THE RSS MODEL: FLUSHING OUT STORMWATER RISKS

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ABSTRACT

Increasing regulatory focus on stormwater discharges under the National Policy Statement on Freshwater Management is placing a spotlight on the management of stormwater runoff from roads. This paper describes a GIS-based road stormwater screening (RSS) model designed to assist road controlling authorities and network operators manage stormwater runoff and develop supporting catchment and asset management plans.

The RSS model provides a robust, conservative method for screening the risk level to receiving waterbodies from road stormwater runoff, based on the copper and zinc contaminant load from road traffic and non-road (urban) sources. Risk is evaluated using a rating for contaminant strength and receiving environment sensitivity with streams/rivers assessed at the sub-catchment level and coasts/estuaries at their stormwater catchment outlets.

The method uses nationally consistent datasets and takes account of variations in traffic volumes and congestion, load attenuation by road drainage and land use. The model can disaggregate contributions from local roads and state highways and has a `drill down' facility to identify `hot spots' where traffic loads are highest. The model's spatial analysis supports a global consenting approach for road networks appropriate to the risk to the receiving environment.

Results from a case study evaluation of the model are presented for the Porirua Harbour catchment (Pauatahanui Inlet and Onepoto Arm) including risk profiling, sensitivity analysis, validation against field data and example applications.

KEYWORDS

Risk assessment, modelling, road runoff, stormwater, receiving environment, vehicle emissions, copper, zinc

PRESENTER PROFILE

Laurie Gardiner is a Principal Environmental Scientist at MWH New Zealand with a career spent largely in environmental consultancy, both internationally and in New Zealand over the last decade. His research interests include risk assessment, stormwater management and applying GIS-based tools to understand and manage network-wide environmental issues.

Jonathan Moores is Group Manager of NIWA's Urban Aquatic Environments Group. He leads research on stormwater quality and its effects on receiving waterbodies, including predictive modeling studies and field-based investigations characterising stormwater quality and treatment device performance. He has previous regulatory, policy development and public liaison experience with local government.

1 INTRODUCTION

Road runoff may adversely affect aquatic receiving environments. Contaminants in road stormwater discharges are complex. They include fuels, additives, oil and brake and tyre residues containing a variety of toxic and ecotoxic components, such as heavy metals and organic compounds.

Receiving environments from road runoff include streams, rivers, lakes, wetlands, estuaries, harbours and the open coastline. The characteristics of these different types of water body influence the fate of contaminant inputs, how they are assimilated and therefore their sensitivity.

Reflecting the need for cost-effective ways of prioritising the management of road runoff in relation to the risk of adverse effects, the NZ Transport Agency commissioned MWH in association with NIWA to develop a screening model that addressed the following research question:

Under what conditions is stormwater run-off likely to cause adverse environmental effects?

Building on earlier research (Gardiner and Armstrong, 2007; Moores et al., 2009, 2010), the aim of this study was to revise and enhance the Transport Agency's VKT screening tool for road runoff to allow its wider application to rivers/streams and coasts/estuaries, and to be able to factor in the effects of pathway attenuation, traffic congestion and non-road contaminant sources. While the principal intention was to develop an improved screening method for road networks, the study also considered how this could be extended to provide for an absolute risk assessment in relation to established effects thresholds.

This paper describes the Road Stormwater Screening (RSS) model and results from a case study evaluation in an environmentally sensitive catchment in the Wellington region. Full details of the model are provided in NZ Transport Agency Research Report 585 (Gardiner et al., 2016).

2 THE RSS MODEL

2.1 BACKGROUND TO MODEL DEVELOPMENT

The VKT screening tool, developed under a 2007 Transport Agency study and later applied to the national state highway network (Gardiner et al., 2007), provided the starting point for the RSS model. The VKT tool also adopted a source-pathway-receptor approach but was limited to the assessment of depositional receiving environments and assessed risk using VKT by sub-catchment as a proxy for contaminant load.

The RSS model has added a range of significant enhancements and new features to the VKT method. These include:

- A road contaminant load module for estimation of zinc and copper loads at the sub-catchment level from road traffic, vehicle emission factors that vary in relation to traffic congestion, pathway attenuation and conversion of VKT to contaminant load;

- A non-road (urban) contaminant load module for estimating zinc and copper loads at the sub-catchment level from the extent of urban non-road impervious surfaces and contaminant yields for residential and industrial/commercial areas, respectively;

- A method for assessing risk to streams and rivers, based on estimates of in-stream copper and zinc concentrations relative to guideline concentrations combined with a receiving environment sensitivity score indicated by modelled values of the macroinvertebrate community index;

- A method for assessing risk to coasts and estuaries, based on estimates of copper and zinc concentrations in sediments delivered to coastal discharge points relative to guideline concentrations combined with a receiving environment sensitivity score determined from the physical depositional characteristics of the water body.

Aside from its technical capability, a key aspect of model development was to ensure it provided end users (e.g. RCAs and network operators) with the means to respond to the increasing regulatory focus on management of stormwater runoff from roads, primarily from the NPS-FM and its implementation at regional level through stormwater strategies and catchment management plans.

To this end, a review of the likely future planning and legislative context was undertaken early in the study to help shape how best to configure the RSS deliver value. Key findings from the review are summarised below.

Catchment level – the NPS-FM supports a catchment-based approach through the delineation of a freshwater management unit (FMU). The RSS model was developed on a sub-catchment basis and therefore is easily configured to any FMU.

Copper/zinc as attributes - While attributes of the ‘compulsory values’ in the NPS-FM for which regional councils must set freshwater objectives do not currently include heavy metals, these may well be added in future. Furthermore, a regional council may set objectives for attributes not currently compulsory. In catchments with urban/roading land use, this may mean heavy metals are an attribute that will be managed. By modelling copper and zinc (and their risk in combination) in such catchments, the RSS model is well placed to support this requirement.

Freshwater quality accounting system - the NPS-FM requires a system to record, aggregate and update information on measured, modelled or estimated loads and/or concentrations of contaminants for FMUs, their sources and amount of each attributed to each source (and where limits have been set, the proportion of the limit that is being used). The RSS model assesses the risk from copper and zinc loads in road runoff at the catchment level, and differentiates contributions from local roads and state highways, and from non-road urban sources. In providing such information for FMUs, the model would also prove useful in identifying methods to meet catchment limits and achieve freshwater objectives.

Impact on coastal waters – the type of water body covered by the NPS-FM includes streams, rivers, ponds, lakes and wetlands. While estuaries are not directly included, the NPS-FM points to the coastal receiving environment as an important consideration in setting limits (e.g. policies A1 and B1). The Parliamentary Commissioner for the Environment (PCE, 2015) recommended explicit inclusion of all New Zealand's 300-odd estuaries in the NPS-FM. The Government's current proposals (Ministry for the Environment, 2016) include seven coastal lakes and lagoons that are intermittently open to the sea. The RSS model is applicable to estuaries and has the flexibility to be extended to all coastal waterbodies.

2.2 RSS MODEL OUTLINE

The RSS model has been developed using a combination of ESRI ArcGIS and MS Excel. ArcGIS is used to determine data inputs and to map results, adopting the River Environment Classification (REC) (Snelder et al., 2010) as the basis for analysis. Excel provides the platform for estimation of contaminant loads and risk.

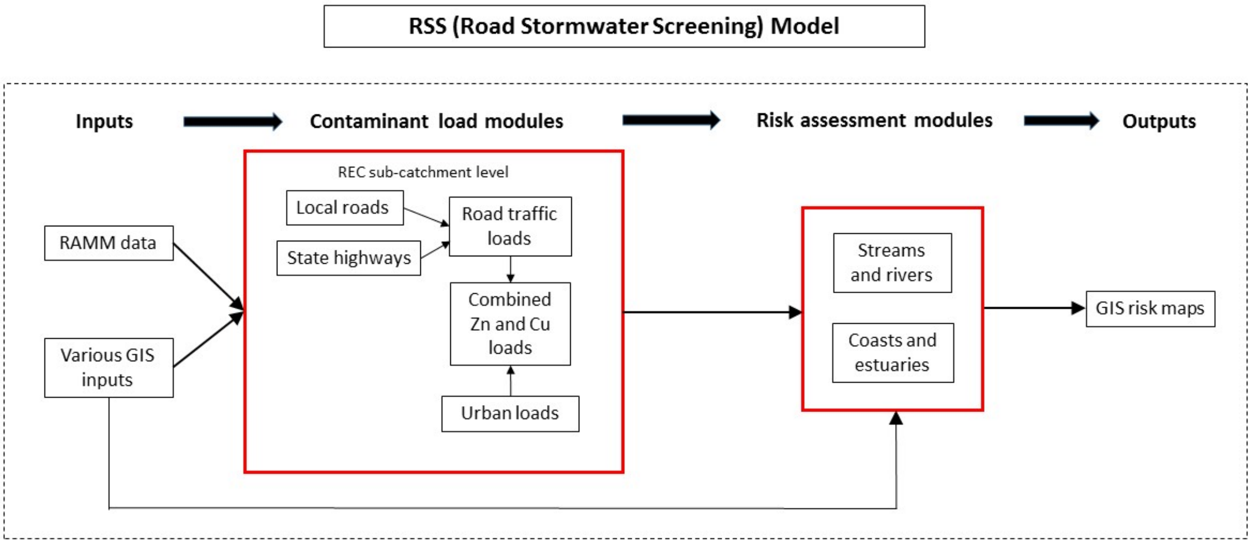
Key concepts underlying the RSS model are:

- The adoption of a source-pathway-receptor conceptual model;
- A focus on potential effects of copper and zinc, using New Zealand road runoff sampling data collected under previous Transport Agency research and other complementary studies, recognising that these metals also function as proxies for a wider range of stormwater contaminants; and
- The ability to assess risk associated with discharges to a range of receiving waterbodies including rivers and streams, and coasts and estuaries.

Figure 1 is a schematic of the RSS model. The main components (outlined in red) are the contaminant load modules (for road traffic, urban and combined loads) that feed into the risk assessment modules (for rivers & streams; and coasts & estuaries).

The RSS model uses the sub-catchment as the basic spatial unit for the contaminant load and risk assessment. For rivers and streams, risk is assessed for each reach sub-catchment based on the REC. For coasts and estuaries, risk is assessed at river and stream mouths based on the contaminant contributions of all upstream REC sub-catchments[1].

Figure 1: Schematic of the RSS model



Input data is provided by the RAMM database and other GIS layers. Users may vary some of the in-built default parameter values (e.g. vehicle emission factors, catchpit retention efficiency, pathway attenuation factor). The output is provided in GIS risk maps.

An overview of the methodology is given below.

2.3 ESTIMATING CONTAMINANT LOAD

2.3.1 ROAD TRAFFIC LOAD

Figure 2 shows the process for estimating annual loads of traffic-derived copper and zinc (‘road traffic’ loads) for a given road section.

Loads are calculated as the product of the VKT and the VEF, selected according to the degree of traffic congestion (using the LoS for the road section), and finally adjusted for attenuation using LRFs that take account of the road drainage characteristics in RAMM (e.g. surface water channels and stormwater treatment devices such as catchpits).

The individual road section values are summed for each sub-catchment to provide an input to the rivers/streams risk assessment. For assessing coasts/estuaries, the road traffic load at each final discharge location (‘outlet’) is the sum of the contributing sub-catchment loads.

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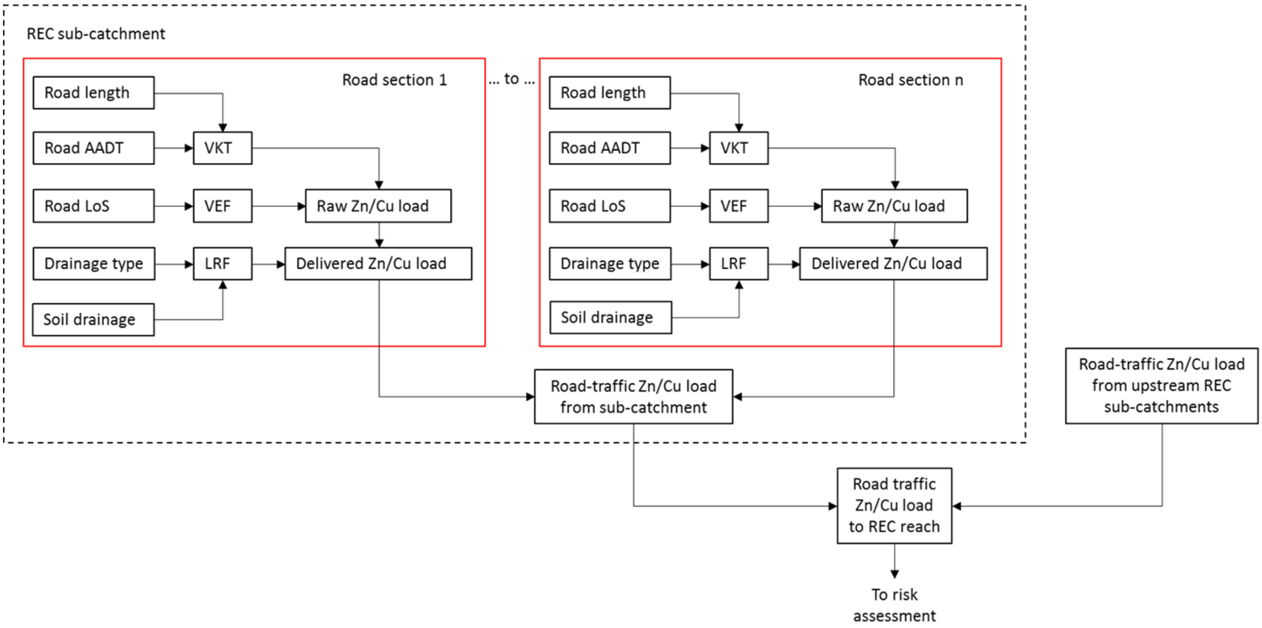
[1] Except where coastal discharge points do not coincide with a river or stream mouth (i.e. a stormwater outlet), in which case risk is based on contaminants from the immediate (non-REC) catchment. Refer to NZ Transport Agency research report 585 (Appendix D) for details.

2.3.2 URBAN LOAD

Annual loads of copper and zinc generated from urban non-road impervious surfaces are calculated as the product of the area of non-road impervious cover and copper and zinc yields for residential and industrial/commercial areas, respectively.

The extent of urban land use within each REC sub-catchment is calculated from the LCDB4 spatial database. This is used to define the urban 'footprint' within each REC sub-catchment.

Figure 2: Method for estimating road traffic loads of copper and zinc



Note: AADT = annual average daily traffic; VKT = vehicle kilometres travelled; LoS = level of service (free-flowing, interrupted or congested); VEF = vehicle emissions factor; LRF = load reduction factor; SWC = surface water channel

The non-road built-up area is then calculated by subtracting the areas of local roads and state highways from the total built-up in each sub-catchment. The road areas in each sub-catchment are estimated from the road network data specifying the lengths and widths of each road segment.

Annual urban loads of copper and zinc are then calculated as the product of the area of non-road impervious cover and the copper and zinc yields. This calculation is made separately for residential and industrial/commercial land uses, respectively, and the results summed to give the total urban copper and zinc loads in each REC sub-catchment.

The copper and zinc yields specified for residential and industrial/commercial land uses are weighted averages of yields specified in Auckland Council's CLM for each of a range of roof materials and for paved areas (Auckland Regional Council, 2010). Weighting is based on the fractions of different roof materials and paved surfaces in representative residential areas and industrial and commercial areas, respectively. Based on the CLM's reference area fractions of each roof type and paved areas, the following weighted average copper and zinc yields were calculated:

- an annual copper yield of 0.016g m^{-2} and an annual zinc yield of 0.31g m^{-2} from non-road impervious surfaces in residential areas
- an annual copper yield of 0.036g m^{-2} and an annual zinc yield of 0.71g m^{-2} from non-road impervious surfaces in industrial/commercial areas.

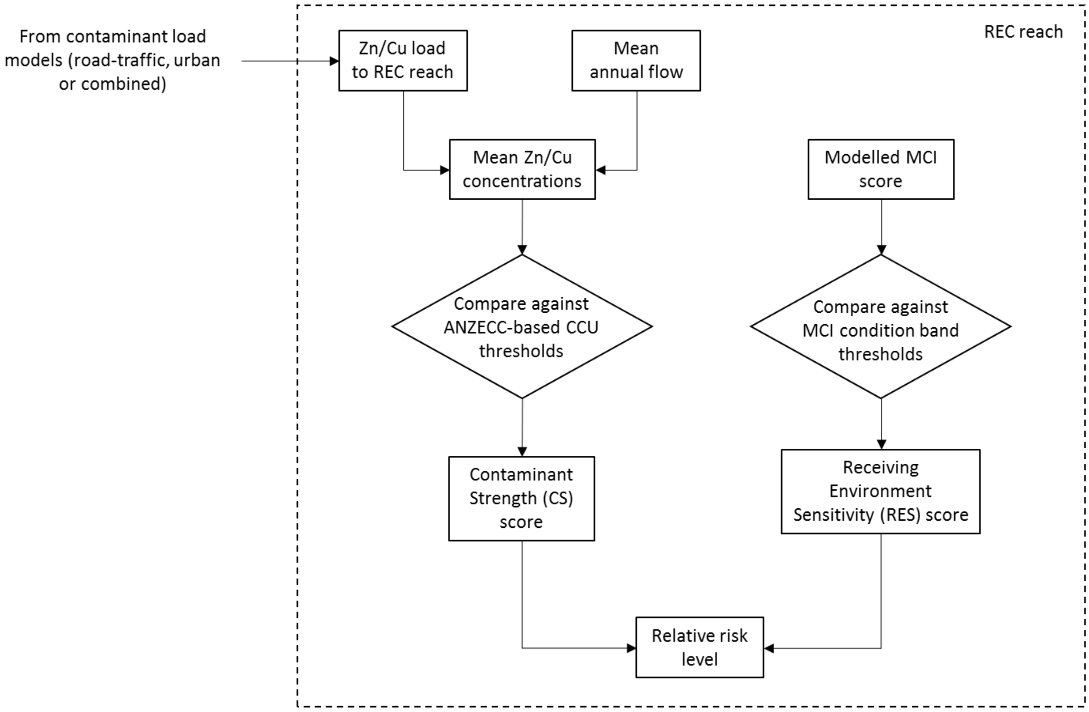
The fractions of each land cover type can be changed to derive location-specific yields, where supported by local information (see point 4 in Section 2.5).

2.4 RISK ASSESSMENT FRAMEWORK

Risk levels are evaluated using a combination of contaminant strength (CS) score and a receiving environment sensitivity (RES) score, with streams/rivers assessed by sub-catchment reach and coasts/estuaries at their catchment outlets.

The method depends on the type of receiving environment. For rivers and streams, the CS score reflects the in-stream concentrations of copper and zinc in the water column while the RES score reflects condition bands associated with application of the macroinvertebrate community index (MCI) – see Figure 3.

Figure 3: Risk assessment process – rivers and streams



For coast and estuaries, the CS score reflects the concentrations of copper and zinc in sediments delivered to the receiving environment while the RES score reflects the extent to which depositional processes dominate in the receiving environment (e.g. measured by sedimentation rates).

While the methods of deriving the CS and RES scores for rivers and streams differ from those for coastal/estuarine receiving environments, the adoption of the same overall framework ensures conceptual consistency.

The risk method takes account of the potential for the effects of copper and zinc to be ‘cumulative’ i.e. elevated concentrations of both metals has the potential to result in effects at lower concentration thresholds than if only one or the other metal was present. Calculation of the CS score is based on comparison of ‘cumulative criterion units’ (Hickey and Golding, 2002) against thresholds derived from environmental quality guidelines (e.g. ANZECC 2000 water quality guideline values for rivers and streams).

Relative risk is determined for the two contaminant sources (i.e. road traffic and urban). The combined risk (road traffic plus urban) is a measure of the risk `seen’ by the receiving water body from zinc and copper loads in stormwater runoff.

Of note is that the ANZECC 2000 guidelines are currently under review and, in relation to the model, will probably include correcting and revising toxicant trigger values for copper and zinc. The RSS model has the flexibility to be updated for any such changes.

2.5 MODEL ASSUMPTIONS AND LIMITATIONS

The RSS model is intended for the specific purpose of screening road networks and their associated catchments for relative risk from stormwater (including road runoff) discharging to receiving environments.

A number of simplifying assumptions (and therefore consequent limitations) have been incorporated and are highlighted for users, as noted below:

1) The RSS model provides estimates of risk to waterbodies based on zinc and copper concentrations in stormwater runoff derived from modelled loads; other stormwater contaminants are not included although these metals provide a proxy for stormwater pollution.

2) The RSS model has two contaminant load modules – one for estimating vehicle-derived zinc and copper in road runoff and the other for urban sources of these metals (e.g. zinc from galvanised roofs). The risk estimates are derived from the combination of road traffic and urban loads and therefore address the main sources of these metals in stormwater runoff.

3) The contaminant load model for road traffic includes provision for LRFs for both stormwater channels (SWCs) and stormwater treatment devices, as included in their respective RAMM datasets.

4) Estimation of urban loads of copper and zinc uses representative yields for residential and industrial/commercial land uses, respectively, derived from land cover fractions and yields in Auckland Council’s CLM. The screening method does not involve detailed land-use analysis, nor does it attempt to address uncertainty in yields adopted from the CLM. Urban loads derived

from the default yields should be considered indicative. However, users may adopt alternative, locally-derived yields where available.

5) The methodology was developed to address longer-term risks to waterbodies from total annual loads of zinc and copper in stormwater runoff. Risk levels do not take account of variations in copper and zinc concentrations during storm events and their potential effects.

6) The model does not disaggregate metal loads into their particulate and dissolved fractions. For rivers and streams, it is the dissolved fraction of copper and zinc that are of most concern and which would be compared with guideline concentrations in a further assessment of absolute risk.

7) The coastal risk assessment method involves calculation of concentrations of copper and zinc in suspended sediment and assumes that these reflect the likely relativity of risk associated with metal concentrations in deposited sediments. Physical, chemical and biological processes operating in receiving environments may result in result in metal concentrations in deposited sediments differing from those in suspended sediments.

8) The RSS model identifies the relative risk to receiving environments from runoff (on a scale 'lowest' to 'highest') and the contributing sections in the road network for the traffic component. It does not assess absolute risk to waterbodies and therefore whether or not stormwater treatment is required to meet environmental standards; however, the output will aid decision making by identifying risks from stormwater discharges in a catchment and therefore prioritising which parts of the road network may warrant further investigation (e.g. monitoring to support a consent application).

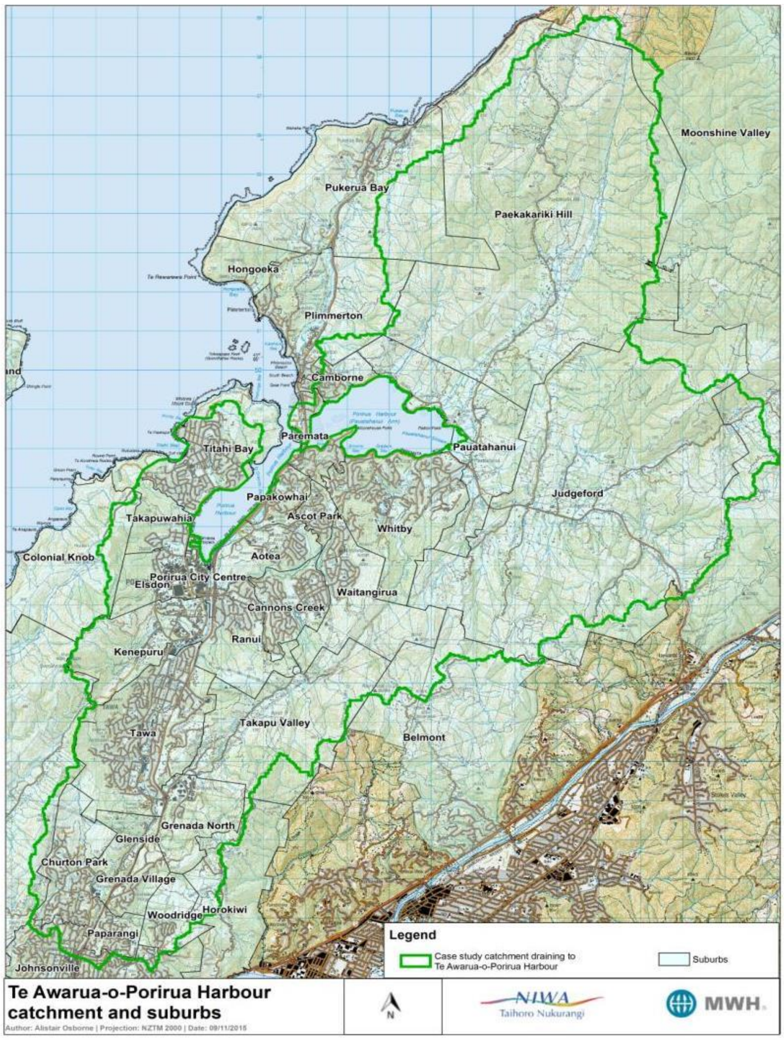
9) The model inputs provide a framework for general (national) application of the RSS model using default values. Certain inputs (e.g. values in look-up tables; land-use mix and copper/zinc yields for determining urban loads) can be adjusted to reflect local conditions, and an example is described in the case study evaluation dealing with model sensitivity testing.

3 CASE STUDY EVALUATION

The RSS model was evaluated in Te Awarua-o-Porirua Harbour and its catchment, situated approximately 20km north of Wellington city (Figure 4).

Figure 4: Te Awarua-o-Porirua Harbour and catchment; Pauatahanui Inlet (east arm) and Onepoto Arm (case study boundary shown by green line)

Te Awarua-o-Porirua Harbour is the largest estuary in the lower North Island and is a significant local and regional ecological resource. The harbour comprises two arms – the larger eastern Pauatahanui Inlet (470ha) and the western Onepoto Arm (240ha) – and an outer harbour facing Cook Strait. Boundaries of catchments draining to each estuary (and the case study area) are shown in Figure 4.



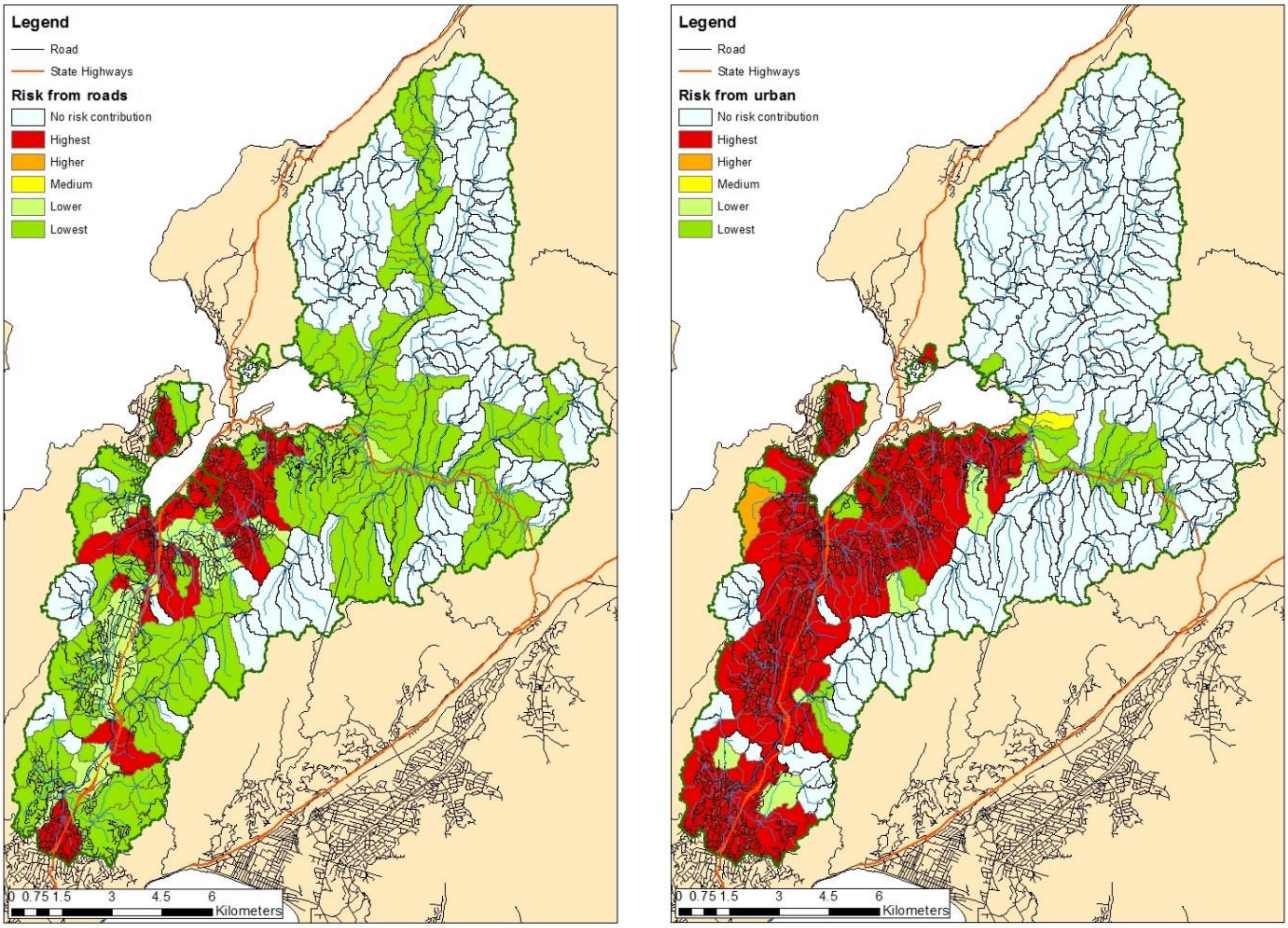
The study area was chosen because it comprises a mix of local roads and state highways that discharge to streams of varying dilution potential as well as two major estuarine / coastal waterbodies. The sub-catchments of these two arms of the harbour contain markedly different urban/rural land use (with Onepoto more urbanised), allowing for model evaluation under widely different catchment conditions. REC river reaches are typically between 500–1,500m in length with an average length of around 750m and average sub-catchment area of around 40ha.

3.1 RISK ASSESSMENT – RIVERS AND STREAMS

Results of the risk assessment for rivers and streams by sub-catchment in the case study area are shown in Figure 5 (road traffic and urban sources). In each case the risk assessment reflects the potentially cumulative effects of zinc and copper.

Figure 5: Risk assessment by sub-catchment for streams/rivers in case study area for road traffic (left) and non-road `urban' sources (right)

For the assessment of road-traffic risk to rivers and streams, the majority of reaches are classified as 'lowest risk'. In most of these sub-catchments, the streams are able to adequately dilute the relatively small copper and zinc loads discharged in road runoff from the limited extent of roads present.



Exceptions are the Onepoto Arm sub-catchments and those south of Pauatahanui Inlet containing SH1 and/or relatively dense local road networks, and which are drained by streams with limited dilution potential. Road traffic risk in these sub-catchments is assessed as 'highest risk'.

In contrast, most sub-catchments containing any urban land use are classified as 'highest risk' according to the urban risk assessment. Thus, even in sub-catchments containing relatively limited areas of urban impervious surfaces, loads of copper and zinc are high in relation to stream dilution potential. Only a small proportion of sub-catchments containing urban land are assessed as being in lower risk categories.

These results show the importance of including contaminants from other urban sources as well as from road traffic when assessing stormwater risk. Considering road traffic derived contaminants in isolation has the potential to lead to a marked under-assessment of risks to aquatic environments.

3.2 RISK ASSESSMENT – COAST AND ESTUARY

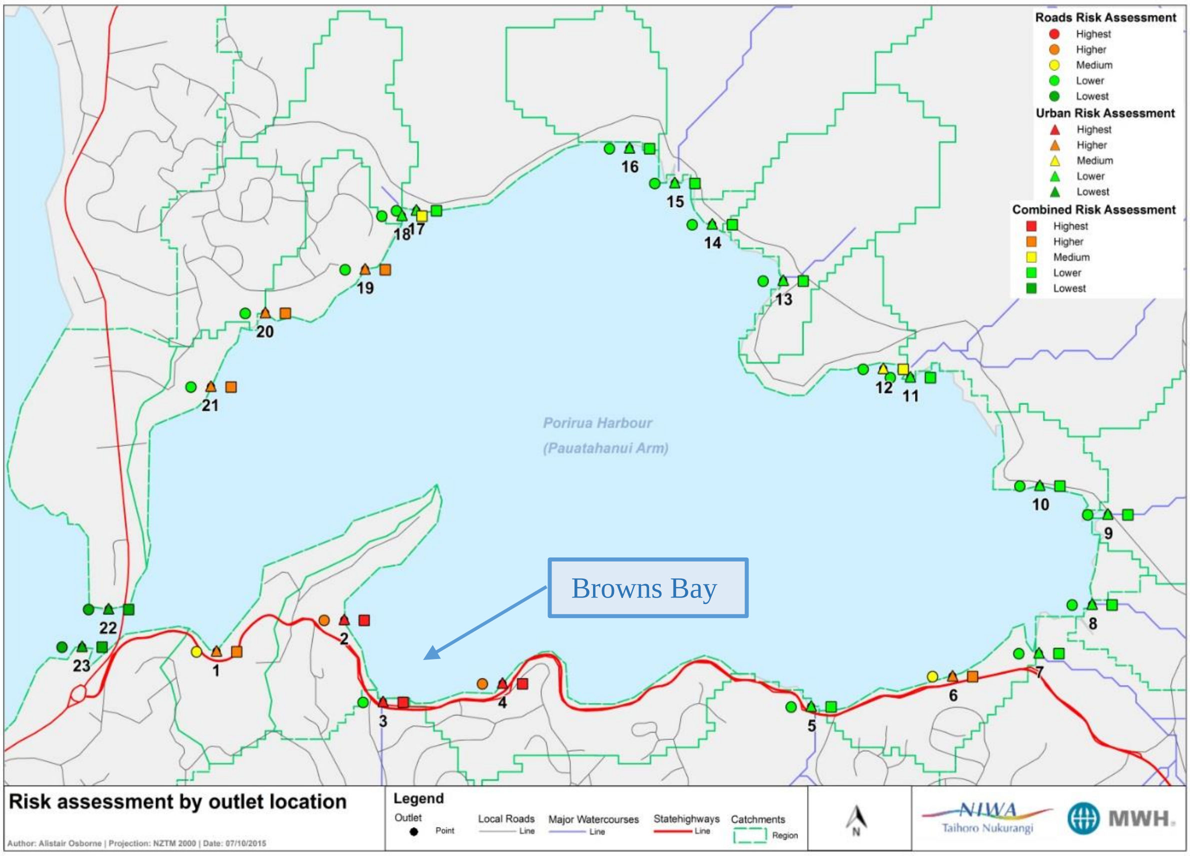
The distribution of metal loads at coastal outlets around the Harbour reflects the mix of urban and rural land use and size of the catchments that discharge to these locations. The stormwater risk profile is determined by the combination of contaminant concentration and receiving environment sensitivity at each discharge point.

For Pauatahanui Inlet (Figure 6), the highest risk occurs for discharges to Browns Bay, reflecting the combination of high copper and zinc loads and the Bay being partly enclosed and highly depositional. While the urban contribution drives the overall 'highest' risk score, road traffic makes a significant contribution at this location, with the traffic-related risk classified as 'lower' to 'medium'.

For Onepoto Arm, where land use is predominantly urban, no stormwater outlets were found with a 'highest' risk level. The load profiles for zinc and copper are both dominated by the relatively high (80% plus) contribution from Porirua Stream and its catchment that discharges to a single outlet (which includes the bulk of Semple Street stormwater catchment draining Porirua's CBD).

Despite having the highest metal load, the high sediment load discharged from the Porirua Stream catchment results in this outlet being ranked only 10th (for zinc) and 11th (for copper) in terms of sediment metal concentrations compared with all 13 outlets, with a resultant risk level of 'medium'.

Figure 6: Results of estuary risk assessment in sediment discharged at outlet locations in Pauatahanui Inlet



3.3 SENSITIVITY ANALYSIS AND VALIDATION

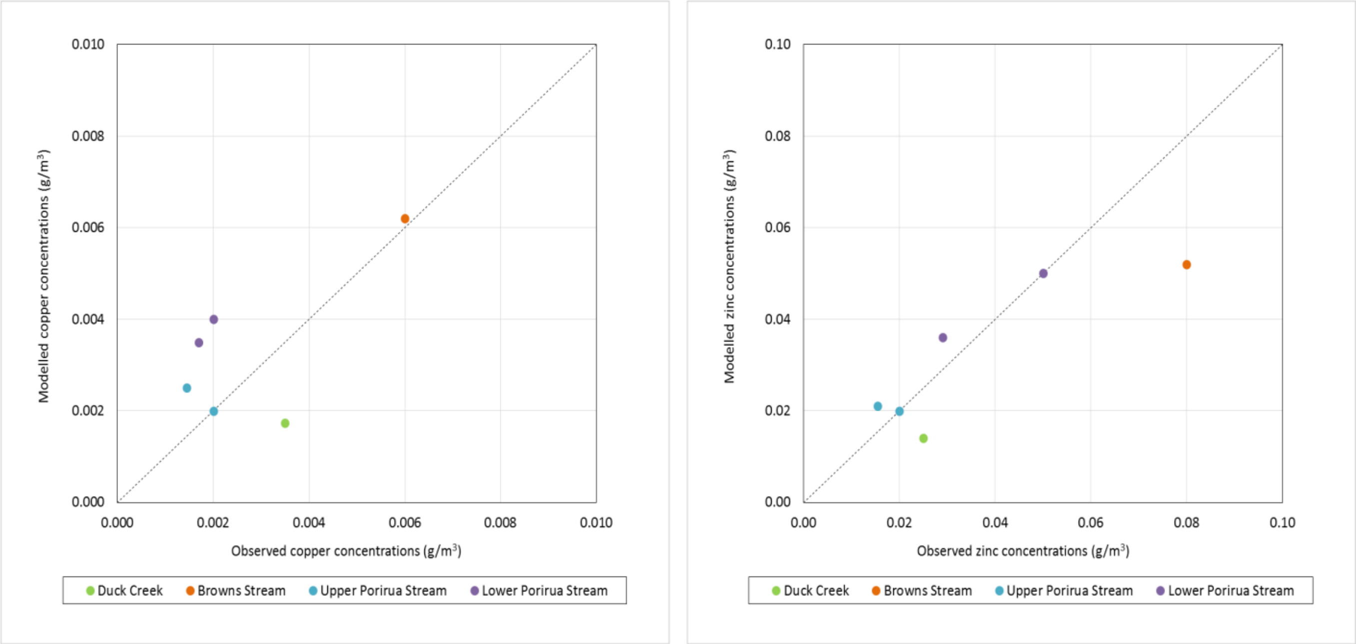
A sensitivity analysis assessed the extent to which uncertainty in model inputs influences the assessment of risk. Varying the road-derived copper and zinc loads by ±15% changed the road-traffic risk classification in around 3% of stream reaches in the case study catchment.

Doubling the residential zinc yields in the urban zinc load estimation resulted in an approximate 2% increase in the proportion of stream reaches assessed as ‘highest’ risk. The minor change in risk level indicates that assumptions made in estimating contaminant loads are unlikely to have a major bearing on the outcome of the risk assessment, thus providing assurance in the reliability of the RSS model output.

Model validation compared modelled concentrations of copper and zinc with observations from water and sediment quality monitoring programmes in the case study area. While based on very limited samples, mean in-stream concentrations of modelled copper and zinc provided a reasonable reflection of observed stream water quality (Figure 7).

Estimates of zinc concentrations were approximately an order of magnitude higher than those for copper. The relativity between sites for modelled and observed concentrations was found to be consistent.

Figure 7: Total copper (left) and total zinc (right) measured in samples from case study stream reaches, compared with modelled concentrations



For the coastal validation, there are no data collected near outfalls with which a direct comparison could be made. Observed sub-tidal concentrations for zinc and copper in sediment were typically up to an order of magnitude lower than those modelled at coastal outlets. This is attributed to significant reworking and dilution of sediment from the point of discharge near the intertidal zone.

Limited data on observed metal concentrations in sediment taken from nearby catchpits that discharge to one outlet suggest reasonable agreement with the 'delivered' sediment metal concentrations modelled at this discharge point.

4 OTHER MODEL APPLICATIONS

In addition to risk assessments described above, the RSS model may be used to further analyse road networks using the following applications:

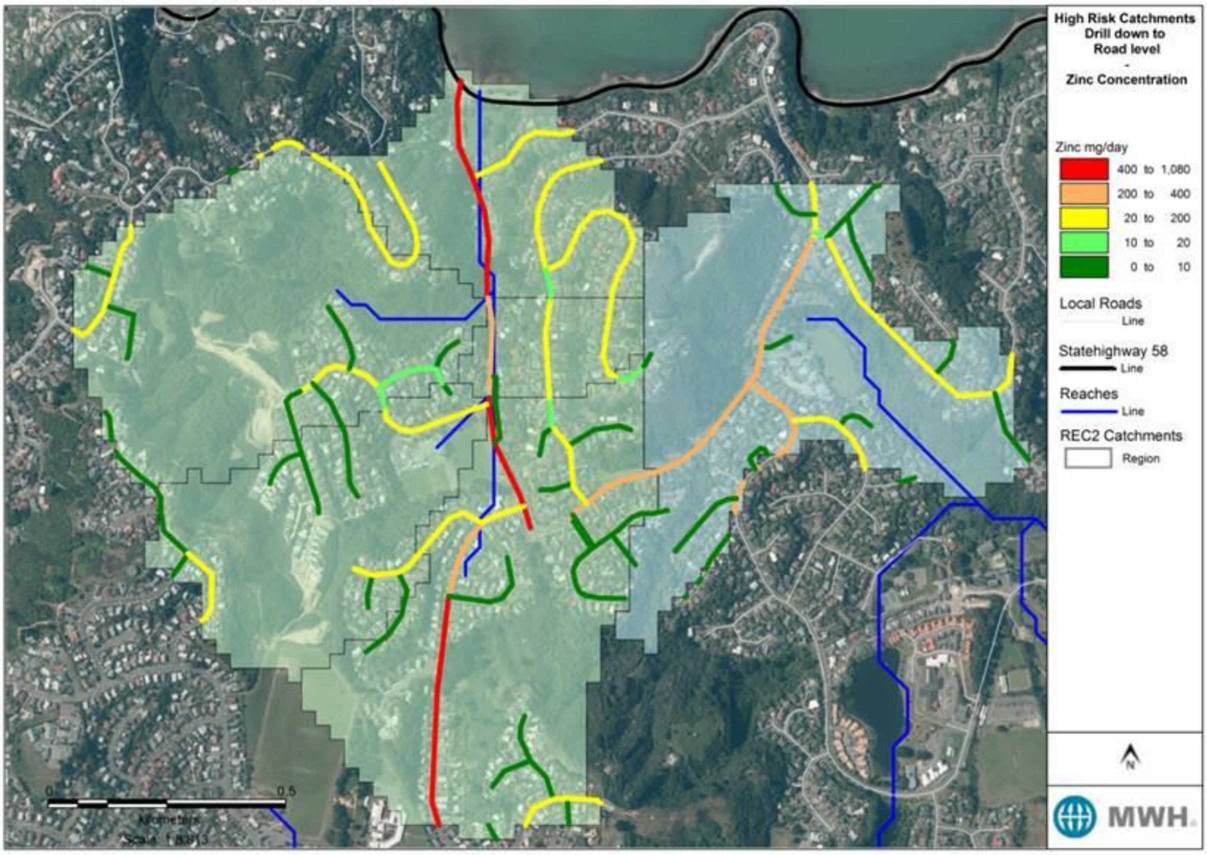
- Screening the road network by contaminant load
- Apportioning contaminant loads between local roads and state highways
- Whole of catchment analysis for road contributions.

Examples of each are described below from the case study.

4.1 NETWORK SCREENING

The road traffic risk can be spatially disaggregated within any identified sub-catchments by examining how contaminant loads are distributed across the road network within that sub-catchment. The following example illustrates how the RSS model can 'drill down' into a previously identified relative 'hot spot' to identify where the road traffic risk is being generated. Figure 8 shows the zinc load (mg/day) delivered from each road in the sub-catchments.

Figure 8: Example 'drill down' to identify zinc loads by road in a 'highest' risk sub-catchment



'No exit' roads with least traffic have the lowest loads followed by connecting roads. The main arterial road with the highest traffic that runs north-south along the alignment of Browns Stream has, not surprisingly, the highest contaminant load. The zinc load varies by three orders of magnitude from the lowest to most trafficked road sections.

Network analysis as shown by the example in Figure 9 could be used to identify where the relative risk from traffic-sourced contaminants in runoff is being generated. This in turn may point to priority road sections for further investigation, and in conjunction with the stormwater network, assist in managing stormwater discharges to the receiving environment.

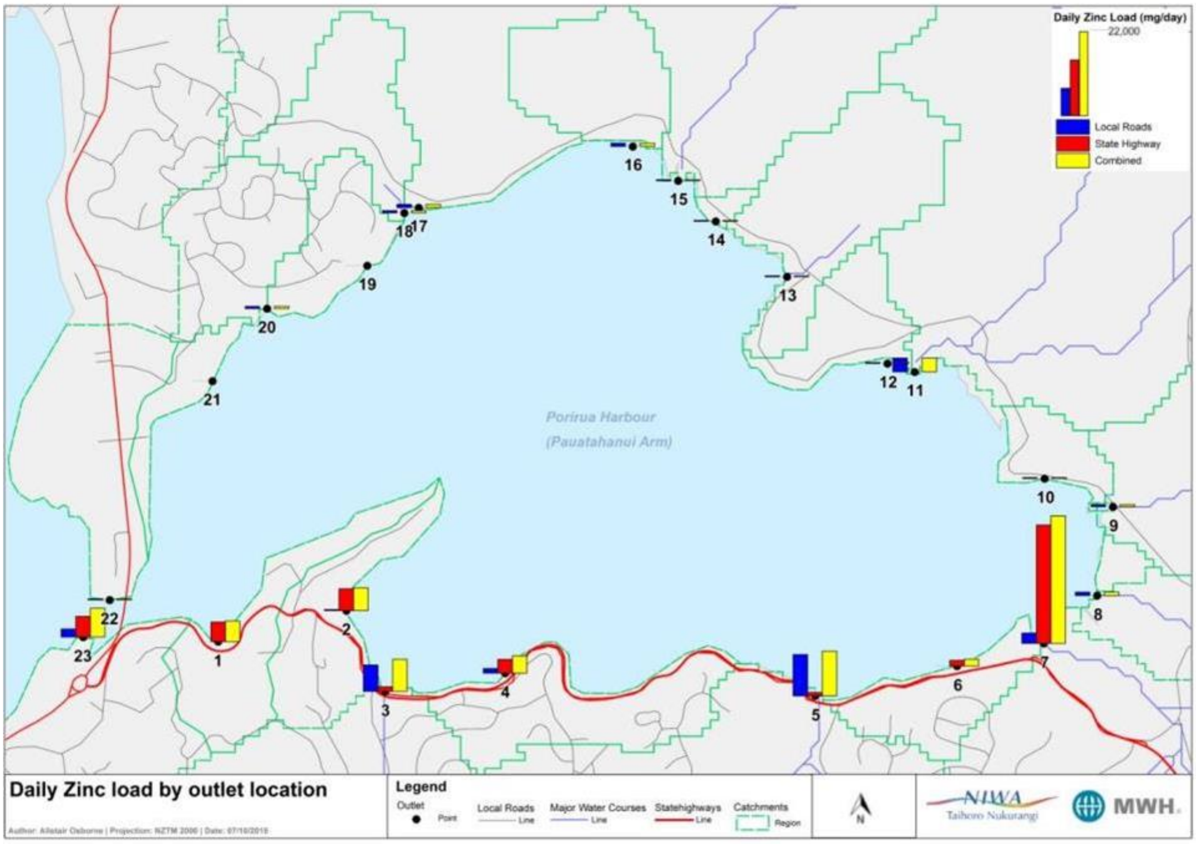
Note that the need or otherwise for stormwater treatment on these road sections will be dependent on the combined metal contaminant risk (i.e. road traffic plus urban sources) in runoff at the receiving water body and the threshold for acceptable discharge after reasonable mixing.

4.2 LOCAL ROAD VS STATE HIGHWAYS

A second application of the model is to apportion how much of the contaminant load (and risk) in runoff to a receiving environment from a road network is attributable to local roads and how much to state highways.

The example looks at the distribution of road traffic contaminants in runoff to Pauatahanui Inlet (Figure 9) which shows the relative contributions and spatial distribution of zinc load from local roads (blue), SH58 (red) and combined (yellow).

Figure 9: Relative contributions of zinc load to Pauatahanui Inlet from local roads (blue), state highways (red) and combined (yellow)



The results highlight the higher impact of traffic contaminants from the urban road networks discharging along the southern flank of the Inlet compared with rural catchments draining to the northern shoreline. Of note is the relatively high load at the eastern end of the inlet, where the total load is dominated by road runoff contributions from SH58 that traverses the upper catchment.

For the remainder of the inlet, discharges from the state highway take the form of a more diffuse pattern along the southern shoreline in proportion to traffic flows. Also of note are the contributions from local roads (blue) to Brown's Bay and Duck Creek, reflecting the larger area of their contributing road catchments.

4.3 WHOLE OF CATCHMENT ANALYSIS

The third application takes a 'whole of catchment' approach by comparing the total copper and zinc loads from road traffic in both arms of Te Awarua-o-Porirua Harbour and surrounding catchments. The road traffic contributions are presented below by Road Controlling Authority (RCA), road type and for each arm of the harbour.

Table 1 gives modelled road traffic loads of zinc and copper (and %) that enter Pauatahanui Inlet and Onepoto Arm, disaggregated by RCA. Also included are the total road traffic loads of zinc and copper that enter as runoff to each arm from their contributing catchments.

Onepoto Arm receives the majority (ca 84%) of traffic-generated zinc and copper in road runoff discharged to the Harbour as a whole. This reflects the more intensive land use development and higher traffic intensity in the catchments draining to Onepoto Arm, compared with the inlet.

Table 1: Road traffic loads of zinc and copper in runoff to case study area by road controlling authority

Study area	**Road controlling authority**	**Road traffic – zinc load**			**Road traffic – copper load**		
		(g/yr)	%	% PH[b]	(g/yr)	%	% PH[b]
Pauatahanui Inlet and catchment	PCC	22,612	39%	–	3,796	40%	7%
	Local roads	22,612	39%	6%	3,796	40%	7%
	SH	35,187	61%	10%	5,771	60%	10%
	All roads	57,800	100%	16%	9,567	100%	17%
Onepoto Arm and catchment	WCC	32,600	11%	–	5,395	11%	–
	PCC	92,885	31%	–	15,301	32%	–
	Local roads	125,484	41%	35%	20,696	43%	36%
	SH	177,255	59%	49%	27,283	57%	47%
	All roads	302,739	100%	84%	47,979	100%	83%
Te Awarua-o-Porirua Harbour[a]	Total all roads	360,539	–	100%	57,545	–	100%

a) Pauatahanui Inlet, Onepoto Arm and their catchments; b) Te Awarua-o-Porirua Harbour; SH - state highways; PCC - Porirua City Council; WCC - Wellington City Council

The split of road traffic load (zinc and copper) between local roads and state highways is shown in Table 2 for runoff to Pauatahanui Inlet and Onepoto Arm.

Table 2 Modelled copper and zinc loads from road traffic by road type

Road type	**Road traffic – zinc load**		**Road traffic – copper load**	
	(g/yr)	%	(g/yr)	%
Local roads	148,097	41%	24,492	43%
State highways	212,442	59%	33,054	57%
All roads[a]	360,539	100%	57,545	100%

a) Pauatahanui Inlet, Onepoto Arm and their catchments

In the study area comprising the two arms of Te Awarua-o-Porirua Harbour, the split in the total zinc (and copper) load from road traffic between state highways and local roads is approximately 60:40.

The traffic-generated contaminant load is directly proportional to the traffic intensity (measured as VKT where VKT = AADT x road length) in the catchment. While the length of local roads in the study area is much greater than for state highways their traffic flows are considerably less. The ca. 50% higher zinc and copper loads from state highways (compared with local roads) reflects their higher traffic intensity as modelled across the whole catchment.

5 CONCLUSIONS

The RSS model is a robust, conservative method for screening risk from road runoff to water bodies, with the following attributes:

- Estimates copper/zinc loads from road and non-road (urban) sources;
- Allows for traffic congestion, load attenuation and sub-catchment land use;
- Assesses relative risk based on contaminant strength and receiving environment sensitivity;
- Applicable to streams/rivers and coasts/estuaries in urban/rural areas;
- Includes a `drill down' facility to identify `hot spots' in the road network;
- The catchment-based model is aligned with the freshwater management unit and quality accounting system in the NPS-FM; and
- Risk-based output supports a global consenting approach for discharges from stormwater networks.

Reflecting uncertainty in estimating contaminant loads, the relative contribution from the RSS model of road and non-road sources of copper and zinc in any given sub-catchment should be considered indicative. For this reason, the RSS model is to be used on a comparative rather than absolute basis for screening road networks and their likely risks to receiving environments.

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NOMENCLATURE

CCU	cumulative criterion unit
CLM	contaminant load model
CS	contaminant strength (score)
LoS	level of service
LRF	load reduction factor
MCI	macroinvertebrate community index
NPS-FM	National Policy Statement for Freshwater Management 2014
RAMM	Road Assessment and Maintenance Management (database)
RCA	road controlling authority
REC	river environment classification
RES	receiving environment sensitivity
RSS	road stormwater screening (model)
SWC	stormwater channel
VEF	vehicle emission factor

VKT	vehicle kilometres travelled