to these other factors we identified a few key objectives. First, we need to download these tools and use a rubric to rank them based on different factors. Second, we need to standardise our rankings so there aren't any skewed data points. Finally, we need to provide recommendations based on our research for the EcoCentre.

Methods

In order to evaluate the software in an impartial way, a general procedure was established for investigating the tools.

First, a rubric was created with general criteria we deemed to be important to the EcoCentre. These criteria included cost, ease of download, usability, customisability, and quality. Research was conducted in order to identify eight to ten viable tools. Each of these tools was downloaded, and a rubric was completed analysing the quality of each of these softwares. These completed rubrics can be found in the appendices. There were a few tools that did not provide any quality features and were completely unusable such as GRASS GIS, and these tools are not included in this report.

An attempt was made to load a standardized set of data into each tool, which was derived from the 2013-2014 trawling data. The dataset contained the same data points, but in some instances the data had to be reformatted in order to import it into the tool. This dataset was too large to be attached in an appendix so it is attached to this project separately in both Excel and Comma Separated Values formatting.

Next, we had different members of the team with different technical skills attempt to use the same tool. This gave us a better standard when we were ranking tools since multiple members with different expertise levels could contribute to one ranking.

Finally, the comments were grouped into three main categories for our analysis matrix: sophisticated, competent, and not yet competent. These categories were assigned colours so that viewers could easily interpret the results. This analysis matrix is included in the results section. The goal of using an analysis matrix is to make these tools easier to compare based on the different variables we used to rate the tools. This should give the user an easy way to glance at the analysis matrix and choose a GIS tool based on the features they find most important.

By doing this, the team was able to experience the user interface of the tool firsthand, instead of relying on third party reviews. General comments and concerns were recorded in the rubrics.

Results

Google Earth Pro. is a free tool that is easy to download and use. The tool had many customisation features such as the ability to input points, lines, and polygons for different types of data. It is simple to input data as a CSV file as long as the file contains longitude and latitude values for each row. After inputting data, points at the same location can be visually separated and renamed to differentiate the dates. Google Earth uses satellite imagery to create a 3D representation of earth. This allows the user to zoom so they can see all of the points from a distance or get closer and see the exact location of

each data point. One unique feature is street view. This allows the user to drop a pin on a street so they can visualise the area from a citizen's perspective. However, Google Earth is not up to date with all of its satellite imagery and in street view, the imagery is blurry. This can be a problem if there are new buildings or the landscape changed since the Google Earth imagery was captured. For the rubric see Appendix A.1.

QGIS. is a free tool that is easy to download. Inputting the data into the tool is slightly challenging at first because finding the proper input values for different rows is not represented properly. For example, attempting to allow the tool to recognise which rows were longitude and latitude was difficult. However, once everything is set up the tool becomes much easier to use. The only downside to the customisation features is that we would need to create the files to import into the tool; the tool does not create these customisations for us. The graphics that this tool outputs are very clear and easy to understand on the data side, however the map output is not as high quality as some of the other tools. For the rubric see Appendix A.2.

The image below shows an example of the user interface for interacting with the data in QGIS.

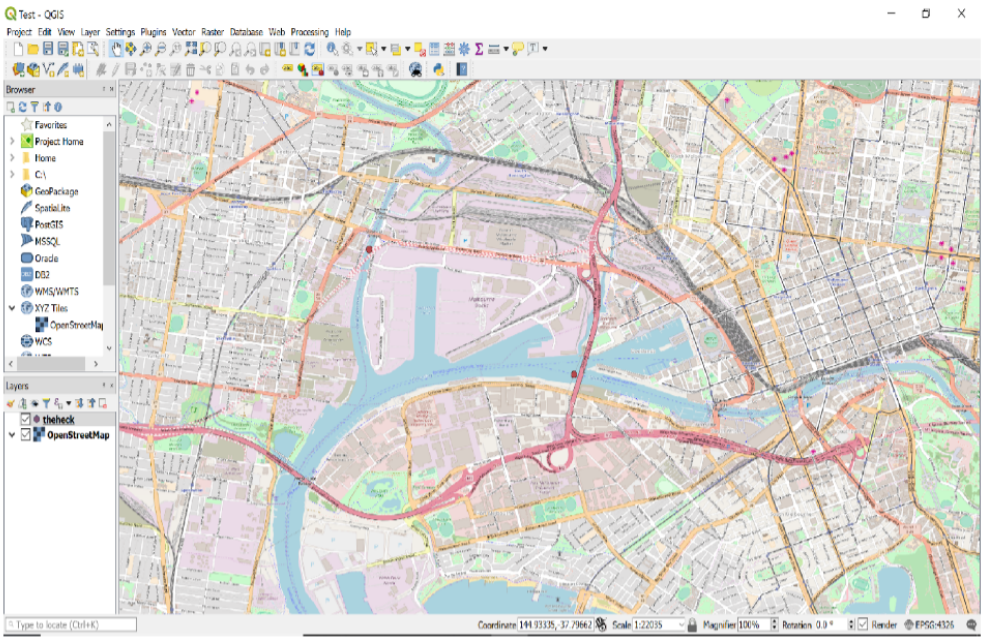


Figure 40. QGIS user interface

MapWindow 5. is another free tool that is relatively easy to download. The company that creates this tool, MapWindow, offers three other GIS tools in addition to MapWindow 5. The user must be conscious of which software is being downloaded. Data can be entered manually through the tool's "attribute table" or can be imported from a .shp file. Files can be converted from the .csv file type to the .shp file type easily using online converter tools such as MyGeodata Converter. There are a great number of formatting options for labels, and plugins are readily available to customise the tool. Despite the graphic quality being relatively low, the labelling options and ease of data input make this tool usable for non-technical audiences. The rubric for MapWindow 5 can be found in Appendix A.3.

Tableau. is a tool that requires a license for businesses to use it at 70 USD a month. Although it isn't free, the tool offers an option for non-profits and NGO's to request a donated license. The qualifications include that the non-profit must be:

1. Officially recognised tax-exempt organisation in one of the countries on the site (including Australia)
2. Operate with an annual budget under $5 million (or equivalent in local currency)
3. Not be a school, college, mutual organisation, healthcare organisation, or government agency
4. Not be a religious organisation incorporated exclusively for the promotion of the religion

Assuming the EcoCentre could gain access to a license, the tool is incredible in terms of all the other features we ranked. The tool is easy for non-technical users to use with minor guidance. The data does need to be input in a specific way, however it did not take long to format the data properly. There are many customisation features such as layered charts, colour selectors, etc. Some are shown in the image below. This is the layout of the tool when the user is editing the different graphs.

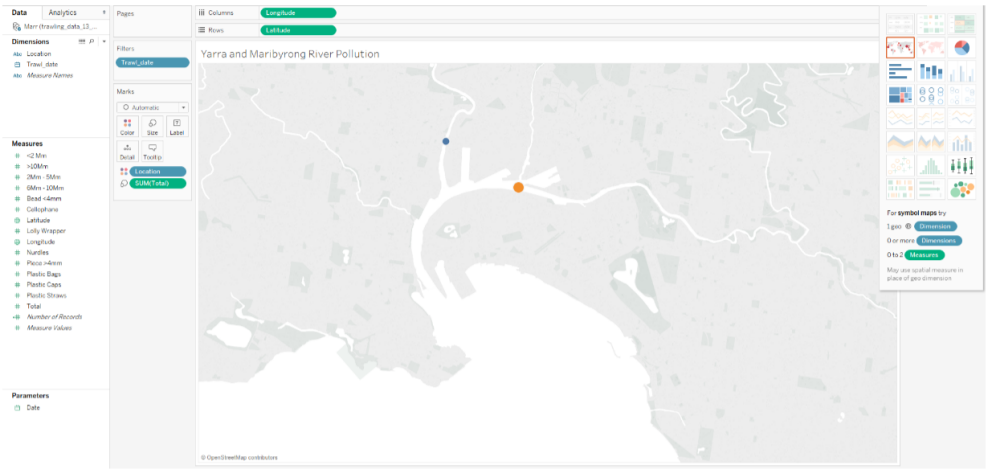


Figure 41. Tableau developer platform

As you can see in the figure there are options to modify what different features, such as total plastic pollution, are represented as, such as size of data point on the map. Integrating these features is as easy as dragging the measure on the left and dropping it on the method of displaying that feature. For example dragging total and dropping it onto the size option. This would make the data point larger for larger totals and vice versa for smaller total plastic counts. For the rubric see Appendix A.4.

ArcGIS. is another tool that costs money, however it does not provide NGO license pricing without signing up for more information on their discounts for NGOs. This tool is also easy to use in terms of data input and manipulation. It is a web-based platform which is nice because it does not require the user to have an advanced computer setup. Also, this tool has many layer customisation features, however it is hard to filter by date with this tool. It would be easy to add spatial layers to convey data with this tool and overall it is a quality tool. For the rubric see Appendix A.5.

DIVA GIS. is a free GIS mapping software that can be easily downloaded. The data must be formatted into TXT format and any maps must be imported as a separate file. Inputting the data is slightly challenging, however the tool is easy to use once the data has been imported. There is the ability to add climate and terrain information if you download their climate and terrain database. However, this tool plots the data based on

latitude and longitude, so multiple data points that all occur at the same location would show up as a singular point, not as multiple points. This software also has some basic data analysis features built in. The image quality of the final product is pretty basic, and there are no legends on the map so it is difficult to understand what is being visualised. The rubric for this tool can be found in Appendix A.6.

Map Express. is easily downloaded from the CadCorp website. The majority of the other tools that have been reviewed come loaded with background maps, however, Map Express requires the user to import a raster file in order to generate a baseline map. This introduces added complexity and the appearance of the finished product will be highly dependent on the quality of the raster file used. Data can be imported from a variety of file types, but the user interface on the left side of the screen can sometimes make it difficult to control and manipulate data and labels. The rubric can be found in Appendix A.7.

Simple GIS. costs $50 per license, meaning that a user could use the software on a single computer for an indefinite period of time after a one-time payment. The software includes background images already, but it was difficult to navigate the user interface to import data. Geolocation was easy to figure out for non-technical users, but it was unclear how to import other data. Error messages occasionally appear on the screen, either by user error or not. The tool doesn't offer any features that would be relevant to the scope of this project, and overall the image quality was quite poor. The rubric can be found in Appendix A.8.

Analysis Matrix

To combine all of these analyses, we created an analysis matrix ranking the GIS mapping tools which can be seen below.

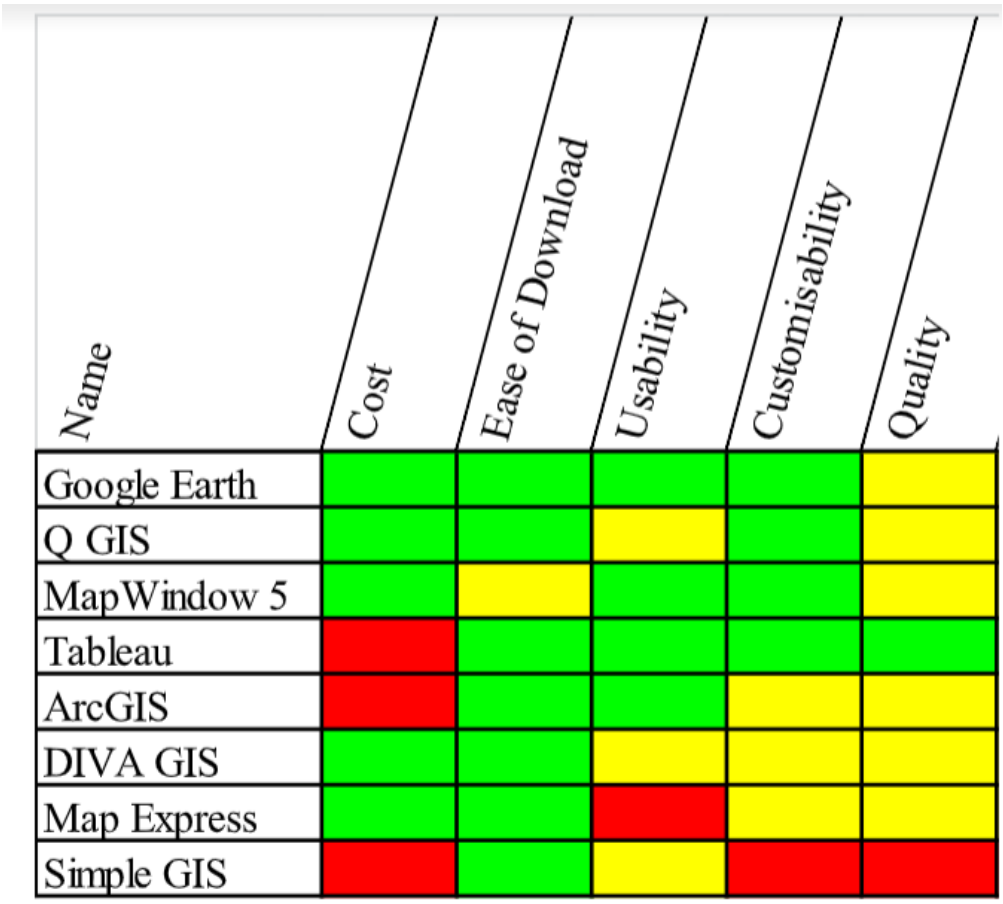


Figure 42. Analysis Matrix

Discussion

Our top four choices based on the analysis matrix are Google Earth Pro, Tableau, QGIS and MapWindow 5. We came to this conclusion as a group and used the analysis matrix as well as personal experience with the tools to determine which tools were the best for our application.

Specifically comparing these four tools, we think Google Earth Pro beats QGIS and MapWindow 5 because of the ease of download and usability features, which we deemed are important to the EcoCentre. The quality of these tools can be easily compared in the screenshots below.

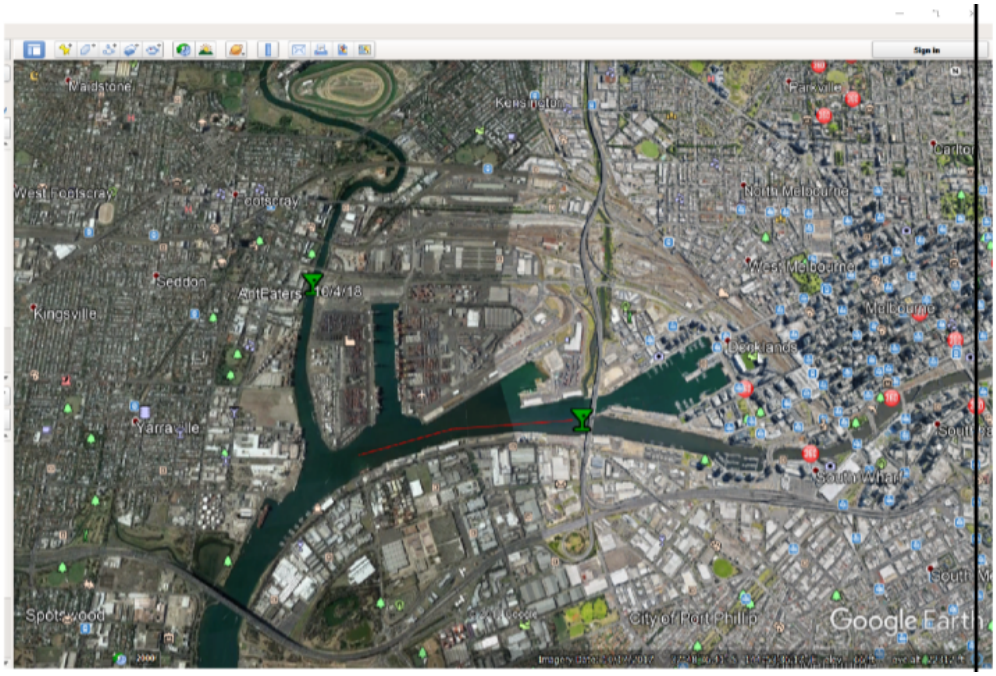


Figure 43. Google Earth Pro

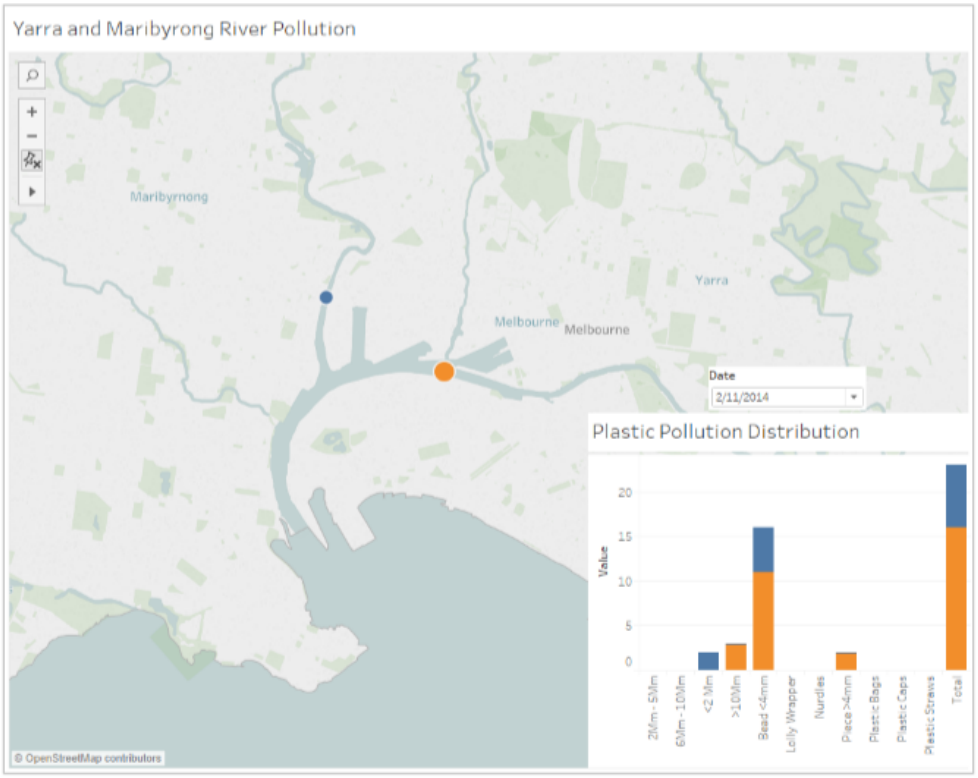


Figure 44. Tableau

Figure 45. QGIS

Figure 46. MapWindow5

Comparing quality of output for the four tools

In our opinion, Google Earth Pro and Tableau provide the easiest to understand basemaps. One benefit of Tableau is the simplicity in adding all of these features once the

initial data has been formatted. QGIS and MapWindow 5 have built in coloured maps with descriptive labels.

The fact that MapWindow 5 only accepts .shp files when importing data may serve as a detriment; however, the user interface is easy to understand and manipulate. Tableau has the option to import multiple file types and can also import multiple data files at once, to layer or display multiple maps in one visualisation. After importing data, all of the tools ranked well in terms of usability.

One feature we know is important to this project is the ability to view data over time on our maps. We defined manual data manipulation as a method of filtering by date, but only in the developer platform of the program. An ingrained date filtering would provide a way to manipulate the date being shown after the visualisation is exported for the user. Below we provide the manual and ingrained methods for the tools, if they exist.

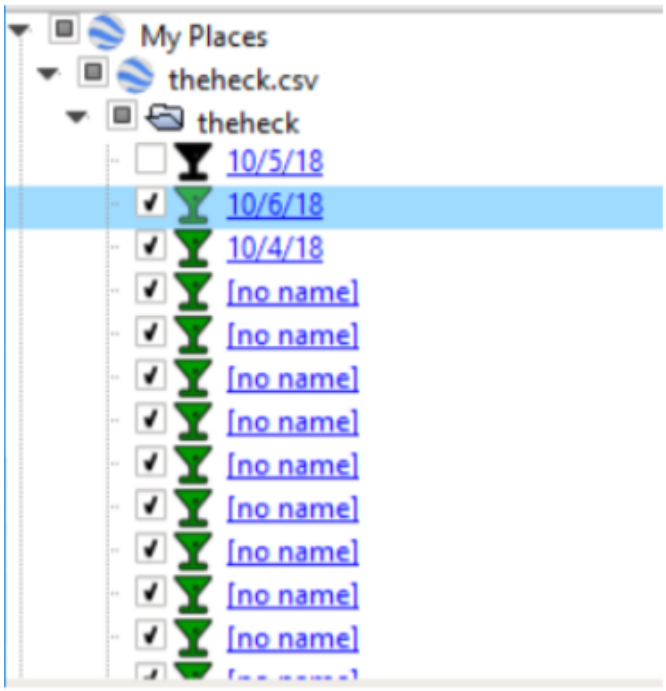


Figure 47. Google Earth Pro: Manual date filtering

Figure 48. Google Earth Pro: Automatic date filtering

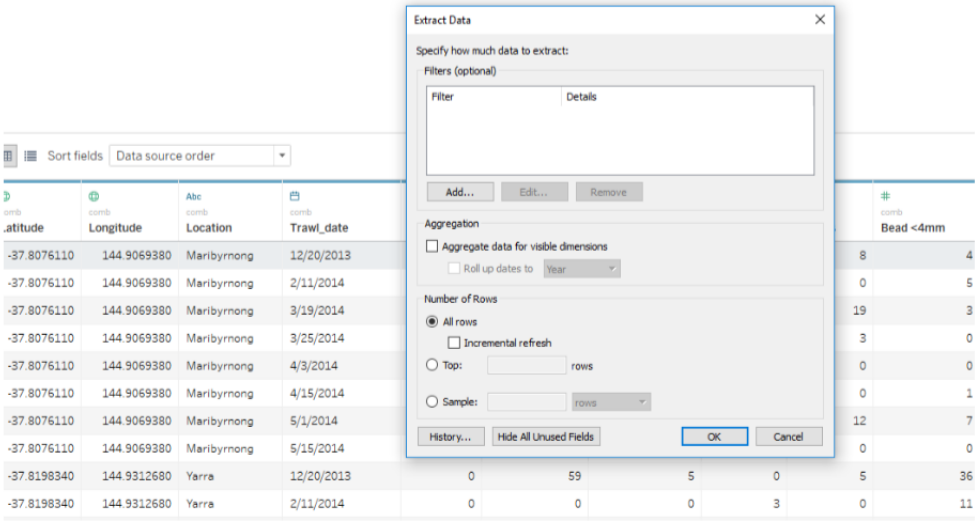


Figure 49. Tableau: Manual date filtering

Figure 50. Tableau: Automatic date filtering

Ultimately, we would recommend Google Earth Pro or Tableau for the EcoCentre to use. Compared to the other software packages, Google Earth Pro and Tableau offer a greater number of features, create a higher quality output, and make data creation and manipulation easy. It is our hope that the EcoCentre already has, or will be able to obtain, a free Tableau license due to their status as a non-profit organisation. If this happens, we feel that Tableau would be a slightly easier tool to use for this project than Google Earth Pro. If the EcoCentre cannot obtain a free Tableau license however, we feel that both of these tools are simple enough to learn, easy enough to understand, and will provide the best opportunity for the EcoCentre to build upon their existing datasets in the future.

Conclusion

Ultimately, the goal of this case study was to present the EcoCentre with multiple options for GIS mapping tools for the use of this project. We have found that our top four tools are Google Earth Pro, Q GIS, MapWindow 5, and Tableau. If the EcoCentre could receive a Tableau license for non-profits, we would recommend Tableau over all other GIS mapping tools.

We have come to this conclusion due to the tools' rankings which can be seen in the analysis matrix that we included. We think that the output of these tools is quality and can provide us with the opportunity to create an intuitive and useful geographic representation of plastic pollution in the Yarra and Maribyrnong rivers.

Appendix A.1: Rubric for Google Earth Pro

Name	Google Earth Pro	
Source	https://earth.google.com/download-earth.html	
Cost	Free	
Availability	Is it easily downloadable?	Yes
Usability	In terms of data input, is it easy to format and input data into the tool?	Data must be in CSV format in order to input with longitudes and latitudes. Step by step process to do so will be included
Usability	Overall, how usable is this tool? Will the Port Phillip EcoCentre be able to use this tool after our team leaves?	Yes, it is simple to add data and visually separates multiple data points at same location. Can easily rename data points to easily distinguish dates and titles
Customisability	What customisation features does the tool have?	3D visualisation maps, and geocoding
Customisability	Are there any standout features that would bring this visualisation to the next level?	Able to import data from excel spreadsheets, ability to zoom and see data points from a distance
Quality	What quality is the output of the program? Consider graphic quality and appearance.	Average to below average quality of imagery, not up to date images
Quality	Is it clear what the data is conveying?	Yes, you can see what types of plastics are imported and what date
Other		https://support.google.com/earth/answer/176685?hl=en Instructions to import data

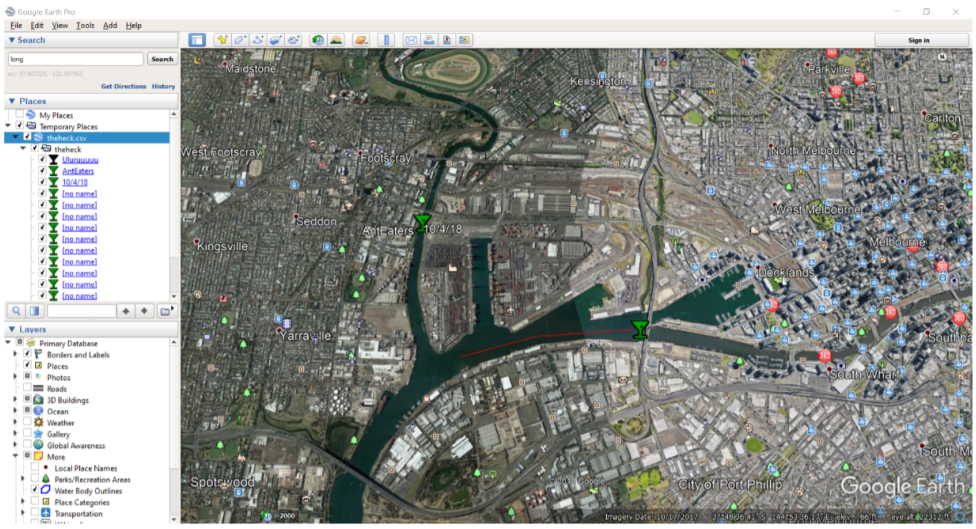


Figure 51. Google Earth Pro Output

Appendix A.2: Rubric for QGIS

Name	QGIS	
Source	https://www.qgis.org/en/site/	
Cost	Free	
Availability	Is it easily downloadable?	Yes
Usability	In terms of data input, is it easy to format and input data into the tool?	Pretty easy
Usability	Overall, how usable is this tool? Will the Port Phillip EcoCentre be able to use this tool after our team leaves?	It is a little difficult to set up, but gets easier once it is set up
Customisability	What customisation features does the tool have?	Seems to have a ton of customisation options but we would need to create the files to import
Customisability	Are there any standout features that would bring this visualisation to the next level?	Yes there are a lot of different geospatial customisation tools
Quality	What quality is the output of the program? Consider graphic quality and appearance.	It is okay... not the best
Quality	Is it clear what the data is conveying?	It is good in terms of data
Other		

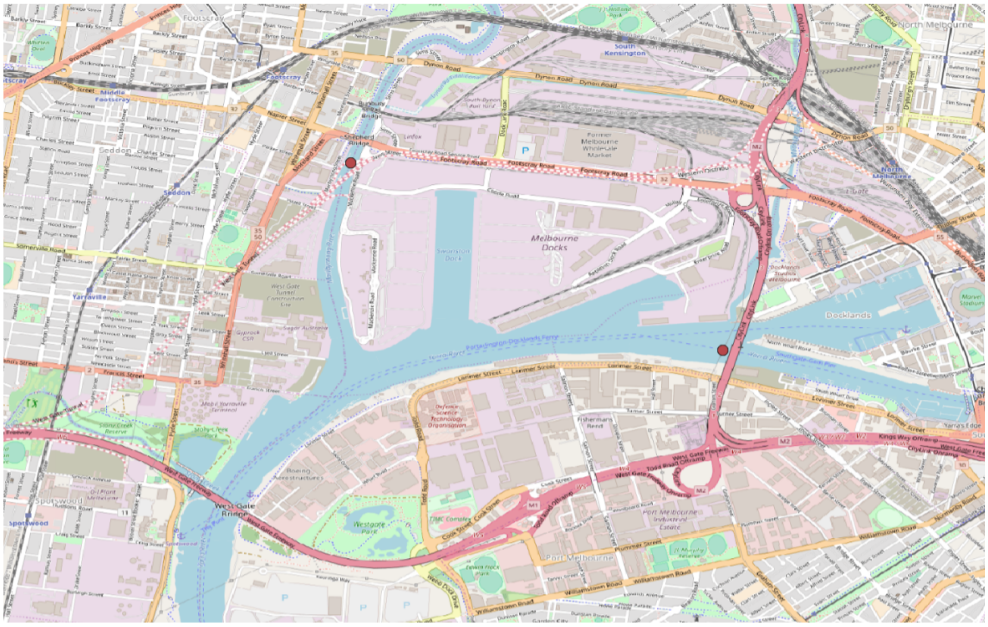


Figure 52. QGIS Output

Appendix A.3: Rubric for MapWindow5

Name	MapWindow5	
Source	https://www.mapwindow.org/	
Cost	Free	
Availability	Is it easily downloadable?	Yes but you need to download the correct software. There are 4 different types of software: MapWinGIS, MapWindow5, HydroDesktop, and DotSpatial
Usability	In terms of data input, is it easy to format and input data into the tool?	Data can be entered into the tool via the "attribute table", and can be imported from a .shp file. File can easily be converted from .csv files to .shp files through online conversion tools. The data can be modified through the "table" editor very easily. When editing shapes and labels, the user can see previews of their changes, and plenty of options exist.
Usability	Overall, how usable is this tool? Will the Port Phillip EcoCentre be able to use this tool after our team leaves?	Because there aren't readily available tutorials, it is difficult to grasp how to use the software. The user interface seems basic, but learning where buttons are and how to modify shapes and data is a time consuming process.
Customisability	What customisation features does the tool have?	Multiple plugins are available for the tool, but it appears as though these plugins provide basic functionality that should be expected from the software, such as editing shapes and data values from inside the tool.

Customisability	Are there any standout features that would bring this visualisation to the next level?	A plugin is available to enable the user to query the data easily.
Quality	What quality is the output of the program? Consider graphic quality and appearance.	The graphic quality is relatively low, but there are a number of labels present on the stock maps. The labels adapt to the user's zooming, and it is easy to see key landmarks and shapes.
Quality	Is it clear what the data is conveying?	The user has a great deal of control over how the data is displayed.
Other		Documentation for the tool is still under construction, but there are some open source video tutorials available.

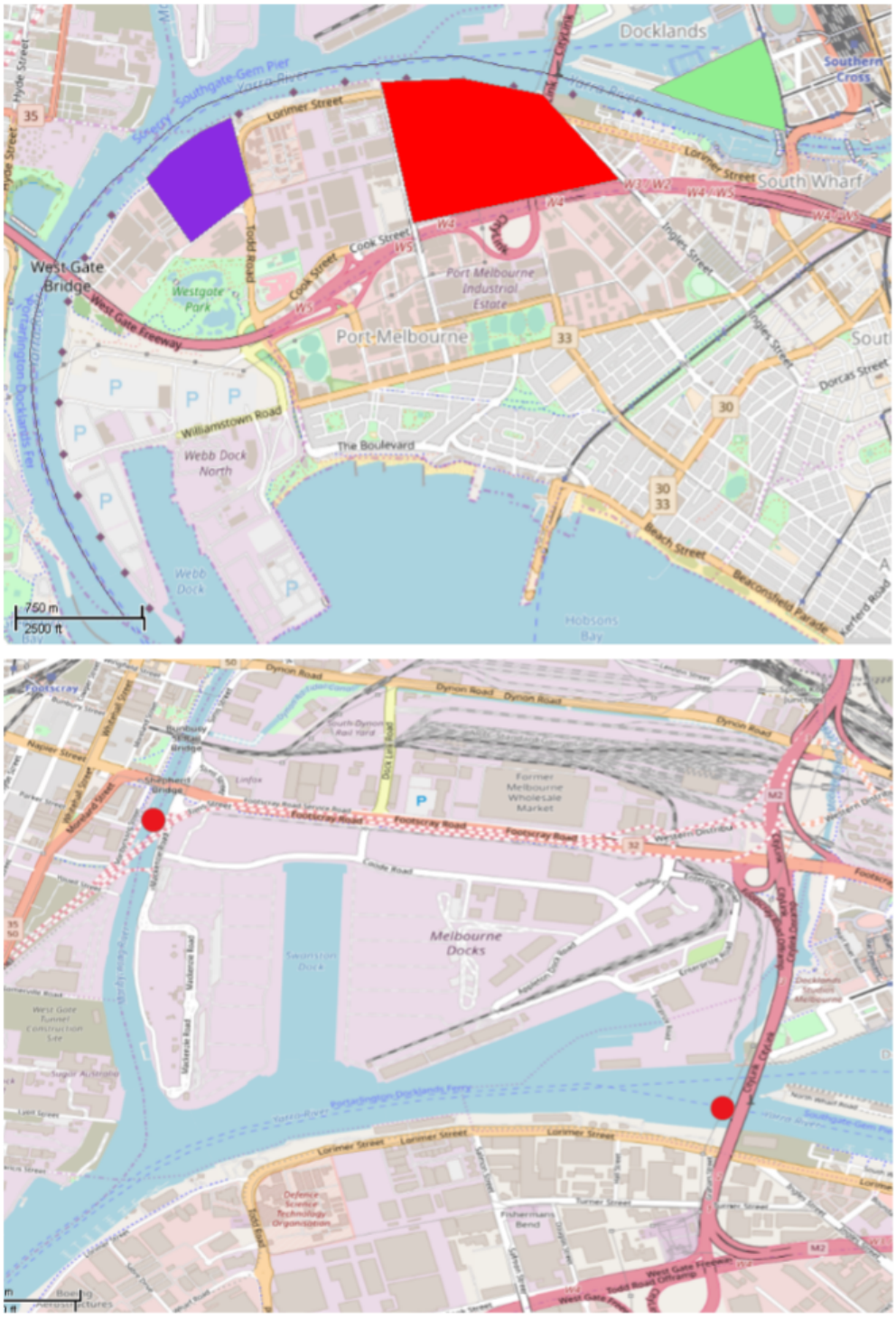


Figure 53. MapWindow5 Output

Appendix A.4: Rubric for Tableau

Name	Tableau	
Source	https://www.tableau.com/	
Cost	70 USD / month, or non-profit donated license	
Availability	Is it easily downloadable?	Yes
Usability	In terms of data input, is it easy to format and input data into the tool?	Data needs to be specifically formatted so the tool can recognise different attributes. Overall, once it's formatted it's easy to move data around.
Usability	Overall, how usable is this tool? Will the Port Phillip EcoCentre be able to use this tool after our team leaves?	They would be able to import new data by putting data into the data sheet easily, however they probably wouldn't have as much expertise as needed for changing formatting within the tool.
Customisability	What customisation features does the tool have?	Easily customisable and ability to layer multiple charts on top of each other which is nice. colour selectors and other features make this tool stand out as well and they are really easy to use.
Customisability	Are there any standout features that would bring this visualisation to the next level?	Layered charts.
Quality	What quality is the output of the program? Consider graphic quality and appearance.	Takes a little to load the full quality but afterwards it's good.
Quality	Is it clear what the data is conveying?	Need to manually add labeling or colouring to the map.
Other		EcoCentre has a visualisation using it already, so they might have a license or preference for it.

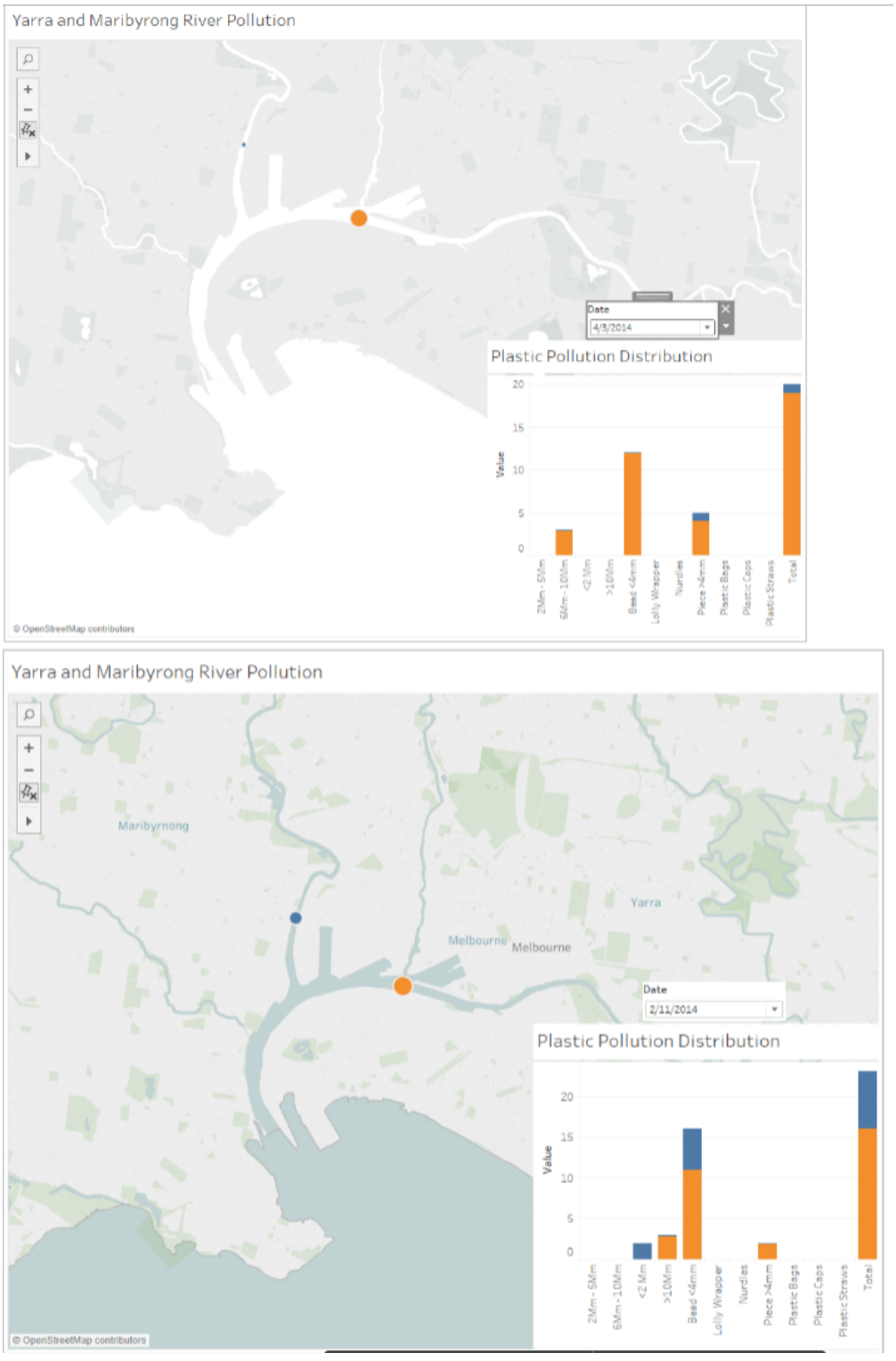


Figure 54. Tableau Output

Appendix A.5: Rubric for ArcGIS

Name	ArcGIS	
Source	https://www.esri.com/en-us/arcgis/	
Cost	500USD per user per year	
Availability	Is it easily downloadable?	It's online so you don't need to necessarily download it
Usability	In terms of data input, is it easy to format and input data into the tool?	Yes, takes in a CSV
Usability	Overall, how usable is this tool? Will the Port Phillip EcoCentre be able to use this tool after our team leaves?	Very usable, importing data and layers is insanely easy
Customisability	What customisation features does the tool have?	Seems to have lots of customisation features with different layer options and adding filters to the variables
Customisability	Are there any standout features that would bring this visualisation to the next level?	n/a
Quality	What quality is the output of the program? Consider graphic quality and appearance.	Image quality is pretty bad unless you use the default base map
Quality	Is it clear what the data is conveying?	Yes, it would be easy to add spatial layers to convey data
Other		Cloud based, easy for multiple contributors

Figure 55. ArcGIS Output

Appendix A.6: Rubric for Diva GIS

Name	Diva GIS	
Source	http://www.diva-gis.org/documentation	
Cost	Free	
Availability	Is it easily downloadable?	Yes
Usability	In terms of data input, is it easy to format and input data into the tool?	The data must be in a TXT file, so you just have to convert it from excel
Usability	Overall, how usable is this tool? Will the Port Phillip EcoCentre be able to use this tool after our team leaves?	Once the data is input, using the tool is pretty easy to use, but it took me a while to figure out how to input the data
Customisability	What customisation features does the tool have?	Ability to add climate and terrain layers from their websites database
Customisability	Are there any standout features that would bring this visualisation to the next level?	Ability to zoom and see data points from a distance, has some data analysis features built in
Quality	What quality is the output of the program? Consider graphic quality and appearance.	Average, basically just an outline of a map with a few lines and coloured dots on it
Quality	Is it clear what the data is conveying?	There isn't any legends or anything on the map. There is only the single dot for the data.
Other		This tool plots based on latitude and longitude, so there is not a way to separate the different kinds of plastic in a particular sample that I have been able to figure out http://www.diva-gis.org/docs/DIVA-5_Tutorial.pdf basic tutorial on how to use this software

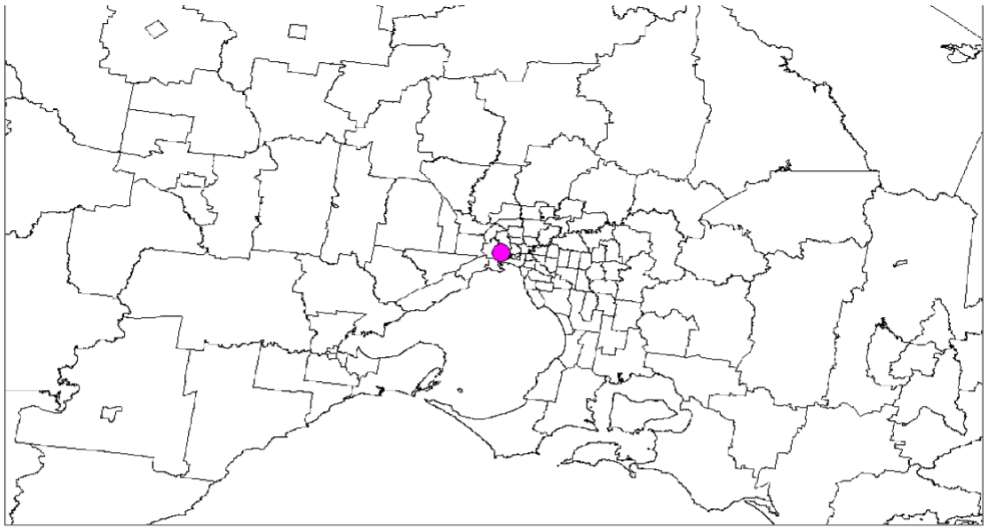


Figure 56. Diva GIS Output

Appendix A.7: Rubric for MapExpress

Name	MapExpress	
Source	https://www.cadcorp.com/products/free-mapping-software/	
Cost	cost	
Availability	Is it easily downloadable?	Yes
Usability	In terms of data input, is it easy to format and input data into the tool?	You can load raster files (.ecw) to create maps, and can load data from .tab, .dgn, .dwg, .dxf, .bds, .mdb, and .mif file types.
Usability	Overall, how usable is this tool? Will the Port Phillip EcoCentre be able to use this tool after our team leaves?	The tool is very slow to load and update. In addition, many of the colours change during zooming and panning, and is not very user friendly.
Customisability	What customisation features does the tool have?	As far as I'm aware, there are no plugins or add-ons available for this software to make it more customisable.
Customisability	Are there any standout features that would bring this visualisation to the next level?	The tool can support 3D visualisations, but is mostly equivalent to many other softwares in that the user can zoom, pan, add data, and perform formatting operations.
Quality	What quality is the output of the program? Consider graphic quality and appearance.	The tool can support 3D visualisations, but is mostly equivalent to many other softwares in that the user can zoom, pan, add data, and perform formatting operations.
Quality	Is it clear what the data is conveying?	There are a number of style/formatting options for labelling. Through good formatting, the data can probably be presented in a clear way.

Other		Details aren't clear at the lowest zoom levels; however, this may be a function of poor map quality.

Figure 57. MapExpress Output

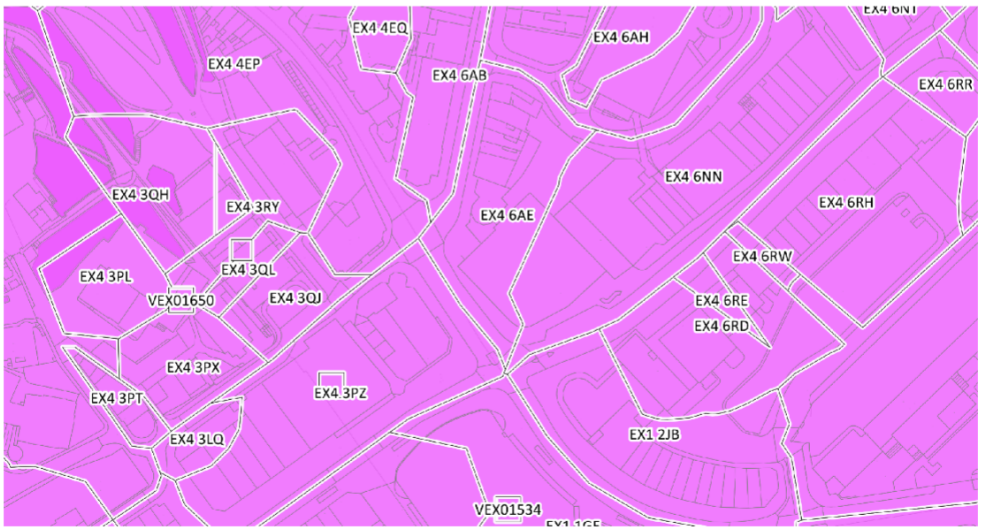


Figure 58. MapExpress Output 2

Appendix A.8: Rubric for Simple GIS

Name	Simple GIS	
Source	https://www.simplegissoftware.com/simple-gis-client.html	
Cost	50 USD per license	
Availability	Is it easily downloadable?	Yes
Usability	In terms of data input, is it easy to format and input data into the tool?	Example maps come with the tool. Importing the data was hard, the Geolocation was somewhat easy but I cannot figure out how to input the other relevant data
Usability	Overall, how usable is this tool? Will the Port Phillip EcoCentre be able to use this tool after our team leaves?	The tool isn't very usable, as error messages commonly pop up, and data entry and formatting options are scarce.
Customisability	What customisation features does the tool have?	Very difficult to use and doesn't seem to have any features
Customisability	Are there any standout features that would bring this visualisation to the next level?	No
Quality	What quality is the output of the program? Consider graphic quality and appearance.	Image and picture quality aren't good at all
Quality	Is it clear what the data is conveying?	Not really, hard to customise
Other		

Figure 59. Simple GIS Output

Appendix B: Introduction to GIS Mapping with Tableau

Introduction to GIS Mapping with Tableau

Cameron Collins, Samantha Comeau, Brendan Gallagher, Gina Visser

15 November 2018

Table of Contents

How to Continue Data Collection

In order to understand trends in plastic pollution, it is important that the EcoCentre is able to add data to the visualisation. The visualisation was created in a GIS mapping software called Tableau and information on how to use Tableau or edit the

current data within a Tableau visualisation can be found later in this document in the section titled How to Use Tableau. In order for the software to understand the data, it must be formatted in a specific way and this document will cover the necessary formatting of street, beach, and river litter audit data for use in EcoCentre Tableau visualisations.

	Street Usage	Zone	Latitude	Longitude	Council	Street / Business Name	Date	bait	ice	retail store	shopping (grey)	shopping (white)	zip-lock	Plastic Bags	bleach/cleaner	caps	soft drink bottle	fruit juice / milk bottle	water bottle	Plastic Bottles	cigarette butts	cellophane wrap	cigarette lighters	Cigarettes	fruit juice/milk	straws	Drink Cartons	bubble wrap
2	Business	Footpath	-37.870209	144.980796	St. Kilda	7 Eleven	10/11/17	0	0	0	0	0	0	0	0	4	0	0	0	4	121	2	0	123	0	0	0	0
3	Business	Grass/mulch	-37.870232	144.980776	St. Kilda	7 Eleven	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	0	0	0	0
4	Business	Kerb/gutter	-37.870363	144.980753	St. Kilda	7 Eleven	10/11/17	0	0	0	0	0	0	0	0	1	0	0	0	1	64	0	0	64	0	0	0	0
5	Business	Total	-37.870363	144.980753	St. Kilda	7 Eleven	10/11/17	0	0	0	0	0	0	0	0	5	0	0	0	5	190	2	0	192	0	0	0	0
6	Industrial	Footpath	-37.86791	144.98619	St Kilda	Car Wash	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	3	0	0	0	0
7	Industrial	Grass/mulch	-37.867803	144.986193	St Kilda	Car Wash	10/11/17	0	0	0	0	0	0	0	0	2	0	0	0	2	62	0	0	62	0	4	4	0
8	Industrial	Kerb/gutter	-37.867870	144.986189	St Kilda	Car Wash	10/11/17	0	0	0	1	0	0	1	0	2	1	0	1	4	31	1	0	32	0	3	3	0
9	Industrial	Total	-37.867870	144.986189	St Kilda	Car Wash	10/11/17	0	0	0	1	0	0	1	0	4	1	0	1	6	95	2	0	97	0	7	7	0
10	Park	Footpath	-37.86948	144.983088	St. Kilda	Botanical Gardens, Blessington St	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0	0	40	0	0	0	0
11	Park	Grass/mulch	-37.86948	144.983088	St. Kilda	Botanical Gardens, Blessington St	10/11/17	0	0	0	0	0	0	0	0	1	0	0	0	1	231	9	0	240	0	0	0	0
12	Park	Kerb/gutter	-37.86948	144.983088	St. Kilda	Botanical Gardens, Blessington St	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	17	0	0	0	0
13	Park	Total	-37.86948	144.983088	St. Kilda	Botanical Gardens, Blessington St	10/11/17	0	0	0	0	0	0	0	0	1	0	0	0	1	288	9	0	297	0	0	0	0
14	Public	Footpath	-37.868305	144.989128	St. Kilda	Town Hall	10/11/17	0	0	0	0	0	0	0	0	0	1	0	0	1	99	0	0	99	0	1	1	0
15	Public	Grass/mulch	-37.868305	144.989128	St. Kilda	Town Hall	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	199	1	0	200	0	0	0	0

Figure 60. This shows the first 15 rows of the formatted street litter audit datasheet.

Since GIS tools use the first row as a header for the data below, each of the categories of litter must be a different column with each street litter audit as a row. In addition to the fields found on the EcoCentre's datasheet, the latitude and longitude of each audit location must be recorded since this is how Tableau knows where on the map to place the data points. An example of the different columns that are included in the current datasheet can be seen above. The information recorded for each of the audits is stored as headers along the top row. These headers are applicable for the street litter audits only.

There are different headers that apply to street, beach and river litter audits. A sample spreadsheet was created for each of the audits and can be found in Appendix B.1, Appendix B.2, and Appendix B.3, respectively.

In the street litter audit spreadsheet, one audit is made up of four rows, one for each of the zones (footpath, grass / mulch, and kerb / gutter) and one row for the total amounts of each category found during the audit. In the beach litter audit spreadsheet, one audit is made up of 13 rows, one for each of the quadrats (narrowest top, narrowest middle, narrowest lower, middle top, middle middle, middle lower, widest top, widest middle and

widest lower), one for the totals of each of the transects and one for overall total of the entire audit. In the river litter audit spreadsheet, there is only one row representing each audit.

The sample sheets attached represent the bare minimum of the columns that must be included for the GIS software. More columns could be added before the start of the coloured columns if the auditor chose to store more data. For example, the auditor could add a row after *Date* called *Number of Volunteers* that keeps track of the number of volunteers that completed that audit.

It is important to note that the columns in the datasheet that are shaded grey denote totals of categories of plastic pollutants. For each audit completed, the total of each pollutant category was needed in order to generate the Breakdown of Total by Plastic Pollutant. The totals are calculated using an excel or google sheets formula. The formula to calculate the sum of cells is *=sum()* with the cells to include in the parenthesis. This formula was used by typing *=sum(* into the cell that the auditor wanted to store the sum in and then pressing *CTRL+*the cell(s) to include in the sum and finally typing the *)* end parenthesis and hitting enter. It is important to note that the total column at the right most end of each spreadsheet is calculated excluding these grey shaded columns so as to avoid adding data twice to the final total. If the auditor was not feeling inclined to type these formulas, they could copy the four rows that represent a single audit and paste them at the end of the document and the formulas would transfer.

The visualisation uses latitudes and longitudes to place data points on the map. For many of the audit sites that the EcoCentre currently samples, the latitudes and longitudes have already been determined. As the EcoCentre expands the scope of their data collection, it may be necessary for employees or volunteers to determine the latitude and longitude of new audit sites. The existing latitudes and longitudes were determined using Google Maps. If the auditor is recording a previously audited site, they can copy the latitude and longitude values from previous audits. In other cases, Google Maps is a free

software that can be used to accurately determine the geographic location of buildings. A screenshot from Google Maps is shown below.

Figure 61. Google Maps screenshot.

To determine the location of the area in question, simply click on that location on the map. The user's cursor should change to a grey pointer, as circled in red above. This shows that the user has selected a position. Google Maps will access information about that position. A dialog box at the bottom will appear, showing an approximate street address, a picture of the location, and the geographic coordinates of the position. It is the geographic coordinates that will be recorded as latitude and longitude, respectively. These latitudes and longitudes are displayed to six decimal places which means that they are accurate enough to distinguish between the footpath, grass/mulch, and kerb/gutter zones. The existing coordinates were obtained by first identifying the approximate centre of the property frontage that was audited. The approximate centre of these points should be used by looking at the "start landmark" and "end landmark" points written on paper audit sheets. By zooming in as much as possible, the user can distinguish between the three

zones.

When no litter items of a particular category were found, a 0 was placed in the respective cell. This is because all the cells must have values in them in order for a GIS software to read the data. If a cell is empty, a GIS software could interpret the value as null, which can affect the creation of graphs. The colours in the spreadsheet above are simply to help the auditor keep track of the category of pollutant they are recording. This way, cells with values as well as total columns, stand out to the human eye. We recommend continuing with this colour coordinating to allow the spreadsheet to be more easily read by people who are entering data into it or are doing manual data analysis.

Once you have formatted the data properly you can move on to the How to Use Tableau section of this document.

How to Use Tableau

Downloading and Setting up Tableau. Download

Visit `https://public.tableau.com/en-us/s/`, enter your email, and download the app.

Language Settings

To ensure your workbook is understanding the proper date and time settings you will need to edit the date and time settings within Tableau.

1. First, click "File" -> "Workbook Locale" -> "More..."
2. Use the dropdown menu to select “English (Australia)”.
3. A pop-up will show up, click "Yes" so Tableau will interpret dates in the new specified format.

Inputting Data.

1. Click the leftmost bottom tab called “Data Source”

2. Click on “Microsoft Excel” and this should open up a file explorer window

3. Navigate to the Excel file that you would like to visualise in Tableau. Select the Excel file and click "Open".

4. To select a sheet from your Excel file, click and drag it to the area that says “Drag sheets here”.

   You should see the data populate in the lower rectangular area. If data does not appear here, it means that the data may be formatted incorrectly.

5. In the bottom left of the screen, click on "Sheet1". Right click on the tab and rename it to something meaningful. After you rename it, left click on the tab to select it.

Creating a Graph.

1. First, create a workbook using the input data instructions. For this example, we will be using the EcoCentre_Audits.xlsx file.

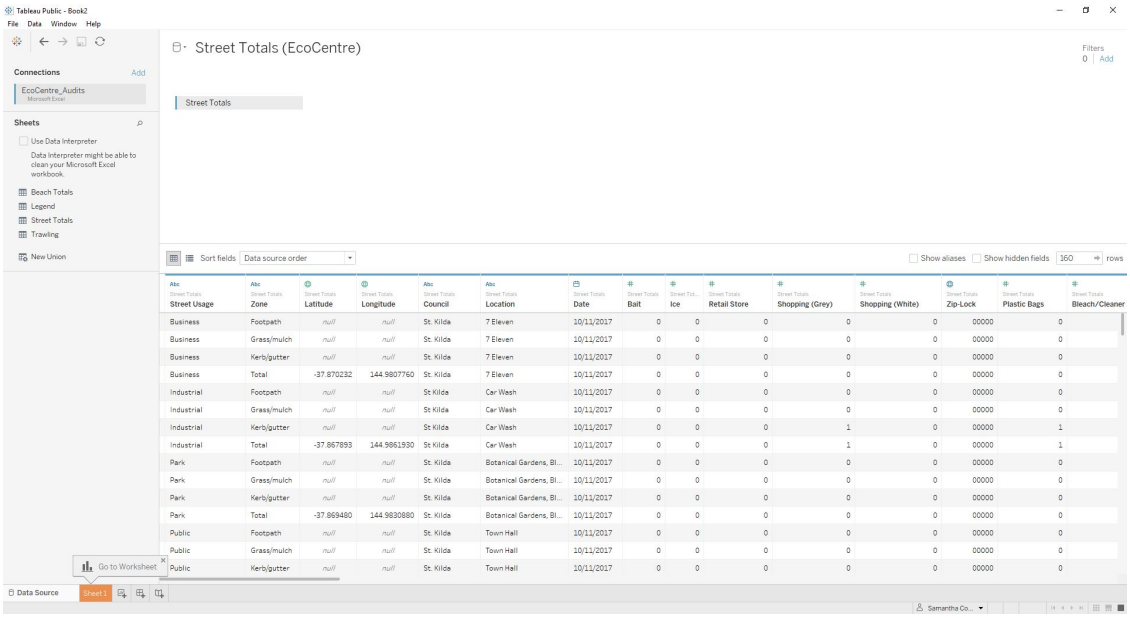


Figure 62. EcoCentre Audits File Upload

2. Create a new worksheet by clicking “Sheet1”. This can be renamed by right clicking and choosing “Rename”.

3. Here we want to graph the total plastic pollutants found per each street usage type. To do this, we will first define our rows and columns.

   Drag “Street Usage” from “Dimensions” to the columns in the top of the screen.

   Drag "Total” from “Measures” to the rows in the top of the screen.

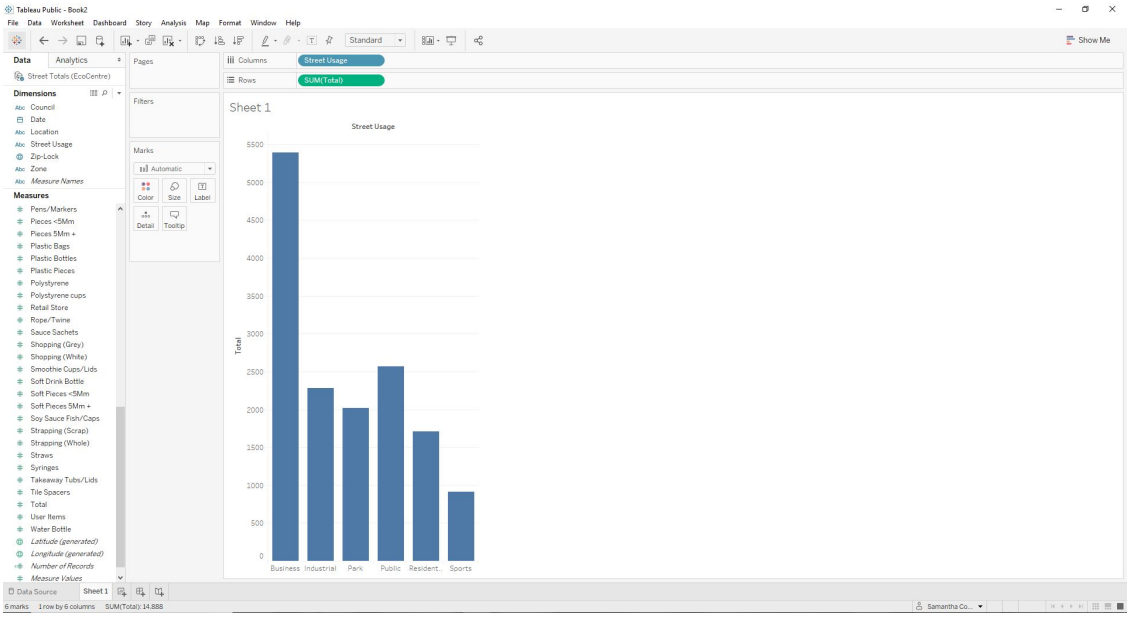


Figure 63. Simple Bar Chart in Tableau

It is important to note that when we added “Total” to the graph, it automatically added "SUM(Total)". This value represents the sum of all the totals found for each street use category. If we wanted the average of these values instead so we could visualise the average of each street usage’s total values we must select the "Total" value from the rows box. A small arrow as shown in the picture below should show up and upon clicking it will show the drop down box.

Figure 64. How to Edit the Values

To change it to average select “Measure” and “AVG”.

Changing Chart Type.

1. To change the chart type, select the menu item in the top right of the screen that says “Show Me”. Depending on the type of values that are in the "Column" and "Row" at the top of the chart, different charts will be available and these are shown in full colour.

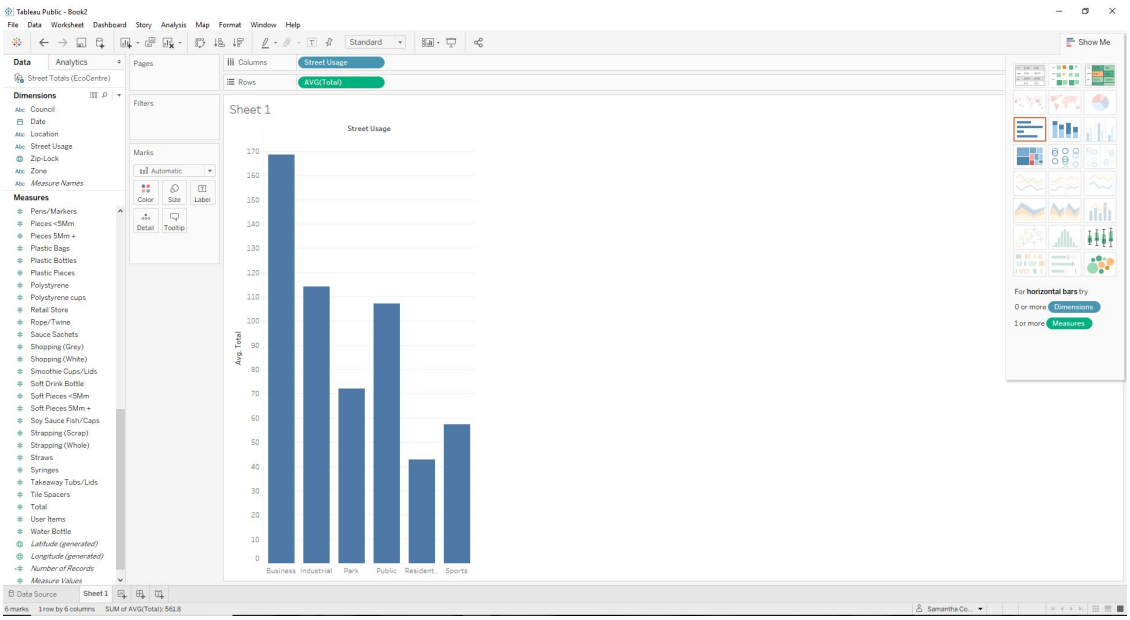


Figure 65. How to change a chart using the "Show Me" box

2. To create a chart, hover over the desired chart type and read the values at the bottom. These values represent what type of data needs to be available in your "Column" and "Row" boxes in order to create that chart. To create a GIS map go to the *Creating a GIS Map* section of this document.

Customising a Graph. There are many customisation features within Tableau. Using the graph created above we will demonstrate some of these.

To change the title simply click on the title and type in the desired title.

The “Marks” box shows the options for customising the current chart.

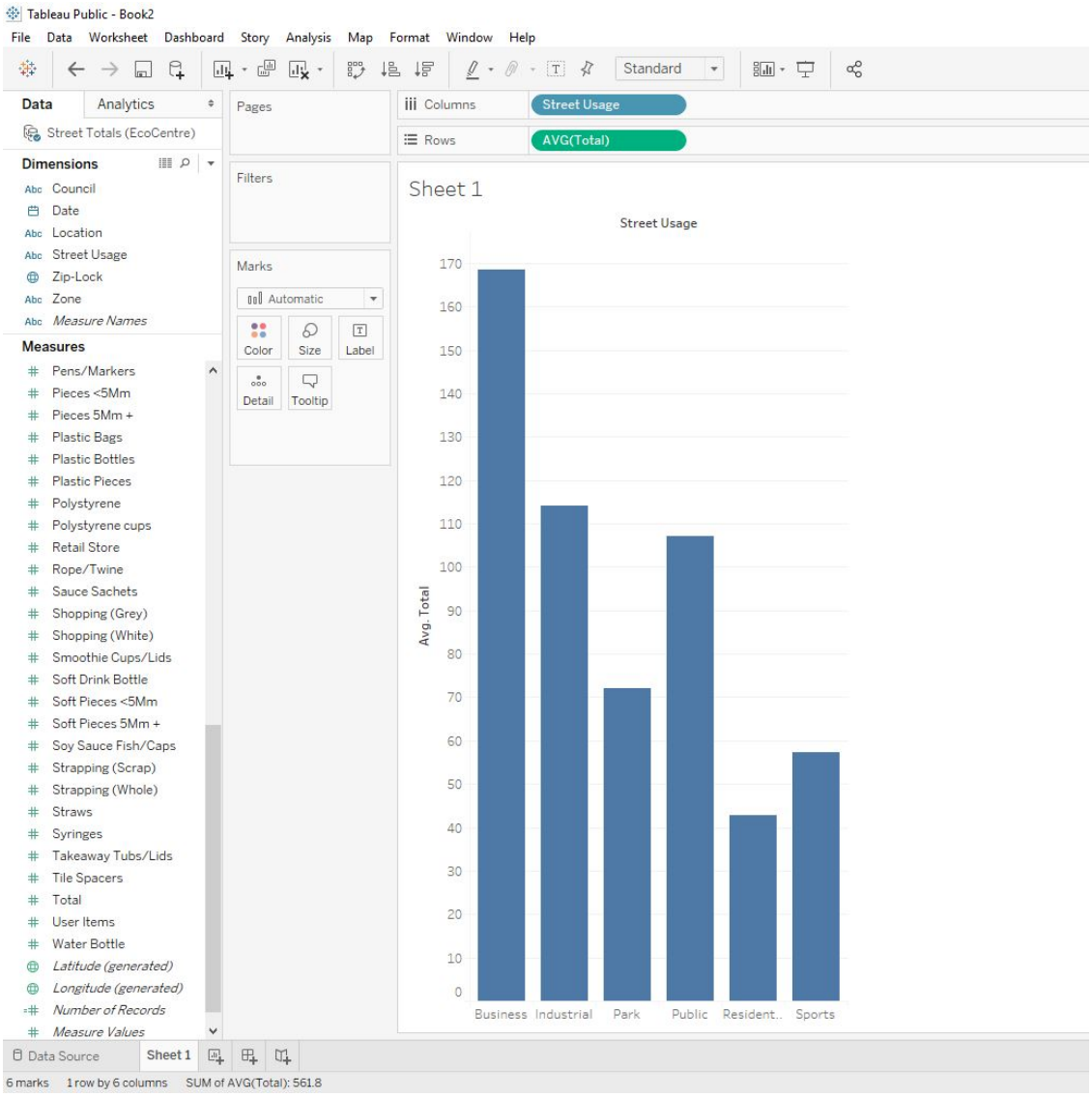


Figure 66. Simple Chart to Customise

1. colour

   To change the colour that represents a specific item in the chart, drag an item onto the "colour" box within the "Marks" menu. For this visualisation we will be showing the location data as the colour so we can see which locations are represented within the street types.

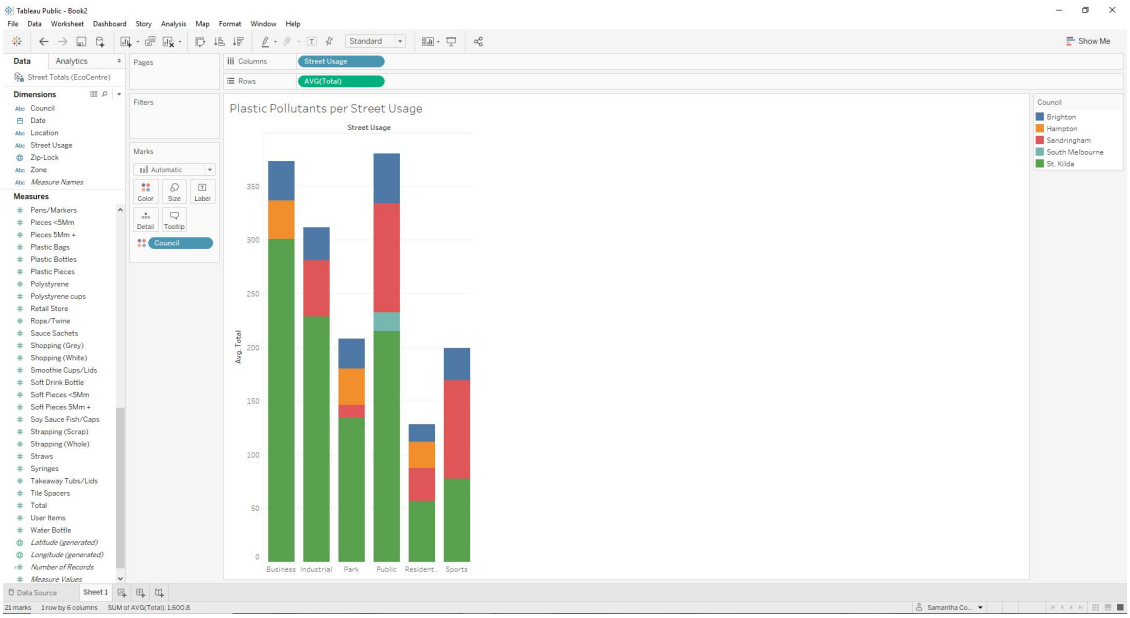


Figure 67. Adding colour to a customisable chart

To change the colours that are used in the chart, you can select the box on the right that shows the colours selected now. To change them, click the arrow and choose "Edit colours". Here we can change the colours and choose "Ok". In this visualisation we have chosen to use the colour Blind sensitive colours.

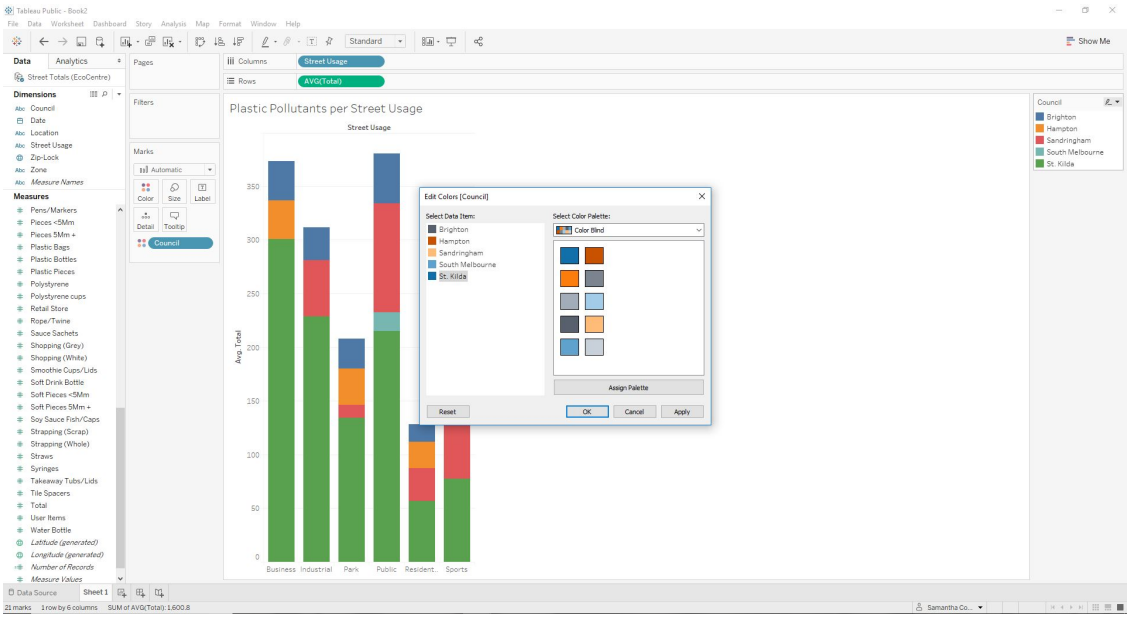


Figure 68. Selecting colours for the chart

2. Tooltips

   To add a tooltip drag the value you'd like to see when you hover over a bar to the "Tooltip" box in the "Marks" menu. You can add multiple tooltips by doing the same thing multiple times.

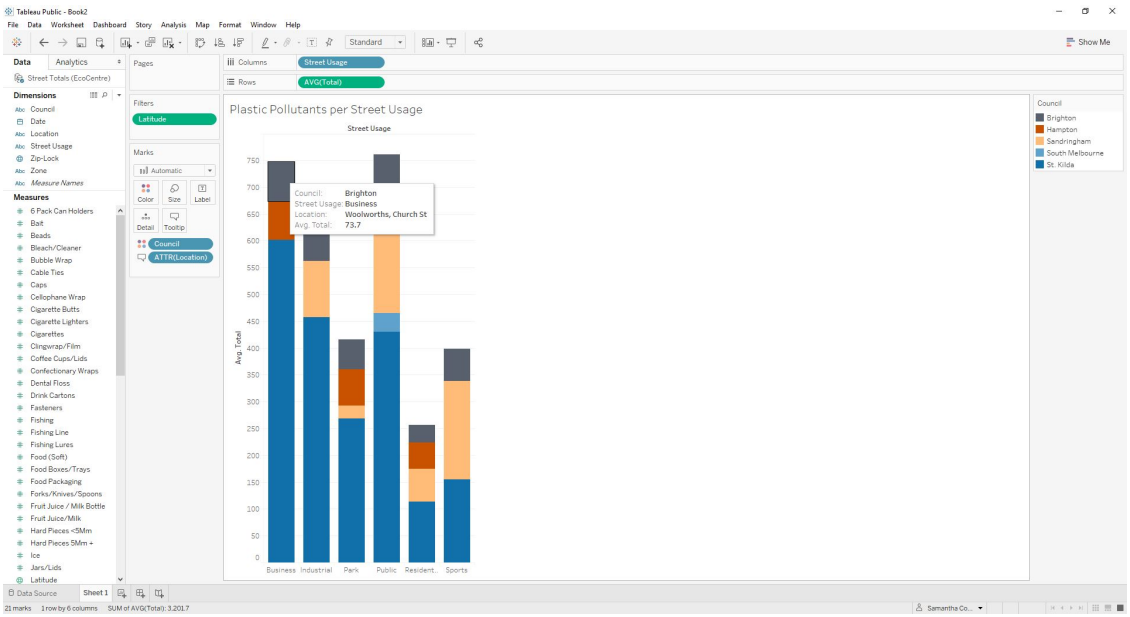


Figure 69. Adding tooltips to the chart

3. The rest of the customization features can be edited the same way. Depending on the type of chart, different options are available for customisation. For example, if we had chosen a "Shape" chart we would be able to change the shape of the points on a GIS map.

Filtering Data in a Graph. Sometimes it will be necessary to interact with the data dynamically rather than the Excel spreadsheet. To do this, add a filter to the chart created in the *Create a Chart* section. In this example we will be filtering by date.

1. Drag the "Date" value from the "Dimensions" tab to the "Filter" box.

2. Select "Individual Dates" or whichever option represents how you would like to view the dates.

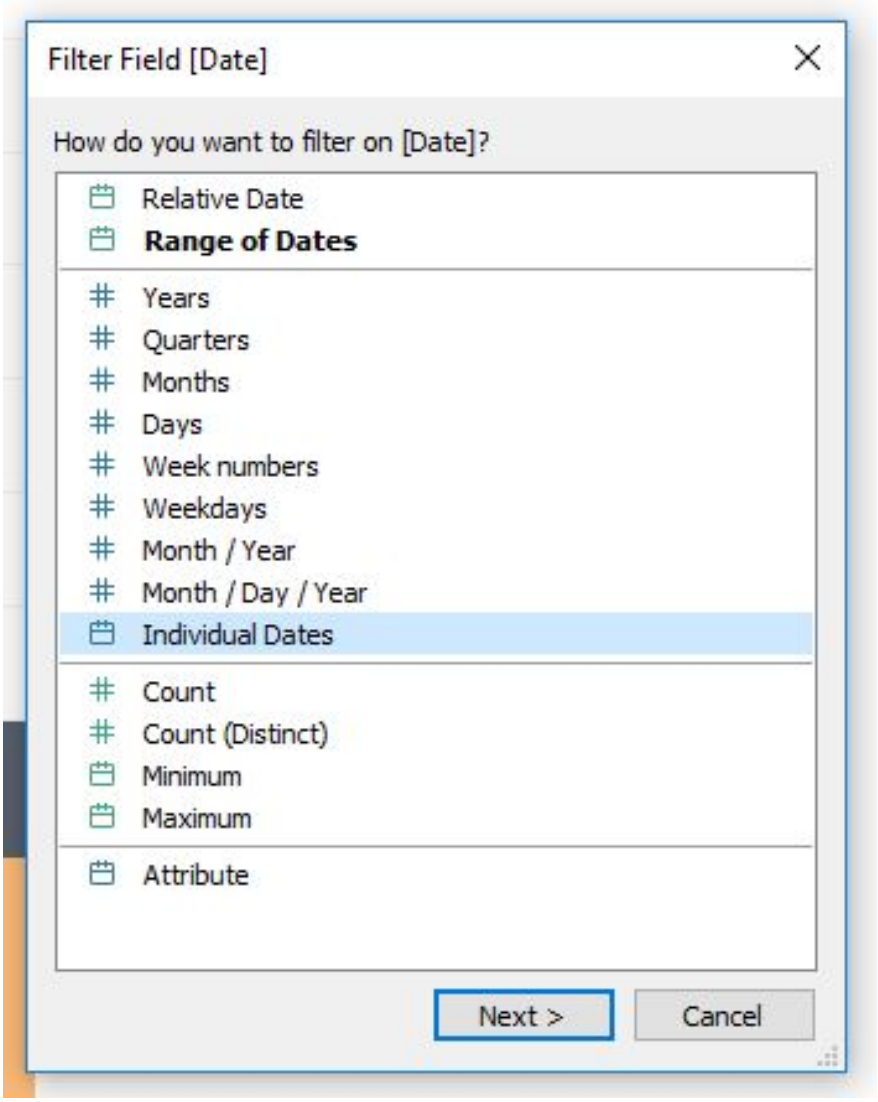


Figure 70. Filtering on date options

3. For this example we will be using all the dates so we select “Use All”.

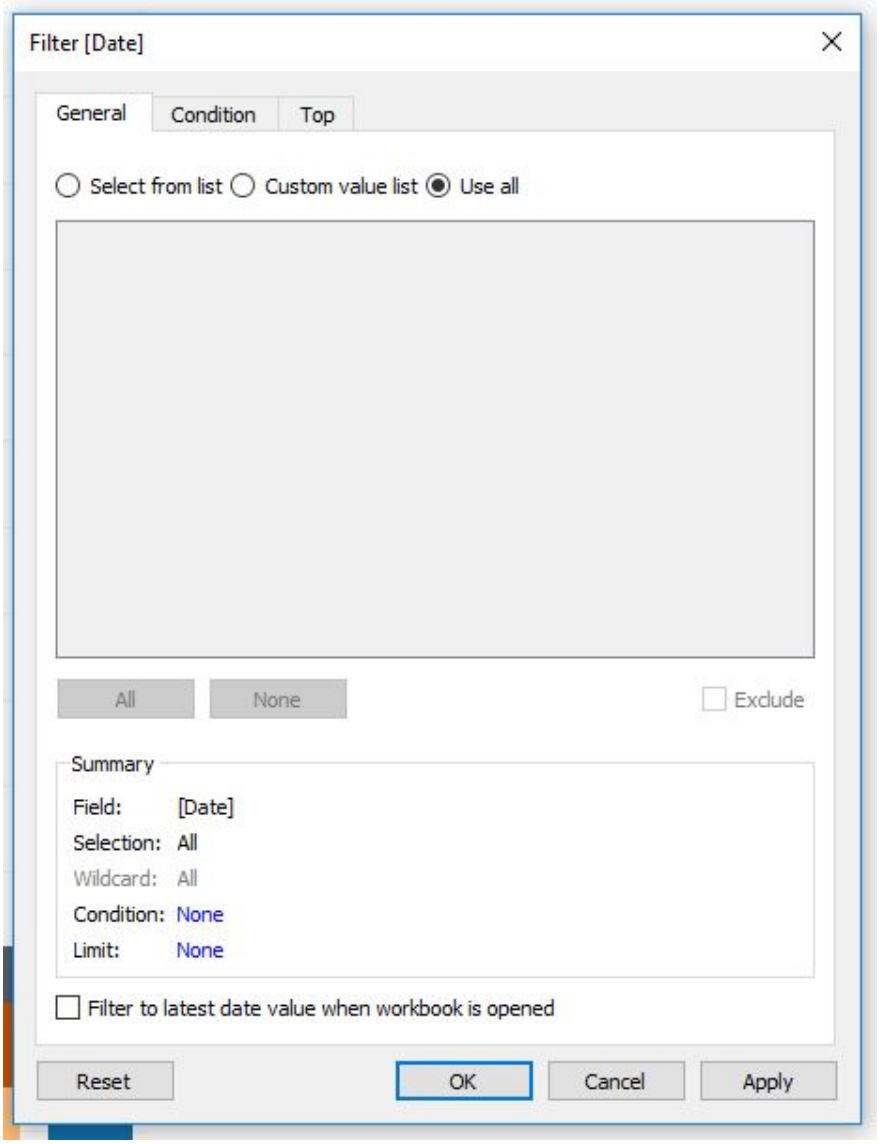


Figure 71. Choosing which dates to use for the filter

4. Next select the dropdown on the Date from the "Filters" box and choose “Show Filter”.

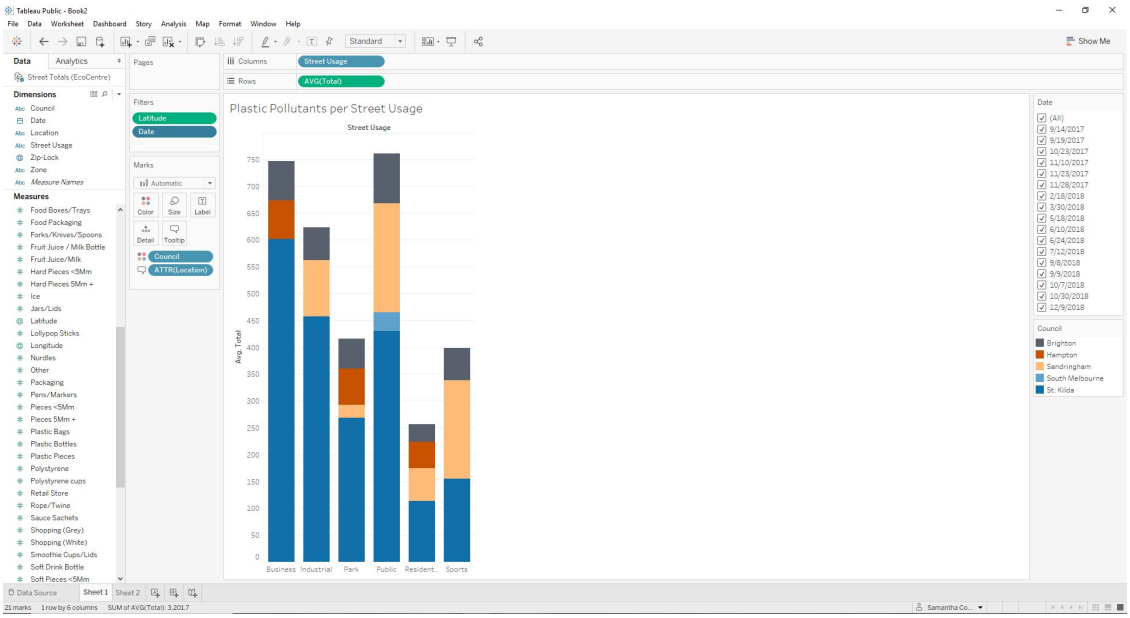


Figure 72. Showing the date filter on the right

5. The date selector can be reformatted by hovering over the word "Date" and clicking on the arrow. This will open a drop down menu that will allow you to reformat the selector based on the style you are trying to achieve. Here we chose a slider and also selected "Only Relevant Values" which will only show the dates where audits occured on the visualisation.

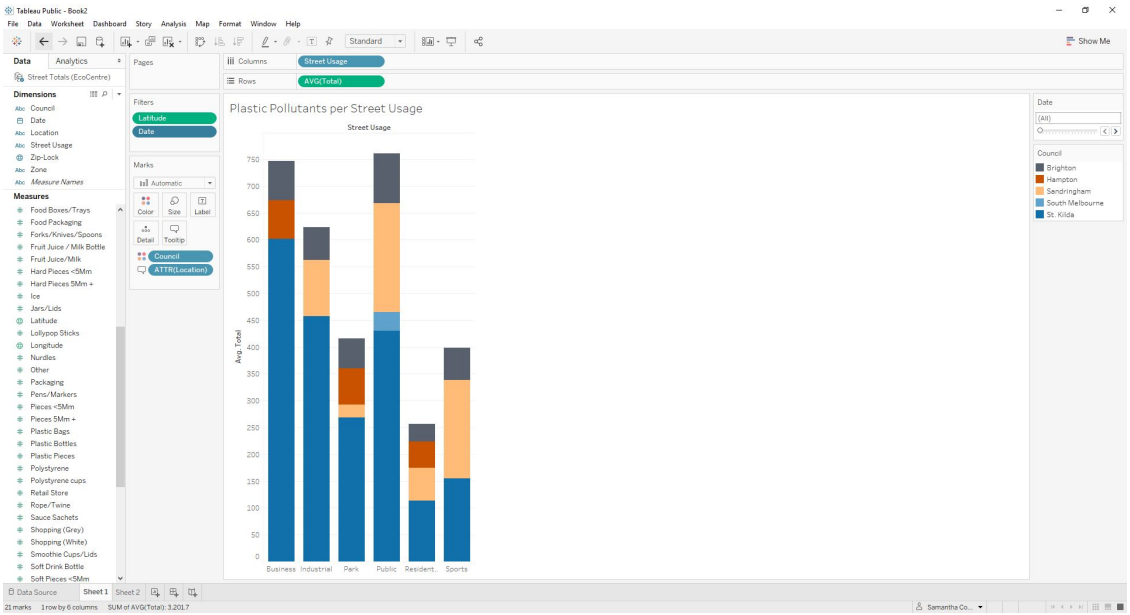


Figure 73. Reformatting the date selector

Creating a GIS Map.

1. Input data that has "Latitude" and "Longitude" columns and ensure that the data was input properly. To do this you will need to locate the measures in the "Measures" box on the left of the screen and ensure that they say “Geometric Role -> Latitude” or "Longitude", depending on the value.

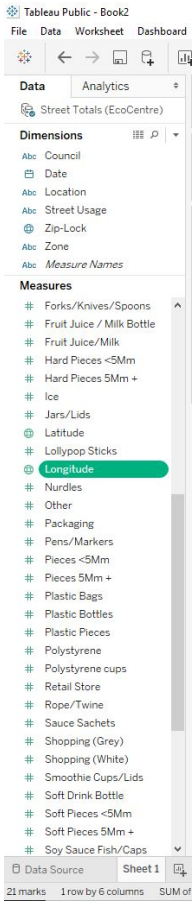


Figure 74. Finding values in the "Measures" box

2. Drag the "Longitude" value to the "Row" box and the "Latitude" value to the "Column" box. Change both of the latitude and longitude values to “Dimensions” rather than “AVG”s.

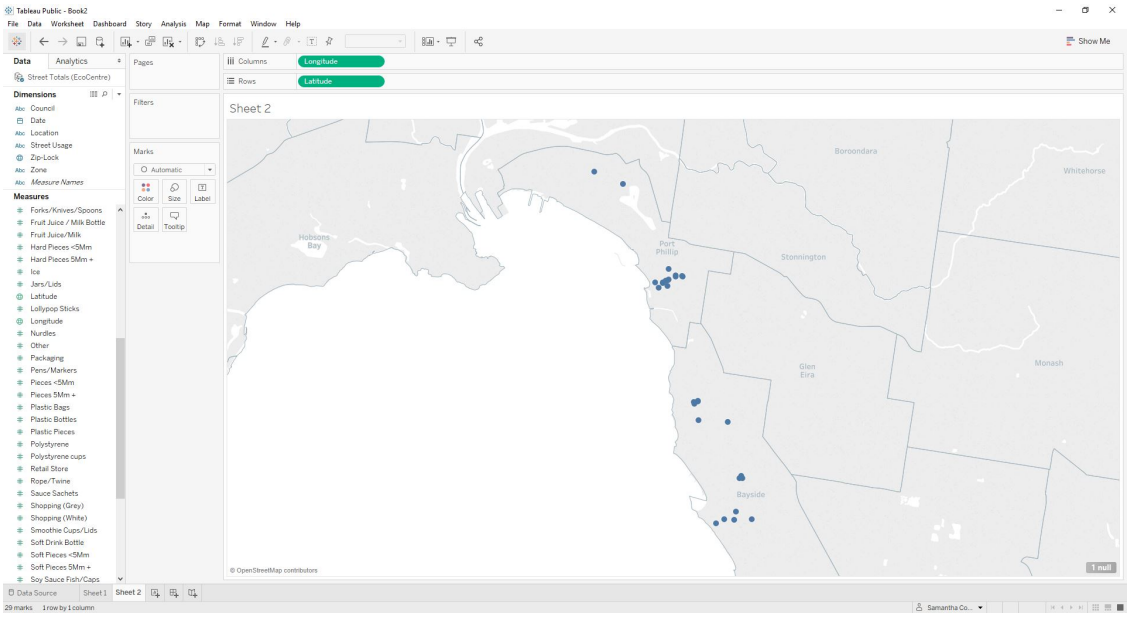


Figure 75. The simple outcome of the GIS map in Tableau

3. To customise the GIS Map, we will have total represented by the size of the dot and street usage represented by the colour. This is shown in the image below.

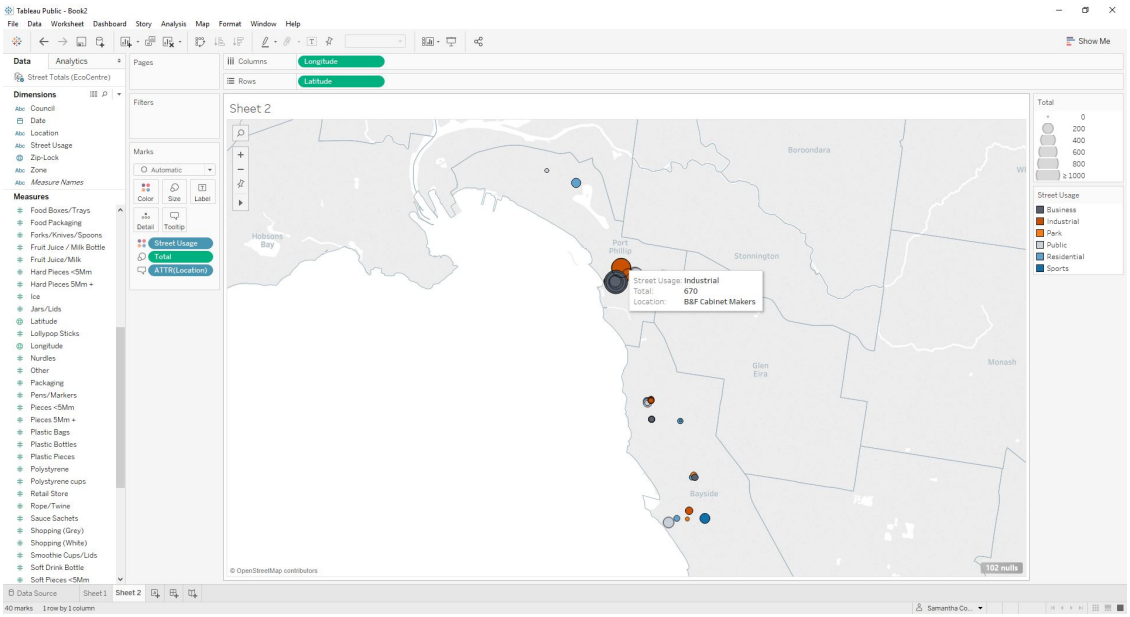


Figure 76. Customising the GIS Map

Creating a Tableau Dashboard.

1. Create a new dashboard by clicking “Dashboard” and “New Dashboard” in the toolbar.

2. Drag the sheets that you want to overlay into the area that says “Drag sheets here”. In this case we will drag “Sheet1” (the bar chart) and “Sheet2” (the GIS Map).

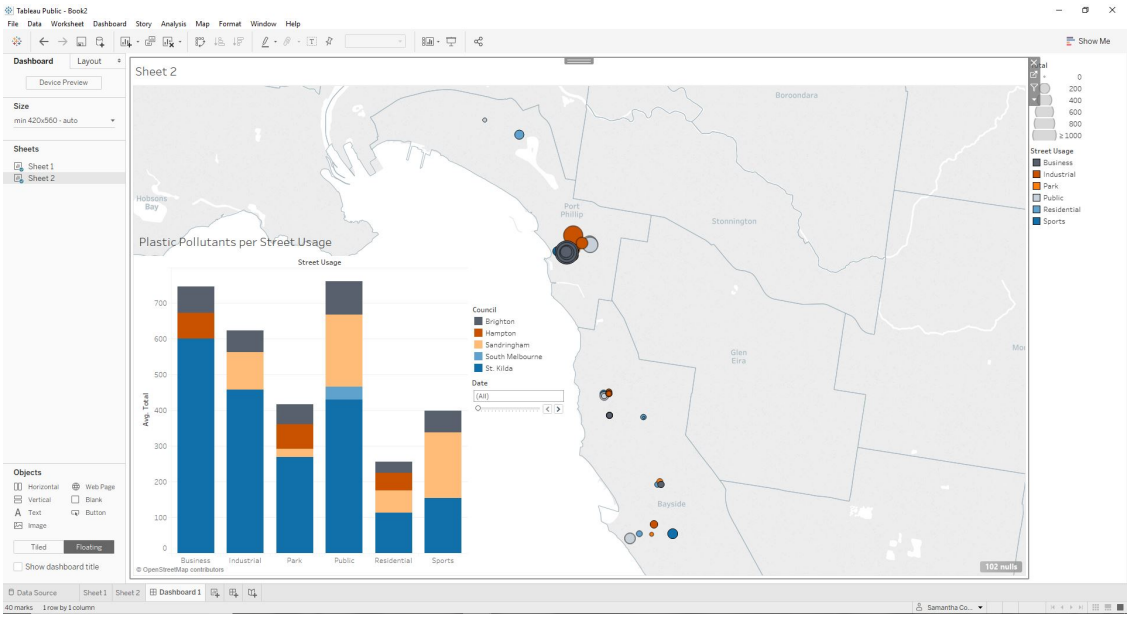


Figure 77. Combining charts into a dashboard

Here we dragged the map onto the sheet, then chose “Floating” at the bottom and dragged “Sheet 1” onto it afterwards.

To move things around, select them and move them using the bars that appear on the top.

3. To apply any filters to both of the sheets simply select the filter, choose the drop down menu, "Apply to Worksheets", "Selected Worksheets", and select the worksheets you want the filter to apply to.

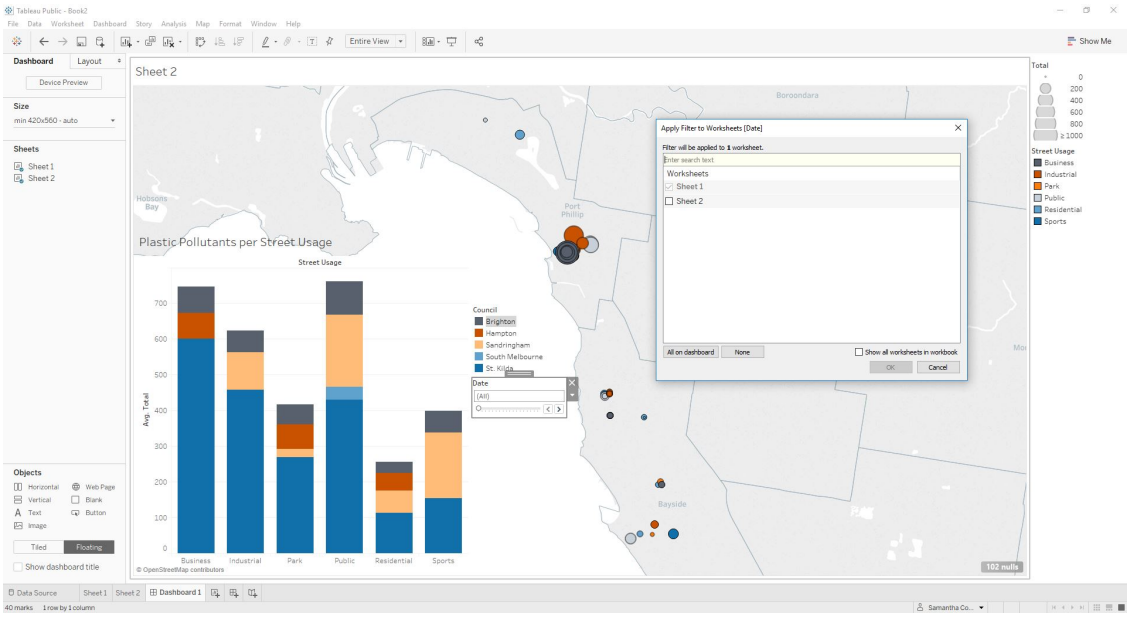


Figure 78. Applying a filter to multiple worksheets in a dashboard

Creating a Tableau Story. The difference between a story and a dashboard that tabs can be added to stories, but not to dashboards. Tabs reduced crowding of the visualisation.

1. Create a new story by clicking “Story” and “New Story”.

2. Double click or drag sheets/dashboards onto the storyboard and rename the tabs based on the desired tab name.

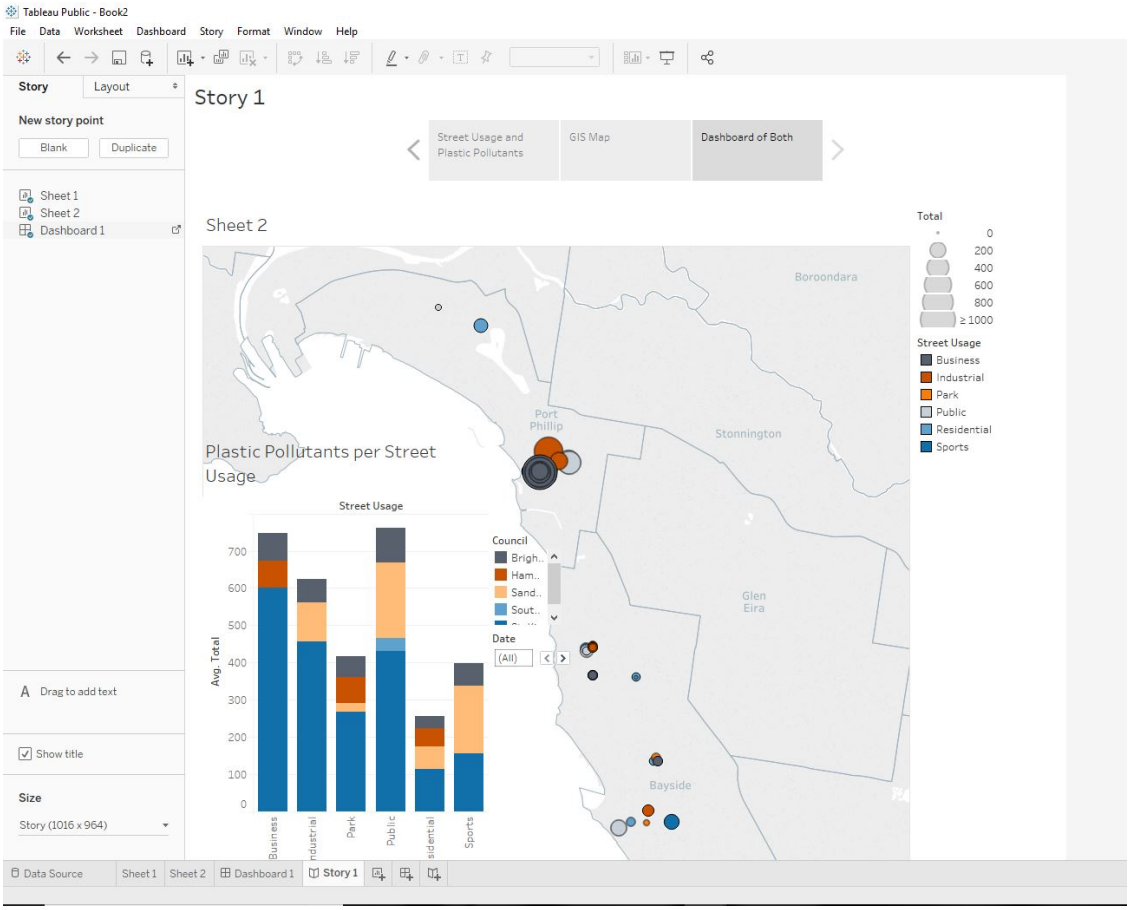


Figure 79. Creating a story with tabs in Tableau

How to Overlap Data Sources.

1. Repeat the steps listed in the *To Input Data* section to input the shape and Excel files.

2. We will need to create a data union.

   Drag the relevant files to the right.

   Click on the union and ensure it is all inclusive. Use two fields that are related, creating a "<>" relationship to include all the data.

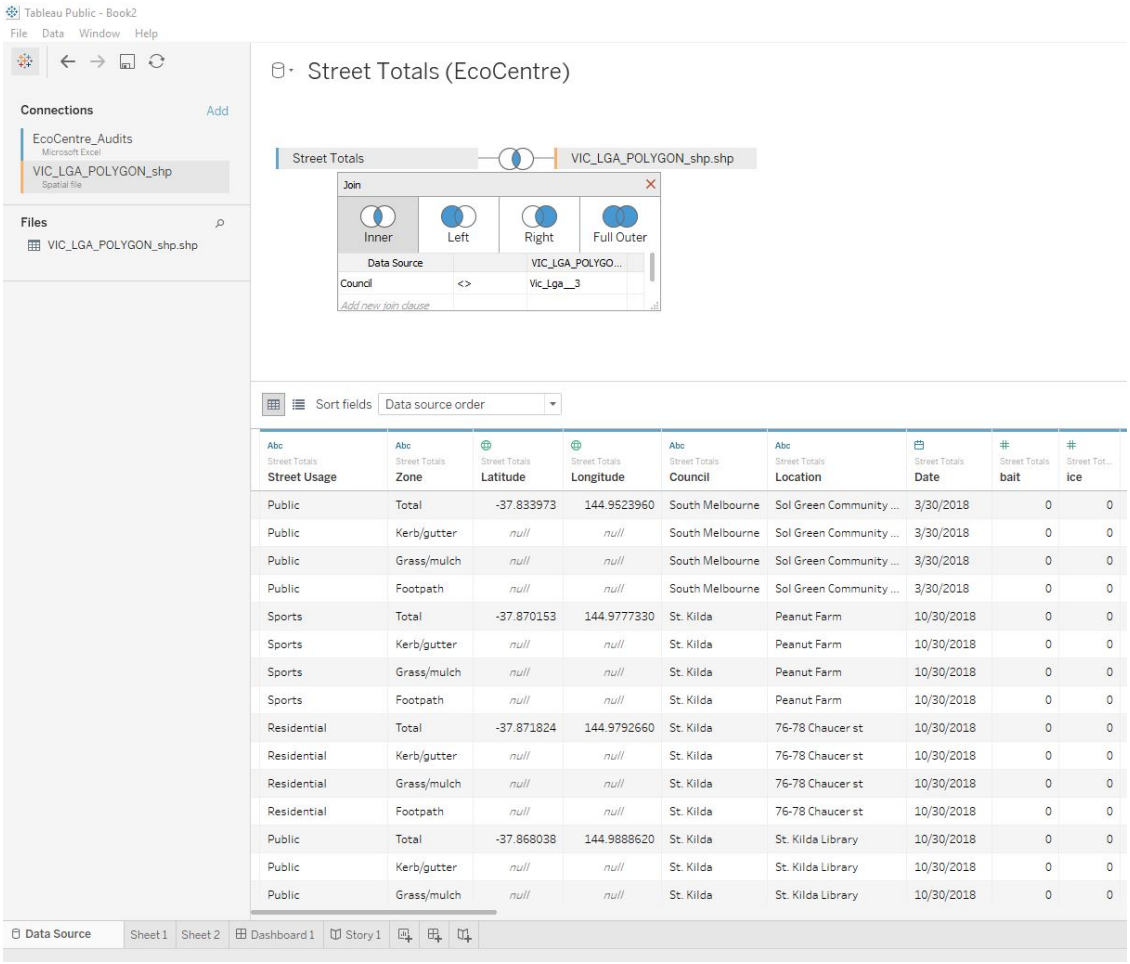


Figure 80. Creating a Union by overlaying shape and Excel files

3. In order to overlay a shapefile and an Excel file, we will begin by creating two maps, side by side.

   First, drag the "Latitude (generated)" and "Longitude (generated)" values to the "Column" and "Row" section respectively. We will add the geometry to the chart from the local government authority (LGA) file for Victoria.

   Next, to create two charts, hold CTRL and drag the "Longitude (generated)" value so there are two longitude values in the "Column" box.

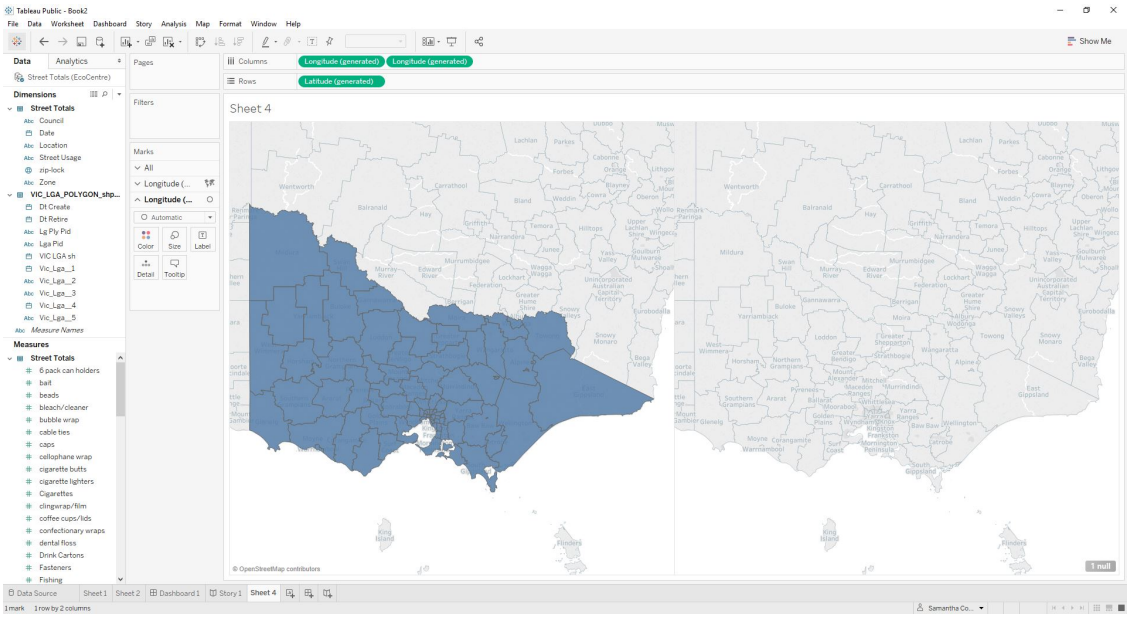


Figure 81. Creating two maps to soon be customised and overlaid

Originally, this had two of the same exact map. To replace those map features with the new features of the beach litter audits, remove the label and detail customisation by dragging the two selectors away from the "Marks" options.

To add new details for the beach litter audits, we drag the "Latitude" and "Longitude" values from the "Measures" area to the detail on the second "Longitude(2)" in the "Marks" options. Ensure the longitude and latitude values are dimensions by clicking the drop down and changing it from "AVG()" to "Dimension". Then we can add the "Total (Dimension)" to the "Size" and the "Location" to the "colour" to add more features.

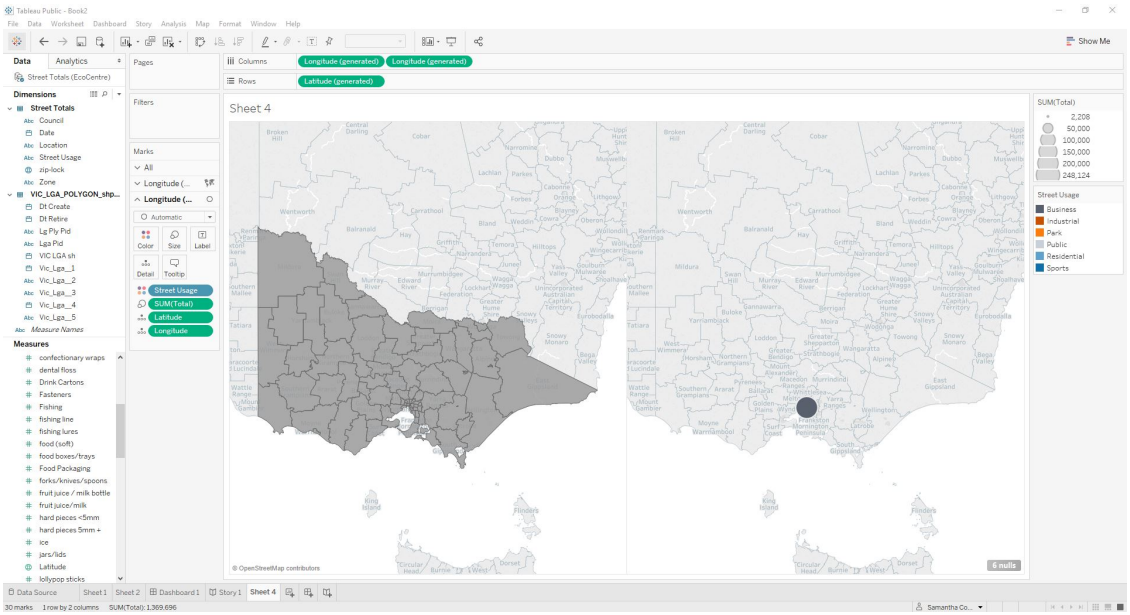


Figure 82. Customising the second map to have the EcoCentre Audit data

4. To combine the maps, select the drop down from the "Longitude (2)" in the "Column" tab, and choose “Dual Axis”

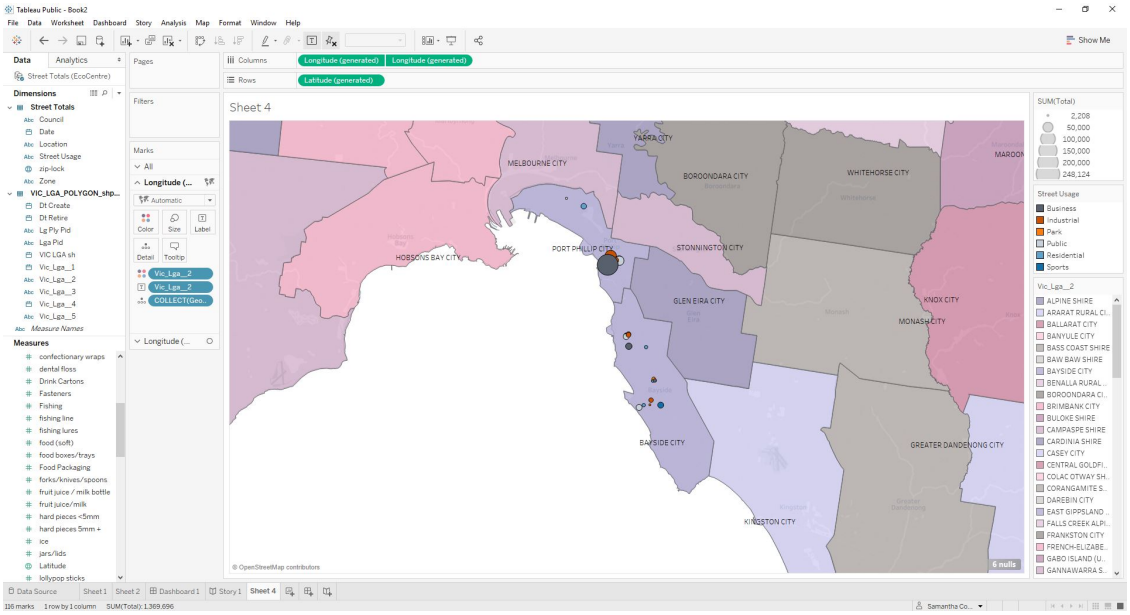


Figure 83. The final overlay of the two datasheets using the union

To access all the examples referenced within this document visit:

`https://public.tableau.com/profile/port.phillip.ecocentre#!/vizhome/IntroToTableau_3/Story`

Editing an Existing Tableau Visualisation. Sometimes, instead of creating a map from scratch you will want to edit an existing map. This is applicable when you want to add new data to a map. To do this, you will need a Tableau Public account and the Tableau Public Application downloaded onto your computer.

1. Find the visualisation you would like to edit online. You will need to download it to your computer using the download workbook button.

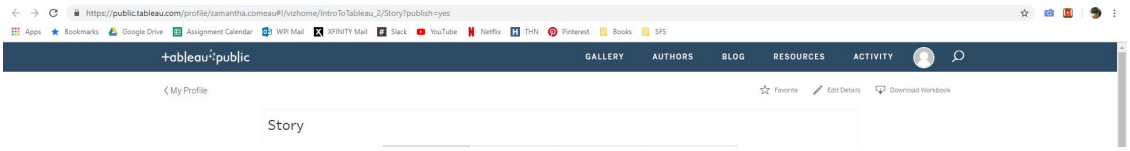


Figure 84. Downloading an existing Tableau workbook off of Public Tableau websites

2. To edit the existing data you will need to go to the "Data Source" tab in the bottom left. To update one of the datasheets, hover over it, select the dropdown and choose “Edit Connection”. Then select your updated datasheet.

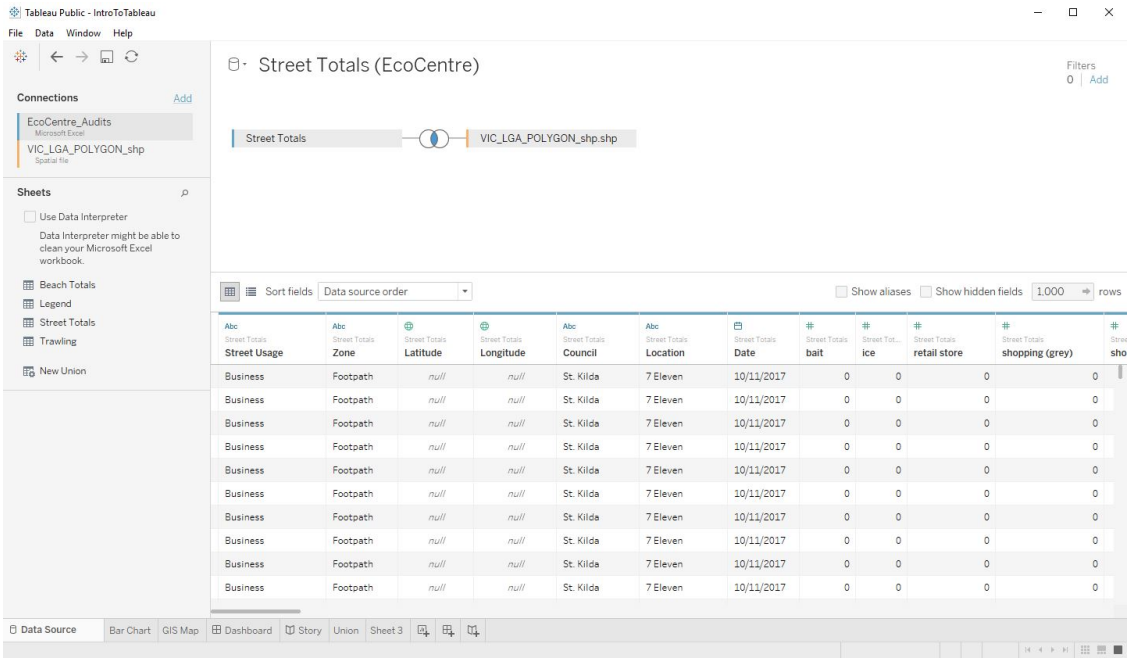


Figure 85. Modifying data using the drop down that appears when you hover over the datasheet and "Edit Connection"

This should automatically update your spreadsheet and data in the charts, if the new sheet is in the same format as the original sheet.

Appendix B.1: Street Litter Audit Sample Spreadsheet

Street Usage	Zone	Latitude	Longitude	Council	Location	Date
Business	Footpath			St Kilda	7 Eleven	10/11/2017
Business	Grass/mulch			St Kilda	7 Eleven	10/11/2017
Business	Kerb/gutter			St Kilda	7 Eleven	10/11/2017
Business	Total	-37.870232	144.980776	St Kilda	7 Eleven	10/11/2017

bait	ice	retail store	shopping (grey)	shopping (white)	zip-lock	Plastic Bags	bleach/cleaner	caps	soft drink bottle	fruit juice / milk bottle	water bottle	Plastic Bottles	Cigarette Butts	fruit juice/milk	straws	Drink Cartons	bubble wrap	cable ties	rope/twine	strapping (scrap)	strapping (whole)	tile spacers	Fasteners	fishing line	fishing lures	Fishing
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

cellophane wrap	cigarette lighters	clingwrap/film	coffee cups/lids	confectionary wraps	food (soft)	forks/knives/spoons	jars/lids	lollypop sticks	6 pack can holders	sauce sachets	smoothie cups/lids	soy sauce fish/caps	takeaway tubs/lids	Food Packaging	dental floss	pens/markers	syringes	Medical/Cosmetic	nurdles	hard pieces <5mm	hard pieces 5mm +	soft pieces <5mm	soft pieces 5mm +	Plastic Pieces	beads	Polystyrene cups	food boxes/trays	pieces <5mm	pieces 5mm +	packaging	Polystyrene	other	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 86. Sample Street Litter Audit Spreadsheet

Appendix B.2: Beach Litter Audit Sample Spreadsheet

Transect	Quadrat	Latitude	Longitude	Location	Date
Narrowest	Top			Eastern Geelong	03/11/2017
Middle	Top			Eastern Geelong	03/11/2017
Widest	Top			Eastern Geelong	03/11/2017
Top Total	Top			Eastern Geelong	03/11/2017
Narrowest	Middle			Eastern Geelong	03/11/2017
Middle	Middle			Eastern Geelong	03/11/2017
Widest	Middle			Eastern Geelong	03/11/2017
Middle Total	Middle			Eastern Geelong	03/11/2017
Narrowest	Lower			Eastern Geelong	03/11/2017
Middle	Lower			Eastern Geelong	03/11/2017
Widest	Lower			Eastern Geelong	03/11/2017
Lower Total	Lower			Eastern Geelong	03/11/2017
Total Total		-38.146563	144.36924	Eastern Geelong	03/11/2017

bait	ice	retail store	shopping (grey)	shopping (white)	zip lock	Plastic Bags	bleach/cleaner	caps	soft drink bottle	fruit juice / milk bottle	water bottle	Plastic Bottles	Cigarette Butts	fruit juice/milk	straws	Drink Cartons	bubble wrap	cable ties	rope/twine	strapping (scrap)	strapping (whole)	tile spacers	Fasteners	fishing line	fishing lures	Fishing
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Cellophane Wrap	Cigarette Lighters	clingwrap/film	cups	confectionary wraps	food (soft)	forks/knives/spoons	jars/lids	lolypop sticks	6 pack can holders	sauce sachets	smoothie cups/lids	soy sauce fish/caps	takeaway tubs/lids	Food Packaging	dental floss	pens/markers	syringes	User Items	nurdles	hard pieces <5mm	hard pieces 5mm +	soft pieces <5mm	soft pieces 5mm +	Plastic Pieces	beads	cups	food boxes/trays	pieces <5mm	pieces 5mm +	packaging	Polystyrene	Other	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 87. Sample Beach Litter Audit Spreadsheet

Appendix B.3: River Litter Audit Sample Spreadsheet

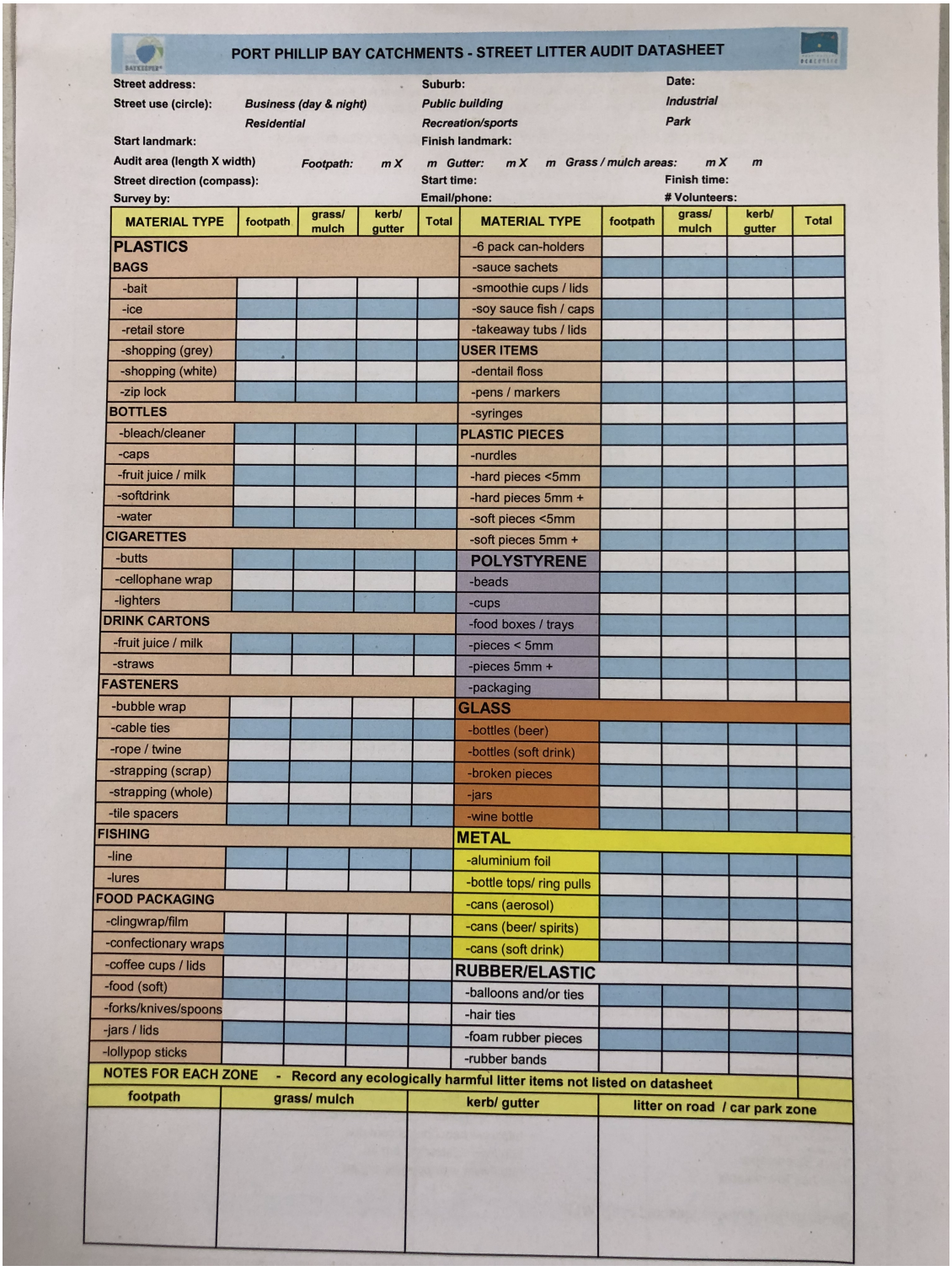
WATERWAY	SOCK	ID	Date	Season	Start lat	Start long	Finish lat	Finish long	Average lat	Average long
Maribyrnong	Blue	M1	07/01/2015	Summer	-37.81782	144.90614	-37.805803	144.90776	-37.811812	144.90695

Maribyrnong () Yarra (Southbank)River Max (m)	River Min (m)	River Mean (m)	Trawl speed	Organic mass (g)	Microplastic mass (g)	Total Mass (g)	% Microplastic
0.3	-0.44	0.007	1000 RPM	N/A	0.455	N/A	N/A

Hard<2	Hard2-5	Hard6-10	Hard10+	PlasticCaps	Hard Plastics	Nurdles	Poly<4	Poly4+	Polystyrene	soft Plastic<5	SoftPlastic 5+	Cello <5	Cello 5+	Soft Plastics	Cigarette Butts	PlasticStraws	Sponge	Twine/line	Lolly	Other Other	Other	Total	TotalMicro<5	Micro for report
36	2	7	1	0	**46**	2	6	24	**30**	0	0	0	0	0	0	0	0	0	0	0	**0**	**78**	**46**	46

Figure 88. Sample River Litter Audit Spreadsheet

Appendix C: Collection Methods for Street Litter Audits



PORT PHILLIP BAY CATCHMENTS - STREET LITTER AUDIT DATASHEET

Street address: | Suburb: | Date:

Street use (circle): *Business (day & night)* *Public building* *Industrial*
Residential *Recreation/sports* *Park*

Start landmark: | Finish landmark:

Audit area (length X width) *Footpath:* *m X* *m* *Gutter:* *m X* *m* *Grass / mulch areas:* *m X* *m*

Street direction (compass): | Start time: | Finish time:

Survey by: | Email/phone: | # Volunteers:

MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
PLASTICS				
BAGS				
-bait				
-ice				
-retail store				
-shopping (grey)				
-shopping (white)				
-zip lock				
BOTTLES				
-bleach/cleaner				
-caps				
-fruit juice / milk				
-softdrink				
-water				
CIGARETTES				
-butts				
-cellophane wrap				
-lighters				
DRINK CARTONS				
-fruit juice / milk				
-straws				
FASTENERS				
-bubble wrap				
-cable ties				
-rope / twine				
-strapping (scrap)				
-strapping (whole)				
-tile spacers				
FISHING				
-line				
-lures				
FOOD PACKAGING				
-clingwrap/film				
-confectionary wraps				
-coffee cups / lids				
-food (soft)				
-forks/knives/spoons				
-jars / lids				
-lollypop sticks				

MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
-6 pack can-holders				
-sauce sachets				
-smoothie cups / lids				
-soy sauce fish / caps				
-takeaway tubs / lids				
USER ITEMS				
-dentail floss				
-pens / markers				
-syringes				
PLASTIC PIECES				
-nurdles				
-hard pieces <5mm				
-hard pieces 5mm +				
-soft pieces <5mm				
-soft pieces 5mm +				
POLYSTYRENE				
-beads				
-cups				
-food boxes / trays				
-pieces < 5mm				
-pieces 5mm +				
-packaging				
GLASS				
-bottles (beer)				
-bottles (soft drink)				
-broken pieces				
-jars				
-wine bottle				
METAL				
-aluminium foil				
-bottle tops/ ring pulls				
-cans (aerosol)				
-cans (beer/ spirits)				
-cans (soft drink)				
RUBBER/ELASTIC				
-balloons and/or ties				
-hair ties				
-foam rubber pieces				
-rubber bands				

NOTES FOR EACH ZONE - Record any ecologically harmful litter items not listed on datasheet

footpath	grass/ mulch	kerb/ gutter	litter on road / car park zone

Figure 89. Street Litter Audit Page 1

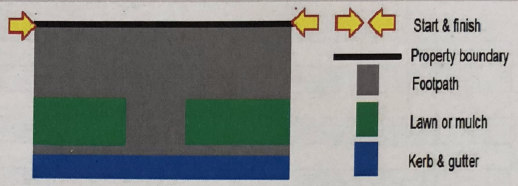
GUIDE TO STREET LITTER AUDITS

BEFORE YOU START: Do **Street2Bay Audits Summary Checklist.** Have First Aid Kit and gloves on-site. Check entire site to note possible hazards. As this audit involves data collection near roads and car park bays a JOB SAFETY OBSERVER MUST BE APPOINTED to
WARN DATA COLLECTORS OF ANY CAR MOVEMENTS (INCLUDING CAR DOORS OPENING).
Warn all collectors: DON'T PUT YOUR FINGERS WHERE YOU CAN'T SEE THEM! DO NOT COLLECT SYRINGES. Use dustpan for glass. REMAIN ON KERB WHEN COLLECTING FROM GUTTER AREA. DO NOT STAND ON STREET OR IN GUTTER or CAR PARK AREA.

PURPOSE: Reference sites on streets are regularly audited to track any increase or decrease of litter items that are known to threaten wildlife and/or human health, or are the subject of ongoing campaigns, eg Container Deposit Legislation. The data will help make a case for legislation, education, infrastructure and enforcement to reduce these items in our waterways.

The data is entered into the Port Phillip Bay Litter Database and the 'Australian Marine Debris Initiative Database'.

Litter is recorded as collected from 3 zones (defined areas for which observations/records are made) located at the footpath, grass and/or mulch beds, and gutter zones of the street frontage to quantify litter from source to the stormwater system.



EQUIPMENT: safety cheklist, tape measure, dustpan/broom, compass, clip board, datasheet, pen, chalk, gloves, 3 buckets (1 per zone).

GUIDE TO AUDIT SET-UP

1. Each audit zone (footpath, gutter and car park) runs the entire length of the property frontage.
   Permanent landmark structures at the property boundaries serve as the starting point for repeated surveys.
2. Describe the survey start & finish points (at the property boundary) in the 'Start Landmark' and "Finish landmark" fields at top of the datasheet.
3. Measure and record the length between the property boundary landmarks; then the width of each zone.
4. At the start landmark , use a compass to record the direction along the streeet. Record the direction on the datasheet.
5. Use chalk to mark the ends of the audit area at the property line and gutter.
6. Begin litter data collection in zone 1 (footpath), proceeding to zone 2 (grass and/or mulch beds) and zone 3 (kerb & gutter).

TIPS ON LITTER COLLECTION

TO SAVE TIME: Divide group into 3 (1 for each zone). Teams collect and put all litter in the bucket for their zone. Counting and data recording should be done after all litter is collected.

Litter in audit area zones is to be collected, recorded, bagged, and responsibly disposed.
Note: Any litter collected from outside the audit zones is NOT TO BE RECORDED ON THIS DATASHEET.

Do not record food and paper as they ARE NOT ECOLOGICALLY HARMFUL.

TIPS ON DATA RECORDING

Be sure to complete all details at the top of datasheet!

Please write clearly! Any errors should be crossed out with an X (not squiggly lines).
Record the number of each item in the correct zone column (Footpath, Grass/mulch or Kerb & gutter).
Any harmful litter items found that are not on the datasheet can be recorded in NOTES FOR EACH ZONE.

Take photos of litter collected from each zone and the completed audit sheet and send to: baykeeper@ecocentre.com
Questions: Call Neil Blake on 0409 138 565

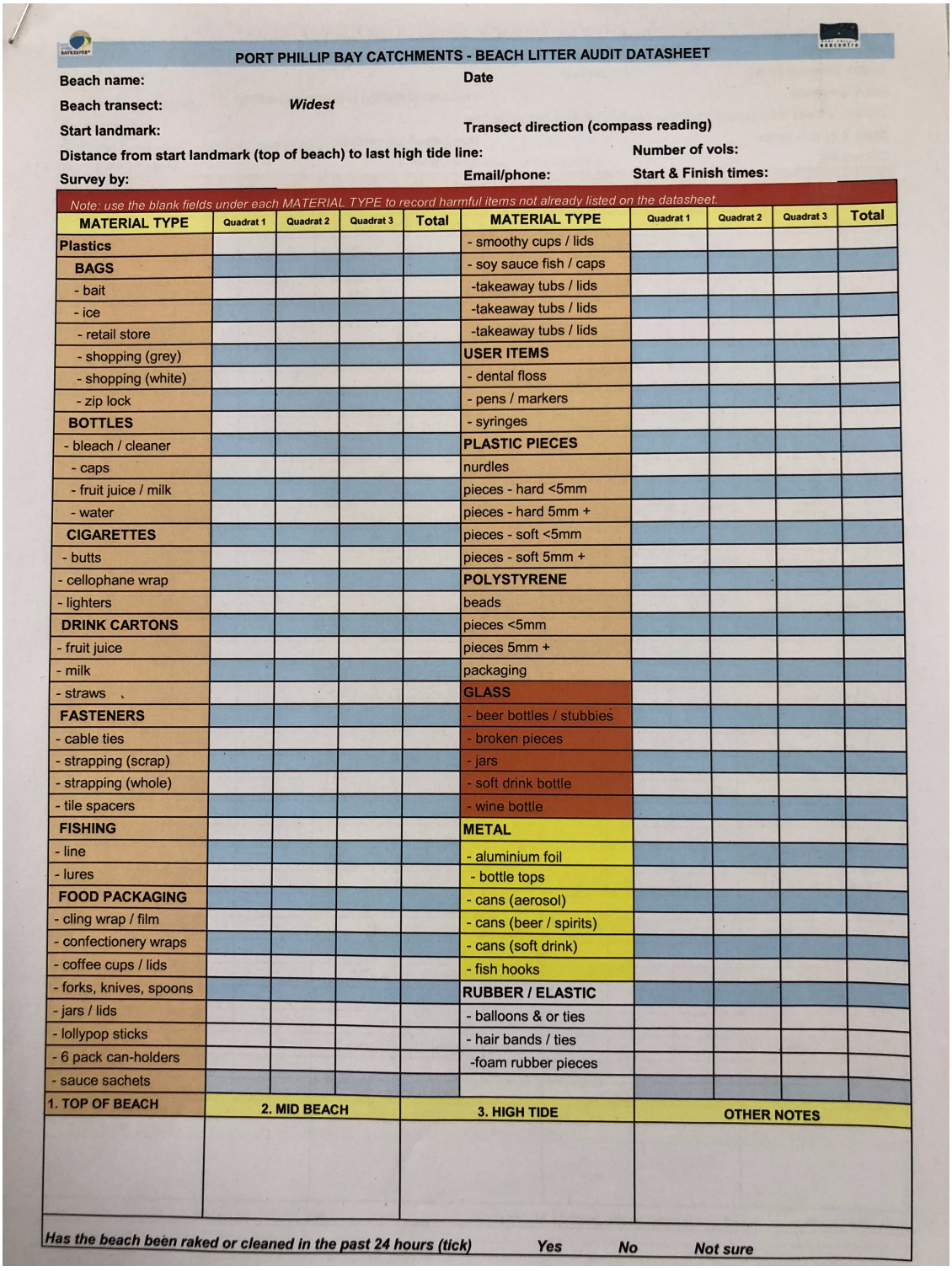
More Information:

Australian Marine Debris Initiative Database	http://tangaroablue.org/database.htlm
Victorian Litter Action Alliance	http://www.litter.vic.gov.au/
CSIRO	http://blog.csiro.au/tag/marine-debris
Beach Patrol Australia	http:www.beachpatrol.com.au/
Yarra Riverkeeper	http://www.yarrariver.org.au
Werribee Riverkeeper	http://www.werribeeriver.org.au

Street to Bay Project sponsored by DEWLP

Figure 90. Street Litter Audit Page 2

Appendix D: Collection Methods for Beach Litter Audits



PORT PHILLIP BAY CATCHMENTS - BEACH LITTER AUDIT DATASHEET

Beach name: Date

Beach transect: *Widest*

Start landmark: Transect direction (compass reading)

Distance from start landmark (top of beach) to last high tide line: Number of vols:

Survey by: Email/phone: Start & Finish times:

Note: use the blank fields under each MATERIAL TYPE to record harmful items not already listed on the datasheet.

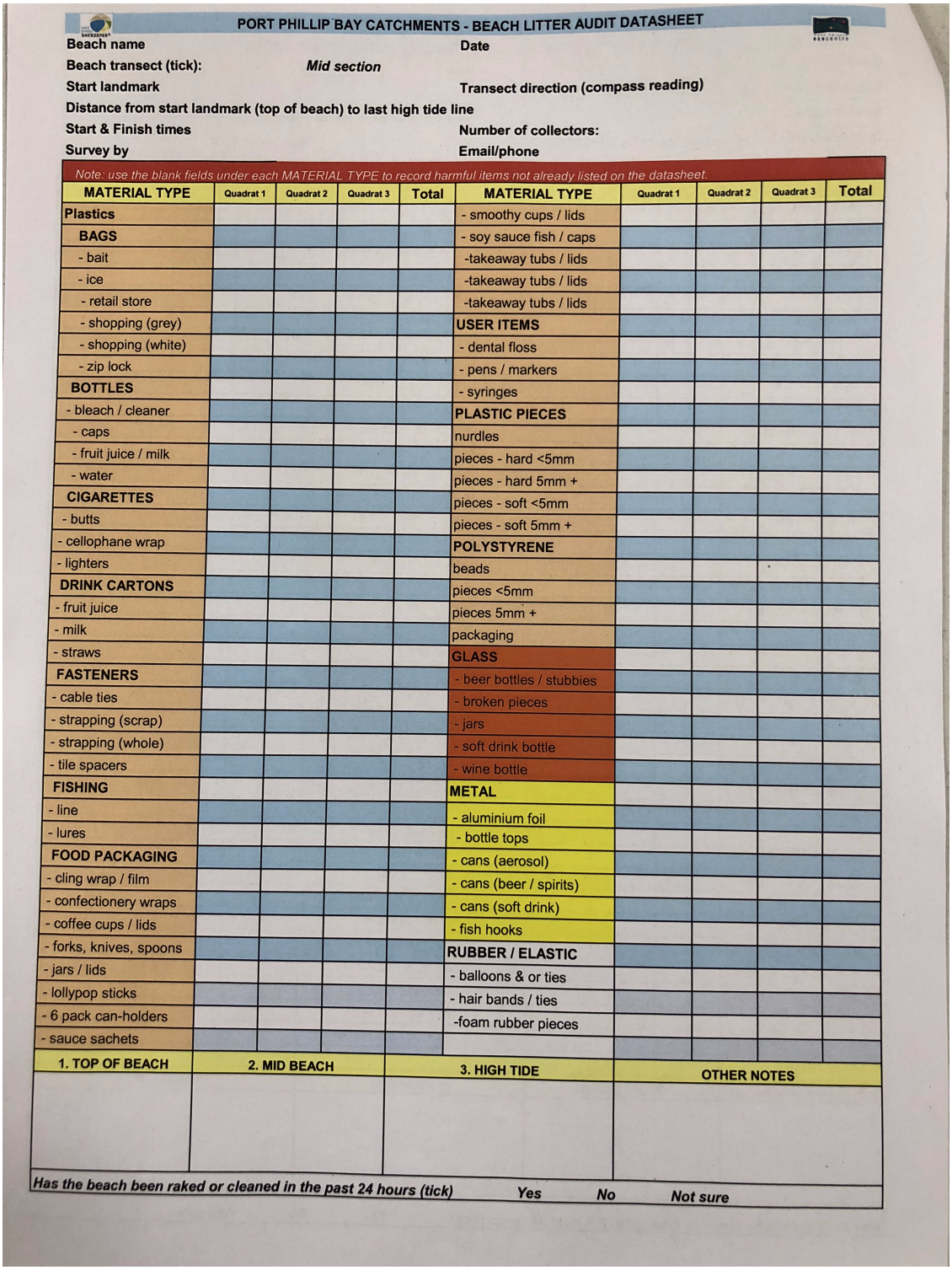
MATERIAL TYPE	Quadrat 1	Quadrat 2	Quadrat 3	Total
Plastics				
BAGS				
- bait				
- ice				
- retail store				
- shopping (grey)				
- shopping (white)				
- zip lock				
BOTTLES				
- bleach / cleaner				
- caps				
- fruit juice / milk				
- water				
CIGARETTES				
- butts				
- cellophane wrap				
- lighters				
DRINK CARTONS				
- fruit juice				
- milk				
- straws				
FASTENERS				
- cable ties				
- strapping (scrap)				
- strapping (whole)				
- tile spacers				
FISHING				
- line				
- lures				
FOOD PACKAGING				
- cling wrap / film				
- confectionery wraps				
- coffee cups / lids				
- forks, knives, spoons				
- jars / lids				
- lollypop sticks				
- 6 pack can-holders				
- sauce sachets				

MATERIAL TYPE	Quadrat 1	Quadrat 2	Quadrat 3	Total
- smoothy cups / lids				
- soy sauce fish / caps				
-takeaway tubs / lids				
-takeaway tubs / lids				
-takeaway tubs / lids				
USER ITEMS				
- dental floss				
- pens / markers				
- syringes				
PLASTIC PIECES				
nurdles				
pieces - hard <5mm				
pieces - hard 5mm +				
pieces - soft <5mm				
pieces - soft 5mm +				
POLYSTYRENE				
beads				
pieces <5mm				
pieces 5mm +				
packaging				
GLASS				
- beer bottles / stubbies				
- broken pieces				
- jars				
- soft drink bottle				
- wine bottle				
METAL				
- aluminium foil				
- bottle tops				
- cans (aerosol)				
- cans (beer / spirits)				
- cans (soft drink)				
- fish hooks				
RUBBER / ELASTIC				
- balloons & or ties				
- hair bands / ties				
-foam rubber pieces				

1. TOP OF BEACH	2. MID BEACH	3. HIGH TIDE	OTHER NOTES

Has the beach been raked or cleaned in the past 24 hours (tick) *Yes* *No* *Not sure*

Figure 91. Beach Litter Audit Page 1



PORT PHILLIP BAY CATCHMENTS - BEACH LITTER AUDIT DATASHEET

Beach name **Date**

Beach transect (tick): ***Mid section***

Start landmark **Transect direction (compass reading)**

Distance from start landmark (top of beach) to last high tide line

Start & Finish times **Number of collectors:**

Survey by **Email/phone**

Note: use the blank fields under each MATERIAL TYPE to record harmful items not already listed on the datasheet.

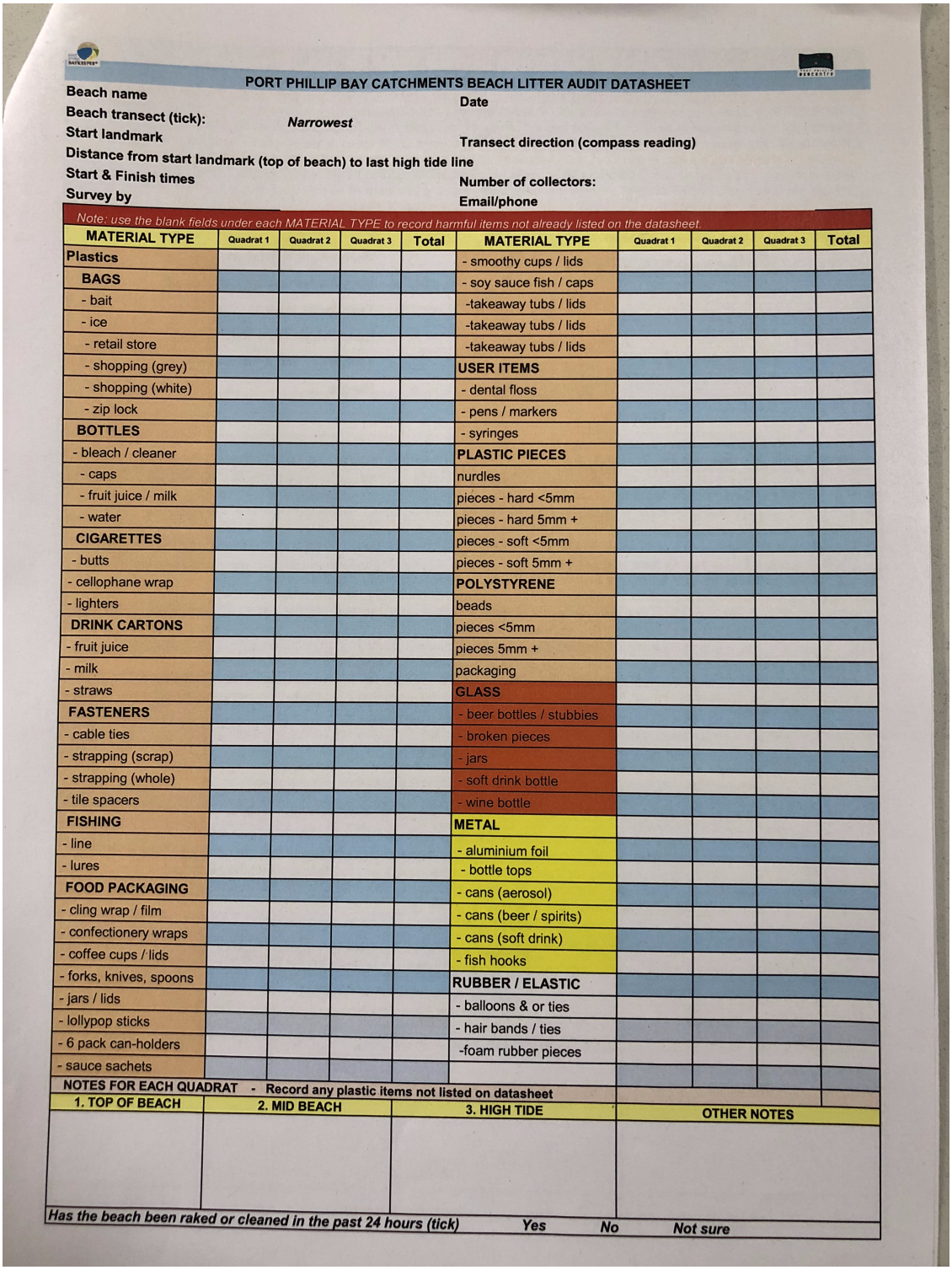
MATERIAL TYPE	Quadrat 1	Quadrat 2	Quadrat 3	Total
Plastics				
BAGS				
- bait				
- ice				
- retail store				
- shopping (grey)				
- shopping (white)				
- zip lock				
BOTTLES				
- bleach / cleaner				
- caps				
- fruit juice / milk				
- water				
CIGARETTES				
- butts				
- cellophane wrap				
- lighters				
DRINK CARTONS				
- fruit juice				
- milk				
- straws				
FASTENERS				
- cable ties				
- strapping (scrap)				
- strapping (whole)				
- tile spacers				
FISHING				
- line				
- lures				
FOOD PACKAGING				
- cling wrap / film				
- confectionery wraps				
- coffee cups / lids				
- forks, knives, spoons				
- jars / lids				
- lollypop sticks				
- 6 pack can-holders				
- sauce sachets				

MATERIAL TYPE	Quadrat 1	Quadrat 2	Quadrat 3	Total
- smoothy cups / lids				
- soy sauce fish / caps				
-takeaway tubs / lids				
-takeaway tubs / lids				
-takeaway tubs / lids				
USER ITEMS				
- dental floss				
- pens / markers				
- syringes				
PLASTIC PIECES				
nurdles				
pieces - hard <5mm				
pieces - hard 5mm +				
pieces - soft <5mm				
pieces - soft 5mm +				
POLYSTYRENE				
beads				
pieces <5mm				
pieces 5mm +				
packaging				
GLASS				
- beer bottles / stubbies				
- broken pieces				
- jars				
- soft drink bottle				
- wine bottle				
METAL				
- aluminium foil				
- bottle tops				
- cans (aerosol)				
- cans (beer / spirits)				
- cans (soft drink)				
- fish hooks				
RUBBER / ELASTIC				
- balloons & or ties				
- hair bands / ties				
-foam rubber pieces				

1. TOP OF BEACH	2. MID BEACH	3. HIGH TIDE	OTHER NOTES

Has the beach been raked or cleaned in the past 24 hours (tick) ***Yes*** ***No*** ***Not sure***

Figure 92. Beach Litter Audit Page 2



PORT PHILLIP BAY CATCHMENTS BEACH LITTER AUDIT DATASHEET

Beach name **Date**

Beach transect (tick): ***Narrowest***

Start landmark **Transect direction (compass reading)**

Distance from start landmark (top of beach) to last high tide line

Start & Finish times **Number of collectors:**

Survey by **Email/phone**

Note: use the blank fields under each MATERIAL TYPE to record harmful items not already listed on the datasheet.

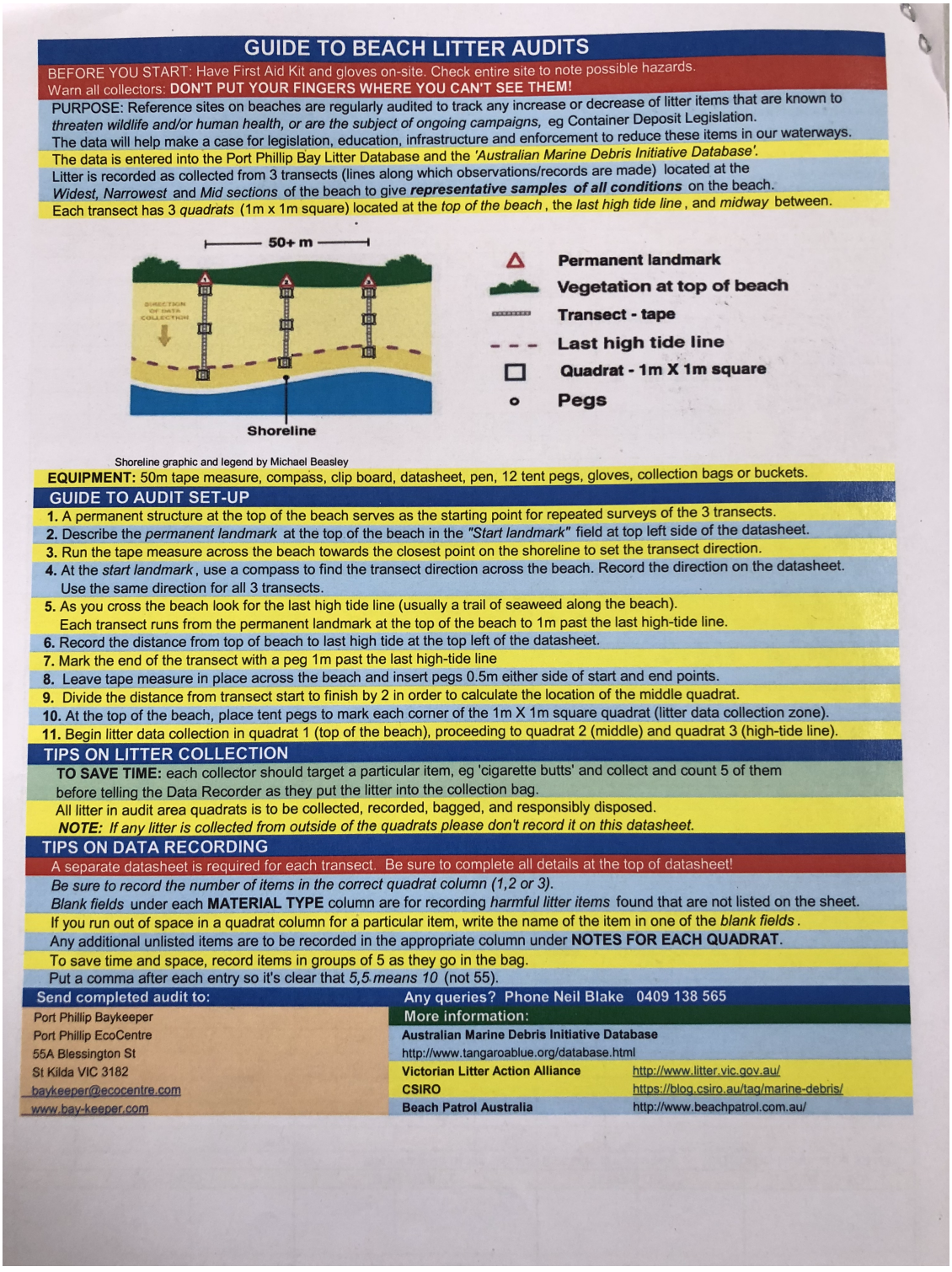
MATERIAL TYPE	Quadrat 1	Quadrat 2	Quadrat 3	Total	MATERIAL TYPE	Quadrat 1	Quadrat 2	Quadrat 3	Total
Plastics					- smoothy cups / lids				
BAGS					- soy sauce fish / caps				
- bait					-takeaway tubs / lids				
- ice					-takeaway tubs / lids				
- retail store					-takeaway tubs / lids				
- shopping (grey)					**USER ITEMS**				
- shopping (white)					- dental floss				
- zip lock					- pens / markers				
BOTTLES					- syringes				
- bleach / cleaner					**PLASTIC PIECES**				
- caps					nurdles				
- fruit juice / milk					pieces - hard <5mm				
- water					pieces - hard 5mm +				
CIGARETTES					pieces - soft <5mm				
- butts					pieces - soft 5mm +				
- cellophane wrap					**POLYSTYRENE**				
- lighters					beads				
DRINK CARTONS					pieces <5mm				
- fruit juice					pieces 5mm +				
- milk					packaging				
- straws					**GLASS**				
FASTENERS					- beer bottles / stubbies				
- cable ties					- broken pieces				
- strapping (scrap)					- jars				
- strapping (whole)					- soft drink bottle				
- tile spacers					- wine bottle				
FISHING					**METAL**				
- line					- aluminium foil				
- lures					- bottle tops				
FOOD PACKAGING					- cans (aerosol)				
- cling wrap / film					- cans (beer / spirits)				
- confectionery wraps					- cans (soft drink)				
- coffee cups / lids					- fish hooks				
- forks, knives, spoons					**RUBBER / ELASTIC**				
- jars / lids					- balloons & or ties				
- lollypop sticks					- hair bands / ties				
- 6 pack can-holders					-foam rubber pieces				
- sauce sachets									

NOTES FOR EACH QUADRAT - Record any plastic items not listed on datasheet

1. TOP OF BEACH	2. MID BEACH	3. HIGH TIDE	OTHER NOTES

Has the beach been raked or cleaned in the past 24 hours (tick) ***Yes*** ***No*** ***Not sure***

Figure 93. Beach Litter Audit Page 3



GUIDE TO BEACH LITTER AUDITS

BEFORE YOU START: Have First Aid Kit and gloves on-site. Check entire site to note possible hazards.
Warn all collectors: **DON'T PUT YOUR FINGERS WHERE YOU CAN'T SEE THEM!**

PURPOSE: Reference sites on beaches are regularly audited to track any increase or decrease of litter items that are known to *threaten wildlife and/or human health, or are the subject of ongoing campaigns,* eg Container Deposit Legislation.
The data will help make a case for legislation, education, infrastructure and enforcement to reduce these items in our waterways.
The data is entered into the Port Phillip Bay Litter Database and the *'Australian Marine Debris Initiative Database'.*
Litter is recorded as collected from 3 transects (lines along which observations/records are made) located at the *Widest, Narrowest* and *Mid sections* of the beach to give ***representative samples of all conditions*** on the beach.
Each transect has 3 *quadrats* (1m x 1m square) located at the *top of the beach*, the *last high tide line*, and *midway* between.

Shoreline graphic and legend by Michael Beasley

EQUIPMENT: 50m tape measure, compass, clip board, datasheet, pen, 12 tent pegs, gloves, collection bags or buckets.

GUIDE TO AUDIT SET-UP

1. A permanent structure at the top of the beach serves as the starting point for repeated surveys of the 3 transects.
2. Describe the *permanent landmark* at the top of the beach in the *"Start landmark"* field at top left side of the datasheet.
3. Run the tape measure across the beach towards the closest point on the shoreline to set the transect direction.
4. At the *start landmark*, use a compass to find the transect direction across the beach. Record the direction on the datasheet. Use the same direction for all 3 transects.
5. As you cross the beach look for the last high tide line (usually a trail of seaweed along the beach). Each transect runs from the permanent landmark at the top of the beach to 1m past the last high-tide line.
6. Record the distance from top of beach to last high tide at the top left of the datasheet.
7. Mark the end of the transect with a peg 1m past the last high-tide line
8. Leave tape measure in place across the beach and insert pegs 0.5m either side of start and end points.
9. Divide the distance from transect start to finish by 2 in order to calculate the location of the middle quadrat.
10. At the top of the beach, place tent pegs to mark each corner of the 1m X 1m square quadrat (litter data collection zone).
11. Begin litter data collection in quadrat 1 (top of the beach), proceeding to quadrat 2 (middle) and quadrat 3 (high-tide line).

TIPS ON LITTER COLLECTION

TO SAVE TIME: each collector should target a particular item, eg 'cigarette butts' and collect and count 5 of them before telling the Data Recorder as they put the litter into the collection bag.
All litter in audit area quadrats is to be collected, recorded, bagged, and responsibly disposed.
NOTE: *If any litter is collected from outside of the quadrats please don't record it on this datasheet.*

TIPS ON DATA RECORDING

A separate datasheet is required for each transect. Be sure to complete all details at the top of datasheet!
Be sure to record the number of items in the correct quadrat column (1,2 or 3).
Blank fields under each **MATERIAL TYPE** column are for recording *harmful litter items* found that are not listed on the sheet.
If you run out of space in a quadrat column for a particular item, write the name of the item in one of the *blank fields*.
Any additional unlisted items are to be recorded in the appropriate column under **NOTES FOR EACH QUADRAT**.
To save time and space, record items in groups of 5 as they go in the bag.
Put a comma after each entry so it's clear that *5,5 means 10* (not 55).

Send completed audit to:

Port Phillip Baykeeper
Port Phillip EcoCentre
55A Blessington St
St Kilda VIC 3182
baykeeper@ecocentre.com
www.bay-keeper.com

Any queries? Phone Neil Blake 0409 138 565

More information:

Australian Marine Debris Initiative Database
http://www.tangaroablue.org/database.html

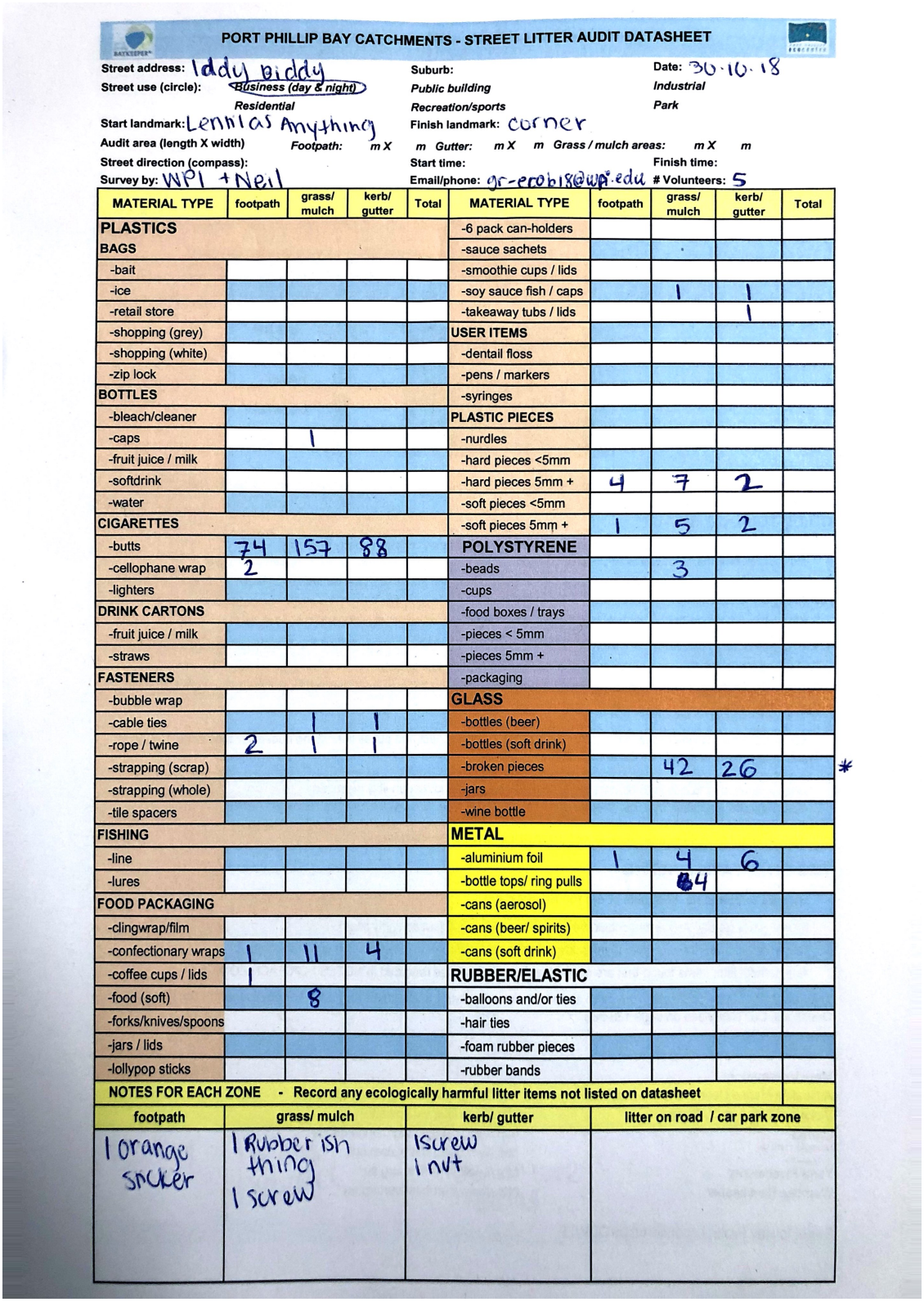
Victorian Litter Action Alliance	http://www.litter.vic.gov.au/
CSIRO	https://blog.csiro.au/tag/marine-debris/
Beach Patrol Australia	http://www.beachpatrol.com.au/

Figure 94. Beach Litter Audit Page 4

Appendix E: Observations Rubric

Location		
Start Landmark		
End Landmark		
Date		
Orientation of Street		
Street Use Category		
Pollution maintenance	Number of trash cans	
Pollution maintenance	Number of recycling bins	
Effectiveness of pollution maintenance	Number of overflowing trash cans	
Effectiveness of pollution maintenance	Number of overflowing recycling bins	
Summary of Street Litter Audit Trial Datasheet	Zone with the most litter by volume displacement	
Summary of Street Litter Audit Trial Datasheet	Most commonly littered material	
Summary of Street Litter Audit Trial Datasheet	Most common item	
Other noteworthy observations		

Appendix F: Street Litter Audit - Business



PORT PHILLIP BAY CATCHMENTS - STREET LITTER AUDIT DATASHEET

Street address: Iddy Biddy | Suburb: | Date: 30.10.18

Street use (circle): Business (day & night) | Public building | Industrial

Residential | Recreation/sports | Park

Start landmark: Lennias Anything | Finish landmark: corner

Audit area (length X width) | Footpath: m X | m Gutter: m X | m Grass / mulch areas: m X | m

Street direction (compass): | Start time: | Finish time:

Survey by: WPI + Neil | Email/phone: gr-ecobi18@wpi.edu | # Volunteers: 5

MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total	MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
PLASTICS					-6 pack can-holders				
BAGS					-sauce sachets				
-bait					-smoothie cups / lids				
-ice					-soy sauce fish / caps		1	1	
-retail store					-takeaway tubs / lids			1	
-shopping (grey)					**USER ITEMS**				
-shopping (white)					-dentail floss				
-zip lock					-pens / markers				
BOTTLES					-syringes				
-bleach/cleaner					**PLASTIC PIECES**				
-caps		1			-nurdles				
-fruit juice / milk					-hard pieces <5mm				
-softdrink					-hard pieces 5mm +	4	7	2	
-water					-soft pieces <5mm				
CIGARETTES					-soft pieces 5mm +	1	5	2	
-butts	74	157	88		**POLYSTYRENE**				
-cellophane wrap	2				-beads		3		
-lighters					-cups				
DRINK CARTONS					-food boxes / trays				
-fruit juice / milk					-pieces < 5mm				
-straws					-pieces 5mm +				
FASTENERS					-packaging				
-bubble wrap					**GLASS**				
-cable ties		1	1		-bottles (beer)				
-rope / twine	2	1	1		-bottles (soft drink)				
-strapping (scrap)					-broken pieces		42	26	*
-strapping (whole)					-jars				
-tile spacers					-wine bottle				
FISHING					**METAL**				
-line					-aluminium foil	1	4	6	
-lures					-bottle tops/ ring pulls		64		
FOOD PACKAGING					-cans (aerosol)				
-clingwrap/film					-cans (beer/ spirits)				
-confectionary wraps	1	11	4		-cans (soft drink)				
-coffee cups / lids	1				**RUBBER/ELASTIC**				
-food (soft)		8			-balloons and/or ties				
-forks/knives/spoons					-hair ties				
-jars / lids					-foam rubber pieces				
-lollypop sticks					-rubber bands				

NOTES FOR EACH ZONE - Record any ecologically harmful litter items not listed on datasheet

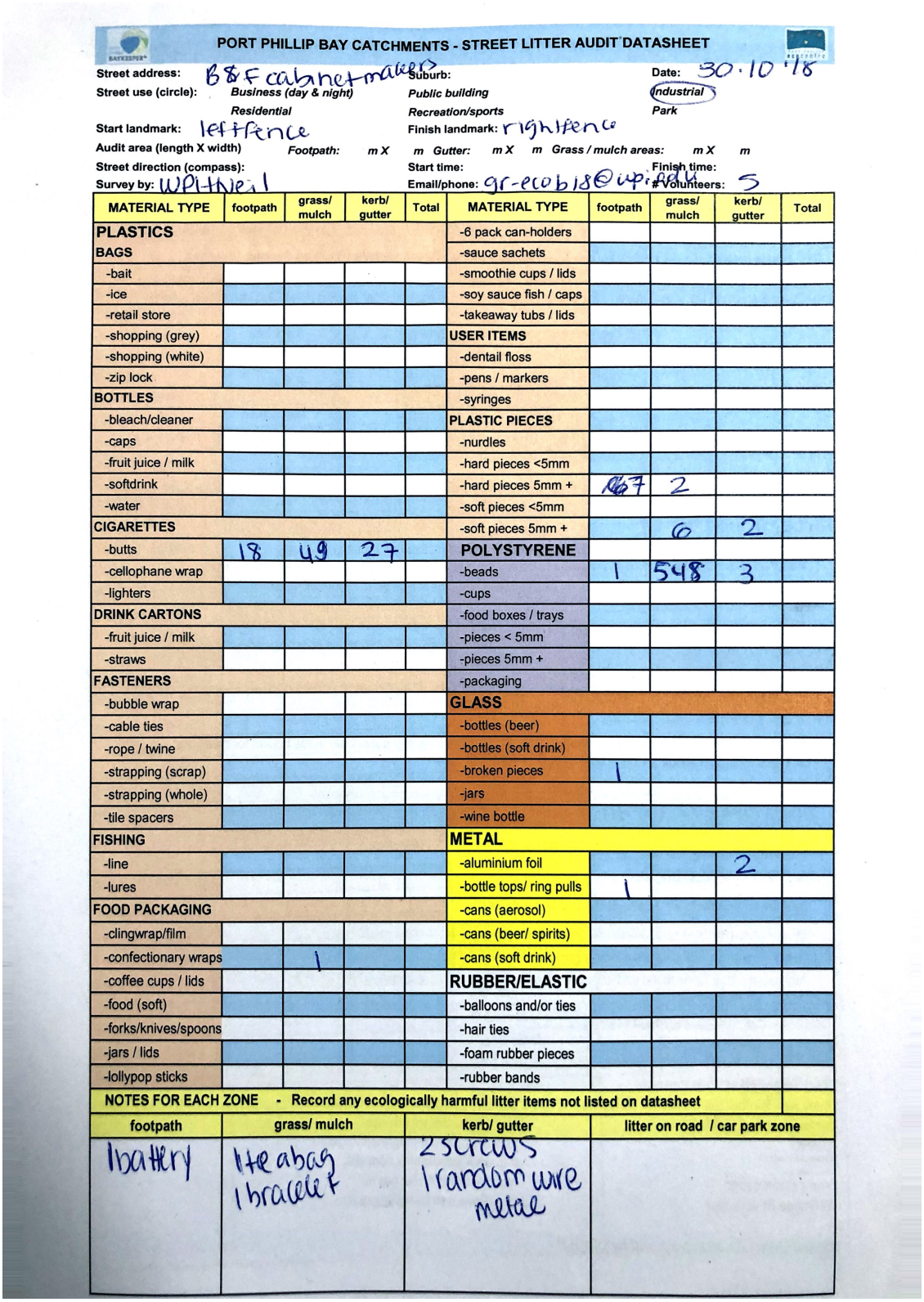
footpath	grass/ mulch	kerb/ gutter	litter on road / car park zone
1 orange sucker	1 Rubber ish thing 1 screw	1 screw 1 nut	

Figure 95. Business Audit

Appendix G: Observation - Business

Location	Iddy Biddy Bar	
Start Landmark	Lentil as anything	
End Landmark	Corner	
Date	30 October 2018	
Orientation of Street	Business/Retail	
Street Use Category	Lentil as anything to corner	
Pollution maintenance	Number of trash cans	6
Pollution maintenance	Number of recycling bins	2
Effectiveness of pollution maintenance	Number of overflowing trash cans	0
Effectiveness of pollution maintenance	Number of overflowing recycling bins	0
Summary of Street Litter Audit Trial Datasheet	Zone with the most litter by volume displacement	Grass/Mulch
Summary of Street Litter Audit Trial Datasheet	Most commonly littered material	Plastic
Summary of Street Litter Audit Trial Datasheet	Most common item	Cigarette butts
Other noteworthy observations		

Appendix H: Street Litter Audit - Industry



PORT PHILLIP BAY CATCHMENTS - STREET LITTER AUDIT DATASHEET

Street address: B&F cabinet makers Suburb: Date: 30.10.18

Street use (circle): Business (day & night) Public building Industrial

Residential Recreation/sports Park

Start landmark: left fence Finish landmark: right fence

Audit area (length X width) Footpath: m X m Gutter: m X m Grass / mulch areas: m X m

Street direction (compass): Start time: Finish time:

Survey by: WPitney1 Email/phone: gr-ecob18@up.edu #Volunteers: 5

MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
PLASTICS				
BAGS				
-bait				
-ice				
-retail store				
-shopping (grey)				
-shopping (white)				
-zip lock				
BOTTLES				
-bleach/cleaner				
-caps				
-fruit juice / milk				
-softdrink				
-water				
CIGARETTES				
-butts	18	49	27	
-cellophane wrap				
-lighters				
DRINK CARTONS				
-fruit juice / milk				
-straws				
FASTENERS				
-bubble wrap				
-cable ties				
-rope / twine				
-strapping (scrap)				
-strapping (whole)				
-tile spacers				
FISHING				
-line				
-lures				
FOOD PACKAGING				
-clingwrap/film				
-confectionary wraps		1		
-coffee cups / lids				
-food (soft)				
-forks/knives/spoons				
-jars / lids				
-lollypop sticks				

MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
-6 pack can-holders				
-sauce sachets				
-smoothie cups / lids				
-soy sauce fish / caps				
-takeaway tubs / lids				
USER ITEMS				
-dentail floss				
-pens / markers				
-syringes				
PLASTIC PIECES				
-nurdles				
-hard pieces <5mm				
-hard pieces 5mm +	167	2		
-soft pieces <5mm				
-soft pieces 5mm +		6	2	
POLYSTYRENE				
-beads	1	548	3	
-cups				
-food boxes / trays				
-pieces < 5mm				
-pieces 5mm +				
-packaging				
GLASS				
-bottles (beer)				
-bottles (soft drink)				
-broken pieces	1			
-jars				
-wine bottle				
METAL				
-aluminium foil			2	
-bottle tops/ ring pulls	1			
-cans (aerosol)				
-cans (beer/ spirits)				
-cans (soft drink)				
RUBBER/ELASTIC				
-balloons and/or ties				
-hair ties				
-foam rubber pieces				
-rubber bands				

NOTES FOR EACH ZONE - Record any ecologically harmful litter items not listed on datasheet

footpath	grass/ mulch	kerb/ gutter	litter on road / car park zone
1battery	1teabag 1bracelet	2screws 1random wire metal	

Figure 96. Industrial Audit

Appendix I: Observation - Industry

Location	B&F Cabinet Makers	
Start Landmark	Fence on left	
End Landmark	Right fence	
Date	30 October 2018	
Orientation of Street	Unknown	
Street Use Category	Industrial	
Pollution maintenance	Number of trash cans	5
Pollution maintenance	Number of recycling bins	0
Effectiveness of pollution maintenance	Number of overflowing trash cans	1
Effectiveness of pollution maintenance	Number of overflowing recycling bins	0
Summary of Street Litter Audit Trial Datasheet	Zone with the most litter by volume displacement	Grass/Mulch
Summary of Street Litter Audit Trial Datasheet	Most commonly littered material	Polystyrene
Summary of Street Litter Audit Trial Datasheet	Most common item	Polystyrene Beads
Other noteworthy observations		

Appendix J: Street Litter Audit - Park

PORT PHILLIP BAY CATCHMENTS - STREET LITTER AUDIT DATASHEET

Street address: Botanical Gardens Suburb: Date: 30.10.18

Street use (circle): *Business (day & night)* *Public building* *Industrial*
Residential *Recreation/sports* (*Park*)

Start landmark: corner Finish landmark: gate

Audit area (length X width) *Footpath:* *m X* *m Gutter:* *m X* *m Grass / mulch areas:* *m X* *m*

Street direction (compass): Start time: Finish time:

Survey by: NPI+Neil Email/phone: gr-ecobis@unpi.edu # Volunteers: 5

MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
PLASTICS				
BAGS				
-bait				
-ice				
-retail store				
-shopping (grey)				
-shopping (white)				
-zip lock				
BOTTLES				
-bleach/cleaner				
-caps		1		
-fruit juice / milk				
-softdrink				
-water		1		
CIGARETTES				
-butts	28	106	43	
-cellophane wrap				
-lighters				
DRINK CARTONS				
-fruit juice / milk				
-straws			2	
FASTENERS				
-bubble wrap				
-cable ties				
-rope / twine				
-strapping (scrap)				
-strapping (whole)				
-tile spacers				
FISHING				
-line				
-lures				
FOOD PACKAGING				
-clingwrap/film				
-confectionary wraps		19		
-coffee cups / lids	1		1	
-food (soft)	1	1	4	
-forks/knives/spoons			1	
-jars / lids				
-lollypop sticks				

MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
-6 pack can-holders				
-sauce sachets				
-smoothie cups / lids				
-soy sauce fish / caps		1		
-takeaway tubs / lids				
USER ITEMS				
-dentail floss				
-pens / markers				
-syringes				
PLASTIC PIECES				
-nurdles				
-hard pieces <5mm				
-hard pieces 5mm +	2	14	3	
-soft pieces <5mm				
-soft pieces 5mm +	5	6	2	
POLYSTYRENE				
-beads				
-cups				
-food boxes / trays				
-pieces < 5mm				
-pieces 5mm +				
-packaging				
GLASS				
-bottles (beer)				
-bottles (soft drink)				
-broken pieces		16	400	*
-jars				
-wine bottle				
METAL				
-aluminium foil	2	7	3	
-bottle tops/ ring pulls	1	2	3	
-cans (aerosol)				
-cans (beer/ spirits)				
-cans (soft drink)			2	
RUBBER/ELASTIC				
-balloons and/or ties				
-hair ties				
-foam rubber pieces				
-rubber bands				

NOTES FOR EACH ZONE - Record any ecologically harmful litter items not listed on datasheet

footpath	grass/ mulch	kerb/ gutter	litter on road / car park zone
1 lysol wipe	1 metal rod 1 screw 2 washers 1 fridge magnet/ pin	2 condom wrapper 1 condom 1 screw 1 felt 1 ? 1 hair clip	
	3 lysol wipes	4 lysol wipes	

Figure 97. Park Audit

Appendix K: Observation - Park

Location	St. Kilda Botanical Gardens	
Start Landmark	Corner	
End Landmark	Gate	
Date	30 October 2018	
Orientation of Street	Park	
Street Use Category	Gate to corner	
Pollution maintenance	Number of trash cans	1
Pollution maintenance	Number of recycling bins	2
Effectiveness of pollution maintenance	Number of overflowing trash cans	0
Effectiveness of pollution maintenance	Number of overflowing recycling bins	0
Summary of Street Litter Audit Trial Datasheet	Zone with the most litter by volume displacement	Kerb/Gutter
Summary of Street Litter Audit Trial Datasheet	Most commonly littered material	Glass
Summary of Street Litter Audit Trial Datasheet	Most common item	Broken Glass Pieces
Other noteworthy observations		

Appendix L: Street Litter Audit - Public

PORT PHILLIP BAY CATCHMENTS - STREET LITTER AUDIT DATASHEET

Street address: Library | Suburb: | Date: 30.10.18

Street use (circle): Business (day & night) | (Public building) | Industrial

Residential | Recreation/sports | Park

Start landmark: Genovese corner | Finish landmark: Library sign

Audit area (length X width) | Footpath: m X | m Gutter: m X | m Grass / mulch areas: m X | m

Street direction (compass): | Start time: | Finish time:

Survey by: WPITNell | Email/phone: gr-ecobis@up.edu | # Volunteers: 5

MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
PLASTICS				
BAGS				
-bait				
-ice				
-retail store				
-shopping (grey)				
-shopping (white)				
-zip lock				
BOTTLES				
-bleach/cleaner				
-caps		1		
-fruit juice / milk				
-softdrink	1			
-water				
CIGARETTES				
-butts	112	220	29	
-cellophane wrap		1		
-lighters				
DRINK CARTONS				
-fruit juice / milk				
-straws				
FASTENERS				
-bubble wrap				
-cable ties				
-rope / twine				
-strapping (scrap)				
-strapping (whole)				
-tile spacers		5		
FISHING				
-line				
-lures				
FOOD PACKAGING				
-clingwrap/film				
-confectionary wraps	1	8		
-coffee cups / lids				
-food (soft)	2	3		
-forks/knives/spoons				
-jars / lids				
-lollypop sticks				

MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
-6 pack can-holders				
-sauce sachets				
-smoothie cups / lids				
-soy sauce fish / caps	1	1		
-takeaway tubs / lids				
USER ITEMS				
-dentail floss				
-pens / markers				
-syringes				
PLASTIC PIECES				
-nurdles				
-hard pieces <5mm				
-hard pieces 5mm +	3	6	3	
-soft pieces <5mm				
-soft pieces 5mm +	1	24	3	
POLYSTYRENE				
-beads	1		1	
-cups				
-food boxes / trays				
-pieces < 5mm				
-pieces 5mm +				
-packaging				
GLASS				
-bottles (beer)				
-bottles (soft drink)				
-broken pieces	8	20		
-jars				
-wine bottle				
METAL				
-aluminium foil		1		
-bottle tops/ ring pulls	1	~~8~~ 8	1	
-cans (aerosol)				
-cans (beer/ spirits)				
-cans (soft drink)				
RUBBER/ELASTIC				
-balloons and/or ties				
-hair ties				
-foam rubber pieces		1		
-rubber bands	2			

NOTES FOR EACH ZONE - Record any ecologically harmful litter items not listed on datasheet

footpath	grass/ mulch	kerb/ gutter	litter on road / car park zone
2 sticker 2 washers	8 stickers 1 clothing tag ~~5 grout rubber~~	1 tape	

Figure 98. Public Audit

Appendix M: Observation - Public

Location	St. Kilda Library	
Start Landmark	Genovese corner	
End Landmark	Public library brown sign	
Date	30 October 2018	
Orientation of Street	Public	
Street Use Category	Probably, corner to sign	
Pollution maintenance	Number of trash cans	0
Pollution maintenance	Number of recycling bins	0
Effectiveness of pollution maintenance	Number of overflowing trash cans	0
Effectiveness of pollution maintenance	Number of overflowing recycling bins	0
Summary of Street Litter Audit Trial Datasheet	Zone with the most litter by volume displacement	Grass/Mulch
Summary of Street Litter Audit Trial Datasheet	Most commonly littered material	Plastic
Summary of Street Litter Audit Trial Datasheet	Most common item	Cigarette butts
Other noteworthy observations	Stuff caught in cracks a lot/underneath benches and out of the way	

Appendix N: Street Litter Audit - Residential

PORT PHILLIP BAY CATCHMENTS - STREET LITTER AUDIT DATASHEET

BAYKEEPER ecocentre

Street address: Chaucer | Suburb: | Date: 30.10.18

Street use (circle): Business (day & night) | Public building | Industrial
(Residential) | Recreation/sports | Park

Start landmark: 76 | Finish landmark: 78

Audit area (length X width) Footpath: m X m Gutter: m X m Grass / mulch areas: m X m

Street direction (compass): | Start time: | Finish time:

Survey by: WPHNeil | Email/phone: grecubis@cup.edu | # Volunteers: 5

MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total	MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
PLASTICS					-6 pack can-holders				
BAGS					-sauce sachets				
-bait					-smoothie cups / lids				
-ice					-soy sauce fish / caps				
-retail store					-takeaway tubs / lids				
-shopping (grey)					**USER ITEMS**				
-shopping (white)					-dentail floss				
-zip lock					-pens / markers				
BOTTLES					-syringes				
-bleach/cleaner					**PLASTIC PIECES**				
-caps					-nurdles				
-fruit juice / milk					-hard pieces <5mm				
-softdrink			1		-hard pieces 5mm +			2	
-water					-soft pieces <5mm				
CIGARETTES					-soft pieces 5mm +			[illegible]2	
-butts	2	3	8		**POLYSTYRENE**				
-cellophane wrap			1		-beads				
-lighters					-cups				
DRINK CARTONS					-food boxes / trays				
-fruit juice / milk					-pieces < 5mm				
-straws					-pieces 5mm +				
FASTENERS					-packaging				
-bubble wrap					**GLASS**				
-cable ties					-bottles (beer)				
-rope / twine	1		1		-bottles (soft drink)				
-strapping (scrap)					-broken pieces		29		
-strapping (whole)					-jars				
-tile spacers					-wine bottle				
FISHING					**METAL**				
-line					-aluminium foil	1		1	
-lures					-bottle tops/ ring pulls		1	1	
FOOD PACKAGING					-cans (aerosol)				
-clingwrap/film					-cans (beer/ spirits)				
-confectionary wraps	2		3		-cans (soft drink)				
-coffee cups / lids					**RUBBER/ELASTIC**				
-food (soft)			1		-balloons and/or ties				
-forks/knives/spoons					-hair ties				
-jars / lids					-foam rubber pieces	9			
-lollypop sticks					-rubber bands				

NOTES FOR EACH ZONE - Record any ecologically harmful litter items not listed on datasheet

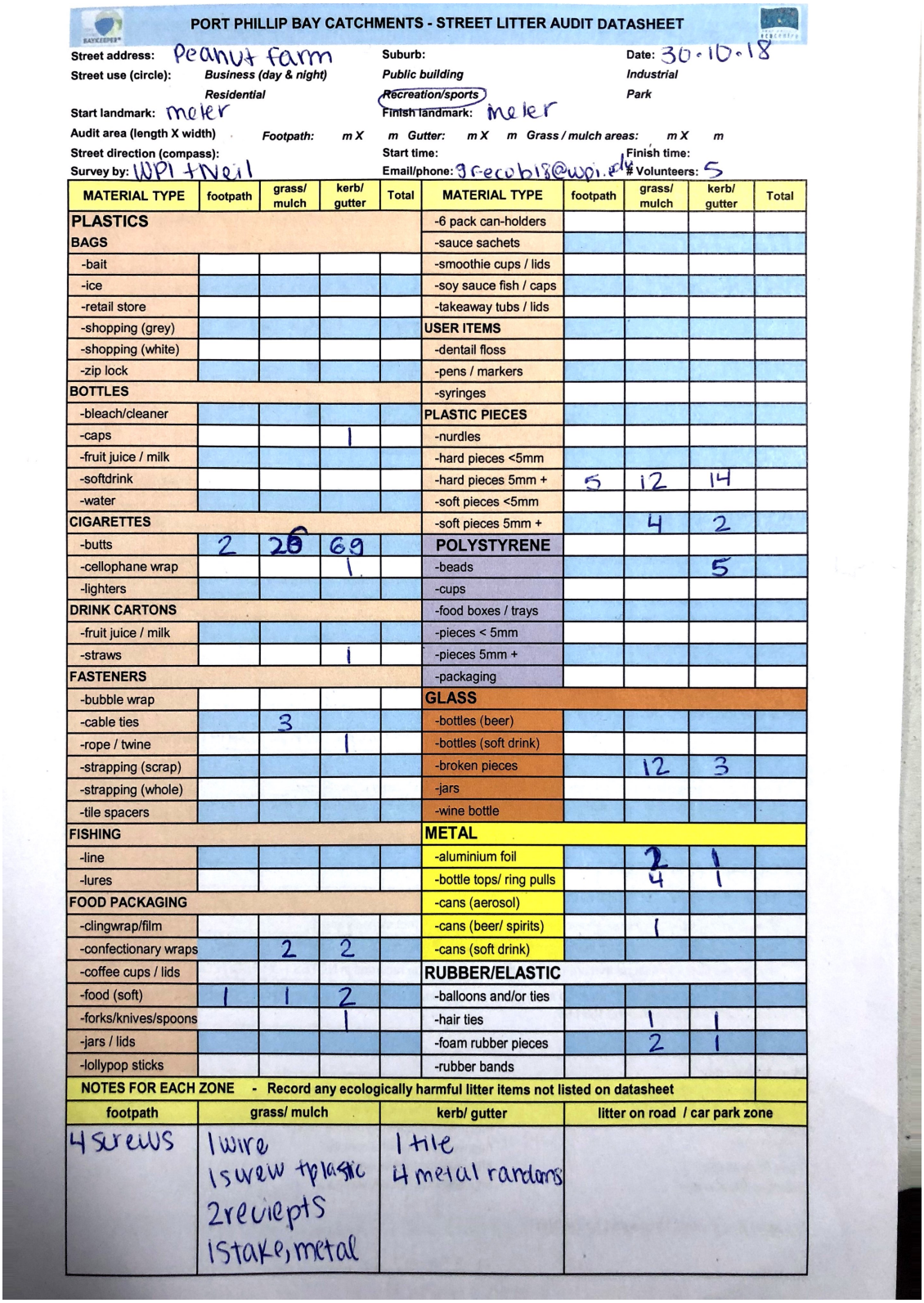
footpath	grass/ mulch	kerb/ gutter	litter on road / car park zone
	1 nail metal	1 lysol wipe	

Figure 99. Residential Audit

Appendix O: Observation - Residential

Location	Chaucer St	
Start Landmark	Tree 76	
End Landmark	78	
Date	30 October 2018	
Orientation of Street	Residential	
Street Use Category	Unknown	
Pollution maintenance	Number of trash cans	0
Pollution maintenance	Number of recycling bins	0
Effectiveness of pollution maintenance	Number of overflowing trash cans	0
Effectiveness of pollution maintenance	Number of overflowing recycling bins	0
Summary of Street Litter Audit Trial Datasheet	Zone with the most litter by volume displacement	Grass/Mulch
Summary of Street Litter Audit Trial Datasheet	Most commonly littered material	Glass
Summary of Street Litter Audit Trial Datasheet	Most common item	Broken Glass Pieces
Other noteworthy observations		

Appendix P: Street Litter Audit - Sport



PORT PHILLIP BAY CATCHMENTS - STREET LITTER AUDIT DATASHEET

Street address: Peanut farm | Suburb: | Date: 30.10.18

Street use (circle): Business (day & night) | Public building | Industrial | Residential | Recreation/sports | Park

Start landmark: meter | Finish landmark: meter

Audit area (length X width) | Footpath: m X m | Gutter: m X m | Grass / mulch areas: m X m

Street direction (compass): | Start time: | Finish time:

Survey by: WPI tNeil | Email/phone: jrecobl8@wpi.edu | # Volunteers: 5

MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total	MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
PLASTICS					-6 pack can-holders				
BAGS					-sauce sachets				
-bait					-smoothie cups / lids				
-ice					-soy sauce fish / caps				
-retail store					-takeaway tubs / lids				
-shopping (grey)					**USER ITEMS**				
-shopping (white)					-dentail floss				
-zip lock					-pens / markers				
BOTTLES					-syringes				
-bleach/cleaner					**PLASTIC PIECES**				
-caps			1		-nurdles				
-fruit juice / milk					-hard pieces <5mm				
-softdrink					-hard pieces 5mm +	5	12	14	
-water					-soft pieces <5mm				
CIGARETTES					-soft pieces 5mm +		4	2	
-butts	2	26	69		**POLYSTYRENE**				
-cellophane wrap			1		-beads			5	
-lighters					-cups				
DRINK CARTONS					-food boxes / trays				
-fruit juice / milk					-pieces < 5mm				
-straws			1		-pieces 5mm +				
FASTENERS					-packaging				
-bubble wrap					**GLASS**				
-cable ties		3			-bottles (beer)				
-rope / twine			1		-bottles (soft drink)				
-strapping (scrap)					-broken pieces		12	3	
-strapping (whole)					-jars				
-tile spacers					-wine bottle				
FISHING					**METAL**				
-line					-aluminium foil		2	1	
-lures					-bottle tops/ ring pulls		4	1	
FOOD PACKAGING					-cans (aerosol)				
-clingwrap/film					-cans (beer/ spirits)		1		
-confectionary wraps		2	2		-cans (soft drink)				
-coffee cups / lids					**RUBBER/ELASTIC**				
-food (soft)	1	1	2		-balloons and/or ties				
-forks/knives/spoons			1		-hair ties		1	1	
-jars / lids					-foam rubber pieces		2	1	
-lollypop sticks					-rubber bands				

NOTES FOR EACH ZONE - Record any ecologically harmful litter items not listed on datasheet

footpath	grass/ mulch	kerb/ gutter	litter on road / car park zone
4 screws	1 wire 1 screw + plastic 2 reciepts 1 stake, metal	1 tile 4 metal randoms	

Figure 100. Sport Audit

Appendix Q: Observation - Sport

Location	Peanut Farm	
Start Landmark	Parking metre entrance	
End Landmark	Parking metre 5th tree	
Date	30 October 2018	
Orientation of Street	Recreation/Sports	
Street Use Category	Unknown	
Pollution maintenance	Number of trash cans	2
Pollution maintenance	Number of recycling bins	0
Effectiveness of pollution maintenance	Number of overflowing trash cans	0
Effectiveness of pollution maintenance	Number of overflowing recycling bins	0
Summary of Street Litter Audit Trial Datasheet	Zone with the most litter by volume displacement	Kerb/Gutter
Summary of Street Litter Audit Trial Datasheet	Most commonly littered material	Plastic
Summary of Street Litter Audit Trial Datasheet	Most common item	Cigarette butts
Other noteworthy observations		

Appendix R: Interview Statement of Consent

Investigators: Cameron Collins, Samantha Comeau, Brendan Gallagher, Gina Visser

Contact Information: gr-ecoB18@wpi.edu

Title of Research Study: Using Data Visualisation to Identify the Sources of Plastic Pollution in Port Phillip Bay

Sponsor: Port Phillip EcoCentre

- I agree to participate in an interview at _____ on _____ date about plastic pollution in Port Phillip Bay.
- I understand that this interview is expected to take less than an hour.
- I understand that this interview is part of a research project that is exploring the sources of plastic pollution in Port Phillip Bay and the causes for fluctuating levels of plastic pollution.
- I understand that I am under no obligation to participate and that I may leave at any time. I understand that my participations (or decision not to participate) in this interview will in no way affect my standing with the Port Phillip EcoCentre.
- I understand that this research is expected to bring no harm to me and that it also will be of no substantial benefit to me personally.
- I understand that the findings from the interview will be published but will not identify me, personally, in any way unless I give consent and that efforts will be made to present findings in ways that will not permit a reader to identify the particular source of any information.
- I agree to have all proceedings _____ typed or _____ recorded. I understand that all members of the project team (including faculty advisors) from Worcester Polytechnic

Institute will have access to the recordings if I choose to allow this interview to be recorded.

Name (print) and Date

Signature

Appendix S: Council / Non-profit Interview Questions

Hello, we are students working with the Port Phillip EcoCentre. We are currently working on a project that is intended to help the EcoCentre determine the sources of plastic pollution in Port Phillip Bay and causes of fluctuating levels of plastic pollution. This interview will be completed in under an hour.

Your participation in this interview is voluntary and you do not have to answer anything you do not want to. Additionally, we will keep your answers confidential upon request.

Otherwise can we quote you? _____ Yes _____ No

If so, do you prefer that we refer to you by name or by organisation? _____ Name _____ Organisation

If you have any questions or concerns you can contact us at gr-ecoB18@wpi.edu

1. What area or business within Victoria do you represent?
2. Are you aware of microplastic pollution and the existence of it within your area or business?
3. Does this area or business provide recycling facilities? If you could, describe the availability of these facilities. *For example, providing recycling in park zones but not residential zones*
4. What waste management regulations are in place for this area or business? *For example, do you have a street sweeping schedule?*
5. What factors go into these waste management regulations? *For example, collecting litter more frequently during different parts of the week due to high volume visitors*
6. Is there a specific company or contractor that is used for waste management in this area?
7. Are there waste management regulations specific to different zones within your area or business? *For example, banning smoking in public parks, but not outside businesses*

8. On a scale from 1 [very ineffective] to 10 [very effective], can you rate how effective the current waste management process is at preventing lingering pollution and explain your reasoning?

9. Who do you think is responsible for cleaning up lingering plastic pollution in this area? *For example, councils, consumers, private companies, waste management companies*

10. How serious do you think the problem of plastic pollution is? If you could, rate the seriousness on a scale of 1 [not a problem] to 10 [immediate solution is required] and explain.

11. Are there any plastic use regulations currently in place in your area or business and, if so, when were they implemented? *For example, banning the use of plastic bags or disposable cups*

12. Are there any changes to these regulations coming in the future?

13. What are your thoughts on plastic pollution in this area?

14. Have you personally seen any high pollution areas? This could be anywhere or specifically in this area.

15. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

16. Does your area or business fund any campaigns discouraging the use of plastics? *For example, advertisements educating the public of the harmful effects of pollution*

17. Are you aware of the state funded street litter audit program?

18. Does this area or business sponsor any litter audit programs? If so, what methodologies are involved? *For example, do you record the area you are auditing, do you measure the amount of litter by weight or count or other, etc.*

Appendix T: Council / Non-profit Interviewees

Organisation	Interviewee(s)
City of Port Phillip Council	Nick Dunstan and Emily Richards
Hobsons Bay Council	Shaun Young
City of Monash Council	April Williams
City of Yarra Council	Kirsty Richards

Appendix U: Experts in the Field Interview Questions

Hello, we are students working with the Port Phillip EcoCentre. We are currently working on a project that is intended to help the EcoCentre determine the sources of plastic pollution in Port Phillip Bay and causes of fluctuating levels of plastic pollution. This interview will be completed in under 45 minutes.

Your participation in this interview is voluntary and you do not have to answer anything you do not want to. Additionally, we will keep your answers confidential upon request.

Otherwise can we quote you? _____ Yes _____ No

If so, do you prefer that we refer to you by name or by organisation? _____ Name _____ Organisation

If you have any questions or concerns you can contact us at gr-ecoB18@wpi.edu

1. What organisation are you from?
2. What research does this organisation primarily focus on?
3. Have you or your organisation worked with the Port Phillip EcoCentre in the past?
4. What previous or present projects relating to plastic pollution has this organisation worked on?
5. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.
6. What do you think the main source of this plastic pollution is?
7. If you could, list some environmental or human factors that you think contribute to this pollution. *For example, environmental would be rainfall, wind, elevation and human would be sporting event schedules, flea markets etc.*
8. Do you have any advice for effectively communicating research findings with the public?

9. Do you recommend that we contact any other people who have knowledge about plastic pollution that may help our project?

10. What are your thoughts on plastic pollution in this area?

Appendix V: Experts in the Field Interviewees

Organisation	Interviewee(s)
EPA Victoria	Randall Lee
Scouts Victoria	Peter Kennedy
Port Phillip EcoCentre	Neil Blake
Port Phillip EcoCentre	Fam Charko
Tangaroa Blue	Jodi Jones
Boomerang Alliance	Annette Finger

Appendix W: Interview - City of Port Phillip

Interviewees: Nick Dunstan and Emily Newton

1. What area or business within Victoria do you represent?

   City of Port Phillip. There is no difference between cities and councils. Generally, shires are rural but cities and councils are the same thing. We are the City of Port Phillip Council. There used to be a bunch of cities that conglomerated to become a council but now we are the same thing.

2. Are you aware of microplastic pollution and the existence of it within your area or business?

   Yes. Neil has probably done a lot more work than we have.

3. Does this area or business provide recycling facilities? If you could, describe the availability of these facilities. *For example, providing recycling in park zones but not residential zones*

   Yes, to both. In general, we have a household curbside recycling program. Businesses are entitled to the same collection program. It does not cost any extra cost to them. In general, for most businesses the residential sized bin is not going to be useful for them. Offer 4ish curbside bins in addition to regular recycling collection. We don't charge for recycling. We do charge for extra bins. There is the drop off centre across the road which is a hard waste booking service. 70% of this is recycled. 4-6 bookings per year per property are allowed. Weekly garbage collection and recycling each week. Each zone (there are 5) has its own schedule and goes on its own day. Schedule is on City of Port Phillip website. Spillage is something that happens. We try and get the guys to go back and collect what is spilled while they are picking up. I wouldn't be surprised if there was a bit of correlation between the two. Also during events. Port Phillip is end of greater cities storm water drains. Storm water comes out of the bay and then washes back onto the beach.

4. What waste management regulations are in place for this area or business? *For example, do you have a street sweeping schedule?*

   No regulation to it. Residents have to use their bins properly. Anti-Littering laws exist that are all enforceable. EPA has variations that apply to constructions, individuals, etc. Fines available through them. We have made the move to ban all single-use plastics at events. We have previously banned plastic bags at shopping centres but more as an agreement between vendors. Not necessarily enforceable. Have recycling facilities that are well used and well maintained in all new buildings. Main one is really the events. Probably move to ban all single-use plastics flat out. Many places within council where events are to be held. St Kilda is highly used. Big park near the beach is often used for events. If it's a particularly warm day population in City of Port Phillip will triple. We have a plan in place for summer and these extra warm days. Extra pickup of bins during summer and install extra bins to cope with the increased volumes. Each event has to submit waste management plans that they must submit before approval. Use solar compactor bins to better maintain the litter in addition to pick up 3 times a day. Solar powered and they compact the litter within. Won't get much pickup saving but do avoid bin overflowing. Linked via GPS to tell when the bin will overflow or is getting close. They are very expensive though.

5. What factors go into these waste management regulations? *For example, collecting litter more frequently during different parts of the week due to high volume visitors*

   We have got a lot of bins that have been there for a while. There will always be new bins placed in new areas that exist. We respond to people asking for bins placed. We monitor area for a few months and if see a problem then we install a new bin. That's our system at the moment but it will probably change as we move towards solar compactor bins.

6. Is there a specific company or contractor that is used for waste management in this

area?

We do most of data collection over summer we will do 300-400 litter audits over the summer in parks, shore, etc. This year we will use Tangaroa blue's app/database. We will add our data to that. Keep lots of data on what litter is collected and volume we don't do as many audits not over summer. Process for audits are identified by Tangaroa blue. Whatever the metreage is in transect, categorise the material within that transect some people pick up the stuff afterwards and some don't. Can trace the source of some of the litter through tangaroa's app and barcode scanning.

7. Are there waste management regulations specific to different zones within your area or business? *For example, banning smoking in public parks, but not outside businesses*
   Four seasons waste. Have in house teams that pick up on street and beach are done by in-house crew. They also do street sweeping and emptying bins in the city. Also a street sweeping schedule. The aim is to get to each street each fortnight. All the schedules are on the website. Beach cleaning is generally done every day in St. Kilda, but other locations are rotated each week. Beaches are handpicked every day at the tidelines (done by in-house crew). 50 staff in street and beach cleaning, 14 staff in picking up bins. Contractors have a lot more staff. Schedule is established on a need basis. In general, we have guys drive past every day and double check the bins. Have a lot of traders filling up bins with their rubbish. Nov-April goes afternoon and normal daily. It seems to be almost enough most of the time

8. On a scale from 1 [very ineffective] to 10 [very effective], can you rate how effective the current waste management process is at preventing lingering pollution and explain your reasoning?
   In general, I'd give us a decent score. We are pretty good given the number of visitors. Given nature of the sudden unmanaged, unscheduled events lead to worse things. 95% of the time we do very well. It's the popup events that make it hard or

on really hot days where people stay out on the beach all night. Idk what pretty good is. Maybe like an 8. As soon as the party goers leave the crew is out there cleaning. In general, we have a good response. We spend lots of money on it. Unscheduled events summer holidays, especially nice days, etc. We have specific plans around public holidays to cut down on impacts of the litter and the overflowing stuff. The multiple super nice days are harder since St. Kilda is the closest beach to the city and if everyone in Melbourne wants to go to the beach it gets harder to control the litter. Looking at doing a microplastics campaign this summer so that people can decrease single-use plastics since we all know it contributes to microplastics in the long run.

9. Who do you think is responsible for cleaning up lingering plastic pollution in this area? *For example, councils, consumers, private companies, waste management companies*

10. How serious do you think the problem of plastic pollution is? If you could, rate the seriousness on a scale of 1 [not a problem] to 10 [immediate solution is required] and explain.

    Pretty serious. I think given the recent news articles about plastic in everything it's a huge scale and I don't think people are aware of it yet. The reason I work in waste management is because of plastic pollution (EMILY). The biosphere impact is huge, but the human health impacts are huge and it's going to gain traction and bring the envi impacts along with it. It's going to be an interesting one to convey to people without putting them in terror mode. Trying to show here is a fact off the scale of the problem please do something about it.

11. Are there any plastic use regulations currently in place in your area or business and, if so, when were they implemented? *For example, banning the use of plastic bags or disposable cups*

    No single-use plastic are used at public events. Australian product stewardship

scheme covers e waste but also single-use plastics. When gov policies come up from review we put in comments about reducing single-use plastic.

12. Are there any changes to these regulations coming in the future?

    In the future at public events not disposable plastics will be used. Its either already in or its coming they are educating private event companies. Balloons are gone and single-use plastics are either gone or on the way. Can only enforce so much through permits.

13. What are your thoughts on plastic pollution in this area?

    There are a bunch of ways you can look at where the source is. There are numerous sources for a city like Port Phillip. We are the end of the storm water drains. We have an opportunity to trap a bunch of litter before it gets into the bay. All of drains are fitted with pollution catching filters. Education campaigns and enforcement come in for people dropping litter. And managing events litter is where we come in we can advocate for reducing plastics. We can educate, we can stop things coming in, pick stuff up, advocating for broader problem to be solved, supporting community groups working on the issue. Lots of waste education programs about reducing plastic and litter

14. Have you personally seen any high pollution areas? This could be anywhere or specifically in this area.

    Yeah sure. Depends on the big storm. Will find lots of stuff comes up after weather or big events. Every day the guys pick up a lot of dropped litter from the beach and the streets. We don't have massing industrial areas. Across river is large plastic producers that will have nurdle spills but we don't have that. Foreshore is for big events, or on parks next to foreshore or shopping districts

15. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

Can comment more on litter items: cigarette butts, drink containers, straws that kind of stuff. That would be the top two. Food based plastics I guess you could say. Also plastic bags but I guess they have been kinda banned. State gov is inducing a ban across all stores in Victoria by 2019 (or at least starting then)

16. Does your area or business fund any campaigns discouraging the use of plastics? *For example, advertisements educating the public of the harmful effects of pollution*
    Yeah. We spend a substantial amount of money over summer on litter education. Depends on what you mean by fund programs. All that stuff is part of our anti-litter campaigns over the summer. Support community groups in terms of managing events. involved in all the state gov education campaigns.

17. Are you aware of the state funded street litter audit program?

18. Does this area or business sponsor any litter audit programs? If so, what methodologies are involved? *For example, do you record the area you are auditing, do you measure the amount of litter by weight or count or other, etc.*

Appendix X: Interview - Hobsons Bay Council

Interviewee: Shaun Young

1. What area or business within Victoria do you represent?

   Part of Hobsons Bay city council we represent the city of Hobsons bay which represents 6-7 suburbs (Williamstown to Leviton).

2. Are you aware of microplastic pollution and the existence of it within your area or business?

   Yeah definitely we've run a few programs about it over the years. We've done various projects around cigarette butts and we do a lot of community cleanups and tend to focus on microplastics and the impacts that plastic and litters have. Particularly at schools. Try to talk about it whenever we are doing any sort of community engagement

3. Does this area or business provide recycling facilities? If you could, describe the availability of these facilities. *For example, providing recycling in park zones but not residential zones*

   All residents have curbside recycling (commingled), we include flexible plastics in curbside recycling (aka single-use). We don't have any public place recycling bins at this stage. We are putting in some trial ones here in Altona this summer and the idea is to try and expand that. We have temporary ones that we put out along beaches during peak times but they are not permanent. Big issue with public place is contamination level and that's the biggest issue we are trying to get around at this stage. Waste is weekly, fortnight is recycling, green waste is the alternating fortnight. Green waste all gets brought to a composting facilities (does not include food waste, but that's an area we might expand upon)

4. What waste management regulations are in place for this area or business? *For example, do you have a street sweeping schedule?*

I am more the education side of things. The cleansing department does street sweeping, bin pickup. We do have street sweeping, I'm not sure what the schedule is but I would assume it is every day. I can get those details if that would be helpful.

5. What factors go into these waste management regulations? *For example, collecting litter more frequently during different parts of the week due to high volume visitors*

6. Is there a specific company or contractor that is used for waste management in this area?

   Done in house

7. Are there waste management regulations specific to different zones within your area or business? *For example, banning smoking in public parks, but not outside businesses*
   In eating areas in Victoria you can't smoke anymore. You have to be a certain (10m) away from that area. That's enforced by the health team. That's across all of Victoria. Playground is another one, not sure if that's a local or state one. And some beaches you can't smoke either. Smoking regulation came in through last year.

8. On a scale from 1 [very ineffective] to 10 [very effective], can you rate how effective the current waste management process is at preventing lingering pollution and explain your reasoning?

   In some commercial areas council doesn't service them, they have to get their own waste management contractors. Those contractors may have different rules. Council mainly deals with residential collection. We won't pick up bins if its overflowing we have made that clear to residents. I think it's pretty good about preventing litter. I think it's more of an education thing to teach people to avoid overflowing bins. We are at the mouth of the Yarra, we get a lot of litter coming down the yarra and washing up on our foreshore. There is always room for improvement with waste management. I think construction is probably an issue. Metropolitan waste recovery group is doing some things with inner city council upstream about preventing litter

there. We do clean beaches, collect some seaweed and obviously litter gets collected up during that. I'd have to check with our cleansing group to see if they handpick beaches. We have two beach patrol organisations within our council that are very active. A lot of the time it's very reactive, we get a call and we will go and pick it up. It gets a bit tricky with who is managing the land (Melbourne water vs council)

9. Who do you think is responsible for cleaning up lingering plastic pollution in this area? *For example, councils, consumers, private companies, waste management companies*

   I would say it should be a joint effort. Everyone should be involved in trying to tackle it. That's the challenging part is trying to have everyone take ownership.

10. How serious do you think the problem of plastic pollution is? If you could, rate the seriousness on a scale of 1 [not a problem] to 10 [immediate solution is required] and explain.

    I would say it's pretty serious. Whenever we conduct our cleanup days the majority of what we collect is plastics of some form. I would say it's a pretty significant problem across Victoria.

11. Are there any plastic use regulations currently in place in your area or business and, if so, when were they implemented? *For example, banning the use of plastic bags or disposable cups*

    Ban on plastic bags will be big when that comes into enforcement. It has been in the public eye over the last few months. Container deposit legislation schemes is one that is always being thrown around. It would be great if it came from a national level rather than every state trying to figure out their own policies. Council supports plastics bans and we have advocated for the banning of single-use plastics for many years now. We will have an anti littering campaign in the summer to try and put across the keep Altona beautiful message. In terms of the in your face stuff, I save

that more for schools with the images. It does have shock factor; I personally feel we need to be making the change with the younger generations. The older people have already developed their habits.

12. Are there any changes to these regulations coming in the future?

    Recycling labels are changing on a lot of products. Recycling is still quite confusing to a lot of people. There is still a bit of perception in the community that stuff doesn't actually get recycled, that it all just goes to landfill anyways. Nurdles is a big problem that we have here. We have a few plastic manufacturing companies here in Altona. Reducing pellet losses is something we would really like to address in the future.

13. What are your thoughts on plastic pollution in this area?

    It's a problem but I don't think it's focused just here, it's a nationwide problem really. Because we are on the coast we can see it here, generally speaking its relatively clean but you can see it in the remote areas. The biggest issue from us is the mouth of the yarra and everything coming from the inner city. That's a joint problem with us and everyone in Melbourne really.

14. Have you personally seen any high pollution areas? This could be anywhere or specifically in this area.

    Mouth of the yarra, Wader beach: there is a report that the ecocentre helped with, Beaches are probably where its seen the most because that is where all the storm water and everything leads to. When we have big storm events the bay tends to get highly polluted. We have days where you can't go in the water and we put up warnings about it. Industry zones: pellet loss and illegal dumping (industrial zones are hotspots)

15. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

single-use plastics. Confectionary, chips, plastic bags, drink bottles. It's hard to just pinpoint any source. I would say a lot of it comes down just to people throwing it on the ground. I don't know whether you can pinpoint the industry or manufacturers, it needs to be a joint thing and educating everything. Maybe manufacturers should take a little more ownership of their products

16. Does your area or business fund any campaigns discouraging the use of plastics? *For example, advertisements educating the public of the harmful effects of pollution*
    We try to promote reusable stuff. Internally we try and promote it to all the staff and things. Boomerang bags has been extremely popular. Council helped get that up and running and support it. We have various types of grants that community groups can apply for. Australian program but its run by individual communities. There is no lead that helps set them up around Australia. It has been good because it's brought the community together. And they support all our other campaigns that we do as well.

17. Are you aware of the state funded street litter audit program?
    No I am not.

18. Does this area or business sponsor any litter audit programs? If so, what methodologies are involved? *For example, do you record the area you are auditing, do you measure the amount of litter by weight or count or other, etc.*
    We do have a program for community groups to do litter audits (follow Tangaroa blue). Not so much council things, but some of our friends of groups have cleanup days. We try and promote them to do audits and actually sort through stuff. People generally just want to pick up stuff and go home. The community groups keep the data and put it right into the Tangaroa blue database.

Appendix Y: Interview - City of Monash

Interviewee: April Williams

1. What area or business within Victoria do you represent?

   From the city of Monash and the senior sustainability officer. I've worked here for 7 years and I only started this year since 8 months. Previous to that I was in the waste area.

2. Are you aware of microplastic pollution and the existence of it within your area or business?

   Yes

3. Does this area or business provide recycling facilities? If you could, describe the availability of these facilities. *For example, providing recycling in park zones but not residential zones*

   City of Monash provides curbside recycling for residents. Public litter and recycling bins strategically placed where there is high volume of people. We have a recycling center where you can take items that don't go in your curbside bin. At civic center we have a hub for e waste. We have a waste bin, recycling bin, green waste for residents. Businesses only have waste bin included in rates and they have to pay extra for a recycling bin. In our main shopping center, we have cardboard collection for traders

4. What waste management regulations are in place for this area or business? *For example, do you have a street sweeping schedule?*

   All of our cleaning operation are in house. Street sweeping (every residential every 5 weeks), main activity centers every 6 days, run sweeping services 23 hours a day. Footpath sweeping, laneway sweeping, collect all the street litter bins in house. Award winning litter collection model called Monash Pride Crew. There is a person at each specific zone all day that takes care of cleaning and bin emptying. That way

people know council is present and then the traders get to know the staff. Residential collection every week, fortnight green and recycling. Public bins are collected 7 days a week (busy shopping area), in parks every fortnight, schedule collection depends on feedback from drivers and how busy the bins are. No way to check if bins are overflowing. Trialed bin sensors at strategic spots (5 bins), we haven't pursued that as an option. The city of Monash is quite small, one truck for litter bins and one truck for recycling 3 days and 2 days litter bins. They sort of cover all the same ground together all the time. We can get around to the bins we need to. We have looked into a technology that helps map your cycle but we determined that the cost of purchasing your software would not weigh out the benefits

5. What factors go into these waste management regulations? *For example, collecting litter more frequently during different parts of the week due to high volume visitors*
   We have heavy leaf fall that in autumn and summer drop a lot of leaf material. We have to do extra sweeping during those times. In summer there is the risk of smelly bins and the perception of that so we have to empty those more frequently. We do liter pickups, dump rubbish (near university move outs)

6. Is there a specific company or contractor that is used for waste management in this area?
   Household litter is contracted out. Public bins are all in house. Solo is contractor at the moment. That expires in 2020. They only do residential

7. Are there waste management regulations specific to different zones within your area or business? *For example, banning smoking in public parks, but not outside businesses*
   We have a pretty good relationship with them. They do a pretty good. We have cameras on the trucks so If its overflowing, or there is litter around it, or contaminated they can take a picture of it and send it to us. We have issues with university areas, so we are constantly trying to target those populations and educate

them. State gov has banned smoking where people are serving food. Our envi health officers enforce that law. Local law can't smoke within 10-15m of council building or school.

8. On a scale from 1 [very ineffective] to 10 [very effective], can you rate how effective the current waste management process is at preventing lingering pollution and explain your reasoning?

   We have got a waste management strategy that was just endorsed last year for the next 10 years. I think we are quite good in our responsiveness and areas like that. I think we could improve on education. We have a good record of getting grants and then having great education campaigns but then as soon as the grant funding ends those programs taper off. Introduce food and organics recycling for residents is coming (talked about in the strategy), Introduction of e waste ban in Victoria, Trying to work with people living in apartments, etc

9. Who do you think is responsible for cleaning up lingering plastic pollution in this area? *For example, councils, consumers, private companies, waste management companies*

   I think everyone should be responsible. The way legally it works its whoever is the land owner is responsible. But I think if we all wait for someone else to pick up rubbish then it's never going to happen. We have two staff whose job is to pick up litter. Once litter gets into the waterways it's harder to get out. We do have a lot of community support with cleanup Australia day, and lots of community groups. Community groups always want to go to parks and council already maintains parks so it's a bit of a catch 22.

10. How serious do you think the problem of plastic pollution is? If you could, rate the seriousness on a scale of 1 [not a problem] to 10 [immediate solution is required] and explain.

In Monash: I would have to say it's probably, cigarette butts are always most littered item, it's about an 8 for Monash. In general Victoria: I would say 9 because plastic never breaks down and its ubiquitous in society. Even though we have the plastic bag ban, society has a long way to go to embrace that as the norm. I think until legislation comes in a federal level to ban single-use plastics (which federal gov has said they will, by 2025 I think) our society needs those legislative changes to come in for us to adapt. If its voluntary it doesn't seem to work

11. Are there any plastic use regulations currently in place in your area or business and, if so, when were they implemented? *For example, banning the use of plastic bags or disposable cups*

    Plastic bag ban across Victoria. Soft plastic use within council, it was approved that we would look at reducing soft plastics and single-use plastics within council and then if we could reduce that then we would look to reducing them in the community. We have a 12-month plan. We have put in guidelines to force. Anyone holding events on public lands can't use single-use plastics or balloons. Working with catering and cafes that operate on council land and look at changing the way they use plastics to try and get them away from plastics and soft plastics. Installed solar compactor bin in fleet store area since that's the biggest source of soft plastics. I really want to do a war on waste kind of thing since those kinds of things that are on national tv and we get a lot of residents contacting us about that and seeing if they can do anything about the scale of it. Trying to work with engineers and try and buy recycled plastic materials for our construction products, etc. trying to create that circular economy. Red-cycle: Coles and Woolworths have soft plastic collection points. all melted down and makes plastic that councils will buy (durable outside furniture, signs, etc). they have a much greater supply of plastics than they have demand for their products. So they have stockpiles of soft plastic and made agreements with people saying they won't accept your recycling unless you buy more in weight than the plastic you send.

There is a lot of companies working with red-cycle to do this.

12. Are there any changes to these regulations coming in the future?

    No there aren't. What we would really like to do is to get more recycled products bought but I don't know whether we can legislate for that. We have asked that when we purchase something we don't just look at the cost we also look at the lifecycle cost.

13. What are your thoughts on plastic pollution in this area?

    I think it's probably one of the worst types of pollution since it doesn't break down or if it does then it goes into microplastic which are very harmful. We as a society have a very consumerist tendency. A lot of what they buy is crap and junk. The top level of the waste hierarchy is avoiding waste and we don't talk about it a lot because council thinks it's too much of a societal issue and nobody wants to tell people how they need to live their lives. At end of lives nobody wants to have responsibly for the end of life processes. I think there needs to be a cultural shift as to whose responsibility waste is and what a problem plastic.

14. Have you personally seen any high pollution areas? This could be anywhere or specifically in this area.

    We get a lot of cigarette butt litter in main shopping areas. We have a lot of illegal dumping in certain hot spots. Monash is within region that is called national employment innovation cluster. It's an area that's considered the highest employer outside CBD. I don't know how much pollution they produce. From time to time you have a spill with companies of polystyrene or things like that. That would more be EPA, that issue wouldn't really go to us. Illegal discharge into creek is also EPA but I have heard a little bit about that. We have an app in Victoria where if you see someone litter outside of their car you can report them using license plate and they get a fine. You can get taken to court on it. There must be a way that they can verify that but I don't know what that is

15. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

    Cigarette butts, Industry, Littering, Illegal dumping

16. Does your area or business fund any campaigns discouraging the use of plastics? *For example, advertisements educating the public of the harmful effects of pollution*

    We haven't done anything like that before apart from that internal thing I was talking about. Partly because we don't tell people what to do with their lives. We have never really looked at it as a council issue and I don't know that we would get much support from council if we did try to do that. Unless you count polystyrene recycling and have done a little bit about that

17. Are you aware of the state funded street litter audit program?

    Is that the dumping data app?

18. Does this area or business sponsor any litter audit programs? If so, what methodologies are involved? *For example, do you record the area you are auditing, do you measure the amount of litter by weight or count or other, etc.*

    We have done a few audits from time to time. Victorian litter alliance developed a rating system of how much litter there is at an audit site. We've been using that method for a while. We don't do anything with that data. They also have an app for recording any litter you find when gets mapped. We don't currently use that because it doesn't interface with our council reporting systems. The state gov is thinking about changing that app so that it can interface with council software. We tend to do audits when they relate to campaigns or products in order to measure the success of the project. We don't tend to audit in mass throughout the municipalities. Cleanup Australia day we do an audit of everything they have collected

Appendix Z: Interview - City of Yarra Council

Interviewee: Kirsty Richards

1. What area or business within Victoria do you represent?

   I work with Yarra city council which is an inner city council. A bunch of little suburbs that have come together. Small tight houses. They don't have parks. Inner city.

2. Are you aware of microplastic pollution and the existence of it within your area or business?

   Yeah I am aware that there is heaps of it in the sea and that it's in the Yarra. The Yarra runs through the suburbs and I'm trying to make people aware that if it's in the gutter it goes into the Yarra and then into the sea. Its opens people's world to understand the concept of how far the effect of what they have does. More and more they talk about the gyres of plastic and it's a bit hard to comprehend.

3. Does this area or business provide recycling facilities? If you could, describe the availability of these facilities. *For example, providing recycling in park zones but not residential zones*

   Every home or resident has a recycling bin which we encourage them to use. We have been developing more and more signage about what goes in what bin. That has been one of the biggest pushes to not use plastic bags. Every project we do whether with school or community project that is with school, Collingwood children's farm (close connection to river and animals you love). We do have problems with recycling in large apartment complexes because its large communal bins. We are doing a lot of work with those about recycling. We used to offer same for business (2 recycling and a rubbish), as you can imagine businesses have a lot of recycling. We are cutting that back to 1 rubbish and 1 recycling, if they need more they need to pay for another one. They are being very good about what they put in the recycling. There have been several program about what goes in the right bin and staff have more ownership

of the whole thing. Every week they get picked up. For business that's usually not enough and they need a commercial service. There is one café that has it serviced every day. There are also been encouraging them to use the reground coffee service (coffee grounds are composted).

4. What waste management regulations are in place for this area or business? *For example, do you have a street sweeping schedule?*

   We have daily street sweeping, retail areas are everyday twice a day. The residential days I'm not sure frequency but they would be more in autumn. We have hard waste collection (2 collections a year: couches, computer, etc). if we let people dump it they will and then more people will put stuff there and that will make things worse. We encourage people to work together. Two or three homes can work together on one collection.

5. What factors go into these waste management regulations? *For example, collecting litter more frequently during different parts of the week due to high volume visitors*

   Because recycling is of more and more importance to people we are getting more feedback from residents and councilors about what they want. That has lifted what we do, we are now looking to employ someone to see if there is a way we can reuse the hard waste that we are picking up. The problem is we would need a warehouse, people, truck, and safety. A lot of the stuff we collect is recycled anyways. At the depot we have a section for electrical, precious metals, plastics, etc. there is now a recycle thing for mattresses. With the electrical waste there is a ban on taking that to landfill starting June next year so we are upping the fact that it doesn't go to the rubbish bin, take it to the depot. We have places for it at libraries or enabled houses. That would be ban, it will stop stuff leaking from landfill into the water. We definitely have more litter and cleanup collection in summer when it gets hot and people get out and do stuff. We have done a lot of work with the bins and people

through signage. We want it to be part of this whole Yarra culture where we just do the right thing. Summer definitely, footie if there is a final there is stuff everywhere, festivals in the summer we have to bring in special cleaning regimes. The cleaning guys have brought in a new regime in the last 6 months they get together once a month and everybody comes in and does a blitz on an area and then go back to the normal stuff. Its worked. The cleaner it is the cleaner it will stay. You have different areas of the culture keeping it clean, recycling more, understanding the consequence, and having fun doing it.

6. Is there a specific company or contractor that is used for waste management in this area?

   Somebody does recycling, rubbish (pick it up), there are standards they have to meet. They have to go beyond this. These companies we have to make them care more about what they are doing. We also employ contractors to pick one area (say 200 households) early morning see what's in their recycling, give them a little sticker. Go back 2 weeks later and see how they are doing and if they have improved they get a reward (worm farm, compost, or tickets). Its working and people are doing the right thing. It's a lot of work, so trying to spread that across Yarra. There are suburbs that will get a better result in and some are harder. Visy does recycling, Four seasons does waste and rubbish

7. Are there waste management regulations specific to different zones within your area or business? *For example, banning smoking in public parks, but not outside businesses*

   Can't smoke within 2 m I think. We have put butt bins on most of the bins. I have just developed some art about making it fun about making people noticing butt bins. There are still a lot of butts in parks, outside pubs, that kind of thing. We have got a lot of work to do. Amount of cigarettes put in ocean in year is equal to weight of 120,000 elephants. If you can get that across to people and school kids, they will

change their behavior phenomenally. With butt bins: we have seen people using the butt bins. There are still tables outside of pubs covered in cigarette butts. Different cultures and difference races have different cultures where some will go for a bin and others won't

8. On a scale from 1 [very ineffective] to 10 [very effective], can you rate how effective the current waste management process is at preventing lingering pollution and explain your reasoning?

   Its definite improving, we have had a radical change in understanding within the last year with everything we have done behavior wise its improving, but you still have the parties outside pubs or a hot day in the park. It's hard to measure across the whole thing, but it's improving. Its helped by the amount of work that the EcoCentre has done. The bay grants have raised the profile. I think the envi minister could make some profiles or activities to get the message across. Local high school introduced a subject about litter. At the end we took them canoeing on the Yarra to see this is what's done in Yarra and this is what your peers do. And it's working. Little kids tell me my mum tells me to pick up litter. The bad spots are still bad after a hot night or whatever

9. Who do you think is responsible for cleaning up lingering plastic pollution in this area? *For example, councils, consumers, private companies, waste management companies*

   I would say the people. There is a famous Australian environmentalist (Flannery). The struggle is the solution. Council will lead and will follow, so it's up to the people and the council. If we can inspire that then the champions will do it on their own.

10. How serious do you think the problem of plastic pollution is? If you could, rate the seriousness on a scale of 1 [not a problem] to 10 [immediate solution is required] and explain.

I would say 10. It's getting more obvious how serious it is. It's definitely in this council, I'm not sure about all over. There are more affluent suburbs with less space and time. You can't fit in enough bins so you notice it more. Yarra is under greater pressures and responds better to them than other councils

11. Are there any plastic use regulations currently in place in your area or business and, if so, when were they implemented? *For example, banning the use of plastic bags or disposable cups*

    Ban of plastic bags which is coming in. there are notices in supermarkets. A lot of schools are making their own boomerang bags. The supermarkets have plastic bag recycling. There is talk about plastic straws and balloons (blow bubbles not balloons). It was about 6 months ago, driven by the zoo and well received by the kids. It's time to have a campaign. People are ready to do stuff, to use less plastic. There has been a lot of stuff about coffee cups since they are lined and they can't be recycled. In a sense you would probably achieve more with a behavior change campaign than a regulation. We encourage traders not to use single-use plastics during campaigns. We supply bins, we have people who tell festival goers to recycle, we monitor and empty the bins. We are looking at the solar compactor bins. We could use those in places like a big park on a big day. In a way we know already when they need to be emptied, but sensors would good.

12. Are there any changes to these regulations coming in the future?

    I don't know of any definite ones. Once they are confident that people will accept the response then they will push it through. They need to drift through the communication to see if people will accept the regulation and change their behavior first. More and more industries are looking at doing more in Australia with recycling since china has stopped accepting industries. They are living up to what they should be doing and doing it.

13. What are your thoughts on plastic pollution in this area?

    It can still be terrible at events, hot summer days. There is less of it. You actually see people picking stuff up and putting it in the bins. People are getting passionate about it. People are littering less. Its improving. We still have issues if people have had a lot to drink or are in a large group

14. Have you personally seen any high pollution areas? This could be anywhere or specifically in this area.

    Big park, Victoria street: lots of Vietnamese restaurants. Old area, old kitchens, etc. there can be a lot of pollution at that place. I think that's half cultural and half logistics, Big events, Footie games: a lot of people put things under their seats, Bars and pubs, especially late night ones. You can't speak with someone who has a lot to drink. That's going to be a long term behavior change and with peer pressure. It's going to be tough

15. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

    Cigarette butts, Coffee cups, Food containers (takeaway) ***, Straws, Nappies, but that's only in certain areas

16. Does your area or business fund any campaigns discouraging the use of plastics? *For example, advertisements educating the public of the harmful effects of pollution*

    We are building it into everything we do. I always tell people what things come back as (in terms of recycling). We are targeting the schools, total community. (little kid cigarette picking up and making sign, huge social media response). We can also apply for the litter innovation fund that gives out funds for programs. We apply for a grant that helps us do what we want to do (signage, bins, promotion, cleanup, etc)

17. Are you aware of the state funded street litter audit program?

    No. I guess have been doing that intuitively

18. Does this area or business sponsor any litter audit programs? If so, what methodologies are involved? *For example, do you record the area you are auditing, do you measure the amount of litter by weight or count or other, etc.*

    We run litter audits as part of the campaigns we do. Especially if we get funding. We got funding to do litter campaigns on two business streets. We do a litter audits of the street before, mid, and after the campaign. The data goes into the report for the grant. She said she would send us her data. We can send you an email to remind you. We have a litter cleanup early in the morning and at night, so the hard part is catching it between those times.

Appendix AA: Interview - EPA Victoria

Interviewee: Randall Lee

1. What organisation are you from?

   EPA Victoria, state based pollution protection department in Australia instead of federal one in US would have. I am in the applied science directorates division, science is a direct voice at the top level of the EPA, so the executives can make science based decisions. We are second oldest EPA in world after US EPA. In the water team within the applied science directorates

2. What research does this organisation primarily focus on?

   Deal with everything atmospheric, protecting envi and human health (human health is relatively recent). Do a lot of R and D into emerging contaminants, microplastics, PFAS (or maybe PVAS), other high profile stuff, endocrine disruptors, new chemicals in the envi that we don't have a handle on what the chemicals are other than nasty, more effective ways of defining envi conditions (including more effective ways of monitoring), more emergency response work and modeling/forecasting efforts so we can better respond to that. Get involved in projects such as research into seagrass health in bay as an indicator as to health of the bay, and recently we have revised policies that are 15 years old and have established bio indicators. Applied science is what we do, we might work with other fringe groups who are doing blue sky science. It's not that different than what universities do. Public expectations dictate a lot of what we do. A lot more stuff on water quality, the scare that the bay would become like Chesapeake Bay and that has been driving a lot of R and D on algae blooms and nitrogen. Looking at nitrogen budgets into the bay and this is sort of the last unsolved issue into that and understanding all the contributors and how to distribute the nutrients into the bay. Mt. Martha is a bit of a collection hotspot for plastics (my modeling has shown that). Lots of weathered microplastics that come from

remote sources that wash up on the west coast of Victoria, but that might be outside your scope. New microplastics project: (Allison Kemp is head of project), she will give us summary copy of the project, its just in the first phases. She was here in voice only. It's only desktop looking at the literature and quickly evaluate some of the literature. Look at recent research and try and decide what that means for EPA and regulation of microplastics. Part of what the project is looking at is categorizing different sources within Victoria. Looking at diffuse sources vs point source. Point source example = wastewater. Not necessarily trying to point finger at those source but looking to see what's available to regulate those sources. We are really hoping this is phase one and that there will be a phase two with possible partnerships with other organisation and authorities to do some more targeted research. We are currently trying to work out what EPA's role is in this issue Look at this issue overall and try and separate it into parts and more specific problem based issues. (Have worked with a few outside organisations to collect data in other unrelated projects, but not officially through EPA.) This project is more tangible and looking at areas where EPA can have direct effects, such as permits or license premises. They have been raising awareness for a few years, we've done a fair amount of education in the past, but we are trying to do something a little bit more tangible. We would be really interested in your results. Have hard rubbish collection days in councils that is just like people put stuff out on the street and other people can go through it and stuff gets everywhere. We deal with multiple issues relating to water: microplastics all the way through to algal blooms. Its difficult to delve deeper into specific projects, that where we've struggled and are a little bit behind, but we are working to get some momentum into that. It's been a slow start.

3. Have you or your organisation worked with the Port Phillip EcoCentre in the past? Provided modeling support to help provide guidance on beach cleanups in the past to try and help optimise cleanup efforts.

4. What previous or present projects relating to plastic pollution has this organisation worked on?

5. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

   I would say packaging is a pretty big one. We are also doing a study on the characterization based deposit scheme. Looking at a mangrove site in Melbourne and plastics there and categorizing them on a monthly basis. I have experience there seeing all the packaging material that gets caught up in the mangroves. Both industrial and normal packaging. We find a lot of packaging in the envi but I think it's actually linked to the fact that we throw that stuff away and there is a more fundamental issue that we don't value the resource that plastic is and that we don't reuse this we just throw it away. Ellen MacArthur foundation has been doing a lot of research into looking at circular plastics economy and how to use plastics as a resource better. If some packaging or nurdles escape we don't go and get it because we just think we can go and get some more. Victoria banned plastic bags in supermarkets starting in July, but the interpretation of that is different. Plastic bags from Coles are made from recycled bags from Germany since Europe has a policy where the companies who make the plastics have to pay for the recycling, so now I guess they are just exporting their plastics elsewhere. There are solutions elsewhere in the world for how to deal with plastic packaging, I guess we just have to look at the effective means that are being take elsewhere. We have some engagement with our industry influenced people and they do have some influence as to what the industry does, but not much and ultimately industry drives how much plastics. We need to be aware that we shouldn't just look at the surface intervals. We may start looking at plankton or shrimp and seeing how much plastics are in their stomachs as part of monitoring how much microplastics are in the water column as an emerging pollutant. As well as the ratio of plankton to microplastics in the water. Thiolates

are a byproduct of plastics degradation and at the moment we don't know much about the concentration of that in the envi and the possible issues that could have. From the bit of education we have done, people just want to know what can they do. They want to know from a domestic scale, not just let some giant waste water plant deal with it for you. People are looking for something that they can do to help.

6. What do you think the main source of this plastic pollution is?

   Storm water is probably a very big area. I am not quite sure what the quantities are coming out of wastewater treatment systems, but I am sure its significant. Storm water isn't necessarily the source its more of the transport mechanisms. After huge storms you will see huge quantities of plastics in the local creeks. That's mainly from littering of mismanaging of waste management systems. I don't know that we don't have the answer to that yet, that's part of why we got the extra funding for this microplastics projects. It's a really key question and I don't know that we know the answer to that yet. At least from an EPA perspective, I think what posed the most risk is more important that what is the largest source. Maybe Cam's suggestion of a risk index for different litter and types of plastic would be helpful to help up profile the different litter types.

7. If you could, list some environmental or human factors that you think contribute to this pollution. *For example, environmental would be rainfall, wind, elevation and human would be sporting event schedules, flea markets etc.*

   Illegal dumping, a lot of people illegally dump, it's pretty common since there is a financial disincentive to go and do it properly. Trying to help councils develop a way to deal with this since EPA is so busy with other things. I think there was some research done about socioeconomic factors (at a neighborhood level with container deposits (maybe in NSW), littering, etc). I'm not aware of anything in Victoria doing research on the effectiveness of the plastic bag ban. Wind can definitely pick up a lot

of stuff. You see these plastic bags heading up to space sometimes on very windy days. Improperly managed landfills are also a problem.

8. Do you have any advice for effectively communicating research findings with the public?

   Think of other coms of engagement you could do in addition to the report (brochure, online products, looking for opportunities at events where you can engage directly with the public, trying to transport what you are doing here back to the states). Look at the audiences you are trying to target. Engaging with schools or friends of groups. Tap into networks that already exist that are also trying to make the messages you are trying to convey. EPA is interested in our report once its finished and could potentially help carry some of the messages after our report is finished. Might be worth doing some parallels to different bays around the world since they are similar systems and similar systems may have similar issues. They could also be years ahead of what we are doing here.

9. Do you recommend that we contact any other people who have knowledge about plastic pollution that may help our project?

   Ben Rowland- also at EPA who deals with waste and regulations (industry guidance unit) Some info on EPA website about site practices, Mark Brown-University of NSW (done lots of research on microplastics), Heidi at Tangaroa Blue. Doing some pilot studies trying to identify repeat offenders for nurdles spills. Using storm drain filters as data collection to gain information about who has good on-site practices that could be used as examples for others who do not have as good practices.

10. What are your thoughts on plastic pollution in this area?

    Plastic bag ban is mostly just a financial disincentive to make people bring their own bag rather than the money charged for the bags being used towards research.

Appendix AB: Interview - Scouts Victoria

Interviewee: Peter Kennedy

1. What organisation are you from?

   I guess I represent Scouts Victoria. My official title is Venture leader for Australia Scouts, I am affiliated with Brighton Sea Scouts. We run one project the beach litter auditing through Brighton Sea Scouts. We are running another project on behalf of Scouts Victoria for the streets to bay audits.

2. What research does this organisation primarily focus on?

3. Have you or your organisation worked with the Port Phillip EcoCentre in the past?

   Have been working with the EcoCentre for the past few years

4. What previous or present projects relating to plastic pollution has this organisation worked on?

   Not relevant

5. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

   Littering, bad habits, inadequate facilities, overflow from storage areas, inability to care for the environment

6. What do you think the main source of this plastic pollution is?

   For me the two are commercial retail areas (supermarkets) and sporting fields. Bars vs. retail stores: in my opinion I think it's more commercial hubs that are frequented by a lot of people and it's not just a bar or a supermarket or a railway station. Its that its a hub and people are moving from one place to the other. We've definitely seen huge spikes during very communal areas where people are moving about, hanging out, etc.

7. If you could, list some environmental or human factors that you think contribute to this pollution. *For example, environmental would be rainfall, wind, elevation and human would be sporting event schedules, flea markets etc.*

   Inclined to litter: I am not sure there is envi or human. Maybe a pub if you've had a few drinks but I don't have any data on that. There are people who litter and people who don't, i'm not sure that changes or is circumstantial. Three types of people those two throw and out of sight out of mind, people two notice it, and those who pick it out. Transportation I think the more rain,the more that gets washed off. It's more of a timing thing, it was going to get there anyways. It may just be bursts of litter going but it was always going to get there anyways. Envi effects when it's going to get there. The most litter is in the grass area and i don't think street sweepers mow the grass. If there is x percentage of people who are going to litter, if you have a large group you are going to litter. It's just more concentrated.

8. Do you have any advice for effectively communicating research findings with the public?

9. Do you recommend that we contact any other people who have knowledge about plastic pollution that may help our project?

10. What are your thoughts on plastic pollution in this area?

11. Added questions.

    How would you track plastic pollution over time?

    We are first people as far as i know of to go count litter, and pick it up. The first time you expect a lot, after you go back it's just going to be what got there during that time period. We went to one location and the second time there was more litter the second time than the first time and it was no more than 8 weeks between the two audits. It gets there and it turns over frequently. Don't take street sweeping schedules into account. We've been out the day after very heavy rain and there has

been just as much litter. I think there is more litter than we know, we collect things every few months and its possible most of it has washed away.

After heavy rain vs wind have you noticed that grass is more populated than other areas?

The grass areas is the obvious trap and that's where we find the most street litter. We also find lots of stuff in the path.

Do you have reasonings behind what is the most common plastics?

Statistically we probably don't have enough data at the moment. The thing that gets me is that cigarettes are always the most. Nothing stands out as being different in different areas. Personal opinion i think that smokers that throw things in the city will throw things anywhere. We are finding cigarette bars everywhere. We are finding hundreds in little strips. There has gotta to be something about education.

Difference in areas where trash bin has cigarette vs not?

No. one of the biggest areas we have hit is outside coles and there was trash bins there and right across the board. Litter in general was just incredible.

Appendix AC: Interview - Port Phillip EcoCentre

Interviewee: Neil Blake

1. What organisation are you from?

   I'm with the Port Phillip EcoCentre

2. What research does this organisation primarily focus on?

   Primarily the programs that relate to litter and microplastics but also breach profiling and mollusks stuff. We also do research on local biodiversity too and im involved in that as well, but litter and microplastics is taking up most of my time

3. Have you or your organisation worked with the Port Phillip EcoCentre in the past?

   Yes

4. What previous or present projects relating to plastic pollution has this organisation worked on?

   Street to bay program involves the beach litter audits which are currently funded by the state gov, the river trawls also currently funded by the state gov, and the street litter audits in partnership with the scouts. The scouts are being funded by state gov, I'm just helping them. I also have audit methods for river banks and school grounds but not much has been done with that yet

5. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

   Technically the main one is inadequate or irresponsible disposal. Plastic in the wrong place comes down to the way it's handled and inadequacies. I think cigarette butts are often there because cigarette smokers have a grim view of the world and don't care. Most other times i think people want to do the right thing, but do something like put their trash in an overflowing bin. There are occasions that will all the best intentions things will happen. I think humans are herd animals and they will do what

the herd does because they don't want to stand out or seem to be a nerd. People are used to having things cleaned up after them. Some people think of littering as a job creation program because now someone can have a job to clean that up. I think people allow that mindset to seep out into other areas

6. What do you think the main source of this plastic pollution is?
   Sporting events, Industrial sources, Domestic. There is no doubt that stuff it put on the streets with the idea that the council will clean it up with the idea that the local council will clean it up, There seems to be a major component of convenience food and drink containers. When people are on the move they often leave a trail behind them. Recent winds, We need to look at the street cleaning regime. The data we have so far is fairly preliminary in terms of the trends that we will show up.

7. If you could, list some environmental or human factors that you think contribute to this pollution. *For example, environmental would be rainfall, wind, elevation and human would be sporting event schedules, flea markets etc.*
   Sporting events it seems to me that in all religions (because sport is a religion), [referenced marathons and throwing of cups] litter is seen as part of the culture and it's perfectly acceptable to behave that way. Because people are unaware of plastic as a pollutant it's hard for them to do the right thing. The mindset is about aesthetics rather than this is pollution so people just don't have an idea about how serious that issue is. Our campaign with microplastics is to shift that viewpoint that it's not just about keeping things clean. I think that's where we need to have a campaign that really gets to the heart of the issue and get a better understanding of the problem and that it is a pollutant. I suspect that the kind of people who are the protagonists don't care about the animals unless maybe they are fishing and it's in the stuff they are trying to eat

8. Do you have any advice for effectively communicating research findings with the

public?

I'm hopeful that the Tableau things will be a really helpful way to do that. I think the one thing that we have as an advantage is that we are applying and approach that we are applying to an entire region that's going to be relevant to a whole load of people. Particularly to the people in the clean network. Getting them to understand that micropaltisc is not just a coastal council issue. Make sure graphic takeaways are very clear with no ambiguity. I would think the visualston would be going online as well as an education tool because I'm sure it will be good and we will want it to be as easy for the most amount of people to see

9. Do you recommend that we contact any other people who have knowledge about plastic pollution that may help our project?

10. What are your thoughts on plastic pollution in this area?

    Challenging. Things are improving even though there are more people consuming plastic products and probably dispersing them inappropriately. There is a growing awareness in the community and I'm hoping that this project is helping to have people change their behavior. There is a constant need in my view of finding ways of communicating to the wider audience. Our challenge is finding ways to communicating to people who don't already travel the paths we do. In the meantime we do need to keep advocating for product stewardship. single-use plastics should be phased out. If we can't get people to dispose of things properly then maybe those things shouldn't exist. I have to express about a little bit of frustration about people who are campaigning about just one specific thing (ex plastic bags) rather than about the bigger picture. It's almost as though some of those campaigns are put downs and part of embarrassing people rather than appealing to people's intellectual but i could be an old fart though. I think communication is key though.

11. Additional questions.

Streets to bay

Many people aren't aware (from Dolphin research institute survey 3-4 years ago) that stormwater drains connect the streets to the bay. If you cant see a bay or a creek many people just wouldn't understand that connection. People are unaware of the physical connection of where they are in the suburbs because they just can't see it. Idea is that choices that people make and choices of where they live in the suburbs will have a direct impact on the bay even if they don't know it. Educational programs to get them to understand it. Choices made in suburbs make an impact on the bay even if people are unaware

What is worse large sporting events once a year or multiple

Multiple would be more of a problem because I would assume there is a cleanup taem after major events to come in and pick up all the litter. Pokemon go could be a source because people conglomerate there and then drop their litter. Fun runs or marathon events when people drop their cups on the side of the road

Appendix AD: Interview - Port Phillip EcoCentre

Interviewee: Fam Charko

1. What organisation are you from?

   EcoCentre, I also work for Tangaroa Blue foundation. They specialise in plastic pollution that is all that they do. They have a big database AMDI and they are a national not for profit organisation that works with reducing plastic pollution. I have been running a project for them as a project manager.

2. What research does this organisation primarily focus on?

   Clean Bay Blueprint, the plastics research quantifying the plastic pollution going into the Yarra, Maribyrnong, and the bay. That's my main project. I have another one that is seasonal where I was contracted by RMIT to take seawater samples in the bay and they are analysed by RMIT researchers to look at the chemicals in sunscreen. I also do human resources and financial stuff for the EcoCentre, you have to wear a lot of hats when you work for a non-profit. At Tangaroa Blue I do a lot of event organisation. Getting passionate people into the room and brainstorming how we can prevent the most commonly littered items that they find in their particular council. It's a workshop on making source reduction plans and how they can take that back to their own councils to implement their projects in their council. Tangaroa Blue works with the EcoCentre a lot. Mainly with nurdles and getting plastic companies to adopt nurdle spill manuals. We audited 85 plastic factories and found evidence of their nurdles and then Tangaroa blue is opening those conversations with factories management.

3. Have you or your organisation worked with the Port Phillip EcoCentre in the past?

4. What previous or present projects relating to plastic pollution has this organisation worked on?

Clean Bay Blueprint. Program before was called Turn Off the Tap, it was part of the Litter Hotspots Program funded by the previous gov that's where we started the trawls (2015-2017). Then we changed gov and the labor gov came up with the Clean Bay Fund. Neil Blake is doing a lot, working with the scouts. Over the years he has worked on his audits really and the microplastics really. It's all about the data collection and not just cleaning it up.

5. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes. Overconsumption, that's the biggest cause of plastic pollution the more it gets consumed the more it gets into the environment. I think it's about 10% of plastics that get lost into the environment. Sometimes it's wind, birds, garbage people spilling things, people littering, but really the problem is overconsumption. If you can't use it then you can't lose it. Lack of understanding by consumers, on what plastic does, what kind of material it is and what kind of effect it has on the environment. There is a lot of people who throw the plastic in the bin and they don't see it anymore so they think it goes away. There is a lot of education on what the material is, how to handle it properly and the repercussions of what happens if they don't handle it correctly. Industry gets away with the produce produce produce model that is unsustainable. The attitudes of people and either their indifference in disposing plastics properly or their lack of education on how to properly dispose. There is no difference between natives and visitors because everyone seems clueless.

6. What do you think the main source of this plastic pollution is?
   That's a really hard one. Sources are different for every country, or state, or patch. The biggest source for the bay is what comes out of the Yarra and Maribyrnong. If you are looking at the Yarra and the Maribyrnong well that's what you guys are looking at. In Port Phillip Bay it would be the suburbs of metropolitan Melbourne

and the users of plastic there.

7. If you could, list some environmental or human factors that you think contribute to this pollution. *For example, environmental would be rainfall, wind, elevation and human would be sporting event schedules, flea markets etc.*

   I spoke with Ross of Beach Patrol and he told me he sees a spike in pollution at his beach after a nice sunny day or a nice sunny week. Because people go outside and they get lunch or bring a picnic or whatever. I don't necessarily see rain as a cause of it, rain is something that plastic pollution gets moved by. I reckon the nice days are the causes.

8. Do you have any advice for effectively communicating research findings with the public?

   Executive summary is the best thing ever. Use normal peoples language, it is so important not to use super industry or science specific words that people don't understand. Think about who your audience is, who is going to see your results, who wants to know about it, who are you going to communicate your findings to. What does my audience need to really fully grasp those contexts. It's really important to know your audience. I think the map is really good because there are a lot of people who are visual learners. I always like to use a combination of visual tools and written things for people with different learning styles

9. Do you recommend that we contact any other people who have knowledge about plastic pollution that may help our project?

   Ross Headifen from beach patrol. He is very into beach patrol Australia, he does his own beach patrol and he is a biochemist so he knows everything about plastics. He has a company that produces landfill biodegradable plastic. Carolyn from City of Melbourne. Send me an email to remind me and I will send you her details. You might have to ask her who the right person to talk to is. Also send me an email with

info for the person from Docklands

10. What are your thoughts on plastic pollution in this area?

    I think they are very lucky to have a Ecocentre here. The City of Port Phillip does what they can. They are doing a good job, but is it what we need to concentrate on? They spend $4000 a year to pay people to clean up the beaches with plastics that come from other suburbs. It's just a bandaid because people don't see the reality of what's happening because nobody knows the city does anything about it. The sustainability department used to be really well funded, and then the gov changed everything and now they can't do much of anything now a days. I think the best thing for sustainability they are doing is funding the Ecocentre.

11. Additional questions

    Tangaroa Blue's Auditing

    Tangaroa Blue is a national organisation so they organise audits and cleanups all around Australia (3,000 locations). They are even overseas as well. They have also just launch the app which helps to make it easier. It is the biggest litter database in Australia, possibly in the southern hemisphere. It is well established but that doesn't mean it is suitable to answer every specific scientific research question. For what Neil is trying to do here in Victoria it doesn't give him the information that he wants and that's why he's come up with his own method. There is no single method of counting litter, and it depends on what you are trying to find.

    Litter traps or gross pollutant traps that Tangaroa Blue has

    19 floating litter traps by Parks Victoria. Some councils have nets that they use to catch pollutants. It works, but you have to deal with lots of organic material. They have to put substantial funding into paying people to empty those and that's where it usually falls flat. I think litter traps are okay as long as you can get it emptied enough times for it to be effective. Microplastics fall through all the holes so its not

helpful for that. And it's kinda putting a bandaid on the issue. In 2051 Melbourne is going to have twice as many people than they do now, and that correlates to twice as much plastic pollution and no amount of litter traps is going to handle that.

Appendix AE: Interview - Tangaroa Blue

Interviewee: Jodi Jones

If you have any questions or concerns you can contact us at gr-ecoB18@wpi.edu

1. What organisation are you from?

   TANGAROA BLUE FOUNDATION Australian Marine Debris Initiative

2. What research does this organisation primarily focus on?

   Marine Debris and Litter source reduction

3. Have you or your organisation worked with the Port Phillip EcoCentre in the past?

   Not directly

4. What previous or present projects relating to plastic pollution has this organisation worked on?

   The Tangaroa Blue Foundation manages the Australian Marine Debris Database and also takes an active role in removal of litter through facilitating clean-up activities across Australia and the south pacific.

5. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

   single-use plastics being discarded.

6. What do you think the main source of this plastic pollution is?

   single-use plastics

7. If you could, list some environmental or human factors that you think contribute to this pollution. *For example, environmental would be rainfall, wind, elevation and human would be sporting event schedules, flea markets etc.*

   There is no known source of plastic pollution that occurs. Naturally, humans are responsible for the manufacture of plastic pollution and for the release of the

pollution into the environment. It is important that we recognise that humans are the sole source of plastic and plastic pollution. How the release of plastic pollution occurs is again an act of humans making bad decisions in many different ways. These differ between spaces and places, organisations and events, industries and processes. Natural disasters and weather events can cause plastics to wash up on beaches in greater quantities, but these items need to be already present in the environment, already littered. Often runoff during high rainfall events will carry plastics quickly into the ocean. Some remote areas of Australia are heavily impacted by debris transported via oceanic currents from foreign lands where plastics are treated differently and often dumped. Sporting and community recreational areas often specifically reflect litter datasets for single-use food and beverage packaging. Sources of litter range from Individuals, groups to industry practices. It is a diverse and challenging issue to address.

8. Do you have any advice for effectively communicating research findings with the public?

   The Tangaroa Blue Foundation, facilitates source reduction workshops and manages source reduction plans that strategically target items of litter by locations. Using data to as a driver for change in practices and for public education.

9. Do you recommend that we contact any other people who have knowledge about plastic pollution that may help our project?

10. What are your thoughts on plastic pollution in this area?

    Sadly Plastic pollution is a man made problem that we are only just starting to understand the magnitude of. Action across many spaces and places is needed to divert plastics from our environment.

Appendix AF: Interview - Boomerang Alliance

Interviewee: Annette Finger

1. What area or business within Victoria do you represent?

   Boomerang alliance is not for profit alliance group of 47-48 alliance members. We are Australian, founded in 2003 and have always focused on waste and helping communities moving towards a zero waste community. Container deposit, e waste, mattress recycling, and marine pollution. Communities taking control, going out into communities that are taking control and work together on creating a plastic free community, council, neighbourhood, etc. Noosa and Wollongong (NSW) is the pilot project. They have been going gangbusters and replacing so many single-use plastics with other alternatives. I think we chose these cites based on the people who were working there. I am the only staff member in Victoria, my campaign is more of trying to get Victoria to adapt a container deposit scheme.

2. Are you aware of microplastic pollution and the existence of it within your area or business?

   Yes. One of my daughter's friend at school has a farm near a private beach. Because of the way its situated it gets the current (Cape Liptrap) from Bass Strait but all Port Phillip Bay (southwest current) and over the last 5 years he has noticed more and more microplastic pollution on the beach. Clearly its coming from Port Phillip Bay because only 5 families have access to this beach and they all know each other and are conscious about plastic pollution and that kind of stuff. The high tide line is covered with things. I can show you pictures later. Stephen Price, the project, on TV. He said yesterday that he goes anywhere and never sees any plastic. And I really want to take him to this pristine beach and show him the plastic pollution. Because once you see it you can't unsee it.

3. On a large scale how well do you think councils manage waste? Both public facilities

as well as private rubbish collection, etc.

I think councils are doing a really good job in Victoria. Compared to other states, Victorian councils are doing a great job. But there are jurisdictions in Stall which is 3 hours west from here towards the Grampians. Its more rural area, there is no curbside recycling. There are areas in Victoria that are a bit more remote. The other thing I wanted to say is that while they are good at collecting the recycling, at the moment they are having trouble having those materials actually being recycled and brought back into a circular economy. Because as we know with China not accepting the contaminated waste, and its plunged Victoria into a bit of a recycling crisis. I know my local council is a very progressive council and they are doing a very good job of sorting things out, even things that most people wouldn't collect. They have really passionate people and they are putting so much effort into this depot and they have about 6 months left before they are bursting at the seams with recycling and will have nowhere to send, sell, or give away the recycling. Indonesia or Malaysia has announced they are going to do the same as China. Nobody wants our recycling anymore, so we are in a real pickle. And the councils are in a hard situation because they can't just keep increasing rates to store all this recycling until local recycling companies get up and going, or other alternatives exist. This is a real big issues for council at the issue, a lot of councils have called on the government to put in a container deposit program because it takes out most of the glass and what is left in the curbside is cleaner. We need to encourage new recycling business to start up and we need to protect them (through grants or procurement policy so that the products they are producing are actually being sold). We need the pull of consumerism and demand for those products. They need to be protected from oil price crashes when it becomes cheaper to buy virgin plastic than recycled plastic. I think there needs to be a plastic tax on virgin plastic because people think through their hip pocket. The money from that tax can go towards local recycling. The problem is our political

system because someone saying they are going to introduce a tax they don't get elected. I am from the City of Yarra. A drink container (mostly what you would take out of the house, not like milk or wine bottles. Includes water bottles, beer bottles, cans, etc) those get a deposit put on them before they are produced and they will have a stamp or something on them will say container deposit. And when you go to deposit them, it's like a reverse vending machine where you put in your bottles, it totals them up and gives you a docket that can be redeemed for that money or could be donated to charity. And that vending machine sorts everything out by material so you don't get any of that contamination or damaged bottles. In this way the material is more valuable.

4. Are there any plastic use regulations currently in place in your area or business and, if so when were they implemented?

   Victoria doesn't have plastic bag ban yet but we have been promised one next year. There is fined against littering. Close the loop for fishing line. Blow bubbles not balloons. There have been a lot more campaigns and education events. Formula 1. Lots of local council stuff about festivals/large public events. There isn't that much, there should be more. We want the bag ban to be written very cleverly so that it can be amended to those people who are producing 36 micron bags. And we reserve the right to add if they are seeing a lot of the thicker bags littered that we can ban those too. We are massively missing a container deposit scheme in Victoria. All the other states have one or are working on getting one. We are the only ones who keep saying Victoria is the cleanest state.

5. What are your thoughts on plastic pollution in this area?

   Global issue, on par with climate change. Its gaining more publicity thanks to war on waste, documentaries like plastic ocean, blue (the film, It doesn't just deal with the plastic pollution, it also looks at overfishing, sharks, beach debris and plastic

pollution) Here is my own philosophy behind it. Chemistry is a marvelous thing but those polymers were not meant for this. It's something that nature has no idea what to do with. Because these don't exist in nature, nature has no idea how to incorporate it into their circle of life. We are producing and we keep producing because it's such a marvelous material. Because of its qualities that make is great it's an absolute nightmare in the envi once it gets displaced. The proportion of material being produced as packaging have increased and those are the ones that have entered the waste management area in the same year that they were produced. We cannot keep up with the amount that we are producing in terms of managing the end of life of all these products. That's why we have all these rivers of plastic going into the ocean and once it's in the ocean it's a nightmare to produce. We can learn from the climate change issue. It's getting more and more dire with climate change but we have enough scientific issue to prove that plastic pollution is a problem. Cleaning up alone is not the solution, recycling alone is not the solution, we need to go back to the equivalent to leaving the coal in the ground we need to change something drastically about the way we are consuming plastic. We cannot live without plastic yet. Maybe we can save the 30 years we wasted trying to convince people climate change is an issue and make people do this.

6. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes?

   Mostly stuff that comes through the storm water drains isn't it. And that comes from streets. We haven't even started talking about microfibers and microbeads. They are pretty much impossible to get out of our water at water treatment plants. The larger pieces are mismanaged from the consumer to the recycling or the bin. Weather events like what we had last night. There has been some illegal dumping of nurdles, there might be some accidental or semi irrespirable dumping of nurdles. Sure there is people tossing stuff out of the car or going for a picnic and leaving it but I

don't think there is too many of those people. There is commercial and recreational fishing. Overall I would say the largest chunk would be things that get blown out of bins and blow away and end up somewhere in the creek and from there it's downhill.

7. Who do you think is responsible for plastic pollution?

   We are all responsible I think but we need to get a proper product stewardship responsibility scheme happening. There is a product stewardship on a federal level and it's just went up for submission and they have never received so many submissions as they received this year. Break free from plastic just did brand auditing for what brands contribute to marine litter (just published report a few weeks ago). They need to be held responsible and they are the ones who can afford to pay for it. Ideally whoever produced the product is responsible from the moment its produced until the end of its life. There should be tax on that, people shouldn't have to do these cleanups for free, people should be paid for it. I don't know how you would get that happening, short of a revolution. Product stewardship: some companies are doing quite well; Officeworks is taking back batteries. McDonald's is doing this thing where they have to go around their block and clean up all their litter. There is a certain radius that they have been told that their staff has to go around and clean up. I think it's also councils to come extent, you have all these beautiful restaurants along the harbors and they are all selling single-use plastics and stuff and the ocean is right there. There should be some sort of barrier. They should also help businesses transition away from single-use plastics. We all have responsibilities not to litter. Schools have a responsibility to instill that education. Europe has banned polystyrene packaging for white goods. The same plant in China is producing white goods and depending on what market is going to its packaged in polystyrene or cardboard. Why can't we just say we don't want polystyrene and package it all in cardboard. I don't think there is a more damaging material than polystyrene. Yarra blitz is this Sunday. I'm going to be there. They focus on

polystyrene but they find a lot of drink containers, tennis balls.

8. Auditing methods that go on when you do these events

   I've audited with Heidi Taylor at the last Yarra blitz. She's incredibly fast with her hand held device. The auditing can be really quite laborious. What we usually do especially when there is a system that picks up a lot of stuff really fast and you have people trying to categorise what is in it. If you can do a subset, say 10% and then extrapolate its really good if you can follow Heidi's system. Heidi is Tangaroa Blue which goes into AMDI database which is biggest and best database that we have in Australia. We want to expand that to when we do audits on the streets. The issue is that its laborious and there are a lot of subcategories. And a lot of the things we need to the lobby for in legislation is hidden in all these subcategories (straws for example, there are not a category for them). I think it is important for the integrity and reliability of the database that we all do this. One of the issues I've had in my campaigning in gov that I've talked to where they say that Victoria is the least littered state. They are using the national litter index (NLI) which is executed by keep Australia beautiful which is co-funded by Coca-Cola. They go to different sights and all the different states and a fixed number of sites. You would look at it and go awesome, but not so because their numbers are ridiculously low compared to every other organisation. I don't know what they are doing but it's not representative of the litter that's actually out there. They can't explain what they have done and people keep referring to this NLI and this number is bogus. They are secret sights and they don't tell you when they go.

9. Spring clean the city

   300 volunteers, 2 hours and we went through the city

   People were given a little map and they would go and clean up a specific block and then we all collected and put our litter in one location. We sorted out coffee cups and

lids, straws, some tried to do cigarette butts, other cups and lids, drink containers that would be covered under container deposit schemes, other recyclable materials, the rest went into landfill. I've made this chart where you look by volume about what each category makes up. About 7 cubic metres of litter and 1/3 of it was drink containers. The drink containers, people went through and counted by brand at the end. I can get you those numbers and those charts.

We didn't have time to do an audit or even do a subsection. I would like to do that this time. This was the first time we have done this and we really wanted to focus on those 5 main categories of litter we find and we wanted to try and find the volume this makes up. We wanted to use that as a catalyst for action.