OUR CAPITAL BEACHES – EFFECTS OF STORMWATER DISCHARGES

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ABSTRACT

Wellington's public stormwater system has 550 km of piped systems and approximately 25km of open semi-urban watercourses. The current stormwater network is a complex gravity system of reticulated pipes, culverts, catch-pits, grit traps, secondary overland flow paths and streams; which convey almost 80 million cubic meters of stormwater every year from buildings, roads, open spaces and other land uses into the city's coastal receiving waters.

Stormwater transports sediment, debris, litter, biological matter and traces of other contaminants such as hydrocarbons and heavy metals. At the input end, these stormwater services clean the catchment environment, but do so by depositing the pollutants in the receiving environments. This means that the stormwater discharges affect the ecological, cultural, recreational and amenity values of the shared receiving environments.

Detailed catchment studies reveal that some of Wellington's most intensive land uses and traffic flows, that generate more runoff and more contaminants, drain into areas where amenity and recreational values are also the highest - Lambton Harbour/Oriental Bay, Evans Bay, Lyall Bay and Houghton Bay. This paper discusses:

- types, sources and loads of sediment and key physical and chemical contaminants in stormwater
- receiving environment status, impacts and recreational grading

KEYWORDS

stormwater, urban water quality, sources, contaminant loads, recreational grading

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   Tim Strang is an Environmental Engineer with a broad background in three waters engineering in New Zealand. His field of experience includes collection and conveyance and treatment systems. Tim's current role is the Chief Stormwater Advisor for Wellington Water Limited.

1 INTRODUCTION

Wellington is a city where the natural environment permeates the urban environment, enabling a high quality of life for its inhabitants and an attractive, healthy city environment. Our environment carries significant ecological, economic, social and cultural value, and creates economic opportunities for the city.

Wellington was once covered by about 20,000 hectares of lowland broadleaved-podocarp forest. Today, less than 5% of this forest remains, mostly in gullies and remote areas out of the reaches of development and fire. Less than 1% of coastal forest remains. The land has also been modified by the combined effects of earthquakes that uplifted land and reclamation that further extended the shoreline.

Wellington’s steep hills, thin clay soils, intensive development and variable climate pose challenges for effectively collecting and managing stormwater. At the discharge end, the receiving environment has a wide variety of significant habitats and a distinctive collection of plants and animals, including giant kelp, blue penguins, dolphins, string-rays and orca.

The map in figure 1 shows that the City’s most intensive land uses and traffic flows, that generate more runoff and more contaminants, are generally concentrated in four of the eight catchments draining into places where amenity and recreational values are also the highest – Lambton Harbour/Oriental Bay, Evans Bay, Lyall Bay and Houghton Bay.

Human and urban activities generate contaminants, which have increased in step with population growth. Traditional piped stormwater networks very efficiently move these contaminants to aquatic receiving environments. Contamination of stormwater can result in public health risks, closing beaches and negatively affecting water-based recreation, shellfish gathering and have adverse effects on cultural and tourism values.

2 DRAINAGE NETWORK

2.1 STORMWATER SYSTEM

Wellington's public stormwater system has developed over the last 130 years or more. While there are still some remnants of the open watercourses and streams in reserves and other parts of the City, most areas are serviced by piped stormwater drains. There are now some 550km of piped systems and upwards of approximately 25km of open semi-urban watercourses (excluding those in rural areas).

The current stormwater network comprises a complex gravity system of reticulated pipes, culverts, catch-pits, grit traps, secondary overland flow paths and streams, that together convey almost 80 million cubic metres of stormwater every year from buildings, roads, urban areas and open spaces into the city’s coastal receiving waters untreated.

Over 80% of the stormwater pipes are 40-60 years old, and only about 10% meet Council’s current 50-year return storm capacity standard. The remaining 90% of pipes generally have capacity for the 2-5 year return storms.

Conventional stormwater management has traditionally focused on flood risk management. Urban development needs and flood issues have been dealt with by building pipes and culverting streams.

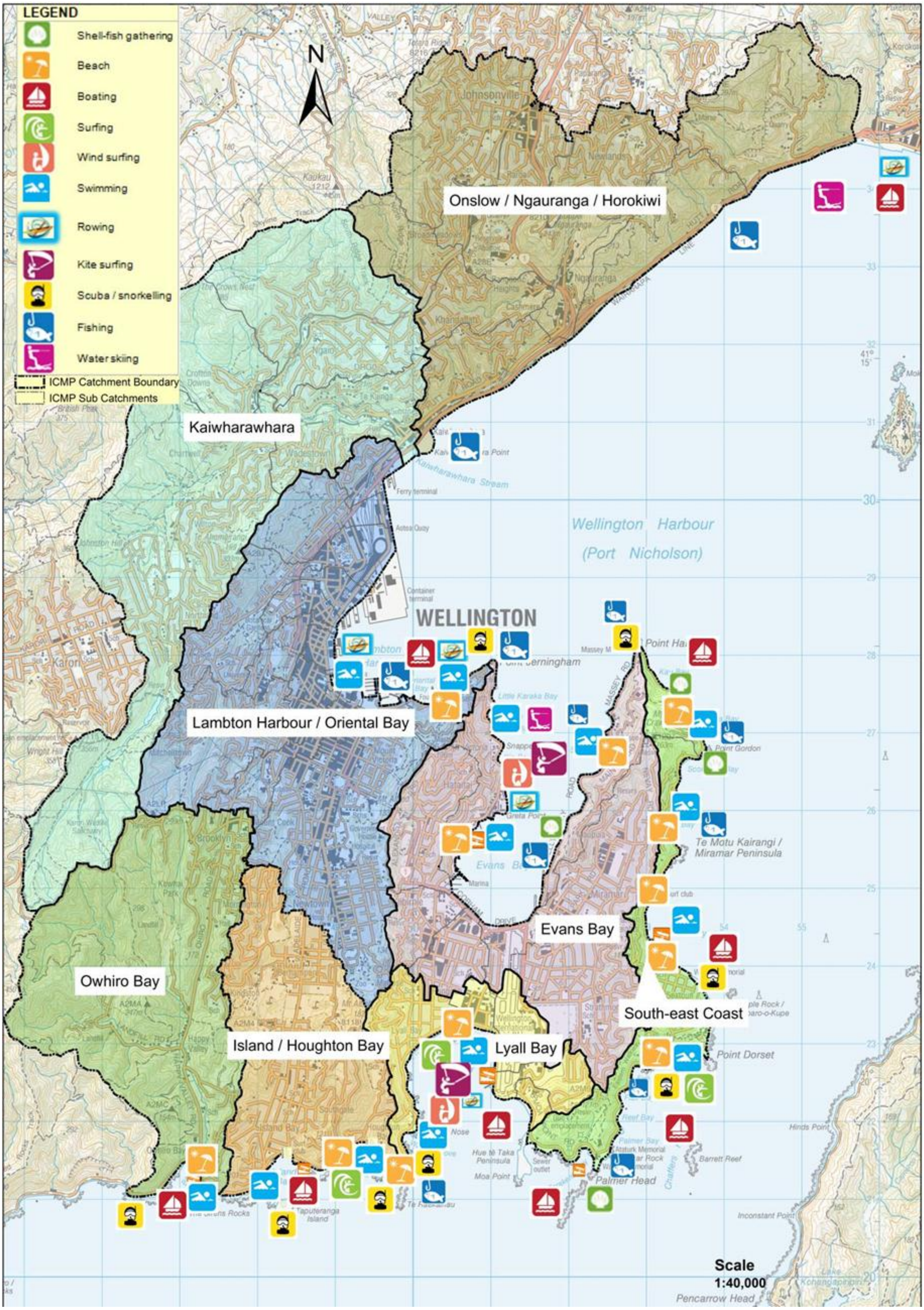


Figure 1: Recreational features

2.2 WASTEWATER SYSTEM

The current wastewater reticulation system is conveyed to the main trunk wastewater pipe which flows by gravity from Ngauranga Gorge through the central city, beneath Mt Victoria, through the low-lying coastal areas and the eastern suburbs to Moa Point. Wastewater from Island Bay, Brooklyn, Houghton Bay and Berhampore is delivered by gravity and pumped to a major pump station located between Island Bay and Owhiro Bay. Wastewater is pumped from this station back through Island Bay and a tunnel beneath Mount Albert to join the main interceptor at Kilbirnie. This intercepts all wastewater from the Wellington area, except Karori and the Northern suburbs. Moa Point Treatment Plant serves a population of approximately 130,000. Most of the wastewater comes from domestic and commercial sources (approximately 70%). Industrial flows comprise less than 15% of the total wastewater flow. Approximately 10 to 15% of the dry weather flow comes from inflows and infiltration into the system.

Inflow and infiltration results in stormwater entering the wastewater system and wastewater entering the stormwater system through inter-connected pipes built in the past, current illegal cross-connections, leaky joints, old cracked pipes or overflows as the wastewater system becomes overloaded or fails. The result is wastewater contaminated stormwater entering freshwater and/or coastal receiving environments.

Inflow and infiltration is estimated to account for approximately 10 to 15% of the dry weather flows arriving at the Moa Point Wastewater Treatment Plant. The proportion of inflow and infiltration increases significantly during or immediately after rainfall events, and in some wastewater catchments in the City the ratio of peak wet weather flows to average dry weather flow is as high as 10:1.

2.3 SEDIMENT LOADS IN STORMWATER

Sediment loads from Wellington City are relatively low to the Harbour and coastline, as presented in Table1. There is relatively little ongoing urban development and hence bare soil, which is the major source of fine sediments in urban areas. Limited sampling of Wellington's stormwater drains showed fine sediment concentrations were not particularly high (Capacity, 2014) and typical of mature urban areas (Williamson 1993). There are no reports or strong indications that urban-derived sediment deposition or discolouration is a major issue in Wellington's harbour or coastline.

There will be a decrease in clarity of stormwater discharges during rain events which greatly increase flow and this will result in visible plumes in the harbour near outfalls. There is little information characterising this, apart from a few observations near outfalls. In the absence of information, we have categorized this as a less than significant effect. The effect is considered to be less than significant because such events are not readily visible during rain storms, and the decreased clarity is highly localised and of short duration due to the small 'flashy' urban catchments. Decreased clarity during rain storms is also a common feature of all streams, irrespective of landuse.

Beyond a reasonable mixing zone, we do not anticipate that urban-derived sediments will impact the harbour sediments significantly in terms of sedimentation rate or benthic ecology.

Urban derived sediments beyond the mixing zone will dilute contaminant concentrations accumulating in the harbour, but because of sediment loads are anticipated to be relatively low, the effect will be relatively minor.

Annual sediment loads entering to the Wellington harbour is estimated from different catchments are shown in Table 1.

Table 1: Estimated sediment loads to Wellington Harbour

Catchment	**Area (km^2)**	**Annual sediment load (tonnes/year)**
Hutt River	615	132000
Kaiwharawhara stream (including urban areas)	16.8	1300
Ngauranga stream (including urban areas)	9.2	600
Wellington Harbour urban area (Lambton Harbour, Kaiwharawhara, North Coast, Evans Bay)	56.5	2200

Note: This is an approximate estimation only. Open space and rural estimation are based on NIWA's Water Resources Explore Model and urban yields are based on a global average. Detailed monitoring is recommended to develop Wellington specific yields.

3 URBAN STORMWATER QUALITY

Urban stormwater quality in Wellington is monitored by Wellington Water Ltd (formerly Capacity Infrastructure Ltd) and Greater Wellington Regional Council. Water quality is monitored within the network, at major outfalls and recreational beaches. A brief summary is given below.

3.1 GENERAL

General water quality and trace metals are monitored twice yearly (at least once each year in wet weather) in stormwater at the Evans Bay Culvert (Hataitai), Waring Taylor Culvert, Overseas Passenger Terminal Culvert, Houghton Bay Culvert and the Island Bay Culvert. The results show that total suspended solids and biological oxygen demand (BOD_5) concentrations are generally low in Wellington's urban stormwater. The highest total suspended solids concentrations were recorded at the Houghton Bay culvert, which drains a steep catchment which includes the closed Houghton Bay Landfill. Nutrient concentrations (TKN and TP) are moderately elevated, but these and BOD_5 are not considered an issue for the marine receiving environment in Wellington.

Of the metals tested in Wellington stormwater only copper and zinc were frequently elevated above water quality guidelines (ANZECC 2000). MWH (2003, 2008) concluded that dilution, typically of the order 10 to 20-fold, would be required to achieve compliance with ANZECC receiving water trigger values for these metals.

WCC have been measuring Faecal Coliforms and enterococci in 20 major discharge and 21 receiving water locations, during dry and wet weather. Additional samples are taken to examine the stormwater system's response to remediation work (e.g. fixing cross connections, leaks, overflow systems). Regular reporting (e.g., WCC 2014) has provided detailed summaries and analyses of these data. These data have been further analysed to assess trends over time in stormwater microbiological quality.

GWRC undertook limited monitoring of organic compounds (including PAHs, PCBs, organochlorine pesticides and chlorophenols) in its urban stormwater monitoring investigation, reported by Kingett Mitchell Limited (KML 2005).

That investigation detected elevated levels of PCBs and DDT metabolites (the latter an organochlorine pesticide) both dissolved in stormwater and attached to particulate material carried by stormwater. Since neither PCBs nor DDT has been used in New Zealand since around the 1980s, this contamination is thought to be historical and concentrations are expected to gradually decrease over time. Chlorophenol compounds (historically used in timber preservation) were found only at low concentrations.

PAHs were detected at most sampling locations. While concentrations in stormwater were mostly lower than ANZECC (2000) receiving water trigger levels, the concentrations in particulate material carried by stormwater frequently exceeded ANZECC (2000) sediment quality trigger levels. The identified PAH profile appeared to reflect emission of PAHs from motor vehicles.

3.2 URBAN STREAM SEDIMENT STUDIES

Heavy metals, PAH and DDT were measured in sediments from 22 streams across the whole Wellington Region (Milne & Watts 2008). Zinc, and to a lesser extent, lead, were the most common metals present in streambed sediments at concentrations exceeding ANZECC (2000) Interim Sediment Quality Guidelines (ISQG). Concentrations of total high molecular weight polycyclic aromatic hydrocarbons (PAHs) and total PAHs also exceeded guideline values at some sites. Almost all of the 29 sites sampled in 2005 and 24 sites sampled in 2006 recorded concentrations of total DDT above guideline values. Contaminant concentrations in sediment samples from several streams exceeded ISQG–High trigger values, indicating probable adverse effects on benthic biota.

3.3 URBAN STREAM WATER QUALITY MONITORING

Heavy metals were monitored in several urban streams (Milne & Watts 2008). Copper and zinc were the most commonly detected heavy metals in stream waters during both 'base flow' and runoff sampling events. Dissolved concentrations of both metals were consistently above ANZECC (2000) trigger values in runoff samples, with dissolved concentrations of one or both of these metals also above the trigger values in 'base flow' samples from a number of streams including Kaiwharawhara and Ngauranga streams. The bulk of the contaminant load was found to be associated with suspended sediments, so a further (and possibly greater) risk the contaminants pose to aquatic ecosystems is to the benthic biota in depositional coastal environments.

3.4 RUBBISH AND LITTER

Larger and heavier objects that could be discharged at the beach are removed by street sweeping, the baffles in sumps, sump cleaning (2 x per year) , and, in some of the major streams and pipes, a large sediment trap in the main channel. This is not only beneficial for the aesthetic quality of the coast, but also for protection of aquatic life (oceanic fish and bird life).

3.5 EMERGING CONTAMINANTS (CPEC)

There is a very large range of contaminants that are of emerging concern in the aquatic environment – sometimes called Chemicals of Potential Environmental Concern (CPEC). These are not usually as acutely toxic or persistent as the primary pollutants such as Pb, Zn, Cu, DDT, PAH, Hg. They include chemicals found in cosmetics, paints, solvents, flame retardants, tyres, bitumen, building materials, cleaners, disinfectants, sealants and fillers, plastics and plasticizers, and many more (Ahrens 2008). They can be found in runoff and wastewater, particularly sewage. Their effects are largely unknown, except in some cases overseas where some of CPEC have reached high concentrations and are causing biological effects (Ahrens 2008). They are currently being measured in Auckland estuaries, so a NZ database is beginning to emerge (Stewart et al. 2008, 2009, 2013, 2014). However, their environmental threat there or in Wellington is unknown (Diffuse Sources et al. 2012).

3.6 LOADS OF STORMWATER DERIVED CONTAMINANTS

Loads were calculated for each major stormwater outfall, or groups of outfalls. There are many different approaches and databases that could be used to calculate loads. Because of the type of information available on present day and future land use, we used the combination of event mean concentrations (EMC; for contaminant concentrations and the rational formula (to estimate annual stormwater runoff volumes). The methodology was similar to that employed in Seyb & Williamson (2004); some of the EMC data were also sourced from that document.

This is a relatively simple, but robust, method. It allows for easy revision if better or additional information comes to hand for contaminant concentrations, additional contaminants, or improved information on runoff volumes. More sophisticated methods may provide greater detail, for example, of the relative importance of different contaminant sources, but there is currently insufficient information to make these any more accurate than the approach used.

EMCs were summarised from about 20 studies (see references). Where possible, EMCs were selected directly from the data for different Wellington City land uses, or were based on best professional judgment.

3.7 WASTEWATER CONTAMINATION IN STORMWATER

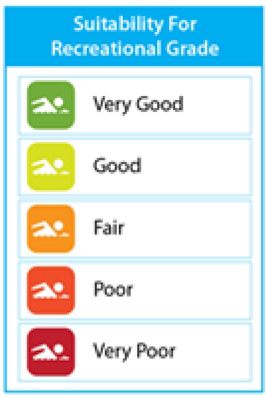
If faecal coliform levels exceed 1500 cfu/100 mL in dry weather flow or 10,000 cfu/100 mL during wet weather flow, Capacity notifies GWRC and instigates an investigation into causes. This is based on best professional judgment that such levels indicate significant contamination by sewage (Capacity, 2014).

Wastewater contamination of stormwater can occur through cross-connections, from leaking wastewater pipes, and from overflows when the wastewater system become overloaded or fails. Stormwater discharges have historically been contaminated with sewage., This contamination was addressed as part of the Sewage Pollution Elimination (SPE) project – a 15 year, $70 million project involving pump station rehabilitation, drain condition surveys and rehabilitation, and cross connection survey and repair The SPE project was successful in meeting its goals of reducing sewage pollution across the city; persistent dry weather sewage pollution has been eliminated to an acceptable standard however wet weather pollution remains more of a challenge.

4 ENVIRONMENT PARAMETERS

A "Fact Sheet" for each receiving environment around Wellington City has prepared, which summarised the stormwater quality, receiving environment characteristics (recreational and amenity), and the chemical, microbiological and ecological impacts. Altogether nine environmental parameters were assessed for each receiving environment.

4.1.1 SUITABILITY FOR RECREATIONAL GRADE



The SFRG measures the suitability for full body immersion ("primary" contact) that might occur in swimming, surfing, scuba/snorkel, waterskiing, kite and wind surfing. If it is suitable for primary contact, then it is suitable for "secondary" contact activities such as boating and fishing. Suitability for Recreational Grade is assessed by GWRC based on 5 years of monitoring and a sanitary assessment of the catchment (GWRC 2013). Most Wellington recreational sites are "good", two are "very good", two are "fair", and one is "poor".

4.1.2 RECEIVING WATER IMPACTS

Aesthetics are assessed visually at major stormwater outfalls once per month. The colour of the icon in the map key denotes a grading:

Green – impacts are observed infrequently observed

Amber – impacts are observed occasionally

Red – impacts are observed frequently

In the example to the left:

- Scums and foams; floating or suspended matter, biological growths & dieoff, erosion at discharge point are infrequently observed or not at all;
- Visible oil & grease; colour or clarity change is observed occasionally;
- Objectionable odours occur frequently.

4.1.3 WATER QUALITY FOR SHELLFISH GATHERING

This is monitored at two sites only. There is no simple grading system. For water quality to be suitable for shellfish gathering (MFE 2003), then two conditions need to be met: 1) Median FC over shellfish gathering season <14 MPN per 100 mL and 2) No more than 10% of samples >43 MPN per 100 mL

We created a simple grading system where:

- Good – both conditions above are fulfilled
- Marginal – only condition (1) is met
- Poor – neither condition is met

4.1.4 CONTAMINATION EFFECTS

These are graded according to the ARC Traffic Light System for Sediment Quality Criteria (ARC 2004).

Parameter	Red[1,2]	Amber[1,2]	Green[1,2]	Source of Red-Amber Threshold	Source : Amber-Green Threshold[3]
Zinc	>150	124-150	<124	ERL	ISQG (CCME)
Copper	>34	19-34	<19	ERL	ISQG (CCME)
Lead	>50	30-50	<30	ISQG ANZECC	ISQG (CCME)
HMW PAH[4]	>1.7	0.66-1.7	<0.66	ISQG ANZECC	TEL

[1] Values rounded to two significant figures.

[2] Values are for the total sediment in the settling zone and for the mud fraction within the outer zone.

[3] Source:

ERL = Effects Range Low (Long et al. 1995)

TEL = Threshold Effects Level for Florida Department of Environmental Protection (MacDonald 1996)

ISQG-Low = Interim Sediment Quality Guideline-Low (ANZECC 2000)

ISQG CCME = Interim Sediment Quality Guideline for Canadian Council of Ministers for the Environment (CCME 1999).

[4] After normalization to an organic carbon content of 1%.

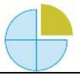
4.1.5 LEGACY CONTAMINATION

This grades the concentrations of priority pollutants Pb, Hg, DDT, PAH where it is suspected that concentrations in the harbor are mainly due to high concentration in stormwater in the past, or are due to other sources.

	One of more contaminants exceed the ARC Red Category
	One of more contaminants exceed the ARC Amber Category
	is not used in this grade
	Contaminants all below Amber Category

4.1.6 PRESENT DAY STORMWATER CONTAMINATION

This grades the present-day contamination by the major stormwater contaminants Zn and Cu.

	One of more contaminants exceed the ARC Red Category
	One of more contaminants exceed the ARC Amber Category
	Light Green is not used in this grade
	All contaminants are below Amber Category

4.1.7 FUTURE STORMWATER CONTAMINATION

This grades the rate of buildup of major stormwater contaminant Zn and the time taken to exceed the ARC Amber and Red Category. It is an indication of the concern for the buildup of toxic contaminants from future stormwater discharges.

	ARC Red Category predicted to be exceeded within 30 years
	ARC Amber Category predicted to be exceeded in within 30 years
	Light Green is not used in this grade
	**ARC Amber Category is unlikely to be exceeded within 30 years.**

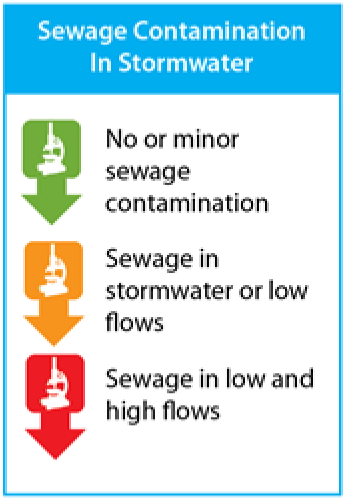
4.1.8 ECOLOGY GRADE

Ecological effects have been summarized in Figure 2 according to the observations at the GWRC monitoring sites based on Kelly (2010).

	Highly impacted
	Moderately impacted

	Low-moderate impact (slight)
	Low or no impact

4.1.9 WASTEWATER CONTAMINATION IN STORMWATER



If faecal coliform levels exceed 1500 cfu/100 mL in dry weather flow or 10,000 cfu/100 mL during wet weather flow, Capacity notifies GWRC and instigates an investigation into causes. We have used these notification values to grade contamination by sewage in stormwater in the following way:

- Red – contamination during wet and dry weather flow
- Amber – contamination during either wet or dry weather flow
- Green – neither notification level exceeded

5 RECEIVING ENVIRONMENT STATUS

Urban stormwater has the potential to affect:

- the aesthetic quality of water in the harbor, bays and the beaches
- human health through primary contract recreation activities such as swimming, kite and wind surfing, scuba diving and snorkelling;
- marine organisms in the Wellington Harbour and bays

Key findings for the Wellington catchments are briefly summarised in the Figure 2 (compiled all fact sheets into single map). Note that most of the catchments have their own "hotspots", or industries and other high risk facilities like old landfills or factories and old wastewater network that may potentially make a disproportionate contribution to stormwater contamination.

5.1 AESTHETICS

Some scum & foam, floating and suspended matter, oil and grease, biological growth and die-off, as well as discoloration have been observed at the Lambton harbour, Hataitai and Kilbirnie stormwater outfalls. These outfalls are located in sheltered waters of the harbour. It is possible that the debris is windblown from activities on the beaches and surrounding streets rather than from local stormwater run-off. Another factor might be spillages at the port or marina. The debris issue is consistent with the location of the city on a major harbour.

The southern shores of Evans Bay, Island Bay, and Owhiro Bay and the South-east coast aesthetics factors are generally observed to be good. However, "aesthetics" are poor in Houghton Bay with reports of odours, discoloration and erosion some occasions. The discoloration appears to arise from iron oxide deposits (landfill leachate), while hydrocarbons appear to be the source of the odours (Capacity, 2014). Discoloration is observed in the beach water after rain.

5.2 HUMAN HEALTH

The suitability for full body immersion (primary contact) which occurs with swimming, surfing, scuba diving, snorkelling, water-skiing, and kite and wind surfing is measured by the Suitability for Recreational Grades (SFRG). Suitability for recreation, is monitored at all recreation beaches in the harbor and along the south coast . Suitability for full body immersion is measured, i.e. for the primary contact that occurs in swimming, surfing, scuba diving, and snorkelling, and water-skiing.

SFRG values are Very Good at beaches in Evans Bay, Shark Bay, Balaena Beach, Koi Bay Scorching Bay, Mahanga Bay, Island Bay at the beach near Derwent St, (but only Fair in the inner part of the Bay Surf Club and Reef St Recreational Ground), Princess Bay and at the three sites along Worser Bay, and at Breaker Bay. Occasionally the action level is breached in beach monitoring at one or other, but these are short-lived and have not necessitated the erection of warning signs. Overall, the stormwater discharges do not affect the amenity values associated with this coastline. Indicator bacteria levels are exceeded from time to time and this has been attributed to rainfall-runoff events. Indicator bacteria often exceed MfE guidelines for contact recreation during rainfall events in Island Bay, occasionally persisting over several days, requiring warning signs to be erected.

The SFRG is rated as Poor at Owhiro Beach. Indicator bacteria at the beach often exceed MfE guidelines for contact recreation, which has resulted in warning signs being erected from time to time. A more detailed investigation at Owhiro Bay (termed "faecal source tracking") late in the 2012/13 bathing season suggested wildfowl as one of the main sources, although human, dog and ruminant sources could have compounded the effects. Seagulls can gather in large numbers in the bay. High concentrations of indicator bacteria were also found with no obvious warm-blooded source, which led scientists to consider the source was the decaying seaweed (the tidal wrack) on the beach, where indicator bacteria are known to occur, presumably after being 'inoculated' from elsewhere.

The beach and shellfish monitoring suggests that bacteriological pollution of eastern bays is low, and that it does not affect recreational uses over most of the bay, most of the time. The test carried out on blue mussels in 2006 at Shark Bay, Mahanga Bay, Scorching Bay or Pt. Dorset; it was fully compliant for shellfish gathering and consumption.

5.3 CHEMICAL CONTAMINANTS

Urban stormwater, stream water, and stream sediment monitoring has shown that Wellington urban catchments have chemical contaminant concentrations that are typical of urban streams and runoff throughout the world. Cu and Zn are the widespread contaminants of concern in present-day stormwater in terms of impacts in receiving waters, while PAH, DDT, PCB and Pb may also be contaminants of concern in some places. There may be ongoing diffuse source inputs of these contaminants and/or legacy contamination from past use. Zn, Cu, Pb, PAH and DDT are all contaminants of concern in Wellington's harbour due to elevated sediment concentrations.

PAH, Pb, DDT and Hg are not currently being discharged in sufficient quantities in urban stormwater to result in high levels of contamination, but stormwater may have carried high loads of these substances in the past (termed "legacy contamination"). However, there may have been other sources, such as industrial discharges, spillage during port operations, and leaching and cleaning of antifouling paints from ships and boats.

Very high levels of heavy metals (Zn, Pb and Cu) have been found within 50m of Miramar and Kilbirnie outfalls. These high concentrations and their rapid decrease with distance from the stormwater outfalls. High concentrations of polynuclear aromatic hydrocarbons (PAH) and total petroleum hydrocarbons (TPH) were also found close to the Miramar outfall. This may be partly attributed to the former gasworks. They may also be due to the historical use of coal tar (a by-product of the gasworks) for roading adhesive or are perhaps the result of spillage of petroleum products during port activities. Over the wider bay area, Pb, Hg, DDT, Cu and Zn exceed sediment quality guidelines. These guidelines are used to signal the possibility of harmful effects on benthic animals that live in and on the sediment of the bay.

There is no information on receiving water contamination within Island Bay, and Owhiro Bay. Re-suspension, dilution, and dispersion processes are likely to be high in the south coast, so contaminants should not occur in high concentrations. Legacy contamination, present day stormwater contamination, and future stormwater contamination have all been classified as low for the south coast bay areas.

The chemical contamination of the receiving environment has not been assessed for south-eastern bay areas. Because of low urban density, powerful dilution and dispersion and the resulting low concentrations, contaminants are not expected to have a significant effect. Legacy contamination, present day stormwater contamination, and future stormwater contamination have all been classified as low.

6 CONCLUSIONS

Wellington is a city where the natural environment permeates the urban environment, enabling an attractive and livable city environment. The marine areas surrounding Wellington play an essential part of our environment, heritage and economy. Ensuring the marine environment is healthy adds to the natural advantage the sea and harbour offer for the city.

Most of Wellington's popular recreational sites are currently graded good to very good meaning they are safe for swimming most of the time. Indicator bacteria occasionally exceed guidelines for contact recreation at beaches during rainfall events and occasionally warning signs are erected; for example, once in the 2012-13 season. Overall, the stormwater discharges have only minor effects on the amenity values during rainfall events.

Results suggest Wellington coastal area has overall very good water quality however in urban areas overflows of wastewater into stormwater drains can spoil the water. The most intensive land uses and traffic flows in Wellington include catchments draining into places where amenity and recreational values are of the highest concern. This provides an opportunity to investigate improved ways of managing stormwater.

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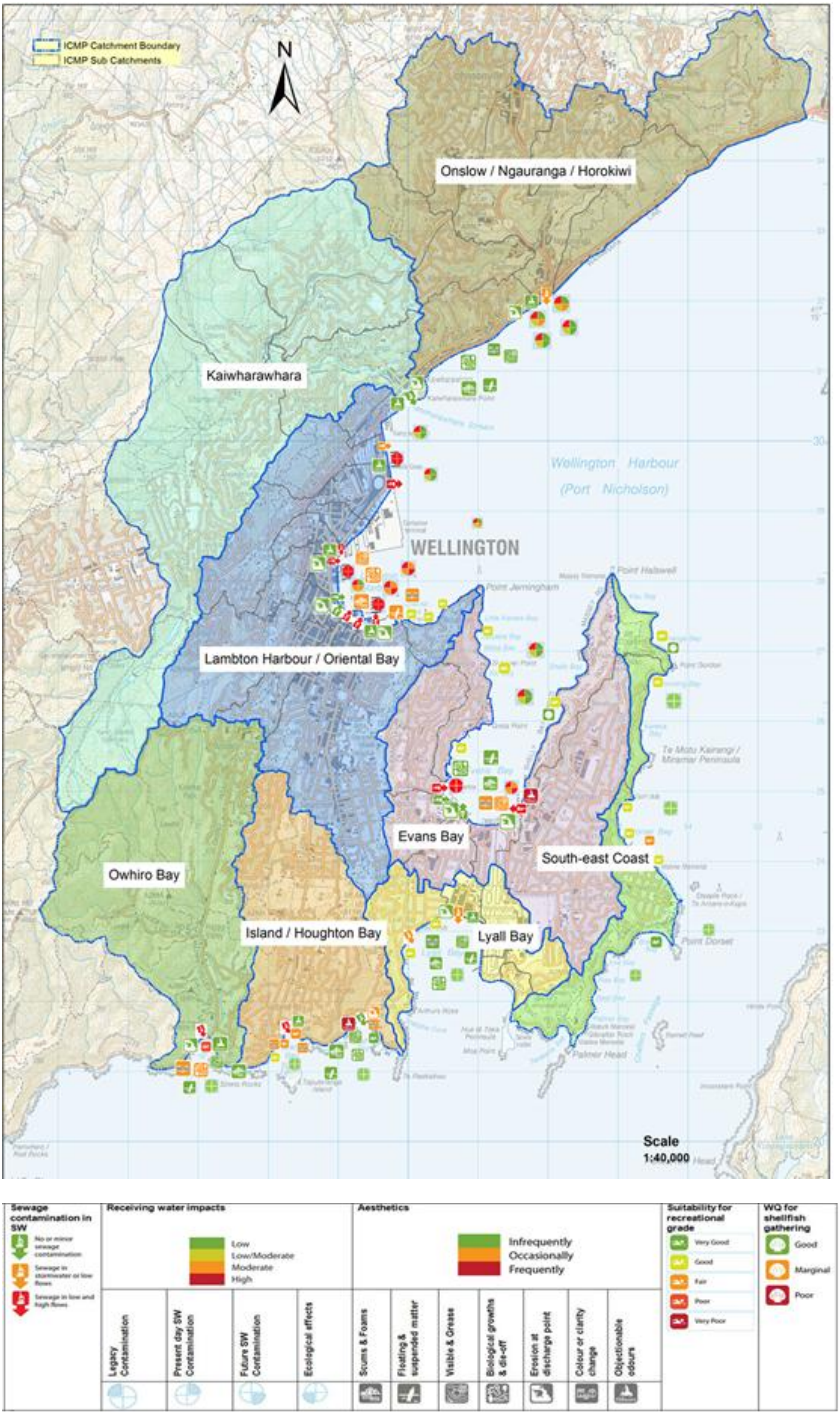

Figure 2: Status of receiving waters

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