Polystyrene Pollution in the Yarra River

Sources and Solutions

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Acknowledgments

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Figure 1
Polystyrene on Yarra river bank
Anthony Despotellis

Disclosure Statement

Cleanwater Group (CWG) acknowledges that some of the recommendations made herein (particularly regarding the protection of stormwater infrastructure in hotspot areas) could be construed as in the interest of the company, as CWG provides such services and stands to gain financially if an employment opportunity should arise. In light of this, all possible efforts have been made to ensure impartiality in all recommendations and discussions provided. Cleanwater Group does not promote their business practices in this document, nor one technology or supplier over another. The advice they put forward in this document is therefore meant to be taken as general in nature. It is also acknowledged that the company will only participate in any possible future action that may be taken in this space if the process of involvement is deemed to be fair, unbiased and based on merit.

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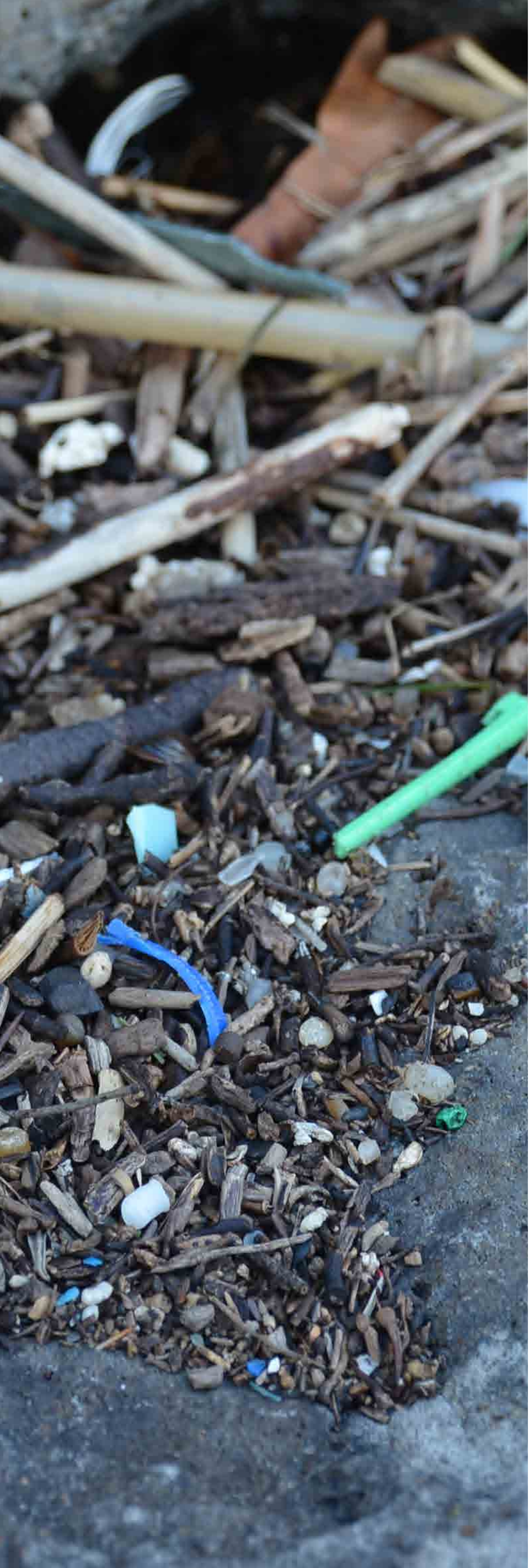
Figure 2
Microplastics in the soil at the Docklands
Anthony Despotellis



The Yarra Riverkeeper Association

The Yarra Riverkeeper Association (YRKA) is the credible and authoritative voice for the Yarra, Melbourne's own beautiful, resilient, iconic river. The Association is an independent community of citizen advocates that works solely in the interest of the river with the advocacy strategy built around the motto: 'Our Yarra, healthy, protected and loved'. The Yarra Riverkeeper team monitor the river by boat and on foot, by bike and by canoe. That enables the Association to build a detailed understanding of the complex interactions of the ecology of river and its role in the City of Melbourne. This understanding is shared with the community through the Association's educational programs, website, and social media. YRKA's aims are to protect the Yarra from mouth to source, to revitalise the river and to foster love for the river by current and future generations.

The Cleanwater Group

The Cleanwater Group is a profit-for-purpose business with a mission to reduce the amount of plastic and other pollutants entering our ocean. We do this by focusing on prevention, data collection, source reduction, and community engagement. Our vision is a world where plastic is valued so much so that it no longer pollutes the environment.

Figure 3
Nikki at the Yarra River
Blitz on the Yarra
Anton Tejeda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Executive Summary

Polystyrene is pervasive on the Yarra River. Since 2018, polystyrene has consistently been found to be the highest littered item found on the River. Being both a light weight and brittle material, means that the ecological impacts of polystyrene, which can unfold gradually over time, can be widespread and devastating for the River and Port Phillip Bay.

This report presents the findings of a study aiming to identify potential sources of polystyrene, particularly expanded polystyrene, pollution along the inner city and suburban reaches of the Yarra River. Data was gathered over the period from September to October 2019, with supplementary data added in January 2020. Both desktop research and field observations were conducted, in combination with a key informant survey through semi-structured interviews.

With over 80% of field observations finding some level of polystyrene leakage, the results suggest that polystyrene leakage is widespread and prevalent within every industry that manufactures, distributes, handles and/or uses the material.
In most cases, observations can be linked back to one of 64 sources with photographic evidence provided. While the analysis identified that the retail industry, which uses polystyrene in white goods, brown goods and general packaging, is likely to be a major contributor of polystyrene pollution, the construction and building industry is, collectively, likely to also be a significant source, even though the amount of data collected on building sites was relatively limited as there is only a narrow window of a few days when EPS products can be observed being placed into concrete slabs or as insulation at a site. The results have been presented in an interactive geographical information system map, which will later be incorporated into the Yarra Atlas, with an access portal available on the Yarra Riverkeeper Association website.

Figure 4
Vacuuming the Yarra River banks
Cleanwater Group

1.0 Introduction

Where the Yarra meets Port Phillip Bay

The Yarra River traverses an enormous range of habitats from pristine forested catchments to a range of agricultural lands and dense urban areas. The Yarra flows 242 kilometres from headwaters to sea – from its source on the flanks of Mt Baw Baw in the Yarra Ranges National Park, north-east of Melbourne, through the Yarra Valley and greater Melbourne into Port Phillip Bay at Newport. More than one-third of Victoria's population lives in the Yarra catchment, which spans about 4000 square kilometres and includes 50 rivers and creeks (Melbourne Water Corporation, 2018).

The Yarra River corridor is 22% urbanised, 21% natural vegetation and 57% agricultural (Melbourne Water Corporation, 2018). Historically, the Yarra River was treated as a large, open dumping site, transporting human detritus out of sight and out of mind. In 2018, the State of the Yarra and its Parklands investigation reported 18 of the 25 environmental health indicators were 'poor'. Only 1 of the overall 36 indicators scored in the 'good' category, which was the indicator for "post settlement colonial heritage" (Victoria, 2018). The three main issues facing the Yarra today are overdevelopment, invasive species and habitat loss, as well as poor water quality. Water quality has been adversely affected by litter, pollution incidents, sewerage, stormwater quality, and climate change. The Yarra River discharges into the northern most section of Port Phillip Bay, Hobsons Bay. Port Phillip Bay is the largest marine embayment in Victoria, with an area of approximately 1,930 square kilometres, a coastline of 333 kilometres and a catchment area close to 10,000 square kilometres. Melbourne, with a population in 2018 of 4.9 million people, surrounds much of the Bay. The Yarra River provides most of the freshwater inflow into the Bay and is the largest litter contributor.

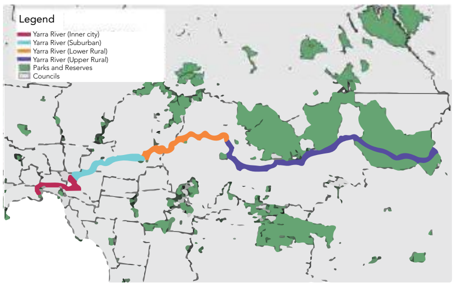


Figure 5
Map of the Yarra River showing the boundaries of each of the four reaches and its entry into Hobsons Bay.

Figure 6
The Yarra River
Anthony Despotellis

Litter in the Yarra River

Waterways such as rivers act as a major transport pathway for all sizes and types of litter. High plastic litter loads in rivers, including both macro and microplastics, are due to high levels of mismanaged plastic waste arising from population-rich river catchments. The State of the Bays 2016 report highlighted the impact of waterway litter on Port Phillip Bay beaches, including the potential for litter to cause injury, high toxicity in biota and even death. The State of the Yarra 2019 report further identifies litter as a key threat to our waterways and highlights an increasing trend in litter volumes along the river corridor.

Through YRKA's Litter and Flows and the Yarra River Blitz projects, it was identified that polystyrene, especially expanded polystyrene (EPS), is the most prevalent and pervasive litter item in the Yarra River. Since April 2018 and following 7 Blitz events approximately 38,000 kg of polystyrene contaminated soil and general waste have been removed from the Yarra's riverbanks and reedbeds. Microplastic trawl sample analyses also indicated that over 828 million litter items flow into Port Phillip Bay annually from the Yarra's surface waters, and over 612 million (74%) of these are microplastics, including polystyrene fragments (Charko et al, 2018).

Seeking to identify potential sources and distributions of polystyrene on the Yarra, YRKA submitted an application for the Port Phillip Bay Fund Round 3 Grant from Victoria Government's Department of Environment, Land, Water and Planning. Upon successfully receiving this grant, the YRKA partnered with the Cleanwater Group to research, map and conduct field inspections of potential sites around the inner-city and suburban reaches of the Yarra, where high-volumes of polystyrene were thought to be leaking into the environment and finding their way into the river.
The project aimed to track down key sources of polystyrene pollution and identify potential solutions to contain this material at the source. This report has been prepared in order to present the results of this study and provide recommendations on source reduction actions that can be implemented to prevent polystyrene from entering our iconic waterways and Port Phillip Bay.

Expanded Polystyrene in Australia

EPS, derived from the addition polymerization of phenyl ethane (styrene monomer), is produced in white beads consisting of a number of closed cells, solidly supported and heat-sealed tangentially to each other, which contain still air occluded inside (Tsivintzelis et al., 2007). PS foam is produced by treating crystalline PS with a blowing agent, typically a hydrocarbon or carbon dioxide, to produce a cellular structure in the material, which reduces the brittleness, making it an excellent cushioning and insulating material. Its use in food and electronics packaging, airplane and automotive parts, and sporting equipment (among other applications), has increased in the last few years due to its advantages of being lightweight, easy to form, acoustic and thermally insulating, inexpensive to produce, cushioning, dimensionally stable, and heat and moisture resistant (Castro et al. 2017).

In Australia, the expandable polystyrene manufacturing industry produces and markets long life-cycle products, such as geoblocks, cornices, insulation systems for construction, and refrigerators, as well as short life-cycle products, such as multipurpose boxes and packaging systems for the transport of fragile goods and foods, to name a few.

According to Expanded Polystyrene Australia (EPSA), the national industry body for all manufacturers and distributors of EPS products across Australia, an estimated 71,000 tonnes of EPS is consumed annually, growing at a rate of 5% per annum. This consists of:

- 47,000 tonnes, which is domestically manufactured from imported resins. Of this, 70% is used in the built environment, in long-term use such as waffle pods used in housing construction and engineering/manufacturing components (Metropolitan Waste and Resource Recovery Group, MWRRG, 2018). Approximately 30% of this is used for packaging, typically single-use or short-term packaging that can be recycled after use. Of the 30%, approximately half is exported as fresh food packaging;

- 24,000 tonnes imported as packaging with products;

- 3,000 tonnes, which is the estimated amount of EPS reprocessed and used locally.

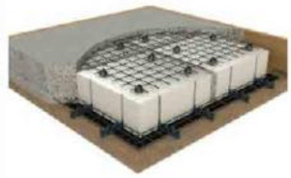


Figure 7
Example of EPS waffle pod used in the construction of a concrete slab
(WPMA, 2017)

Figure 8 - Above
. Various uses of expanded polystyrene in the packaging and construction industries.

It is also estimated that the total amount of EPS used in packaging is 44,000 tonnes, distributed into the following applications (Australian Packaging Covenant Organisation, APCO, 2018):

20,000 tonnes for electrical and electronic products;

24,000 tonnes for other packaging,

Of the EPS that is being used in construction (which constitutes 70% of all EPS used in Australia), it is estimated that more than 90% is consumed as waffle pods, with the remainder going into composite structure insulated wall panels and other building products (One Planet Consulting, 2018; Expanded Polystyrene Australia, EPSA, 2019a). Waffle pods are used in the construction of concrete slabs for both residential homes and commercial industrial buildings (Waffle Pod Manufacturers of Australia, WPMA, 2017). They are made from EPS, and act as void formers for concrete slabs. They are known to reduce construction costs, provide insulation, reduce soil disturbance and improve the time-efficiency of building sites (WPMA, 2017). "Waffle pods are EPS blocks incorporated into building foundation slabs to significantly reduce the amount of concrete (along with other benefits) required (One Planet Consulting, 2018:8)."

In practice, waffle pods are laid out according to the site's foundation plan and are evenly placed in a grid-like pattern using spacers between each pod (EPSA, 2014c). Each pod is around 1.09m wide by 1.09m long, with thicknesses ranging from 150mm, 225mm, 300mm, and 375mm depending on the site specifications (EPSA, 2014c). Reinforcing mesh is then placed on top of the pods, prior to concrete being poured on top of and between the pods to complete the foundation (EPSA, 2014c). It is common practice to over-order waffle pod material in order to ensure that there is enough on hand during construction. In addition, there are also off-cuts generated on site during the installation process (One Planet Consulting, 2018).

EPS Recycling

While EPS is reported to be 100% recyclable (EPSA, 2014b), it is estimated that "almost all EPS in Australia currently goes in general waste to landfill (One Planet Consulting, 2018:15)." This is largely due to polystyrene being excluded as an acceptable form of recyclable material in residential kerbside collections, as well as the lack of a consistent EPS recycling collection and drop off services for most users apart from isolated cases run by bulk-goods retailers (e.g. Harvey Norman and the Good Guys) or local councils.

In terms of EPS recycling, there are different figures reported for the amount of polystyrene recycled in Australia. EPSA (2014b) reports that during the 2018/19 period, over 5,800 tonnes of EPS was recycled, which is in line with One Planet Consulting (2018)'s reported recycling rate of 12.1% for EPS across all applications over the 2015-2016 period. More recently, however, according to the 2017-18 Australian Plastics Recycling Survey commissioned by the Australian Government Department of Environment and Energy, New South Wales Environment Protection Authority, and others, the national recycling rate for expanded polystyrene is now lower, at 7.6% with the major end-market use being for waffle pods (Envisage Works, 2019). In terms of EPS packaging, according to a 2018 EPSA study, the national recycling rate is relatively low with approximately 3,000 tonnes of EPS recycled locally and 6,000 tonnes exported for recycling (EPSA, 2018). This forecasts a recycling rate for EPS packaging in Australia at 29% (Envisage Works, 2016). This is in contrast to the NSW EPA, which reported that less than 10% of EPS was recycled in NSW (being one of the most poorly recycled plastics in the state). It estimated that 12,000 tonnes of EPS is disposed to landfill each year, taking up 240,000 cubic metres of landfill space.

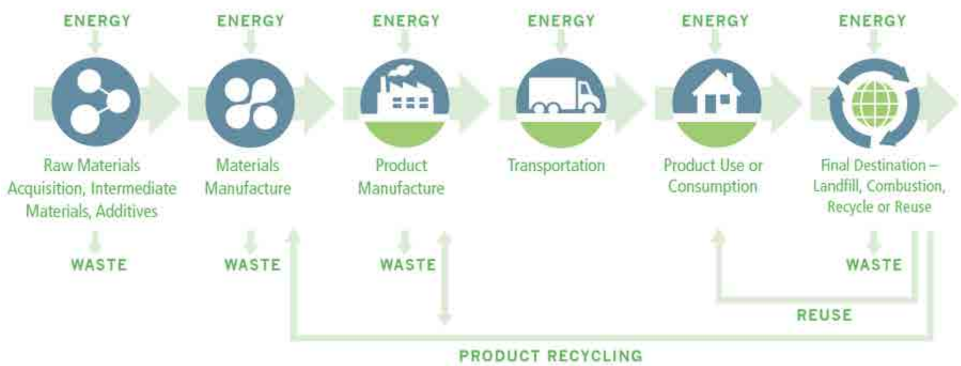


Figure 9 - Above
General material flows for EPS Packaging (Source: EPS Industry Alliance Packaging, 2019).

A report by One Planet Consulting (2018:15) that was commissioned by ACT NoWaste, summarises the problem for EPS: "EPS is inert in landfill and lasts for hundreds of years. However, it occupies a large volume (space) in landfill for a long time. Positively, it is recyclable and there is a market demand for it in Australia and offshore; however, collection costs are often greater than landfill costs."

The key challenges summarised by APCO (2018) for recycling and recovering EPS and other foamed plastics include:

Challenges in landfill: While EPS only makes up a small percentage of solid waste to landfill, it takes up a lot of space and inhibits the compaction of waste. These problems and associated costs to local government are not reflected in landfill disposal costs.

Impacts in litter: EPS is one of the most common materials found in illegally dumped rubbish. In the litter stream, EPS is a particular problem because it is lightweight and easily breaks down into small pieces.

Limited collection network: EPS is generally not collected through kerbside systems and the network of drop-off points are fragmented and not accessible by all consumers. Logistics are relatively expensive due to the high volume-to-weight ratio.

Economics of disposal: It is cheaper for a consumer to landfill EPS than pay for recycling.

Quality of collected materials: High levels of contamination in many commercial and industrial sources reduce its commercial value.

Alternative materials: Some users are switching from EPS to alternative foams such as expanded polypropylene (EPP) and expanded polyethylene (EPE) which are less recyclable.

End markets: There are limited local markets for recovered EPS (most is exported at present).

Consumer engagement: There is a high level of consumer frustration as they do not know if or how to recycle EPS

Polystyrene in the Yarra River

One of the benefits of monitoring litter in river systems is the relatively intact structure of litter items, making them identifiable. This is in contrast with marine litter, which is often degraded, making it nearly impossible to track the sources of the litter. The Litter and Flows Project highlighted the main litter types found along and within the Yarra River by using the following auditing methods:

a) Bandalong litter trap audits;

b) Microplastic trawls;

c) Community clean-ups, and;

d) Vacuuming reedbeds and riverbanks along the Yarra.

As illustrated below, the quantitative and qualitative data gathered through these audits clearly revealed that Expanded Polystyrene (EPS) was the most abundant litter item, both in terms of quantity and volume.

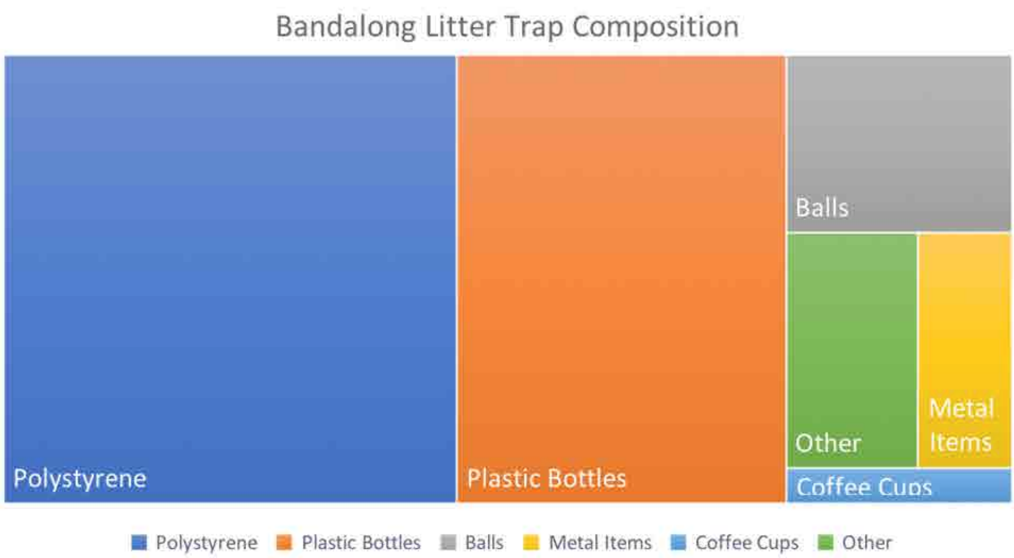


Figure 10
Average composition of a Bandalong litter trap in the Yarra River (combining all litter traps between years 2017-2019 and excluding organic matter which accounts for approx. 60% of trap contents).

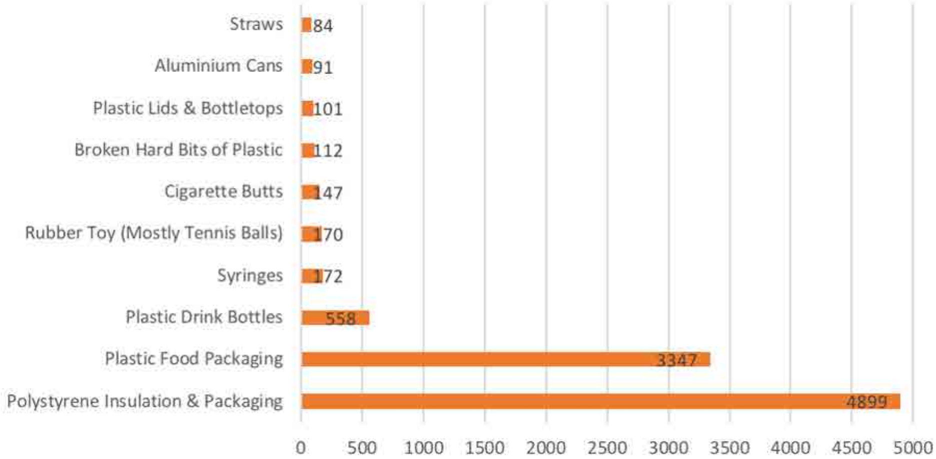


Figure 11
Top 10 most common items collected from the banks of the lower Yarra River (between Church Street Bridge and MacRoberston Bridge), based on a 100kg (20 bags) sample on 18 April 2018.

From these audits, it was identified that polystyrene pollution comes in a number of forms as listed below. An example of the various types can be seen in the photo included in Figure 14.

- Polystyrene sheets (in various thickness - likely a construction industry source);
- Polystyrene blocks (whole and cut offs - likely a construction industry source);
- Polystyrene packaging for small and large appliances (packaging) as illustrated in Figure 9;
- Meat/fruit trays and food packaging including cups, bowls, clam shells (packaging);
- Polystyrene balls (Christmas decorations and other décor);
- Polystyrene beads (in various dimensions);
- Polystyrene peanut shape packaging;
- Flexible polyethylene foams.

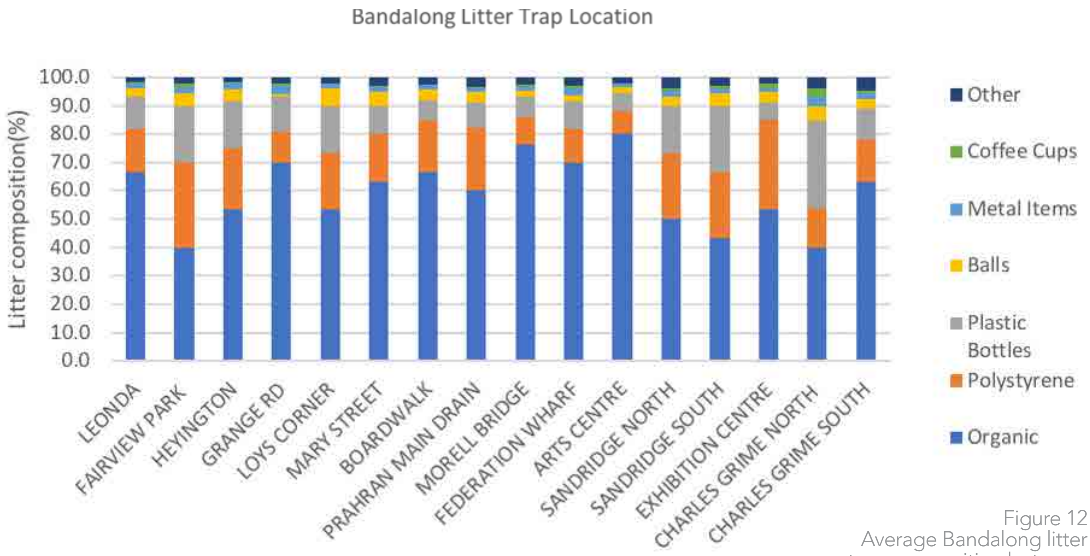


Figure 12
Average Bandalong litter trap composition between years 2017 and 2019.

Figure 13
Examples of polystyrene used in white goods packaging
YRKA

Figure 14
Close-up of Bandalong litter trap contents in the lower Yarra.
YRKA

Environmental Impacts of EPS

Worldwide, EPS is commonly reported as one of the top items of debris recovered from riverbanks, shorelines and beaches (Thaysen et al., 2018). It's widespread distribution and persistence have resulted in EPS being found in the gut contents of freshwater invertebrate and vertebrate wildlife (Jianann et al., 2018). In addition to physical EPS material, styrenes, the building blocks of the polymer, are found in marine and freshwaters and sediments globally (Kwon et al., 2015, 2017). Because polystyrene plastic is thought to be one of the only sources of styrenes in the environment, the styrene contamination is likely a result of polystyrene weathering and leaching in marine and freshwater systems (Kwon et al., 2017). Furthermore, in some parts of the world EPS has been cited as a source of other chemicals to the environment (Rani et al., 2015; Jang et al., 2017) and wildlife (Jang et al., 2016).

In Asia, hexabromocyclododecanes (HBCDs) have been detected in EPS buoys and other consumer products (Rani et al., 2014). This contamination originates from recycled EPS materials containing flame retardants. The same research group found that sediments near aquaculture farms using recycled EPS buoys have relatively higher concentrations of HBCD compared to other sites (Al-Odaini et al., 2015). Further, mussels living on EPS buoys have EPS fragments and greater concentrations of HBCD in their tissues than mussels that live on other materials (Jang et al., 2016). These studies confirm that HBCD from EPS leach into the environment and surrounding organisms.

In 2015, the European Union banned HBCD (hexabromocyclododecane), the brominated flame retardant used in polystyrene building insulation, arguing that the health and environmental hazards associated with HBCD were significant. HBCD is not manufactured in Australia but is imported in EPS resin, as liquid dispersions and as a component of the EPS in finished articles, (Australian Government, Department of Health-Hexabromocyclododecane (HBCD)).

Polystyrene is more harmful than other types of plastic because it is composed of relatively hazardous chemicals (Lithner et al., 2011). Under certain conditions, EPS leaches styrene and benzene, chemicals that have known toxic properties (Gibbs and Mulligan, 1997; Niaz et al., 2017). Laboratory toxicity studies suggest polystyrene microspheres can impact feeding behaviour (Besseling et al., 2012; Cole et al., 2015), cause weight loss (Besseling et al., 2012), and affect reproduction (Cole et al., 2015; Sussarellu et al., 2016) in invertebrate species. More research into the impact of EPS and associated chemicals in vertebrates are needed to confirm broadscale negative ecological impacts.

Although inconclusive, these results highlight potential environmental impacts of large volumes of EPS within the Yarra River. Many governments have now accepted the recommendation from the science community that society should not wait until there is more quantified evidence of the degree of damage before acting to reduce marine plastic pollution impacts (Lavers and Bond, 2017, Gall and Thompson, 2015). In their report 'Marine Plastic Debris and Microplastics', the United Nations stated that there is a moral argument that we should not allow the ocean to become further polluted with plastic waste, and that marine littering should be considered a "common concern of humankind" (UNEP, 2016). Locally, the wildlife living in and around the Yarra River is diverse, with one-third of Victoria's animal species found in the Yarra catchment. The river and local surrounds are home to 22 species of fish, 190 bird species, 10 frog species, 16 reptile species and 38 species of mammals, with several of these listed as endangered. Hence, immediate measures to manage plastic pollution at all stages of its life, particularly at the early stages where plastic sources are known and can be more easily contained, need to be addressed.

2.0 *Aims*

The specific aim of this project was to identify potential sources of expanded polystyrene that are polluting the inner city and suburban reaches of the Yarra River. The secondary aim of this project was to gauge the level of understanding amongst the industry on the extent and severity of polystyrene pollution around the Yarra River, and map hotspots identified through the Yarra River Blitz project.

The final aim of this study was to develop a list of actions and recommendations to reduce further pollution from the sources identified as contributors, with the ultimate goal of preventing this substance entering the Yarra River and Port Phillip Bay.

Figure 15
The Yarra River
Anthony Despotellis

Area of Study

The area of study for this research covered the inner city and the suburban reaches of the Yarra River. Both reaches have been designated and described by Melbourne Water Corporation (2018b) in the Yarra Strategic Plan Map Book.

The first, suburban reach, extends from Warrandyte which sits at the edge of metropolitan Melbourne, to Dights Falls in Abbotsford. This reach primarily consists of a near-continuous network of parklands and conservation areas as it transitions from rural at the metropolitan edge to suburban once it gets closer to central Melbourne (Melbourne Water Corporation, 2018b).

The second, inner city reach, starts at Dight's Falls which marks a clear transition from the suburban to the inner city and is also the transition point between tidal and freshwater flows. The reach then extends through industrial areas on the river flats, well-established residential neighbourhoods, the Melbourne CBD, parklands and recreation spaces down to the central city where it ends (at Webb Bridge). While the precincts of Docklands, Fishermans Bend and the Port of Melbourne are not technically considered part of the inner city reach by Melbourne Water Corporation (2018b), they were included in this study.

Figure 16
Map of the inner-city reach
(Source: Melbourne Water, 2018)

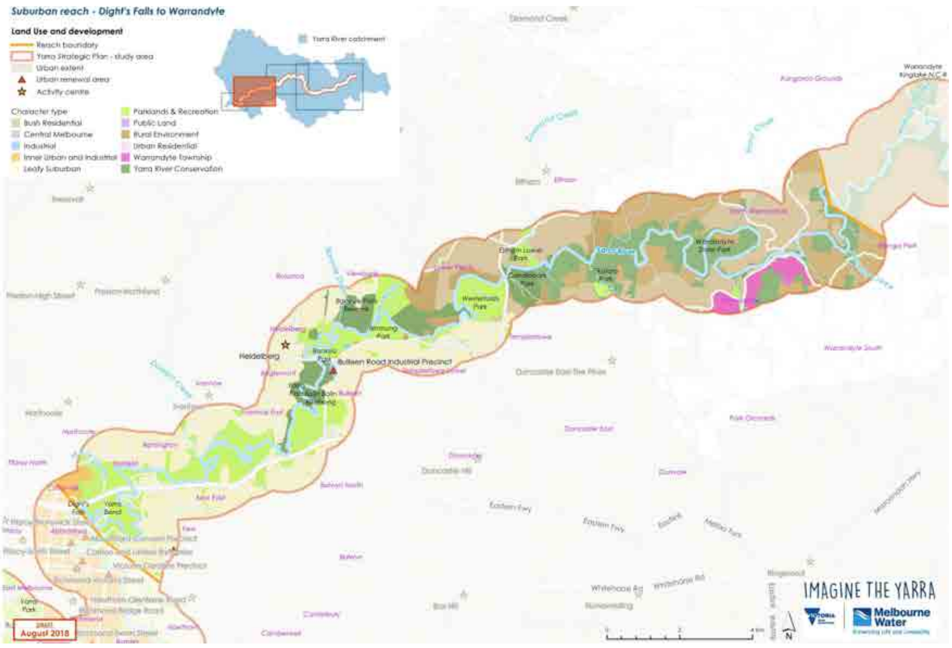


Figure 17
Map of the suburban reach
(Source: Melbourne Water, 2018)

3.0 *Methods and Objectives*

In order to identify potential sources and distributions of polystyrene on the Yarra River, data on EPS manufacturers, high-volume users, recyclers and distributors was first collected using desktop research. These potential sources were then mapped using an interactive geographic information system which also included data on major polystyrene hotspots on the Yarra River (informed by the Yarra River Blitz project), drainage catchments, stormwater outlets on the River, and the locations of each Bandalong Litter Trap. Discussions with key industry leaders were held using a semi-structured interview in order to measure the current understanding of polystyrene pollution around Melbourne, as well as to identify other potential sources and hotspots that could be included in the study. Finally, each potential source was inspected using observations in the field in order to gauge the potential level of contribution of polystyrene pollution originating from that source.

Objective	Method
Identify potential polystyrene producers located near the inner city and suburban reaches of the Yarra River.	Desktop research with geographical information system (GIS) analysis and map output, combined with a key informant survey through semi-structured interview.
Identify high-volume polystyrene users located within the inner city and suburban reach of the Yarra River.	Desktop research with GIS analysis and map output, combined with a key informant survey through semi-structured interview.
Create a polystyrene leakage/litter rating system to assess sites based on Victoria Litter Action Alliance's "Litter Hotshots Rating Tool."	Literature review of Yarra River Blitz data, Microplastic trawl data, and community-group data, paired with graphic design.
Create a heatmap of polystyrene hotspots on the Yarra River.	GIS analysis paired with qualitative analysis through semi-structured interviews with Yarra River Blitz site supervisors.
Conduct inspections of 50 sites along the inner city and suburban reach of the Yarra River in order to identify how polystyrene leakage and spillage occurs.	Field observation using mobile GIS data capture tools.
Identify which procedures can be put in place to reduce polystyrene pollution.	Desktop research, literature review, and analysis of field data.

Table 1
Summary of objectives and methods

The target type of polystyrene included in this study was EPS which is used in a range of applications that are listed by the Australian Packaging Covenant (2019) and illustrated in Table 2 below. Note that the last row for construction applications has been added as, "significant volumes of EPS are used in long-term applications, such as building insulation panels and waffle pods for the housing construction industry and engineering/manufacturing components (APCO, 2019:8)."

In order to identify potential sources of EPS producers and users, a desktop research study was conducted using web-based searches in Google (using keywords such as: polystyrene products Melbourne; polystyrene manufacturing Melbourne; EPS Melbourne; thermocol manufacturing Melbourne; packaging Melbourne; waffle pods Melbourne), the Yellow Pages (using keywords such as: polystyrene products; EPS polystyrene in Greater Melbourne), the White Pages, and Gumtree (using keywords such as: polystyrene in Melbourne). Despite this, delineating which users and producers used EPS over other types of polystyrene proved difficult. Therefore, all potential sources that could be verified as manufacturing or using polystyrene on a daily basis were included in the map. The line of logic on whether to include a search result in the study followed the decision tree (next page).

Application	Description	Examples
Single-use food packaging	Consumer packaging to insulate hot or cold food (e.g. hamburgers, noodles, ice cream) or beverages. Distributed by quick service restaurants (QSR), food halls, cafes etc.	Foam coffee or juice cups, foam trays and clamshells.
Consumer fresh produce packaging	Consumer packaging used to sell products in retail stores.	Foam meat and fresh produce trays.
Business-to-business fresh produce boxes	B2B packaging to distribute fresh produce to supermarkets, restaurants etc. Used to provide insulation and cushioning to fresh or frozen foods vulnerable to temperature and/or impact.	Boxes for broccoli, beans, seafood, etc.
Loose fill EPS 'peanuts'	Used to prevent movement and for cushioning in consumer and B2B packaging.	On-line retail sales, e.g. loose fill in cardboard boxes.
Dry bulky goods packaging	Moulded packaging to prevent movement and protect electrical and electronic products, furniture, homewares etc. Used for consumer and B2B products.	Protective packaging for white good and electronics, e.g. computers, TVs, printers, fridges, toasters.
Specialist applications	Used for insulation and/or cushioning for transport or storage.	Organ transport, temperature-controlled pharmaceuticals, etc.
Construction applications	Used in long-term use for the building construction industry (e.g. for slabs and footings, geofoam) and engineering/ manufacturing components.	Building insulation panels and waffle pods.

Table 2
EPS Packaging Types (APCO, 2019)

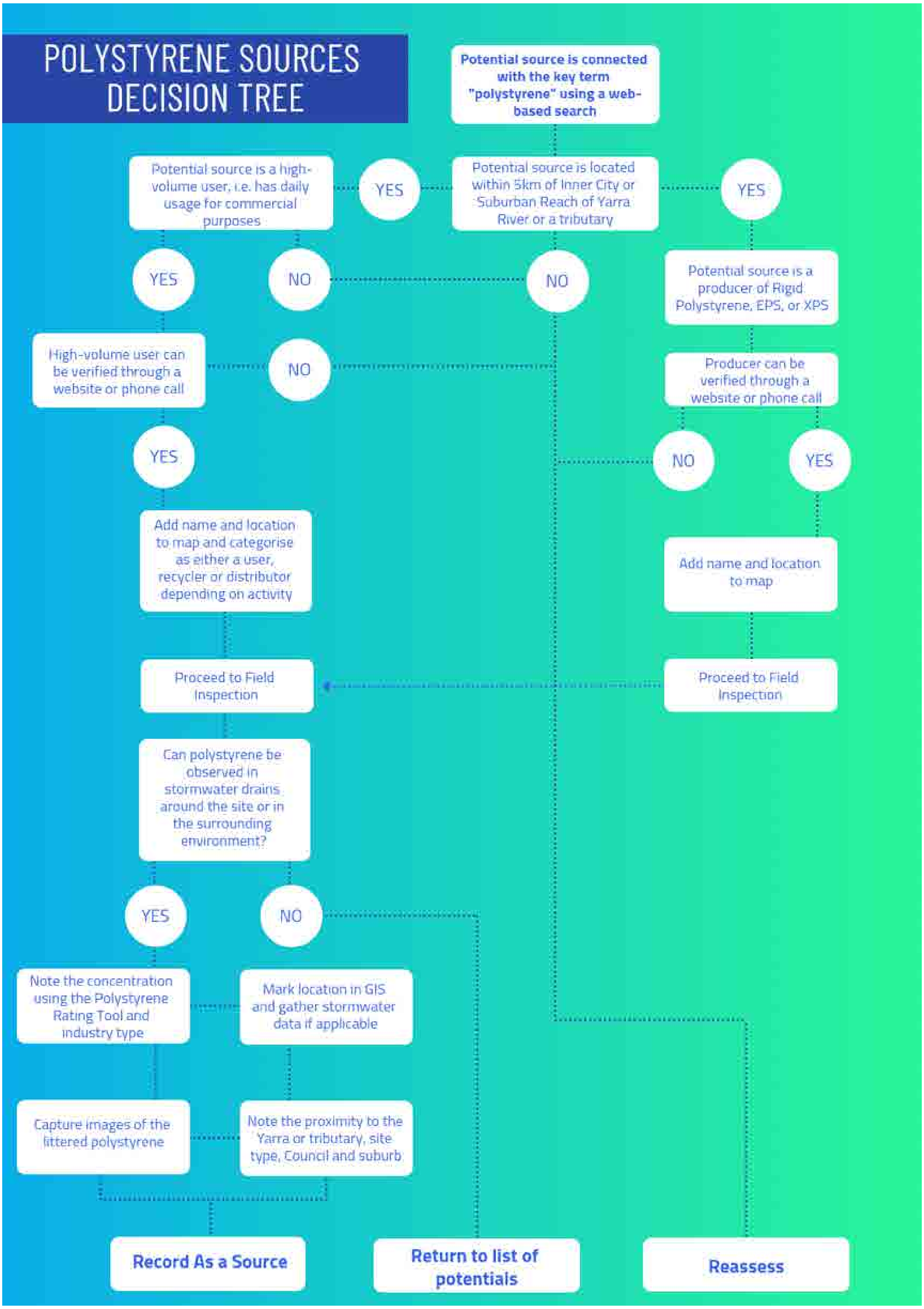


Figure 18
Decision-support tool for mapping (large-scale version included in Appendix B).

As noted in the decision tree, each potential source was categorised as either a user, recycler, producer or distributor. In order to contain the geographic extent of potential sources within a reasonable area and ensure that potential pollution originating from that source would likely reach the Yarra River to some degree, the majority of users, recyclers, producers, and distributors included in the map were located within 5km of either the inner-city reach, the suburban reach, or a tributary of the Yarra that connects with one of the two reaches. There were a few unique cases outside of these criteria, where sources were deemed as potentially significant or worth observation (e.g. for comparison or to serve as a control site) and were thus included in the map.

In addition, a second method of data collection was used following a key informant survey with a semi-structured interview process. The intention of this qualitative method was to gauge expert opinion on potential sources and hotspots in order to qualify the premises and assumptions made for the analysis and recommendations made in the final report. A sample of the semi-structured interview is provided below as well as in Appendix C of this report.

Semi-Structured Interview

1. **What is your relationship and history with the Yarra River?**
2. **If you were to say, in your experience, what the highest littered item on the Yarra is, what would you say?**
3. **Do you have any thoughts or evidence as to what the predominant source of Polystyrene on the Yarra and its tributaries are?**
4. **Are there any sites that you know of that may have a high concentration of PS leaking into the environment that are worth inspecting?**
5. **Do you have any resources that you would recommend we review?**
6. **Do you have any questions for us?**
7. **Are you comfortable with being cited as a source in this Key Informant Survey or would you prefer to remain anonymous?**

Field Investigations

Field investigations were then conducted from October 2019 to January 2020. Observations collected in the field were guided by the results of the desktop study on potential sources located around the Yarra River. Field data was collected using a digital smart-form in the same geographical information system as the map of potential sources and hotspots of polystyrene, in order to ensure that each observation (or record) could be geo-referenced for easy visualisation in the final project map. Data collected ranged from the location of the site to specific information on the status, type and condition of stormwater drains inspected. A comprehensive list of information collected is included in Table 3 below.

Table 3
Types of Data Recorded in Field Observations

Data Recorded	Description
Location	GPS coordinates were collected in order to include each observation on the final project map
Time and Date	-
Source Type	Where identifiable, the source type was recorded (either user, producer, recycler or distributor) for categorisation
Local Government Area	-
Suburb	-
Accuracy of the Geopoint	This is a qualitative assessment to ensure geolocations are accurate and corrected where needed
Presence of Observable Pollutants	This is a qualitative assessment (either yes, no or other) on whether pollutants can be observed at the site
Presence of Polystyrene Pollution	This is a qualitative assessment (either yes, no or other) on whether polystyrene pollution can be observed at the site
Polystyrene Hotspot Rating	Where polystyrene pollution is observed, this quantifies the level of pollution according to the 1-5 Category ratings developed in the two Polystyrene Hotspot Rating Tools as part of the desktop study
Distribution of Polystyrene	This is a qualitative assessment of whether the incidence of polystyrene pollution is either widespread or clustered in a specific area
Most Common Types of EPS Observed	Where possible to discern, this qualitative assessment records the most common types of EPS observed at the site, including the categories: EPS Balls, Bulk Goods / Box Packaging, Drink and Food Packaging, EPS Peanuts, Insulation, Waffle Pods, or Unknown
Industry Source	Where possible to discern, the source industry of the polystyrene (based on either the closest potential source or the type of EPS observed) was recorded, including the categories: Building and Construction, General Packaging (this category was used if the specific type of EPS packaging could not be determined), White Goods, Brown Goods, Recycling, Furniture, Office Supplies and Unknown
Land-use Zone	This includes the land-use zone of the site where the observation was recorded, ranging from River or Creek, to Shopping Precinct, Residential Area, Recycling or Waste Transfer Centre, Industrial Area, General Commercial (which is generally a stand-alone commercial business not in a shopping centre, e.g. Bunnings), or a Transport Corridor
Site Type	The site type was recorded to provide a finer level of detail on the site (i.e. the area being observed within the land-use zone). This includes: Loading Dock, Stormwater Drain or Outlet, River, Street or Footpath, Car Park, Landfill, Side of Highway, or the General Environment
Notes	This includes any important points worthy to note from the observation
Stormwater Data	This includes specific information on the status, type and condition of stormwater drains or outlets inspected

4.0 Results

Desktop Research

The desktop study revealed 139 potential sources of polystyrene pollution reaching the Yarra River. These were categorised as either users, producers, recyclers or distributors. Of these, 130 were verifiable as currently operating and using, handling or manufacturing expanded polystyrene in some way. Users mostly included white goods retailers, brown goods retailers, furniture suppliers, packaging suppliers (e.g. Pack and Send) and retailers of office supplies. Producers included all those verified as manufacturing EPS or products deriving from EPS. Recyclers included recycling and waste transfer facilities that accept EPS for collection and/or recycling, while distributors were characterised as potential sources that sell EPS packaging or building products wholesale. From the desktop study, 99 users, 18 producers, 7 recyclers and 6 distributors were identified. Of the producers and distributors, 10 were identified as participating in an industry association such as Expanded Polystyrene Australia and/or Waffle Pod Manufacturers of Australia (WPMA).

The geographical locations of each potential source identified in the desktop study was then mapped using an interactive geographic information system as illustrated in the map snapshot on the right.

In order to further improve the analysis and hone-in on potential sources of polystyrene, a number of additional layers of information were added to the map, including: data collected on each Yarra River Blitz; a layer of the qualitative data on polystyrene concentrations for various sites on the Blitz (using the Polystyrene Hotspot Rating Tool – Natural Environment); and layers that illustrate stormwater drain outlets on the Yarra, Victorian Local Government Area (LGA) boundaries, the location of microplastic trawls conducted by YRKA and Port Phillip EcoCentre, waterway drains and tributaries, and sub-catchment boundaries. The list of layers with accompanying descriptions and reasoning is provided in Table 4, over the page.

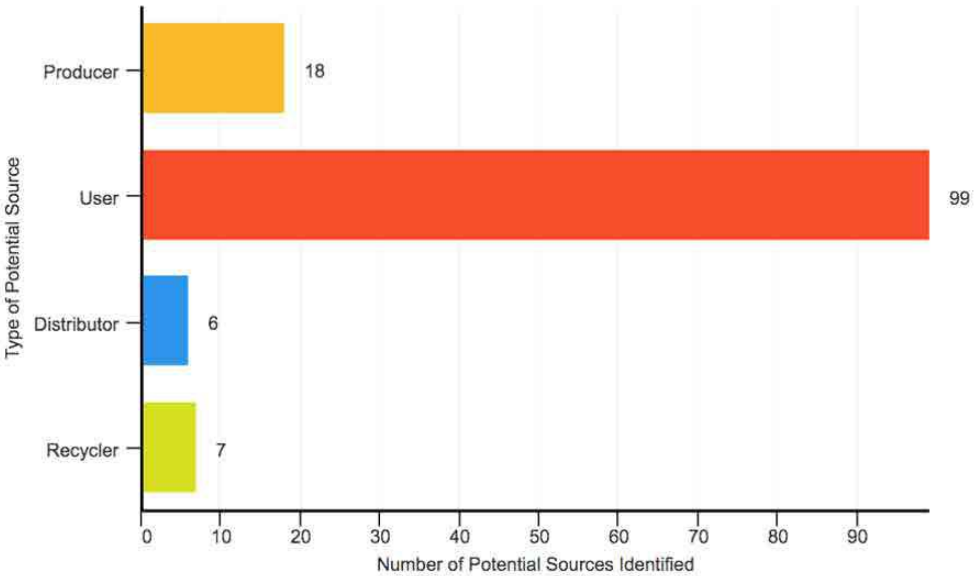


Figure 19
. Number of potential sources
identified using desktop research

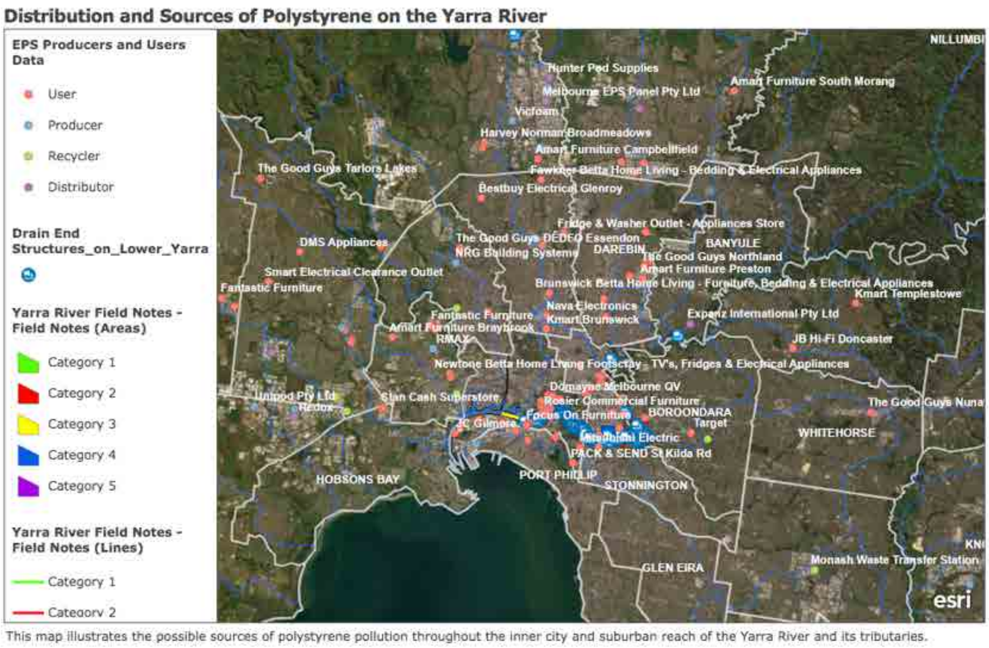


Figure 20
Snapshot of map illustrating users, producers, recyclers and distributors of polystyrene identified through desktop research

Layer Title	Description	Reasoning
EPS Producers and Users Data	This layer provides information on potential sources (categorised as producers, users, recyclers and distributors) of polystyrene around the Yarra River that have been identified through desktop research	The information provided in this layer will be used for field observations and is a key component of the study.
Yarra River Blitz EPS Hotspot Data	This layer provides qualitative data on polystyrene concentrations for various sites on the Yarra River Blitz. The data averages scores from 1-5 (5 being the highest concentration) from Cleanwater Group field team supervisors through one-on-one interviews.	The Yarra River Blitz has been running since 2018. Data gathered from the field includes quantities of all pollutants and does not disaggregate polystyrene from other plastics observed. This rating provides a qualitative assessment of concentrations of EPS at the various sites visited on the Yarra River through key stakeholder elicitation.
Yarra River Blitz Data (Nov 2019); (Aug 2019); (May 2019); (March 2019); (March 2018); (Nov 2018)	This layer provides field data from day sheets submitted to the YRKA during each Yarra River Blitz. The data has been disaggregated to be a separate layer for each event so that certain events can be toggled on and off, depending on how the viewer wants to visualise the map.	This information is important to include as it contains quantities, photos, and field notes from the Yarra River Blitz which is an important source of observational data of EPS occurrence on the river.
Yarra River Blitz Field Notes (Areas); (Lines); (Points)	This layer provides important Field Notes from the Yarra River Blitz. In this layer, points designate areas of significance (e.g. bandalong trap locations or boat ramps). Lines illustrate geographic locations of interest such as the extent of microplastic trawls or the end of a reach of the Yarra River. Areas illustrate the extent of area cleaned for a particular site during Yarra River Blitz events.	This layer provides field data from the Yarra River Blitz, including area extent of all sites visited on the Yarra River. It also provides locations of previous analysis work conducted on the Yarra such as the microplastic trawl site and the location of all Bandalong litter traps. It is useful for hotspot analysis work.
Victorian LGAs	This layer includes the geographic boundaries of each Local Government Area in Victoria.	This layer is important to include so that sources and stormwater networks can be visualised within the context of the governing body that is responsible for regulating/maintaining them.

Subcatchment Boundaries - Healthy Waterways Strategy	This layer from Melbourne Water illustrates the boundaries of each sub-region of the Melbourne Water operating region as part of the Healthy Waterways Strategy 2018. The layer includes 5 catchments (Werribee, Maribyrnong, Yarra, Dandenong, Westernport) and 69 sub-catchments (69 polygons).	The reason this layer has been included is because its primary purpose is for reporting targets, performance objectives, conditions, values etc. relating to the Healthy Waterways Strategy, and therefore is relates data from the PS study back to relevant sub-catchment areas for Melbourne Water.
Major Waterways Drains and Tributaries Catchments	This layer from Melbourne Water illustrates the watershed/hydraulic catchment of major waterways. The Major Catchment layer divides each primary catchment into the tributaries of a primary river. The delineation of a Major Catchment is by the watershed (natural or constructed) of a major drain or watercourse. Examples include: Tributary of Yarra River, Darebin Creek, Tarago River, and Corhanwarrbul Creek.	Geographic extent of various catchments is important when studying the distribution and flow of pollutants into a major waterway such as the Yarra River.
Yarra River DTP	This dataset displays the Yarra River locations within the municipal boundary of the City of Melbourne.	This has been included to aid visualisation of the River when viewing at the synoptic scale.
Catchments of all Waterways and Drains - DR MWC Catchment	This dataset from Melbourne Water illustrates the catchment areas for all Waterways and Drains.	This has been included as it is useful for understanding distribution and flow of pollutants in the context of stormwater.
Constructed Wetland Stormwater Quality Assets	This layer from Melbourne Water illustrates the location and extent of natural and constructed wetlands and lakes. This data set is used to indicate the location and types of assets used for stormwater treatment and flow management, for ongoing condition monitoring, maintenance and hydrologic or vegetation analysis and to assist with the planning and design, construction of future stormwater management options.	This layer was assessed however determined not to be necessary at this time.

Table 4
Descriptions and Reasoning for Layers included in the Potential Sources and Distribution Map

Polystyrene Litter Rating Tool

In preparation for the field investigation, a polystyrene litter rating system was developed in order to assess sites based on the concentration of polystyrene observed. This rating system followed the model developed by the Victoria Litter Action Alliance in their "Litter Hotshots Rating Tool," however, was made specific to polystyrene instead of all types of litter. Categories were assigned and assessed using field data and photos collected during the Yarra River Blitz. While the example photos provided in the tool are taken in a riparian environment, it is intended that this rating tool be applied when assessing polystyrene concentrations in both natural areas as well as in developed areas such as parking lots, nature strips, streets, footpaths, etc. where leakage has occurred. A larger scale version provided in Appendix A.

While creating the tool, it became clear that there would be a need for a separate rating system that followed a similar model but contained metrics and photos specific to assessing polystyrene concentrations in stormwater drains, as this would be a key component of the field investigation. As such, a separate "Polystyrene Hotspot Rating Tool – Stormwater Drainage" was created.

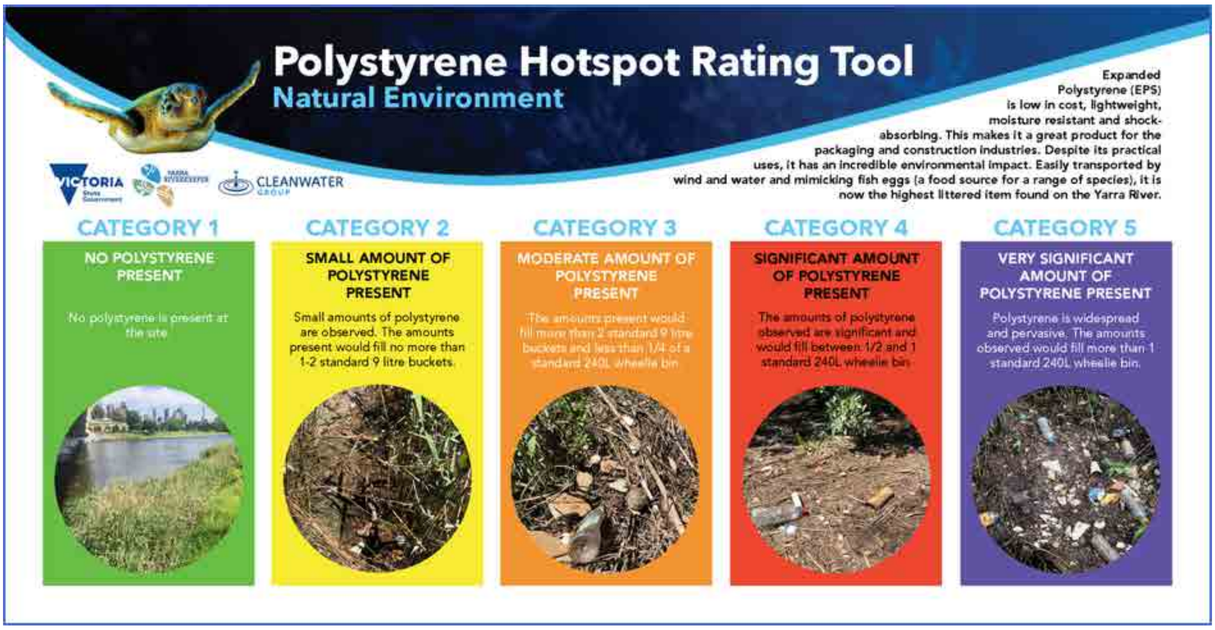


Figure 21
Polystyrene Hotspot Rating Tool –
Natural Environment

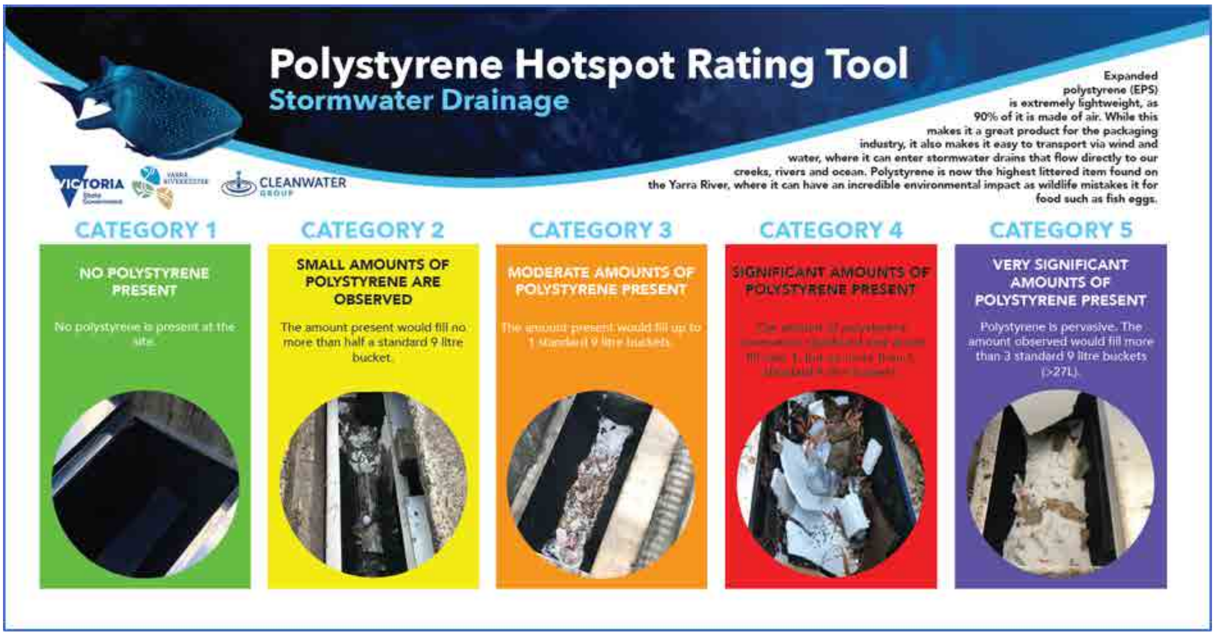


Figure 22
Polystyrene Hotspot Rating Tool –
Stormwater Drainage

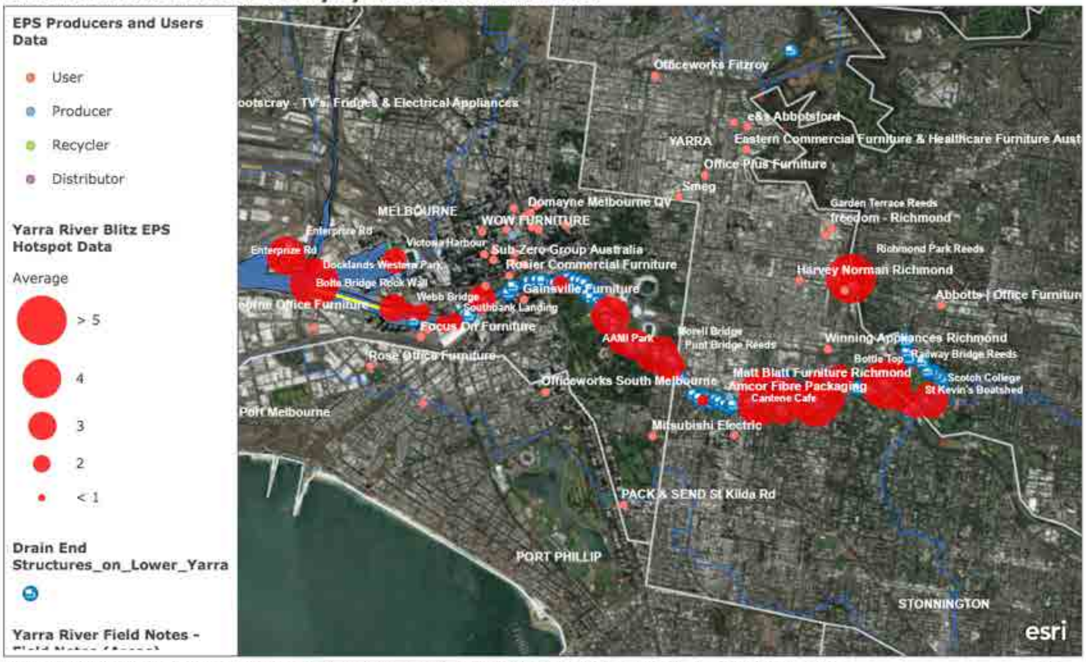
Heatmap of Polystyrene Hotspots on the Yarra River

Following the desktop study identifying users, producers, recyclers and distributors of EPS that could be potential sources for polystyrene pollution on the River, a series of short, one-on-one interviews were conducted with three Cleanwater Group employees that had served as site supervisors on one or more Yarra River Blitz events that took place quarterly, over the period covering November 2018 to November 2019. The supervisors were shown a map of the Yarra River with all 39 sites cleaned on the Yarra River Blitz illustrated in green. Using their experience and observations in the field, they were then asked to qualitatively assign a category rating to each site using the "Polystyrene Hotspot Rating Tool – Natural Environment." Where a respondent could not recall the level of polystyrene pollution with certainty or did not visit a particular site in their time spent on the River, the field was left blank. The average score per site was then calculated across the three respondents, with photographic evidence collected where available. The results of this qualitative assessment were then included in the interactive map, illustrating the locations of hotspots on the Yarra River, and the intensity to which polystyrene occurs in each area. Figures 23 and 24 illustrate this data as a bubble chart, which shows large symbols for larger data values, and a heatmap, which shows areas of high activity with stronger (hotter) colours, respectively.

Figure 23 - Top
Bubble Map illustrating qualitative data on EPS hotspots on the Yarra River

Figure 24 - Bottom
Heatmap illustrating qualitative data on EPS hotspots on the Yarra River

Distribution and Sources of Polystyrene on the Yarra River

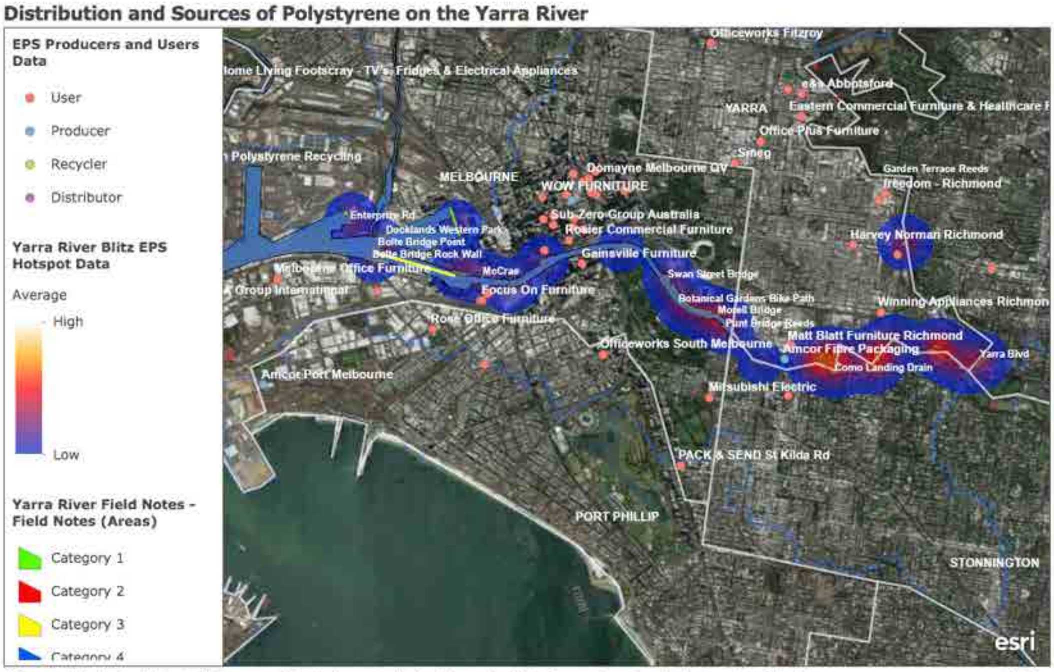


This map illustrates the possible sources of polystyrene pollution throughout the inner city and suburban reach of the Yarra River and its tributaries.

2km

DigitalGlobe, Earthstar Geographics

Distribution and Sources of Polystyrene on the Yarra River



This map illustrates the possible sources of polystyrene pollution throughout the inner city and suburban reach of the Yarra River and its tributaries.

2km

DigitalGlobe, Earthstar Geographics

“While the number of observations per source type remain relatively small, it is interesting to note that approximately 81% of EPS users, 83% of recyclers, 71% of producers and 67% of distributors investigated had some level of polystyrene pollution somewhere around their site or in close enough proximity to be able to be attributed to their activities.”

Figure 25
Drain on the Merri Creek
Anthony Despotellis

Field Investigation

Using the data obtained from the desktop study and the interactive GIS map that could be accessed remotely, field inspections were conducted in October, November and December 2019, as well as January 2020. The locations of potential sources were informed by the GIS map of users, producers, recyclers and distributors, which ranged from manufacturers of EPS in industrial areas, and high-volume users such as white and brown goods suppliers, to recycling centres that accept EPS and residential development sites that use EPS products for insulation and concrete foundations. The types of sites where observations were recorded ranged from retail loading docks, border fences, footpaths and nature strips, to stormwater drains and sections of the Yarra River and its tributaries.

A total of 64 sites were investigated with 107 observations recorded and 375 photos captured in the field. The difference between the former two figures is due to some sites having more than one instance of polystyrene pollution in the surrounding area (e.g. evidence of polystyrene in a stormwater drain in front of the site, as well as along the border fence and in the creek downstream from the site). Of all the sites investigated, 42 could be categorised as users of EPS, 6 could be identified as recyclers (or waste transfer stations), 7 as producers and 3 as distributors, with varying instances of pollution observed around each site. Note that some sites where polystyrene leakage was observed could not be linked back to a particular source and were therefore not included in the list of source types.

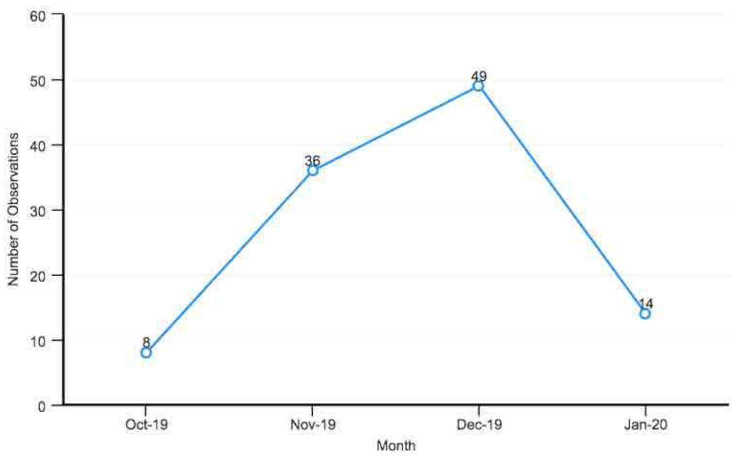


Figure 26
Number of observations
recorded per month

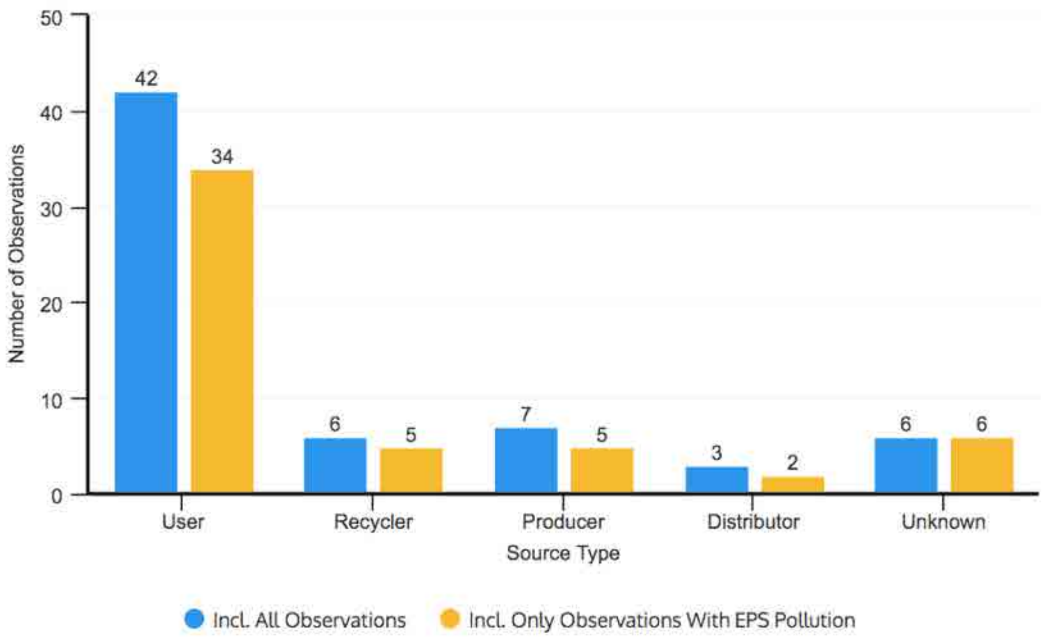


Figure 27
Number of observations per type of source (blue colour includes all observations; orange colour includes only observations that marked some level of polystyrene pollution)

While the number of observations per source type remain relatively small, it is interesting to note that approximately 81% of EPS users, 83% of recyclers, 71% of producers and 67% of distributors investigated had some level of polystyrene pollution somewhere around their site or in close enough proximity to be able to be attributed to their activities.

Of the 107 observations recorded, 92 observations (or 86%) found some level of polystyrene pollution – either a Category 2 (small amount), Category 3 (moderate amount), Category 4 (significant amount) or Category 5 (very significant amount). Small to moderate amounts of EPS were the most prevalent ratings observed, constituting approximately 70% of total observations recorded. The average hotspot rating across all sites that contained polystyrene pollution was 2.8.

Of the 17 observations that were rated as having significant and very significant amounts of polystyrene pollution (Categories 4 and 5, respectively), 6 of the sites can be attributed to users of EPS, 2 to producers (National Polystyrene Systems and Auspod Styrene Industries Pty), 1 to recyclers (Eco Solutions (AUST)), and 1 to distributors (Omega Packaging).

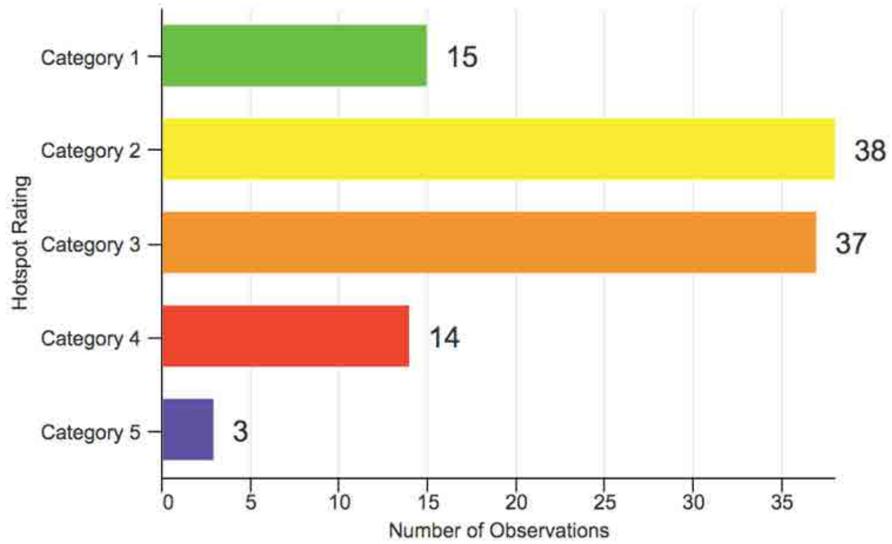


Figure 28
Number of observations per hotspot category rating

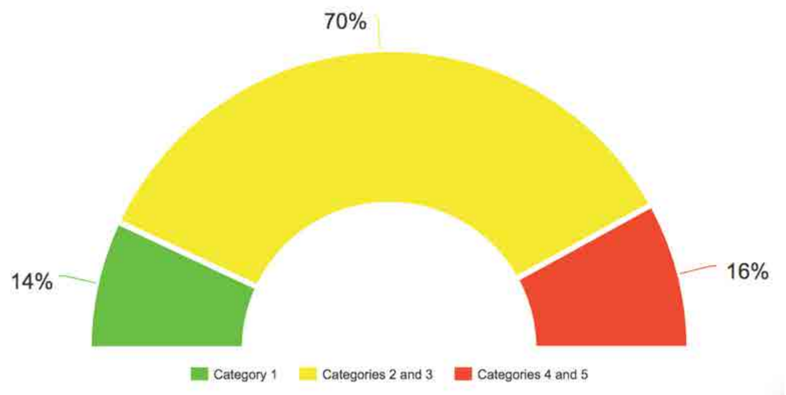


Figure 29
Percentage of observations per hotspot category rating

The most common types of EPS observed, as well as the source industry, were difficult to determine once the material had fragmented and reached the environment. Unless the instance of polystyrene leakage could be attributed to a known source nearby, there is low confidence in the accuracy of types of EPS observed, as well as medium confidence on the accuracy of specific source industry. Nevertheless, Figure 30 illustrates the most common types of EPS observed across observations that contained some level of polystyrene pollution. In a number of cases, more than one type of EPS was recorded as being present in an observation.

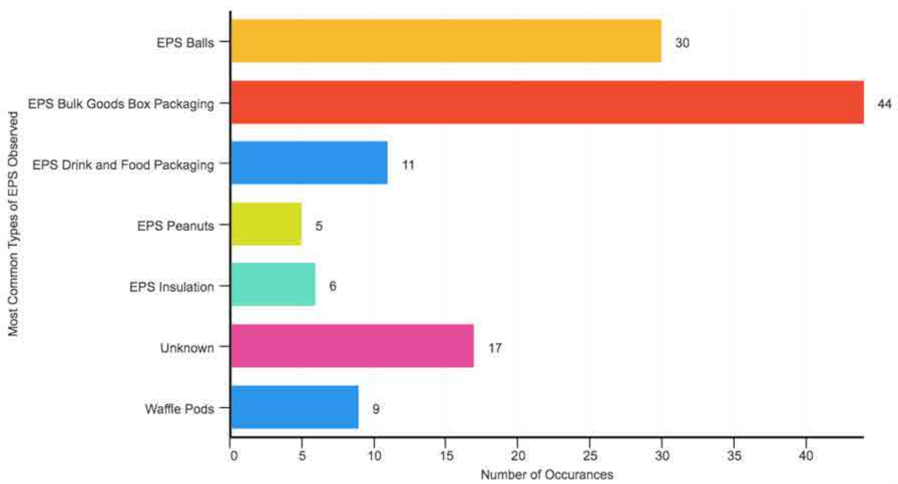


Figure 30
Most common types of
EPS observed

Figure 31 - Right
Yarra River rocks
Anthony Despotellis

The following figure breaks down the source type into industries and provides information on the number of observations that contained some level of polystyrene pollution according to each industry category. In some cases, a user, producer or distributor could be associated with more than one industry (e.g. a retailer such as Good Guys supplies both white goods and brown goods, or a producer such as RMAX supplies EPS products for both the construction industry and the food packaging industry), so would therefore be assigned to multiple source industry categories.

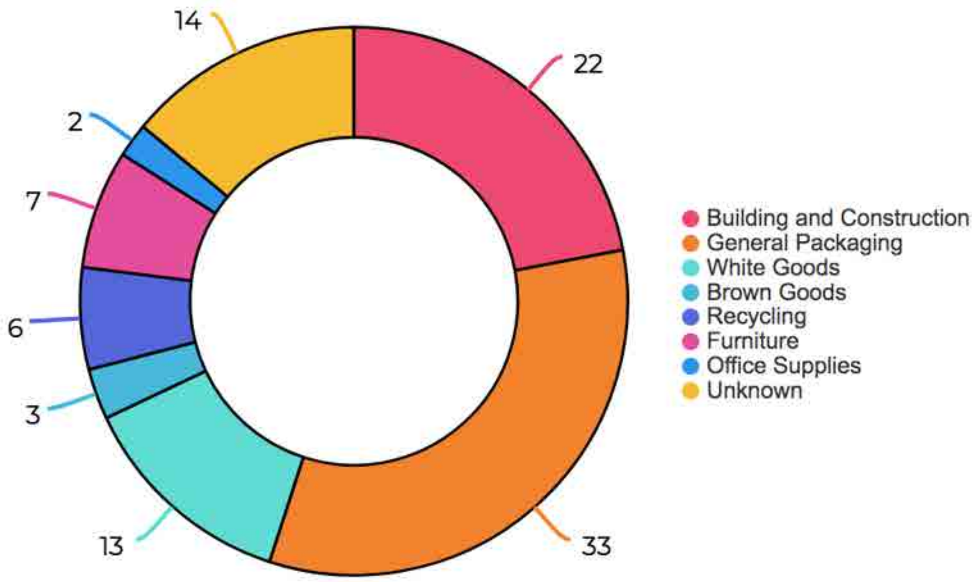


Figure 32
Number of observations according to source industry

From the 92 observations that found a presence of polystyrene pollution, 31 were located in shopping precincts, 20 were located in stand-alone commercial areas, and 18 were located in industrial areas. Although the second highest number of observations were cited as having a source industry of building and construction, 7 of these were observed in residential areas (at residential development sites using EPS insulation or waffle pods) while 9 were observed in industrial areas (associated with manufacturers of EPS insulation or waffle pods), indicating that both users and producers have role to play in reducing pollution from the construction industry. As seen in Figure 33, the land use zone is further broken down into site type, which highlights that the highest number of observations were made on stormwater drains or outlets, followed by streets and footpaths, and loading docks.

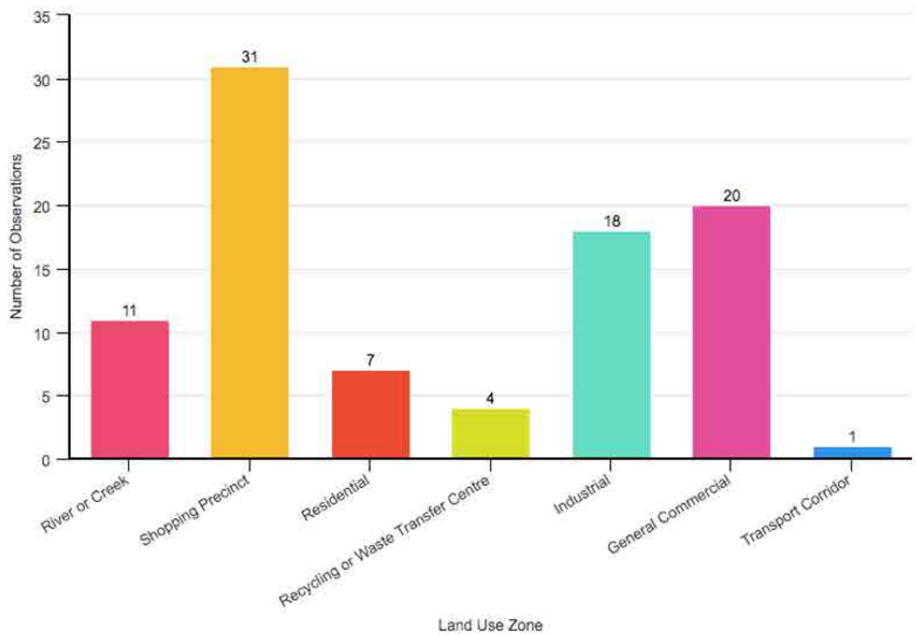


Figure 33
Number of observations
recorded in each land use zone

In terms of spatial extent, the observations collected in the field spanned across 14 Local Government Areas and 36 suburbs. In some suburbs, such as in Maribyrnong, nearly all observations are made on individual sources, while in others, such as in Box Hill South, all observations can be associated with one source, Spotlight Box Hill. Note that two potential sources visited had closed or moved location and were therefore not included in the final record of field data.

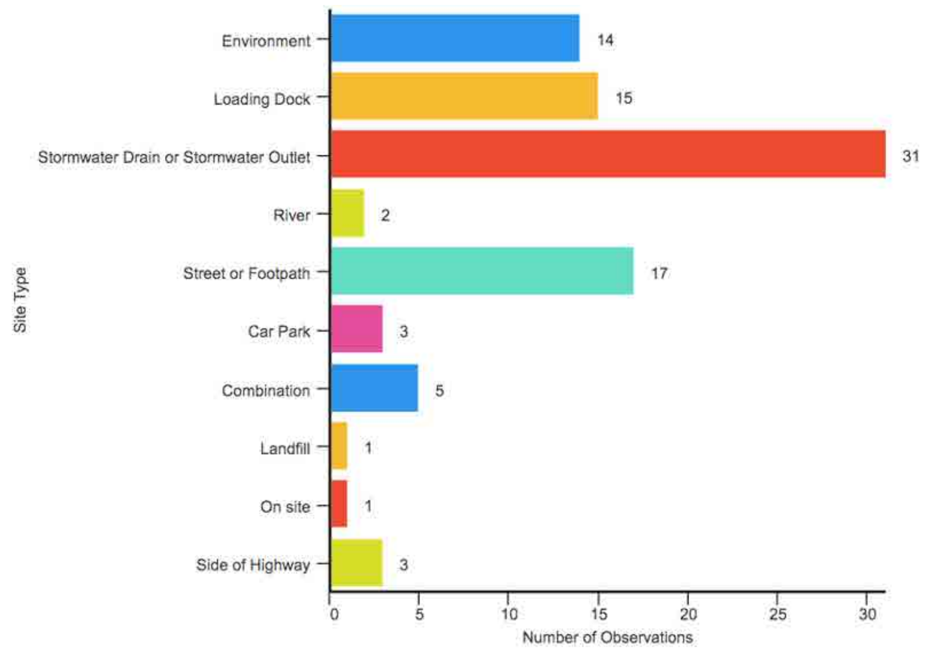


Figure 34 - Above
Number of observations according to site type

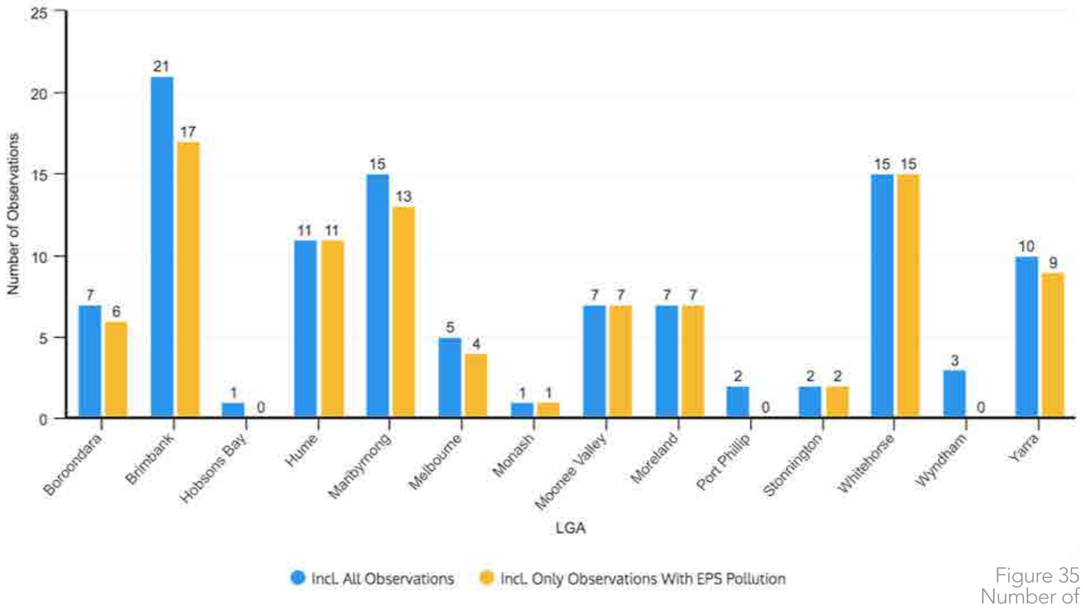


Figure 35
Number of
Observations per LGA

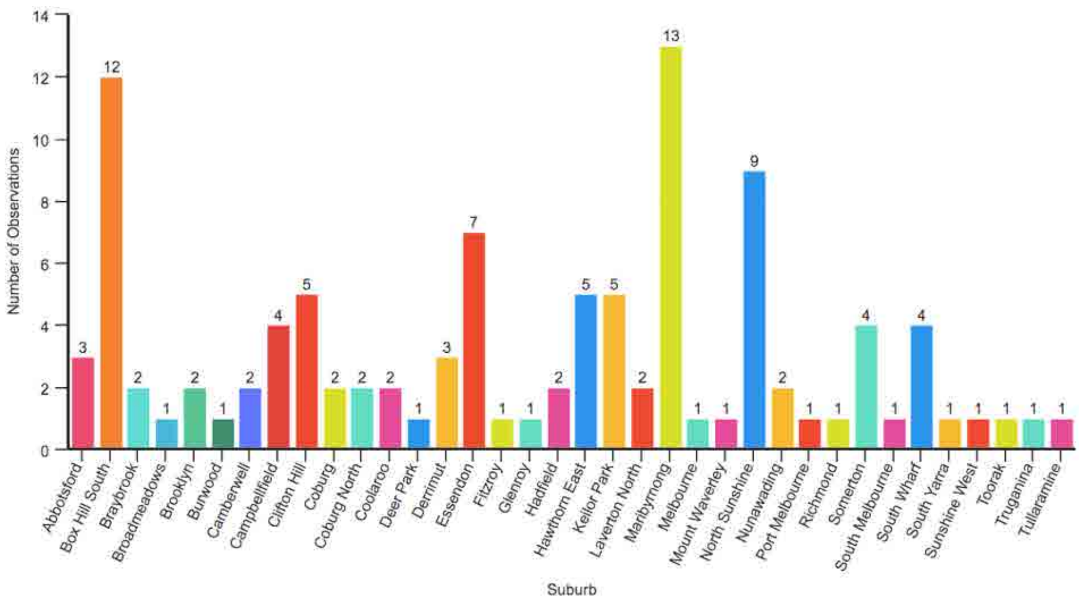


Figure 36
Number of observations
made per suburb


Katie

In terms of spatial extent, the observations collected in the field spanned across 14 Local Government Areas and 36 suburbs. In some suburbs, such as in Maribyrnong, nearly all observations are made on individual sources, while in others, such as in Box Hill South, all observations can be associated with one source, Spotlight Box Hill. Note that two potential sources visited had closed or moved location and were therefore not included in the final record of field data.

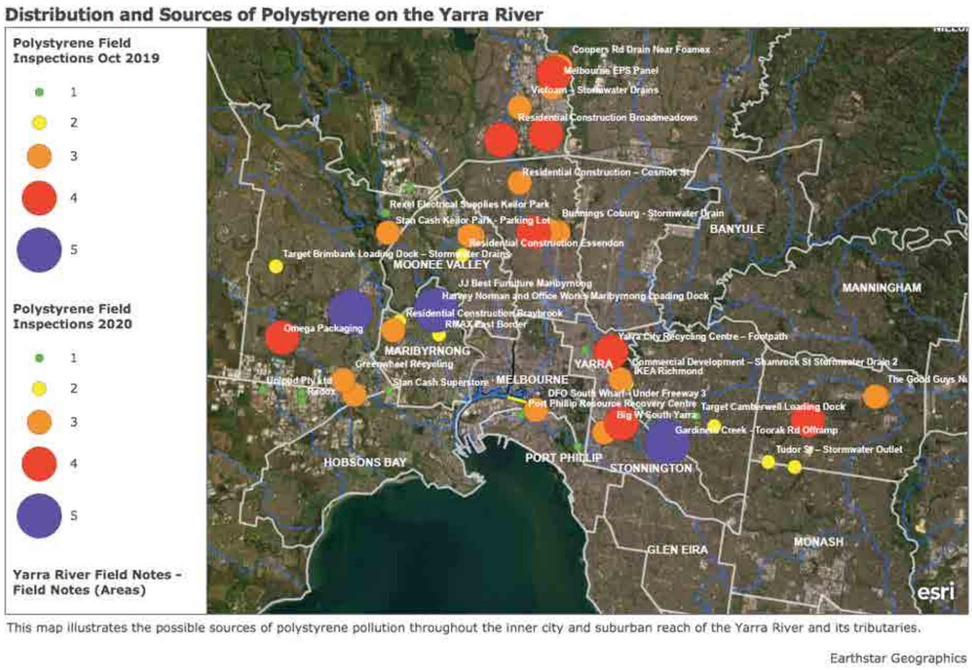


Figure 38
Map illustrating polystyrene hotspot ratings for each field observation

Figure 37 - Left
Cleanwater Group vacuuming the Yarra River bank
Cleanwater Group

Key Informant Survey

A total of five interviews were conducted with key industry-leaders working on issues of litter within Melbourne. This is illustrated in Table 5 below.

3 out of 5 key informants noted that in their experience, polystyrene is the highest littered item on the Yarra River (note that one of the three mentioned it is the highest littered item downstream, around the Port, but upstream it can vary from plastic bottles to tennis balls and dog toys). The two informants that did not cite polystyrene as the highest littered item could not answer with certainty as their experience, or line of work, does not directly involve litter on the Yarra. 3 out of 5 key informants also cited the construction industry, and residential developments in particular, as a major source of polystyrene leakage.

4 out of 5 respondents provided sites worth inspecting and three of these sites were included in either the field investigation (e.g. Spotlight Box Hill) or during a special audit over the November 2019 Yarra River Blitz. The key informants also provided useful suggestions on how to improve both the analysis, and the effort to reduce polystyrene on the Yarra River. A recommendation was provided to encourage Councils to increase their routine cleaning regimes after storm events, as well as the possibility to cut EPS building products on site with a hot wire instead of a hand saw. Additional hotspot data was also received and reviewed from three of these sources via their respective community groups. This data included locations and photographs of potential sites for future field investigation.

Key Informant	Organisation	Contacted	Consent Provided	Interviewed
Neil Blake	Port Phillip Eco Centre & Scout Group	Yes	Yes	Yes
Ross & Ramona Headifen	Beach Patrol	Yes	Yes	Yes
Victoria Clarke	Coordinator – Waste and Amenity Programs, City of Melbourne	Yes	Yes	Yes
Narelle Huxley	Marine Debris Coordinator Melbourne, Sea Shepherd	Yes	Yes	Yes
Jillian Sokol	Love Our Street	Yes	Yes	Yes

Table 5
List of Key Informants

5.0 Discussion and Limitations

Sources of Polystyrene Pollution

The results of this study clearly indicate that polystyrene leakage is widespread and prevalent within every industry that manufactures, distributes, handles and/or uses the material. Although the number of sources investigated remains relatively small, the results suggest that there are a high number of point sources with widespread distribution around Melbourne that are leaking small to moderate amounts of polystyrene (around 70% of total observations recorded), and only a handful of sources leaking significant or very significant amounts. All together though, over 80% of observations inspected found some level of polystyrene leakage, indicating that there is a systemic problem with the material, the control measures we currently have in place, and the ease to which this material can leak into the environment.

Even in situations where retail staff, such as those at Big W Highpoint, were observed to be taking as much precaution as possible (e.g. reorganising skip bins so they would not overfill, sweeping the surrounding area, etc.), polystyrene was observed leaking into nearby stormwater drains. Similarly, both the site and loading dock at Amart Furniture in Braybrook was generally kept very clean, however, polystyrene was observed in 2 of 5 stormwater drains leading to the loading dock and in the parking area near the loading dock. Again, this suggests that the nature of polystyrene as such a lightweight product means that on a windy or rainy day, it would prove difficult to control and prevent all leakage into the environment.

In most cases, the polystyrene pollution observed seemed to be unintentional. Only in one instance did the observations suggest deliberate dumping. This was due to the sheer size of the polystyrene block on the creek-side of the border fence of the manufacturing facility, National Polystyrene Systems (NPS). It is unlikely that a block of this size would have blown off the site and made it over the border fence. Interestingly, NPS is also an EPSA Organisation Member and a registered recycling centre with EPSA, which indicates that they should be adhering to best practice standards regarding usage of polystyrene.

In some cases, the actual physical site may be well-maintained with no observable polystyrene leaking into the environment, however, the road to and from their loading dock would display observable signs of the material. This is the case with Omega EPS Packaging Box Suppliers, in Derrimut. Although their showroom, front loading dock and parking lot showed no signs of polystyrene leakage, the vacant lot adjacent to their backside loading dock contained very high quantities of polystyrene on both sides of the fence, indicating high quantities of the material is spilling off of transport vehicles as they arrive or leave the site. Another example is Target Brimbank, where the loading dock itself appeared clean and orderly, however, the three stormwater drains on the road leading to the loading zone contained EPS balls, suggesting that either they blew into the drains from the loading dock around the corner, or they spilled off of transport vehicles.

Such accidental leakage appears to also be the case with recycling or waste transfer centres that accept polystyrene waste. Even when having a designated and enclosed drop-off point that minimises the effects of wind and rain, as well as requiring users to place all polystyrene waste into provided plastic bags prior to disposal, significant quantities could be observed entering the nearby environment. In some instances, such as the Brooklyn Waste Transfer Station, the leaked polystyrene that was observed appeared to remain within the landfill site, likely due to the sheer size of the site and the netting that borders certain sections of the landfill. In other cases, such as at Yarra City Recycling Centre, the leaked polystyrene could be observed on footpaths alongside the site, inside the nearest stormwater drains, and entering the nearest creek (Merri Creek) via the stormwater outlet pipe. This just goes to show that even where efforts are made to "do the right thing" (recycle polystyrene), the very nature of polystyrene means that it is highly likely, in one way or another, to find its way into the environment.

This suggests that perhaps mitigative management measures must be met with a possible gradual phase-out of the material in its current form, particularly in single-use, short-term applications. Possible alternative products that are similar in nature yet are biodegradable, such as those being used at Pack & Send St. Kilda Rd. and illustrated in Figure 38, could be considered.

Figure 38
. Example of biodegradable alternative to EPS peanuts

There are cases where polystyrene leakage was observed in the environment but could not be seen in proportional quantities inside the nearest stormwater drain or creek. This is the case with National Polystyrene Systems, where significant quantities (Category 5 hotspot rating) of polystyrene were observed in the environment outside of the border fence along the Stony Creek, however, large quantities were not observed directly in the creek water itself. There are four possible reasons that may explain this phenomenon. While they are intuitive, it is important to discuss here as they can apply to most cases and can also highlight limitations to the method of direct observation. The first possibility is that there has not been a heavy rain or strong wind in recent times that would have carried the material into the nearest drainage area. The second possibility is that there may have recently been a heavy downpour (which increases the flow and velocity of stormwater) that would have transported most of the material downstream, and that what was observed along the fence line in the environment is newly-deposited material. The third is that recent winds and rains have been light and gradual, and thus the transport from the site to the nearest creek is slow with small portions being carried at a time. The fourth possibility is a combination of some or all of these scenarios, illustrating that there can be a number of reasons why pollutants observed inside the nearest stormwater drain or creek are not proportional to the pollutants observed at or near a site. The most prudent approach would be to operate using the precautionary principle, and assume that whatever is observed as improperly disposed of at a site will eventually find its way into the nearest creek or river (whether via wind, rain, or stormwater drains) where it will end up in Port Phillip Bay.

It is interesting to note that most of the preventative measures being taken to minimise polystyrene pollution are voluntary measures taken by waffle pod manufacturers. The onus is on manufacturers to voluntarily inform their clients, the users, of the best practice standards, following the "Pod Scrap Bag Program", they have put in place as part of an industry-led product stewardship scheme (Australian Government, 2012). There are three noticeable problems with this system. The first is that, unfortunately, all responsibility and liability is transferred to the user, who has to comply with the rules established by the standards in order to participate, with seemingly no requirement and no incentive.

The second problem is that it appears that this practice only applies to recycling off-cuts of pod waste on-site. It does not apply to containing possible leakage when cutting and handling the material at any stage. This could be the reason why, at some observed sites such as 'Residential Construction Essendon', polystyrene fragments and balls were observed on the nature strip in front of the site, in the stormwater drain and along the curb, without any evidence of polystyrene in the site itself, indicating that any off-cuts would have presumably been bagged and collected by the supplier in accordance with the Pod Scrap Bag Program.

The third problem is that there is little evidence of any other industry (white goods, brown goods, office supplies, EPS manufacturers, etc.) employing industry-wide measures to minimise polystyrene pollution. Some users and manufacturers appear to employ preventative measures and others do not. Future research could build on the understanding of why, how and what measures are being used by some and not others, in order to develop industry-wide standards on handling polystyrene.

Best-Practice Examples Observed in the Field

There were two instances of best practice observed in the field that are worthy of note. The first is proper fence netting as seen in Figure 39 from the site of the producer, Joyce Foam Products.

This netting is ultra-fine mesh, is tightly fitted and runs from the very bottom of the fence to the very top. This type of border fence protection would be extremely beneficial in cases such as that observed at National Polystyrene Systems and illustrated in Figure 40.

The second method of best practice observed in the field is for transport trucks handling polystyrene to employ truck netting similar to that shown in Figure 41. This type of tarp would ensure polystyrene, particularly broken or fragmented, would not escape moving vehicles or be blown out of the truck beds.

Figure 39
Example of effective border fence netting to contain EPS leakage

Figure 40
Example of border fence that does not contain proper netting

Figure 41
Example of truck tarp that can be used to contain EPS during transport

The Regulatory Environment

Australia's history when it comes to waterway pollution dates back to the first colonies in NSW in the late 1700's. Despite this, official concern with the issue seems only to have commenced after the establishment of the Sydney Commission, which was tasked with investigating the establishment of a sewage facility in Sydney in the mid-1850's (Norberry, 1994).

It wasn't until the 1950's that actual penalties for pollution of waterways were first seen in Australia, with environmental legislation and waterway pollution regulations coming into play and gaining traction through the 1960's and 70's.
In Sydney, the effects of unregulated industrialisation, where waterways were used as disposal sites for factory waste, caused a public outcry and finally led to the enactment of the Clean Waters Act 1970 (NSW) (Norberry, 1994). The Act originally had little enforcement weight behind it, with only very small penalties for breaches, however, in time, penalties and enforcement regulations increased substantially, especially between the 1970's and 1980's (as outlined later in this section).

The final version of the Act (No. 78), dated 1 July 1998 to 30 June 1999 outlined (under Section 4, Part 16) that:

(1) A person shall not pollute any waters;

(2) Without limiting the generality of subsection (1), a person shall be deemed to pollute waters if:

a. the person places any matter (whether solid, liquid or gaseous) in a position where:

i. it falls, descends, is washed, is blown or percolates, or

ii. it is likely to fall, descend, be washed, be blown or percolate, into any waters, on to the dry bed of any waters, or into any drain, channel or gutter used or designed to receive or pass rainwater, floodwater or any water that is not polluted, or causes or permits any such matter to be placed in such a position, or;

b. the person places any such matter on the dry bed of any waters, or in any drain, channel or gutter used or designed to receive or pass rainwater, floodwater or wany water that is not polluted, or causes or permits any such matter to be placed on such a dry bed or in such a drain, channel or gutter, and the matter would, had it been placed in any waters have polluted or have been likely to pollute those waters.

(3) A person shall not cause any waters to be polluted, whether intentionally or not.

(4) A person shall not permit any waters to be polluted.

(5) (Repealed).

(6) Notwithstanding the foregoing provisions of this section it shall not be an offence arising under those provisions for a person to pollute any waters if he holds a licence (including a licence granted under the Waste Minimisation and Management Act 1995 in respect of a waste facility) and does not pollute the waters in contravention of any of the conditions of the licence.

(7) Any person who contravenes the provisions of this section is guilty of an offence against the Environmental Offences and Penalties Act 1989.

Any breach of the regulations above, were subject to either removal, clean-up or fines under the Environmental Offences and Penalties Act 1989.

Across other Australian states, population increases coupled with growing connection and concern to broader environmental issues, also led to more stringent environmental regulations throughout this period. In Victoria, this led to the formation of The Environmental Protection Act 1970. By the 1980's there were significant increases in fines and enforcement around waterway pollution, with many states increasing fines by >100 times pre-1980's levels.

The National Parks and Wildlife Conservation Act of 1975 (which had no specific regulations on water quality, instead leaving this largely to State and local government legislation) (NPWCA, 1975) was replaced by the Environment Protection and Biodiversity Conservation (EPBC) Act 1999. The new EPBC Act included penalties and enforcement for contaminants entering waterways, which can be administered by local or State government, depending on jurisdiction (Section 440Z) (EPBC Act, 1999). It is important to note, however, that proof that a certain person/business is the point source of this pollution is needed in order for legislation and enforcement to be enacted.

Below is a table outlining the maximum enforcement actions that can be taken in various states, as well as Federally under the EPBC Act, 1999.

While all states now have legislative policies, enforcement actions, pollution hotlines and other reporting mechanisms to report polluters, many, including the Victorian Environment Protection Act, 1970, and the Federal EPBC Act, 1999 only seems to go so far in actually enforcing anti-pollution legislation. Critics argue that, in many cases, penalties do not go far enough. This, in part, is due to the fact that the Victorian legislation was now produced 50 years ago and the Federal EPBC Act is also over 20 years old. Perhaps also to blame is the lack of separation between categories when it comes to environmental pollution laws - with land, water, air, illegal dumping and other legislation often coming under the same umbrella. This could, again, reflect Australia's dated policies when it comes to pollution and the significant changes that the country has seen in terms of product development, usage, as well as pollution potential and impact over the past few decades.

It is interesting to note that a number of relevant themes emerged in Jennifer Norberry's 1994 article titled, Australian Pollution Laws ¾ Offences, Penalties and Regulatory Agencies, despite it being over 25 years old. Norberry states that, "…in relation to early pollution control laws. First, historically, pollution control was seen in many jurisdictions as an adjunct to responsibilities for public health and public utilities. Second, in many jurisdictions, pollution-related provisions have been scattered through a variety of statutes, often administered by diverse and changing government instrumentalities. Without making too much of these factors, it could be argued that they have had some influence on the fact that offence structures have been complicated, penalties have historically been low and there has been little in the way of enforcement of pollution laws (Norberry, 1994)." This summation still seems apt in terms of today's regulatory environment around waterway (and other forms of) pollution in Australia.

STATE / FEDERAL LEVEL	LEGISLATION	MAX FINE (INDIVIDUAL)	MAX FINE
Federal Level	EPBC Act (1999).	$550,000.	$5,500,000.
NSW	Protection of the Environment Operations Act 1997 (NSW) (POEO Act) / Waste Avoidance and Resource Recovery Act 2001 (NSW).	$1,000,000 / 7 years jail.	$5,000,000.
VIC	Environmental Protection Act 1970.	Limited enforcement information available.	Limited enforcement information available.
QLD	The Environmental Protection Act 1994.	$1760 (up to $44,000 for serious cases in court)	$3300 (up to $250,000 for serious cases in court.
SA	Environmental Protection Act 1993 / Natural Resources Management Act 2004.	$500,000 / 4 years jail.	$2,000,000.
ACT	The Environmental Protection Act 1997.	Limited enforcement information available.	Limited enforcement information available.
NT	The Waste Management and Pollution Control Act 1998.	Limited enforcement information available.	Limited enforcement information available.
WA	The Environmental Protection Act 1986.	$62,500.	$125,000.
TAS	The Environmental Management and Pollution Control Act 1994.	$5,000.	$250,000 / 4 years jail.

Table 6
Penalties for waterway pollution in Australia
(Federal and State)

Limitations

Perhaps the most evident limitation of this analysis is that each site was only visited once, and what was observed at that time is assumed to be the status quo. Although unlikely, it is possible that in some cases the polystyrene leakage observed was an anomaly. Monitoring sites over time would be a useful approach for future research conducted in this space. In addition, it was not known whether potential sources were already in the midst of implementing management measures to prevent and reduce polystyrene pollution. Future research would benefit from engaging with manufacturers and users, and gauging the level of awareness, difficulty and action toward pollution reduction.

Another limitation is the difficulty to identify the correct type and source industry of polystyrene observed in the environment, particularly where the material has already fragmented. Future work would benefit from involving either specialised expertise in the material or have it analysed in a laboratory for specific properties or additives that may trace it back to a source industry. Future research could also look to improve the polystyrene hotspot rating tools as the descriptions for each category were informed by experience in the field but would benefit if obtained objectively through field investigation. Apart from minor conversations with builders, concreters and EPSA, it was outside the scope of this work to interview sources to discuss current best practices, environmental standards and where gaps can be filled. Future research would benefit from engaging industry and business to develop and implement a best practice polystyrene handling guide wherever EPS is being used.

Figure 42
The Yarra River
Anthony Despotellis


RALD SUN
southgate

6.0 Recommendations

Expand and Improve the Polystyrene Collection and Recycling Network

Collecting and disposing of polystyrene once it reaches the environment imposes significant costs to the community. Polystyrene leakage also leads to a significant resource loss of what could otherwise be a valuable recyclable material. The solutions provided here intend to reduce the amount of polystyrene polluting the Yarra River and Port Phillip Bay, and promote a circular economic model whereby EPS uses, which cannot easily be replaced, are locked in a closed-loop system. The recommendations are informed from both experience and as a result of observation from field investigations. A number of recommendations are also reiterated and expanded upon from work conducted by APCO (2018).

Increasing the number drop off sites and the recycling capability at these sites is likely to address collection and logistic issues, thereby improving the amount of polystyrene that is properly disposed of.

Polystyrene packaging currently cannot be recycled using kerbside recycling systems; it can only be dropped off at specific locations in Melbourne. There are currently 6 locations listed on the Victoria State Government's Metropolitan Waste and Resource Recovery Group (MWRRG) website as accepting polystyrene for recycling, and 2 of these only accept polystyrene from local Council residents (MWRRG 2018). There is also one location which is not listed on the MWRRG's website (Yarra City Council Recycling Drop-off Centre), although it has been verified as accepting polystyrene from local residents. An additional 6 locations (mostly EPSA members who are manufacturers, suppliers and recyclers) are listed on the EPSA site, albeit they have strict requirements on the forms of polystyrene that can be recycled. While the EPS industry claims that EPS is 100% recyclable (EPSA 2014b), only 3 forms of polystyrene can currently be recycled in Victoria: packaging for small and large appliances, white polystyrene fruit and vegetable boxes, and plastic bags (MWRRG 2018). There are a number of polystyrene forms that cannot be recycled: coloured polystyrene or foam, meat trays or other similar food packaging, plastic or foam wrapping, tape or strapping, bean bag beans, and peanut shaped loose foam packaging. This is illustrated in Figure 42 - right. Furthermore, it is recommended to contact collection centres to double check addresses, opening hours and possible fees prior to drop off. According to APCO (2018), it is currently cheaper and more convenient for a consumer to landfill EPS than to pay for, and go through the effort of, dropping it off at a collection centre.

While it would be useful to conduct a public survey gauging to what extent users are aware of and using these recycling facilities, these limitations would likely

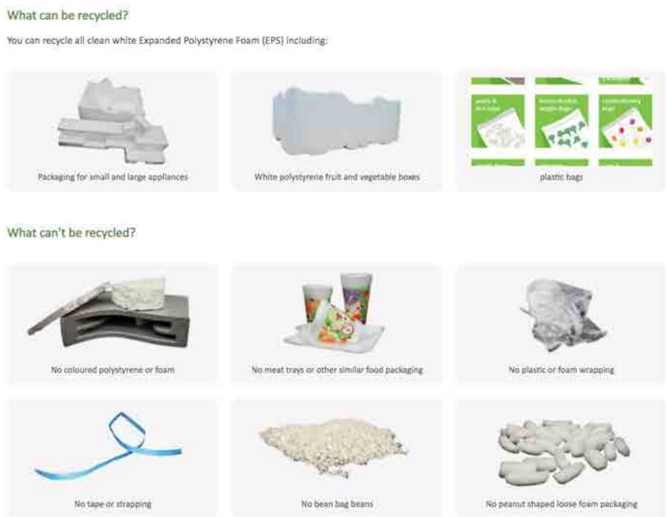


Figure 42
Recyclable and non-recyclable forms of EPS in Victoria (MWRRG 2018).

hinder the amount of polystyrene that is recycled in Melbourne. This may lead users to either illegally dump or place polystyrene in the general waste bin, where it does not break down and ends up taking space in landfill. A simple requirement to remove all labels prior to drop-off, as is the case with EPSA member sites, can deter a user from making the effort to recycle their polystyrene. APCO (2018:9) recognises that households have "no easy access to drop-off points" as well as a "misunderstanding of recyclability". With the widespread use of polystyrene in all types of packaging, it would be beneficial to increase the convenience of polystyrene recycling by increasing the number of collection points around the city.

Recycling, both for the consumer and the recovered-product manufacturer, should also be incentivised in order to make it attractive. This could be in the form of subsidies covered through a product levy, or, from proper landfill disposal fees that are based on volume rather than weight. One Planet Consulting (2017:6) states that EPS "occupies a large space in landfill without commanding a fair price per tonne due to its extremely low density (weight)." Simple changes such as this can help to increase the rate of polystyrene recycling and reduce the amount of virgin material leaking into the environment.

In order to address collection and logistic issues, success stories can be used as a model for replication across collection centres. Monash Council gained the Metropolitan Local Government Waste and Resource Recovery Fund's assistance and bought the first EPS heat extrusion machine for use at a metropolitan Melbourne transfer station. In the project's first six months, EPS recycling at the transfer station increased by 33%. In addition, in the 2014-15 financial year, council's recovery of EPS increased 200 per cent on the previous year. The number of customers bringing EPS to the transfer station rose 75 per cent, transport costs of taking recovered EPS off site have been eradicated, and more than 2300m3 of EPS has been diverted from landfill. Recycled EPS is now turned into briquettes, which are exported globally. This project will have undoubtedly reduced EPS litter in the Yarra catchment and beyond (Williams, 2015).

Develop Comprehensive Industry Waste Management Plans

Organisations that use a vast quantity of EPS in their business should look at developing a waste management plan that covers the handling of EPS disposal. If the business case warrants it, such organisations can also invest in equipment such as an EPS hot compacting machine to more easily manage their EPS waste. This was the approach taken by Sydney Fish Market via a grant from the New South Wales EPA and the Australian Packaging Covenant. The Alliance of Foam Packaging Recyclers has a manual for implementing a recycling program in workplaces.

On an industry level, EPS can be vastly reduced in the environment by implementing a stewardship best practice product handling program. Such a manual has been widely implemented for the plastic resin pellet industry under a program called Operation Clean Sweep (opcleansweep.org.au). Best practice should be mandatory for all users and manufacturers of EPS in Victoria.

Review Current Legislation and Revise Where Needed

Technically, there is legislation to enforce waterway pollution, yet the vast majority of cases are going unnoticed, with limited enforcement and a lack of political will or power (across Federal and State levels) to enforce stronger penalties, which would discourage polluters in the first place. There are a number of examples of this, especially on recent times where the punishment has not fit the crime, so to speak (EPA, 2018 / ABC, 2018).

Many argue that the EPBC Act and State regulations are out of date and have not adapted to Australia's increasing population and the associated environmental challenges. It is also argued that existing legislation is overly complex, making it difficult to follow, open to interpretation and not having enough teeth to enforce stringent penalties for polluters, thereby lowering the incentive to do the right thing. This lack of perceived action has seen a major push in recent times, especially amongst NGO's, to redesign Australia's Federal and State environmental laws.

With this considered, NGOs play an important role in ensuring stronger legislation, holding companies and polluters to account through a number of public interest environmental litigation cases. In many jurisdictions throughout Australia there are opportunities for NGOs to bring civil proceedings in order to enforce statutory obligations or to challenge decision-making processes in respect to approvals or breaches of environmental laws. This is despite proposals at the Commonwealth level to limit the statutory standing rights of environmental NGOs.

There is currently a wide gap in current State and Federal legislation, which needs to be filled when it comes to waterway pollution and illegal dumping laws. In addition to this, case studies such as the Construction and Demolition Waste Guide (Australian Government, 2012) are vital to ensuring stronger industry standards and enforceable regulations around managing waste. The upcoming review of the EPBC Act (1999) presents a prime opportunity to close the existing gap and ensure stronger accountability, enforcement and action when it comes to waterway pollution and illegal dumping.

Monitor and Strengthen Current Control Measures for Waffle Pod Pollution

Industry associations like Expanded Polystyrene Australia (EPSA) have produced a best practice guide (EPSA, 2019b) for EPS usage and disposal, however this only seems to be targeted to the construction industry (who utilise waffle pods in concrete slab production), with other users of EPS not targeted. Whilst a step in the right direction, there are clear gaps that need to be addressed in order to address the range of environmental concerns created by waffle pods (specifically, waffle pod disposal), as well as the broader issues around non-construction EPS usage, leakage and disposal (including within the retail, manufacturing and consumer markets). EPSA's 2020 Airpod Pod Supply Code of Practice (EPSA, 2019) outlines guidelines for best practice when it comes to usage and disposal of Waffle Pod's on site (including best practice for collection and tie down of waste materials), however it is not known how many construction site users are abiding by these regulations, as well as why the onus is on the user to 'do the right thing', rather than the manufacturer.

A Federal Government Report, Construction and Demolition Waste Guide - Recycling and Re-Use Across the Supply Chain, highlights, "it is estimated that where the Pod Scrap Bag program has been implemented, the collection and recycling of EPS pod offcuts is extremely effective – around 90 percent" (Australian Government, 2012). While this is an impressive statistic, it fails to address the percentage of Waffle Pod users who are implementing the Pod Scrap Bag program, as well as where this research is coming from (e.g. which users were monitored, where, how, when, as well as the study design that was used).

This is especially important in light of the extremely low recycling rates for EPS across all applications (One Planet Consulting, 2017). One Planet Consulting (2017) highlights that around 20-30% (or nearly 3 million cubic metres) of EPS consumed in Australia goes to landfill. This is mostly from packaging and building applications, which would put into question the reach of the Pod Scrap Bag program. It is thus recommend that more research is needed into the Pod Scrap Bag Program, including an estimate on the number of Waffle Pod users around Melbourne, the number of these users actively and correctly utilising the Program, and the recycling rates as a percentage of Waffle Pod users both correctly utilising the program and not utilising the program. This would provide a more accurate assessment on the effectiveness of the program and highlight potential gaps that need to be addressed. Given that comprehensive EPS collection schemes in Europe have reached highs of around 50% recycling rates, with a domestic average of 27% (One Planet Consulting, 2017), Australia's EPS recycling system clearly needs to be improved. It is important to note, however, that Europe's rates (although much higher than our own) reflect that even a well-thought out, highly regulated recycling industry around EPS still struggles to reach acceptable levels of recycling. There are a number of reasons why this may be the case:

1. It is still cheaper to landfill EPS than it is to recycle it;

2. The onus of EPS recycling tends to fall on the consumer, rather than the manufacturer. Like many single-use plastic products, this has proven ineffective;

3. EPSA only target Waffle Pods and the construction industry in terms of outreach around best practice. This leaves an enormous gap in terms of other retailers, consumers, as well as manufacturers of EPS;

4. There is a lack of state and federal government enforcement around EPS littering / leakage, with convoluted legislation and a lack of incentives for producers and users to abide by existing regulations;

5. Even with existing guidelines for Waffle Pod 'best practice', there is a lack of information on handling and cutting the material. These two areas, we observed, are responsible for a large amount of leakage and are not yet being addressed.

In summary, EPS is sold cheaply, it is expensive to recover, difficult to contain and leads to a high environmental impact. Despite this, there is a lack of regulation, enforcement and industry responsibility around its distribution and disposal. It is recommended an investigation be conducted into EPS distribution, leakage and pollution; including the effectiveness of existing 'best practice' programs; as well as a comprehensive report on the environmental impacts of EPS in Victoria.

Develop a Stronger Knowledge Base on the EPS Industry

Provide a stronger knowledge base for system-wide decision-making including consumption, where EPS waste is being generated, as well as for local markets.

Phase Out Unnecessary Packaging

Promote a voluntary phase-out of 'unnecessary and problematic' packaging formats, particularly where there are more sustainable alternatives available (e.g. food service packaging).

Rethink Packaging Design

Ensure that all EPS-derived products are designed for recycling and utilise a minimum of 30% recycled content in line with the 2025 National Packaging Targets (APCO 2018).

Support market development

Support the development of local end markets, e.g. waffle pods and pelletisation, to enable local manufacture of skirting board, picture frames, concrete panels, or commodity export.

Expand the Use of Environmentally-Friendly Alternatives

There are a number of sustainable alternatives to using EPS for packaging. These include:

- Starch-based packing peanuts that use bioplastics such as polylactic acid (PLA);
- Mushroom foam;
- Plantable packaging made of fibre board material that is 100% recycled and 100% recyclable, with a variety of flower, herb and vegetable seeds embedded within the packaging;
- Bagasse which is a natural by-product of sugarcane refinement and moulded fibre.

Examples can be taken from companies like Dell, which have pioneered the use of mushroom-based compostable moulded cushions as an alternative to foam. The company say that 72 percent of their flat-panel monitors, and 65 percent of desktops are packaged in foam-free, sustainably sourced materials. Apple has also replaced EPS with alternatives such as cardboard, fungi or bamboo (APCO 2018). With regard to food packaging, there are also cases of retailers replacing EPS produce boxes for fruits and vegetables with reusable plastic crates (APCO 2018).

These examples should be further explored to see whether wider adoption of environmentally-friendly alternative materials are viable for all dry goods packaging (e.g. electronics and furniture) and produce packaging markets.

Improve Consumer Education

Promote EPS recycling opportunities to consumers and waste generators. For example, educate end users of waffle pods, such as builders and concreters, on the correct use of the pod scrap bags to ensure the EPS offcuts are segregated without contamination from other building site waste.

7.0 EPS Drop-off locations

Household quantities of polystyrene can be dropped off for recycling at the locations listed below.

Boroondara Recycling and Waste Centre
648 Riversdale Road, Camberwell
T: 92784444
*For residents only

Brooklyn Transfer Station
12 Old Geelong Road, Brooklyn
T: 93142297

Clayton Transfer Station
Cnr Fraser Rd and Deals Rd, Clayton South
T: 95512351

Greenwheel Recycling
Factory 2, 67 Proximity Drive, Sunshine West
T: 1300289894

Monash Waste Transfer Station and Recycling Centre
380 Ferntree Gully Road, Notting Hill
T: 95183767
*For residents only

Moonee Valley City Council Transfer Station
188 Holmes Road, Aberfeldie
T: 83251730
*For residents only

Unipod Engineering Performance, Truganina site
Access is via 8 Foundation Road, Truganina, Victoria, 3029.
T: +61 3 93945516

Complete Pod Solutions
17/21 Freight Drive
Somerton 3062
*Refer to the EPSA drop off requirements on the home page of this website
T: (03) 9308 8455

AndPak
731/733 Koorlong Avenue
Irymple 3498
*Refer to the EPSA drop off requirements on the home page of this website
T: (03) 5024 5819

FOAMEX
31-33 Gatwick Road
Bayswater North 3153
*Refer to the EPSA drop off requirements on the home page of this website
T: (03) 9720 4200

Polyfoam
32 Dandenong Street
Dandenong 3175
*Refer to the EPSA drop off requirements on the home page of this website
T: (03) 9794 8320

National Polystyrene Systems
329 St Albans Road
Sunshine 3020
*Refer to the EPSA drop off requirements on the home page of this website
T: (03) 8326 8080

Yarra City Council Recycling Drop-off Centre
168 Roseneath St, Clifton Hill
T: 9205 5555
*For residents only

8.0 Conclusion

Research by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) shows that the vast majority of marine debris in Australia derives from land-based sources (Hardesty et al., 2016). With 98% of its volume as air (EPSA 2014a), EPS that is moved and used all over Melbourne daily, can easily be leaked into the environment it can have a damaging effect on Yarra River's rich and diverse ecological system.

This project aimed to identify potential sources of polystyrene pollution and identify solutions that can be implemented to prevent polystyrene from entering the Yarra River. The study started by conducting a desktop analysis of users, producers, distributors and recyclers of expanded polystyrene (EPS) around Melbourne. Each potential source was then mapped using an interactive geographic information system which also included data on major polystyrene hotspots on the River. Discussions with key industry leaders were then held using a semi-structured interview in order to gauge expert opinion on the prevalence of polystyrene and any potential sources and hotspots that could be added to the study. Finally, each potential source was inspected in the field and rated on the level of polystyrene pollution observed according to two polystyrene hotspot rating tools developed during the project.

A total of 64 sites were investigated with 107 observations recorded and 375 photos captured in the field. While the majority of sites investigated could be identified as users of EPS (in contrast to producers, recyclers and distributors), around 86% of all observations recorded found some level of polystyrene pollution, with an average hotspot rating of 2.8 on a scale of 1 to 5. The findings suggest that stronger action can and must be taken across all industries that manufacture, transport, distribute and handle polystyrene. While a step in the right direction, voluntary product stewardship schemes have not gone far enough to contain this material from entering the environment and becoming the highest littered item on the Yarra River. Increased monitoring and control measures implemented by the EPS industry therefore needs to be met with improved legislation and stronger enforcement from both local and state governments in order to stop the flow of this material into the iconic Yarra River and eventually Port Phillip Bay.

Figure 43
The Yarra River
Anthony Despotellis

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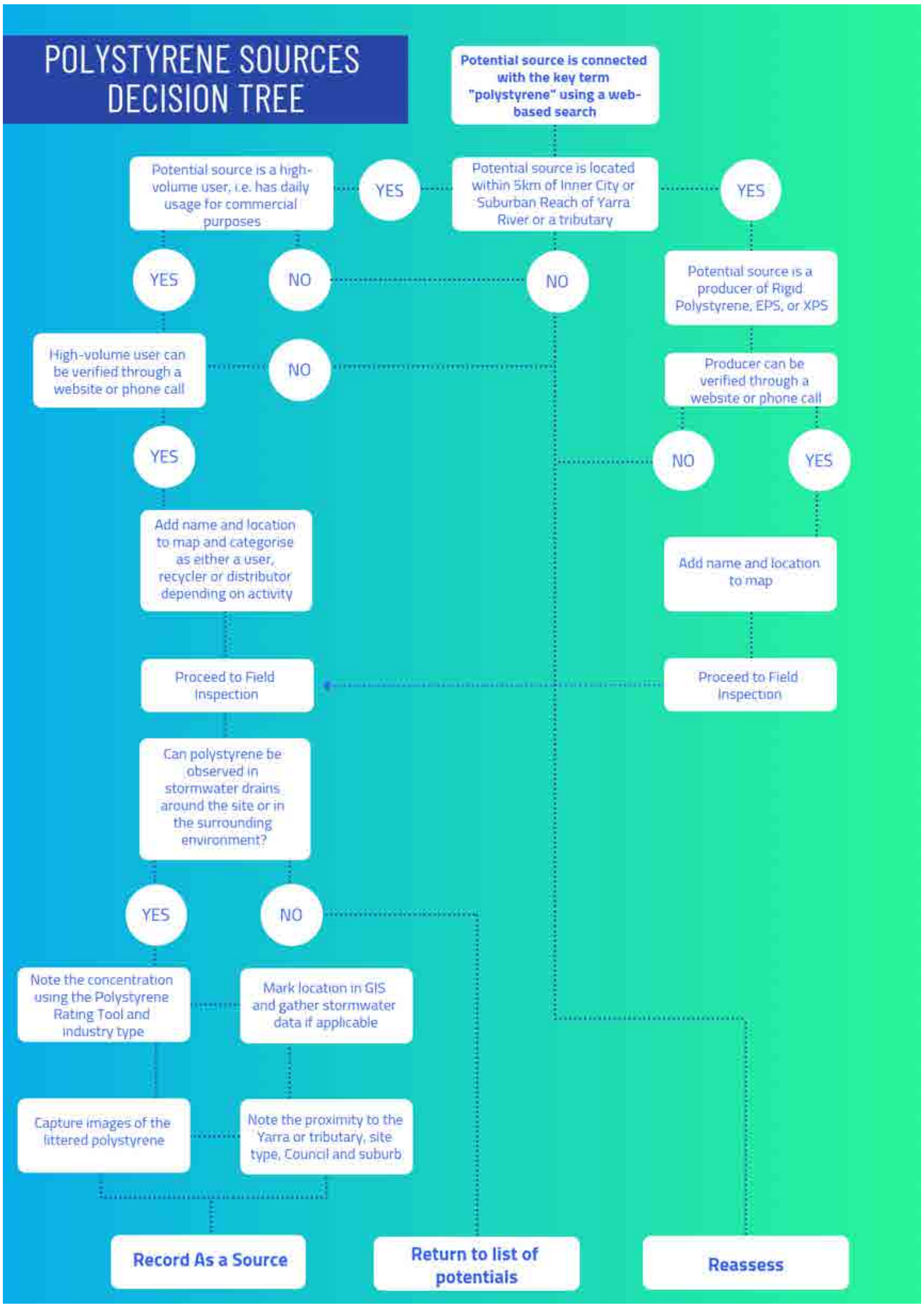
10.0 Appendices

Appendix A Polystyrene Hotspot Rating Tool – Natural Environment


Polystyrene Hotspot Rating Tool
Stormwater Drainage
Expanded polystyrene (EPS) is extremely lightweight, as 90% of it is made of air. While this makes it a great product for the packaging industry, it also makes it easy to transport via wind and water, where it can enter stormwater drains that flow directly to our creeks, rivers and ocean. Polystyrene is now the highest littered item found on the Yarra River, where it can have an incredible environmental impact as wildlife mistakes it for food such as fish eggs.
CATEGORY 1
NO POLYSTYRENE PRESENT
No polystyrene is present at the site.
CATEGORY 2
SMALL AMOUNTS OF POLYSTYRENE ARE OBSERVED
The amount present would fill no more than half a standard 9 litre bucket.
CATEGORY 3
MODERATE AMOUNTS OF POLYSTYRENE PRESENT
The amount present would fill up to 1 standard 9 litre buckets.
CATEGORY 4
SIGNIFICANT AMOUNTS OF POLYSTYRENE PRESENT
CATEGORY 5
VERY SIGNIFICANT AMOUNTS OF POLYSTYRENE PRESENT
Polystyrene is pervasive. The amount observed would fill more than 3 standard 9 litre buckets (>27L).

Appendix B Decision-Support Tree



Appendix C Semi-Structured Interview Template

Key Informant Survey

Background

Tools employed:

- Key Informant Survey through semi-structured interview

Thank you for agreeing to speak with me.

This is a semi-structured interview where I will use a short list of prompt questions regarding the incidence of polystyrene in the region so we can start to hone-in on potential sources.

We have created a map of users, recyclers, producers and distributors of PS products that are located within 5km of either the inner-city reach, the suburban reach, or a tributary of the Yarra that connects with one of those two sections.

Key Informant Survey – Distribution & Sources of Polystyrene on the Yarra River

Researcher : Shayan Barmand (shayan@cleanwatergroup.com)
Client : Nicole (eduofficer@yarrariverkeepers.com.au)

Description : CWG is working with the Yarra River Keepers on a project to identify potential sources and distributions of polystyrene (primarily expanded polystyrene) on the Yarra River as it is the highest litter item found, and the one we observe most during the Yarra River Blitz.

Research Intention : The intention of this research is to illuminate the potential sources of PS on the Yarra and gauge expert opinion on this issue. It also intends to strengthen the premises and assumptions made for the analysis and recommendations made in the final report.

By filling out the details below, you consent to participating in this research as an expert. Your name is not required, you will only be counted as an expert part of the organization you are affiliated with. Please inform if you wish for your organization to remain anonymous. Your kind participation is truly appreciated, and we thank you in advance for taking the time to fill out this short survey. Once completed, please return to shayan@cleanwatergroup.com.au.

Participant Agreement : ______________________

Date : ______________________

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Semi-Structured Interview

1. What is your relationship and history with the Yarra River?

2. If you were to say, in your experience, what the highest littered item on the Yarra is, what would you say?

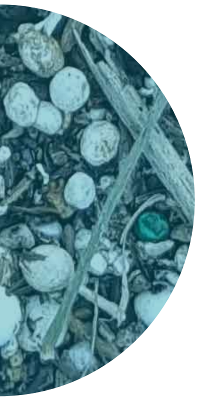
3. Do you have any thoughts or evidence as to what the predominant source of Polystyrene on the Yarra and its tributaries are?

4. Are there any sites that you know of that may have a high concentration of PS leaking into the environment that are worth inspecting?

5. Do you have any resources that you would recommend we review?

6. Do you have any questions for us?

7. Are you comfortable with being cited as a source in this Key Informant Survey or would you prefer to remain anonymous?



YARRA
RIVERKEEPER