AN APPLIED STORMWATER EDUCATION PROGRAMME

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ABSTRACT

Environmental education is a process that allows individuals to explore environmental issues, engage in problem solving, and act to improve the environment. As a result, individuals develop a deeper understanding of environmental issues and have the skills to make informed and responsible decisions.

The key components of environmental education are:

- Awareness and sensitivity to the environment and environmental challenges
- Knowledge and understanding of the environment and environmental challenges
- Attitudes of concern for the environment and motivation to improve or maintain environmental quality.
- Skills to identify and help resolve environmental challenges
- Participation in activities that lead to the resolution of environmental challenges

Mountains to Sea, Wellington delivers inspiring freshwater and marine education programs for schools and communities across the greater Wellington region. One of their programs, “Healthy Harbours” explores the link between land and sea through the waterways in the Porirua or Wellington catchments.

The program engages students by initially connecting them with the ocean through a snorkeling experience and then moves back up into the catchment to consider the issues associated with urban runoff through discovery walks.

As an extension to the program, groups of students actively monitor an at-source gross pollutant trap treatment device. By monitoring the device in different locations and considering the findings, the students gain greater awareness of the problems of marine pollution and a better understanding of the issues and the solutions thereby fostering kaitiakitanga and action for the environment.

KEYWORDS

Stormwater Education, Environmental Education, Monitoring, Community participation, Plastic Free Oceans

PRESENTER PROFILE

Mike Hannah is chairman of the Water New Zealand Stormwater Group. The Stormwater Group was established in 2001 and has a membership of over 500 stormwater management professionals throughout New Zealand. Mike has been a member of this group for 15 years.

He is also the co-founder and Managing/Technical Director of a specialist stormwater management company, Stormwater360 New Zealand. With 27 years' experience as a stormwater management and green infrastructure practitioner, Mike has designed, developed, and implemented numerous stormwater solutions across the Asia Pacific region.

Highly regarded within the industry, Mike has had 5 academic peer review papers published. He has also written and presented 19 non-academic published conference papers and journal articles around the world. As part of Mike's ongoing commitment to stormwater management, he has many international affiliations, and is a regular attendant at international stormwater conferences. He is also regularly called on to consult on planning and legislative changes to the New Zealand stormwater policy and practice.

1 INTRODUCTION

In *2016, students from Wilford School in Petone were snorkelling at Lowry Bay, Wellington as part of the Mountains to Sea Wellington (MTSW), Experiencing Marine Reserves (EMR) programme. Under the ocean, they were amazed by all the different forms of life: fish, starfish, seaweed, a stingray. The 253 pieces of rubbish they found were less impressive. The students realised that rubbish from Petone town centre was ending up at their local beach. Three students, Harvey, Ethan, and Jemma decided, "enough was enough." It was time to do something about it! The students found that stormwater was gathering rubbish from Petone town centre and washing it down footpaths and gutters into drains. From there, it was going directly into Lowry Bay. Jemma, Ethan, and Harvey wanted to find a way of catching the rubbish before it reached the sea. They decided to target the gateway that all the rubbish passed through, the stormwater drains.*

The students set up traps in two drains on Jackson Street, the main street in Petone. They investigated different technologies and chose the LittaTrap™ because it was easy to use[i]*. Trap one was set up outside restaurants and cafes in the shopping area. Trap two was at the far end of the street, surrounded by houses. Once a week, their teacher Mrs Webb drove the students to the two sites to empty the traps. Back at school, they put on disposable gloves, laid a large sheet of paper on a desk, and emptied the rubbish bag onto it. Then they sorted the rubbish into categories, such as hard and soft plastics, food, paper, and cigarette butts. They didn't count any organic material, such as wet leaves, because it doesn't harm the environment. Lastly, they counted the items in each category and entered the data onto a computer spreadsheet. The students repeated this process for twelve weeks.*

At the end of the investigation, the students held an information evening to share their findings with the community. People from Hutt City Council, the Department of Conservation, Wellington Water, and other community groups were there. "They were a bit shocked by the amount of stuff we had collected," Harvey said.

- *In twelve weeks, the students collected 2,680 pieces of rubbish from two drains. That meant 2,680 pieces of rubbish that didn't end up in the sea.*

- *Half of these pieces (50 percent) were cigarette butts.*

- *Other rubbish included plastic, aluminium cans, polystyrene, wood, broken glass, straws, soft drink bottles, parking tickets, library receipts, food wrappers, cardboard, and fabric.*

- *The stormwater drain outside the cafes and restaurants collected much more rubbish than the drain outside the houses.*

The students used a calculator to estimate how much rubbish is sent to Lowry Bay from Jackson Street every year. The two drains that the students investigated collected 2,680 pieces of rubbish over 12 weeks. This meant that one drain would have sent about 1,340 pieces of rubbish to the sea in 12 weeks and each week, one drain would have sent about 110 pieces of rubbish to the sea. To work out how much rubbish this is over one year (52 weeks), the students multiplied 110 by 52. There are 93 stormwater drains in and around Jackson Street, all leading to the sea. If one drain sends about 5,720 pieces of rubbish, then 93 drains could send 531,960 pieces of rubbish into Lowry Bay every year. That's over half a million pieces of rubbish!

Jemma, Harvey and Ethan presented their findings to community members at an information evening. They had kept all the rubbish collected so this could be revealed to those attending. Parents and community members were shocked to see just what the students had found and supported their message of needing change to happen. More people started talking about stormwater pollution, and the Hutt City Council donated two "Drains to Sea" plaques for the students to attach to the drains. Students from other schools were even inspired to start similar projects.

The above paragraphs are an edited extract from the Ministry of Educations connected series journal "Down the Drain".

It tells the environmental education journey experienced through the Mountains to Sea Wellington [MTSW], "Experiencing Marine Reserves Drain Monitoring Programme". The programme has now been extended to 8 schools in the greater wellington region, 11 LittaTraps have been deployed to monitor gross pollutant loads from various land uses. The programme can be easily integrated into the New Zealand curriculum for level 2 students, teachings of Science, Maths, and Technology skills. This Environmental education project has a real-life context by the children snorkelling in their local waters and the use of a simple, innovative piece of technology to help students connect with the magnitude of the problem and develop solutions to address it.

2 ENVIRONMENTAL EDUCATION

Environmental education is a process that allows individuals to explore environmental issues, engage in problem solving, and act to improve the environment. As a result, individuals develop a deeper understanding of environmental issues and have the skills to make informed and responsible decisions. (USEPA)

The components of environmental education are:

- Awareness and sensitivity to the environment and environmental challenges

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Environmental education does not advocate a particular viewpoint or course of action. Rather, environmental education teaches individuals how to weigh various sides of an issue through critical thinking and it enhances their own problem-solving and decision-making skills.

The MTSW program addresses all the components of a good environmental education programme. Students grow awareness and knowledge of their local marine environment through their snorkeling trips. In the process, supervisors from MTSW bring to the children's' attentions, the large amount of plastic and gross pollution in their local environment. Concern is heightened as the children directly experience the problem through monitoring and maintaining a LittaTrap. With this knowledge, they research and develop skills to come up with solutions to address the issue and in doing so, the need for action over the problem becomes ingrained in their thinking.

3 THE MOUNTAINS TO SEA WELLINGTON EXPERIENCE MARINE RESERVES PROGRAM

This programme takes students on a journey of discovery, diving into a local marine environment and exploring the links between the ocean, land, and people. The full programme is a term-long inquiry and comprises of several sessions. Teachers enhance these learning experiences with their own classroom planning integrating it into their curriculum.

The full program consists of:

- 1 introduction classroom session (1.5 hours)
- 1 pool session (1.5 hours)
- 1 or 2 Snorkel field trips (3.5 hours each) to a marine reserve and a non-marine reserve if possible,
- Active project planning session

3.1 SNORKEL FIELD TRIPS AND FOLLOW UP CLASS ROOM SESSIONS

Students snorkel at a local marine environment and/or marine reserve to explore the links between the land and the sea and to explore humans' impacts/biodiversity at the site.

Students are split into 2 groups at the snorkel site and work with a MTSW educator, and then swap over. Group 1 undertakes a snorkelling session - identifying numerous marine animals and experiences the beauty and wonder of the underwater world. As part of the snorkel, stressors such as rubbish are also pointed out.

Group 2 carries out land-based activities. Activities may include a stormwater walk, where the concept of the natural water cycle and stormwater pollutant sources and

pathways are identified in the catchment draining to where the students went snorkelling. Other land based activities may include rocky shore/beach explore or a beach clean-up.

The following activities are suggested to the teachers as a follow up Marine Field trip:

- Complete a field report on the snorkel site and the species found.
- Investigate other human impacts observed at the snorkel site, and what steps could be taken to reduce or resolve these issues.
- Sort rubbish collected and investigate environmental impacts of each different type. How long do each of these pollutants remain in the environment? Follow up by creating a visual display out of what was found.
- Start brainstorming stormwater related action projects to be completed during the rest of the term.

In the follow up class room sessions, attitudes of concern are grown in the students. This, in turn, leads to a motivation to improve or maintain environmental quality which is fostered through the next step viz action projects.

3.2 ACTION PROJECTS

Action projects are to be carried out in the weeks following the field trip until the end of term. Actions may be focused on areas of concern that the students have related to their marine environment. Actions must be locally relevant and reach beyond the classroom. Each class can undertake several different action projects. The different projects can be combined to deliver a multi-faceted approach to educating the students and their communities about stormwater pollution.

Actions Projects may include:

- Drain monitoring using a LittaTrap.
- Designing information posters/pamphlets to increase community awareness
- Investigating stormwater pollutants.
- Letter to politicians and local papers
- Community engagement events
- Public awareness signs
- Fundraising projects for marine conservation
- Drain stencil design and implementation
- Organise a beach clean-up and display
- Mural painting
- Marine monitoring projects
- Public presentations
- Coastal and riparian planting events
- Initiating marine reserve or other marine protection projects

The participation in these action projects drives a deeper understanding of the issues. It also creates ownership of the issue and the solution

4 CURRICULUM CONTEXTS

The MTSW, "Experience Marine Reserves Stormwater Programme" has several linkages with the New Zealand Curriculum. It is targeted at level 2 students (year 2 – 6 students). Teachers can use the programme to help them achieve the learning objectives in Science, Mathematics, and Technology. Below are examples of the New Zealand level 2 school curriculum context:

4.1 SCIENCE: NATURE OF SCIENCE: PARTICIPATING AND CONTRIBUTING

Students will explore and act on issues and questions that link their science learning to their daily living

Key nature of science ideas:

- When we engage scientifically with an issue we:
    - Look for a range of scientific information that related to the issue.
    - Check that information we use is from a trustworthy source.
    - Consider the reliability and validity of the evidence.
    - Decide if and how to respond to the issue, justifying our decisions based on evidence and/or reliable scientific information.
    - Monitor the effects or any actions we take.

4.2 SCIENCE: PLANET EARTH AND BEYOND: INTERACTING SYSTEMS

Students will describe how natural features are changed and resources affected by natural events and human actions.

Key science ideas:

- People can cause changes to habitats and environments from which recovery may be difficult.
- People can intervene to aid the recovery.

4.3 TECHNOLOGY: NATURE OF TECHNOLOGY: CHARACTERISTICS OF TECHNOLOGICAL OUTCOMES

Students will understand that technological outcomes are developed through technological practice and have related physical and functional natures.

Key technology ideas:

- Technological outcomes are fit for purpose.
- Environmental issues can influence what technological outcomes are made.

4.4 MATHEMATICS AND STATISTICS: STATISTICS & STATISTICAL INVESTIGATION

Students conduct a statistical investigation by:

- posing and answering questions;
- gathering, sorting, and displaying category and whole-number data;
- communicating findings based on the data.

Key mathematics ideas:

- Data can be used to answer multiple questions.
- Organising data can reveal information, patterns, and trends.
- Looking for patterns is an important part of statistical thinking

5 DRAIN MONITORING ACTION PROJECT

The use of an at source treatment device by students to identify, evaluate and quantify the source of marine pollution is unique. By engaging with technology and using scientific knowledge, students help their communities better understand the problem and come up with achievable solutions. Collectively over the 8 schools, the data collected is showing the size of New Zealand's litter problem - the results are presented below.

5.1 RESULTS FROM MTSW LITTATRAP MONITORING

Over the last two years, the LittaTrap program has been extended to 8 schools. 13 stormwater drains have had LittaTraps fitted into them and monitored. Monitoring has varied between 1 – 14 weeks. Site specific risk assessment and management plans were developed by MTSW. The Traps were installed by MTSW coordinators/volunteers or Stormwater360. Training for the teachers and students was provided by MTWS on how to safely monitor the Traps.

Locations for the LittaTraps were chosen by Mountains to Sea. The locations were chosen to be close to the school and to demonstrate the different sources of gross and plastic solution. Table 1 below summarises the results.

Location	Land use	Public / Private	Number of Pieces	Number of Weeks	Litter Loading (Pieces/Drain/Year)	Plastic	Cigarette Butts
Kapti College South	School	Private	143	2	3718	45%	21%
Berhampore	School	Private	87	2	2262	60%	0%
Paparangi Shops	Commercial	Public	60	5	624	67%	13%
Titahi Bay School	School	Private	112	5	1165	43%	12%
St Anne's School	School	Private	181	11	856	25%	20%
Glenview	Commercial	Public	42	5	1092	36%	36%
Island Bay 2	Commercial	Public	411	14	1527	42%	48%
Lyall Bay	Residential	Public	49	6	425	39%	51%
Titahi School 2	School	Private	112	5	774	59%	0%
Marine Gardens	Carpark	Public	16	1	832	88%	0%

Kapiti College North	School	Private	4	1	208	100%	0%
Wilford (Petone) (2 pits)	Commercial	Public	2680	12	5807	40%	50%

Table 1: MTSW LittaTrap Monitoring Data

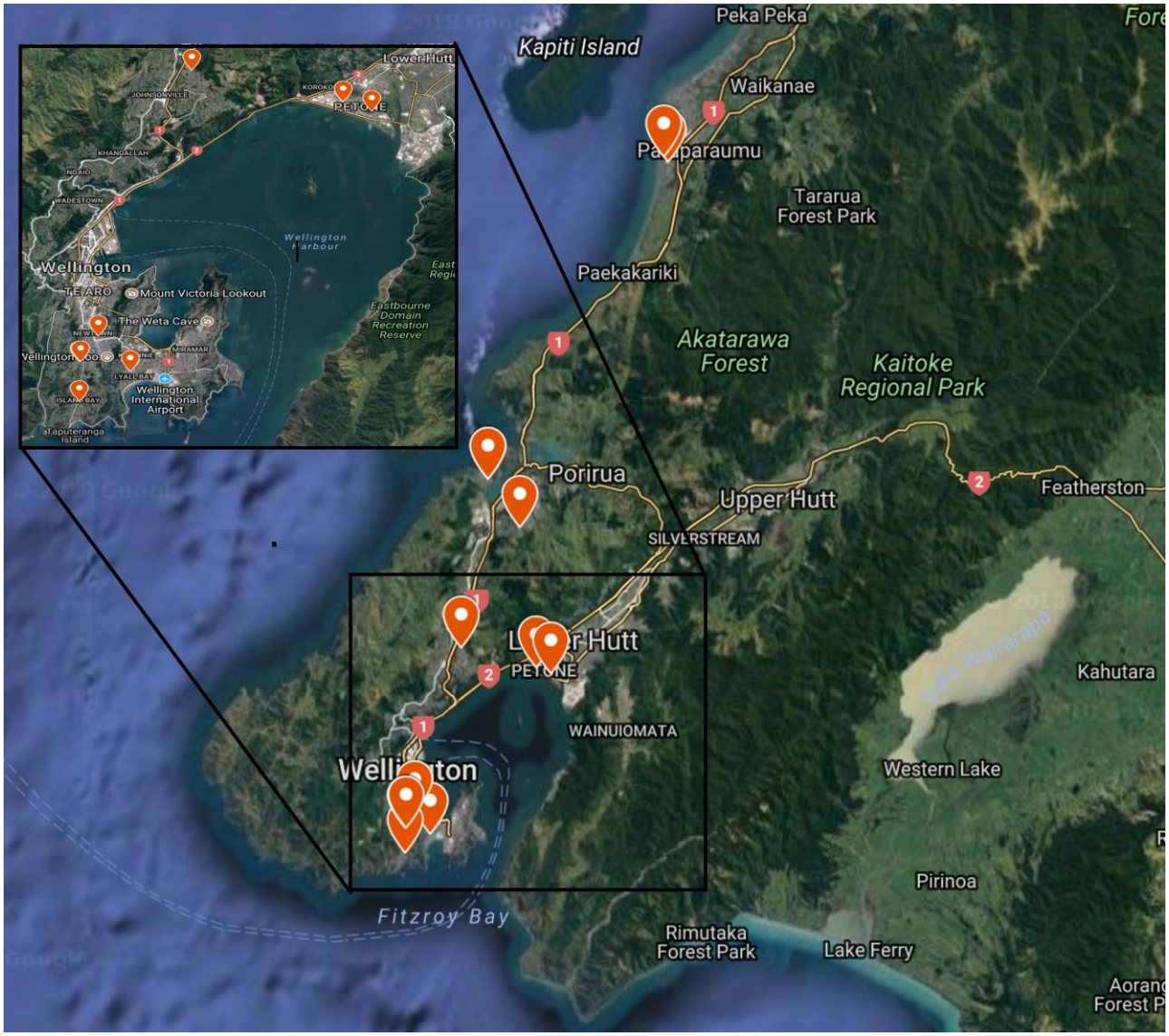

Figure 1: MTSW LittaTrap Locations.

On average, 1,607 pieces of litter a year are entering the study area's stormwater drains. The amount collected varied from pit to pit, land use to land use and from week to week. The lowest accumulation rate was 4 pieces of litter per week and the highest was 71 pieces in a week. However, many classes witnessed zero accumulation when there was no rain in the week. Organic material such as leaves, and food scraps were not included in the analyses.

Figure 2 shows the annual litter loading rate per drain across different land uses. The analysis separated cigarette butts, even though they are made of plastic. This is because cigarette buts were the single largest pollutant with 43% of all litter being cigarette butts.

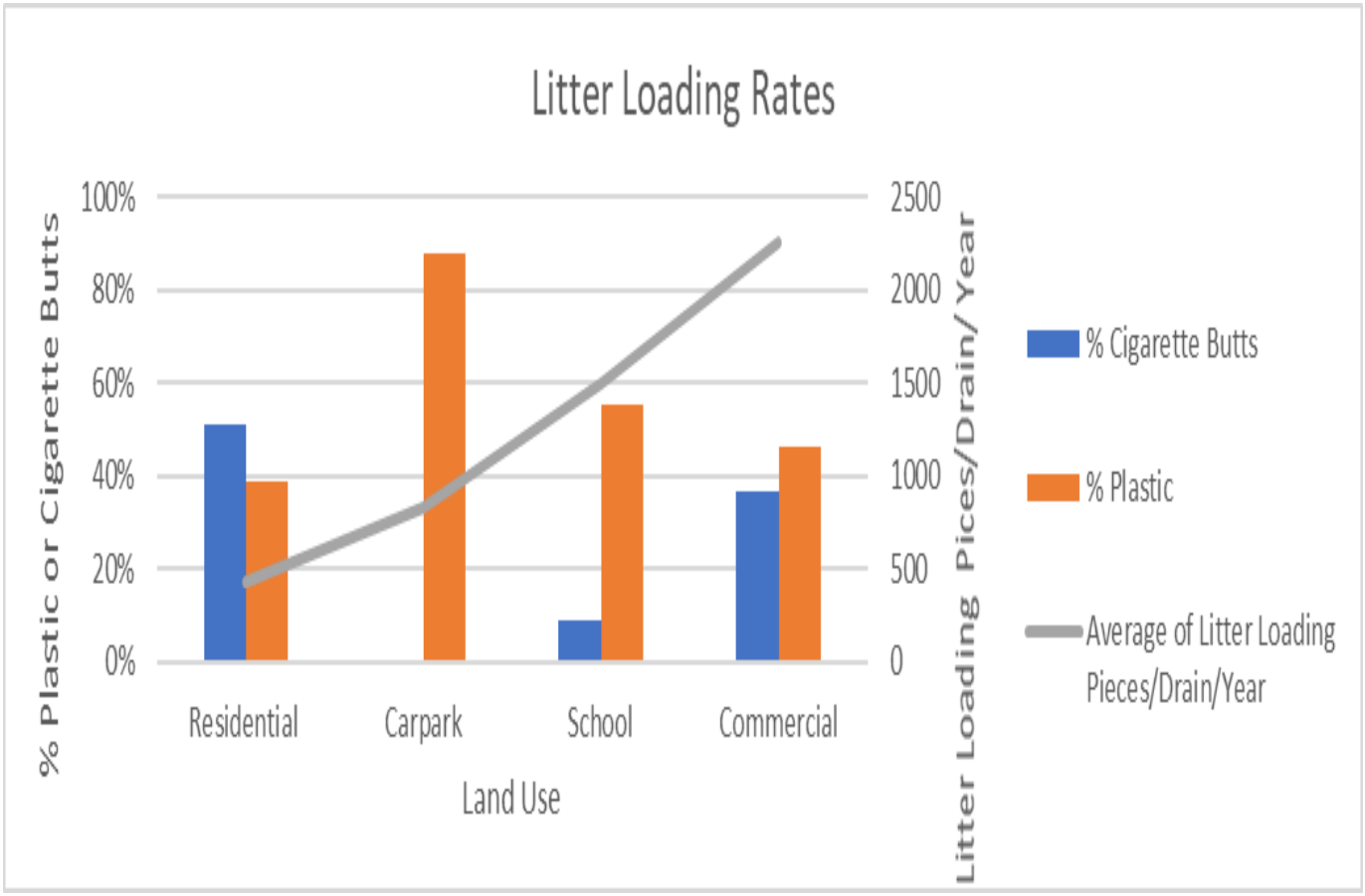

Figure 2: Litter Loading Rates.

Figures 3 and 4 below show that the litter problem is not isolated to road side or public drains. Figure 3 shows that the 47% of the annual litter loading observed, was in privately owned catchpits. Figure 4 shows that in Wellington, 22 % of the city's imperviousness is roads, on which the Council owns the road side drains. 33% of the catchment is hard stand area (footpaths, driveways, and carparks). It is assumed that most of this hardstand area would be in private ownership.

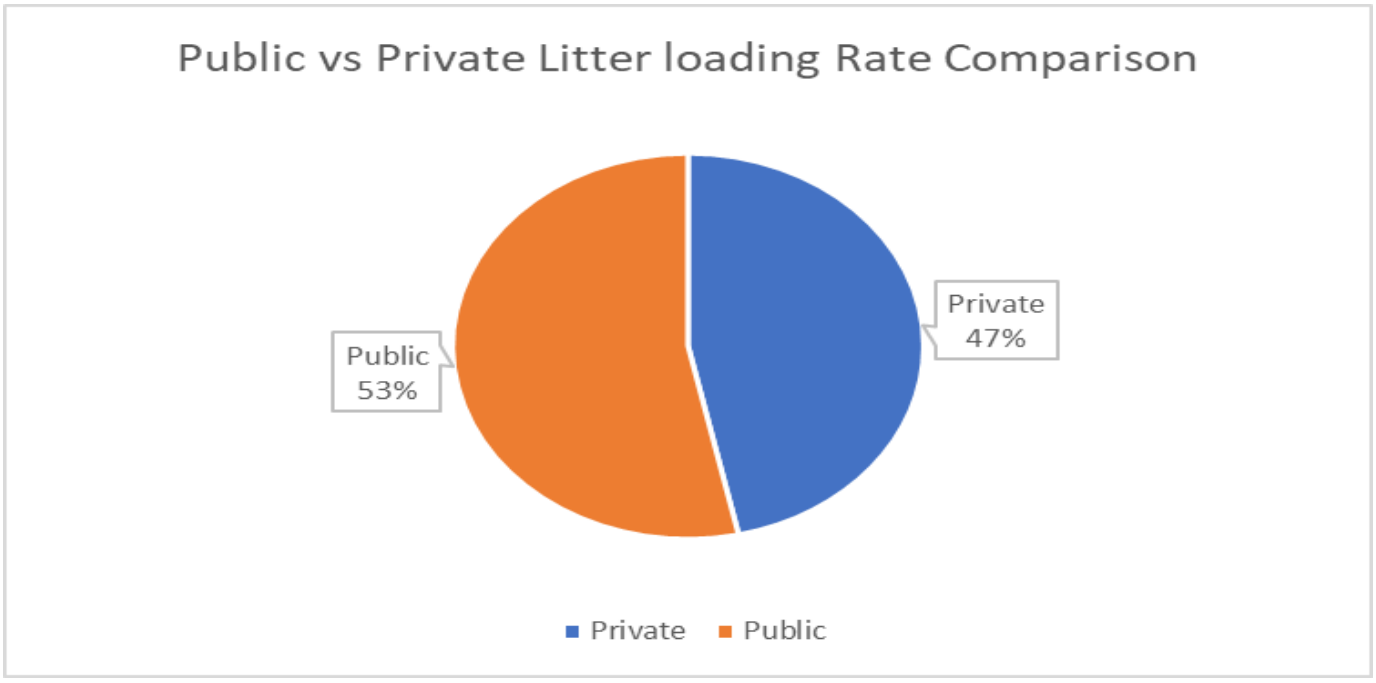

Figure 3: Comparison of Public or Private Drains.

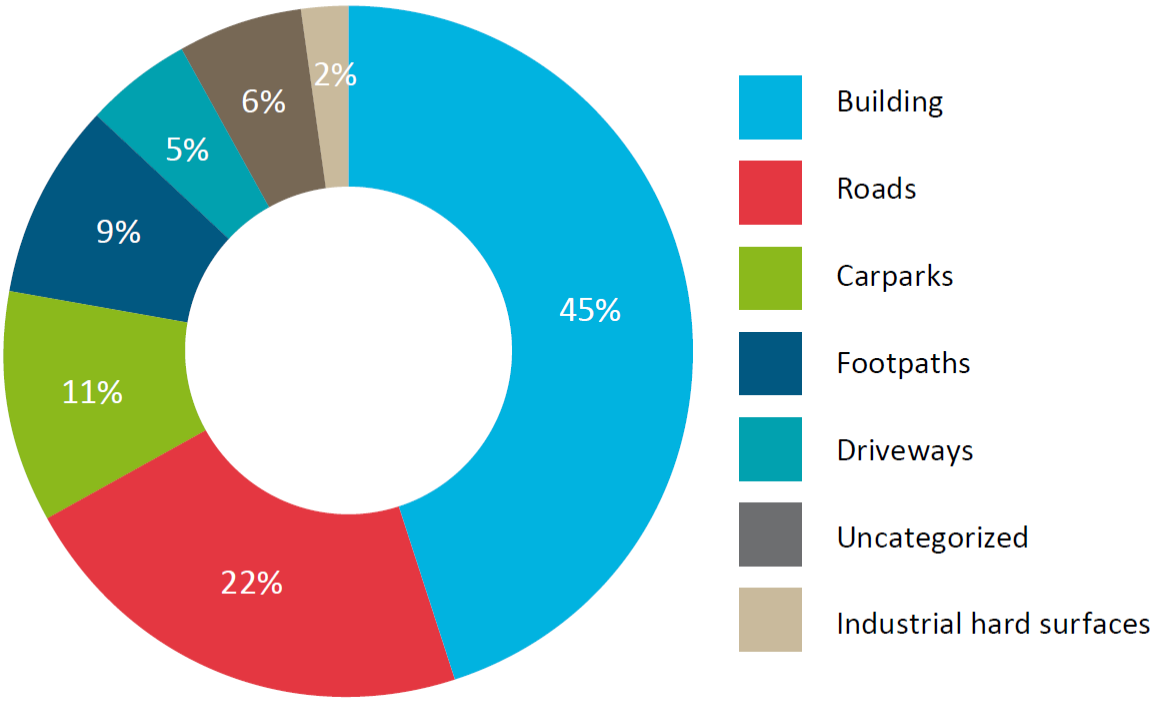

Figure 4: Percentage impervious in Wellington
Source: Wellington Water, Wellington City ICMP News October 2015

5.2 THE SCALE GROSS POLLUTANT/ PLASTIC PROBLEM?

The World Economic Forum estimates that by 2025, there will be one ton of plastic for every three tons of fish in the worlds' oceans. By 2050, the oceans will contain more plastics than fish by weight. This was one of the conclusions from their report into the New Plastics Economy. The report also states at least 8 million tons of plastics leak into the ocean each year, which is equivalent to dumping the contents of one garbage truck into the ocean per minute. Another report from the University of Connecticut estimates there are at a minimum of 5.25 trillion pieces of plastic in the ocean.

To date there has been little research into gross pollutant loads in New Zealand. This is because, for many years, gross pollutants have only been considered an aesthetic problem. The first edition of Auckland Regional Council's Design of Stormwater Treatment Devices Manual 1995(ARC Technical Publication 10), noted litter as having a visual impact but stated it was not an extensive problem.

The CRC for Catchment Hydrology, Australia estimated that gross pollutant loading (particles greater than 5 mm in size) was 30 kg/ha/year in their industry report on gross pollutants in 1995. This number was derived from the analysis of captured material in end-of-line gross pollutant devices. Ingal Environmental Services (now known as Stormwater 360) estimated the annual loading rate of bed load and gross pollutants (particles greater than 1 mm in size) to be 371 kg/ha/yr. from a study of EnviroPod catchpit filters across Australia and New Zealand. In 1995 the Island Care Marine Trust, Auckland estimated that there were 28,000 pieces of litter a day (10.2 million pieces/year) on average that were being discharged into the waters of the Waitemata Harbour.

Using the data obtained by the students undertaking the MTSW program, the following estimates can be derived about the current level of litter making its way into New Zealand's storm drains.

Over the 13 drains monitored, the median litter loading was 974 pieces of litter per year per catchpit. Considering that Wellington City has public 12,500 catchpits and there are at least as many private catchpits as there are public catchpits (when impervious area is considered), Wellington City could be discharging over 24 million pieces of litter a year.

The Wellington city urban area is approximately 290 km2. This gives an estimated loading rate of 83,840 pieces of litter per km2 of urban area per year. Using information from Statistics New Zealand 2001, the following table was derived as a conservative estimate of litter loading for major urban areas of New Zealand.

Main Urban Areas	Area (km2)	Population density (People/km2)	Percentage of New Zealand's resident population	Estimated litter loading (Pieces of litter /Yr.)
Whangarei	133	347	1.2	11,130,545
Auckland	1,086	989	28.8	91,198,761
Hamilton	1,100	151	4.4	92,360,394
Tauranga	178	537	2.6	14,962,742
Rotorua	89	593	1.4	7,447,186
Gisborne	85	373	0.8	7,131,240
Napier-Hastings	375	303	3	31,515,292
New Plymouth	112	425	1.3	9,436,800
Wanganui	105	376	1.1	8,804,349
Palmerston North	178	408	1.9	14,973,150
Kapiti	60	563	0.9	5,016,875
Wellington	444	765	9.1	37,263,793
Nelson	146	367	1.4	12,273,549
Christchurch	608	549	8.9	51,070,609
Dunedin	255	420	2.9	21,420,112
Invercargill	123	377	1.2	10,311,134
Total	5,078	522.8	71	426,308,801

The above table estimates that there is over 400 million pieces of litter that are entering our stormwater drains from New Zealand's urban areas. What is further concerning, is that marine plastic pollution is increasing. The World Economic Forum report draws a connection between the growing amount of plastic in the world's oceans with the increased production of plastic. The report estimated that 32% of the plastic packaging materials produced in the world are lost into the environment and that global plastic production has tripled since 1990.

This study that has focused on quantifying the amount of plastic and litter entering the stormwater drains across a region is the first of its kind. It offers valuable insight into the potential pathways for plastic, which can assist decision makers in management and intervention strategies.

6 DISCUSSION AND CONCLUSION - CHILDREN AS A VEHICLE OF CHANGE

Environmental education is a management practice designed to change attitudes and behaviors of the participants. By focusing on environmental education, targeted at children, it is hoped that it will influence the attitudes of their parents and will change their behaviors

Although adults can beat children at most cognitive tasks, research shows that children's limitations can sometimes be their strength. Researchers have found that adults were very good at remembering information they were told to focus on, and ignoring the rest. In contrast children tended to pay attention to all the information that was presented to them - even when they were told to focus on one item. Children tend to notice things that adults don't catch because the adults have selective attention. (Science Daily)

In many ways the realisation that there is a lot of litter going down our drains and that we need to do something about it is easier for children. Children's views and actions are not restricted. Children do not think of reasons not to do things. They do not present barriers such as; "That costs too much" or "Is it really a problem?" Their minds are full of aspiration and they are hopeful in their thinking.

This study has shown how children experiencing plastic and litter in their local marine environment can drive change. It also demonstrates how learning about the sources of these pollutants and how they make their way to the ocean, can influence a community.

Collectively MTSW and the 8 participating schools have highlighted the scale of New Zealand's gross pollutant and plastic stormwater problem. This is a problem that has been overlooked for many years by adults.

The study has shown that in New Zealand, there are large amounts of plastic and litter entering our stormwater drains from a variety of land uses both private and public. Litter and plastic in the world's oceans, is a significant problem, yet gross pollutants entering stormwater drains is avoidable. This form of stormwater pollution is not an unfortunate by-product of an essential human activity such as tyre wear from automobiles. Further because of the size of gross pollutants i.e. > 5mm it is the easiest of all stormwater contaminants to manage.

The children in this program have realised something needs to be done about litter and plastic marine pollution and that action over the problem is not difficult. It is hoped that with this information adults in our community can be motivated to take similar action.

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