SETTING LIMITS FOR *E. COLI* - THE URBAN ALLOCATION

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ABSTRACT

The 2017 amendments to the National Policy Statement-Freshwater (NPS-FW) includes new objectives and policies that require councils to improve water quality in large lakes and rivers so they are suitable for swimming more often, and requires councils to identify which large lakes and rivers are suitable for swimming now, and which will be improved so that they are suitable for swimming in the future.

The Porirua District Council has numerous urban streams draining to the marine environment. The marine receiving environments are valued for swimming and the quality of marine waters is influenced by urban streams. Swimming occurs in some freshwater locations within the catchment.

This presentation will discuss *E. coli* modelling being undertaken to inform Greater Wellington's collaborative limit setting process for the Porirua Whaitua. The Whaitua committee will use the model to test scenarios that will inform the Whaitua's understanding of the catchment limits (catchment *E. coli* load) that would be required to achieve instream objectives that reflect the community's values and the national targets set in the NPS-FW.

The *E. coli* catchment model is an integrated hydrological and water quality model developed using eWater Source software. Non-point *E. coli* sources were modelled by assigning dry weather and event mean concentrations to the predominate land uses within the catchments. The non-point *E. coli* concentrations for urban land were informed by the data collected from the Kāpiti Coast District Council stormwater network, because there was limited data from the Porirua stormwater network. There are no wastewater treatment plant discharges within the Porirua Harbour catchment, but there are multiple wastewater overflows, the location and frequency of wastewater overflows was modelled in MOUSE. These predicted overflows were then represented in the Source model as daily time series.

There was limited *E. coli* calibration data, but for the four sites where data was available a good calibration was achieved. In the Porirua Whaitua the majority of sites are predicted to be in E attribute state, which is the poorest attribute state in the NPS-FW, with a predicted average campylobacter infection risk of greater than 7%.

The Whaitua committee will consider the cost and benefit of mitigation options that allocate the catchment *E. coli* limit across different land use types and activities. Improving the *E. coli* attribute state in urban streams will require reductions in the load of *E. coli* from upstream rural catchments, stormwater networks and for some catchments wastewater overflows.

KEYWORDS

***E.Coli*, Swimming, National Policy Statement for Freshwater, Stormwater,**

Wastewater overflows

PRESENTER PROFILE

Stuart is an Environmental Scientist based in Jacobs's Wellington office. Stuart's background is in environmental and ecosystem modelling, mapping, and assessment. Currently Stuart is involved in a variety of water resources, flood management, water quality and catchment planning projects.

1 INTRODUCTION

This paper discusses the development of an integrated hydrological and water quality model developed using Source software. This paper discusses the development of the *E. coli* model and compares measured and predicted *E. coli* concentrations against the NPS-FW attribute states.

The purpose of the model is to inform Greater Wellington's Porirua Whaitua Committee, who are in the process of recommending freshwater objectives. The Whaitua will use the model as a tool to inform their understanding of the potential changes to *E. coli* for future land use scenarios and mitigation options, and to inform how catchment limits for *E. coli* could be set to achieve in-stream objectives.

2 *E. COLI* LOAD

E. coli sources are modelled by assigning dry weather and event mean concentrations to the predominate land uses within the catchment.

Figure 1 below illustrates the land uses within the Porirua Whaitua catchment. The land use is predominately rural pasture, with a large area of residential and urban land and some forestry in the hills.

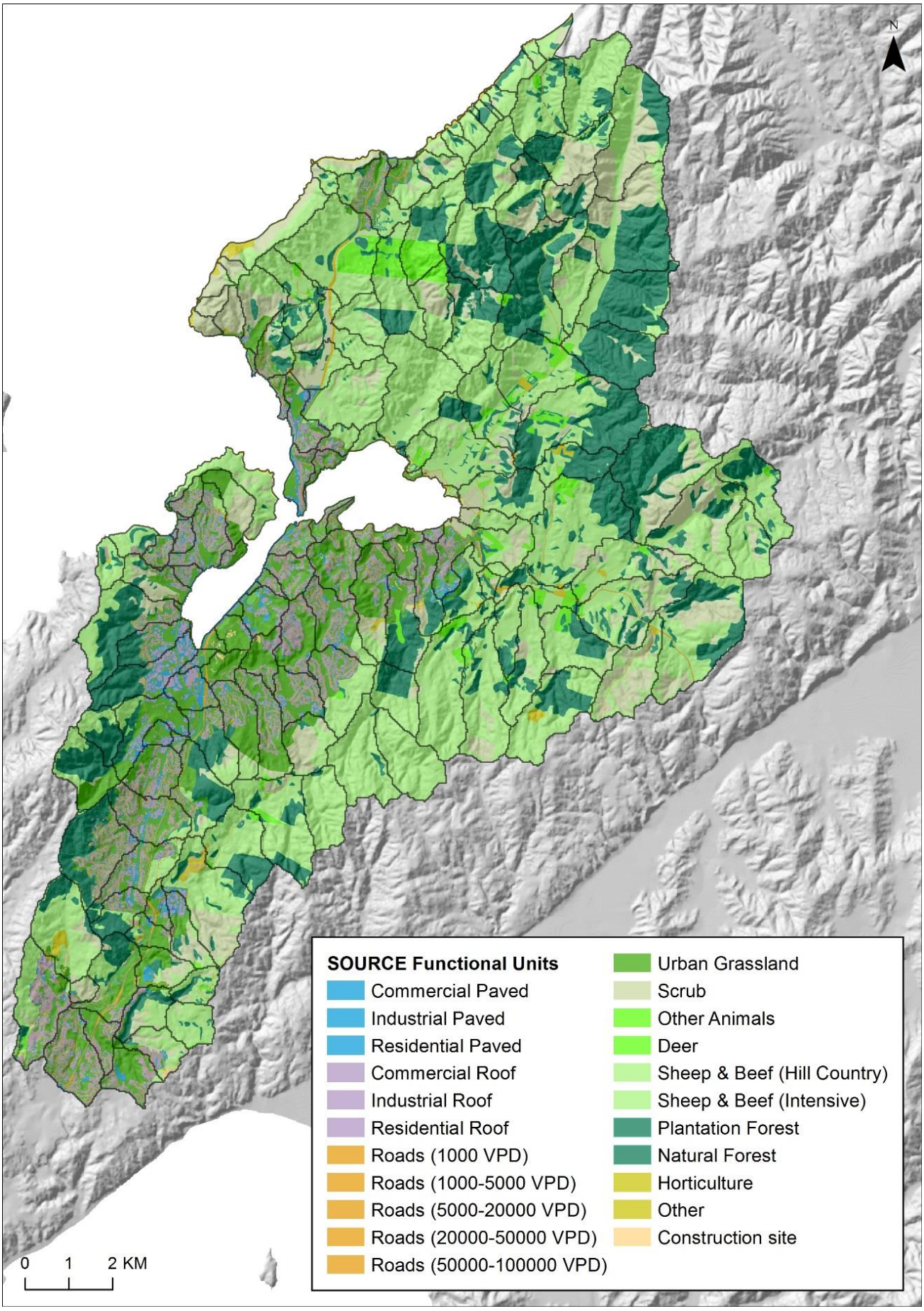

Figure 1: *Porirua Landuse*

The *E. coli* concentrations for urban land were informed by the data collected from the Kāpiti Coast District Council stormwater network, because there was limited data from the Porirua stormwater network. Jacobs has collected stormwater discharge data from the Kāpiti Coast District stormwater network for over 10 years. Data has been collected at 16 discharge locations. None of the sampled Kāpiti Coast District Council stormwater network discharges are piped streams, and all data was collected in wet weather data. Table 1 below summarizes the Kāpiti Coast stormwater data compared with data collated by NIWA from other New Zealand and international urban stormwater data.

Table 1: Summary of E. coli concentrations in stormwater discharges (Moores et al., 2017)

Parameter	***E. coli*** **(No./100ml)**			
	NZ data	**KCDC[a]**	**NSQD (US)[b]**	**BMP database (international)[c]**
N	541	188	139	539
Median	2300	2350	1520	2420
Mean	10,000	6230	5769	278,000
Minimum	1	22	5	<1
10%ile	100	194	94	50
25%ile	580	775	475	425
75%ile	7600	5525	4170	12,500
90%ile	23,000	15,000	17,000	65,000
Maximum	242,000	88,000	66,000	16,600,0000

There are no wastewater treatment plant discharges within the Porirua Harbour catchment, but there are multiple wastewater overflows. The location and frequency of wastewater overflows were modelled in MOUSE by Mott MacDonald for Wellington Water, and these are illustrated in Figure 2 below. These predicted wastewater overflows were then represented in the Source model as daily time series. The *E. coli* concentration for wastewater overflows was assumed to be 1,000,000 cfu/100mL.

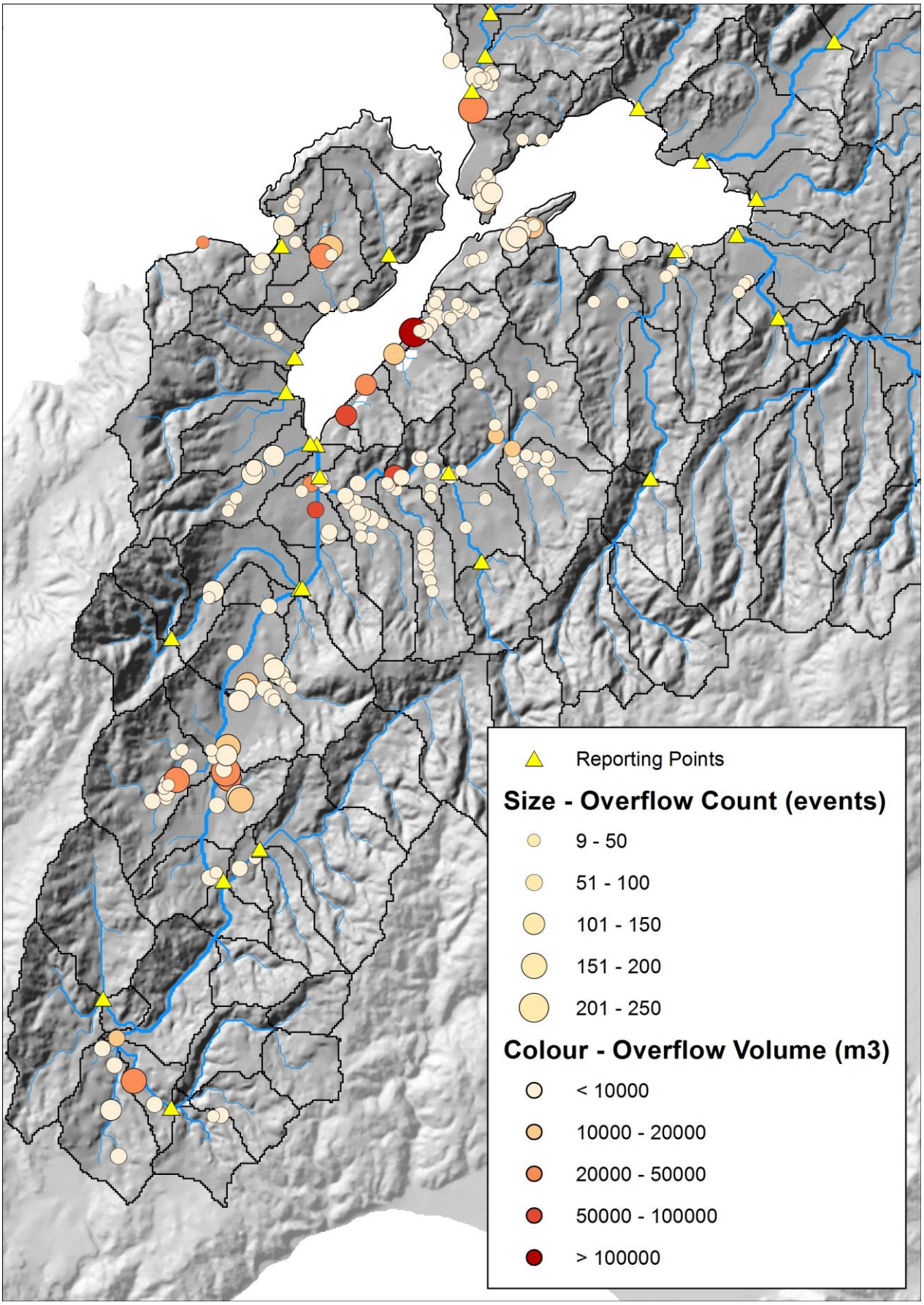

Figure 2: *Modelled Wastewater overflows 10-year time series*

3 MODEL CALIBRATION

E. coli concentrations were applied to catchment land uses, the initial concentrations were informed by the urban stormwater data summarized in Table 1, and from CLUES for rural land uses. The calibrated event mean concentrations and dry weather concentrations for *E. coli* are summarized in Table 2 below.

Table 2: Final calibrated EMC/DWC parameters for E. coli.

Land use	Final Calibrated Concentrations E. coli (cfu/100ml)	
	EMC	DWC
Commercial Paved	10000	2000
Industrial Paved	10000	2000
Residential Paved	10000	2000
Roads 1000	10000	2000
Roads 1000-5000	10000	2000
Roads 5000-20000	10000	2000
Roads 20000-50000	10000	2000
Roads 50000-100000	10000	2000
Commercial Roof	10000	2000
Industrial Roof	10000	2000
Residential Roof	10000	2000
Urban Grassland	10000	2000
Other	78	15
Natural Forest	92	18
Plantation Forest	93	18
Scrub	143	29
Sheep and Beef Hill	23774	4755
Other Animals	141	29
Sheep and Beef Intensive	25679	5136
Deer	32738	6548
Horticulture	62	12
Construction Site	0	0

There were only four sites for calibration. Good calibration was achieved at the four calibration sites as illustrated in Figure 3 below.

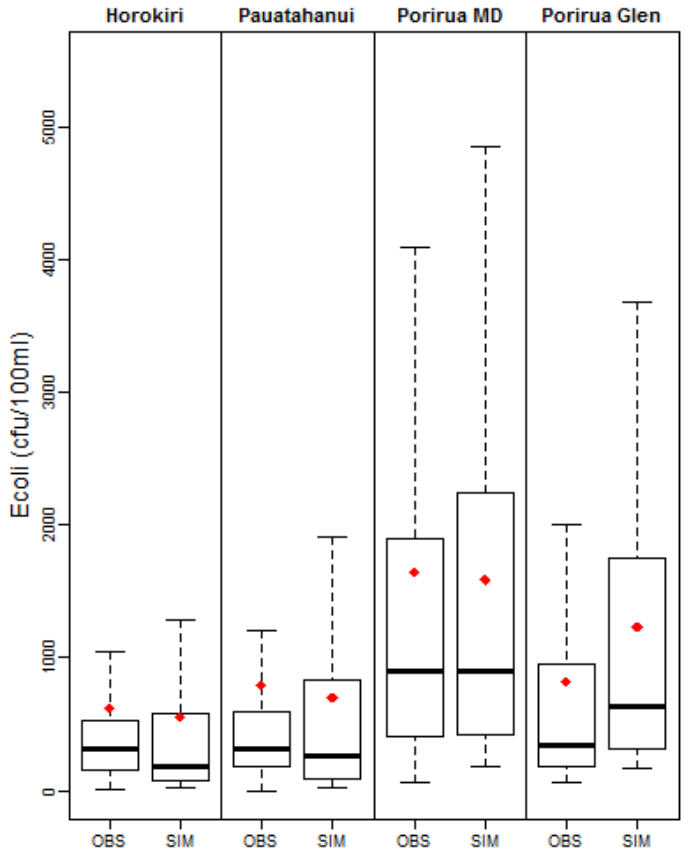

Figure 3: E. coli calibration (OBS = observed, SIM = simulated)

4 NATIONAL POLICY FOR FRESHWATER

The NPS-FW sets an objective for freshwater management units to be improved so they are suitable for primary contact more often and includes policies to achieve regional and national targets for primary contact recreation for specified rivers and lakes, which include fourth orders streams. The national objectives framework provides a national approach for setting freshwater objectives. The attribute state, for *E. coli* is summarized in Table 3 below.

Table 3: The statistical measures for Human Health for Recreation Attribute States (Ministry for the Environment, 2017)

Attribute State	% of exceedances over 540 CFU/100mL	% of exceedances over 260 CFU/100mL	Median concentration CFU/100mL	95th percentile *E.coli* /100mL
A	< 5%	< 20%	≤ 130	≤ 540
B	5 – 10%	20 – 30 %	≤ 130	≤ 1000
C	10 – 20%	20 – 34%	≤ 130	≤ 1200
D	20 – 30%	>34%	>130	>1200
E	>30%	>50%	>260	>1200

The calibrated model was able to achieve a reasonable agreement with the NPS-FW attribute states as illustrated in table 4 below.

Table 4: Comparison of observed and simulated statistics for NPS Human Health Attribute States.

Calibration Site		Exceedances over 540 cfu/100ml (%)	Exceedances over 260 cfu/100ml (%)	Median (cfu/100 ml)	95th Percentile (cfu/100ml)	Attribute State
Horokiri Snodgrass	OBS	24	58	315	2540	E
	MODEL	29	40	182	2778	D
Pauatahanui Elmwood	OBS	27	58	315	3070	E
	MODEL	33	49	256	2833	E
Porirua Milk Depot	OBS	66	85	900	6750	E
	MODEL	61	97	927	5985	E
Porirua Glenside	OBS	37	60	340	2777	E
	MODEL	57	99	779	4860	E

Of the calibration sites, Horokiri and Pauatahanui are rural sites, with predominately sheep and beef landuse upstream. The Porirua sites are approximately 50% urban.

5 MODEL RESULTS

The model predicts all streams within the Porirua catchment are in the E attribute state, with the exception of the Horokiri Stream, although the observed data puts the Horokiri Stream in the E attribute state. The model results are illustrated spatially in images in Figure 3 on the following page.

The Whaitua committee will use the model to test scenarios that will inform the committee's understanding of the catchment limits (catchment *E. coli* load) that are required to achieve instream *E.coli* objectives (described as an attribute state) that reflect the community's values and the national targets set in the NPS-FW.

The urban catchment scenarios being considered by the Whaitua include wastewater overflow reductions, water sensitive urban design to reduce *E. coli* and reductions in infiltration and inflow. In rural catchments the scenarios include land retirement, conversion to lifestyle and stock exclusion. The scenarios, in order of mitigation investment are BAU (Business as usual), Improved, and Water Sensitive.

In Porirua, the modelling we have undertaken indicates the reduction in wastewater overflows will not improve the attribute state without other urban and rural mitigations. This is because urban stormwater and rural landuses are the driver for the attribute state class, and although wastewater overflows occur reasonably frequently (on average 20 days per year), at this frequency the overflows have an influence on the 95th percentiles at some sites only, in particular those sites where the most frequent overflow events occur. In most locations the sites are in the E attribute state for the medians, so reducing the 95th percentiles through reducing wastewater overflows would not achieve an improvement in attribute state on its own.

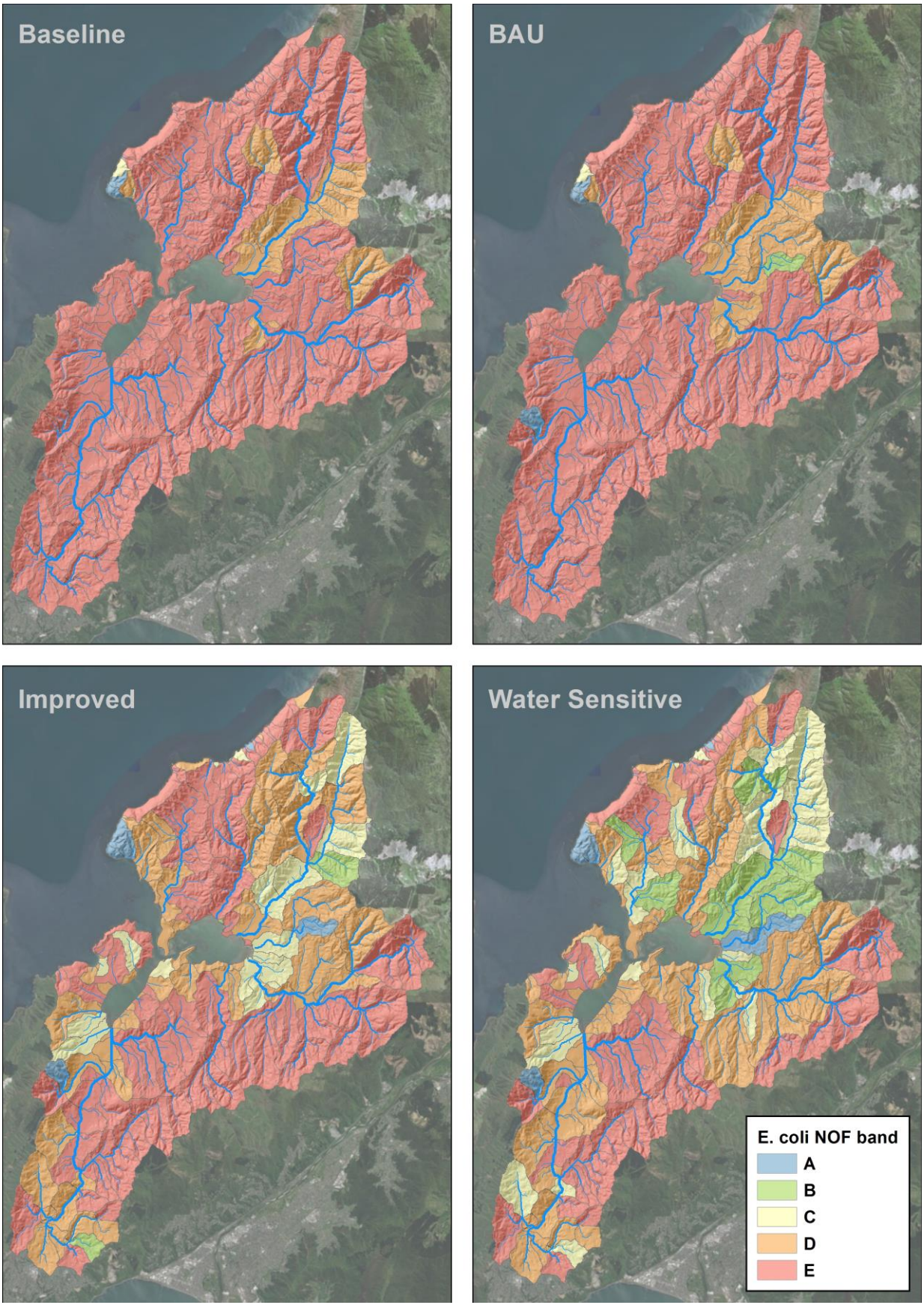

Figure 3: Spatial maps of NPS Human Health for Recreation Attribute States in the catchment based on modelled outputs for *E.coli* for the calibrated baseline and three scenarios; Business as usual (BAU), Improved, Water Sensitive.

6 CONCLUSIONS

In the Porirua Catchment, there are four sites were *E. coli* data is collected, these are all on fourth order streams. Each of these streams is within the E attribute state. Two of these sites are predominately rural, and two are approximately 50% urban.

The Whaitua committee will use the model to test scenarios that will inform their understanding of the catchment limits (catchment *E. coli* load) that would be required to achieve instream objectives that reflect the community's values and the national targets set in the NPS-FW.

The Whaitua committee will consider the cost and benefit of mitigation options that allocate the catchment *E. coli* limit across different land use types and activities. Improving the *E. coli* attribute state in urban streams will require reductions in the load of *E. coli* from upstream rural catchments, stormwater networks and for some catchments wastewater overflows.

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REFERENCES

Moores, J, Easton, E, Gadd, J, Sands, M: (2017) Te Awarua-o- Porirua Collaborative Modelling Project Customisation of urban contaminant load model and estimation of contaminant loads form source excluded form the core models, NIWA client report WRC17103

Roberston, A, Drewitt, T (2017). Stormwater Discharge Consent Monitoring Report 2016-17, prepared for the Kapiti Coast District Council (NZ)

Ministry for the Environment, 2017. Swimming categories for E. coli in the Clean Water package: A summary of the categories and their relationship to human health risk from swimming. Wellington: Ministry for the Environment. New Zealand.

Ministry for the Environment, 2017 National Policy Statement for Freshwater Management 2014. Updated August 2017 to incorporate amendments from the National Policy Statement for Freshwater Amendment Order 2017