Porirua Whaitua Collaborative Modelling Project

Greater Wellington Regional Council

Scenario Modelling Technical Report

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Jacobs New Zealand Limited

Level 8, 1 Grey Street,
PO Box 10-283
Wellington, New Zealand
T +64 4 473 4265
F +64 4 473 3369
www.jacobs.com

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Abbreviations

Term	Meaning
CFU	Colony Forming Unit
CLM	Contaminant Load Model
CLUES	Catchment Land Use for Environmental Sustainability
CMP	Collaborative Modelling Programme
Cu	Copper
DIN	Dissolved Inorganic Nitrogen
DRP	Dissolved reactive Phosphorus
DWC	Dry Weather Concentration
E. coli	*Escherichia coli*
EMC	Event Mean Concentration
FU	Functional Unit
FWO	Freshwater Objective
GWRC	Greater Wellington Regional Council
LRF	Load Reduction Factor
MALF	Mean Annual Low Flow
MLG	Modelling Lead Group
NH_4-N	Ammoniacal – Nitrogen
NRP	Natural Resources Plan
NOF	National Objectives Framework
NPSFM	National Policy Statement for Freshwater Management
NO_3-N	Nitrate – Nitrogen
NSE	Nash-Sutcliffe Efficiency
NZLRI	New Zealand Land Resource Inventory
PBIAS	Percent Bias
PCC	Porirua City Council
PET	Potential evapotranspiration
REC	River Environment Classification
SS	Suspended Sediment
TAoP	Te Awarua-o-Porirua
TAoPWC	Te Awarua-o-Porirua Whaitua Committee
TN	Total Nitrogen
TP	Total Phosphorus
VCSN	Virtual Climate Station Network
VPD	Vehicles Per Day
WCC	Wellington City Council
WIP	Whaitua Implementation Plan
Zn	Zinc

Executive Summary

This report describes the technical modelling of three scenarios within the Source model framework for the Porirua Whaitua. The scenarios, Business as Usual (BAU), Improved, and Water Sensitive (WS) were conceptually developed by the Porirua Whaitua committee to explore alternative approaches involving land use change, wastewater network upgrades, contaminant source control and implementation of stormwater treatment devices. The scenarios represent three levels of increasing management intervention and provide for population projections to a nominal date, 2043. Scenarios are not representative of an expected or planned catchment configuration but are rather utilised as tools to explore and help understand the level of intervention required to meet potential water quality targets.

Scenarios were investigated across the Collaborative Modelling Programme (CMP), including sub-catchment scale stormwater, economics, ecology, and harbour models. This report focuses on how scenarios are represented in the Source catchment model, outputs of which then informed the Whaitua Committee and other modelling partners within the CMP.

Results are presented for the modelled daily flows and associated loads and concentrations for Suspended Sediment, *E. coli*, Total Nitrogen, Nitrate-Nitrogen, Ammoniacal-Nitrogen, Dissolved Inorganic Nitrogen, Total Phosphorus, Dissolved Reactive Phosphorus, Dissolved Copper, and Dissolved Zinc. In general, water quality for the modelled contaminants is predicted to remain largely unchanged between the Baseline and the BAU scenario, and to improve under the Improved and WS scenarios.

Model results for each contaminant are the product of site-specific interactions between modelled water runoff response, contaminant yields from different land uses, and treatment interventions. Land use change was found to be the primary driver of water quality improvements observed across the modelled scenarios.

In rural areas, retirement of grazed pasture, conversion to low-intensity lifestyle blocks, and riparian management in particular, serve to reduce in-stream concentrations for suspended sediment, nutrients, and *E. coli*. Pole planting in the Improved scenario also reduces sediment and phosphorus exported to streams.

Modelling of stormwater mitigations in urban areas shows a lower impact on overall catchment water quality compared to land use change. This is because mitigations are generally applied to new development which represents additional contaminant sources not present in the Baseline and this tends to temper the benefit of the mitigations in the overall catchment results. However, the results show stormwater mitigations did reduce in-stream contaminants generated from new urban development, with significant improvements in water quality predicted in the Improved and WS scenarios compared to the BAU where minimal stormwater mitigations were modelled.

In urban streams, *E. coli* concentrations are predicted to continue to exceed the national bottom line even with the significant reductions observed in the WS scenario for many streams, indicating that improving the water quality in urban areas for primary contact will be a significant challenge. A significant reason for the poor level of swimmable quality in many streams in the Whaitua (independent from generation rates from various land uses) is the low dilution afforded by small stream flows. In catchments with larger rivers, greater flow can help dilute the *E. coli* and other contaminant concentrations, somewhat buffering effects from land use.

Te Awarua-o-Porirua (TAoP) Whaitua Committee has subsequently used this scenario modelling information, along with other information, to help them set freshwater and coastal water objectives, and recommend limits, targets and policy approaches to achieve those objectives.

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to develop a land use and contaminant model for the Te Awarua-o-Porirua (TAoP) Whaitua, in accordance with the scope of services set out in the contract between Jacobs and Greater Wellington Regional Council (GWRC). That scope of services, as described in this report and the Porirua Whaitua Baseline Modelling report (Jacobs, 2019), was developed with GWRC.

In preparing this report, Jacobs has relied upon, and presumed accurate, certain information (or absence thereof) provided by GWRC and other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

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This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of, GWRC and the TAoP Whaitua Committee, and is subject to, and issued in connection with, the provisions of the agreement between Jacobs and GWRC. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

1. Introduction

Te Awarua-o-Porirua (TAoP) Whaitua Committee has used a number of sources of information to help them set freshwater and coastal water objectives, and recommend limits, targets and policy approaches to achieve those objectives. These include members' own knowledge, catchment modelling and monitoring, and knowledge from community members and experts

The Greater Wellington Regional Council (GWRC) led TAoP Whaitua Collaborative Modelling Programme (CMP) has developed scenario modelling to provide the Committee with insights into how fresh and coastal water quality might change under alternative land use and land management practices. This information has helped the Committee understand the opportunities, challenges, mitigations, and investment that are likely required to make shifts in water quality outcomes.

Models are simplifications of reality and have imperfections consequential to the simplification of complex and often poorly understood biophysical processes that govern contaminant generation and transport in freshwater. This necessitates a number of assumptions to be made for various reasons, including reliance on the Baseline model development and calibration, data availability, time constraints, modelling efficiencies, and practicalities. However, all attempts have been made to ensure model reliability for the intended purpose of fresh water quality characterisation to help GWRC and the Whaitua committee set freshwater and coastal water objectives, and recommend limits, targets and policy approaches.

This report provides a technical summary of the scenario modelling undertaken by Jacobs using the integrated catchment flow and water quality modelling framework eWater Source. The purpose of this document is to:

- Provide a brief background on the baseline model and some context about how model parameters are influenced during scenarios,
- Outline the scenarios modelled, their core assumptions and limitations,
- Discuss the modelling methodology and how the methodology influences results,
- Provide an overview of the scenario results and their meaning for water quality.

A significant number of results were generated from the scenario modelling. This report should be used to help understand why certain changes have occurred in each of the catchments, without explicitly describing every result output.

1.1 Baseline model

The baseline model for Porirua whaitua was built and calibrated for flow and in-stream contaminants using the eWater Source modelling framework and is documented in the Porirua Whaitua Baseline Modelling report (referred to herein as 'Baseline report') (Jacobs, 2019). The Source platform is a semi-distributed catchment modelling framework designed for exploring a range of water management problems (Welsh et al., 2012).

The developed baseline model has been successfully calibrated to local in-stream observations to predict daily flows and associated loads and concentrations for Suspended Sediment (SS), *E. coli*, Total Nitrogen (TN), Nitrate-Nitrogen (NO_3-N), Ammoniacal-Nitrogen (NH_4-N), Total Phosphorus (TP), Dissolved Reactive Phosphorus (DRP), Dissolved Copper (Dissolved Cu), and Dissolved Zinc (Dissolved Zn). Dissolved Inorganic Nitrogen (DIN) is also estimated as the sum of NO_3-N and NH_4-N.

A summary of the modelling framework is provided:

- Relevant information including topographical, climatic, and spatial land use data and modelled wastewater overflow timeseries data were sourced from respective agencies to represent the spatial and temporal heterogeneity of catchment characteristics.
- An integrated model was developed to simulate flow, and contaminant generation and transport for sediment, nutrients (Nitrogen and Phosphorus species), metals (Copper and Zinc) and *E. coli* at a

daily time-step. The model was calibrated against in-stream monitoring data sourced from Greater Wellington Regional Council (GWRC).

- The daily flow model was configured using GR4J, a conceptual rainfall-runoff sub-model. Suspended sediment generation and loads were modelled using the dSednet plugin in Source. Nutrients, metals and *E. coli* generation and transport utilised an Event Mean Concentration and Dry Weather Concentration (EMC/DWC) approach with decay models.

- The model was sufficiently calibrated over a representative historical period and is used to investigate various land use changes and intervention options described in this report.

1.1.1 Whaitua overview

TAoP whaitua area extends to 20,235 ha. It is characterised by predominantly rural land uses with grazed pasture, mostly for sheep, accounting for 41% of the total catchment area followed by forest and scrub cover (33%) as shown in Figure 1.1. Parts of the whaitua, particularly the Porirua stream, are heavily urbanised with 23% of the total catchment area comprised of roads, residential, industrial, commercial, and urban greenspace land uses.

The whaitua is divided into 166 sub-catchments in the developed Source model, with 23 baseline (current state) functional units (FUs). FUs represent areas of similar hydrological response and contaminant generation. FUs were defined for the study area with the Whaitua Modellers Lead Group (MLG) based on a combination of GWRC held land use and zoning information, Porirua City Council (PCC) and Wellington City Council (WCC) building data, CLUES land use data, and satellite imagery classification. FU development is described in detail in the Baseline report (Jacobs 2019). A full list of baseline and scenario FUs is given in Table 2.1.

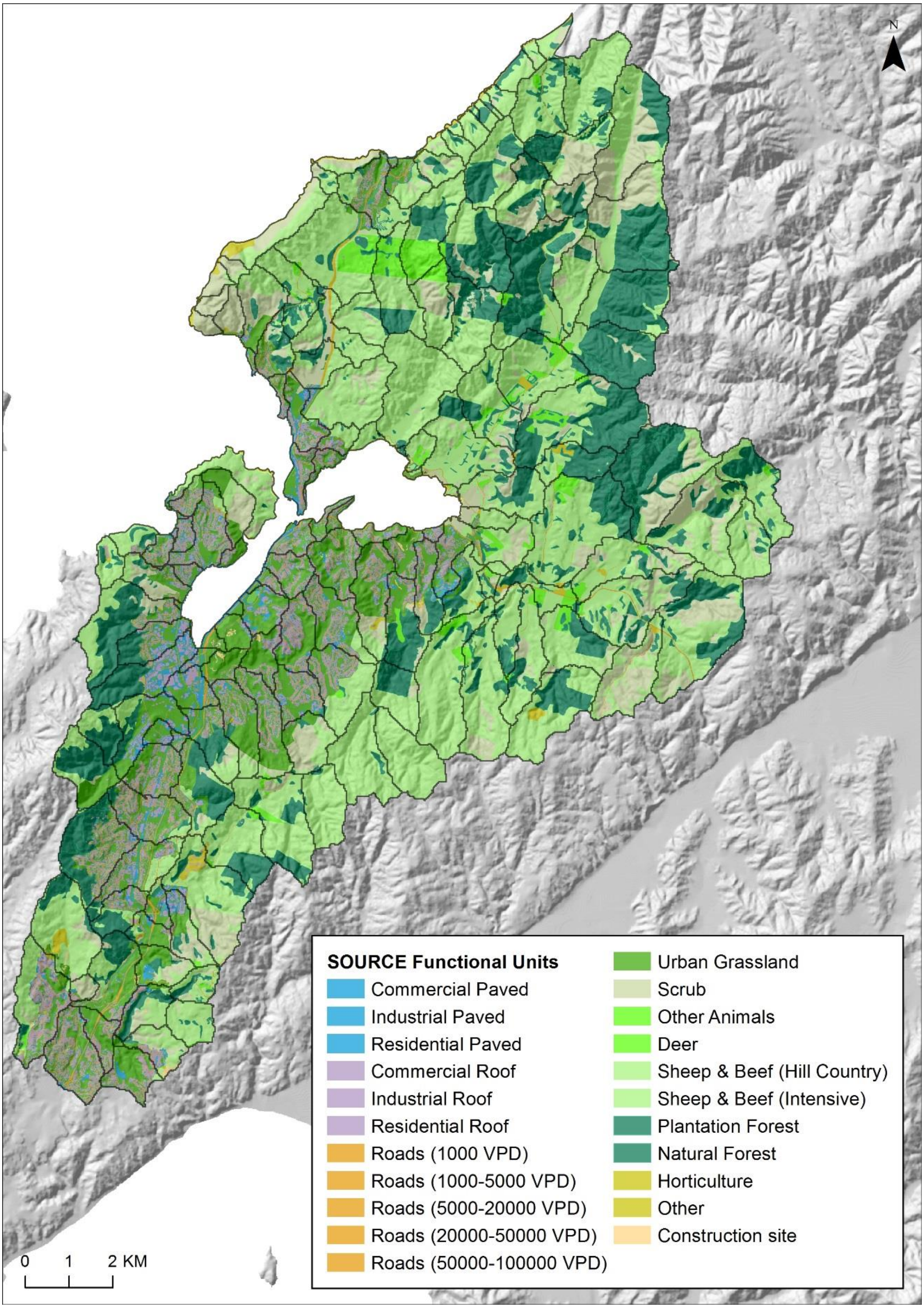

Figure 1.1: Land use categories and functional units used in SOURCE

1.1.2 Baseline model calibration

In general, the baseline model calibrates well to the observed flow and contaminant record (see Baseline report, Jacobs 2019). Rainfall-runoff parameters were calibrated to four locations representative of the largest sub-catchments in the whaitua. The application of the calibrated rainfall-runoff parameters to the remaining un-monitored catchments is justified for the purpose of this modelling project, however flow predictions for small urban catchments are likely to be the most uncertain, as hydrology for these catchments is likely to be 'flashy' with runoff response times somewhat different from those in observed calibration catchments and difficult to accurately represent in a daily model. Furthermore, flow calibration was most uncertain during low-flows, which may result in contaminant load underestimation when baseflow is dominant.

The nutrient, dissolved metals, and *E. coli* sub-models are calibrated to observed in-stream concentrations. Loads are calculated as the product of concentration and flow and are not independently calibrated from concentrations. In general, the contaminant sub-models are well calibrated and use parameter sets within ranges published in the literature. Contaminant yields are largely drawn from the customised CLM (Moores et al. 2017) for urban land uses and CLUES for rural land uses. Contaminant generation parameters are applied consistently across the whaitua for each land use following calibration (see Baseline report, Jacobs 2019) without accounting for potential site-specific characteristics that may increase or reduce contaminant generation and loss. This ensures consistency for testing the effects of land use change between the scenarios at catchment scales but means that potentially variable contaminant generation at local scales within land use categories is not captured. For nutrients and *E. coli*; contaminant uptake, transformation, decay and other biochemical processes are accounted for simplistically through half-life decay functions. Total metals are estimated as described in the Baseline report and are not independently calibrated.

The suspended sediment sub-model utilises the dSedNet plugin to Source and custom functions simulating streambank erosion and shallow land sliding processes. Suspended sediment is calibrated to daily loads derived from continuous turbidity observations. The disaggregation of total load between hillslope, shallow landslide, and streambank processes is not calibrated. The available data period utilised for calibration is relatively short and captures few large events that account for significant sediment loading to Te Awarua-o-Porirua harbour, resulting in uncertainty in sediment loading rates for large events.

The developed baseline model is fit for purpose to be used to test the relative changes in water quality for alternative development scenarios and inform decision making by the Whaitua committee.

2. Scenarios

This section outlines the changes made during scenario modelling, and describes each of the scenarios, reporting locations, and metrics. Section 3 describes the technical implementation and data sources for scenario changes within the Source model.

GWRC and the Whaitua Committee designed the scenarios and their configuration within the CMP modelling framework was developed collaboratively within the Modelling Lead Group (MLG). The scenarios represent hypothetical land use change (e.g. urban development and retirement of marginal pasture land) and mitigation implementation (e.g. installation stormwater treatment devices). Representing these changes makes assumptions around the locations, form and performance of land use changes and mitigation implementations. These assumptions are uncertain and made on the best information available at the time. They are not intended to represent an expected or planned catchment configuration required to meet a particular desired water quality outcome. Rather, they allow a relative exploration of potential water quality changes with different levels of intervention in catchment management.

Three alternative scenarios were tested using the calibrated baseline Source model:

- Business as Usual (BAU);
- Improved; and
- Water Sensitive (WS).

The three scenarios, from BAU to WS, generally represent an increasing level of effort to mitigate contaminants generated by urban and rural land uses, stormwater and wastewater discharges, with an expected corresponding improvement in receiving environment quality.

Each scenario represents the completed implementation of land use changes and contaminant mitigations applied for a nominal snapshot in time. The scenarios don't represent a particular date or a progression of change from the baseline state, though the extent of urban development and associated land use change accommodates population projections to 2043[1].

2.1 Climate

The scenarios were run through the model for a 10-year period of climate data between 2005-2014 (inclusive) to account for the inter-annual variability in effects of land and water use due to climatic variability. This period was selected as representative of a range of climate conditions and individual storm events while allowing comparison to available in-stream sample information. This period is consistent with the 10-year wastewater overflow timeseries provided by Wellington Water.

Daily rainfall and PET information was taken from the NIWA Virtual Climate Station Network (VCSN) (Tait et al., 2012). Source modelling of scenarios has not attempted to account for climate change which may change both rainfall depth, intensity and evaporative demand. The Whaitua Committee has been informed separately on predictions of direction and approximate magnitude of various climate change indicators (e.g., rainfall, temperature, river flows etc).

2.2 Scenarios outline

Scenarios differ from the baseline model's representation of the current state through changes in land use and implementation of contaminant mitigations.

2.2.1 Land use change

Land use change has been classified as urban, rural, and roads.

[1] https://forecast.idnz.co.nz/porirua

Urban land use change is associated with urban development and is further categorised as infill, i.e. the redevelopment of existing urban areas, and greenfield, the expansion of the urban zone into previously undeveloped rural land. Areas of anticipated development have been spatially identified based on GWRC projections. For each scenario, the total area of infill and greenfield is the same, representing a consistent population growth expectation to 2043. Within the identified infill and greenfield zones, the configuration of roofs, impervious surfaces, and greenspace changes across the scenarios representing alternative approaches to the urban form. Land use proportionality within the identified infill and greenfield areas are based on configurations used in MUSIC stormwater modelling undertaken by Morphum Environmental within the Whaitua CMP (Morphum Environmental Ltd. 2018).

Rural land use change is categorised as retirement and rural residential. Retirement represents the conversion of grazed pasture to native bush, and rural residential encompasses the development of low grazing intensity lifestyle blocks. The area classified as either retired or rural residential varies for each scenario; for example the Water Sensitive scenario has the greatest retired area, followed by the Improved then the BAU.

Roads have been updated for the three scenarios to account for changes in traffic flows (represented as VPD – Vehicles Per Day) following population growth and the expected completion of the Transmission Gully (TG) and Petone to Grenada (P2G) motorways. Land use change for roads are consistent across the three scenarios however the treatment of road generated run-off differs between scenarios.

Scenario diffuse contaminant yields from each FU are consistent with the calibrated baseline model. Table 2.1 lists the Functional Units (FUs) used in the Baseline model and those utilised for the Scenario modelling. The ‘conceptual group’ column in Table 2.1 relates to the graphical summary of the scenario land use changes in Figure 2.1.

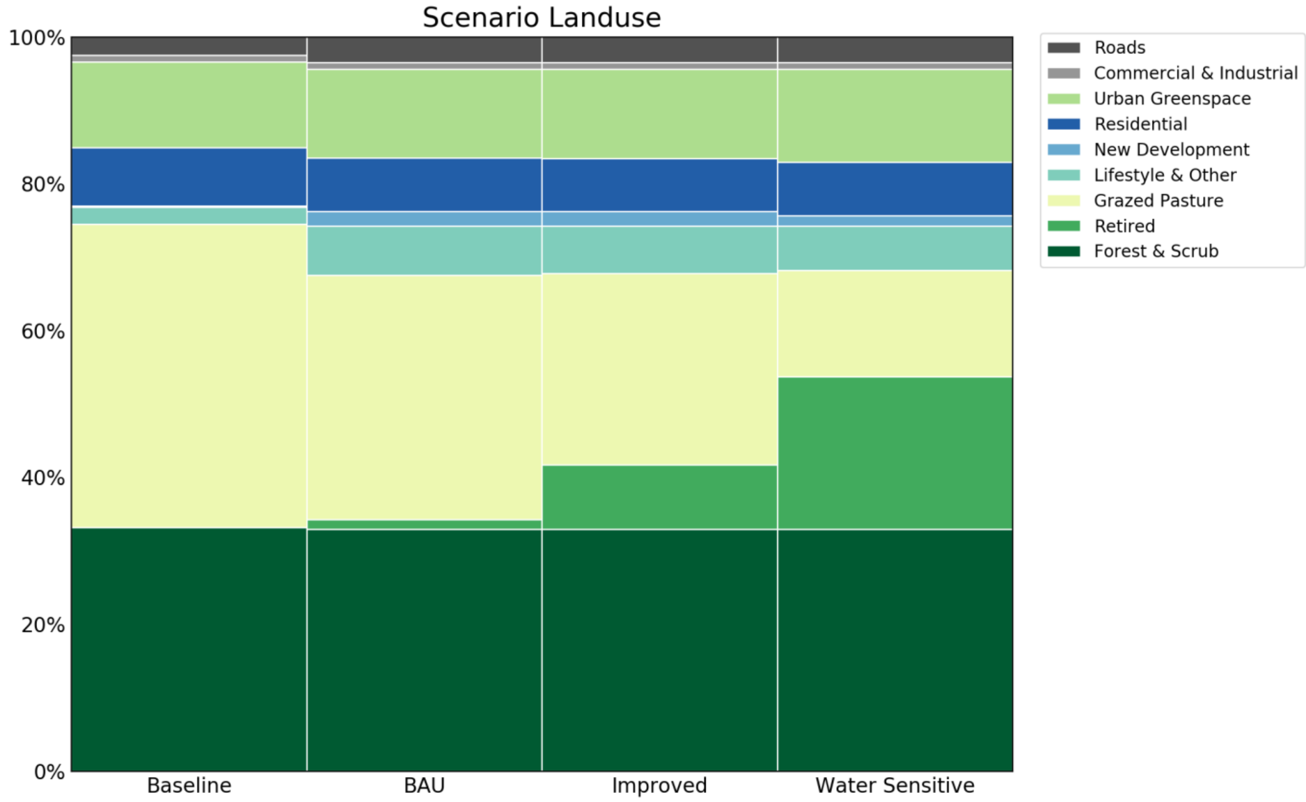

Figure 2.1 Scenario land use changes – categories relate to the Conceptual Group provided in Table 2.1

Table 2.1 Functional Unit list

Baseline / Scenario	Functional Unit	Conceptual Group
Baseline	Commercial Roof	Commercial & Industrial
Baseline	Commercial Paved	Commercial & Industrial
Baseline	Industrial Roof	Commercial & Industrial
Baseline	Industrial Paved	Commercial & Industrial
Baseline	Residential Roof	Residential
Baseline	Residential Paved	Residential
Baseline	Roads (< 1000 VPD)	Roads
Baseline	Roads (1000 – 5000 VPD)	Roads
Baseline	Roads (5000 – 20000 VPD)	Roads
Baseline	Roads (20000 – 50000 VPD)	Roads
Baseline	Roads (50000 – 100000 VPD)	Roads
Baseline	Natural Forest	Forest & Scrub
Baseline	Plantation Forest	Forest & Scrub
Baseline	Scrub	Forest & Scrub
Baseline	Urban Grassland	Urban Greenspace
Baseline	Deer	Grazed Pasture
Baseline	Sheep & Beef (hill country)	Grazed Pasture
Baseline	Sheep & Beef (lowland intensive)	Grazed Pasture
Baseline	Other Animals	Lifestyle & Other
Baseline	Horticulture	Lifestyle & Other
Baseline	Other	Lifestyle & Other
Baseline	Construction Site	Construction
Baseline	Water	-
Scenario	Replacement Low Yield Roof	Residential
Scenario	Greenfield Residential Paved	New Development
Scenario	Greenfield Residential Roof	New Development
Scenario	Greenfield Urban Grassland	Urban Greenspace
Scenario	Infill Residential Paved	New Development
Scenario	Infill Residential Roof	New Development
Scenario	Infill Urban Grassland	Urban Greenspace
Scenario	Infill Roads (1000 VPD)	Roads
Scenario	Infill Roads (1000 – 5000 VPD)	Roads
Scenario	Infill Roads (5000 – 20000 VPD)	Roads
Scenario	Infill Roads (20000 – 50000 VPD)	Roads
Scenario	Greenfield Roads (1000 VPD)	Roads
Scenario	Retirement	Retired

2.2.2 Mitigations

A range of flow and water quality mitigations have been applied in the scenario models, encompassing contaminant source control measures, construction of wetlands and biofiltration systems, and infrastructure upgrades. Mitigations include:

- Rainwater tanks,
- Low Zinc yielding roof use,
- Permeable paving,
- Media filters,
- Wetlands,
- Bioretention,
- Wastewater to stormwater cross-connection repair,
- Pole planting, and
- Riparian management.

Mitigations are applied to identified FUs within certain catchments using percent removal Load Reduction Factors (LRFs). The treated area and mitigation effectiveness generally increases from the BAU through Improved to the WS scenario, which encompasses the most comprehensive mitigation suite. Mitigation effectiveness is based on literature values, locally observed data, and modelled predictions (see section 3).

2.2.3 Wastewater overflows

Scenarios adopted a simplistic approach to overflows focussed on the reduction of the frequency of overflow events. For the BAU scenario, no change to the Baseline is applied, with an average of 12 overflow events (at multiple locations) occurring each year (Figure 2.2). In the Improved scenario, overflow frequency has been reduced to 4 events per year on average, and 2 per year on average in the WS scenario. The 4 and 2 average events per year adopted in the Improved and WS scenarios respectively were nominated by the Whaitua committee in discussion with GWRC and WW during development of the scenarios. While these organisations considered these reduced overflow frequencies plausible for the purpose of scenario exploration, they do not necessarily reflect expected or particular planned infrastructure upgrades.

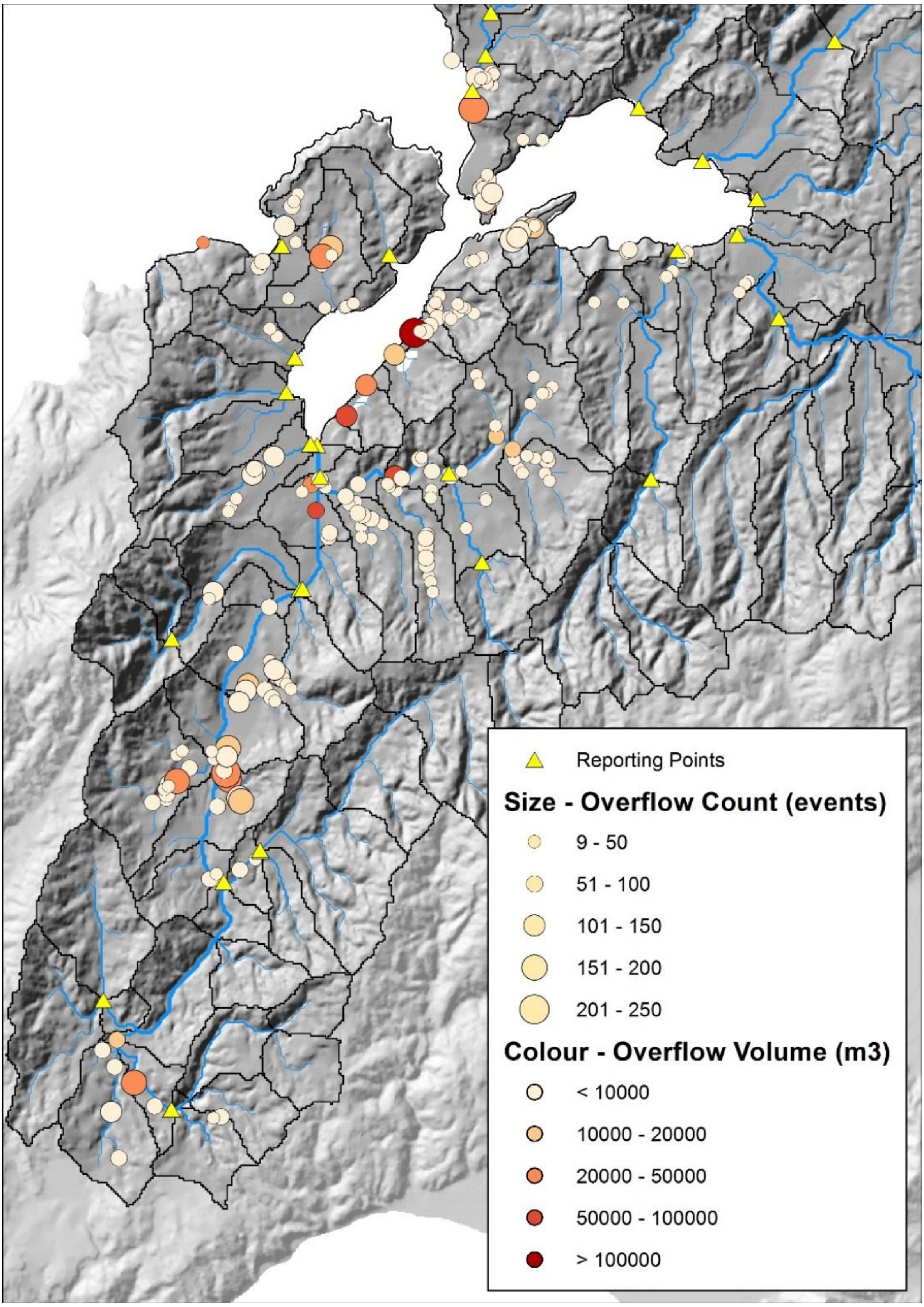

Figure 2.2: Wastewater overflow locations (Baseline and BAU)

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2.3 Business as Usual (BAU)

The BAU scenario represents a vision of the whaitua to accommodate the projected population increase to 2043 using current land use and management practices incorporated within the Proposed Natural Resources Plan (PNRP, GWRC 2018).

An overview of the changes applied in the BAU scenario is provided in Table 2.2. See section 3 below for a detailed description of how changes are configured in the Source model and data sources for assumed treatment performance.

2.3.1 Land use change

Urban land use configuration within the identified greenfield and infill development zones is based on the currently used residential urban form. Within these zones, roofs are expected to utilise modern low Zinc-yielding materials (e.g. Coloursteel). There are no stormwater treatment devices assumed for new development in the BAU scenario.

In the rural zone, two areas of retirement have been identified. A 275-hectare area in the headwaters of the Kenepuru Stream and Duck Creek has been retired as an offset for the Transmission Gully motorway project. A further 50 ha area in the headwaters of the Rangituhi and Whitireia catchments in the western hills has also been retired following identification from GWRC and the Whaitua Committee that these reserve areas were misclassified in the baseline model. The expected development of low-intensity rural residential ‘lifestyle blocks’ has also been simulated, with 912 ha of rural land converted in the BAU scenario.

Road traffic volumes have been updated to account for increased traffic volumes and changes in traffic flows following population growth and the expected completion of the Transmission Gully and Petone to Grenada motorways.

2.3.2 Mitigations

The sole mitigation applied in the BAU scenario additional to the Baseline is the implementation of construction sediment control practices. Sediment control mitigations assume GWRC Erosion and Sediment Control guidelines are followed and the widespread use of well-managed chemically treated sediment retention ponds, reducing contaminant export from construction sites.

In all scenarios and the Baseline, the stream length of existing stock exclusion and riparian planting has been accounted for. There is assumed to be no additional riparian management implemented in the BAU scenario.

Table 2.2 Business as Usual Scenario matrix – note that BAU land use changes and mitigations are also applied in the Improved and WS scenarios

Business as Usual Scenario			
Land use change or Mitigation	**Description**	**Areas applied**	**Representation in the SOURCE model**
Land use change	Greenfield, infill and rural residential development	• Areas within council identified development zones (see Figure 2.3) • Amount of change designed to accommodate population projections to 2043 • Density and	Adopt residential rainfall-runoff characteristics and contaminant generation characteristics. Greenfield and Infill roofs assumed to utilize low-Zinc yielding materials. See section 3.1.1

Business as Usual Scenario			
Land use change or Mitigation	**Description**	**Areas applied**	**Representation in the SOURCE model**
		development form reflect current development practice	
Land use change	Retirement of pastoral land for Transmission Gully offset	Identified areas (see Figure 2.3)	Adopt native forest rainfall runoff and contaminant generation characteristics, see section 3.1.3
Land use change	Transmission Gully and Petone to Grenada are operational	Identified areas (see Figure 2.3)	Adopt major road rainfall-runoff characteristics and contaminant generation characteristics, see section 3.1.2
Land use change	Western Hills retirement – recognise current state not accounted for in Baseline	Pastoral land in Rangituhi and Whitireia catchments	Adopt native forest rainfall runoff and contaminant generation characteristics, see section 3.1.3
Mitigation	Construction sediment control practices	100% of construction areas	LRF applied, see section 3.3.5

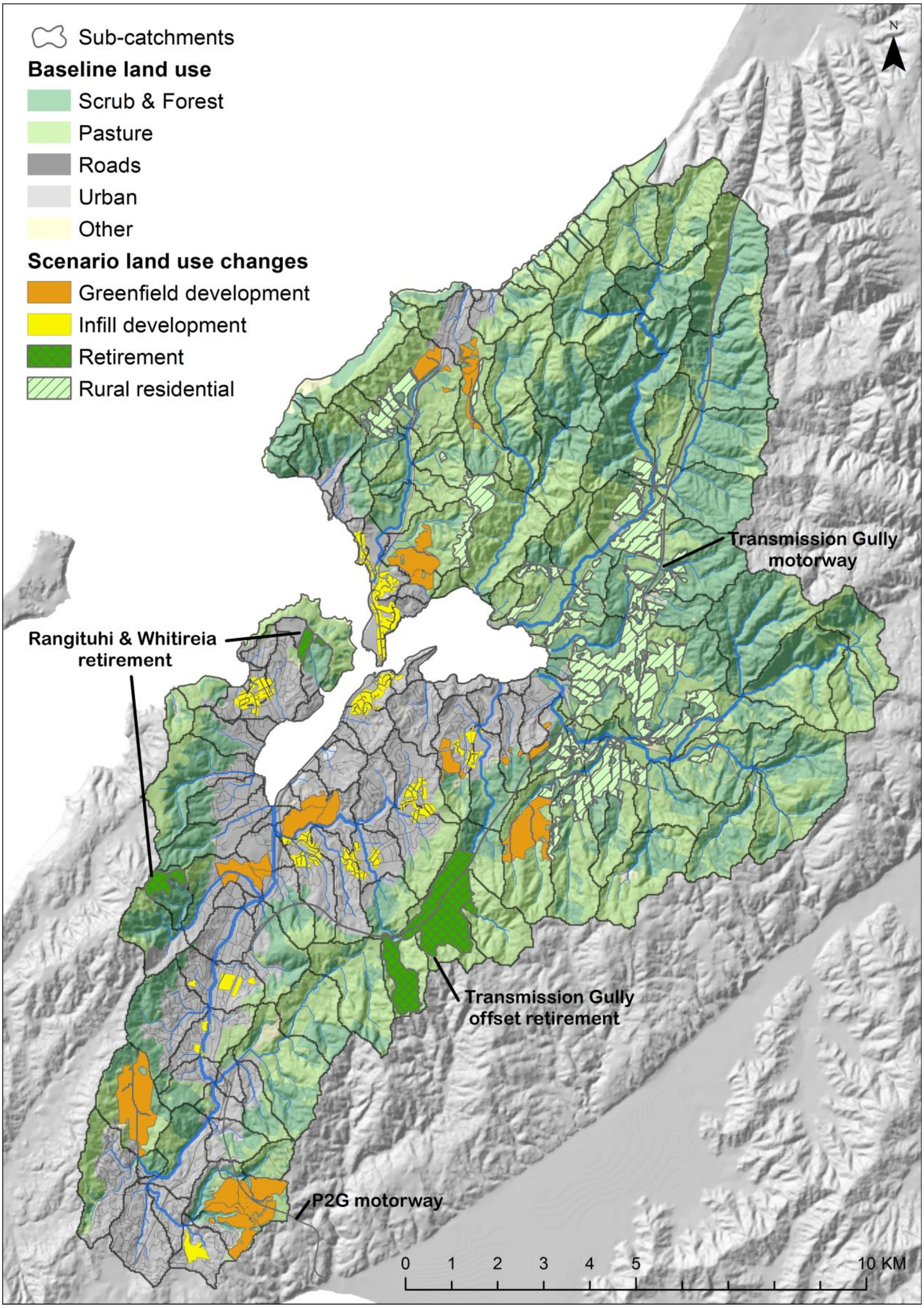

Figure 2.3 BAU scenario land use change

2.4 Improved

The improved scenario represents an increased level of land use change and mitigation implementation from the BAU scenario. Land use change and mitigations applied in the BAU scenario are also applied in the Improved scenario, as well as the following.

An overview of the changes applied in the improved scenario is provided in Table 2.3. See section 3 below for a detailed description of how changes are configured in the Source model and data sources for assumed treatment performance.

2.4.1 Land use change

Urban land use configuration within the identified infill zones is the same as for the BAU scenario. For greenfield sites, there is an increased proportion of urban greenspace, and a corresponding decrease in paved surfaces. In the rural zone, 1719 ha of pastoral land in Land Use Capability (LUC) class 7e and 8 has been classified as retired.

2.4.2 Mitigations

Mitigations are applied to urban development land uses, existing urban land uses, and pastoral land in the rural zone.

In the infill and greenfield urban development areas, 50% of roofs are fitted with rainwater tanks, 40% of road areas are treated with bioretention devices, and 100% of paved and roof areas are treated with wetlands. For existing urban land uses, 50% of existing residential, commercial, and industrial roofs use low Zinc-yielding roof materials, and 50% of commercial and industrial paved areas and major roads (greater than 20,000 VPD) are treated with media filter devices. Wastewater infrastructure upgrades reduce the number of overflow events to an average of 4 per year (from 12 in the baseline and BAU), and all cross-connections between the wastewater and stormwater networks are repaired. In rural areas, 72,353 metres of second-order and greater streams in low-slope pastoral land are fenced and planted and 2,422 ha of pastoral land in LUC class 6e has been classified as pole planted for erosion control (additionally to the retired land).

Table 2.3 Improved scenario matrix

Improved Scenario			
Land use change or Mitigation	**Description**	**Areas applied**	**Representation in the SOURCE model**
Mitigation	Rainwater tanks on some new dwellings	50% of new greenfield and infill dwellings and 10% of existing dwellings	Flow reduction factor applied, see section 3.3.3
Mitigation	Limited treatment of road runoff in new urban developments with bioretention	40% of roads in greenfield and infill development	LRF applied, see section 3.3.2
Mitigation	Construction sediment control practices	100% of construction areas	LRF applied, see section 3.3.5
Mitigation	Treatment of stormwater runoff in new urban developments with catchment scale devices such as wetlands	All new paved and roof surfaces in greenfield and infill development areas	LRF applied, see section 3.3.2

Improved Scenario			
Land use change or Mitigation	**Description**	**Areas applied**	**Representation in the SOURCE model**
Mitigation	Treatment or replacement of existing high yielding zinc roofs	50% of existing residential, commercial and industrial roofs	Adopt low zinc roof contaminant generation characteristics, see section 3.3.4
Mitigation	Fixing cross connections and broken pipes in the wastewater network	100% of urban areas	Adopt low urban *E. coli* yields, see section 3.3.1.1.
Mitigation	Media filter treatment of runoff from paved surfaces in commercial and industrial areas	50% of paved commercial and industrial areas	LRF applied, see section 3.3.2
Mitigation	Media filter treatment of runoff from major roads	50% of major roads	LRF applied, see section 3.3.2
Mitigation & Land use change	Fencing and planting of most streams in pastoral areas with a 5m width	All REC order 2 or greater streams with catchment slope less than 15 degrees and pastoral land cover (Figure 2.4)	• Adopt native forest rainfall runoff and contaminant generation characteristics • LRF applied, see section 3.2.1
Mitigation	Space planting of moderately erodible pastoral slopes	LUC class 6e land with pastoral landcover	LRF applied, see section 3.2.2
Land use change	Retirement of highly erodible pastoral slopes	LUC class 7e and 8 pastoral land (Figure 2.4)	Adopt native forest rainfall runoff and contaminant generation characteristics, see section 3.1.3
Mitigation	Reduce wastewater overflows to an average of 4 per year	All overflows	40 largest overflow events retained from original (assumed BAU) timeseries (average 4 per year over 10 years), see section 3.3.1.2

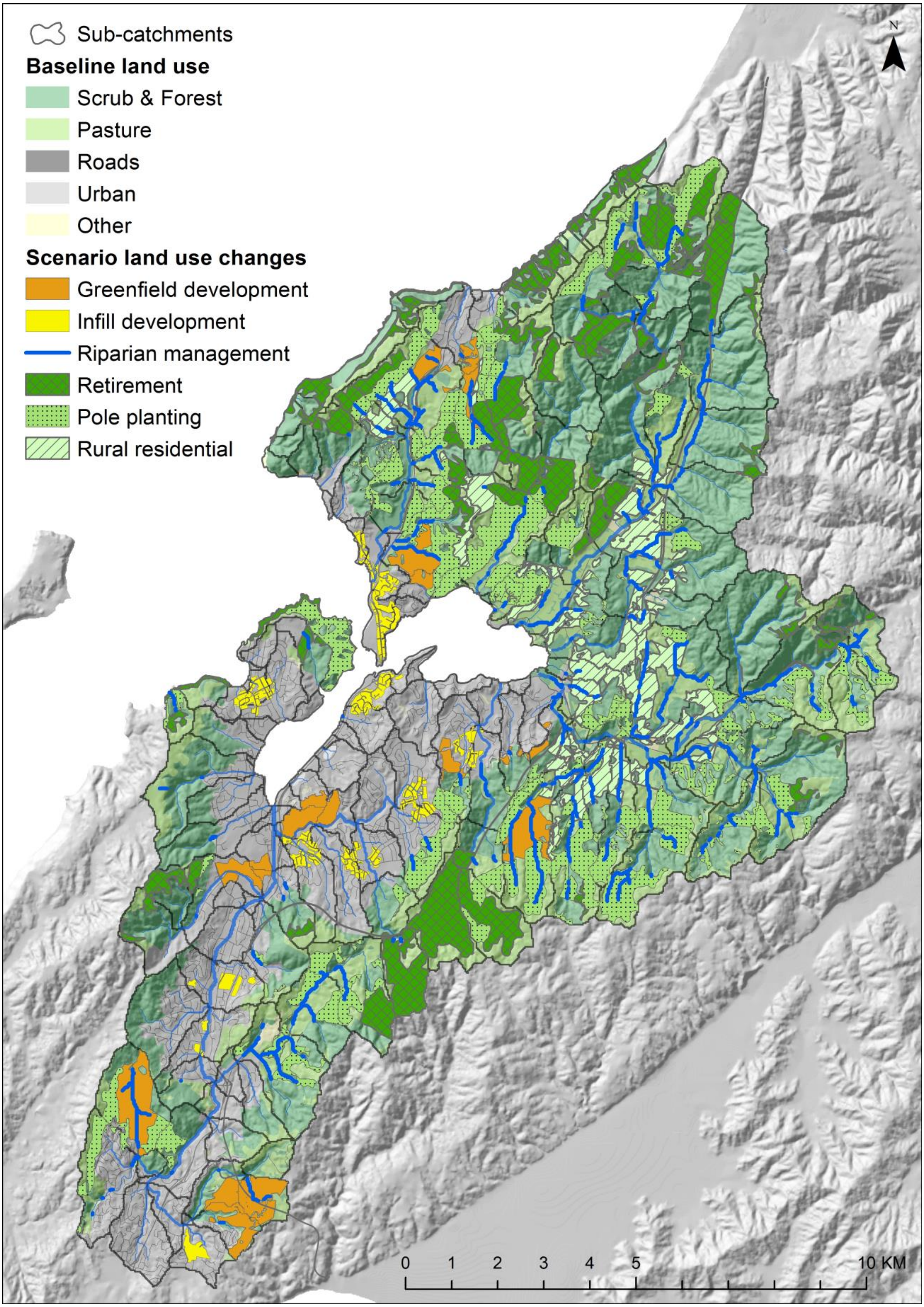

Figure 2.4 Improved scenario land use change

2.5 Water Sensitive

The water sensitive scenario represents an increased level of land use change and mitigation implementation from the BAU and Improved scenarios. Land use change and mitigations applied in the BAU scenario are also applied in the WS scenario, as well as the following.

An overview of the applied changes in the water sensitive scenario is provided in Table 2.4. See section 3 below for a detailed description of how changes are configured in the Source model and data sources for assumed treatment performance.

2.5.1 Land use change

Urban land use configuration within the identified infill zones has an increased proportion of urban greenspace, and a corresponding decrease in paved surfaces. For greenfield sites, there is an increased proportion of urban greenspace, and a corresponding decrease in paved surface and roof area.

In the rural zone, 4,141 ha of pastoral land in Land Use Capability (LUC) class 6e, 7e, and 8 has been classified as retired. This area is equivalent to the combined retired and pole planted area in the Improved scenario.

2.5.2 Mitigations

Mitigations are applied to urban development land uses, existing urban land uses, and pastoral land in the rural zone.

In the infill and greenfield urban development areas, 100% of roofs are fitted with rainwater tanks, 90% of road areas are treated with bioretention devices, 100% of paved and roof areas are treated with wetlands, and 50% and 25% of paved surfaces use permeable materials in greenfield and infill zones, respectively. For existing urban land uses, 50% of residential roofs are fitted with rainwater tanks, 100% of existing residential, commercial and industrial roofs use low Zinc-yielding roof materials, and 100% of commercial and industrial paved areas and major road (greater than 20,000 VPD) runoff is treated with constructed wetlands.

Wastewater infrastructure upgrades reduce the number of overflow events to an average of 2 per year (from 12 in the baseline and BAU and 4 in the Improved scenario), and cross-connections between the wastewater and stormwater networks are repaired. In rural areas, 53,010 metres of second-order and greater streams in low-slope pastoral land are fenced and planted. The riparian managed stream length is less in the WS scenario compared to the Improved because where pole planting and associated stock exclusion occurs in the Improved scenario, retirement to natural forest is implemented in the WS scenario, removing the need for additional riparian management. There is no additional pole planting in the WS scenario.

Table 2.4 Water Sensitive scenario matrix

Water Sensitive Scenario			
Land use change or Mitigation	**Description**	**Areas applied**	**Representation in the SOURCE model**
Mitigation	Rainwater tanks on most new dwellings with internal reuse of water	100% of new greenfield dwellings and infill dwellings, 50% of existing residential dwellings	Flow reduction factor applied, see section 3.3.3
Mitigation	Reduced impervious footprint in new development	100% of new greenfield and infill development	Reduced proportion of paved and roof surfaces and increased proportion of grass surfaces within new development areas, see section 3.1.1

Water Sensitive Scenario			
Land use change or Mitigation	**Description**	**Areas applied**	**Representation in the SOURCE model**
Mitigation	Treatment of stormwater runoff in new urban developments with source control devices such as permeable paving	50% of paved surface in new greenfield dwellings and 25% of infill dwellings	LRF applied, see section 3.3.2
Mitigation	Treatment of most road runoff in new urban developments with bioretention	90% of roads in greenfield and infill development	LRF applied, see section 3.3.2
Mitigation	Construction sediment control practices	100% of construction areas	LRF applied, see section 3.3.5
Mitigation	Treatment of stormwater runoff in new urban developments with catchment scale devices such as wetland	All new paved and roof surfaces in greenfield and infill development areas	LRF applied, see section 3.3.2
Mitigation	Treatment or replacement of existing high yielding zinc roofs	100% of existing industrial, commercial and residential roofs	Adopt low zinc roof contaminant generation characteristics, see section 3.3.4
Mitigation	Fixing cross connections and broken pipes in the wastewater network	100% of urban areas	Adopt low urban *E. coli* yields, see section 3.3.1.1
Mitigation	Media filter treatment of runoff from paved surfaces in industrial areas	100% of paved industrial areas	LRF applied, see section 3.3.2
Mitigation	Bioretention treatment of runoff from paved surfaces in commercial areas	100% of paved commercial areas	LRF applied, see section 3.3.2
Mitigation	Wetland treatment of runoff from major roads	100% of major roads	LRF applied, see section 3.3.2
Mitigation & Land use change	Fencing and planting of most streams in pastoral areas with a 5m width	All REC order 2 or greater streams with catchment slope less than 15 degrees and pastoral land cover (Figure 2.5)	• Adopt native forest rainfall runoff and contaminant generation characteristics. • LRF applied, see section 3.2.1.
Land use change	Retirement of highly and moderately erodible pastoral slopes	LUC class 6e, 7e and 8 pastoral land (Figure 2.5)	Adopt native forest rainfall runoff and contaminant generation characteristics, see section 3.1.3
Mitigation	Reduce wastewater overflows to an average of 2 per year.	All overflows	20 largest overflow events retained from original (assumed BAU) timeseries (average 2 per year over 10 years), see section 3.3.1.2

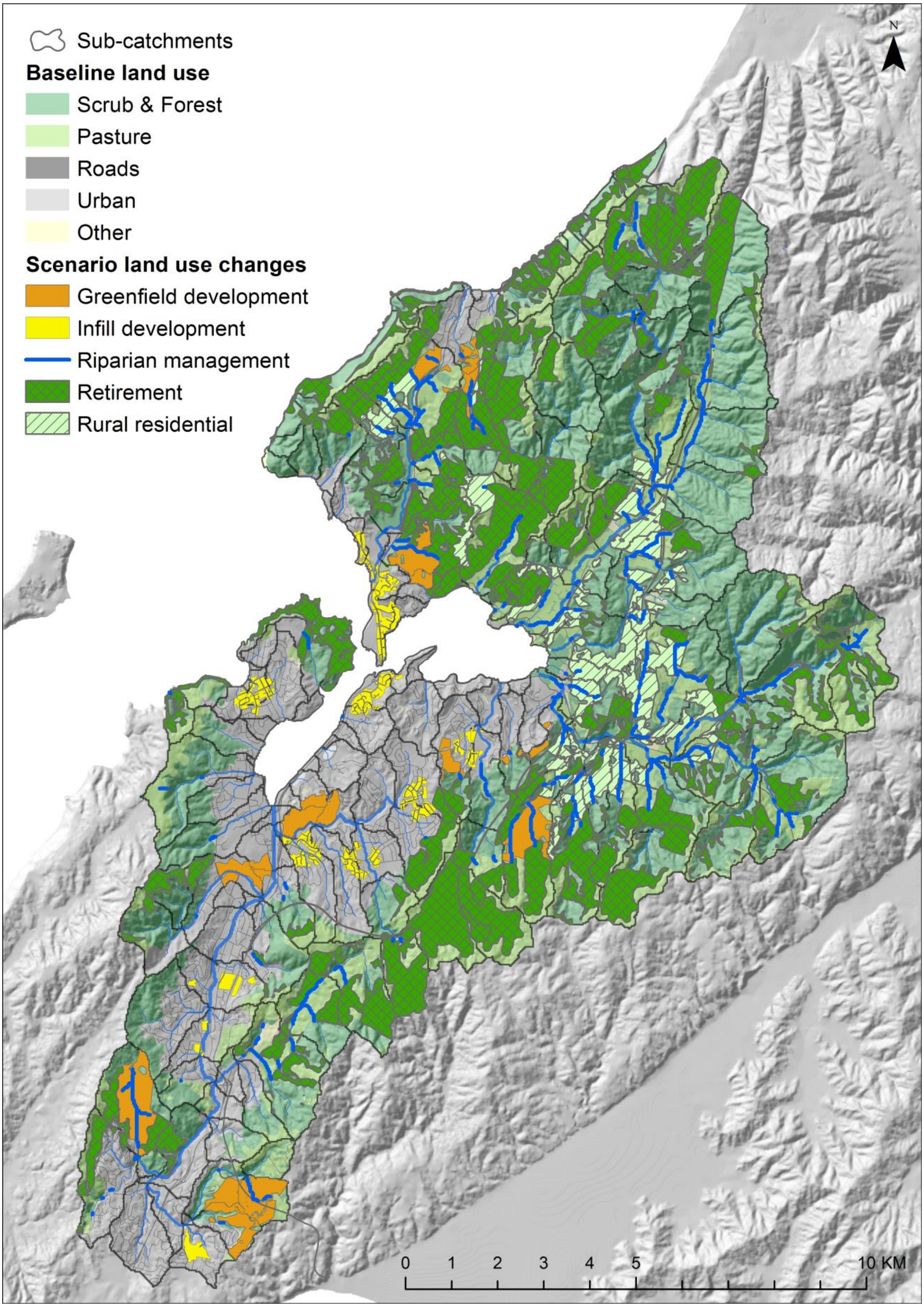

Figure 2.5 WS scenario land use change

2.6 Scenario outputs

Results have been summarised using statistics (e.g. median, mean, 95th percentile etc.) and compared using the NPSFM National Objectives Framework (NOF) attribute state banding system or comparable state band systems for the relevant contaminants at 31 identified reporting points.

Baseline and scenario results are designed to enable further analysis by others within the Whaitua CMP to assess changes in ecosystem health, economic burden, and cultural values, e.g. periphyton growth and Mahinga Kai. The developed model thus provides results for some indicators of water quality and ecosystem health that can be used in combination with other tools. The Source model alone is not intended as a comprehensive representation of stream health and associated values. In combination with other tools and assessments, these results also informed the setting of limits, reductions targets and policy recommendations by TAoP Whaitua Committee.

Daily outputs of flow and contaminant concentration timeseries results were also supplied for 20 stream outlets to DHI (another modelling provider within the Whaitua CMP) as an input into a dynamic harbour model developed within the Whaitua CMP. This allowed the effects of the scenarios to be assessed on Te Awarua-o-Porirua Harbour receiving environment.

2.6.1 Committee reporting points

The 31 reporting locations identified by the Whaitua Committee are shown in Table 2.5 and Figure 2.6. The reporting points encompass headwater and stream mouth sub-catchments with different configurations of rural and urban land uses. Some reporting points are ‘nested’, i.e. the Kenepuru at Mouth reporting point is downstream of both the Kenepuru at Infill Case Study and Upper Kenepuru at Bottom of sub-catchment points.

Table 2.5:Committee reporting points and Baseline upstream land use

ID for Figure 2.6	Reporting point name	Basis	Total Area (ha)	Urban	Roads	Rural
1	Belmont at Lincolnshire Farms	Illustrative localised impacts of greenfield urban development interventions	464	29%	3%	67%
2	Stebbings at Bottom of sub-catchment	Illustrative localised impacts of greenfield urban development interventions	244	3%	0%	96%
3	Porirua at Willowbank	Recreational values	2472	30%	4%	66%
4	Porirua at Granada North industrial	Illustrative localised impacts of industrial interventions	98	39%	2%	58%
5	Porirua at Mitchell Stream	Illustrative localised impacts of infill urban development interventions	399	37%	1%	62%
6	Porirua at Kenepuru Drive	Show the catchment scale impacts for urban streams	3865	38%	4%	58%
7	Kenepuru at Infill case study	Illustrative localised impacts of infill urban development interventions	466	67%	7%	26%
8	Kenepuru at Mouth	Illustrate integrated effects of both rural and urban interventions.	1264	61%	5%	33%
9	Porirua at Mouth	Illustrate integrated effects of both rural and urban interventions.	5359	44%	5%	51%
10	Mahinawa Stream at Mouth	Significant historical and cultural values	253	12%	2%	86%
11	Hukatai Stream at Mouth	Significant historical and cultural values	98	38%	4%	59%

12	Whitireia at Mouth	Open coast recreation and cultural values	98	40%	1%	59%
13	Onepoto Fringe at Elsdon	Illustrative localised impacts of industrial interventions – includes commercial areas	167	45%	4%	51%
14	Kakaho at Mouth	Show catchment scale impacts for rural streams	1251	0%	0%	100%
15	Horokiri and Motukaraka at Mouth	Show catchment scale impacts for rural streams	3320	0%	0%	99%
16	Ration at Mouth	Show catchment scale impacts for rural streams	692	0%	0%	99%
17	Pauatahanui at Mouth	Show catchment scale impacts for rural streams	4183	2%	1%	97%
18	Lower Duck Creek at Mouth	Illustrate integrated effects of both rural and urban interventions. Also has high ecological value	1032	26%	2%	71%
19	Pauatahanui at Middle reaches	Show catchment scale impacts for rural streams	3862	0%	1%	99%
20	Horokiri and Motukaraka at Near Pauatahanui Golf Club	Show catchment scale impacts for rural streams	2884	0%	0%	100%
21	Taupo at Wetland	Ecological and cultural values	806	2%	2%	96%
22	Taupo at Camborne case study	Illustrative localised impacts of greenfield urban development interventions	225	4%	1%	95%
23	Taupo at Mouth	Ecological and cultural values	1120	9%	2%	89%
24	Upper Kenepuru at Bottom of sub-catchment	Show catchment scale impacts for rural streams	271	8%	0%	92%
25	Upper Duck Creek at Bottom of sub-catchment	Show catchment scale impacts for rural streams	531	0%	0%	100%
26	Titahi at Titahi Bay	Open coast recreation and cultural values	31	88%	12%	0%
27	Hongoeka to Pukerua at Hongoeka	Significant historical and cultural values	135	19%	1%	80%
28	Rangituhi at Bottom of sub-catchment	Ecological and recreational values	84	0%	0%	100%
29	Takapu at Bottom of sub-catchment	Show catchment scale impacts for rural streams	771	1%	0%	98%
30	Horokiri and Motukaraka at Battle Hill	Show catchment scale impacts for rural streams	1500	0%	1%	99%
31	Moonshine at Bottom of sub-catchment	Show catchment scale impacts for rural streams	1171	0%	0%	100%

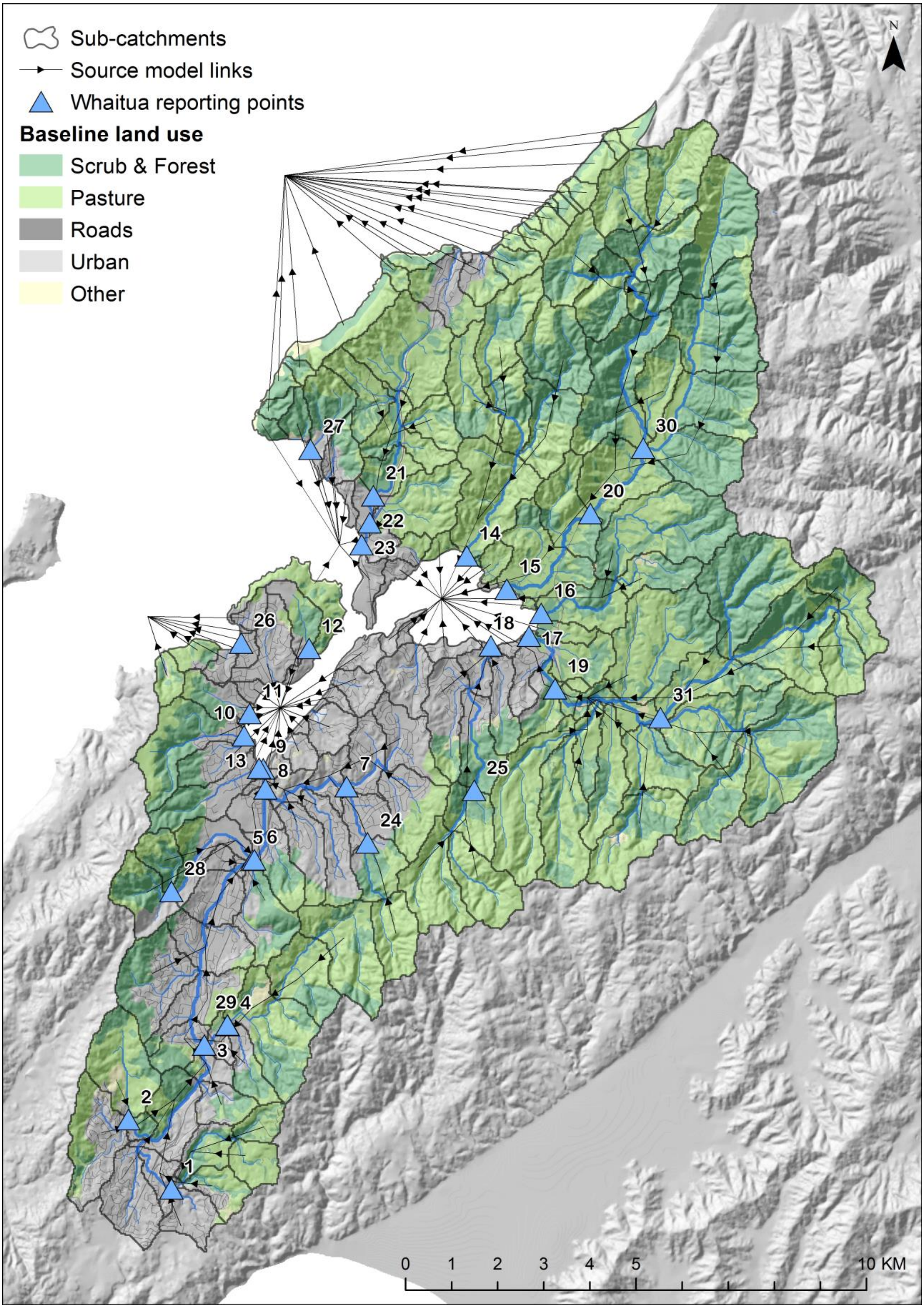

Figure 2.6 Whaitua Committee reporting locations. Location ID matches to Table 2.5

2.6.2 Harbour reporting points

The 20 harbour reporting points correspond to the main inflows into TAoP harbour. Flow and contaminant concentration timeseries, including Total Metals at these locations have been extracted and provided to DHI to serve as inputs into further Harbour modelling within the CMP.

Table 2.6 Harbour reporting points and Baseline upstream land use

ID for Figure 2.7	Reporting name	Total Area (ha)	Urban	Roads	Rural
1	link for catchment SC #165	5359	44%	5%	51%
2	link for catchment SC #116	107	60%	6%	35%
3	link for catchment SC #107	50	95%	5%	0%
4	link for catchment SC #118	98	38%	4%	59%
5	link for catchment SC #123	88	94%	6%	0%
6	link for catchment SC #119	143	84%	10%	6%
7	link for catchment SC #121	77	90%	10%	0%
8	link for catchment SC #120	98	40%	1%	59%
9	link for catchment SC #106	167	45%	4%	51%
10	link for catchment SC #151	32	91%	9%	0%
11	link for catchment SC #143	43	42%	5%	53%
12	link for catchment SC #146	24	0%	4%	96%
13	link for catchment SC #069	1251	0%	0%	100%
14	link for catchment SC #145	44	1%	2%	98%
15	link for catchment SC #063	3320	0%	0%	99%
16	link for catchment SC #168	692	0%	0%	99%
17	link for catchment SC #044	50	9%	2%	90%
18	link for catchment SC #141	4183	2%	1%	97%
19	link for catchment SC #046	1032	27%	2%	71%
20	link for catchment SC #008	133	91%	9%	0%

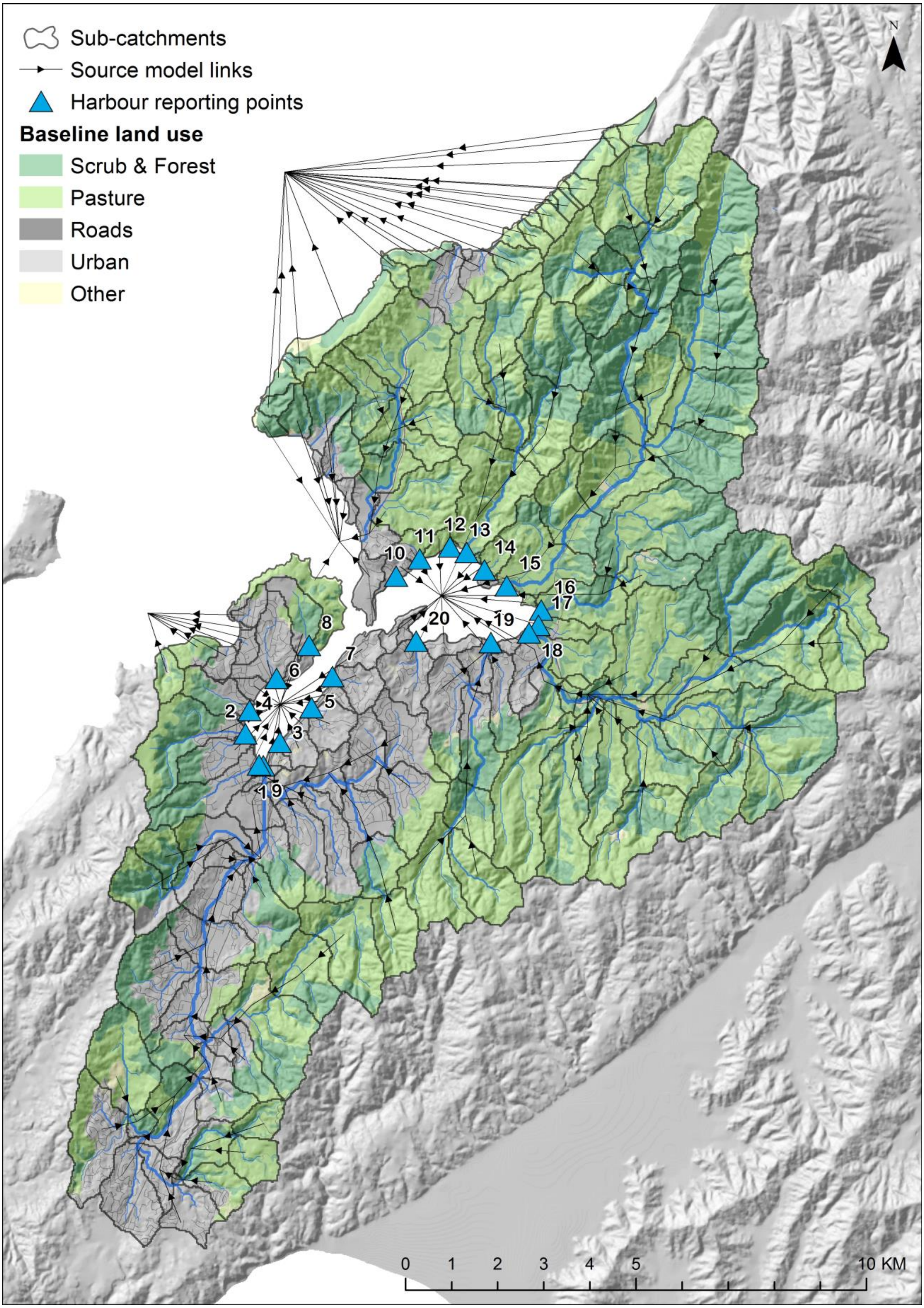

Figure 2.7 Harbour reporting locations. Location ID matches to Table 2.6.

2.6.3 Scenario reporting metrics

Outputs from the baseline and scenario models were produced for flow, suspended sediment, TN, NO_3-N, NH_4-N, TP, DRP, Cu (total and dissolved), Zn (total and dissolved), and *E. coli* at the committee reporting points. In addition, Dissolved Inorganic Nitrogen (DIN) is estimated as the sum of NO_3-N and NH_4-N. Various statistics were evaluated for each analyte including the NPSFM NOF attribute state for several analytes (Table 2.7). NOF attribute states are calculated following the NPSFM 2014 (2017 amendment). All medians and percentiles are calculated following the Hazen method[2]. In addition to the metrics in Table 2.7, percent change for each scenario was calculated for each metric in relation to the Baseline model.

For outputs to the Harbour reporting points, daily timeseries of flow, concentration and loads were extracted for the 21 harbour reporting points. Concentration and loads were extracted for TN, TP, SS, *E. coli*, Total Zinc and Total Copper. Extended timeseries for the full VCSN climate data period (1976-2016) for flow and SS were also extracted for each scenario to support harbour model calibration and sensitivity analyses. This extended timeseries does not include wastewater overflow inputs outside of the 10-year reporting period.

Table 2.7 Scenario reporting metrics

Constituent	Reporting metrics
Flow	• Mean Annual Low Flow (MALF) (m^3/s) • Mean Annual Discharge (ML/year) • FRE3 (m^3/s) – three times median flow • FRE3 frequency (events/year) – events per water year when FRE3 is exceeded (minimum 5 days between events) • 99.8th percentile (m^3/s) – used as proxy for mean annual flood (see Baseline report)
Suspended Sediment	• Median concentration (mg/l) • 95th percentile concentration (mg/l) • Median load (kg/day) • 95th percentile load (kg/day) • Annual load (kg/year)
Total Nitrogen, Dissolved Inorganic Nitrogen, Total Phosphorus, Dissolved Reactive Phosphorus	• Median (mg/l) • 95th percentile (mg/l) • Annual load (kg/year)
Ammoniacal-Nitrogen	• Median (mg/l) • 95th percentile (mg/l) • Annual maximum – average of annual maxima (mg/l) • Annual load (kg/year) • NOF attribute state
Nitrate-Nitrogen	• Median (mg/l) • 95th percentile (mg/l) • Annual load (kg/year) • NOF attribute state

[2] As there is no one correct way to calculate percentiles, the Hazen method is a "middle-of-the-road" option. Other percentile methods include Blom, Tukey, Weibull and Excel (the standard formula used to calculate percentiles in Excel). The methods vary in the minimum number of data they require, the formula used to calculate the percentile and the actual result. For example, the Excel percentile method always gives the lowest percentile result, while the Weibull method always gives the highest (http://www.mfe.govt.nz/publications/fresh-water/bathewatch-user-guide/hazen-percentile-calculator)

Constituent	Reporting metrics
Dissolved Zinc, Dissolved Copper	• Median (mg/l) • 95th percentile (mg/l) • Annual load (kg/year) • Proxy NOF attribute state (see 2.6.3.1)
E. coli	• Median (cfu/100ml) • 95th percentile (cfu/100ml) • Annual load (no./year) • Percentage exceedances over 260 cfu/100ml • Percentage exceedances over 540 cfu/100ml • NOF attribute state

2.6.3.1 Proxy Zinc and Copper attribute state

As dissolved metals are not included in the NOF banding system in the NPSFM at the time of writing, proxy attribute states have been developed by the MLG. Proxy attribute states are based on ANZECC (2000) guidelines and designed to follow the NOF structure for other contaminants. Proxy attribute states are shown for dissolved Zinc in Table 2.8 and Copper in Table 2.9.

Table 2.8 Proxy attribute state for dissolved Zinc

Attribute State	Species Protection	Median below (mg/l)	95th percentile below (mg/l)
A	50% time protect >99% species from chronic toxicity 95% time protect >95% species from chronic toxicity	0.0024	0.008
B	50% time protect >95% species from chronic toxicity 95% time protect >90% species from chronic toxicity	0.008	0.015
C	50% time protect >80% species from chronic toxicity 95% time protect species from acute toxicity	0.031	0.042
D	Chronic and acute toxicity may occur	>0.031	>0.042

Table 2.9 Proxy attribute state for dissolved Copper

Attribute State	Species Protection	Median below (mg/l)	95th percentile below (mg/l)
A	50% time protect >99% species from chronic toxicity 95% time protect >95% species from chronic toxicity	0.001	0.0014
B	50% time protect >95% species from chronic toxicity 95% time protect >90% species from chronic toxicity	0.0014	0.0018
C	50% time protect >80% species from chronic toxicity 95% time protect species from acute toxicity	0.0025	0.0043
D	Chronic and acute toxicity may occur	>0.0025	>0.0043

3. Model Configuration

This section describes the technical implementation of the scenarios in the Source model framework. Figure 2.3 to Figure 2.5 shows the land use change adopted for the BAU, Improved and WS scenarios, respectively.

Contaminant mitigations are assumed equally feasible and effective in the scenario models (except where explicitly stated in this report). The model does not account for potential site-specific characteristics that may influence mitigation effectiveness or feasibility, the time required to implement mitigations, nor the regulatory or economic context that may impact mitigation implementation.

3.1 Land use change

3.1.1 Greenfield and Infill development

Greenfield and infill development zones were identified by GWRC and supplied as GIS polygons. Development zones are defined as Porirua City Council (PCC) infill, Wellington City Council (WCC) infill, and Greenfield (see Figure 2.3, Figure 2.4, and Figure 2.5).

Within the development polygons, FUs were updated for each scenario to the configuration outlined for Infill and Greenfield in Table 3.1 and Table 3.2 respectively. Configuration in Table 3.1 and Table 3.2 are based on MUSIC modelling undertaken by Morphum Environmental within the CMP (Morphum Environmental Ltd., 2018) to ensure consistency between models and allow the application of flow reduction factors derived from MUSIC to the Source model. It is assumed that 4% of each zone is under construction (i.e. one year out of the 25 years through to 2043, under a linear development scenario). For the PCC infill, a separate road layer was supplied, with traffic volumes (Vehicles Per Day – VPD) estimated from the Jacobs SATURN traffic model (for the year 2041). For the WCC infill and greenfield zones, road area is assumed as per the tables below in the <1000 VPD category as suburban roads.

Table 3.1 Configuration of Functional Units within identified Infill zones

Functional Unit	PCC Infill			WCC Infill		
	BAU	Improved	WS	BAU	Improved	WS
Construction Site	4%	4%	4%	4%	4%	4%
Infill Roof	28.2%	28.2%	28.2%	24%	24%	24%
Infill Paved	18.6%	18.6%	12.7%	16%	16%	11%
Infill Urban Grassland	49.1%	49.1%	55.1%	42%	42%	47%
Roads	Additional GIS data*	Additional GIS data*	Additional GIS data*	14%	14%	14%

* VPD category for Infill derived from SATURN traffic model

Table 3.2 Configuration of functional units within identified Greenfield zones

Functional Unit	Greenfield		
	BAU	Improved	WS
Construction Site	4%	4%	4%
Greenfield Roof	28.8%	28.8%	19.2%
Greenfield Paved	13.4%	12.0%	6.2%
Greenfield Urban Grassland	34.6%	36.0%	51.4%
Roads (<1000 VPD)	19.2%	19.2%	19.2%

3.1.2 Traffic and Highways

Traffic and road development changes are consistent between scenarios. The Transmission Gully (TG) and Petone to Grenada (P2G) motorways are assumed operational. Traffic flows for all roads have been updated based on outputs from the Jacobs Wellington regional SATURN traffic model for the year 2041 into the same traffic categories as the baseline model. It is assumed that minor roads (including in greenfield zones) not present in the traffic model are in the <1000 VPD class. Contaminant yields from the five VPD road classes follow the baseline model (see Baseline report).

Table 3.3 shows the area of each road category. There is an increase in road area between the baseline and scenarios for all traffic classes and a total road area increase of 200 ha due to highway, link road, and greenfield road development. Treatment of road runoff varies across the scenarios, see section 3.3.2.

Table 3.3 Road and Highway Functional Units

Road and Highway Functional Units	Baseline		Scenarios	
	Area (ha)	Percentage of total road area	Area (ha)	Percentage of total road area
Roads (< 1,000 VPD)	313	61.8%	426	60.4%
Roads (1,000 – 5,000 VPD)	57	11.2%	73	10.4%
Roads (5,000 – 20,000 VPD)	79	15.7%	100	14.2%
Roads (20,000 – 50,000 VPD)	48	9.5%	92	13.1%
Roads (50,000 – 100,000 VPD)	9	1.7%	14	2.0%
Total	506		706	

3.1.3 Retirement

Retirement represents the conversion of scrub and grazed pasture FUs (Scrub, Sheep and Beef, Deer, Other Animals, and Other) to established and mature native vegetation. Retirement zones were identified by GWRC for each scenario (see relevant Scenario in section 1.1.2). The Retirement FU has the same contaminant generation parameters as for Natural Forest and is characterised by a flow reduction of 17% from pasture based on observations for retired catchments in New Zealand (Beets & Oliver 2006). Flow reduction is applied to the quick- and slow-flow generated from the retired FU.

For sediment generation, retired FUs are assumed to be stabilised and not susceptible to shallow land-sliding processes. The cover factor (C factor) in the surficial erosion sub-model is set to 0.005 for retirement, the same as for Natural Forest.

3.1.4 Rural residential

Rural residential areas represent the development of low-intensity ‘lifestyle blocks’. Rural residential zones were identified by GWRC for each scenario (see relevant Scenario in section 1.1.2). The rural residential functional unit has the same contaminant generation and rainfall-runoff parameters as for the baseline ‘Other Animals’ class, representing a decrease in nutrient and *E. coli* yield compared to the ‘Sheep & Beef hill’ and ‘Sheep & Beef intensive’ FUs (see Baseline report). Development of buildings and access roads within rural residential zones is not explicitly accounted for.

3.2 Rural Mitigations

3.2.1 Riparian management

Riparian management encompasses the fencing of streambanks (i.e. stock exclusion) and planting of riparian margins. Stream reaches assumed practicable for riparian management were identified as those second-order or greater streams in low to moderate slope (≤ 15 degrees) pastoral farmland, based on the NIWA River Environments Classification (REC). All qualifying streams are assumed to be fenced and planted in the Improved and WS scenarios; no additional riparian management was applied in the BAU scenario compared to the Baseline (see relevant Scenario in section 2). Riparian managed stream lengths were mapped for the baseline model using REC stream reach information and satellite imagery (acquired in 2012) in collaboration with the GWRC. This assessment assumed that visually identified planted riparian margins also excluded stock from streams, however recent fencing where plants had not yet become established would not have been identified.

Water quality improvements following fencing and planting were represented in the model using a combination of FU conversion and Load Reduction Factors (LRFs). The FU area in a 5-metre corridor each side of the planted stream reaches has been converted to 'Natural Forest', incorporating the contaminant yield and rainfall-runoff parameters for that FU.

An LRF based on literature was applied to the Phosphorus, *E. coli*, and Suspended Sediment EMC/DWC values for FUs where riparian management is implemented to account for stock exclusion from the stream (Table 3.4). Reductions for *E. coli* and Suspended Sediment are based on literature, while Phosphorus reductions were based on Overseer modelling undertaken for the Ruamahanga whaitua for farm types matching those in Porirua – Sheep and Beef operations on Brown soils (see Jacobs 2018). The LRF provided in Table 3.4 has been applied in a weighted manner to each relevant FU (see relevant scenario in section 2) based on the proportion of stream length where riparian management is implemented.

Contaminant reduction LRFs are based on national data and may not reflect local outcomes. Using these conversions and LRFs assumes fences are maintained, animals are not able to access streams, and riparian vegetation is mature.

Table 3.4 LRFs adopted for streambank fencing

Contaminant	Load Reduction Factor	Source
TP and DRP	50%	Overseer (Jacobs 2018)
E. coli	44%[3]	MPI (2016)
Suspended Sediment (streambank yield only)	80%	Dymond et. al (2016)

3.2.2 Pole planting

'Pole', or 'space' planting represents the planting of poles, generally poplar and willow saplings, on grazed pasture for erosion control. Pole planting allows animals to continue to graze the pasture and so represents a form of contaminant source control rather than land use change. Pole planting is applied only in the Improved scenario to Land Use Capability (LUC) class 6e with a pastoral landcover (Sheep & Beef hill, Sheep & Beef intensive, Other animals, and Deer). It is assumed that poles are mature at the time of the scenario; literature suggests pole planting generally has little effect on sediment reduction when poles are <7 years old and full maturity reached at 15 years (Douglas et al. 2010). In the WS scenario, the pole planted zone is instead fully retired.

[3] 44% is the 'most likely' effectiveness of fencing for Sheep & Beef farms in the southern North Island. Reported effectiveness ranges between 11 – 61% (poor-highly effective).

Pole planting is assumed to act on SS yield and to the particulate portion of Total Phosphorus which is often attached to eroded soils. An LRF of 70% is applied to particulate phosphorus yield and the hillslope sediment yield based on Dymond (2010 and 2014). It is assumed that DRP load primarily occurs as leachate and is unaffected by pole planting. As particulate phosphorus is not explicitly modelled, it is estimated that 40% of TP is particulate based on local in-stream observations (see Baseline report). Pole planting is therefore simulated as achieving a 28% reduction for TP. Potential changes in hydrological response following pole planting establishment have not been accounted for in the modelling.

3.3 Urban Mitigations

3.3.1 Wastewater infrastructure improvements

Modelled wastewater infrastructure improvements encompass the repair of cross-connections between the wastewater and stormwater networks and the reduction of wastewater overflow frequency during storm events.

3.3.1.1 Cross connections

E. coli yields for urban land uses in the baseline model were estimated based on the NIWA Urban Runoff Quality Information System (URQS), corroborated with locally observed data (Moores et al. 2017). Yields assumed the presence of cross-connections between the wastewater and stormwater networks and applied a yield of 80,000,000 cfu/m^2/year to urban land uses equally (Roofs, Roads, Paved surfaces, and Urban Greenspace). For urban land where cross-connections are not present, a yield of 18,000,000 cfu/m^2/year was estimated (Moores et al. 2017).

For all scenarios, Infill and Greenfield development has the reduced *E. coli* yield of 18,000,000 cfu/m^2/year applied to urban FUs. For the Improved and WS scenarios, the reduced yield is also applied to existing urban FUs, simulating the repair of existing cross-connections. No change to existing FUs was applied in the BAU scenario.

The applicability of these yield reductions to the Porirua whaitua is uncertain. Furthermore, the spatial distribution of cross-connections is unknown, as is the practicability and cost of repair.

3.3.1.2 Wastewater overflows

Wastewater overflows were incorporated in the Baseline model as point source inputs into the stream network. The location and frequency of wastewater overflows were modelled using MOUSE by Mott MacDonald for Wellington Water. The provided time series predicts wastewater overflow volumes at 223 locations for a 10-year period between 2005 and 2014 inclusive, chosen as representative of a range of climatic conditions (Figure 2.2). These predicted wastewater overflows were then represented in the Source model as point-source daily time series, aggregated at the sub-catchment scale to 48 overflow locations. Average wastewater concentrations for suspended sediment, nutrients, *E. coli,* and metals based on literature were provided by Wellington Water and are given in Table 3.5.

Scenarios adopted a simplistic approach to overflows focussed on the reduction of the frequency of overflow events. For the BAU scenario, no change to the Baseline is applied, with an average of 12 overflow events (at multiple locations) occurring each year. In the Improved scenario, overflow frequency has been reduced to 4 events per year on average, and 2 per year on average in the WS scenario. The overflow events retained were the largest 40 and 20 overflow volumes across the 10-year timeseries for the Improved and WS scenarios, respectively. All other overflows were removed to simulate a wastewater network that achieves an average of 4 and 2 overflow events per year. Overflow locations, events, and volume is provided in Appendix B.

While Wellington Water, GWRC, and the Committee considered these reduced overflow frequencies plausible for the purpose of scenario exploration, they do not necessarily reflect expected or particular planned infrastructure upgrades. It is likely that network upgrades capable of reducing the frequency of events to the meet the Whaitua Committee targets would also reduce the volume of the remaining overflow events, which is not accounted for in the scenario modelling. As for the cross-connection repair, engineering limitations were not assessed for wastewater overflow reductions.

Table 3.5 Wastewater overflow constituent concentration (based on Metcalf & Eddy, 2014)

Constituent	Concentration
Suspended Sediment	248 mg/l
Total Nitrogen	46 mg/l
Nitrate Nitrogen	0 mg/l
Ammoniacal Nitrogen	25 mg/l
Total Phosphorus	6 mg/l
Dissolved Reactive Phosphorus	5 mg/l
E. coli	1,000,000 cfu/100ml
Copper (Total and Dissolved)	0.077 mg/l
Zinc (Total and Dissolved)	0.48 mg/l

3.3.2 Stormwater treatment devices

The implementation of stormwater treatment devices is modelled for the Improved and WS scenarios.

In the Improved scenario (Table 3.6), bioretention devices are applied to greenfield and infill roads, and media filters to existing industrial/commercial paved surfaces and to highways (roads greater than 20,000 VPD). For the WS scenario (Table 3.7), the proportion of the treated area in each FU increases from the Improved scenario; commercial paved surfaces are treated with bioretention devices, and existing highway runoff is treated with wetlands. Additionally, permeable paving is used in greenfield and infill developments in the WS scenario. For both the Improved and WS scenarios, additional constructed wetland treatment is implemented for greenfield and infill impervious surfaces (Table 3.8).

Device LRFs have been derived from the International Stormwater Best Management Practices (BMP) database and agreed on within the TAoP MLG. LRFs were applied as percentage filters to the contaminant generation from the relevant FUs in the Source model. For each FU receiving stormwater treatment, an aggregated LRF has been applied that encompasses the combined device treatment train (Table 3.9). The treatment train concept assumes that only the proportion of runoff not treated by source-specific treatment devices (Table 3.6 and Table 3.7) will enter the bottom of catchment wetland treatment (Table 3.8).

Stormwater treatment devices are assumed to be consistently effective at contaminant removal at the rates stated in this report. This assumes on-going maintenance is undertaken. Site-specific characteristics that may impact treatment device effectiveness or construction practicality have not been investigated.

Table 3.6 Source-specific treatment (Improved scenario)

FU	Treatment Type	Proportion Treated	Device LRF					
			SS	Zn*	Cu*	TN	TP	*E. coli*
Greenfield Roads	Bioretention	40%	90%	80%	80%	40%	60%	90%
Infill Roads (up to 20000 VPD)	Bioretention	40%	90%	80%	80%	40%	60%	90%
Industrial Paved	Media Filter	50%	75%	50%	50%	40%	40%	75%
Commercial Paved	Media Filter	50%	75%	50%	50%	40%	40%	75%
Roads (> 20000 VPD)	Media Filter	50%	75%	50%	50%	40%	40%	75%
* Total and dissolved								

Table 3.7 Source-specific treatment (WS scenario)

FU	Treatment Type	Proportion Treated	Device LRF					
			SS	Zn*	Cu*	TN	TP	*E. coli*
Greenfield Residential Paved	Permeable Paving	50%	70%	40%	40%	40%	40%	-
Greenfield Roads	Bioretention	90%	90%	80%	80%	40%	60%	90%
Infill Residential Paved	Permeable paving	25%	70%	40%	40%	40%	40%	-
Infill Roads (< 20000 VPD)	Bioretention	90%	90%	80%	80%	40%	60%	90%
Industrial Paved	Media Filter	100%	75%	50%	50%	40%	40%	-
Commercial Paved	Bioretention	100%	90%	80%	80%	40%	60%	90%
Roads (> 20000 VPD)	Wetlands	100%	80%	70%	70%	40%	50%	90%
* Total and dissolved								

Table 3.8 Bottom of catchment wetland treatment (Improved and WS scenarios)

FU	Wetland LRF					
	TSS	Zn*	Cu*	TN	TP	*E. coli*
Greenfield Residential Roof	80%	70%	70%	40%	50%	90%
Greenfield Residential Paved	80%	70%	70%	40%	50%	90%
Greenfield Roads	80%	70%	70%	40%	50%	90%
Infill Residential Roof	80%	70%	70%	40%	50%	90%
Infill Residential Paved	80%	70%	70%	40%	50%	90%
Infill Roads	80%	70%	70%	40%	50%	90%
* Total and dissolved						

Table 3.9 Final LRF as adopted in Source, accounting for combined stormwater treatment train

FU	Treatment train LRF – Improved Scenario						Treatment train LRF – WS Scenario					
	SS	Zn*	Cu*	TN	TP	*E. coli*	SS	Zn*	Cu*	TN	TP	*E. coli*
Greenfield Residential Roof	80%	70%	70%	40%	50%	90%	80%	70%	70%	40%	50%	90%
Greenfield Residential Paved	80%	70%	70%	40%	50%	90%	75%	55%	55%	40%	45%	45%
Greenfield Roads	84%	74%	74%	40%	54%	90%	89%	79%	79%	40%	59%	90%
Infill Residential Roof	80%	70%	70%	40%	50%	90%	80%	70%	70%	40%	50%	90%
Infill Residential Paved	80%	70%	70%	40%	50%	90%	78%	63%	63%	40%	48%	68%
Infill Roads (< 20000 VPD)	84%	74%	74%	40%	54%	90%	89%	79%	79%	40%	59%	90%
Infill Roads (> 20000 VPD)	80%	70%	70%	40%	50%	90%	80%	70%	70%	40%	50%	90%
Industrial Paved	38%	25%	25%	20%	20%	-	75%	50%	50%	40%	40%	-

FU	Treatment train LRF – Improved Scenario						Treatment train LRF – WS Scenario					
	SS	Zn*	Cu*	TN	TP	*E. coli*	SS	Zn*	Cu*	TN	TP	*E. coli*
Commercial Paved	38%	25%	25%	20%	20%	-	90%	80%	80%	40%	60%	90%
Roads (> 20000 VPD)	38%	25%	25%	20%	20%	-	80%	70%	70%	40%	50%	90%
* Total and dissolved												

3.3.3 Stormwater retention

Stormwater retention devices are applied in the Improved and WS scenarios to impervious surfaces (roofs, roads, paved surfaces) in infill and greenfield development zones. Retention devices encompass rainwater tanks, bioretention devices, permeable paving, and constructed wetland storage. Device effectiveness was estimated using the eWater MUSIC software for representative catchments by Morphum Environmental as part of the Whaitua CMP (Morphum Environmental Ltd., 2018).

Table 3.10 below shows the effectiveness of stormwater retention devices as a percent reduction of the total flow generated from impervious surfaces in representative urban sub-catchments. The proportion of FUs treated by each device follows Table 3.6 and Table 3.7. The combined (total) flow reduction is applied as a percentage flow reduction within Source to impervious surfaces (roofs, roads, paved surfaces) in infill and greenfield development zones.

Rainwater tanks, which are not assumed to treat stormwater contaminants, are implemented in greenfield and infill developments and retro-fitted to existing residential houses using 2,000 litre and 10,000 litre tanks in the Improved and WS scenarios, respectively. For infill and greenfield roofs, flow reduction from rainwater tanks is accounted for in Source through the total flow reduction given in Table 3.10, which relate to the implementation proportions and tank size given in Table 3.11. For the retro-fit of rainwater tanks to existing roofs which were not explicitly modelled, a flow reduction percentage was calculated based on the roof fraction of total impervious residential land uses (38%), the total flow reduction achieved by infill rainwater tanks (Table 3.10), and the proportion of roofs with rainwater tanks implemented (Table 3.11). The calculated flow reduction applied in Source for residential roofs only (not all impervious surfaces) is given in Table 3.12.

Table 3.10 Stormwater retention device effectiveness

Development	Stormwater Device	Flow reduction (percent of total flow generated)	
		Improved	WS
Infill	Rainwater tank	1.9%	22.3%
	Bioretention	1.7%	3.7%
	Permeable paving	-	5.1%
	Wetland	2.4%	5.8%
	Total	**6.2%**	**36.9%**
Greenfield	Rainwater tank	4.7%	25.2%
	Bioretention	2.1%	5.2%
	Permeable paving	-	4.8%
	Wetland	2.3%	7.2%
	Total	**9.3%**	**42.6%**

Table 3.11 Rainwater tank implementation for residential roofs

Development	Percent with rainwater tanks	
	Improved	WS
Infill	50%	100%
Greenfield	50%	100%
Existing (retro-fit)	10%	50%
Tank size	2,000L	10,000L

Table 3.12 Flow reduction for existing residential roofs

Development	Flow reduction for Residential Roofs	
	Improved	WS
Existing (retro-fit)	1%	29.5%

3.3.4 Roof source control

The use of low Zinc-yielding roofing materials (e.g. Colorsteel) is predicted for urban development in Porirua. All greenfield and infill development roofs use low Zinc-yielding materials in the three scenarios and increasing proportions of retro-fitted roofs are simulated in the Improved and WS scenario (Table 3.13). Low Zinc-yielding roofs are simulated through a reduction in the EMC/DWC values for Dissolved Zinc for residential roofs by 60% to 0.02 mg/l (EMC) and 0.004 mg/l (DWC) based on the customised CLM (Moores et al., 2017). EMC/DWC values for other contaminants and rainfall-runoff parameters remain the same as for the residential roof FU.

Table 3.13 Low Zinc-yielding roof proportion for residential roofs

Development	Percent with low Zinc-yielding roofs		
	BAU	Improved	WS
Infill	100%	100%	100%
Greenfield	100%	100%	100%
Existing (retro-fit)	0%	50%	100%

3.3.5 Earthworks erosion and sediment control

All scenarios assume that GWRC Erosion and Sediment Control guidelines are followed and the widespread use of well-managed chemically treated (flocculant) sediment retention ponds. Sediment control is assumed to be applied to all construction sites, with a 90% effectiveness for removal of generated SS, metals (dissolved and particulate Zinc and Copper), and nutrients (Nitrogen and Phosphorus and sub-species) (Basher et al. 2016).

4. Results and discussion

This section summarises the results produced from the Scenario models. It is intended as a guide to the general differences in water quality achieved between scenarios - it is not an exhaustive discussion of every reported metric or reporting site. Scenario results provide a guide to the potential changes in water quality under different land use changes and various scales of mitigation implementation. In general, the Source model predicts water quality improvements in the Improved and WS scenarios compared to BAU and the baseline, with the greatest improvements evident in the WS scenario.

Scenario and baseline results are reported for 31 identified reporting points (see section 2.6.1 for reporting point description). Results have been summarised using statistics (e.g. median, mean, 95th percentile etc.) described in Appendix A and using the National Objectives Framework (NOF) attribute state banding system for the relevant contaminants (Table 4.1 to Table 4.5). Flow and contaminant concentration timeseries results were also supplied to DHI for 20 stream outlets as an input into a dynamic harbour model developed within the whaitua CMP.

In general, land use change is the primary driver of water quality improvements between scenarios. Figure 2.1 (page 15) provides a graphical summary of the land use change applied in the scenario models. Appendix C provides an equivalent figure for each reporting site which can aid interpretation of results and identification of the drivers of water quality change between each scenario. In rural areas, retirement and conversion to low-intensity lifestyle blocks serve to reduce in-stream concentrations of suspended sediment, nutrients, and *E. coli*. Pole planting in the improved scenario also reduces sediment and phosphorus exported to streams. Modelling of stormwater mitigations in urban areas shows a lower impact on overall catchment water quality compared to land use change. This is because mitigations are generally applied to new development which represents additional contaminant sources not present in the Baseline and this tends to temper the benefit of the mitigations in the overall catchment results. However, the results show stormwater mitigations did reduce in-stream contaminants generated from new urban development, with significant improvements in water quality predicted in the Improved and WS scenarios compared to the BAU where minimal stormwater mitigations were modelled.

4.1 Results by constituent

4.1.1 Flow

Flow regime is altered in the model by land use change and through the implementation of stormwater treatment and retention devices (e.g. permeable paving, bioretention devices, and rainwater tanks) (Table A.3 in Appendix A). Urban development in Infill and Greenfield zones increases the proportion of impermeable cover within a sub-catchment, thus increasing runoff response and flow.

In the Improved and WS scenarios, this response is tempered as increasing flow retention of stormwater treatment devices is simulated, and the increased proportion of urban grassland modelled in the WS scenario. In rural areas, retirement of land from pasture to native vegetation reduces the water yield by 17% for the areas directly affected, thus reducing downstream flow. Where flows are reduced, contaminant concentrations can in some cases increase due to lack of dilution, as can be seen for the Titahi Bay at Titahi Bay and Kenepuru at Mouth reporting sites. Elsewhere, flow reductions can reduce contaminant generation, particularly for suspended sediment generated by streambank erosion.

4.1.1 Suspended sediment

Suspended sediment generation is heavily influenced by high rainfall events that induce erosive processes. As such, the greatest changes between scenarios for SS concentration and load can be observed for the 95th percentile results (Table A.4 and Table A.5 in Appendix A). The stabilisation of hillslopes following retirement and pole planting is a significant contributor to the reduced SS concentrations predicted in the scenario model results. The extensive retirement modelled in the WS scenario achieves a ~50% reduction in average annual sediment load for the Porirua stream (at mouth), Taupo stream (at mouth), and Horokiri stream (at mouth), and a ~40% reduction for the Pauatahanui stream (Table A.6). SS load generation at high flows is also reduced where riparian management is implemented.

Retirement also serves to reduce runoff generation and subsequent down-stream bank erosion. For example, streambank erosion reduction following retirement can be attributed to the additional 5% reduction in the 95th percentile SS load at Pauatahanui at Mouth between the Improved and WS scenarios. In urban areas, the increased open construction area modelled in the scenarios is largely offset by the adoption of sediment and erosion controls.

Median SS concentrations are relatively stable across the scenarios and between sites, largely due to the adoption of a 5 mg/l DWC for all FUs during model calibration Baseline report (Jacobs 2019).

4.1.2 *E. coli*

Modelled *E. coli* concentrations predict poor water quality for most of the whaitua in the baseline and BAU scenarios, driven by urban and rural (grazing pasture) diffuse sources as well as wastewater overflows during wet weather (Table 4.1). *E. coli* concentrations are reduced in the Improved and especially the WS scenario, where mitigations reduce the median by 55-96% and 95th percentile concentrations by 53-99% (Table A.7 in Appendix A). Improvements in rural areas are largely driven by the retirement of extensive tracts of land.

In urban streams, *E. coli* concentrations are predicted to continue to exceed the national bottom line even with the significant reductions observed in the WS scenario for many streams, indicating that improving the water quality in urban areas for primary contact will be a significant challenge. A large reason for the poor level of swimmable quality in many streams in the Whaitua (independent from generation rates from various land uses) is the low dilution afforded by small stream flows. In catchments with larger rivers, greater flow can help dilute the *E. coli* and other contaminant concentrations, somewhat buffering effects from land use.

4.1.3 Nitrate and ammonia toxicity

For Nitrate-Nitrogen (Table 4.2), concentrations are above the NOF bottom line for toxicity for all streams in the baseline model (i.e. A, B and C bands), with some improvements simulated in the Improved and WS scenarios. The greatest reductions for NO_3-N were predicted where extensive retirement was applied, e.g. Rangituhi at Bottom of sub-catchment and Upper Duck Creek at Bottom of sub-catchment. It should be noted that the nitrate toxicity NOF attribute relates to the toxic effects of nitrate, not the effects of nitrate as a nutrient on the trophic state of streams. Nitrate concentrations, in combination with Ammoniacal-Nitrogen, make up the predicted Dissolved Inorganic Nitrogen (DIN) concentration (see next section) that, along with Total-Nitrogen (TN), DRP, and TP, is commonly used to assess the risk of nutrient promotion of periphyton growth in rivers and phytoplankton or macroalgae growth in estuaries and harbours. Effects of nutrients can impact ecosystem health even in the A and B NOF bands for nitrate and ammonia toxicity and are therefore reported separately below.

Ammoniacal-Nitrogen NOF banding (Table 4.3), which is derived using the annual maximum peak concentrations (and median) are largely driven by wastewater overflows where they occur (i.e. urbanised sub-catchments). For example, wastewater overflow reduction to an average of 2 per year in the WS scenario (alongside retirement in the catchment headwaters) reduces the 95th percentile Ammoniacal-Nitrogen concentration for the Porirua stream mouth by approximately two-thirds between the BAU and WS scenarios, however no NOF band change is predicted (Table A.13). Other reductions across the scenarios are achieved through retirement and pasture conversion to low-intensity lifestyle blocks.

4.1.4 Nutrients

Total-Nitrogen and Dissolved Inorganic Nitrogen (Table A.9, Table A.10, Table A.15, and Table A.16 in Appendix A) display a similar pattern as for NH_4-N and NO_3-N across the scenarios, with the greatest reductions in concentration predicted where extensive retirement was applied, e.g. Rangituhi at Bottom of sub-catchment and Upper Duck Creek at Bottom of sub-catchment. Reductions are also observed where stormwater mitigations treat a relatively large proportion of generated runoff, e.g. Taupo at Camborne case study. Interestingly, for the heavily developed (in the scenarios) Belmont at Lincolnshire Farms site, the concentration of N-species increases between the Improved and WS scenarios (and between the BAU and WS scenarios for TN, NO_3, and DIN) because of reduced flows (and therefore reduced dilution) following the installation of rainwater tanks, permeable paving, bioretention devices, and wetlands.

Despite the increased concentration, TN load decreases across the scenarios for this site, providing for improved water quality in the TAoP receiving environment. The effects of TN and DIN on periphyton growth in rivers and phytoplankton and macroalgae growth in Porirua Harbour are not assessed in this report but the concentrations and loads are reported here to assist assessments by others within the Collaborative Modelling Project.

Reductions in the concentration and loads of Phosphorus species (TP and DRP) (Table A.17, Table A.18, Table A.19, and Table A.20 in Appendix A) across the scenarios are similarly driven by retirement and land use change away from intensively grazing animals. In rural areas, the pole planting modelled in the Improved scenario produces equivalent TP concentration reductions as for the WS scenario, where the same area is retired. For DRP, which pole planting is assumed ineffective, the WS scenario achieves the greatest concentration reductions for sites where there is extensive retirement. Similar to nitrogen described above, the effects of TP and DRP on algal growth in rivers and Porirua Harbour are not assessed in this report but results are reported here so that those assessments can be made by others.

4.1.5 Metals

For both Copper and Zinc (Table A.21, Table A.22, Table A.23, and Table A.24 in Appendix A), concentrations and loads are predicted to increase across the scenarios for some reporting sites and decrease for others. Increases are predominantly due to changes in traffic flows and the establishment of the TG and P2G motorways, especially for rural reporting points that are intersected by the new motorways where the baseline concentrations are very low (e.g. Horokiri and Motukaraka near Pauatahanui Golf Club and Upper Duck Creek at Bottom of sub-catchment).

For some sites, e.g. Taupo at Mouth, traffic is reduced in the scenarios as vehicles are predicted to transfer out of the catchment onto the TG motorway away from the existing SH1. This serves to reduce the predicted in-stream concentrations for Cu and Zn. For urban reporting points, the greatest improvement in concentration is achieved for Zn compared to Cu, especially in the WS scenario as a result of the widespread adoption of low zinc-yielding roof types. Between the BAU, Improved, and WS scenarios, reductions in Cu and Zn concentration can also be observed for sites where increased stormwater treatment devices are implemented (e.g. Taupo at Camborne case study).

Applying the developed attribute state banding system for metals (Section 2.6.3.1) to the scenario results (Table 4.4 and Table 4.5) shows that for Zn, an ‘A’ band is achieved for all but two sites in the WS scenario following widespread stormwater treatment and adoption of low-zinc yielding roofs. For Cu, urban reporting sites generally fall in the ‘C’ band in the Improved and WS scenarios, or in the ‘D’ band for the smallest sub-catchments where dilution of impervious surface runoff is reduced (e.g. Titahi Bay at Titahi Bay, Onepoto Fringe at Elsdon, and Porirua at Granada North industrial). Flow attenuation from retirement and stormwater treatment devices also serves to increase predicted concentrations for some sites between the Improved and WS scenarios (e.g. Titahi Bay at Titahi Bay and Kenepuru at Mouth) due to reduced dilution.

4.1.6 Attribute state tables

Table 4.1: NPS Human Health for Recreation Attribute state for *E.coli* under four scenarios at 31 reporting sites (see Table A.1 in appendix for description of Attribute states)

Reporting Point	Attribute state			
	Baseline	BAU	Improved	WS
Horokiri and Motukaraka at Near Pautahanui Golf Club	D	D	C	B
Belmont at Lincolnshire Farms	E	E	D	D
Porirua at Willowbank	E	E	E	E
Porirua at Kenepuru Drive	E	E	E	D
Taupo at Wetland	E	E	D	C
Titahi at Titahi Bay	E	E	C	C
Hongoeka to Pukerua at Hongoeka	E	E	D	D
Upper Duck Creek at Bottom of sub-catchment	E	E	E	E
Lower Duck Creek at Mouth	E	E	D	D
Horokiri and Motukaraka at Battle Hill	E	E	D	C
Horokiri and Motukaraka at Mouth	D	D	D	B
Kakaho at Mouth	E	E	E	D
Upper Kenepuru at Bottom of sub-catchment	E	E	E	E
Kenepuru at Infill case study	E	E	E	E
Kenepuru at Mouth	E	E	E	E
Porirua at Mitchell Stream	E	E	D	D
Rangituhi at Bottom of sub-catchment	E	A	A	A
Onepoto Fringe at Elsdon	E	E	C	C
Mahinawa Stream at Mouth	E	E	D	D
Hukatai Stream at Mouth	E	E	E	E
Whitireia at Mouth	E	E	C	C
Moonshine at Bottom of sub-catchment	E	E	D	D
Pauatahanui at Middle reaches	E	D	D	C
Pauatahanui at Mouth	E	D	C	B
Porirua at Mouth	E	E	D	D
Ration at Mouth	E	D	C	A
Stebbings at Bottom of sub-catchment	E	E	D	C
Takapu at Bottom of sub-catchment	E	E	E	E
Porirua at Granada North industrial	E	E	E	E
Taupo at Camborne case study	E	E	E	B
Taupo at Mouth	E	E	D	C

Table 4.2: Attribute states for nitrate toxicity concentration for four scenarios at 31 reporting points (see Table 4.2 in appendix for description of Attribute states)

Reporting Point	Attribute State			
	Baseline	BAU	Improved	WS
Horokiri and Motukaraka at Near Pautahanui Golf Club	A	A	A	A
Belmont at Lincolnshire Farms	B	B	B	B
Porirua at Willowbank	B	B	B	B
Porirua at Kenepuru Drive	B	B	B	A
Taupo at Wetland	B	B	B	A
Titahi at Titahi Bay	A	A	A	A
Hongoeka to Pukerua at Hongoeka	B	B	A	A
Upper Duck Creek at Bottom of sub-catchment	B	B	A	A
Lower Duck Creek at Mouth	B	A	A	A
Horokiri and Motukaraka at Battle Hill	B	B	A	A
Horokiri and Motukaraka at Mouth	A	A	A	A
Kakaho at Mouth	B	B	B	A
Upper Kenepuru at Bottom of sub-catchment	B	B	B	B
Kenepuru at Infill case study	B	B	B	B
Kenepuru at Mouth	B	B	B	B
Porirua at Mitchell Stream	B	B	A	A
Rangituhi at Bottom of sub-catchment	B	A	A	A
Onepoto Fringe at Elsdon	A	A	A	A
Mahinawa Stream at Mouth	B	B	B	B
Hukatai Stream at Mouth	B	B	B	B
Whitireia at Mouth	B	B	B	B
Moonshine at Bottom of sub-catchment	B	B	A	A
Pauatahanui at Middle reaches	A	A	A	A
Pauatahanui at Mouth	A	A	A	A
Porirua at Mouth	B	B	A	A
Ration at Mouth	B	B	B	A
Stebbings at Bottom of sub-catchment	C	B	B	B
Takapu at Bottom of sub-catchment	B	B	B	B
Porirua at Granada North industrial	B	B	B	B
Taupo at Camborne case study	C	B	B	A
Taupo at Mouth	B	B	B	A

Table 4.3: Attribute state for Ammonia toxicity (as Ammoniacal-Nitrogen) (see Table A.2 in appendix for description of banding system).

Reporting Point	Attribute state*			
	Baseline	BAU	Improved	WS
Horokiri and Motukaraka at Near Pautahanui Golf Club	A	A	A	A
Belmont at Lincolnshire Farms	C	C	C	C
Porirua at Willowbank	C	C	C	B
Porirua at Kenepuru Drive	C	C	C	C
Taupo at Wetland	B	B	B	A
Titahi at Titahi Bay	C	C	C	B
Hongoeka to Pukerua at Hongoeka	B	B	A	A
Upper Duck Creek at Bottom of sub-catchment	B	B	A	A
Lower Duck Creek at Mouth	B	B	B	B
Horokiri and Motukaraka at Battle Hill	B	B	A	A
Horokiri and Motukaraka at Mouth	A	A	A	A
Kakaho at Mouth	B	B	B	A
Upper Kenepuru at Bottom of sub-catchment	B	B	A	A
Kenepuru at Infill case study	C	C	C	C
Kenepuru at Mouth	C	C	C	C
Porirua at Mitchell Stream	C	C	C	B
Rangituhi at Bottom of sub-catchment	B	A	A	A
Onepoto Fringe at Elsdon	C	C	C	B
Mahinawa Stream at Mouth	B	B	B	B
Hukatai Stream at Mouth	C	C	C	B
Whitireia at Mouth	B	A	A	A
Moonshine at Bottom of sub-catchment	B	B	B	A
Pauatahanui at Middle reaches	B	B	A	A
Pauatahanui at Mouth	A	A	A	A
Porirua at Mouth	C	C	C	C
Ration at Mouth	B	B	B	B
Stebbings at Bottom of sub-catchment	B	B	B	A
Takapu at Bottom of sub-catchment	B	B	B	B
Porirua at Granada North industrial	A	A	A	A
Taupo at Camborne case study	B	B	B	A
Taupo at Mouth	B	B	B	B

*Attribute state follows the NOF banding based on pH 8 and temperature of 20ºC. Ammonia toxicity may be less where pH is lower than 8 and temperatures are less than 20ºC. PH and temperature have not been explicitly modelled.

Table 4.4: Attribute state for Dissolved Copper (for banding system see section 2.6.3)

Reporting Point	Attribute state			
	Baseline	BAU	Improved	WS
Horokiri and Motukaraka at Near Pautahanui Golf Club	A	A	A	A
Belmont at Lincolnshire Farms	C	C	C	C
Porirua at Willowbank	D	D	C	C
Porirua at Kenepuru Drive	D	D	C	C
Taupo at Wetland	C	C	C	B
Titahi at Titahi Bay	D	D	C	D
Hongoeka to Pukerua at Hongoeka	C	C	C	C
Upper Duck Creek at Bottom of sub-catchment	A	C	C	A
Lower Duck Creek at Mouth	C	C	C	C
Horokiri and Motukaraka at Battle Hill	A	A	A	A
Horokiri and Motukaraka at Mouth	A	A	A	A
Kakaho at Mouth	A	A	A	A
Upper Kenepuru at Bottom of sub-catchment	A	C	C	B
Kenepuru at Infill case study	D	D	D	D
Kenepuru at Mouth	D	D	C	D
Porirua at Mitchell Stream	D	D	C	C
Rangituhi at Bottom of sub-catchment	A	A	A	A
Onepoto Fringe at Elsdon	D	D	D	D
Mahinawa Stream at Mouth	C	C	C	C
Hukatai Stream at Mouth	C	C	C	C
Whitireia at Mouth	C	C	C	C
Moonshine at Bottom of sub-catchment	A	A	A	A
Pauatahanui at Middle reaches	A	A	A	A
Pauatahanui at Mouth	A	B	A	A
Porirua at Mouth	D	D	C	C
Ration at Mouth	A	B	A	A
Stebbings at Bottom of sub-catchment	A	C	A	A
Takapu at Bottom of sub-catchment	A	A	A	A
Porirua at Granada North industrial	D	D	D	D
Taupo at Camborne case study	D	D	C	C
Taupo at Mouth	D	C	C	C

Table 4.5: Attribute state for Dissolved Zinc (for banding system see section 2.6.3)

Reporting Points	Attribute state			
	Baseline	BAU	Improved	WS
Horokiri and Motukaraka at Near Pautahanui Golf Club	A	A	A	A
Belmont at Lincolnshire Farms	C	C	B	A
Porirua at Willowbank	C	C	C	A
Porirua at Kenepuru Drive	C	C	C	A
Taupo at Wetland	B	B	A	A
Titahi at Titahi Bay	C	C	C	A
Hongoeka to Pukerua at Hongoeka	A	A	A	A
Upper Duck Creek at Bottom of sub-catchment	A	A	A	A
Lower Duck Creek at Mouth	B	B	B	A
Horokiri and Motukaraka at Battle Hill	A	A	A	A
Horokiri and Motukaraka at Mouth	A	A	A	A
Kakaho at Mouth	A	A	A	A
Upper Kenepuru at Bottom of sub-catchment	A	A	A	A
Kenepuru at Infill case study	C	C	B	B
Kenepuru at Mouth	C	C	B	A
Porirua at Mitchell Stream	D	D	C	A
Rangituhi at Bottom of sub-catchment	A	A	A	A
Onepoto Fringe at Elsdon	D	D	D	B
Mahinawa Stream at Mouth	B	B	A	A
Hukatai Stream at Mouth	B	B	B	A
Whitireia at Mouth	B	B	A	A
Moonshine at Bottom of sub-catchment	A	A	A	A
Pauatahanui at Middle reaches	A	A	A	A
Pauatahanui at Mouth	A	A	A	A
Porirua at Mouth	C	C	C	A
Ration at Mouth	A	A	A	A
Stebbings at Bottom of sub-catchment	A	A	A	A
Takapu at Bottom of sub-catchment	C	C	C	A
Porirua at Granada North industrial	D	D	D	A
Taupo at Camborne case study	D	C	B	A
Taupo at Mouth	C	C	B	A

5. Summary and conclusion

This report describes the technical modelling of three scenarios within the Source model framework for the Porirua Whaitua. Three development scenarios were tested using the calibrated baseline Source model:

- Business as Usual,
- Improved, and
- Water Sensitive

GWRC and the Whaitua Committee designed the scenarios and their configuration within the CMP modelling framework was developed collaboratively within the Modelling Lead Group (MLG). The scenarios represent hypothetical land use change, mitigation implementation (to rural and urban environments), and infrastructure upgrades. Land use change encompasses road network development and changes in traffic flows, urban development as both infill and greenfield to accommodate population growth to 2043, rural development, and the retirement of grazing pasture. Model configuration incorporated land use change through the conversion of FUs within identified sub-catchments. Rural and urban stormwater mitigations included pole planting and riparian management in rural areas, and the implementation of wetlands, bioretention, media filters, roof source control, and rainwater tanks in the urban zone. Mitigations were configured using percent removal filters based on local, national, and international literature and modelled information. The frequency of wastewater overflows was also reduced in the Improved and WS scenarios.

Results for each scenario and contaminant are the product of site-specific interactions between modelled runoff response, contaminant yields from different land uses, and treatment interventions. Land use change was found to be the primary driver of water quality improvements across the modelled scenarios. In rural areas, retirement of grazed pasture, conversion to low-intensity lifestyle blocks, and riparian management in particular; serve to reduce in-stream concentrations for suspended sediment, nutrients, and *E. coli*. Pole planting in the Improved scenario also reduces sediment and phosphorus exported to streams. Urban development in infill and greenfield zones generally increase the contaminant concentrations within urbanised catchments. This response is tempered in the Improved and WS scenarios as stormwater mitigations reduce the increase in contaminants from new urban development.

In urban streams, *E. coli* concentrations are predicted to improve, though continue to exceed the national bottom line even in the WS scenario for many streams, indicating that improving the water quality in urban areas for primary contact will be a significant challenge. A reason for the poor swimmability of many streams in the Whaitua (independent from generation rates from various land uses) is the lack of dilution in streams. In catchments with larger rivers, increased flow can help dilute the *E. coli* and other contaminant concentrations, buffering effects from land use. It is predicted that stream flows may reduce under scenarios with extensive retirement and subsequent establishment of native bush.

The water flow, and contaminant concentration and load outputs from the scenario modelling was used by the Whaitua Committee to help inform the development of their Freshwater Objectives (FWOs) under the NPSFM.

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Appendix A. Results

A.1 Attribute States as defined in National Policy Statement

Table A.1: The statistical measures for Human Health for Recreation Attribute for *E. coli.*

Category	% of exceedances over 540 cfu/100mL	Median concentration (cfu/100mL)	95th percentile cfu/100mL	% of exceedances over 260 cfu/100mL
A (Blue)	< 5%	≤ 130	≤ 540	< 20%
B (Green)	5 – 10%	≤ 130	≤ 1000	20 – 30 %
C (Yellow)	10 – 20%	≤ 130	≤ 1200	20 – 34%
D (Orange)	20 – 30%	>130	>1200	>34%
E (Red)	>30%	>260	>1200	>50%

Table A.2: Description of Attribute state for freshwater River for Nitrate and Ammonia.

Note: The attributes measure the toxic effects of nitrate and ammonia, not the trophic state. Where other attributes measure trophic state, for example periphyton, freshwater objectives, limits and/or methods for those attributes will be more stringent.

Attribute	NPS Attribute State				
Narrative Attribute State	*99% species protection level: No observed effect on any species tested*	*95% species protection level: Starts impacting occasionally on the 5% most sensitive species*	*80% species protection level: Starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species)*		*Starts approaching acute impact level (ie risk of death) for sensitive species*
Nitrate (mg/L)	**A** Annual median ≤1 Annual 95th percentile ≤1.5	**B** Annual median >1 and ≤2.4 Annual 95th percentile >1.5 and ≤3.5	**C** Annual median >2.4 and ≤6.9 Annual 95th percentile >3.5 and ≤9.8	**National Bottom Line** Annual median 6.9 Annual 95th percentile 9.8	**D** Annual median >6.9 Annual 95th percentile >9.8
Ammonia (mg/L)	**A** Annual median ≤ 0.03 Annual maximum ≤ 0.05	**B** Annual median > 0.03 and ≤ 0.24 Annual maximum >0.05 and ≤0.4	**C** Annual median >0.24 and ≤1.3 Annual maximum >0.4 and ≤2.2	**National Bottom Line** Annual median 1.3 Annual maximum 2.2	**D** Annual median >1.3 Annual maximum >2.2

A.2 Flow results

Table A.3: Reported scenario flow statistics. Values in brackets represent percentage change compared to the baseline.

Reporting Point	Statistic	Baseline	BAU	Improved	WS
Horokiri and Motukaraka at Near Pauatahanui Golf Club	*MALF (m^3/s)*	0.05	0.05 (1.96%)	0.05 (1.96%)	0.05 (1.96%)
	Median (m^3/s)	0.28	0.29 (1.42%)	0.28 (0.36%)	0.28 (0%)
	95th Percentile (m^3/s)	2.07	2.09 (0.92%)	2.05 (-0.92%)	2.03 (-1.93%)
	99.8th Percentile (m^3/s)	8.32	8.34 (0.24%)	8.1 (-2.54%)	8.01 (-3.69%)
	Mean Annual Discharge (ML/year)	18302.84	18,453.10 (0.82%)	18,067.33 (-1.29%)	17,915.96 (-2.11%)
	FRE3 threshold (m^3/s)	0.84	0.84 (0%)	0.84 (0%)	0.84 (0%)
	FRE3 Frequency (events/year)	9.7	9.9 (2.06%)	9.7 (0%)	9.7 (0%)
Belmont at Lincolnshire Farms	*MALF (m^3/s)*	<0.005	0.01 (50%)	0.01 (50%)	0.01 (25%)
	Median (m^3/s)	0.03	0.04 (33.33%)	0.04 (26.67%)	0.03 (10%)
	95th Percentile (m^3/s)	0.35	0.41 (18%)	0.4 (14.29%)	0.35 (0%)
	99.8th Percentile (m^3/s)	1.41	1.44 (2.12%)	1.4 (-1.13%)	1.29 (-8.64%)
	Mean Annual Discharge (ML/year)	2559.32	3,132.12 (22.38%)	3,031.15 (18.44%)	2,621.86 (2.44%)
	FRE3 threshold (m^3/s)	0.09	0.09 (0%)	0.09 (0%)	0.09 (0%)
	FRE3 Frequency (events/year)	12.9	14 (8.53%)	13.8 (6.98%)	14.3 (10.85%)
Porirua at Willowbank	*MALF (m^3/s)*	0.02	0.03 (12.5%)	0.03 (8.33%)	0.02 (0%)
	Median (m^3/s)	0.17	0.18 (10.91%)	0.18 (9.09%)	0.16 (-1.21%)
	95th Percentile (m^3/s)	1.78	1.9 (6.98%)	1.88 (5.97%)	1.72 (-3.21%)
	99.8th Percentile (m^3/s)	6.66	6.74 (1.25%)	6.66 (0.02%)	6.29 (-5.51%)
	Mean Annual Discharge (ML/year)	13366.26	14,310.83 (7.07%)	14,092.37 (5.43%)	13,000.35 (-2.74%)
	FRE3 threshold (m^3/s)	0.49	0.49 (0%)	0.49 (0%)	0.49 (0%)
	FRE3 Frequency (events/year)	11.9	13.5 (13.45%)	13.2 (10.92%)	12.4 (4.2%)
Porirua at Kenepuru Drive	*MALF (m^3/s)*	0.05	0.05 (8.89%)	0.05 (6.67%)	0.05 (0%)
	Median (m^3/s)	0.29	0.32 (7.48%)	0.31 (6.12%)	0.29 (-1.7%)
	95th Percentile (m^3/s)	2.73	2.85 (4.17%)	2.82 (3.11%)	2.63 (-3.66%)
	99.8th Percentile (m^3/s)	8.82	8.93 (1.14%)	8.83 (0.07%)	8.38 (-5.04%)
	Mean Annual Discharge (ML/year)	21462.31	22,512.54 (4.89%)	22,246.34 (3.65%)	20,801.85 (-3.08%)
	FRE3 threshold (m^3/s)	0.88	0.88 (0%)	0.88 (0%)	0.88 (0%)
	FRE3 Frequency (events/year)	11	11.2 (1.82%)	11.2 (1.82%)	11.1 (0.91%)
Taupo at Wetland	*MALF (m^3/s)*	<0.005	0.01 (25%)	0.01 (25%)	<0.005 (0%)
	Median (m^3/s)	0.03	0.03 (10.34%)	0.03 (6.9%)	0.03 (-3.45%)
	95th Percentile (m^3/s)	0.43	0.44 (0.92%)	0.43 (-1.39%)	0.4 (-7.39%)
	99.8th Percentile (m^3/s)	1.97	1.96 (-0.25%)	1.92 (-2.49%)	1.81 (-7.97%)
	Mean Annual Discharge (ML/year)	3007.98	3,098.46 (3.01%)	3,027.70 (0.66%)	2,816.13 (-6.38%)
	FRE3 threshold (m^3/s)	0.09	0.09 (0%)	0.09 (0%)	0.09 (0%)
	FRE3 Frequency (events/year)	9.3	9.9 (6.45%)	10 (7.53%)	9.6 (3.23%)
Titahi at Titahi Bay	*MALF (m^3/s)*	<0.005	<0.005 (0%)	<0.005 (0%)	<0.005 (0%)
	Median (m^3/s)	<0.005	<0.005 (0%)	<0.005 (0%)	<0.005 (0%)

Reporting Point	Statistic	Baseline	BAU	Improved	WS
	95th Percentile (m^3/s)	0.03	0.03 (-13.79%)	0.02 (-17.24%)	0.02 (-31.03%)
	99.8th Percentile (m^3/s)	0.09	0.08 (-7.95%)	0.08 (-10.23%)	0.07 (-22.73%)
	Mean Annual Discharge (ML/year)	204.51	180.31 (-11.83%)	175.25 (-14.3%)	144.99 (-29.1%)
	FRE3 threshold (m^3/s)	0.01	0.01 (0%)	0.01 (0%)	0.01 (0%)
	FRE3 Frequency (events/year)	13.7	13.4 (-2.19%)	13.5 (-1.46%)	13.2 (-3.65%)
Hongoeka to Pukerua at Hongoeka	*MALF (m^3/s)*	<0.005	<0.005 (0%)	<0.005 (0%)	<0.005 (0%)
	Median (m^3/s)	<0.005	<0.005 (0%)	<0.005 (0%)	<0.005 (0%)
	95th Percentile (m^3/s)	0.07	0.07 (0%)	0.07 (-4.29%)	0.07 (-4.29%)
	99.8th Percentile (m^3/s)	0.34	0.34 (0%)	0.33 (-3.81%)	0.33 (-4.11%)
	Mean Annual Discharge (ML/year)	486.77	486.77 (0%)	470.26 (-3.39%)	467.97 (-3.86%)
	FRE3 threshold (m^3/s)	0.01	0.01 (0%)	0.01 (0%)	0.01 (0%)
	FRE3 Frequency (events/year)	11	11 (0%)	11 (0%)	10.8 (-1.82%)
Upper Duck Creek at Bottom of sub-catchment	*MALF (m^3/s)*	<0.005	<0.005 (0%)	<0.005 (0%)	<0.005 (0%)
	Median (m^3/s)	0.02	0.02 (0%)	0.02 (-5.56%)	0.02 (-5.56%)
	95th Percentile (m^3/s)	0.32	0.31 (-4.02%)	0.3 (-6.81%)	0.3 (-8.36%)
	99.8th Percentile (m^3/s)	1.59	1.51 (-5.34%)	1.46 (-8.22%)	1.43 (-10.11%)
	Mean Annual Discharge (ML/year)	2200.62	2,097.67 (-4.68%)	2,043.70 (-7.13%)	2,008.78 (-8.72%)
	FRE3 threshold (m^3/s)	0.06	0.06 (0%)	0.06 (0%)	0.06 (0%)
	FRE3 Frequency (events/year)	10.2	11 (7.84%)	10.9 (6.86%)	10.8 (5.88%)
Lower Duck Creek at Mouth	*MALF (m^3/s)*	0.01	0.01 (0%)	0.01 (0%)	0.01 (-11.11%)
	Median (m^3/s)	0.06	0.06 (0%)	0.06 (0%)	0.05 (-7.14%)
	95th Percentile (m^3/s)	0.66	0.64 (-2.29%)	0.63 (-3.96%)	0.61 (-7.47%)
	99.8th Percentile (m^3/s)	2.55	2.5 (-2.19%)	2.45 (-4.04%)	2.37 (-7.33%)
	Mean Annual Discharge (ML/year)	4875.67	4,854.66 (-0.43%)	4,776.61 (-2.03%)	4,540.91 (-6.87%)
	FRE3 threshold (m^3/s)	0.17	0.17 (0%)	0.17 (0%)	0.17 (0%)
	FRE3 Frequency (events/year)	10.6	11.6 (9.43%)	11.5 (8.49%)	11.3 (6.6%)
Horokiri and Motukaraka at Battle Hill	*MALF (m^3/s)*	0.02	0.02 (0%)	0.02 (-4.55%)	0.02 (-4.55%)
	Median (m^3/s)	0.12	0.12 (0%)	0.12 (-1.67%)	0.12 (-2.5%)
	95th Percentile (m^3/s)	1.02	1.02 (0%)	0.99 (-3.23%)	0.97 (-4.7%)
	99.8th Percentile (m^3/s)	4.12	4.12 (0%)	3.96 (-4.1%)	3.85 (-6.6%)
	Mean Annual Discharge (ML/year)	8,460.27	8,460.27 (0%)	8,239.74 (-2.61%)	8,101.07 (-4.25%)
	FRE3 threshold (m^3/s)	0.36	0.36 (0%)	0.36 (0%)	0.36 (0%)
	FRE3 Frequency (events/year)	9.20	9.2 (0%)	9.1 (-1.09%)	9.3 (1.09%)
Horokiri and Motukaraka at Mouth	*MALF (m^3/s)*	0.06	0.06 (1.79%)	0.06 (0%)	0.06 (0%)
	Median (m^3/s)	0.31	0.32 (0.64%)	0.31 (0%)	0.31 (-0.64%)
	95th Percentile (m^3/s)	2.35	2.35 (0.26%)	2.29 (-2.35%)	2.26 (-3.58%)
	99.8th Percentile (m^3/s)	9.73	9.75 (0.18%)	9.5 (-2.35%)	9.36 (-3.83%)
	Mean Annual Discharge (ML/year)	20659.55	20,807.47 (0.72%)	20,413.29 (-1.19%)	20,186.49 (-2.29%)
	FRE3 threshold (m^3/s)	0.94	0.94 (0%)	0.94 (0%)	0.94 (0%)
	FRE3 Frequency (events/year)	9.6	9.6 (0%)	9.5 (-1.04%)	9.5 (-1.04%)

Reporting Point	Statistic	Baseline	BAU	Improved	WS
Kakaho at Mouth	*MALF (m^3/s)*	0.01	0.01 (8.33%)	0.01 (0%)	0.01 (0%)
	Median (m^3/s)	0.08	0.08 (1.33%)	0.07 (-1.33%)	0.07 (-4%)
	95th Percentile (m^3/s)	0.79	0.79 (0.76%)	0.76 (-3.81%)	0.73 (-7.24%)
	99.8th Percentile (m^3/s)	3.67	3.67 (-0.05%)	3.51 (-4.57%)	3.36 (-8.49%)
	Mean Annual Discharge (ML/year)	6097.58	6,152.79 (0.91%)	5,924.48 (-2.84%)	5,734.55 (-5.95%)
	FRE3 threshold (m^3/s)	0.22	0.22 (0%)	0.22 (0%)	0.22 (0%)
	FRE3 Frequency (events/year)	9.5	9.7 (2.11%)	9.6 (1.05%)	9.4 (-1.05%)
Upper Kenepuru at Bottom of sub-catchment	*MALF (m^3/s)*	<0.005	<0.005 (0%)	<0.005 (0%)	<0.005 (0%)
	Median (m^3/s)	0.01	0.01 (0%)	0.01 (0%)	0.01 (0%)
	95th Percentile (m^3/s)	0.17	0.17 (-3.45%)	0.16 (-6.32%)	0.16 (-6.9%)
	99.8th Percentile (m^3/s)	0.87	0.83 (-5.16%)	0.8 (-7.91%)	0.8 (-8.6%)
	Mean Annual Discharge (ML/year)	1148.71	1,103.20 (-3.96%)	1,080.15 (-5.97%)	1,071.96 (-6.68%)
	FRE3 threshold (m^3/s)	0.03	0.03 (0%)	0.03 (0%)	0.03 (0%)
	FRE3 Frequency (events/year)	11.5	11.1 (-3.48%)	11.2 (-2.61%)	11.2 (-2.61%)
Kenepuru at Infill case study	*MALF (m^3/s)*	<0.005	<0.005 (0%)	<0.005 (0%)	<0.005 (-25%)
	Median (m^3/s)	0.03	0.03 (0%)	0.03 (0%)	0.02 (-11.54%)
	95th Percentile (m^3/s)	0.35	0.35 (-1.14%)	0.35 (-1.42%)	0.32 (-9.66%)
	99.8th Percentile (m^3/s)	1.4	1.39 (-0.36%)	1.39 (-0.72%)	1.29 (-7.46%)
	Mean Annual Discharge (ML/year)	2572.12	2,556.64 (-0.6%)	2,545.23 (-1.05%)	2,343.71 (-8.88%)
	FRE3 threshold (m^3/s)	0.08	0.08 (0%)	0.08 (0%)	0.08 (0%)
	FRE3 Frequency (events/year)	14.4	14.5 (0.69%)	14.5 (0.69%)	13.7 (-4.86%)
Kenepuru at Mouth	*MALF (m^3/s)*	0.01	0.01 (12.5%)	0.01 (12.5%)	0.01 (0%)
	Median (m^3/s)	0.07	0.07 (2.99%)	0.07 (1.49%)	0.06 (-5.97%)
	95th Percentile (m^3/s)	0.92	0.94 (2.51%)	0.93 (0.98%)	0.85 (-7.21%)
	99.8th Percentile (m^3/s)	3.59	3.54 (-1.64%)	3.5 (-2.73%)	3.35 (-6.84%)
	Mean Annual Discharge (ML/year)	6599.94	6,728.24 (1.94%)	6,643.21 (0.66%)	6,139.36 (-6.98%)
	FRE3 threshold (m^3/s)	0.2	0.2 (0%)	0.2 (0%)	0.2 (0%)
	FRE3 Frequency (events/year)	12.8	13 (1.56%)	13 (1.56%)	13.1 (2.34%)
Porirua at Mitchell Stream	*MALF (m^3/s)*	0.01	0.01 (0%)	0.01 (0%)	0.01 (0%)
	Median (m^3/s)	0.03	0.03 (7.69%)	0.03 (7.69%)	0.03 (0%)
	95th Percentile (m^3/s)	0.22	0.23 (1.8%)	0.22 (0.9%)	0.22 (-2.25%)
	99.8th Percentile (m^3/s)	0.84	0.82 (-1.67%)	0.81 (-3.47%)	0.79 (-5.14%)
	Mean Annual Discharge (ML/year)	1807.64	1,868.82 (3.38%)	1,839.08 (1.74%)	1,772.64 (-1.94%)
	FRE3 threshold (m^3/s)	0.08	0.08 (0%)	0.08 (0%)	0.08 (0%)
	FRE3 Frequency (events/year)	9.6	10.3 (7.29%)	10.2 (6.25%)	9.3 (-3.12%)
Rangituhi at Bottom of sub-catchment	*MALF (m^3/s)*	<0.005	<0.005 (0%)	<0.005 (0%)	<0.005 (0%)
	Median (m^3/s)	0.01	0.01 (0%)	0.01 (0%)	0.01 (0%)
	95th Percentile (m^3/s)	0.04	0.04 (-7.32%)	0.04 (-7.32%)	0.04 (-7.32%)
	99.8th Percentile (m^3/s)	0.14	0.13 (-8.33%)	0.13 (-8.33%)	0.13 (-8.33%)
	Mean Annual Discharge (ML/year)	352.64	337.06 (-4.42%)	337.06 (-4.42%)	337.06 (-4.42%)

Reporting Point	Statistic	Baseline	BAU	Improved	WS
	FRE3 threshold (m^3/s)	0.02	0.02 (0%)	0.02 (0%)	0.02 (0%)
	FRE3 Frequency (events/year)	6.4	6.2 (-3.13%)	6.2 (-3.13%)	6.2 (-3.13%)
Onepoto Fringe at Elsdon	*MALF (m^3/s)*	<0.005	<0.005 (0%)	<0.005 (0%)	<0.005 (0%)
	Median (m^3/s)	0.02	0.02 (0%)	0.02 (0%)	0.02 (0%)
	95th Percentile (m^3/s)	0.11	0.11 (0%)	0.11 (0%)	0.11 (-0.89%)
	99.8th Percentile (m^3/s)	0.32	0.32 (0%)	0.32 (0%)	0.31 (-0.63%)
	Mean Annual Discharge (ML/year)	956.52	956.55 (0%)	955.62 (-0.09%)	947.87 (-0.9%)
	FRE3 threshold (m^3/s)	0.05	0.05 (0%)	0.05 (0%)	0.05 (0%)
	FRE3 Frequency (events/year)	12.1	12 (-0.83%)	12 (-0.83%)	12 (-0.83%)
Mahinawa Stream at Mouth	*MALF (m^3/s)*	<0.005	<0.005 (0%)	<0.005 (0%)	<0.005 (0%)
	Median (m^3/s)	0.02	0.02 (0%)	0.02 (-5.88%)	0.02 (-5.88%)
	95th Percentile (m^3/s)	0.12	0.12 (0%)	0.12 (0%)	0.12 (-0.84%)
	99.8th Percentile (m^3/s)	0.46	0.46 (0%)	0.46 (0%)	0.46 (-0.65%)
	Mean Annual Discharge (ML/year)	1036.39	1,036.40 (0%)	1,036.03 (-0.03%)	1,024.98 (-1.1%)
	FRE3 threshold (m^3/s)	0.05	0.05 (0%)	0.05 (0%)	0.05 (0%)
	FRE3 Frequency (events/year)	7.5	7.6 (1.33%)	7.6 (1.33%)	7.7 (2.67%)
Hukatai Stream at Mouth	*MALF (m^3/s)*	<0.005	<0.005 (0%)	<0.005 (0%)	<0.005 (0%)
	Median (m^3/s)	<0.005	<0.005 (0%)	<0.005 (0%)	<0.005 (0%)
	95th Percentile (m^3/s)	0.05	0.05 (0%)	0.05 (0%)	0.05 (-2%)
	99.8th Percentile (m^3/s)	0.21	0.21 (0%)	0.21 (0%)	0.21 (-1.42%)
	Mean Annual Discharge (ML/year)	366.74	366.79 (0.01%)	366.63 (-0.03%)	358.44 (-2.26%)
	FRE3 threshold (m^3/s)	0.01	0.01 (0%)	0.01 (0%)	0.01 (0%)
	FRE3 Frequency (events/year)	12.4	12.5 (0.81%)	12.5 (0.81%)	12.3 (-0.81%)
Whitireia at Mouth	*MALF (m^3/s)*	<0.005	<0.005 (0%)	<0.005 (0%)	<0.005 (0%)
	Median (m^3/s)	<0.005	<0.005 (0%)	<0.005 (0%)	<0.005 (0%)
	95th Percentile (m^3/s)	0.05	0.05 (-2.13%)	0.05 (-2.13%)	0.05 (-2.13%)
	99.8th Percentile (m^3/s)	0.25	0.24 (-3.25%)	0.24 (-3.25%)	0.24 (-3.66%)
	Mean Annual Discharge (ML/year)	319.86	310.48 (-2.93%)	310.44 (-2.95%)	307.93 (-3.73%)
	FRE3 threshold (m^3/s)	0.01	0.01 (0%)	0.01 (0%)	0.01 (0%)
	FRE3 Frequency (events/year)	10.6	10.8 (1.89%)	10.8 (1.89%)	10.6 (0%)
Moonshine at Bottom of sub-catchment	*MALF (m^3/s)*	0.02	0.02 (0%)	0.02 (0%)	0.02 (0%)
	Median (m^3/s)	0.1	0.1 (0%)	0.1 (0%)	0.1 (-1.04%)
	95th Percentile (m^3/s)	0.84	0.84 (0%)	0.83 (-0.72%)	0.82 (-2.51%)
	99.8th Percentile (m^3/s)	3.55	3.55 (0%)	3.52 (-0.93%)	3.44 (-3.07%)
	Mean Annual Discharge (ML/year)	7048.75	7,048.75 (0%)	6,999.37 (-0.7%)	6,888.71 (-2.27%)
	FRE3 threshold (m^3/s)	0.29	0.29 (0%)	0.29 (0%)	0.29 (0%)
	FRE3 Frequency (events/year)	9.5	9.5 (0%)	9.5 (0%)	9.7 (2.11%)
Pauatahanui at Middle reaches	*MALF (m^3/s)*	0.04	0.04 (2.63%)	0.04 (2.63%)	0.04 (0%)
	Median (m^3/s)	0.24	0.25 (3.77%)	0.25 (2.93%)	0.24 (-0.42%)
	95th Percentile (m^3/s)	2.46	2.49 (1.43%)	2.47 (0.61%)	2.36 (-3.99%)

Reporting Point	Statistic	Baseline	BAU	Improved	WS
	99.8th Percentile (m^3/s)	11.02	11.04 (0.24%)	10.96 (-0.5%)	10.54 (-4.29%)
	Mean Annual Discharge (ML/year)	19311.86	19,612.72 (1.56%)	19,470.70 (0.82%)	18,718.16 (-3.07%)
	FRE3 threshold (m^3/s)	0.72	0.72 (0%)	0.72 (0%)	0.72 (0%)
	FRE3 Frequency (events/year)	9.2	9.3 (1.09%)	9.3 (1.09%)	9.1 (-1.09%)
Pauatahanui at Mouth	*MALF (m^3/s)*	0.04	0.04 (4.88%)	0.04 (2.44%)	0.04 (0%)
	Median (m^3/s)	0.27	0.27 (3.4%)	0.27 (2.64%)	0.26 (-1.13%)
	95th Percentile (m^3/s)	2.6	2.63 (1.23%)	2.62 (0.5%)	2.51 (-3.46%)
	99.8th Percentile (m^3/s)	11.32	11.34 (0.19%)	11.26 (-0.5%)	10.84 (-4.21%)
	Mean Annual Discharge (ML/year)	20911.05	21,268.96 (1.71%)	21,120.21 (1%)	20,303.04 (-2.91%)
	FRE3 threshold (m^3/s)	0.8	0.8 (0%)	0.8 (0%)	0.8 (0%)
	FRE3 Frequency (events/year)	9.1	9.2 (1.1%)	9.2 (1.1%)	9 (-1.1%)
Porirua at Mouth	*MALF (m^3/s)*	0.06	0.06 (6.9%)	0.06 (5.17%)	0.06 (-1.72%)
	Median (m^3/s)	0.4	0.42 (6.33%)	0.42 (5.32%)	0.38 (-3.04%)
	95th Percentile (m^3/s)	3.79	3.91 (3.2%)	3.86 (2.06%)	3.6 (-4.78%)
	99.8th Percentile (m^3/s)	12.14	12.36 (1.83%)	12.21 (0.63%)	11.45 (-5.64%)
	Mean Annual Discharge (ML/year)	29309.95	30,533.21 (4.17%)	30,165.12 (2.92%)	28,150.96 (-3.95%)
	FRE3 threshold (m^3/s)	1.18	1.18 (0%)	1.18 (0%)	1.18 (0%)
	FRE3 Frequency (events/year)	10.9	11.3 (3.67%)	11.1 (1.83%)	10.5 (-3.67%)
Ration at Mouth	*MALF (m^3/s)*	0.02	0.02 (0%)	0.02 (0%)	0.02 (0%)
	Median (m^3/s)	0.07	0.08 (2.74%)	0.08 (2.74%)	0.07 (1.37%)
	95th Percentile (m^3/s)	0.51	0.52 (1.17%)	0.52 (1.17%)	0.51 (0.2%)
	99.8th Percentile (m^3/s)	2.01	2.02 (0.45%)	2.02 (0.4%)	2 (-0.45%)
	Mean Annual Discharge (ML/year)	4541.76	4,598.24 (1.24%)	4,595.67 (1.19%)	4,562.47 (0.46%)
	FRE3 threshold (m^3/s)	0.22	0.22 (0%)	0.22 (0%)	0.22 (0%)
	FRE3 Frequency (events/year)	8.9	9.5 (6.74%)	9.5 (6.74%)	9.3 (4.49%)
Stebbings at Bottom of sub-catchment	*MALF (m^3/s)*	<0.005	<0.005 (50%)	<0.005 (50%)	<0.005 (0%)
	Median (m^3/s)	0.01	0.02 (54.55%)	0.02 (45.45%)	0.01 (9.09%)
	95th Percentile (m^3/s)	0.14	0.18 (33.82%)	0.17 (27.21%)	0.14 (2.21%)
	99.8th Percentile (m^3/s)	0.65	0.65 (0.77%)	0.63 (-2.78%)	0.56 (-12.83%)
	Mean Annual Discharge (ML/year)	1028.92	1,379.13 (34.04%)	1,311.15 (27.43%)	1,030.30 (0.13%)
	FRE3 threshold (m^3/s)	0.03	0.03 (0%)	0.03 (0%)	0.03 (0%)
	FRE3 Frequency (events/year)	9.7	12.6 (29.9%)	12.8 (31.96%)	12.5 (28.87%)
Takapu at Bottom of sub-catchment	*MALF (m^3/s)*	0.01	0.01 (0%)	0.01 (0%)	0.01 (0%)
	Median (m^3/s)	0.04	0.04 (0%)	0.04 (-2.27%)	0.04 (-4.55%)
	95th Percentile (m^3/s)	0.51	0.51 (0%)	0.5 (-1.18%)	0.48 (-5.13%)
	99.8th Percentile (m^3/s)	2.14	2.14 (0%)	2.11 (-1.5%)	2.01 (-5.99%)
	Mean Annual Discharge (ML/year)	3772.16	3,772.10 (0%)	3,727.74 (-1.18%)	3,594.68 (-4.71%)
	FRE3 threshold (m^3/s)	0.13	0.13 (0%)	0.13 (0%)	0.13 (0%)
	FRE3 Frequency (events/year)	10.3	10.3 (0%)	10.2 (-0.97%)	10 (-2.91%)
Porirua at Granada	*MALF (m^3/s)*	<0.005	<0.005 (0%)	<0.005 (0%)	<0.005 (0%)

Reporting Point	Statistic	Baseline	BAU	Improved	WS
North industrial	*Median (m^3/s)*	0.01	0.01 (0%)	0.01 (0%)	0.01 (0%)
	95th Percentile (m^3/s)	0.07	0.07 (0%)	0.07 (0%)	0.07 (0%)
	99.8th Percentile (m^3/s)	0.27	0.27 (0%)	0.27 (0%)	0.27 (-0.36%)
	Mean Annual Discharge (ML/year)	506.47	506.47 (0%)	506.44 (-0.01%)	504.54 (-0.38%)
	FRE3 threshold (m^3/s)	0.02	0.02 (0%)	0.02 (0%)	0.02 (0%)
	FRE3 Frequency (events/year)	13.5	13.7 (1.48%)	13.7 (1.48%)	13.7 (1.48%)
Taupo at Camborne case study	*MALF (m^3/s)*	<0.005	<0.005 (%)	<0.005 (%)	<0.005 (%)
	Median (m^3/s)	0.01	0.01 (60%)	0.01 (60%)	0.01 (20%)
	95th Percentile (m^3/s)	0.12	0.14 (21.55%)	0.14 (17.24%)	0.11 (-2.59%)
	99.8th Percentile (m^3/s)	0.6	0.6 (0.83%)	0.59 (-2.17%)	0.53 (-12.35%)
	Mean Annual Discharge (ML/year)	779.1	969.49 (24.44%)	928.81 (19.22%)	772.36 (-0.87%)
	FRE3 threshold (m^3/s)	0.02	0.02 (0%)	0.02 (0%)	0.02 (0%)
	FRE3 Frequency (events/year)	11	12.7 (15.45%)	12.7 (15.45%)	13 (18.18%)
Taupo at Mouth	*MALF (m^3/s)*	0.01	0.01 (16.67%)	0.01 (16.67%)	0.01 (0%)
	Median (m^3/s)	0.04	0.05 (14.29%)	0.05 (11.9%)	0.04 (-2.38%)
	95th Percentile (m^3/s)	0.61	0.64 (4.43%)	0.62 (1.97%)	0.57 (-5.9%)
	99.8th Percentile (m^3/s)	2.73	2.71 (-0.59%)	2.65 (-2.78%)	2.49 (-8.79%)
	Mean Annual Discharge (ML/year)	4335.19	4,593.31 (5.95%)	4,474.61 (3.22%)	4,059.01 (-6.37%)
	FRE3 threshold (m^3/s)	0.13	0.13 (0%)	0.13 (0%)	0.13 (0%)
	FRE3 Frequency (events/year)	10.5	10.8 (2.86%)	10.8 (2.86%)	10.3 (-1.9%)

A.3 Water quality results

A.3.1 Suspended Sediment

Table A.4: Scenario Suspended Sediment Concentration (SSC in mg/L) statistics. Values in brackets represent percentage change compared to the baseline.

Reporting Point	Baseline		BAU		Improved		WS	
	Median (mg/l)	95th percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)
Horokiri and Motukaraka at Near Pauatahanui G.C.	4.57	98.54	4.57 (0%)	93.02 (-6%)	4.52 (-1%)	76.29 (-23%)	4.5 (-2%)	75.32 (-24%)
Belmont at Lincolnshire Farms	4.76	247.95	4.77 (0%)	171.11 (-31%)	3.53 (-26%)	69.32 (-72%)	3.98 (-16%)	95.82 (-61%)
Porirua at Willowbank	4.81	203.08	4.81 (0%)	190.29 (-6%)	4.26 (-11%)	117.13 (-42%)	4.41 (-8%)	127.96 (-37%)
Porirua at Kenepuru Drive	4.98	154.06	4.97 (0%)	153.71 (0%)	4.49 (-10%)	103.28 (-33%)	4.61 (-7%)	111.22 (-28%)
Taupo at Wetland	4.49	72.18	4.51 (0%)	62.73 (-13%)	4.23 (-6%)	44.38 (-39%)	4.34 (-3%)	45.8 (-37%)
Titahi at Titahi Bay	4.86	7.16	4.22 (-13%)	24.72 (245%)	2.81 (-42%)	8.02 (12%)	3.35 (-31%)	10.34 (44%)
Hongoeka to Pukerua at Hongoeka	4.58	56.32	4.59 (0%)	62.88 (12%)	4.57 (0%)	52.42 (-7%)	4.57 (0%)	53.18 (-6%)
Upper Duck Creek at Bottom of sub-catchment	4.74	936.14	4.74 (0%)	581.45 (-38%)	4.64 (-2%)	471.71 (-50%)	4.57 (-4%)	464.07 (-50%)
Lower Duck Creek at Mouth	4.75	266.13	4.71 (-1%)	205.5 (-23%)	4.45 (-6%)	141.2 (-47%)	4.47 (-6%)	150.66 (-43%)
Horokiri and Motukaraka at Battle Hill	4.49	100.15	4.49 (0%)	101.46 (1%)	4.45 (-1%)	79.61 (-21%)	4.44 (-1%)	77.77 (-22%)
Horokiri and Motukaraka at Mouth	4.64	98.21	4.64 (0%)	95.54 (-3%)	4.57 (-2%)	77.08 (-22%)	4.55 (-2%)	74.65 (-24%)
Kakaho at Mouth	4.49	135.34	4.49 (0%)	117.38 (-13%)	4.39 (-2%)	84.88 (-37%)	4.41 (-2%)	87.22 (-36%)
Upper Kenepuru at Bottom of sub-catchment	4.9	982.12	4.88 (0%)	601.98 (-39%)	4.79 (-2%)	493.27 (-50%)	4.73 (-3%)	494.75 (-50%)
Kenepuru at Infill case study	4.97	50.59	4.86 (-2%)	58.72 (16%)	4.62 (-7%)	46.65 (-8%)	4.71 (-5%)	47.19 (-7%)
Kenepuru at Mouth	4.97	151.51	4.86 (-2%)	104.4 (-31%)	4.4 (-11%)	71.83 (-53%)	4.56 (-8%)	80.24 (-47%)
Porirua at Mitchell Stream	4.48	223.48	4.49 (0%)	206.09 (-8%)	4.22 (-6%)	188.76 (-16%)	4.28 (-4%)	205.94 (-8%)
Rangituhi at Bottom of sub-catchment	4.29	384.21	4.28 (0%)	343.55 (-11%)	4.28 (0%)	343.55 (-11%)	4.28 (0%)	343.55 (-11%)
Onepoto Fringe at Elsdon	4.48	32.34	4.48 (0%)	32.89 (2%)	4.16 (-7%)	32.3 (0%)	3.95 (-12%)	32.24 (0%)
Mahinawa Stream at Mouth	4.29	104.29	4.29 (0%)	110.23 (6%)	4.29 (0%)	110.18 (6%)	4.28 (0%)	112.28 (8%)
Hukatai Stream at Mouth	4.67	60.05	4.67 (0%)	60.09 (0%)	4.65 (0%)	59.87 (0%)	4.62 (-1%)	61.34 (2%)
Whitireia at Mouth	4.91	164.94	4.91 (0%)	154.55 (-6%)	4.91 (0%)	154.53 (-6%)	4.91 (0%)	158.2 (-4%)
Moonshine at Bottom of sub-catchment	4.71	393.72	4.72 (0%)	394.83 (0%)	4.7 (0%)	336.55 (-15%)	4.7 (0%)	330.52 (-16%)
Pauatahanui at Middle reaches	4.78	436.64	4.79 (0%)	432.24 (-1%)	4.68 (-2%)	347.69 (-20%)	4.71 (-1%)	340.77 (-22%)
Pauatahanui at Mouth	4.91	388.79	4.91 (0%)	361.34 (-7%)	4.79 (-2%)	290.08 (-25%)	4.82 (-2%)	284.76 (-27%)
Porirua at Mouth	5.06	149.1	5.05 (0%)	137.97 (-7%)	4.59 (-9%)	92.63 (-38%)	4.7 (-7%)	102.2 (-31%)
Ration at Mouth	4.52	186.77	4.53 (0%)	174.2 (-7%)	4.47 (-1%)	145.7 (-22%)	4.45 (-2%)	144.55 (-23%)
Stebbings at Bottom of sub-catchment	4.48	600.88	4.71 (5%)	281.75 (-53%)	2.95 (-34%)	96.06 (-84%)	3.56 (-21%)	160.33 (-73%)
Takapu at Bottom of sub-catchment	4.6	458.94	4.6 (0%)	490.31 (7%)	4.56 (-1%)	361.33 (-21%)	4.55 (-1%)	343.12 (-25%)
Porirua at Granada North industrial	4.75	96.56	4.75 (0%)	96.75 (0%)	4.36 (-8%)	96.15 (0%)	4.14 (-13%)	96.66 (0%)
Taupo at Camborne case study	4.89	58.01	4.91 (0%)	43.83 (-24%)	2.85 (-42%)	20.47 (-65%)	3.46 (-29%)	27.32 (-53%)
Taupo at Mouth	4.59	50.15	4.59 (0%)	47 (-6%)	3.96 (-14%)	28.55 (-43%)	4.18 (-9%)	32.6 (-35%)

Table A.5: Scenario Suspended Sediment load statistics (in Tonnes/day). Values in brackets represent percentage change compared to the baseline

Reporting Point	Baseline		BAU		Improved		WS	
	Median (t/day)	95th percentile (t/day)	Median (t/day)	95th Percentile (t/day)	Median (t/day)	95th Percentile (t/day)	Median (t/day)	95th Percentile (t/day)
Horokiri and Motukaraka at Near Pauatahanui G.C.	0.15	3.53	0.15 (0%)	3.66 (4%)	0.15 (-3%)	2.99 (-15%)	0.15 (-3%)	2.96 (-16%)
Belmont at Lincolnshire Farms	0.01	2.76	0.02 (20%)	3.23 (17%)	0.01 (-15%)	1.26 (-54%)	0.01 (-14%)	1.3 (-53%)
Porirua at Willowbank	0.08	11.97	0.08 (4%)	13.39 (12%)	0.07 (-10%)	7.91 (-34%)	0.07 (-13%)	7.61 (-36%)
Porirua at Kenepuru Drive	0.16	15.82	0.16 (3%)	17.81 (13%)	0.14 (-10%)	11.6 (-27%)	0.14 (-12%)	11.11 (-30%)
Taupo at Wetland	0.01	0.50	0.01 (3%)	0.53 (7%)	0.01 (-5%)	0.37 (-26%)	0.01 (-10%)	0.34 (-33%)
Titahi at Titahi Bay	0.00	0.01	0 (-23%)	0.04 (165%)	0 (-49%)	0.01 (-11%)	0 (-51%)	0.01 (-8%)
Hongoeka to Pukerua at Hongoeka	0.00	0.08	0 (1%)	0.09 (11%)	0 (-2%)	0.07 (-8%)	0 (-3%)	0.07 (-8%)
Upper Duck Creek at Bottom of sub-catchment	0.01	3.05	0.01 (-10%)	2.27 (-25%)	0.01 (-15%)	1.84 (-40%)	0.01 (-17%)	1.78 (-42%)
Lower Duck Creek at Mouth	0.03	4.50	0.03 (-5%)	3.93 (-13%)	0.03 (-13%)	2.66 (-41%)	0.03 (-16%)	2.6 (-42%)
Horokiri and Motukaraka at Battle Hill	0.06	1.74	0.06 (0%)	1.76 (1%)	0.06 (-4%)	1.41 (-19%)	0.06 (-5%)	1.37 (-21%)
Horokiri and Motukaraka at Mouth	0.17	3.88	0.17 (1%)	4.04 (4%)	0.17 (-3%)	3.3 (-15%)	0.17 (-4%)	3.23 (-17%)
Kakaho at Mouth	0.04	1.48	0.04 (0%)	1.48 (0%)	0.04 (-4%)	1.02 (-31%)	0.04 (-5%)	0.98 (-34%)
Upper Kenepuru at Bottom of sub-catchment	0.00	1.56	0 (-8%)	1.15 (-26%)	0 (-9%)	0.96 (-38%)	0 (-11%)	0.95 (-39%)
Kenepuru at Infill case study	0.01	0.86	0.01 (-2%)	0.99 (15%)	0.01 (-7%)	0.78 (-9%)	0.01 (-13%)	0.71 (-17%)
Kenepuru at Mouth	0.03	5.20	0.03 (-3%)	4.01 (-23%)	0.03 (-12%)	2.78 (-46%)	0.03 (-15%)	2.69 (-48%)
Porirua at Mitchell Stream	0.01	1.45	0.01 (3%)	1.53 (6%)	0.01 (-3%)	1.34 (-7%)	0.01 (-4%)	1.35 (-7%)
Rangituhi at Bottom of sub-catchment	0.00	0.29	0 (-2%)	0.26 (-11%)	0 (-2%)	0.26 (-11%)	0 (-2%)	0.26 (-11%)
Onepoto Fringe at Elsdon	0.01	0.20	0.01 (0%)	0.21 (2%)	0.01 (-7%)	0.2 (0%)	0.01 (-11%)	0.2 (-1%)
Mahinawa Stream at Mouth	0.01	0.41	0.01 (0%)	0.43 (5%)	0.01 (0%)	0.43 (5%)	0.01 (-1%)	0.43 (5%)
Hukatai Stream at Mouth	0.00	0.11	0 (0%)	0.11 (0%)	0 (-1%)	0.11 (0%)	0 (-3%)	0.11 (-1%)
Whitireia at Mouth	0.00	0.14	0 (-3%)	0.13 (-9%)	0 (-3%)	0.13 (-9%)	0 (-4%)	0.13 (-9%)
Moonshine at Bottom of sub-catchment	0.05	5.98	0.05 (1%)	6.05 (1%)	0.05 (-1%)	5.4 (-10%)	0.05 (-2%)	5.22 (-13%)
Pauatahanui at Middle reaches	0.15	16.80	0.15 (1%)	18 (7%)	0.14 (-2%)	13.85 (-18%)	0.14 (-4%)	13.16 (-22%)
Pauatahanui at Mouth	0.17	17.24	0.17 (1%)	18.6 (8%)	0.17 (-2%)	14.84 (-14%)	0.16 (-4%)	14.01 (-19%)
Porirua at Mouth	0.22	21.51	0.22 (2%)	22.77 (6%)	0.19 (-12%)	14.96 (-30%)	0.19 (-14%)	14.69 (-32%)
Ration at Mouth	0.04	2.11	0.04 (0%)	2.18 (4%)	0.04 (-1%)	1.89 (-10%)	0.04 (-2%)	1.86 (-11%)
Stebbings at Bottom of sub-catchment	0.01	1.37	0.01 (18%)	2.18 (58%)	0 (-27%)	0.7 (-49%)	0 (-29%)	0.71 (-48%)
Takapu at Bottom of sub-catchment	0.02	3.52	0.02 (0%)	3.8 (8%)	0.02 (-3%)	2.96 (-16%)	0.02 (-5%)	2.76 (-22%)
Porirua at Granada North industrial	0.00	0.25	0 (0%)	0.25 (0%)	0 (-7%)	0.25 (0%)	0 (-11%)	0.25 (-1%)
Taupo at Camborne case study	0.00	0.13	0 (48%)	0.23 (75%)	0 (-8%)	0.1 (-22%)	0 (-13%)	0.09 (-27%)
Taupo at Mouth	0.02	0.65	0.02 (7%)	0.82 (26%)	0.02 (-8%)	0.5 (-23%)	0.02 (-13%)	0.45 (-30%)

Table A.6: Scenario Suspended Sediment load statistics (in tonnes/year). Values in brackets represent percentage change compared to the baseline.

Reporting Point	Average annual Load (t/year)			
	Baseline	BAU	Improved	WS
Horokiri and Motukaraka at Near Pauatahanui Golf Club	764	754 (-1.4%)	387 (-49.4%)	382 (-50%)
Belmont at Lincolnshire Farms	271	267 (-1.4%)	111 (-59%)	114 (-57.8%)
Porirua at Willowbank	1313	1393 (6.1%)	643 (-51%)	610 (-53.5%)
Porirua at Kenepuru Drive	1705	1808 (6.1%)	1026 (-39.8%)	981 (-42.5%)
Taupo at Wetland	61	53 (-13.7%)	33 (-45.7%)	29 (-52.4%)
Titahi at Titahi Bay	1	3 (152.8%)	1 (-12.5%)	1 (-11%)
Hongoeka to Pukerua at Hongoeka	7	7 (8.8%)	6 (-9.6%)	6 (-9.6%)
Upper Duck Creek at Bottom of sub-catchment	384	227 (-40.9%)	147 (-61.7%)	143 (-62.8%)
Lower Duck Creek at Mouth	526	381 (-27.5%)	231 (-56.1%)	225 (-57.2%)
Horokiri and Motukaraka at Battle Hill	367	369 (0.6%)	137 (-62.8%)	133 (-63.8%)
Horokiri and Motukaraka at Mouth	955	946 (-0.9%)	490 (-48.7%)	465 (-51.3%)
Kakaho at Mouth	245	238 (-3%)	89 (-63.6%)	86 (-65%)
Upper Kenepuru at Bottom of sub-catchment	526	126 (-76.1%)	88 (-83.2%)	88 (-83.3%)
Kenepuru at Infill case study	74	84 (14.6%)	67 (-8.9%)	61 (-16.6%)
Kenepuru at Mouth	818	372 (-54.6%)	244 (-70.2%)	238 (-70.9%)
Porirua at Mitchell Stream	124	130 (5.1%)	113 (-8.5%)	113 (-8.7%)
Rangituhi at Bottom of sub-catchment	26	22 (-13.1%)	22 (-13.1%)	22 (-13.1%)
Onepoto Fringe at Elsdon	20	20 (1.5%)	19 (-1.1%)	19 (-3%)
Mahinawa Stream at Mouth	41	43 (4.9%)	43 (4.7%)	42 (4.5%)
Hukatai Stream at Mouth	10	10 (0.1%)	10 (-0.4%)	10 (-0.9%)
Whitireia at Mouth	12	11 (-8.6%)	11 (-8.6%)	11 (-8.7%)
Moonshine at Bottom of sub-catchment	634	640 (0.9%)	504 (-20.5%)	489 (-22.9%)
Pauatahanui at Middle reaches	2311	2405 (4%)	1651 (-28.6%)	1473 (-36.3%)
Pauatahanui at Mouth	3214	3318 (3.2%)	2103 (-34.6%)	1840 (-42.7%)
Porirua at Mouth	2655	2329 (-12.3%)	1399 (-47.3%)	1334 (-49.8%)
Ration at Mouth	196	201 (2.5%)	172 (-12.2%)	170 (-13.5%)
Stebbings at Bottom of sub-catchment	112	180 (60.9%)	58 (-48%)	59 (-47.6%)
Takapu at Bottom of sub-catchment	647	667 (3.1%)	255 (-60.6%)	228 (-64.7%)
Porirua at Granada North industrial	22	22 (0.2%)	21 (-0.7%)	21 (-1.2%)
Taupo at Camborne case study	15	18 (25.6%)	8 (-43.2%)	7 (-49.2%)
Taupo at Mouth	87	85 (-1.7%)	52 (-40.1%)	44 (-49.5%)

A.3.2 *E. coli*

Table A.7: *E. coli* statistics as concentrations in cfu/100 mL. Values in brackets represent percentage change compared to the baseline.

Reporting Point	Baseline		BAU		Improved		WS	
	Median (cfu/100ml)	95th Percentile (cfu/100ml)	Median (cfu/100ml)	95th Percentile (cfu/100ml)	Median (cfu/100ml)	95th Percentile (cfu/100ml)	Median (cfu/100ml)	95th Percentile (cfu/100ml)
Horokiri and Motukaraka at Near Pauatahanui G.C.	166	2,723	143 (-14%)	2,129 (-22%)	56 (-66%)	861 (-68%)	46 (-72%)	700 (-74%)
Belmont at Lincolnshire Farms	814	5,704	687 (-16%)	4,431 (-22%)	128 (-84%)	1,134 (-80%)	146 (-82%)	1,237 (-78%)
Porirua at Willowbank	901	5,618	841 (-7%)	5,223 (-7%)	316 (-65%)	2,488 (-56%)	239 (-73%)	1,699 (-70%)
Porirua at Kenepuru Drive	891	5,820	844 (-5%)	5,495 (-6%)	262 (-71%)	1,961 (-66%)	209 (-77%)	1,403 (-76%)
Taupo at Wetland	479	4,586	441 (-8%)	4,089 (-11%)	186 (-61%)	1,983 (-57%)	88 (-82%)	869 (-81%)
Titahi at Titahi Bay	1,309	5,706	1,258 (-4%)	5,648 (-1%)	106 (-92%)	730 (-87%)	121 (-91%)	839 (-85%)
Hongoeka to Pukerua at Hongoeka	1,064	5,864	1,064 (0%)	5,864 (0%)	193 (-82%)	1,204 (-79%)	193 (-82%)	1,200 (-80%)
Upper Duck Creek at Bottom of sub-catchment	892	7,711	666 (-25%)	5,027 (-35%)	385 (-57%)	3,177 (-59%)	273 (-69%)	2,394 (-69%)
Lower Duck Creek at Mouth	703	4,783	647 (-8%)	4,201 (-12%)	180 (-74%)	1,500 (-69%)	137 (-81%)	1,093 (-77%)
Horokiri and Motukaraka at Battle Hill	220	3,355	207 (-6%)	3,152 (-6%)	87 (-60%)	1,345 (-60%)	67 (-70%)	987 (-71%)
Horokiri and Motukaraka at Mouth	157	2,621	127 (-19%)	2,001 (-24%)	73 (-54%)	1,273 (-51%)	50 (-68%)	849 (-68%)
Kakaho at Mouth	531	6,826	485 (-9%)	6,179 (-9%)	241 (-55%)	3,130 (-54%)	132 (-75%)	1,735 (-75%)
Upper Kenepuru at Bottom of sub-catchment	2,505	10,721	1,640 (-35%)	6,590 (-39%)	670 (-73%)	3,238 (-70%)	527 (-79%)	2,610 (-76%)
Kenepuru at Infill case study	1,921	7,731	1,916 (0%)	7,732 (0%)	491 (-74%)	2,751 (-64%)	292 (-85%)	1,542 (-80%)
Kenepuru at Mouth	1,417	6,483	1,334 (-6%)	6,002 (-7%)	314 (-78%)	1,859 (-71%)	262 (-82%)	1,434 (-78%)
Porirua at Mitchell Stream	864	7,024	829 (-4%)	6,451 (-8%)	186 (-78%)	1,788 (-75%)	179 (-79%)	1,674 (-76%)
Rangituhi at Bottom of sub-catchment	384	7,026	25 (-93%)	50 (-99%)	25 (-93%)	50 (-99%)	25 (-93%)	50 (-99%)
Onepoto Fringe at Elsdon	745	5,660	745 (0%)	5,660 (0%)	111 (-85%)	1,189 (-79%)	99 (-87%)	1,018 (-82%)
Mahinawa Stream at Mouth	542	5,682	542 (0%)	5,682 (0%)	205 (-62%)	2,489 (-56%)	202 (-63%)	2,503 (-56%)
Hukatai Stream at Mouth	942	5,086	942 (0%)	5,086 (0%)	303 (-68%)	2,176 (-57%)	303 (-68%)	2,137 (-58%)
Whitireia at Mouth	1,198	5,213	741 (-38%)	3,165 (-39%)	114 (-90%)	711 (-86%)	112 (-91%)	702 (-87%)
Moonshine at Bottom of sub-catchment	319	4,162	283 (-11%)	3,713 (-11%)	198 (-38%)	2,630 (-37%)	145 (-55%)	1,938 (-53%)
Pauatahanui at Middle reaches	231	3,022	193 (-16%)	2,370 (-22%)	111 (-52%)	1,488 (-51%)	72 (-69%)	958 (-68%)
Pauatahanui at Mouth	200	2,353	164 (-18%)	1,826 (-22%)	73 (-64%)	908 (-61%)	48 (-76%)	594 (-75%)
Porirua at Mouth	656	4,454	622 (-5%)	4,175 (-6%)	170 (-74%)	1,388 (-69%)	140 (-79%)	979 (-78%)
Ration at Mouth	241	4,145	99 (-59%)	1,327 (-68%)	61 (-75%)	861 (-79%)	36 (-85%)	475 (-89%)
Stebbings at Bottom of sub-catchment	829	8,682	931 (12%)	5,877 (-32%)	174 (-79%)	1,930 (-78%)	85 (-90%)	855 (-90%)
Takapu at Bottom of sub-catchment	1,361	10,130	1,361 (0%)	10,129 (0%)	765 (-44%)	6,086 (-40%)	500 (-63%)	3,918 (-61%)
Porirua at Granada North industrial	1,363	6,152	1,363 (0%)	6,152 (0%)	441 (-68%)	2,588 (-58%)	423 (-69%)	2,521 (-59%)
Taupo at Camborne case study	1,932	10,066	1,291 (-33%)	6,597 (-34%)	372 (-81%)	2,468 (-75%)	83 (-96%)	529 (-95%)
Taupo at Mouth	735	5,299	641 (-13%)	4,439 (-16%)	184 (-75%)	1,673 (-68%)	91 (-88%)	757 (-86%)

Table A.8: Average annual *E. coli* load (peta organisms/year). Values in brackets represent percentage change compared to the baseline.

Reporting Point	Average annual Load (peta organisms/year)			
	Baseline	BAU	Improved	WS
Horokiri and Motukaraka at Near Pauatahanui Golf Club	0.280	0.227 (-19%)	0.089 (-68%)	0.071 (-74.6%)
Belmont at Lincolnshire Farms	0.135	0.129 (-4.3%)	0.056 (-58.7%)	0.043 (-67.8%)
Porirua at Willowbank	0.557	0.555 (-0.3%)	0.276 (-50.5%)	0.182 (-67.4%)
Porirua at Milk Depot	0.869	0.864 (-0.5%)	0.419 (-51.8%)	0.295 (-66.1%)
Taupo at Wetland	0.109	0.099 (-9.6%)	0.047 (-57.2%)	0.02 (-82.2%)
Titahi at Titahi Bay	0.009	0.008 (-12.5%)	0.001 (-86.2%)	0.001 (-88.2%)
Hongoeka to Pukerua at Hongoeka	0.022	0.022 (0%)	0.004 (-80.7%)	0.004 (-80.8%)
Upper Duck Creek at Bottom of sub-catchment	0.133	0.084 (-37.3%)	0.052 (-61.1%)	0.038 (-71.1%)
Lower Duck Creek at Mouth	0.170	0.142 (-16.4%)	0.059 (-65.5%)	0.042 (-75.3%)
Horokiri and Motukaraka at Battle Hill	0.169	0.159 (-6%)	0.066 (-61.2%)	0.046 (-72.8%)
Horokiri and Motukaraka at Mouth	0.301	0.238 (-21%)	0.141 (-53.1%)	0.094 (-68.9%)
Kakaho at Mouth	0.271	0.249 (-8.1%)	0.12 (-55.7%)	0.064 (-76.5%)
Upper Kenepuru at Bottom of sub-catchment	0.100	0.059 (-41.1%)	0.028 (-71.9%)	0.023 (-77.3%)
Kenepuru at Infill case study	0.207	0.206 (-0.4%)	0.103 (-50.2%)	0.073 (-64.6%)
Kenepuru at Mouth	0.446	0.428 (-4.1%)	0.221 (-50.5%)	0.173 (-61.2%)
Porirua at Mitchell Stream	0.076	0.069 (-9.9%)	0.022 (-70.9%)	0.02 (-74.3%)
Rangituhi at Bottom of sub-catchment	0.013	0 (-99%)	0 (-99%)	0 (-99%)
Onepoto Fringe at Elsdon	0.031	0.031 (0%)	0.009 (-70.4%)	0.007 (-77%)
Mahinawa Stream at Mouth	0.033	0.033 (0%)	0.015 (-53.2%)	0.015 (-53.6%)
Hukatai Stream at Mouth	0.013	0.013 (0%)	0.006 (-52.1%)	0.006 (-54%)
Whitireia at Mouth	0.013	0.007 (-50.3%)	0.001 (-88.8%)	0.001 (-89%)
Moonshine at Bottom of sub-catchment	0.186	0.165 (-11%)	0.117 (-37%)	0.084 (-54.9%)
Pauatahanui at Elmwood Bridge	0.420	0.335 (-20.2%)	0.21 (-49.9%)	0.125 (-70.1%)
Pauatahanui at Mouth	0.320	0.246 (-23.3%)	0.142 (-55.8%)	0.085 (-73.6%)
Porirua at Mouth	1.021	1.007 (-1.4%)	0.522 (-48.9%)	0.387 (-62.1%)
Ration at Mouth	0.098	0.029 (-70.1%)	0.021 (-78.6%)	0.011 (-88.3%)
Stebbings at Bottom of sub-catchment	0.063	0.059 (-5.9%)	0.017 (-72.5%)	0.006 (-89.9%)
Takapu at Bottom of sub-catchment	0.266	0.266 (0%)	0.159 (-40%)	0.098 (-63%)
Porirua at Granada North industrial	0.022	0.022 (0%)	0.01 (-54%)	0.01 (-55.5%)
Taupo at Camborne case study	0.066	0.022 (0%)	0.01 (-54%)	0.01 (-55.5%)
Taupo at Mouth	0.172	0.052 (-21.1%)	0.018 (-72.5%)	0.003 (-95%)

A.3.3 Nitrogen species

Table A.9: Total Nitrogen (mg/L) statistics. Values in brackets represent percentage change compared to the baseline.

Reporting Point	Baseline		BAU		Improved		WS	
	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)
Horokiri and Motukaraka at Near Pauatahanui G.C.	0.4	2.058	0.391 (-2%)	1.883 (-9%)	0.36 (-10%)	1.393 (-32%)	0.35 (-13%)	1.231 (-40%)
Belmont at Lincolnshire Farms	0.924	3.279	0.8 (-13%)	2.105 (-36%)	0.713 (-23%)	1.984 (-39%)	0.825 (-11%)	2.246 (-32%)
Porirua at Willowbank	0.826	2.87	0.782 (-5%)	2.536 (-12%)	0.736 (-11%)	2.419 (-16%)	0.739 (-11%)	2.069 (-28%)
Porirua at Kenepuru Drive	0.737	2.301	0.699 (-5%)	2.083 (-9%)	0.661 (-10%)	1.973 (-14%)	0.656 (-11%)	1.76 (-24%)
Taupo at Wetland	0.597	3.279	0.571 (-4%)	3.058 (-7%)	0.529 (-11%)	2.708 (-17%)	0.46 (-23%)	1.705 (-48%)
Titahi at Titahi Bay	0.59	1.336	0.776 (32%)	1.584 (19%)	0.646 (9%)	1.405 (5%)	0.743 (26%)	1.584 (19%)
Hongoeka to Pukerua at Hongoeka	0.771	2.509	0.771 (0%)	2.509 (0%)	0.703 (-9%)	1.629 (-35%)	0.704 (-9%)	1.632 (-35%)
Upper Duck Creek at Bottom of sub-catchment	0.575	3.667	0.475 (-17%)	2.509 (-32%)	0.429 (-25%)	2.02 (-45%)	0.391 (-32%)	1.651 (-55%)
Lower Duck Creek at Mouth	0.636	2.25	0.599 (-6%)	1.822 (-19%)	0.562 (-12%)	1.645 (-27%)	0.556 (-13%)	1.434 (-36%)
Horokiri and Motukaraka at Battle Hill	0.442	2.344	0.44 (0%)	2.309 (-1%)	0.407 (-8%)	1.686 (-28%)	0.385 (-13%)	1.33 (-43%)
Horokiri and Motukaraka at Mouth	0.326	1.993	0.317 (-3%)	1.811 (-9%)	0.294 (-10%)	1.499 (-25%)	0.279 (-14%)	1.24 (-38%)
Kakaho at Mouth	0.491	3.404	0.479 (-2%)	3.249 (-5%)	0.41 (-16%)	2.37 (-30%)	0.365 (-26%)	1.592 (-53%)
Upper Kenepuru at Bottom of sub-catchment	1.008	3.866	0.828 (-18%)	2.681 (-31%)	0.743 (-26%)	2.134 (-45%)	0.715 (-29%)	1.94 (-50%)
Kenepuru at Infill case study	0.981	2.591	0.992 (1%)	2.609 (1%)	0.97 (-1%)	2.572 (-1%)	0.947 (-3%)	2.03 (-22%)
Kenepuru at Mouth	0.992	2.539	0.93 (-6%)	2.273 (-10%)	0.882 (-11%)	2.137 (-16%)	0.901 (-9%)	1.992 (-22%)
Porirua at Mitchell Stream	0.788	2.52	0.737 (-6%)	2.128 (-16%)	0.699 (-11%)	1.816 (-28%)	0.709 (-10%)	1.793 (-29%)
Rangituhi at Bottom of sub-catchment	0.621	2.889	0.555 (-11%)	0.736 (-75%)	0.555 (-11%)	0.736 (-75%)	0.555 (-11%)	0.736 (-75%)
Onepoto Fringe at Elsdon	0.561	1.246	0.561 (0%)	1.246 (0%)	0.55 (-2%)	1.136 (-9%)	0.54 (-4%)	1.05 (-16%)
Mahinawa Stream at Mouth	0.658	2.478	0.658 (0%)	2.478 (0%)	0.658 (0%)	2.474 (0%)	0.659 (0%)	2.499 (1%)
Hukatai Stream at Mouth	0.859	2.024	0.858 (0%)	2.024 (0%)	0.857 (0%)	2.012 (-1%)	0.862 (0%)	2.026 (0%)
Whitireia at Mouth	1.535	2.908	1.403 (-9%)	1.883 (-35%)	1.403 (-9%)	1.883 (-35%)	1.417 (-8%)	1.887 (-35%)
Moonshine at Bottom of sub-catchment	0.406	2.315	0.401 (-1%)	2.22 (-4%)	0.391 (-4%)	2.059 (-11%)	0.368 (-9%)	1.652 (-29%)
Pauatahanui at Middle reaches	0.301	2.025	0.289 (-4%)	1.833 (-9%)	0.28 (-7%)	1.754 (-13%)	0.256 (-15%)	1.316 (-35%)
Pauatahanui at Mouth	0.234	1.526	0.222 (-5%)	1.371 (-10%)	0.215 (-8%)	1.321 (-13%)	0.197 (-16%)	1.01 (-34%)
Porirua at Mouth	0.725	2.186	0.684 (-6%)	1.972 (-10%)	0.645 (-11%)	1.858 (-15%)	0.636 (-12%)	1.675 (-23%)
Ration at Mouth	0.541	2.767	0.502 (-7%)	2.065 (-25%)	0.497 (-8%)	2.035 (-26%)	0.485 (-10%)	1.827 (-34%)
Stebbings at Bottom of sub-catchment	0.846	4.843	0.802 (-5%)	2.62 (-46%)	0.69 (-18%)	2.485 (-49%)	0.792 (-6%)	1.921 (-60%)
Takapu at Bottom of sub-catchment	0.811	4.243	0.811 (0%)	4.243 (0%)	0.774 (-5%)	3.914 (-8%)	0.683 (-16%)	2.862 (-33%)
Porirua at Granada North industrial	0.814	1.989	0.814 (0%)	1.989 (0%)	0.8 (-2%)	1.962 (-1%)	0.781 (-4%)	1.933 (-3%)
Taupo at Camborne case study	0.874	4.746	0.729 (-17%)	3.064 (-35%)	0.625 (-28%)	2.759 (-42%)	0.614 (-30%)	1.544 (-67%)
Taupo at Mouth	0.556	2.863	0.528 (-5%)	2.501 (-13%)	0.475 (-15%)	2.22 (-22%)	0.43 (-23%)	1.451 (-49%)

Table A.10: Average annual TN load (kg/year). Values in brackets represent percentage change compared to the baseline.

Reporting Point	Average annual Load (kg/year)			
	Baseline	BAU	Improved	WS
Horokiri and Motukaraka at Near Pauatahanui Golf Club	23826	22586 (-5.2%)	16774 (-29.6%)	14736 (-38.2%)
Belmont at Lincolnshire Farms	6616	5261 (-20.5%)	4776 (-27.8%)	4742 (-28.3%)
Porirua at Willowbank	30294	28426 (-6.2%)	26637 (-12.1%)	21686 (-28.4%)
Porirua at Milk Depot	38236	36283 (-5.1%)	34045 (-11%)	29108 (-23.9%)
Taupo at Wetland	7821	7507 (-4%)	6510 (-16.8%)	3941 (-49.6%)
Titahi at Titahi Bay	225	235 (4.6%)	200 (-11%)	189 (-16.1%)
Hongoeka to Pukerua at Hongoeka	1017	1017 (0%)	664 (-34.7%)	663 (-34.9%)
Upper Duck Creek at Bottom of sub-catchment	6301	4213 (-33.1%)	3327 (-47.2%)	2690 (-57.3%)
Lower Duck Creek at Mouth	8867	7259 (-18.1%)	6438 (-27.4%)	5442 (-38.6%)
Horokiri and Motukaraka at Battle Hill	13113	12923 (-1.4%)	9394 (-28.4%)	7377 (-43.7%)
Horokiri and Motukaraka at Mouth	25712	24129 (-6.2%)	19403 (-24.5%)	16172 (-37.1%)
Kakaho at Mouth	13912	13494 (-3%)	9610 (-30.9%)	6376 (-54.2%)
Upper Kenepuru at Bottom of sub-catchment	3673	2490 (-32.2%)	1952 (-46.9%)	1778 (-51.6%)
Kenepuru at Infill case study	5516	5524 (0.1%)	5435 (-1.5%)	4151 (-24.7%)
Kenepuru at Mouth	14301	13156 (-8%)	12277 (-14.2%)	10729 (-25%)
Porirua at Mitchell Stream	3368	2961 (-12.1%)	2532 (-24.8%)	2427 (-27.9%)
Rangituhi at Bottom of sub-catchment	597	216 (-63.9%)	216 (-63.9%)	216 (-63.9%)
Onepoto Fringe at Elsdon	893	893 (0%)	847 (-5.1%)	796 (-10.9%)
Mahinawa Stream at Mouth	1758	1758 (0%)	1755 (-0.2%)	1744 (-0.8%)
Hukatai Stream at Mouth	621	621 (0%)	620 (-0.2%)	611 (-1.6%)
Whitireia at Mouth	842	559 (-33.7%)	559 (-33.7%)	557 (-33.9%)
Moonshine at Bottom of sub-catchment	10923	10561 (-3.3%)	9745 (-10.8%)	7848 (-28.2%)
Pauatahanui at Elmwood Bridge	28425	26271 (-7.6%)	25054 (-11.9%)	18085 (-36.4%)
Pauatahanui at Mouth	23810	21859 (-8.2%)	20927 (-12.1%)	15432 (-35.2%)
Porirua at Mouth	50480	47616 (-5.7%)	44511 (-11.8%)	38374 (-24%)
Ration at Mouth	7460	5911 (-20.8%)	5830 (-21.8%)	5279 (-29.2%)
Stebbings at Bottom of sub-catchment	3547	2762 (-22.1%)	2429 (-31.5%)	1623 (-54.2%)
Takapu at Bottom of sub-catchment	11472	11471 (0%)	10460 (-8.8%)	7474 (-34.8%)
Porirua at Granada North industrial	832	832 (0%)	816 (-1.9%)	798 (-4.1%)
Taupo at Camborne case study	3056	2392 (-21.7%)	2058 (-32.7%)	1029 (-66.3%)
Taupo at Mouth	10044	9225 (-8.2%)	8029 (-20.1%)	4914 (-51.1%)

Table A.11: Nitrate-Nitrogen (in mg/L) statistics. Values in brackets represent percentage change compared to the baseline.

Reporting Point	Baseline		BAU		Improved		WS	
	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)
Horokiri and Motukaraka at Near Pauatahanui G.C.	0.279	1.5	0.272 (-3%)	1.373 (-8%)	0.252 (-10%)	1.022 (-32%)	0.246 (-12%)	0.9 (-40%)
Belmont at Lincolnshire Farms	0.735	2.524	0.639 (-13%)	1.611 (-36%)	0.571 (-22%)	1.541 (-39%)	0.66 (-10%)	1.765 (-30%)
Porirua at Willowbank	0.656	2.272	0.621 (-5%)	2.009 (-12%)	0.588 (-10%)	1.915 (-16%)	0.591 (-10%)	1.645 (-28%)
Porirua at Kenepuru Drive	0.58	1.777	0.55 (-5%)	1.607 (-10%)	0.528 (-9%)	1.534 (-14%)	0.524 (-10%)	1.384 (-22%)
Taupo at Wetland	0.436	2.471	0.416 (-5%)	2.307 (-7%)	0.388 (-11%)	2.053 (-17%)	0.336 (-23%)	1.28 (-48%)
Titahi at Titahi Bay	0.472	1.051	0.62 (31%)	1.252 (19%)	0.517 (10%)	1.108 (5%)	0.597 (26%)	1.266 (20%)
Hongoeka to Pukerua at Hongoeka	0.573	1.915	0.573 (0%)	1.915 (0%)	0.522 (-9%)	1.248 (-35%)	0.523 (-9%)	1.251 (-35%)
Upper Duck Creek at Bottom of sub-catchment	0.376	2.577	0.317 (-16%)	1.773 (-31%)	0.287 (-24%)	1.431 (-44%)	0.263 (-30%)	1.162 (-55%)
Lower Duck Creek at Mouth	0.468	1.602	0.444 (-5%)	1.327 (-17%)	0.419 (-10%)	1.21 (-24%)	0.416 (-11%)	1.057 (-34%)
Horokiri and Motukaraka at Battle Hill	0.315	1.712	0.313 (-1%)	1.68 (-2%)	0.291 (-8%)	1.235 (-28%)	0.277 (-12%)	0.984 (-43%)
Horokiri and Motukaraka at Mouth	0.217	1.434	0.211 (-3%)	1.3 (-9%)	0.197 (-9%)	1.082 (-25%)	0.186 (-14%)	0.898 (-37%)
Kakaho at Mouth	0.346	2.554	0.338 (-2%)	2.427 (-5%)	0.291 (-16%)	1.784 (-30%)	0.258 (-25%)	1.192 (-53%)
Upper Kenepuru at Bottom of sub-catchment	0.756	2.939	0.631 (-17%)	2.065 (-30%)	0.572 (-24%)	1.662 (-43%)	0.549 (-27%)	1.506 (-49%)
Kenepuru at Infill case study	0.78	2.018	0.79 (1%)	2.03 (1%)	0.776 (-1%)	2.014 (0%)	0.757 (-3%)	1.602 (-21%)
Kenepuru at Mouth	0.781	1.94	0.736 (-6%)	1.745 (-10%)	0.702 (-10%)	1.657 (-15%)	0.719 (-8%)	1.547 (-20%)
Porirua at Mitchell Stream	0.628	2.015	0.589 (-6%)	1.682 (-17%)	0.559 (-11%)	1.446 (-28%)	0.567 (-10%)	1.435 (-29%)
Rangituhi at Bottom of sub-catchment	0.497	2.311	0.444 (-11%)	0.588 (-75%)	0.444 (-11%)	0.588 (-75%)	0.444 (-11%)	0.588 (-75%)
Onepoto Fringe at Elsdon	0.447	0.959	0.447 (0%)	0.959 (0%)	0.44 (-2%)	0.904 (-6%)	0.432 (-3%)	0.843 (-12%)
Mahinawa Stream at Mouth	0.526	1.984	0.526 (0%)	1.984 (0%)	0.526 (0%)	1.981 (0%)	0.528 (0%)	2 (1%)
Hukatai Stream at Mouth	0.686	1.609	0.685 (0%)	1.609 (0%)	0.685 (0%)	1.608 (0%)	0.691 (1%)	1.621 (1%)
Whitireia at Mouth	1.227	2.327	1.122 (-9%)	1.506 (-35%)	1.122 (-9%)	1.506 (-35%)	1.133 (-8%)	1.511 (-35%)
Moonshine at Bottom of sub-catchment	0.27	1.627	0.265 (-2%)	1.569 (-4%)	0.259 (-4%)	1.448 (-11%)	0.245 (-9%)	1.161 (-29%)
Pauatahanui at Middle reaches	0.178	1.323	0.17 (-4%)	1.194 (-10%)	0.165 (-7%)	1.147 (-13%)	0.152 (-15%)	0.859 (-35%)
Pauatahanui at Mouth	0.131	0.941	0.123 (-6%)	0.843 (-10%)	0.12 (-8%)	0.814 (-13%)	0.11 (-16%)	0.632 (-33%)
Porirua at Mouth	0.569	1.669	0.538 (-5%)	1.502 (-10%)	0.515 (-9%)	1.43 (-14%)	0.507 (-11%)	1.312 (-21%)
Ration at Mouth	0.399	2.096	0.37 (-7%)	1.567 (-25%)	0.366 (-8%)	1.548 (-26%)	0.358 (-10%)	1.382 (-34%)
Stebbings at Bottom of sub-catchment	0.675	3.875	0.641 (-5%)	2.099 (-46%)	0.552 (-18%)	1.989 (-49%)	0.633 (-6%)	1.537 (-60%)
Takapu at Bottom of sub-catchment	0.648	3.394	0.648 (0%)	3.394 (0%)	0.618 (-5%)	3.131 (-8%)	0.545 (-16%)	2.29 (-33%)
Porirua at Granada North industrial	0.651	1.594	0.651 (0%)	1.594 (0%)	0.64 (-2%)	1.571 (-1%)	0.626 (-4%)	1.549 (-3%)
Taupo at Camborne case study	0.648	3.647	0.544 (-16%)	2.359 (-35%)	0.467 (-28%)	2.114 (-42%)	0.458 (-29%)	1.185 (-68%)
Taupo at Mouth	0.393	2.101	0.372 (-5%)	1.826 (-13%)	0.338 (-14%)	1.629 (-22%)	0.304 (-23%)	1.06 (-50%)

Table A.12: Average annual Nitrate-Nitrogen load (kg/year). Values in brackets represent percentage change compared to the baseline

Reporting Point	Average annual Load (kg/year)			
	Baseline	BAU	Improved	WS
Horokiri and Motukaraka at Near Pauatahanui Golf Club	17224	16280 (-5.5%)	12140 (-29.5%)	10721 (-37.8%)
Belmont at Lincolnshire Farms	5139	4059 (-21%)	3703 (-28%)	3719 (-27.6%)
Porirua at Willowbank	23994	22505 (-6.2%)	21113 (-12%)	17227 (-28.2%)
Porirua at Milk Depot	29636	28076 (-5.3%)	26497 (-10.6%)	22834 (-23%)
Taupo at Wetland	5887	5655 (-3.9%)	4912 (-16.6%)	2955 (-49.8%)
Titahi at Titahi Bay	179	187 (4.5%)	159 (-11%)	151 (-15.8%)
Hongoeka to Pukerua at Hongoeka	777	777 (0%)	507 (-34.8%)	506 (-34.9%)
Upper Duck Creek at Bottom of sub-catchment	4440	2976 (-33%)	2359 (-46.9%)	1901 (-57.2%)
Lower Duck Creek at Mouth	6364	5302 (-16.7%)	4747 (-25.4%)	4019 (-36.8%)
Horokiri and Motukaraka at Battle Hill	9547	9400 (-1.5%)	6857 (-28.2%)	5432 (-43.1%)
Horokiri and Motukaraka at Mouth	18252	17076 (-6.4%)	13859 (-24.1%)	11543 (-36.8%)
Kakaho at Mouth	10407	10087 (-3.1%)	7214 (-30.7%)	4755 (-54.3%)
Upper Kenepuru at Bottom of sub-catchment	2795	1917 (-31.4%)	1518 (-45.7%)	1379 (-50.7%)
Kenepuru at Infill case study	4190	4196 (0.1%)	4136 (-1.3%)	3138 (-25.1%)
Kenepuru at Mouth	10630	9773 (-8.1%)	9167 (-13.8%)	8051 (-24.3%)
Porirua at Mitchell Stream	2684	2359 (-12.1%)	2018 (-24.8%)	1937 (-27.8%)
Rangituhi at Bottom of sub-catchment	477	172 (-63.9%)	172 (-63.9%)	172 (-63.9%)
Onepoto Fringe at Elsdon	694	694 (0%)	664 (-4.3%)	630 (-9.3%)
Mahinawa Stream at Mouth	1407	1407 (0%)	1405 (-0.2%)	1396 (-0.8%)
Hukatai Stream at Mouth	496	496 (0%)	495 (-0.1%)	489 (-1.4%)
Whitireia at Mouth	674	447 (-33.6%)	447 (-33.7%)	445 (-33.9%)
Moonshine at Bottom of sub-catchment	7685	7411 (-3.6%)	6842 (-11%)	5497 (-28.5%)
Pauatahanui at Elmwood Bridge	18638	17191 (-7.8%)	16406 (-12%)	11842 (-36.5%)
Pauatahanui at Mouth	14736	13486 (-8.5%)	12930 (-12.3%)	9579 (-35%)
Porirua at Mouth	38428	36195 (-5.8%)	34010 (-11.5%)	29555 (-23.1%)
Ration at Mouth	5644	4467 (-20.9%)	4406 (-21.9%)	3992 (-29.3%)
Stebbings at Bottom of sub-catchment	2837	2212 (-22%)	1945 (-31.4%)	1299 (-54.2%)
Takapu at Bottom of sub-catchment	9176	9175 (0%)	8367 (-8.8%)	5977 (-34.9%)
Porirua at Granada North industrial	666	666 (0%)	653 (-1.9%)	639 (-4.1%)
Taupo at Camborne case study	2345	1837 (-21.7%)	1580 (-32.6%)	788 (-66.4%)
Taupo at Mouth	7377	6777 (-8.1%)	5906 (-20%)	3602 (-51.2%)

Table A.13: Ammoniacal-Nitrogen (mg/L) statistics. Values in brackets represent percentage change compared to the baseline.

Reporting Point	Baseline		BAU		Improved		WS	
	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)
Horokiri and Motukaraka at Near Pauatahanui G.C.	0.008	0.034	0.008 (0%)	0.032 (-6%)	0.007 (-13%)	0.025 (-26%)	0.007 (-13%)	0.022 (-35%)
Belmont at Lincolnshire Farms	0.017	0.062	0.015 (-12%)	0.043 (-31%)	0.013 (-24%)	0.037 (-40%)	0.016 (-6%)	0.041 (-34%)
Porirua at Willowbank	0.015	0.058	0.015 (0%)	0.052 (-10%)	0.014 (-7%)	0.045 (-22%)	0.014 (-7%)	0.038 (-34%)
Porirua at Kenepuru Drive	0.013	0.098	0.013 (0%)	0.09 (-8%)	0.012 (-8%)	0.04 (-59%)	0.012 (-8%)	0.033 (-66%)
Taupo at Wetland	0.011	0.052	0.011 (0%)	0.05 (-4%)	0.01 (-9%)	0.045 (-13%)	0.009 (-18%)	0.031 (-40%)
Titahi at Titahi Bay	0.011	0.027	0.015 (36%)	0.033 (22%)	0.013 (18%)	0.029 (7%)	0.014 (27%)	0.032 (19%)
Hongoeka to Pukerua at Hongoeka	0.015	0.043	0.015 (0%)	0.043 (0%)	0.014 (-7%)	0.03 (-30%)	0.014 (-7%)	0.03 (-30%)
Upper Duck Creek at Bottom of sub-catchment	0.013	0.063	0.011 (-15%)	0.044 (-30%)	0.01 (-23%)	0.036 (-43%)	0.009 (-31%)	0.03 (-52%)
Lower Duck Creek at Mouth	0.013	0.044	0.012 (-8%)	0.036 (-18%)	0.012 (-8%)	0.032 (-27%)	0.012 (-8%)	0.028 (-36%)
Horokiri and Motukaraka at Battle Hill	0.009	0.038	0.009 (0%)	0.037 (-3%)	0.008 (-11%)	0.029 (-24%)	0.008 (-11%)	0.023 (-39%)
Horokiri and Motukaraka at Mouth	0.006	0.032	0.006 (0%)	0.03 (-6%)	0.006 (0%)	0.026 (-19%)	0.006 (0%)	0.022 (-31%)
Kakaho at Mouth	0.009	0.055	0.009 (0%)	0.053 (-4%)	0.008 (-11%)	0.039 (-29%)	0.007 (-22%)	0.028 (-49%)
Upper Kenepuru at Bottom of sub-catchment	0.019	0.064	0.016 (-16%)	0.046 (-28%)	0.015 (-21%)	0.037 (-42%)	0.014 (-26%)	0.034 (-47%)
Kenepuru at Infill case study	0.019	0.052	0.019 (0%)	0.053 (2%)	0.019 (0%)	0.05 (-4%)	0.018 (-5%)	0.04 (-23%)
Kenepuru at Mouth	0.019	0.08	0.018 (-5%)	0.075 (-6%)	0.017 (-11%)	0.043 (-46%)	0.017 (-11%)	0.039 (-51%)
Porirua at Mitchell Stream	0.015	0.05	0.014 (-7%)	0.043 (-14%)	0.013 (-13%)	0.035 (-30%)	0.014 (-7%)	0.034 (-32%)
Rangituhi at Bottom of sub-catchment	0.012	0.045	0.011 (-8%)	0.014 (-69%)	0.011 (-8%)	0.014 (-69%)	0.011 (-8%)	0.014 (-69%)
Onepoto Fringe at Elsdon	0.011	0.044	0.011 (0%)	0.044 (0%)	0.011 (0%)	0.023 (-48%)	0.011 (0%)	0.021 (-52%)
Mahinawa Stream at Mouth	0.013	0.042	0.013 (0%)	0.042 (0%)	0.013 (0%)	0.042 (0%)	0.013 (0%)	0.042 (0%)
Hukatai Stream at Mouth	0.017	0.039	0.017 (0%)	0.039 (0%)	0.017 (0%)	0.038 (-3%)	0.017 (0%)	0.037 (-5%)
Whitireia at Mouth	0.03	0.052	0.027 (-10%)	0.037 (-29%)	0.027 (-10%)	0.037 (-29%)	0.027 (-10%)	0.037 (-29%)
Moonshine at Bottom of sub-catchment	0.009	0.042	0.009 (0%)	0.041 (-2%)	0.009 (0%)	0.038 (-10%)	0.009 (0%)	0.032 (-24%)
Pauatahanui at Middle reaches	0.008	0.039	0.007 (-13%)	0.037 (-5%)	0.007 (-13%)	0.035 (-10%)	0.007 (-13%)	0.028 (-28%)
Pauatahanui at Mouth	0.006	0.032	0.006 (0%)	0.03 (-6%)	0.006 (0%)	0.029 (-9%)	0.005 (-17%)	0.023 (-28%)
Porirua at Mouth	0.013	0.103	0.012 (-8%)	0.094 (-9%)	0.011 (-15%)	0.04 (-61%)	0.011 (-15%)	0.031 (-70%)
Ration at Mouth	0.011	0.046	0.01 (-9%)	0.039 (-15%)	0.01 (-9%)	0.039 (-15%)	0.01 (-9%)	0.035 (-24%)
Stebbings at Bottom of sub-catchment	0.016	0.076	0.016 (0%)	0.045 (-41%)	0.013 (-19%)	0.042 (-45%)	0.016 (0%)	0.036 (-53%)
Takapu at Bottom of sub-catchment	0.015	0.066	0.015 (0%)	0.066 (0%)	0.014 (-7%)	0.062 (-6%)	0.013 (-13%)	0.047 (-29%)
Porirua at Granada North industrial	0.016	0.036	0.016 (0%)	0.036 (0%)	0.015 (-6%)	0.036 (0%)	0.015 (-6%)	0.035 (-3%)
Taupo at Camborne case study	0.017	0.076	0.014 (-18%)	0.052 (-32%)	0.012 (-29%)	0.047 (-38%)	0.012 (-29%)	0.03 (-61%)
Taupo at Mouth	0.011	0.051	0.01 (-9%)	0.045 (-12%)	0.009 (-18%)	0.039 (-24%)	0.008 (-27%)	0.027 (-47%)

Table A.14: Average annual Ammoniacal-Nitrogen load (kg/year). Values in brackets represent percentage change compared to the baseline.

Reporting Point	Average annual Load (kg/year)			
	Baseline	BAU	Improved	WS
Horokiri and Motukaraka at Near Pauatahanui Golf Club	401	387 (-3.5%)	301 (-24.9%)	271 (-32.5%)
Belmont at Lincolnshire Farms	213	198 (-7.1%)	168 (-21.5%)	137 (-35.7%)
Porirua at Willowbank	667	648 (-2.8%)	592 (-11.2%)	470 (-29.5%)
Porirua at Milk Depot	1253	1234 (-1.5%)	1064 (-15%)	809 (-35.4%)
Taupo at Wetland	127	125 (-1.3%)	110 (-13%)	72 (-43.5%)
Titahi at Titahi Bay	6	6 (3.4%)	5 (-14.4%)	4 (-26.5%)
Hongoeka to Pukerua at Hongoeka	18	18 (0%)	12 (-29.5%)	12 (-29.7%)
Upper Duck Creek at Bottom of sub-catchment	110	76 (-31.4%)	61 (-44.9%)	50 (-54.3%)
Lower Duck Creek at Mouth	183	155 (-15.2%)	139 (-24%)	120 (-34.6%)
Horokiri and Motukaraka at Battle Hill	217	215 (-1%)	163 (-24.9%)	133 (-38.7%)
Horokiri and Motukaraka at Mouth	429	412 (-4.1%)	342 (-20.4%)	293 (-31.6%)
Kakaho at Mouth	229	224 (-2.1%)	163 (-28.5%)	114 (-50.1%)
Upper Kenepuru at Bottom of sub-catchment	61	43 (-30%)	35 (-43.7%)	32 (-47.9%)
Kenepuru at Infill case study	248	248 (0.1%)	239 (-3.6%)	200 (-19.2%)
Kenepuru at Mouth	703	685 (-2.5%)	626 (-11%)	522 (-25.7%)
Porirua at Mitchell Stream	67	61 (-9%)	53 (-21.1%)	49 (-27.2%)
Rangituhi at Bottom of sub-catchment	10	4 (-56.7%)	4 (-56.7%)	4 (-56.7%)
Onepoto Fringe at Elsdon	32	32 (0%)	27 (-17.3%)	21 (-33.3%)
Mahinawa Stream at Mouth	30	30 (0%)	30 (-0.2%)	30 (-0.8%)
Hukatai Stream at Mouth	13	13 (0%)	12 (-2.2%)	12 (-7%)
Whitireia at Mouth	15	11 (-28.5%)	11 (-28.5%)	11 (-28.8%)
Moonshine at Bottom of sub-catchment	204	199 (-2%)	186 (-8.8%)	154 (-24.3%)
Pauatahanui at Elmwood Bridge	559	533 (-4.6%)	510 (-8.7%)	386 (-31%)
Pauatahanui at Mouth	501	477 (-4.8%)	458 (-8.6%)	353 (-29.7%)
Porirua at Mouth	2016	1984 (-1.6%)	1765 (-12.5%)	1388 (-31.1%)
Ration at Mouth	129	113 (-12.2%)	112 (-13.2%)	103 (-19.9%)
Stebbings at Bottom of sub-catchment	57	48 (-14.8%)	42 (-26%)	31 (-46.2%)
Takapu at Bottom of sub-catchment	183	183 (0%)	168 (-7.9%)	125 (-31.7%)
Porirua at Granada North industrial	15	15 (0%)	15 (-2.1%)	15 (-4.3%)
Taupo at Camborne case study	49	41 (-16.9%)	36 (-28.1%)	20 (-59.4%)
Taupo at Mouth	175	167 (-4.6%)	147 (-16.2%)	98 (-44.2%)

Table A.15: Dissolved Inorganic Nitrogen (DIN, mg/L) statistics. Values in brackets represent percentage change compared to the baseline.

Reporting Point	Baseline		BAU		Improved		WS	
	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)
Horokiri and Motukaraka at Near Pauatahanui G.C.	0.286	1.534	0.28 (-2%)	1.4 (-8%)	0.26 (-9%)	1.05 (-32%)	0.25 (-12%)	0.92 (-40%)
Belmont at Lincolnshire Farms	0.756	2.645	0.66 (-13%)	1.7 (-36%)	0.58 (-23%)	1.62 (-39%)	0.68 (-11%)	1.83 (-31%)
Porirua at Willowbank	0.674	2.337	0.64 (-5%)	2.06 (-12%)	0.6 (-11%)	1.98 (-15%)	0.61 (-10%)	1.69 (-28%)
Porirua at Kenepuru Drive	0.601	1.85	0.57 (-5%)	1.67 (-10%)	0.54 (-10%)	1.6 (-14%)	0.54 (-11%)	1.43 (-23%)
Taupo at Wetland	0.447	2.523	0.43 (-4%)	2.36 (-7%)	0.4 (-11%)	2.1 (-17%)	0.35 (-23%)	1.31 (-48%)
Titahi at Titahi Bay	0.484	1.097	0.64 (31%)	1.29 (18%)	0.53 (10%)	1.15 (5%)	0.61 (26%)	1.3 (18%)
Hongoeka to Pukerua at Hongoeka	0.588	1.958	0.59 (0%)	1.96 (0%)	0.54 (-9%)	1.28 (-35%)	0.54 (-9%)	1.28 (-35%)
Upper Duck Creek at Bottom of sub-catchment	0.389	2.639	0.33 (-16%)	1.82 (-31%)	0.3 (-24%)	1.47 (-44%)	0.27 (-30%)	1.19 (-55%)
Lower Duck Creek at Mouth	0.481	1.647	0.46 (-5%)	1.37 (-17%)	0.43 (-10%)	1.24 (-24%)	0.43 (-11%)	1.09 (-34%)
Horokiri and Motukaraka at Battle Hill	0.324	1.75	0.32 (-1%)	1.72 (-2%)	0.3 (-8%)	1.26 (-28%)	0.29 (-12%)	1.01 (-42%)
Horokiri and Motukaraka at Mouth	0.224	1.466	0.22 (-3%)	1.33 (-9%)	0.2 (-10%)	1.11 (-24%)	0.19 (-14%)	0.92 (-37%)
Kakaho at Mouth	0.356	2.608	0.35 (-3%)	2.48 (-5%)	0.3 (-16%)	1.82 (-30%)	0.27 (-26%)	1.22 (-53%)
Upper Kenepuru at Bottom of sub-catchment	0.775	3.003	0.65 (-17%)	2.11 (-30%)	0.59 (-24%)	1.7 (-43%)	0.56 (-27%)	1.54 (-49%)
Kenepuru at Infill case study	0.802	2.106	0.81 (1%)	2.12 (1%)	0.8 (-1%)	2.1 (0%)	0.78 (-3%)	1.66 (-21%)
Kenepuru at Mouth	0.804	2.025	0.76 (-6%)	1.83 (-10%)	0.72 (-11%)	1.73 (-15%)	0.74 (-8%)	1.62 (-20%)
Porirua at Mitchell Stream	0.645	2.06	0.6 (-6%)	1.73 (-16%)	0.57 (-11%)	1.48 (-28%)	0.58 (-10%)	1.47 (-29%)
Rangituhi at Bottom of sub-catchment	0.509	2.357	0.45 (-11%)	0.6 (-74%)	0.45 (-11%)	0.6 (-74%)	0.45 (-11%)	0.6 (-74%)
Onepoto Fringe at Elsdon	0.459	1.013	0.46 (0%)	1.01 (0%)	0.45 (-2%)	0.93 (-8%)	0.44 (-4%)	0.87 (-15%)
Mahinawa Stream at Mouth	0.539	2.026	0.54 (0%)	2.03 (0%)	0.54 (0%)	2.02 (0%)	0.54 (0%)	2.04 (1%)
Hukatai Stream at Mouth	0.703	1.65	0.7 (0%)	1.65 (0%)	0.7 (0%)	1.65 (0%)	0.71 (1%)	1.66 (0%)
Whitireia at Mouth	1.257	2.379	1.15 (-9%)	1.54 (-35%)	1.15 (-9%)	1.54 (-35%)	1.16 (-8%)	1.55 (-35%)
Moonshine at Bottom of sub-catchment	0.279	1.669	0.27 (-2%)	1.61 (-4%)	0.27 (-4%)	1.49 (-11%)	0.25 (-9%)	1.19 (-29%)
Pauatahanui at Middle reaches	0.186	1.362	0.18 (-4%)	1.23 (-10%)	0.17 (-7%)	1.18 (-13%)	0.16 (-15%)	0.89 (-35%)
Pauatahanui at Mouth	0.137	0.972	0.13 (-5%)	0.87 (-10%)	0.13 (-8%)	0.84 (-13%)	0.12 (-15%)	0.65 (-33%)
Porirua at Mouth	0.588	1.739	0.56 (-5%)	1.58 (-9%)	0.53 (-10%)	1.5 (-14%)	0.52 (-12%)	1.36 (-22%)
Ration at Mouth	0.41	2.142	0.38 (-7%)	1.61 (-25%)	0.38 (-8%)	1.59 (-26%)	0.37 (-10%)	1.42 (-34%)
Stebbings at Bottom of sub-catchment	0.692	3.95	0.66 (-5%)	2.14 (-46%)	0.57 (-18%)	2.03 (-49%)	0.65 (-6%)	1.57 (-60%)
Takapu at Bottom of sub-catchment	0.663	3.46	0.66 (0%)	3.46 (0%)	0.63 (-5%)	3.19 (-8%)	0.56 (-16%)	2.34 (-32%)
Porirua at Granada North industrial	0.667	1.631	0.67 (0%)	1.63 (0%)	0.66 (-2%)	1.61 (-2%)	0.64 (-4%)	1.58 (-3%)
Taupo at Camborne case study	0.665	3.723	0.56 (-16%)	2.41 (-35%)	0.48 (-28%)	2.16 (-42%)	0.47 (-29%)	1.22 (-67%)
Taupo at Mouth	0.405	2.152	0.38 (-5%)	1.88 (-13%)	0.35 (-14%)	1.67 (-22%)	0.31 (-23%)	1.09 (-49%)

Table A.16: Average annual Dissolved Inorganic Nitrogen load (kg/year). Values in brackets represent percentage change compared to the baseline.

Reporting Point	Average annual Load (kg/year)			
	Baseline	BAU	Improved	WS
Horokiri and Motukaraka at Near Pauatahanui Golf Club	17625	16668 (-5.4%)	12441 (-29.4%)	10992 (-37.6%)
Belmont at Lincolnshire Farms	5353	4258 (-20.5%)	3870 (-27.7%)	3856 (-28%)
Porirua at Willowbank	24661	23153 (-6.1%)	21705 (-12%)	17697 (-28.2%)
Porirua at Milk Depot	30888	29310 (-5.1%)	27561 (-10.8%)	23643 (-23.5%)
Taupo at Wetland	6014	5780 (-3.9%)	5022 (-16.5%)	3026 (-49.7%)
Titahi at Titahi Bay	185	193 (4.5%)	164 (-11.1%)	155 (-16.1%)
Hongoeka to Pukerua at Hongoeka	795	795 (0%)	519 (-34.6%)	518 (-34.8%)
Upper Duck Creek at Bottom of sub-catchment	4551	3052 (-32.9%)	2420 (-46.8%)	1952 (-57.1%)
Lower Duck Creek at Mouth	6547	5457 (-16.6%)	4886 (-25.4%)	4139 (-36.8%)
Horokiri and Motukaraka at Battle Hill	9764	9615 (-1.5%)	7020 (-28.1%)	5565 (-43%)
Horokiri and Motukaraka at Mouth	18681	17488 (-6.4%)	14200 (-24%)	11836 (-36.6%)
Kakaho at Mouth	10635	10311 (-3.1%)	7377 (-30.6%)	4869 (-54.2%)
Upper Kenepuru at Bottom of sub-catchment	2857	1959 (-31.4%)	1553 (-45.6%)	1411 (-50.6%)
Kenepuru at Infill case study	4438	4444 (0.1%)	4375 (-1.4%)	3338 (-24.8%)
Kenepuru at Mouth	11333	10459 (-7.7%)	9793 (-13.6%)	8574 (-24.3%)
Porirua at Mitchell Stream	2751	2420 (-12%)	2071 (-24.7%)	1986 (-27.8%)
Rangituhi at Bottom of sub-catchment	487	177 (-63.7%)	177 (-63.7%)	177 (-63.7%)
Onepoto Fringe at Elsdon	726	726 (0%)	691 (-4.8%)	651 (-10.3%)
Mahinawa Stream at Mouth	1437	1437 (0%)	1435 (-0.2%)	1426 (-0.8%)
Hukatai Stream at Mouth	508	508 (0%)	507 (-0.2%)	500 (-1.5%)
Whitireia at Mouth	689	458 (-33.5%)	458 (-33.5%)	456 (-33.8%)
Moonshine at Bottom of sub-catchment	7889	7611 (-3.5%)	7028 (-10.9%)	5652 (-28.4%)
Pauatahanui at Elmwood Bridge	19197	17724 (-7.7%)	16917 (-11.9%)	12228 (-36.3%)
Pauatahanui at Mouth	15238	13963 (-8.4%)	13388 (-12.1%)	9932 (-34.8%)
Porirua at Mouth	40444	38180 (-5.6%)	35775 (-11.5%)	30944 (-23.5%)
Ration at Mouth	5773	4580 (-20.7%)	4518 (-21.7%)	4095 (-29.1%)
Stebbings at Bottom of sub-catchment	2894	2260 (-21.9%)	1987 (-31.3%)	1329 (-54.1%)
Takapu at Bottom of sub-catchment	9359	9358 (0%)	8535 (-8.8%)	6102 (-34.8%)
Porirua at Granada North industrial	682	682 (0%)	668 (-1.9%)	654 (-4.1%)
Taupo at Camborne case study	2394	1878 (-21.6%)	1615 (-32.5%)	808 (-66.2%)
Taupo at Mouth	7553	6945 (-8.1%)	6053 (-19.9%)	3700 (-51%)

A.3.4 Phosphorus species

Table A.17: Total Phosphorus (mg/L) statistics. Values in brackets represent percentage change compared to the baseline.

Reporting Point	Baseline		BAU		Improved		WS	
	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)
Horokiri and Motukaraka at Near Pauatahanui G.C.	0.025	0.095	0.024 (-4%)	0.086 (-9%)	0.018 (-28%)	0.038 (-60%)	0.018 (-28%)	0.04 (-58%)
Belmont at Lincolnshire Farms	0.072	0.197	0.059 (-18%)	0.161 (-18%)	0.037 (-49%)	0.133 (-32%)	0.037 (-49%)	0.13 (-34%)
Porirua at Willowbank	0.054	0.161	0.051 (-6%)	0.152 (-6%)	0.034 (-37%)	0.107 (-34%)	0.034 (-37%)	0.11 (-32%)
Porirua at Kenepuru Drive	0.041	0.138	0.04 (-2%)	0.131 (-5%)	0.03 (-27%)	0.096 (-30%)	0.03 (-27%)	0.096 (-30%)
Taupo at Wetland	0.043	0.145	0.04 (-7%)	0.128 (-12%)	0.019 (-56%)	0.045 (-69%)	0.019 (-56%)	0.05 (-66%)
Titahi at Titahi Bay	0.025	0.1	0.043 (72%)	0.116 (16%)	0.021 (-16%)	0.098 (-2%)	0.021 (-16%)	0.1 (0%)
Hongoeka to Pukerua at Hongoeka	0.047	0.14	0.047 (0%)	0.14 (0%)	0.028 (-40%)	0.081 (-42%)	0.028 (-40%)	0.08 (-43%)
Upper Duck Creek at Bottom of sub-catchment	0.07	0.221	0.052 (-26%)	0.147 (-33%)	0.033 (-53%)	0.081 (-63%)	0.033 (-53%)	0.08 (-64%)
Lower Duck Creek at Mouth	0.038	0.134	0.033 (-13%)	0.11 (-18%)	0.022 (-42%)	0.08 (-40%)	0.022 (-42%)	0.08 (-40%)
Horokiri and Motukaraka at Battle Hill	0.03	0.114	0.03 (0%)	0.112 (-2%)	0.021 (-30%)	0.044 (-61%)	0.021 (-30%)	0.04 (-65%)
Horokiri and Motukaraka at Mouth	0.021	0.089	0.02 (-5%)	0.079 (-11%)	0.014 (-33%)	0.037 (-58%)	0.014 (-33%)	0.04 (-55%)
Kakaho at Mouth	0.041	0.17	0.039 (-5%)	0.16 (-6%)	0.022 (-46%)	0.058 (-66%)	0.022 (-46%)	0.06 (-65%)
Upper Kenepuru at Bottom of sub-catchment	0.068	0.182	0.048 (-29%)	0.122 (-33%)	0.03 (-56%)	0.07 (-62%)	0.03 (-56%)	0.07 (-62%)
Kenepuru at Infill case study	0.033	0.136	0.034 (3%)	0.137 (1%)	0.024 (-27%)	0.107 (-21%)	0.024 (-27%)	0.11 (-19%)
Kenepuru at Mouth	0.03	0.123	0.028 (-7%)	0.113 (-8%)	0.02 (-33%)	0.092 (-25%)	0.02 (-33%)	0.09 (-27%)
Porirua at Mitchell Stream	0.036	0.157	0.037 (3%)	0.139 (-11%)	0.029 (-19%)	0.11 (-30%)	0.029 (-19%)	0.12 (-24%)
Rangituhi at Bottom of sub-catchment	0.037	0.155	0.026 (-30%)	0.027 (-83%)	0.026 (-30%)	0.027 (-83%)	0.026 (-30%)	0.13 (-16%)
Onepoto Fringe at Elsdon	0.023	0.086	0.023 (0%)	0.086 (0%)	0.022 (-4%)	0.066 (-23%)	0.022 (-4%)	0.07 (-19%)
Mahinawa Stream at Mouth	0.031	0.106	0.031 (0%)	0.106 (0%)	0.027 (-13%)	0.082 (-23%)	0.027 (-13%)	0.08 (-25%)
Hukatai Stream at Mouth	0.031	0.112	0.031 (0%)	0.112 (0%)	0.031 (0%)	0.112 (0%)	0.031 (0%)	0.11 (-2%)
Whitireia at Mouth	0.041	0.136	0.027 (-34%)	0.104 (-24%)	0.027 (-34%)	0.105 (-23%)	0.027 (-34%)	0.12 (-12%)
Moonshine at Bottom of sub-catchment	0.034	0.125	0.033 (-3%)	0.118 (-6%)	0.026 (-24%)	0.071 (-43%)	0.026 (-24%)	0.07 (-44%)
Pauatahanui at Middle reaches	0.03	0.113	0.028 (-7%)	0.098 (-13%)	0.018 (-40%)	0.049 (-57%)	0.018 (-40%)	0.049 (-57%)
Pauatahanui at Mouth	0.024	0.093	0.022 (-8%)	0.08 (-14%)	0.015 (-38%)	0.045 (-52%)	0.015 (-38%)	0.05 (-46%)
Porirua at Mouth	0.036	0.122	0.035 (-3%)	0.115 (-6%)	0.026 (-28%)	0.086 (-30%)	0.026 (-28%)	0.09 (-26%)
Ration at Mouth	0.029	0.102	0.023 (-21%)	0.053 (-48%)	0.02 (-31%)	0.034 (-67%)	0.02 (-31%)	0.03 (-71%)
Stebbings at Bottom of sub-catchment	0.077	0.233	0.072 (-6%)	0.182 (-22%)	0.029 (-62%)	0.105 (-55%)	0.029 (-62%)	0.1 (-57%)
Takapu at Bottom of sub-catchment	0.06	0.186	0.06 (0%)	0.186 (0%)	0.037 (-38%)	0.079 (-58%)	0.037 (-38%)	0.08 (-57%)
Porirua at Granada North industrial	0.04	0.123	0.04 (0%)	0.123 (0%)	0.037 (-8%)	0.114 (-7%)	0.037 (-8%)	0.11 (-11%)
Taupo at Camborne case study	0.099	0.208	0.074 (-25%)	0.165 (-21%)	0.023 (-77%)	0.065 (-69%)	0.023 (-77%)	0.07 (-66%)
Taupo at Mouth	0.041	0.135	0.038 (-7%)	0.121 (-10%)	0.017 (-59%)	0.057 (-58%)	0.017 (-59%)	0.06 (-56%)

Table A.18: Average annual Total Phosphorus (kg/year) load. Values in brackets represent percentage change compared to the baseline.

Reporting Point	Average annual Load (kg/year)			
	Baseline	BAU	Improved	WS
Horokiri and Motukaraka at Near Pauatahanui Golf Club	1170	1086 (-7.1%)	556 (-52.5%)	518 (-55.7%)
Belmont at Lincolnshire Farms	413	400 (-3%)	282 (-31.6%)	277 (-33%)
Porirua at Willowbank	1711	1716 (0.3%)	1213 (-29.1%)	1101 (-35.6%)
Porirua at Milk Depot	2214	2210 (-0.2%)	1713 (-22.6%)	1567 (-29.2%)
Taupo at Wetland	364	332 (-8.7%)	131 (-63.9%)	104 (-71.4%)
Titahi at Titahi Bay	16	17 (6.5%)	12 (-24%)	11 (-29.6%)
Hongoeka to Pukerua at Hongoeka	57	57 (0%)	30 (-46.6%)	30 (-46.8%)
Upper Duck Creek at Bottom of sub-catchment	406	263 (-35.1%)	163 (-59.8%)	142 (-65.1%)
Lower Duck Creek at Mouth	531	429 (-19.1%)	304 (-42.7%)	280 (-47.2%)
Horokiri and Motukaraka at Battle Hill	676	661 (-2.2%)	306 (-54.8%)	273 (-59.6%)
Horokiri and Motukaraka at Mouth	1236	1123 (-9.2%)	636 (-48.6%)	554 (-55.2%)
Kakaho at Mouth	746	715 (-4.1%)	307 (-58.9%)	256 (-65.6%)
Upper Kenepuru at Bottom of sub-catchment	182	117 (-35.7%)	72 (-60.7%)	65 (-64.4%)
Kenepuru at Infill case study	299	302 (0.8%)	246 (-18%)	222 (-25.9%)
Kenepuru at Mouth	693	652 (-6%)	538 (-22.3%)	498 (-28.2%)
Porirua at Mitchell Stream	196	180 (-8%)	139 (-29.1%)	136 (-30.7%)
Rangituhi at Bottom of sub-catchment	33	9 (-72.3%)	9 (-72.3%)	9 (-72.3%)
Onepoto Fringe at Elsdon	53	53 (0%)	49 (-9%)	43 (-19.4%)
Mahinawa Stream at Mouth	76	76 (0%)	55 (-27.8%)	54 (-28.5%)
Hukatai Stream at Mouth	33	33 (0%)	32 (-0.3%)	32 (-1.8%)
Whitireia at Mouth	37	27 (-27.6%)	27 (-27.6%)	27 (-27.8%)
Moonshine at Bottom of sub-catchment	629	599 (-4.7%)	407 (-35.3%)	368 (-41.5%)
Pauatahanui at Elmwood Bridge	1681	1498 (-10.9%)	834 (-50.4%)	728 (-56.7%)
Pauatahanui at Mouth	1507	1321 (-12.3%)	774 (-48.7%)	677 (-55.1%)
Porirua at Mouth	2772	2735 (-1.3%)	2164 (-21.9%)	1977 (-28.7%)
Ration at Mouth	300	174 (-41.9%)	139 (-53.6%)	125 (-58.4%)
Stebbings at Bottom of sub-catchment	187	201 (7.9%)	88 (-52.9%)	83 (-55.5%)
Takapu at Bottom of sub-catchment	546	546 (0%)	286 (-47.7%)	233 (-57.4%)
Porirua at Granada North industrial	50	50 (0%)	49 (-3.2%)	46 (-7.8%)
Taupo at Camborne case study	145	139 (-4.3%)	51 (-65%)	43 (-70.6%)
Taupo at Mouth	491	462 (-5.9%)	206 (-58%)	173 (-64.7%)

Table A.19: Dissolved Reactive Phosphorus (mg/L) statistics. Values in brackets represent percentage change compared to the baseline.

Reporting Point	Baseline		BAU		Improved		WS	
	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)
Horokiri and Motukaraka at Near Pauatahanui G.C.	0.009	0.03	0.008 (-11%)	0.027 (-10%)	0.006 (-33%)	0.014 (-53%)	0.006 (-33%)	0.013 (-57%)
Belmont at Lincolnshire Farms	0.027	0.065	0.023 (-15%)	0.056 (-14%)	0.013 (-52%)	0.039 (-40%)	0.014 (-48%)	0.043 (-34%)
Porirua at Willowbank	0.021	0.054	0.02 (-5%)	0.052 (-4%)	0.014 (-33%)	0.039 (-28%)	0.013 (-38%)	0.036 (-33%)
Porirua at Kenepuru Drive	0.016	0.05	0.015 (-6%)	0.048 (-4%)	0.012 (-25%)	0.036 (-28%)	0.011 (-31%)	0.034 (-32%)
Taupo at Wetland	0.019	0.051	0.018 (-5%)	0.046 (-10%)	0.011 (-42%)	0.025 (-51%)	0.008 (-58%)	0.018 (-65%)
Titahi at Titahi Bay	0.015	0.047	0.024 (60%)	0.052 (11%)	0.012 (-20%)	0.038 (-19%)	0.013 (-13%)	0.041 (-13%)
Hongoeka to Pukerua at Hongoeka	0.018	0.044	0.018 (0%)	0.044 (0%)	0.011 (-39%)	0.027 (-39%)	0.011 (-39%)	0.027 (-39%)
Upper Duck Creek at Bottom of sub-catchment	0.026	0.064	0.019 (-27%)	0.044 (-31%)	0.014 (-46%)	0.03 (-53%)	0.012 (-54%)	0.025 (-61%)
Lower Duck Creek at Mouth	0.018	0.05	0.016 (-11%)	0.042 (-16%)	0.011 (-39%)	0.034 (-32%)	0.011 (-39%)	0.033 (-34%)
Horokiri and Motukaraka at Battle Hill	0.011	0.035	0.01 (-9%)	0.034 (-3%)	0.008 (-27%)	0.018 (-49%)	0.007 (-36%)	0.015 (-57%)
Horokiri and Motukaraka at Mouth	0.008	0.028	0.007 (-13%)	0.025 (-11%)	0.006 (-25%)	0.016 (-43%)	0.005 (-38%)	0.013 (-54%)
Kakaho at Mouth	0.015	0.052	0.014 (-7%)	0.049 (-6%)	0.009 (-40%)	0.026 (-50%)	0.008 (-47%)	0.019 (-63%)
Upper Kenepuru at Bottom of sub-catchment	0.032	0.062	0.023 (-28%)	0.043 (-31%)	0.016 (-50%)	0.03 (-52%)	0.014 (-56%)	0.027 (-56%)
Kenepuru at Infill case study	0.02	0.057	0.021 (5%)	0.058 (2%)	0.017 (-15%)	0.049 (-14%)	0.015 (-25%)	0.046 (-19%)
Kenepuru at Mouth	0.021	0.058	0.019 (-10%)	0.054 (-7%)	0.015 (-29%)	0.043 (-26%)	0.014 (-33%)	0.042 (-28%)
Porirua at Mitchell Stream	0.013	0.051	0.014 (8%)	0.047 (-8%)	0.01 (-23%)	0.036 (-29%)	0.01 (-23%)	0.035 (-31%)
Rangituhi at Bottom of sub-catchment	0.013	0.047	0.009 (-31%)	0.009 (-81%)	0.009 (-31%)	0.009 (-81%)	0.009 (-31%)	0.009 (-81%)
Onepoto Fringe at Elsdon	0.011	0.041	0.011 (0%)	0.041 (0%)	0.01 (-9%)	0.035 (-15%)	0.01 (-9%)	0.031 (-24%)
Mahinawa Stream at Mouth	0.014	0.044	0.014 (0%)	0.044 (0%)	0.012 (-14%)	0.034 (-23%)	0.012 (-14%)	0.034 (-23%)
Hukatai Stream at Mouth	0.016	0.046	0.016 (0%)	0.046 (0%)	0.016 (0%)	0.045 (-2%)	0.016 (0%)	0.046 (0%)
Whitireia at Mouth	0.022	0.05	0.014 (-36%)	0.04 (-20%)	0.014 (-36%)	0.04 (-20%)	0.014 (-36%)	0.04 (-20%)
Moonshine at Bottom of sub-catchment	0.012	0.039	0.012 (0%)	0.037 (-5%)	0.01 (-17%)	0.027 (-31%)	0.009 (-25%)	0.023 (-41%)
Pauatahanui at Middle reaches	0.011	0.035	0.01 (-9%)	0.031 (-11%)	0.007 (-36%)	0.02 (-43%)	0.007 (-36%)	0.016 (-54%)
Pauatahanui at Mouth	0.009	0.03	0.008 (-11%)	0.026 (-13%)	0.006 (-33%)	0.019 (-37%)	0.005 (-44%)	0.016 (-47%)
Porirua at Mouth	0.015	0.05	0.015 (0%)	0.048 (-4%)	0.011 (-27%)	0.035 (-30%)	0.011 (-27%)	0.033 (-34%)
Ration at Mouth	0.011	0.035	0.009 (-18%)	0.019 (-46%)	0.008 (-27%)	0.016 (-54%)	0.007 (-36%)	0.013 (-63%)
Stebbings at Bottom of sub-catchment	0.028	0.072	0.028 (0%)	0.061 (-15%)	0.012 (-57%)	0.033 (-54%)	0.011 (-61%)	0.032 (-56%)
Takapu at Bottom of sub-catchment	0.022	0.058	0.022 (0%)	0.058 (0%)	0.016 (-27%)	0.037 (-36%)	0.013 (-41%)	0.027 (-53%)
Porirua at Granada North industrial	0.016	0.043	0.016 (0%)	0.043 (0%)	0.015 (-6%)	0.041 (-5%)	0.014 (-13%)	0.038 (-12%)
Taupo at Camborne case study	0.038	0.067	0.029 (-24%)	0.054 (-19%)	0.013 (-66%)	0.029 (-57%)	0.009 (-76%)	0.023 (-66%)
Taupo at Mouth	0.017	0.047	0.016 (-6%)	0.043 (-9%)	0.009 (-47%)	0.025 (-47%)	0.007 (-59%)	0.021 (-55%)

Table A.20: Average annual Dissolved Reactive Phosphorus (kg/year) load. Values in brackets represent percentage change compared to the baseline.

Reporting Point	Average annual Load (kg/year)			
	Baseline	BAU	Improved	WS
Horokiri and Motukaraka at Near Pauatahanui Golf Club	376	349 (-7%)	199 (-47.1%)	177 (-53%)
Belmont at Lincolnshire Farms	151	155 (2.5%)	107 (-29.4%)	98 (-35%)
Porirua at Willowbank	590	603 (2.2%)	455 (-22.9%)	384 (-34.9%)
Porirua at Milk Depot	822	833 (1.4%)	670 (-18.5%)	572 (-30.4%)
Taupo at Wetland	130	122 (-6.7%)	64 (-51%)	41 (-68.5%)
Titahi at Titahi Bay	8	8 (2%)	5 (-29.2%)	5 (-36.5%)
Hongoeka to Pukerua at Hongoeka	18	18 (0%)	10 (-44.2%)	10 (-44.4%)
Upper Duck Creek at Bottom of sub-catchment	123	81 (-34.2%)	55 (-55.5%)	44 (-64%)
Lower Duck Creek at Mouth	199	167 (-15.9%)	126 (-36.8%)	110 (-44.5%)
Horokiri and Motukaraka at Battle Hill	214	209 (-2.2%)	112 (-47.6%)	92 (-57%)
Horokiri and Motukaraka at Mouth	399	362 (-9.1%)	230 (-42.3%)	189 (-52.7%)
Kakaho at Mouth	236	226 (-4.1%)	118 (-50%)	84 (-64.3%)
Upper Kenepuru at Bottom of sub-catchment	65	43 (-34%)	28 (-56.6%)	25 (-61.7%)
Kenepuru at Infill case study	146	147 (0.7%)	129 (-11.8%)	110 (-24.7%)
Kenepuru at Mouth	378	363 (-4%)	308 (-18.5%)	271 (-28.2%)
Porirua at Mitchell Stream	63	60 (-4.6%)	46 (-26.4%)	44 (-30.1%)
Rangituhi at Bottom of sub-catchment	10	3 (-70.1%)	3 (-70.1%)	3 (-70.1%)
Onepoto Fringe at Elsdon	26	26 (0%)	23 (-10.3%)	20 (-22.2%)
Mahinawa Stream at Mouth	30	30 (0%)	22 (-26.7%)	22 (-27.6%)
Hukatai Stream at Mouth	13	13 (0%)	13 (-0.6%)	13 (-2.9%)
Whitireia at Mouth	14	10 (-28.8%)	10 (-28.8%)	10 (-29.2%)
Moonshine at Bottom of sub-catchment	201	191 (-4.9%)	144 (-28.1%)	121 (-39.8%)
Pauatahanui at Elmwood Bridge	539	484 (-10.3%)	320 (-40.5%)	244 (-54.7%)
Pauatahanui at Mouth	487	431 (-11.5%)	296 (-39.1%)	230 (-52.8%)
Porirua at Mouth	1166	1164 (-0.1%)	958 (-17.8%)	824 (-29.3%)
Ration at Mouth	105	64 (-38.6%)	54 (-48.3%)	47 (-55.3%)
Stebbings at Bottom of sub-catchment	60	70 (16.7%)	34 (-42.8%)	26 (-55.8%)
Takapu at Bottom of sub-catchment	176	176 (0%)	111 (-37%)	79 (-54.9%)
Porirua at Granada North industrial	17	17 (0%)	17 (-3.7%)	16 (-9.1%)
Taupo at Camborne case study	48	47 (-1.2%)	23 (-52%)	15 (-69.7%)
Taupo at Mouth	173	166 (-4.1%)	93 (-46.5%)	65 (-62.8%)

A.3.5 Dissolved Metals

Table A.21: Dissolved Copper (mg/L) statistics. Values in brackets represent percentage change compared to the baseline.

Reporting Point	Baseline		BAU		Improved		WS	
	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)
Horokiri and Motukaraka at Pauatahanui G.C	0.00003	0.00012	0.00012 (300%)	0.00102 (750%)	0.0001 (233%)	0.00079 (558%)	0.00006 (100%)	0.00036 (200%)
Belmont at Lincolnshire Farms	0.00065	0.00349	0.00102 (57%)	0.00409 (17%)	0.00063 (-3%)	0.00227 (-35%)	0.00058 (-11%)	0.00282 (-19%)
Porirua at Willowbank	0.00081	0.00448	0.00099 (22%)	0.00459 (2%)	0.00092 (14%)	0.00366 (-18%)	0.00067 (-17%)	0.00341 (-24%)
Porirua at Kenepuru Drive	0.00094	0.00471	0.00108 (15%)	0.00474 (1%)	0.00103 (10%)	0.004 (-15%)	0.00076 (-19%)	0.00359 (-24%)
Taupo at Wetland	0.00029	0.00273	0.0003 (3%)	0.00223 (-18%)	0.00059 (103%)	0.00236 (-14%)	0.00019 (-34%)	0.00153 (-44%)
Titahi at Titahi Bay	0.00177	0.00575	0.00153 (-14%)	0.00485 (-16%)	0.00114 (-36%)	0.00383 (-33%)	0.0011 (-38%)	0.0037 (-36%)
Hongoeka to Pukerua at Hongoeka	0.00027	0.00223	0.00027 (0%)	0.00223 (0%)	0.00028 (4%)	0.00225 (1%)	0.00028 (4%)	0.00231 (4%)
Upper Duck Creek at Bottom of sub-catchment	0.00004	0.00013	0.00032 (700%)	0.00369 (2738%)	0.00026 (550%)	0.00279 (2046%)	0.00013 (225%)	0.00117 (800%)
Lower Duck Creek at Mouth	0.00047	0.00293	0.00065 (38%)	0.00366 (25%)	0.00055 (17%)	0.0031 (6%)	0.00046 (-2%)	0.00287 (-2%)
Horokiri and Motukaraka at Battle Hill	0.00003	0.00012	0.00003 (0%)	0.00012 (0%)	0.00003 (0%)	0.00011 (-8%)	0.00003 (0%)	0.00011 (-8%)
Horokiri and Motukaraka at Mouth	0.00004	0.00013	0.00012 (200%)	0.00091 (600%)	0.0001 (150%)	0.00069 (431%)	0.00006 (50%)	0.00032 (146%)
Kakaho at Mouth	0.00003	0.00013	0.00007 (133%)	0.00038 (192%)	0.00003 (0%)	0.00012 (-8%)	0.00003 (0%)	0.00012 (-8%)
Upper Kenepuru at Bottom of sub-catchment	0.00012	0.00097	0.00034 (183%)	0.00361 (272%)	0.00028 (133%)	0.00285 (194%)	0.00018 (50%)	0.00162 (67%)
Kenepuru at Infill case study	0.00136	0.00495	0.00133 (-2%)	0.00481 (-3%)	0.0015 (10%)	0.00466 (-6%)	0.00129 (-5%)	0.00474 (-4%)
Kenepuru at Mouth	0.00125	0.00467	0.00127 (2%)	0.00466 (0%)	0.00128 (2%)	0.00412 (-12%)	0.00112 (-10%)	0.00422 (-10%)
Porirua at Mitchell Stream	0.00063	0.00545	0.0007 (11%)	0.0054 (-1%)	0.00056 (-11%)	0.00391 (-28%)	0.00038 (-40%)	0.00311 (-43%)
Rangituhi at Bottom of sub-catchment	0.00004	0.00009	0.00004 (0%)	0.00007 (-22%)	0.00004 (0%)	0.00007 (-22%)	0.00004 (0%)	0.00007 (-22%)
Onepoto Fringe at Elsdon	0.00177	0.0103	0.00177 (0%)	0.01032 (0%)	0.00183 (3%)	0.00879 (-15%)	0.00079 (-55%)	0.00451 (-56%)
Mahinawa Stream at Mouth	0.00025	0.00219	0.00025 (0%)	0.00223 (2%)	0.00025 (0%)	0.00221 (1%)	0.00025 (0%)	0.00221 (1%)
Hukatai Stream at Mouth	0.00076	0.00376	0.00079 (4%)	0.00392 (4%)	0.00079 (4%)	0.00384 (2%)	0.00078 (3%)	0.0039 (4%)
Whitireia at Mouth	0.00035	0.00256	0.00035 (0%)	0.00258 (1%)	0.00035 (0%)	0.00258 (1%)	0.00036 (3%)	0.0027 (5%)
Moonshine at Bottom of sub-catchment	0.00004	0.00014	0.00004 (0%)	0.00014 (0%)	0.00005 (25%)	0.00014 (0%)	0.00004 (0%)	0.00013 (-7%)
Pauatahanui at Middle reaches	0.00006	0.00027	0.00011 (83%)	0.00072 (167%)	0.00015 (150%)	0.00055 (104%)	0.00006 (0%)	0.00032 (19%)
Pauatahanui at Mouth	0.00011	0.00094	0.00018 (64%)	0.00147 (56%)	0.00023 (109%)	0.00124 (32%)	0.00012 (9%)	0.00098 (4%)
Porirua at Mouth	0.00109	0.00477	0.0012 (10%)	0.00479 (0%)	0.00116 (6%)	0.00404 (-15%)	0.00089 (-18%)	0.00371 (-22%)
Ration at Mouth	0.00003	0.00013	0.00013 (333%)	0.00147 (1031%)	0.0001 (233%)	0.00112 (762%)	0.00006 (100%)	0.00049 (277%)
Stebbings at Bottom of sub-catchment	0.0001	0.00025	0.00085 (750%)	0.00374 (1396%)	0.00012 (20%)	0.0005 (100%)	0.00018 (80%)	0.00093 (272%)
Takapu at Bottom of sub-catchment	0.00013	0.00135	0.00013 (0%)	0.00135 (0%)	0.00011 (-15%)	0.00105 (-22%)	0.00009 (-31%)	0.00074 (-45%)
Porirua at Granada North industrial	0.00193	0.00933	0.00193 (0%)	0.00934 (0%)	0.00197 (2%)	0.00791 (-15%)	0.00087 (-55%)	0.00415 (-56%)
Taupo at Camborne case study	0.00077	0.00659	0.0012 (56%)	0.0047 (-29%)	0.00077 (0%)	0.00213 (-68%)	0.00049 (-36%)	0.00245 (-63%)
Taupo at Mouth	0.00061	0.00469	0.00067 (10%)	0.00403 (-14%)	0.00079 (30%)	0.00298 (-36%)	0.00039 (-36%)	0.00269 (-43%)

Table A.22: Average annual Dissolved Copper load (kg/year). Values in brackets represent percentage change compared to the baseline.

Reporting Point	Average annual Load (kg/year)			
	Baseline	BAU	Improved	WS
Horokiri and Motukaraka at Near Pauatahanui Golf Club	1.4	4.6 (224.2%)	3.6 (158.2%)	2.2 (53.2%)
Belmont at Lincolnshire Farms	3.4	7 (107.4%)	3.8 (12.5%)	3.4 (1.5%)
Porirua at Willowbank	21.9	28.5 (29.8%)	22.6 (2.9%)	18.7 (-14.8%)
Porirua at Milk Depot	42.0	49.4 (17.7%)	41.9 (-0.2%)	34.9 (-17%)
Taupo at Wetland	1.5	1.6 (4.7%)	1.6 (6.2%)	1 (-37.8%)
Titahi at Titahi Bay	0.8	0.6 (-29.4%)	0.5 (-46.4%)	0.4 (-50.6%)
Hongoeka to Pukerua at Hongoeka	0.2	0.2 (0%)	0.2 (-2.1%)	0.2 (-2.5%)
Upper Duck Creek at Bottom of sub-catchment	0.2	1.1 (381.9%)	0.8 (275.2%)	0.4 (91.1%)
Lower Duck Creek at Mouth	4.5	6.1 (36.7%)	5.1 (13.5%)	4.3 (-4%)
Horokiri and Motukaraka at Battle Hill	0.7	0.7 (-0.5%)	0.6 (-9.9%)	0.6 (-15.7%)
Horokiri and Motukaraka at Mouth	1.7	4.8 (183.7%)	3.9 (128.5%)	2.4 (39.6%)
Kakaho at Mouth	0.5	0.8 (57.7%)	0.5 (-8.5%)	0.4 (-15.3%)
Upper Kenepuru at Bottom of sub-catchment	0.2	0.5 (135.9%)	0.4 (96.2%)	0.3 (30.3%)
Kenepuru at Infill case study	7.5	7.2 (-3.7%)	7 (-5.8%)	6.5 (-12.4%)
Kenepuru at Mouth	15.8	16.9 (6.5%)	15.1 (-4.7%)	13.6 (-13.8%)
Porirua at Mitchell Stream	2.9	3.4 (15%)	2.4 (-16.4%)	1.9 (-36.1%)
Rangituhi at Bottom of sub-catchment	0.02	0.02 (-19.7%)	0.02 (-19.7%)	0.02 (-19.7%)
Onepoto Fringe at Elsdon	5.0	5 (0.2%)	4.4 (-11.6%)	3.3 (-33.3%)
Mahinawa Stream at Mouth	0.7	0.7 (1.8%)	0.7 (0.9%)	0.7 (-1.2%)
Hukatai Stream at Mouth	0.5	0.6 (3.9%)	0.6 (2.2%)	0.5 (-1.8%)
Whitireia at Mouth	0.1	0.1 (-1.8%)	0.1 (-1.9%)	0.1 (-2.4%)
Moonshine at Bottom of sub-catchment	0.6	0.6 (-1.2%)	0.6 (0.6%)	0.6 (-8.3%)
Pauatahanui at Elmwood Bridge	2.4	4.1 (74.4%)	3.4 (42.7%)	2.3 (-2.4%)
Pauatahanui at Mouth	5.0	7.7 (53.2%)	6.7 (34.8%)	5 (0.8%)
Porirua at Mouth	62.6	71.5 (14.1%)	61.8 (-1.4%)	52.3 (-16.6%)
Ration at Mouth	0.3	1.5 (365.8%)	1.2 (261.6%)	0.6 (86.2%)
Stebbings at Bottom of sub-catchment	0.1	2.5 (1625%)	0.4 (140.7%)	0.4 (155.3%)
Takapu at Bottom of sub-catchment	1.1	1.1 (0%)	0.9 (-17.5%)	0.7 (-37.4%)
Porirua at Granada North industrial	2.0	2 (0.1%)	1.7 (-13%)	1.3 (-36.7%)
Taupo at Camborne case study	0.7	1.8 (140.3%)	0.8 (7.6%)	0.6 (-16.2%)
Taupo at Mouth	4.8	5.6 (15.7%)	4.2 (-12.2%)	3.1 (-36.2%)

Table A.23: Dissolved Zinc (mg/L) statistics. Values in brackets represent percentage change compared to the baseline.

Reporting Point	Baseline		BAU		Improved		WS	
	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)	Median (mg/l)	95th Percentile (mg/l)
Horokiri and Motukaraka at Pauatahanui G.C	0.00007	0.00023	0.00021 (200%)	0.00174 (657%)	0.00017 (143%)	0.00135 (487%)	0.00011 (57%)	0.00062 (170%)
Belmont at Lincolnshire Farms	0.00501	0.03302	0.00461 (-8%)	0.02191 (-34%)	0.0023 (-54%)	0.0115 (-65%)	0.00107 (-79%)	0.00528 (-84%)
Porirua at Willowbank	0.00619	0.03622	0.00602 (-3%)	0.03047 (-16%)	0.00341 (-45%)	0.01762 (-51%)	0.00123 (-80%)	0.00629 (-83%)
Porirua at Kenepuru Drive	0.00763	0.0406	0.00746 (-2%)	0.03634 (-10%)	0.00425 (-44%)	0.02071 (-49%)	0.00141 (-82%)	0.00667 (-84%)
Taupo at Wetland	0.00119	0.01279	0.00118 (-1%)	0.01054 (-18%)	0.00067 (-44%)	0.0059 (-54%)	0.00034 (-71%)	0.0027 (-79%)
Titahi at Titahi Bay	0.00967	0.03149	0.00798 (-17%)	0.0265 (-16%)	0.00459 (-53%)	0.01549 (-51%)	0.00203 (-79%)	0.00686 (-78%)
Hongoeka to Pukerua at Hongoeka	0.00081	0.0072	0.00081 (0%)	0.0072 (0%)	0.00067 (-17%)	0.00571 (-21%)	0.00051 (-37%)	0.00423 (-41%)
Upper Duck Creek at Bottom of sub-catchment	0.00008	0.00026	0.00055 (588%)	0.00616 (2269%)	0.00044 (450%)	0.00467 (1696%)	0.00023 (188%)	0.00196 (654%)
Lower Duck Creek at Mouth	0.00196	0.01304	0.00215 (10%)	0.01281 (-2%)	0.00143 (-27%)	0.00865 (-34%)	0.00085 (-57%)	0.00523 (-60%)
Horokiri and Motukaraka at Battle Hill	0.00007	0.00024	0.00007 (0%)	0.00024 (0%)	0.00007 (0%)	0.00022 (-8%)	0.00006 (-14%)	0.00021 (-13%)
Horokiri and Motukaraka at Mouth	0.00008	0.0003	0.00021 (163%)	0.00158 (427%)	0.00018 (125%)	0.0012 (300%)	0.00011 (38%)	0.00056 (87%)
Kakaho at Mouth	0.00007	0.00028	0.00013 (86%)	0.00076 (171%)	0.00007 (0%)	0.00026 (-7%)	0.00007 (0%)	0.00024 (-14%)
Upper Kenepuru at Bottom of sub-catchment	0.00035	0.00374	0.0007 (100%)	0.00769 (106%)	0.00055 (57%)	0.0057 (52%)	0.00032 (-9%)	0.00283 (-24%)
Kenepuru at Infill case study	0.00606	0.0221	0.00579 (-4%)	0.02123 (-4%)	0.00395 (-35%)	0.01452 (-34%)	0.00237 (-61%)	0.00891 (-60%)
Kenepuru at Mouth	0.00519	0.01982	0.00479 (-8%)	0.01787 (-10%)	0.00323 (-38%)	0.01199 (-40%)	0.00207 (-60%)	0.00785 (-60%)
Porirua at Mitchell Stream	0.00871	0.07886	0.0084 (-4%)	0.0684 (-13%)	0.00449 (-48%)	0.03655 (-54%)	0.00071 (-92%)	0.00577 (-93%)
Rangituhi at Bottom of sub-catchment	0.00008	0.00018	0.00008 (0%)	0.00014 (-22%)	0.00008 (0%)	0.00014 (-22%)	0.00008 (0%)	0.00014 (-22%)
Onepoto Fringe at Elsdon	0.04271	0.24914	0.04272 (0%)	0.24916 (0%)	0.02213 (-48%)	0.12893 (-48%)	0.00148 (-97%)	0.0085 (-97%)
Mahinawa Stream at Mouth	0.00087	0.00821	0.00088 (1%)	0.00828 (1%)	0.00067 (-23%)	0.00612 (-25%)	0.00046 (-47%)	0.00406 (-51%)
Hukatai Stream at Mouth	0.00259	0.01298	0.00264 (2%)	0.01323 (2%)	0.00203 (-22%)	0.01006 (-22%)	0.00142 (-45%)	0.00712 (-45%)
Whitireia at Mouth	0.00133	0.01084	0.00135 (2%)	0.01097 (1%)	0.001 (-25%)	0.00788 (-27%)	0.00066 (-50%)	0.00499 (-54%)
Moonshine at Bottom of sub-catchment	0.00008	0.00027	0.00007 (-13%)	0.00026 (-4%)	0.00007 (-13%)	0.00026 (-4%)	0.00007 (-13%)	0.00025 (-7%)
Pauatahanui at Middle reaches	0.00011	0.00048	0.00021 (91%)	0.00133 (177%)	0.00012 (9%)	0.00052 (8%)	0.00012 (9%)	0.00056 (17%)
Pauatahanui at Mouth	0.00027	0.00258	0.00039 (44%)	0.00341 (32%)	0.00026 (-4%)	0.00221 (-14%)	0.00022 (-19%)	0.00177 (-31%)
Porirua at Mouth	0.00808	0.03623	0.00779 (-4%)	0.03338 (-8%)	0.00453 (-44%)	0.01925 (-47%)	0.00164 (-80%)	0.00695 (-81%)
Ration at Mouth	0.00008	0.00041	0.00023 (188%)	0.00259 (532%)	0.00018 (125%)	0.00194 (373%)	0.0001 (25%)	0.00084 (105%)
Stebbings at Bottom of sub-catchment	0.00021	0.00054	0.00162 (671%)	0.00709 (1213%)	0.00024 (14%)	0.001 (85%)	0.00033 (57%)	0.00175 (224%)
Takapu at Bottom of sub-catchment	0.00218	0.02976	0.00218 (0%)	0.02976 (0%)	0.00118 (-46%)	0.01575 (-47%)	0.00017 (-92%)	0.00141 (-95%)
Porirua at Granada North industrial	0.05057	0.24819	0.05058 (0%)	0.2482 (0%)	0.02614 (-48%)	0.12819 (-48%)	0.00163 (-97%)	0.00778 (-97%)
Taupo at Camborne case study	0.00932	0.08422	0.00682 (-27%)	0.02888 (-66%)	0.00325 (-65%)	0.01438 (-83%)	0.0009 (-90%)	0.00449 (-95%)
Taupo at Mouth	0.00391	0.03225	0.0036 (-8%)	0.02455 (-24%)	0.00195 (-50%)	0.01358 (-58%)	0.00072 (-82%)	0.00491 (-85%)

Table A.24: Average annual Dissolved Zinc load (kg/year). Values in brackets represent percentage change compared to the baseline.

Reporting Point	Average annual Load (kg/year)			
	Baseline	BAU	Improved	WS
Horokiri and Motukaraka at Near Pauatahanui Golf Club	2.8	8 (188%)	6.4 (130.2%)	3.9 (41.1%)
Belmont at Lincolnshire Farms	28.0	39.8 (42%)	20.4 (-27.1%)	9.2 (-67%)
Porirua at Willowbank	171.5	192 (11.9%)	112.6 (-34.3%)	43.6 (-74.6%)
Porirua at Milk Depot	348.6	370.9 (6.4%)	222.8 (-36.1%)	83.2 (-76.1%)
Taupo at Wetland	81.3	101.3 (24.7%)	63.3 (-22%)	36.4 (-55.2%)
Titahi at Titahi Bay	6.6	7.5 (13.5%)	4.1 (-37.6%)	2 (-69.6%)
Hongoeka to Pukerua at Hongoeka	4.6	3.6 (-22.4%)	2 (-56.3%)	0.8 (-81.5%)
Upper Duck Creek at Bottom of sub-catchment	0.6	0.6 (0%)	0.6 (-13.1%)	0.5 (-28.8%)
Lower Duck Creek at Mouth	0.5	1.9 (309.6%)	1.5 (220%)	0.8 (67.4%)
Horokiri and Motukaraka at Battle Hill	19.0	22 (15.5%)	15.8 (-17%)	10.2 (-46.4%)
Horokiri and Motukaraka at Mouth	1.4	1.4 (-0.6%)	1.2 (-11%)	1.1 (-17.4%)
Kakaho at Mouth	3.6	8.6 (140.4%)	6.9 (94.1%)	4.4 (21.8%)
Upper Kenepuru at Bottom of sub-catchment	1.1	2.1 (94.4%)	1.1 (1.4%)	0.9 (-14.3%)
Kenepuru at Infill case study	0.6	1.1 (81.4%)	0.9 (47.2%)	0.6 (-5.8%)
Kenepuru at Mouth	33.9	32.9 (-3.1%)	25.1 (-26.1%)	16.6 (-51.2%)
Porirua at Mitchell Stream	69.0	70.7 (2.4%)	52.3 (-24.2%)	35.5 (-48.5%)
Rangituhi at Bottom of sub-catchment	41.0	42.2 (2.9%)	22.4 (-45.3%)	4 (-90.3%)
Onepoto Fringe at Elsdon	<0.05	<0.05 (-22.2%)	<0.05 (-22.2%)	<0.05 (-22.2%)
Mahinawa Stream at Mouth	120.4	120.4 (0%)	63.4 (-47.4%)	6 (-95%)
Hukatai Stream at Mouth	2.5	2.5 (0.8%)	2.1 (-15.9%)	1.5 (-38.2%)
Whitireia at Mouth	1.8	1.9 (1.9%)	1.6 (-13.4%)	1.2 (-34.8%)
Moonshine at Bottom of sub-catchment	0.5	0.5 (-1.1%)	0.4 (-16.5%)	0.3 (-37.3%)
Pauatahanui at Elmwood Bridge	1.3	1.2 (-1.2%)	1.2 (-3.6%)	1.1 (-9.2%)
Pauatahanui at Mouth	4.5	10.3 (128.9%)	5.3 (18%)	4.6 (2.4%)
Porirua at Mouth	12.4	19.9 (60.7%)	13.1 (5.6%)	10.3 (-16.7%)
Ration at Mouth	469.8	494.5 (5.3%)	306.7 (-34.7%)	128 (-72.7%)
Stebbings at Bottom of sub-catchment	0.8	2.7 (239.4%)	2.1 (163.9%)	1.1 (39.1%)
Takapu at Bottom of sub-catchment	0.3	8 (2625.2%)	1.6 (440.7%)	1.1 (266.3%)
Porirua at Granada North industrial	18.4	18.4 (0%)	10.1 (-45.3%)	1.6 (-91.1%)
Taupo at Camborne case study	51.8	51.8 (0%)	27.2 (-47.6%)	2.4 (-95.4%)
Taupo at Mouth	8.5	12 (40.6%)	5.3 (-37.8%)	1.3 (-84.5%)

Appendix B. Wastewater overflows

Table B.1: Wastewater overflow summary

Reporting Point	All Scenarios	Baseline and BAU		Improved		WS	
	Overflow locations*	Total overflow volume (m^3)**	Total overflow events***	Total overflow volume (m^3)**	Total overflow events***	Total overflow volume (m^3)**	Total overflow events***
Belmont at Lincolnshire Farms	2	3421.0	100	3176.3 (-7%)	69 (-31%)	2190.2 (-36%)	38 (-62%)
Stebbings at Bottom of sub-catchment	0	0.0	0	0	0	0	0
Porirua at Willowbank	13	74348.7	929	61090.9 (-18%)	453 (-51%)	38486.5 (-48%)	246 (-74%)
Porirua at Granada North industrial	0	0.0	0	-	-	-	-
Porirua at Mitchell Stream	3	3391.9	222	2688.4 (-21%)	93 (-58%)	1571 (-54%)	51 (-77%)
Porirua at Kenepuru Drive	57	316666.7	4903	245702.3 (-22%)	2009 (-59%)	151019.6 (-52%)	1064 (-78%)
Kenepuru at Infill case study	20	67150.1	696	63716.6 (-5%)	423 (-39%)	54968 (-18%)	278 (-60%)
Kenepuru at Mouth	63	211211.0	2708	189488.5 (-10%)	1492 (-45%)	152370.4 (-28%)	914 (-66%)
Porirua at Mouth	126	619414.1	7950	521087.6 (-16%)	3686 (-54%)	366371.6 (-41%)	2076 (-74%)
Mahinawa Stream at Mouth	0	0.0	0	0	0	0	0
Hukatai Stream at Mouth	2	522.5	72	406 (-22%)	38 (-47%)	202 (-61%)	20 (-72%)
Whitireia at Mouth	0	0.0	0	-	-	-	-
Onepoto Fringe at Elsdon	7	6700.7	567	4551.5 (-32%)	195 (-66%)	2668.2 (-60%)	102 (-82%)
Kakaho at Mouth	0	0.0	0	0	0	0	0
Horokiri and Motukaraka at Mouth	0	0.0	0	0	0	0	0
Ration at Mouth	0	0.0	0	0	0	0	0
Pauatahanui at Mouth	3	664.9	59	596.3 (-10%)	41 (-31%)	496.4 (-25%)	28 (-53%)
Lower Duck Creek at Mouth	8	7351.7	156	6755.8 (-8%)	115 (-26%)	5403.1 (-27%)	80 (-49%)
Pauatahanui at Middle reaches	0	0.0	0	0	0	0	0
Horokiri and Motukaraka at Near Pauatahanui G.C.	0	0.0	0	0	0	0	0
Taupo at Wetland	0	0.0	0	0	0	0	0
Taupo at Camborne case study	0	0.0	0	0	0	0	0
Taupo at Mouth	8	4995.2	314	4136.4 (-17%)	180 (-43%)	3106.1 (-38%)	111 (-65%)
Upper Kenepuru at Bottom of sub-catchment	0	0.0	0	0	0	0	0
Upper Duck Creek at Bottom of sub-catchment	0	0.0	0	0	0	0	0
Titahi at Titahi Bay	1	592.3	37	437.2 (-26%)	20 (-46%)	222.1 (-62%)	12 (-68%)
Hongoeka to Pukerua at Hongoeka	0	0.0	0	0	0	0	0
Rangituhi at Bottom of sub-catchment	0	0.0	0	0	0	0	0
Takapu at Bottom of sub-catchment	0	0.0	0	0	0	0	0
Moonshine at Bottom of sub-catchment	0	0.0	0	0	0	0	0
Horokiri and Motukaraka at Battle Hill	0	0.0	0	0	0	0	0

*Overflow locations are aggregated within each sub-catchment

**Volume is total volume over 10-year scenario period (2005-2014)

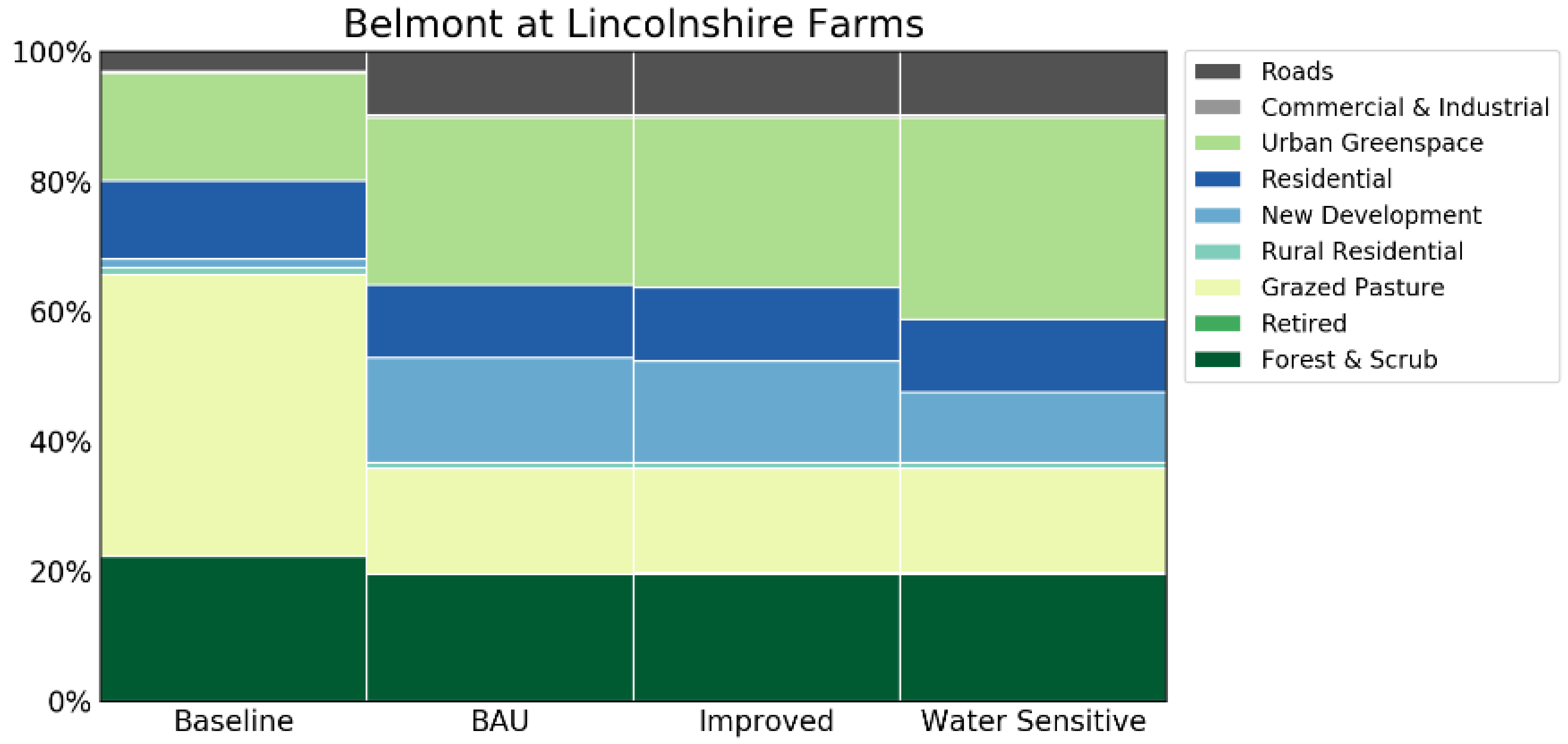
***Events sum overflows occurring for all locations – i.e. a single storm event will contribute 2 events if an overflow occurs at 2 locations

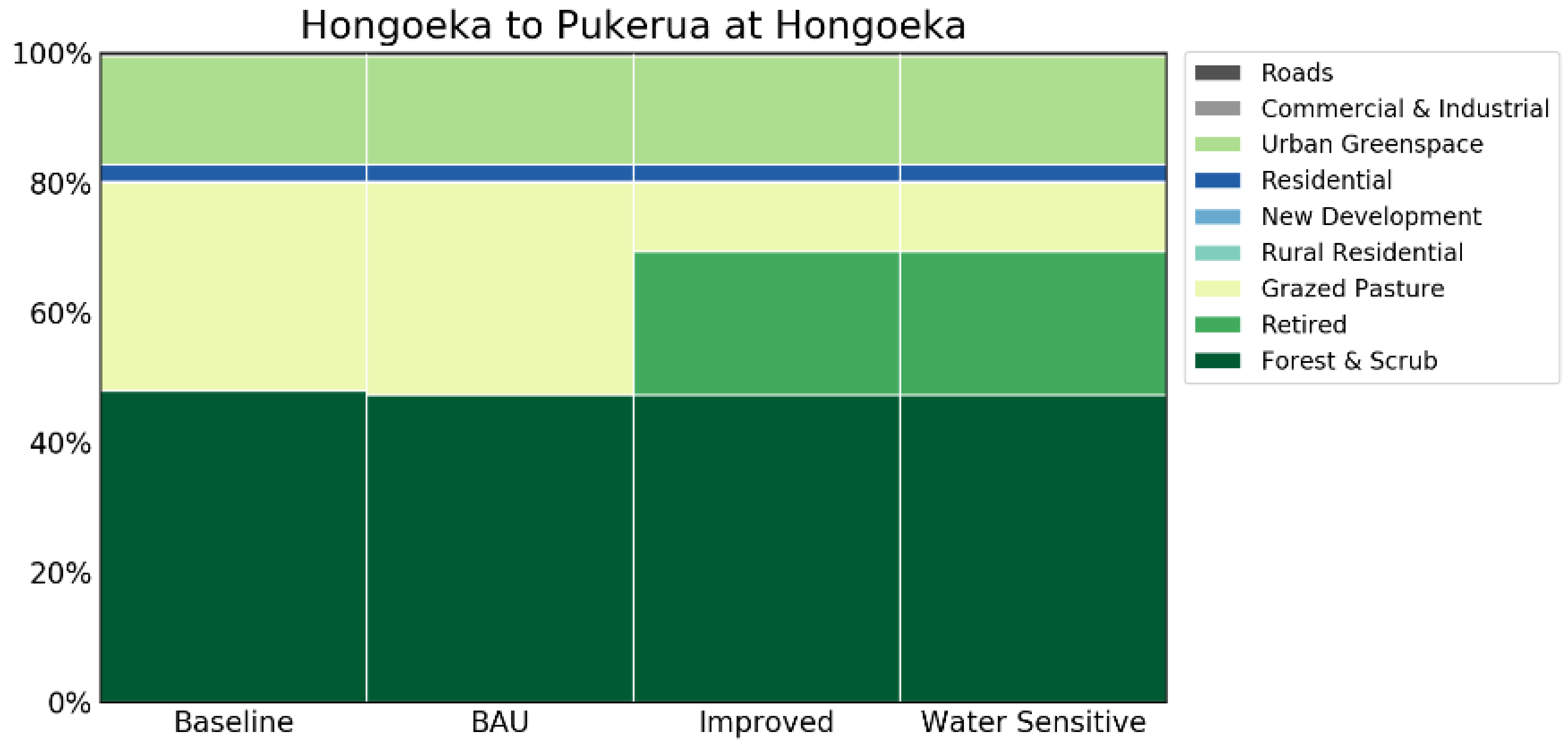
Appendix C. Scenario land use change

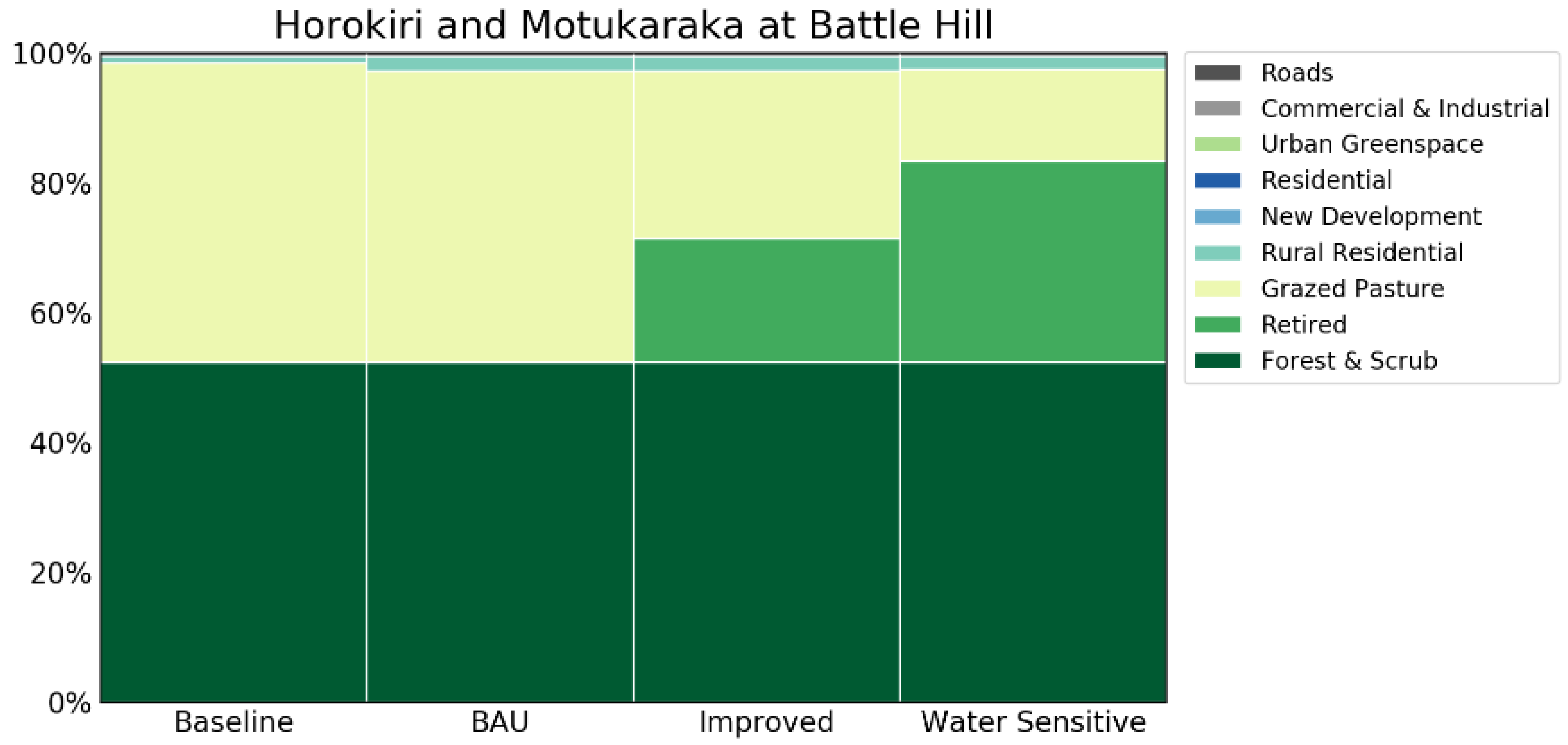
Table C.1: Scenario Functional Units and Conceptual Group

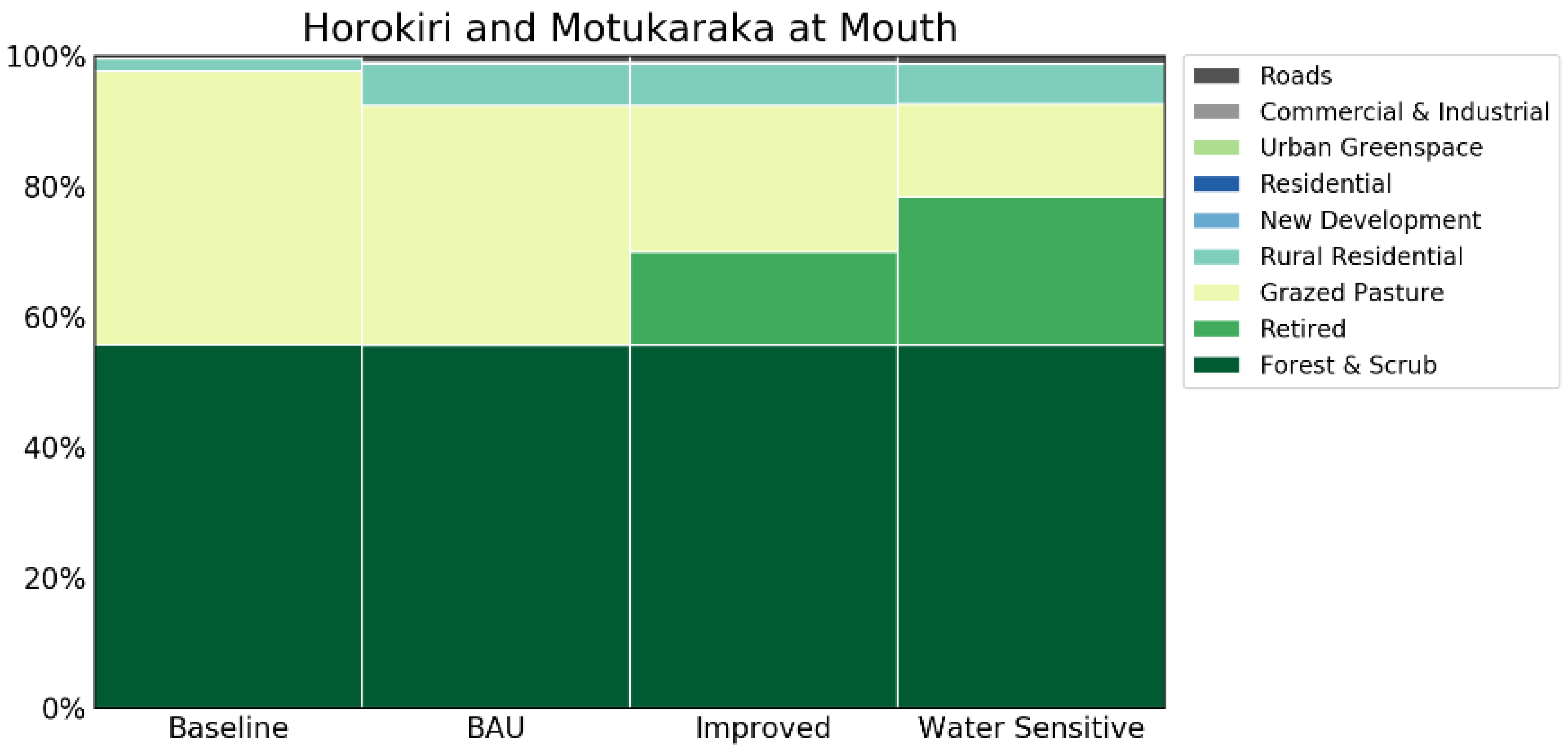
Baseline / Scenario	Functional Unit	Conceptual Group
Baseline	Commercial Roof	Commercial & Industrial
Baseline	Commercial Paved	Commercial & Industrial
Baseline	Industrial Roof	Commercial & Industrial
Baseline	Industrial Paved	Commercial & Industrial
Baseline	Residential Roof	Residential
Baseline	Residential Paved	Residential
Baseline	Roads (< 1000 VPD)	Roads
Baseline	Roads (1000 – 5000 VPD)	Roads
Baseline	Roads (5000 – 20000 VPD)	Roads
Baseline	Roads (20000 – 50000 VPD)	Roads
Baseline	Roads (50000 – 100000 VPD)	Roads
Baseline	Natural Forest	Forest & Scrub
Baseline	Plantation Forest	Forest & Scrub
Baseline	Scrub	Forest & Scrub
Baseline	Urban Grassland	Urban Greenspace
Baseline	Deer	Grazed Pasture
Baseline	Sheep & Beef (hill country)	Grazed Pasture
Baseline	Sheep & Beef (lowland intensive)	Grazed Pasture
Baseline	Other Animals	Lifestyle & Other
Baseline	Horticulture	Lifestyle & Other
Baseline	Other	Lifestyle & Other
Baseline	Construction Site	Construction
Baseline	Water	-
Scenario	Replacement Low Yield Roof	Residential
Scenario	Greenfield Residential Paved	New Development
Scenario	Greenfield Residential Roof	New Development
Scenario	Greenfield Urban Grassland	Urban Greenspace
Scenario	Infill Residential Paved	New Development
Scenario	Infill Residential Roof	New Development
Scenario	Infill Urban Grassland	Urban Greenspace
Scenario	Infill Roads (1000 VPD)	Roads
Scenario	Infill Roads (1000 – 5000 VPD)	Roads
Scenario	Infill Roads (5000 – 20000 VPD)	Roads
Scenario	Infill Roads (20000 – 50000 VPD)	Roads
Scenario	Greenfield Roads (1000 VPD)	Roads
Scenario	Retirement	Retired

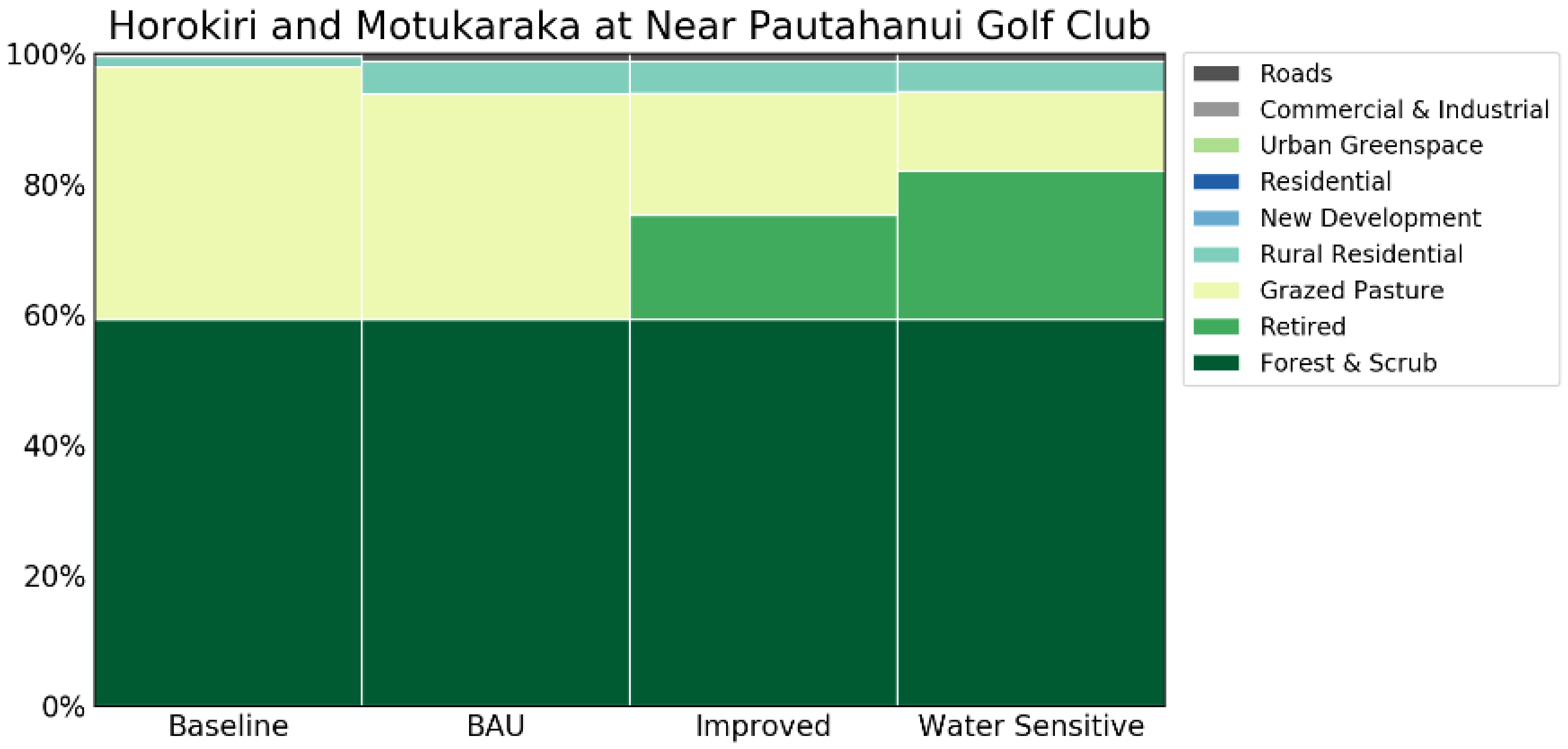
Figure C.1: Land use change plots. Legend corresponds to the 'Conceptual Group' column in Table C.1.

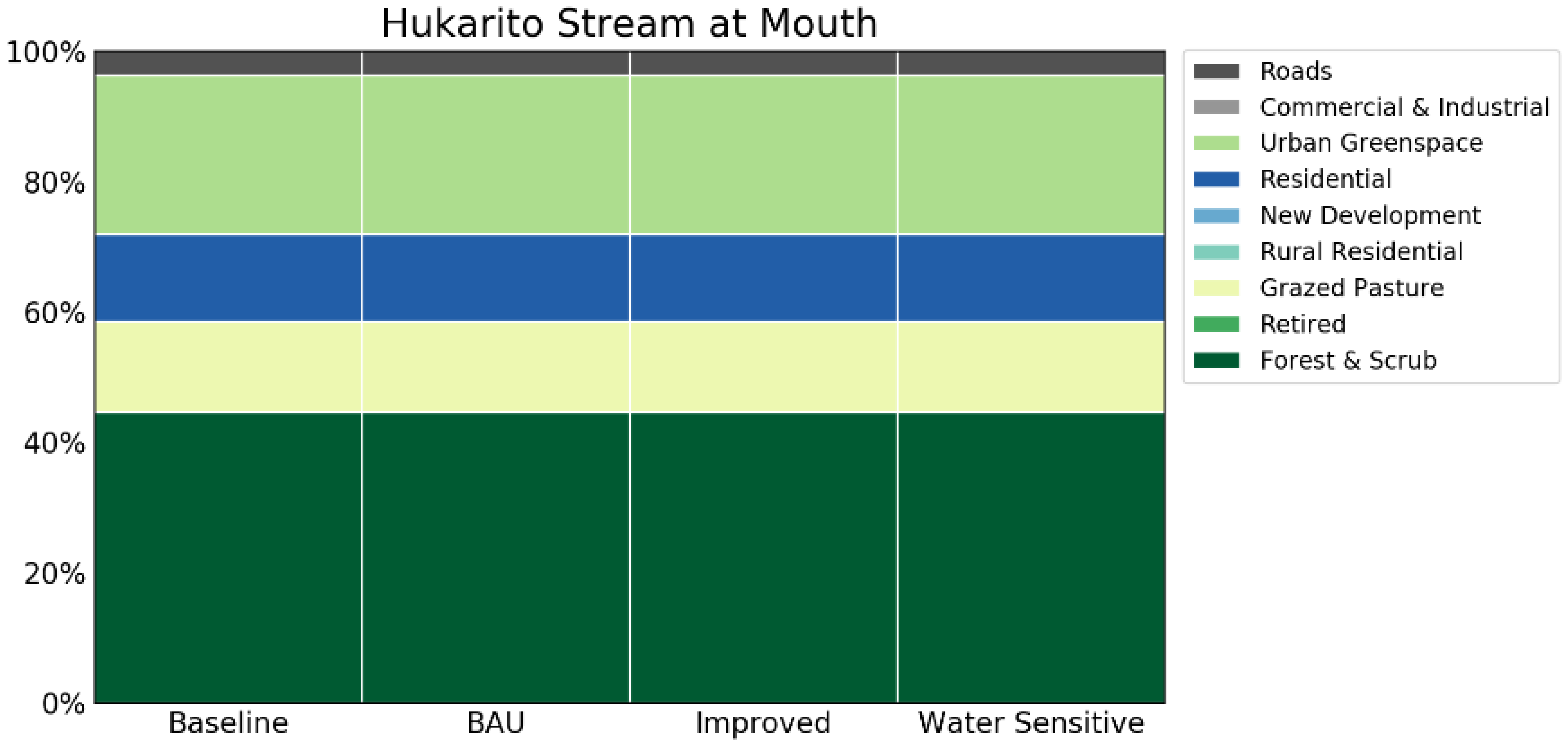


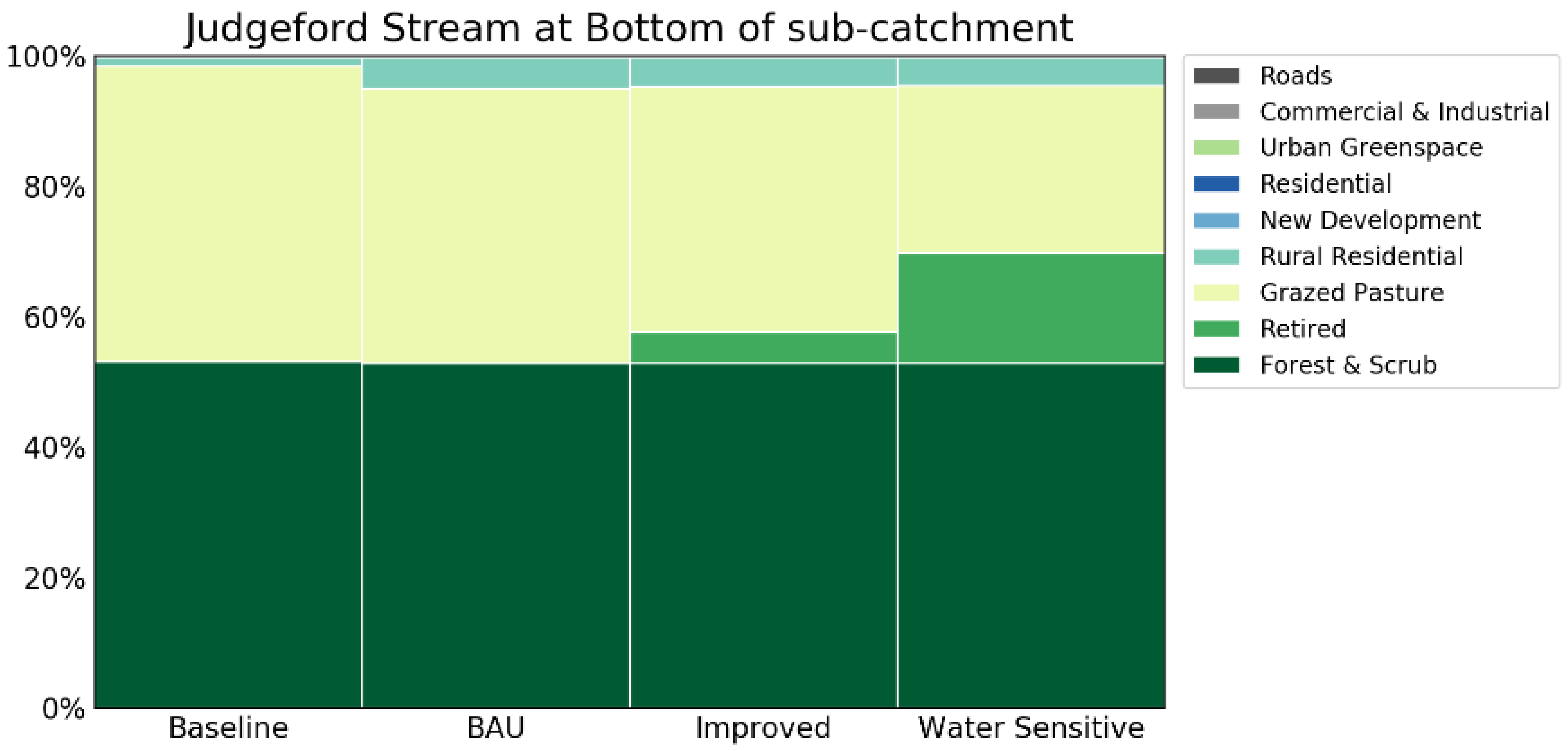


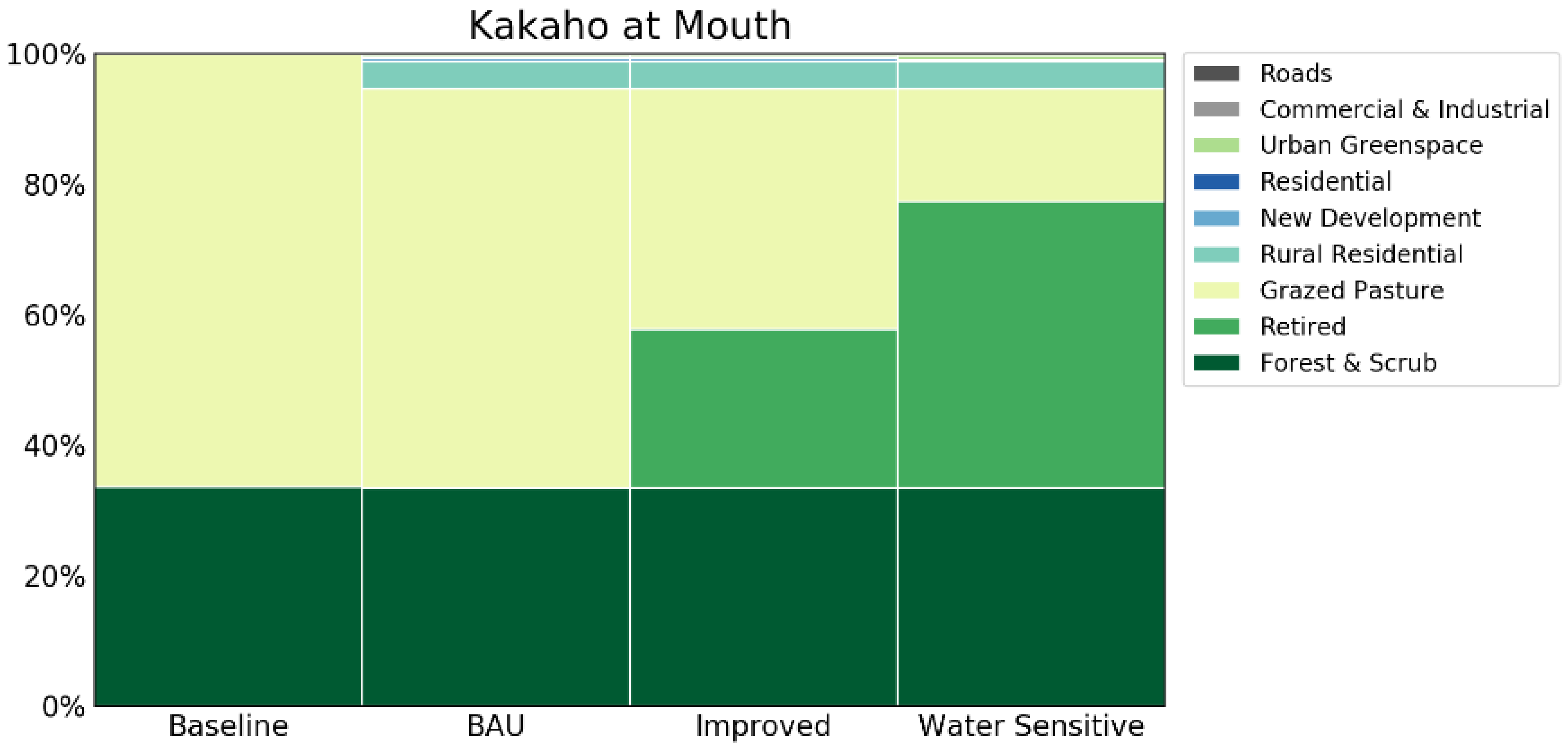


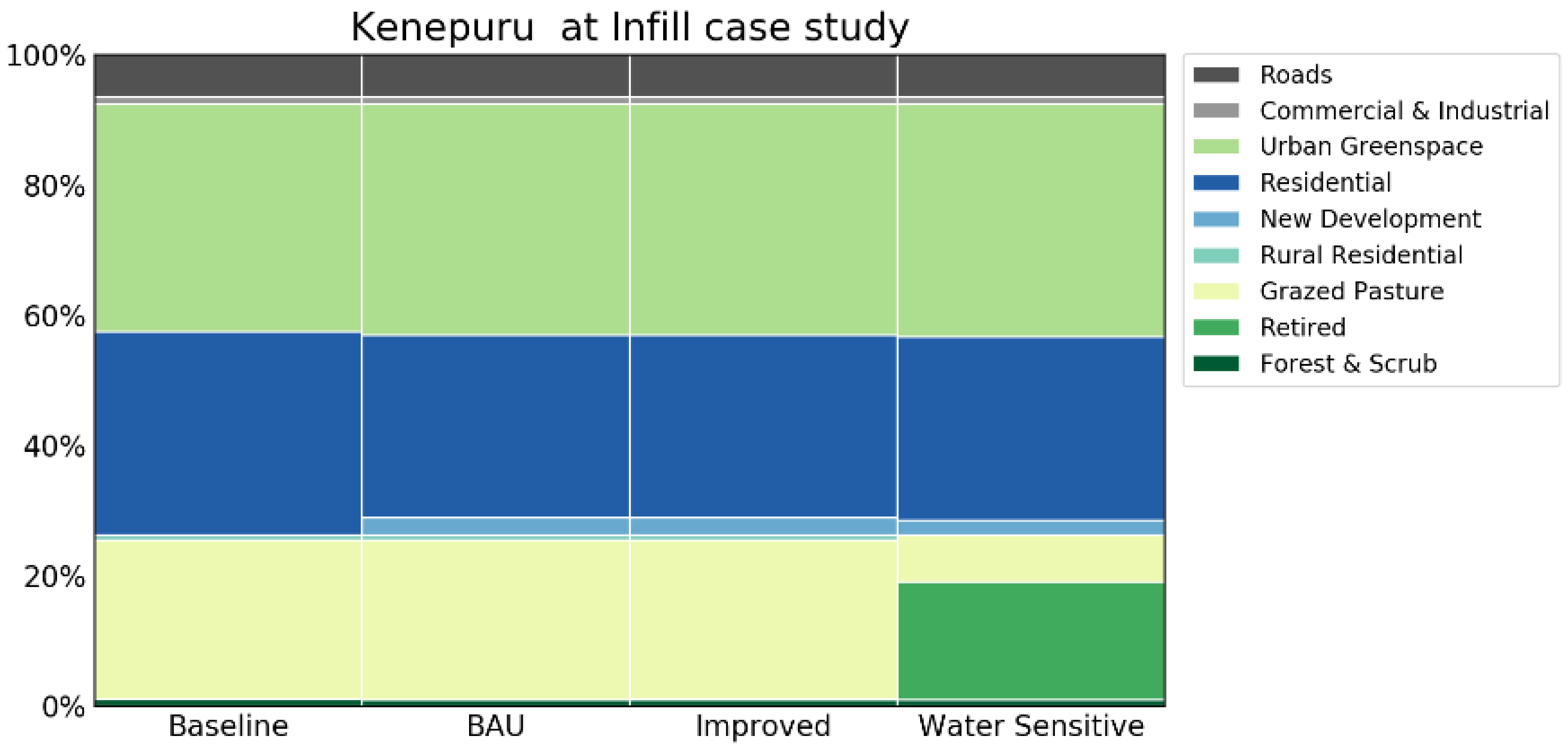

Horokiri and Motukaraka at Mouth
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

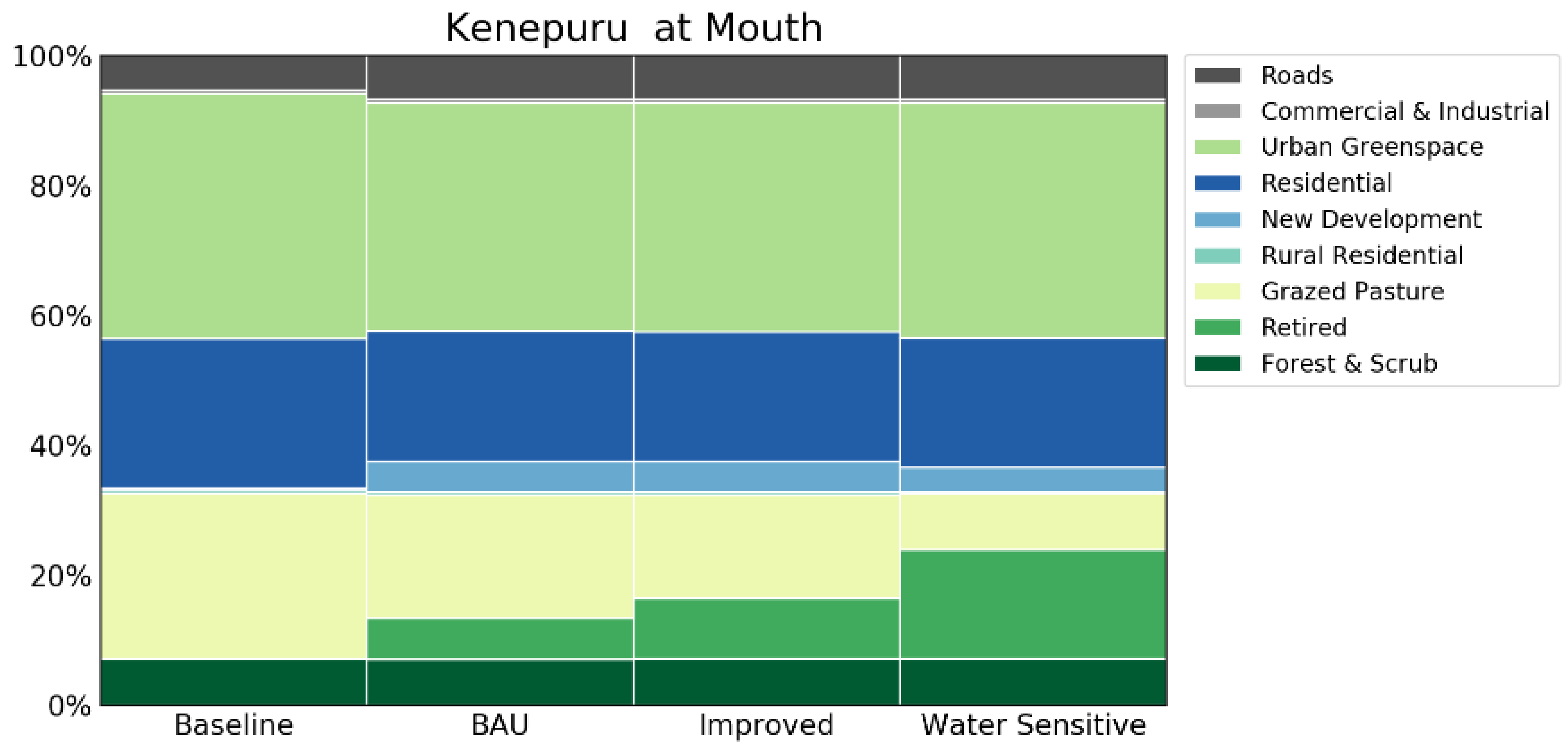

Horokiri and Motukaraka at Near Pautahanui Golf Club
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

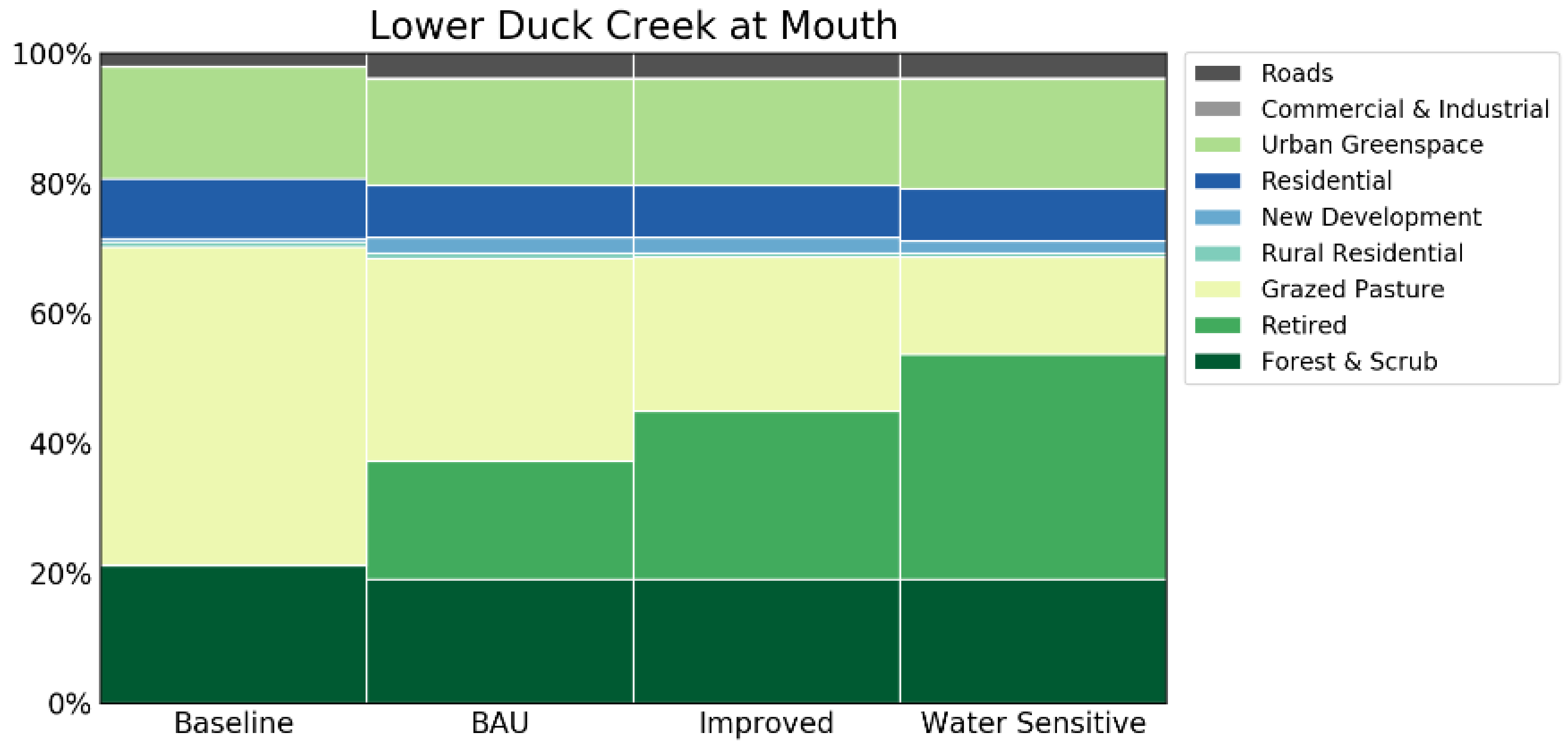

Hukarito Stream at Mouth
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

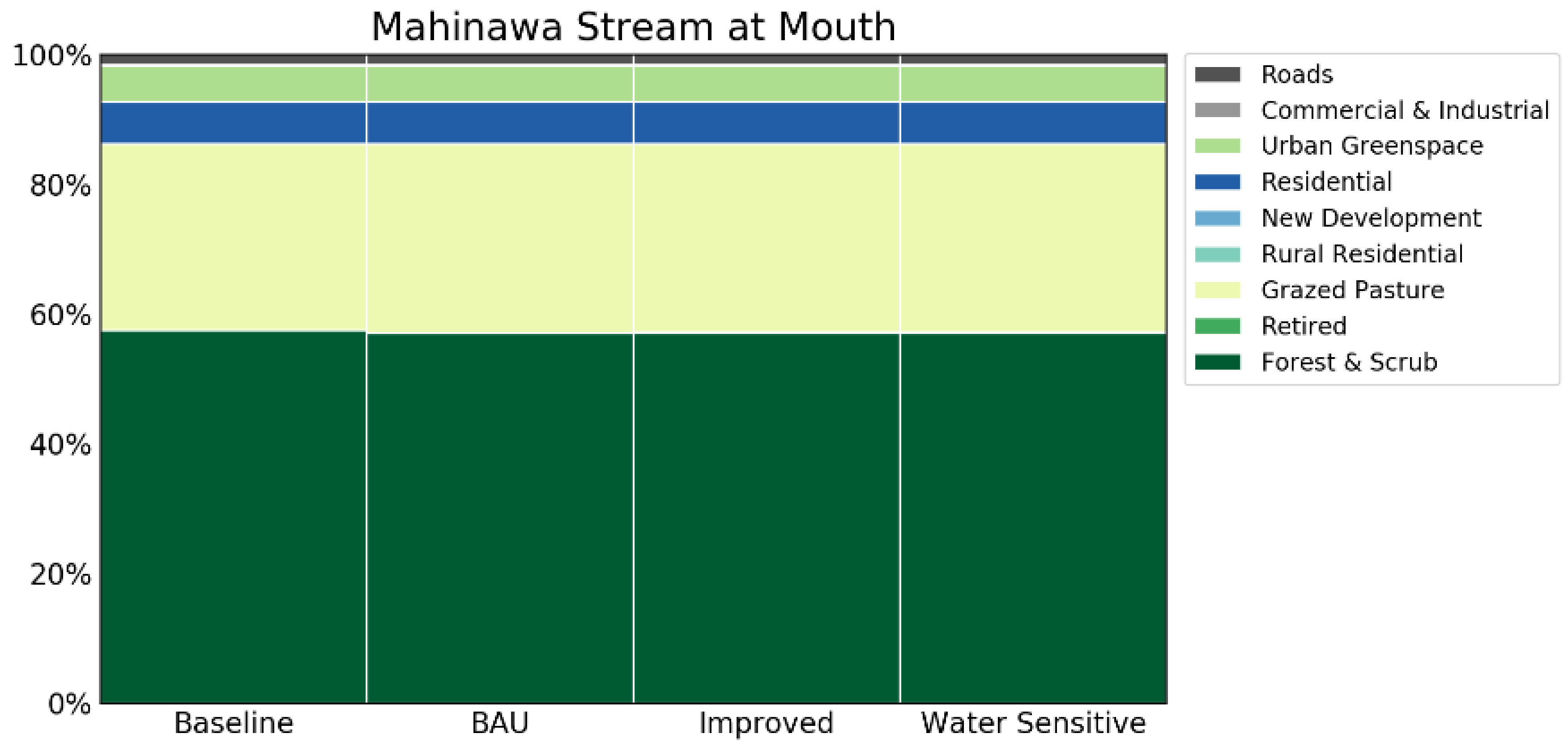

Judgeford Stream at Bottom of sub-catchment
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

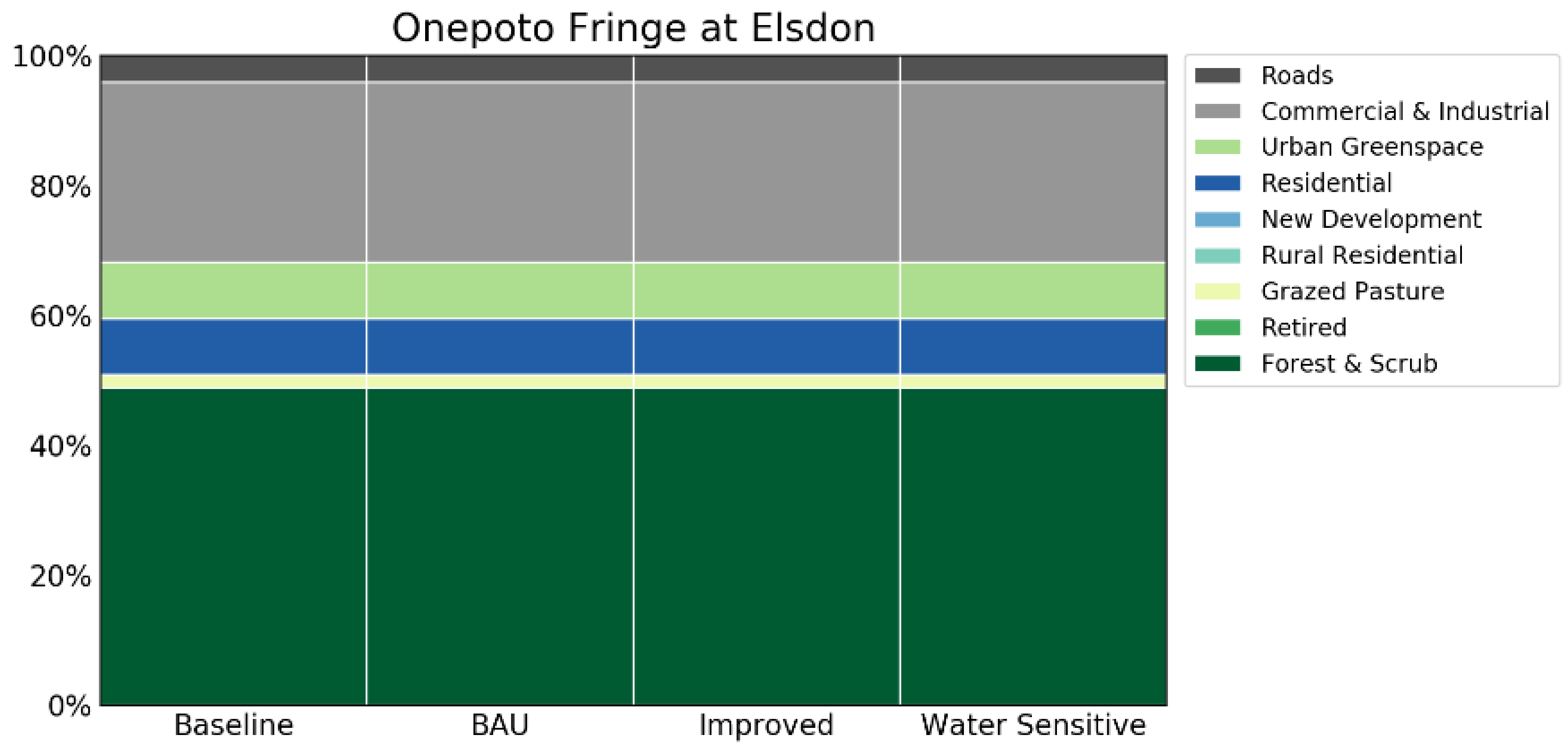

Kakaho at Mouth
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

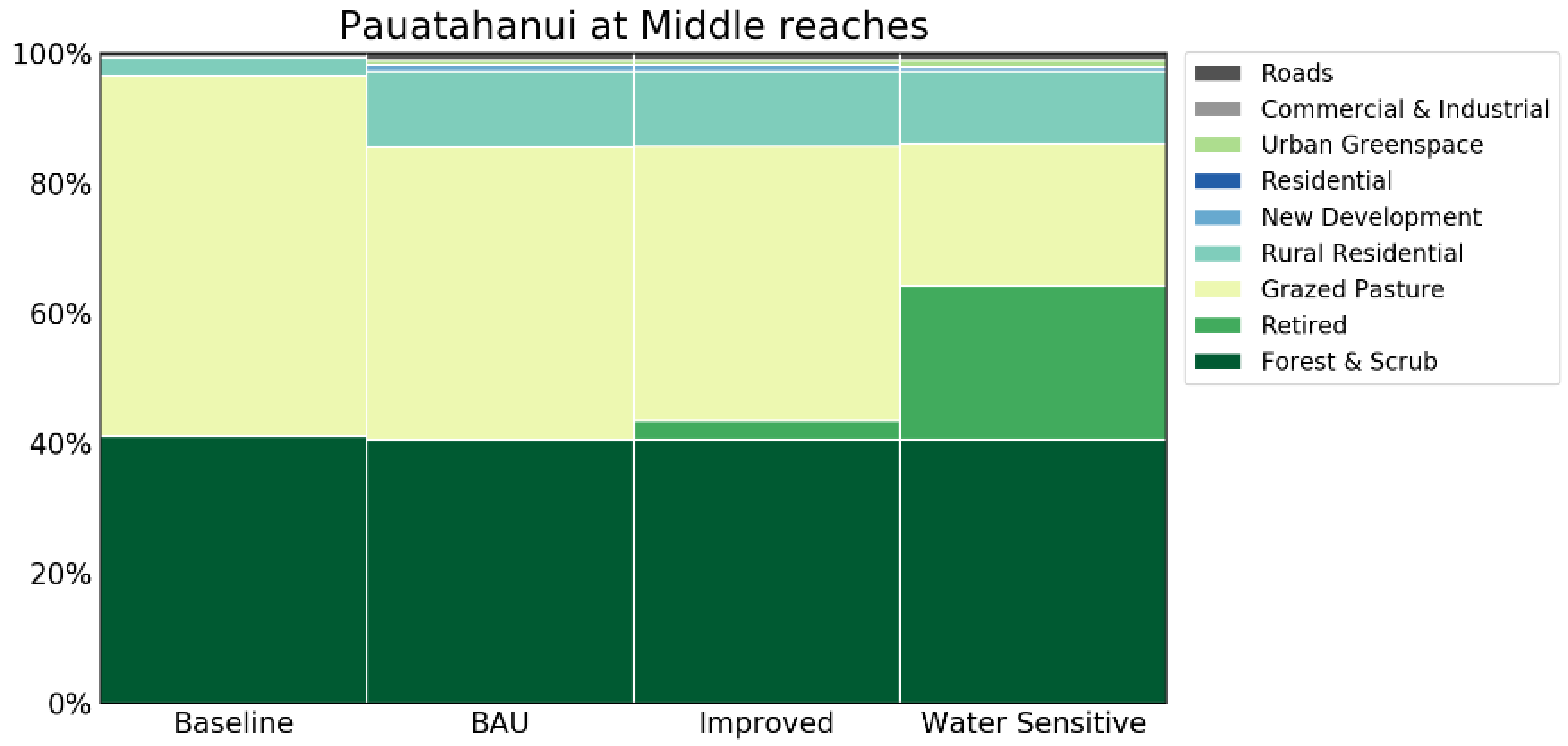

Kenepuru at Infill case study
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

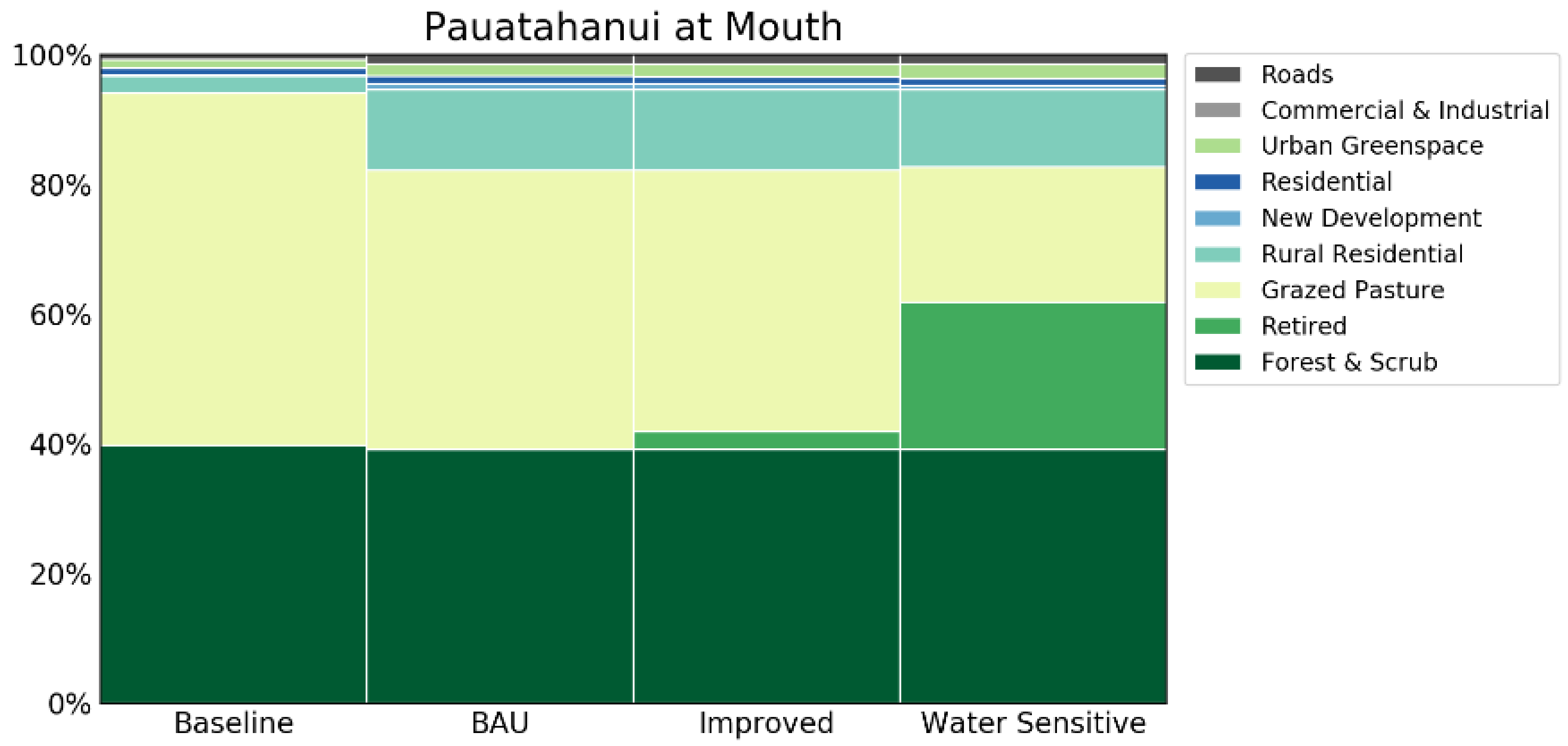

Kenepuru at Mouth
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

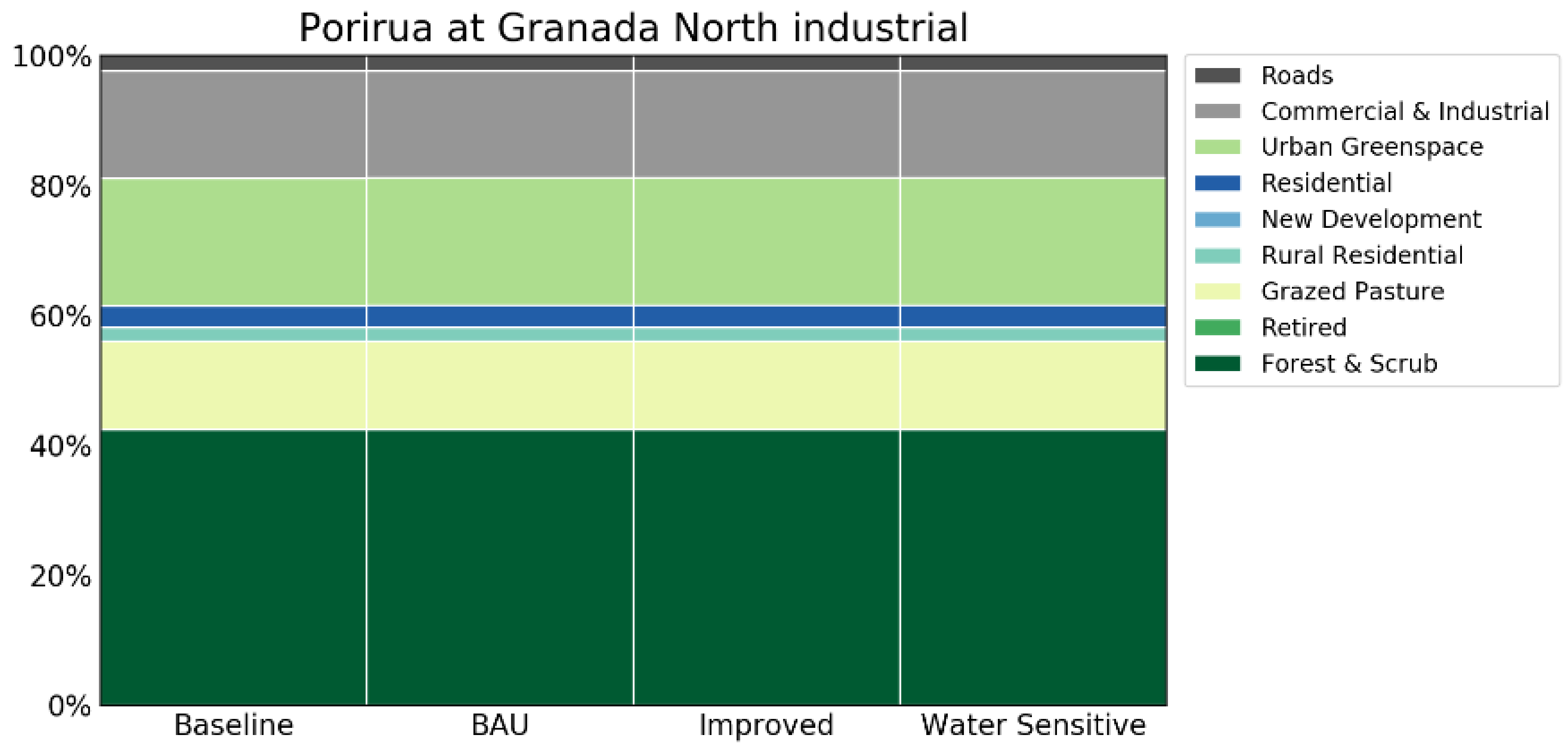

Lower Duck Creek at Mouth
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

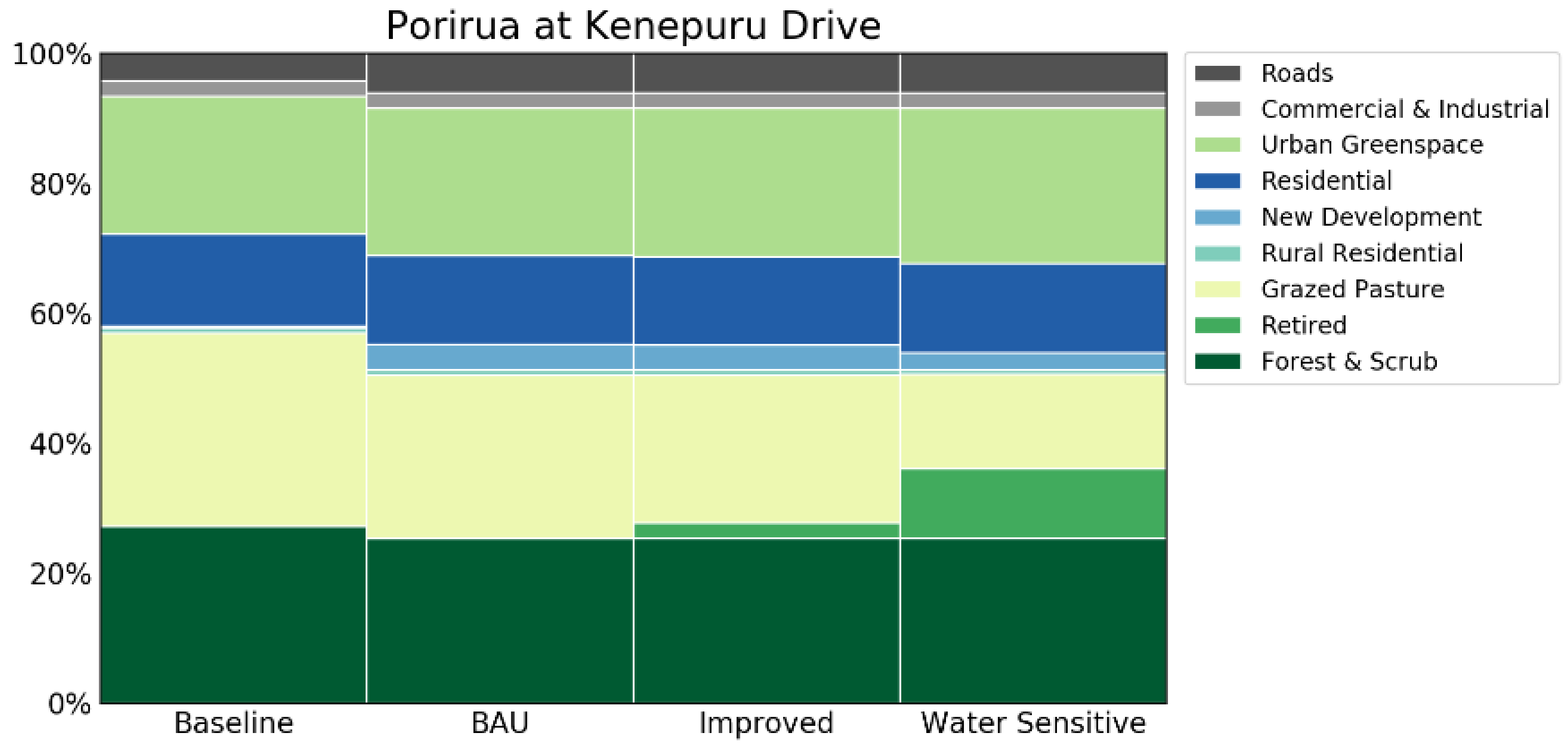

Mahinawa Stream at Mouth
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

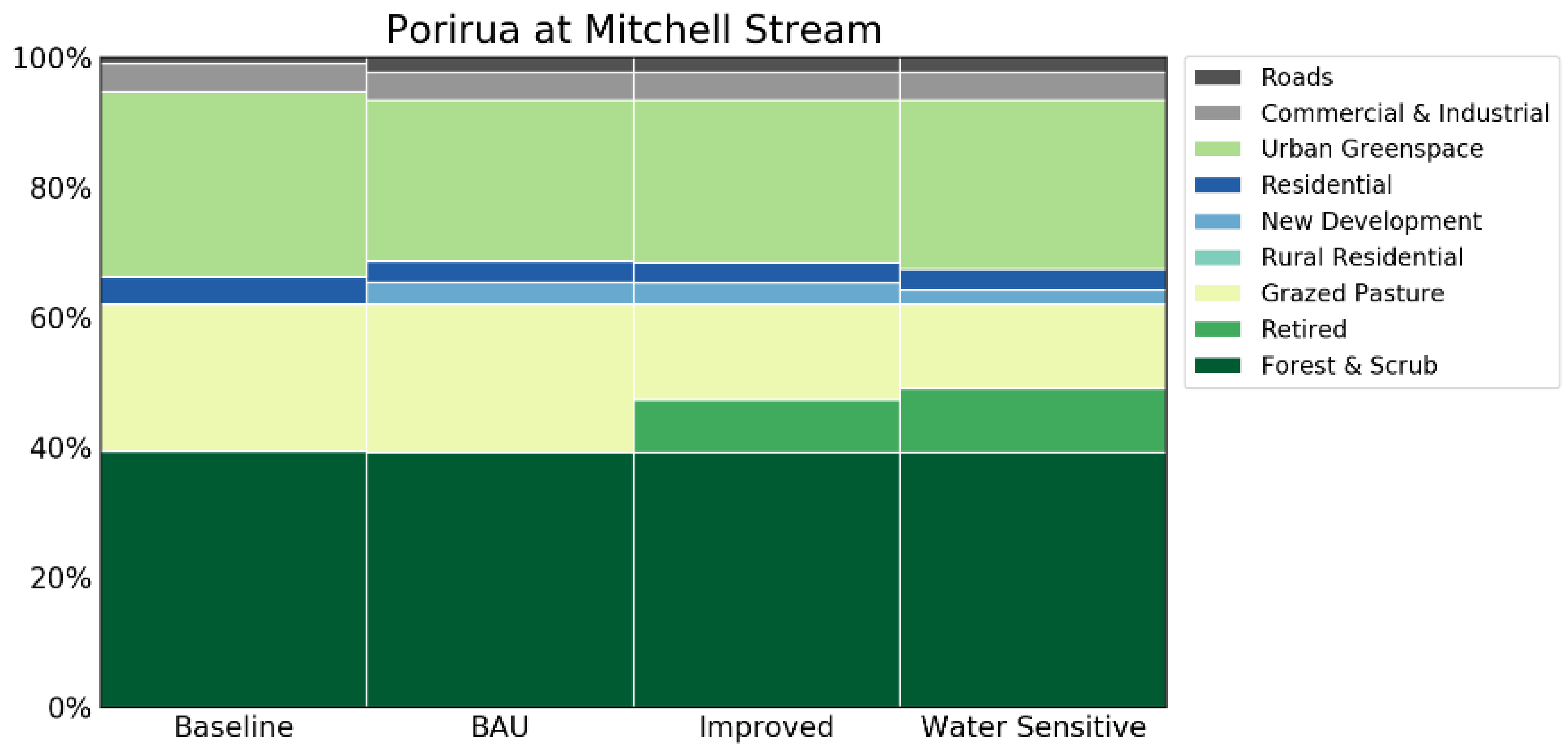

Onepoto Fringe at Elsdon
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

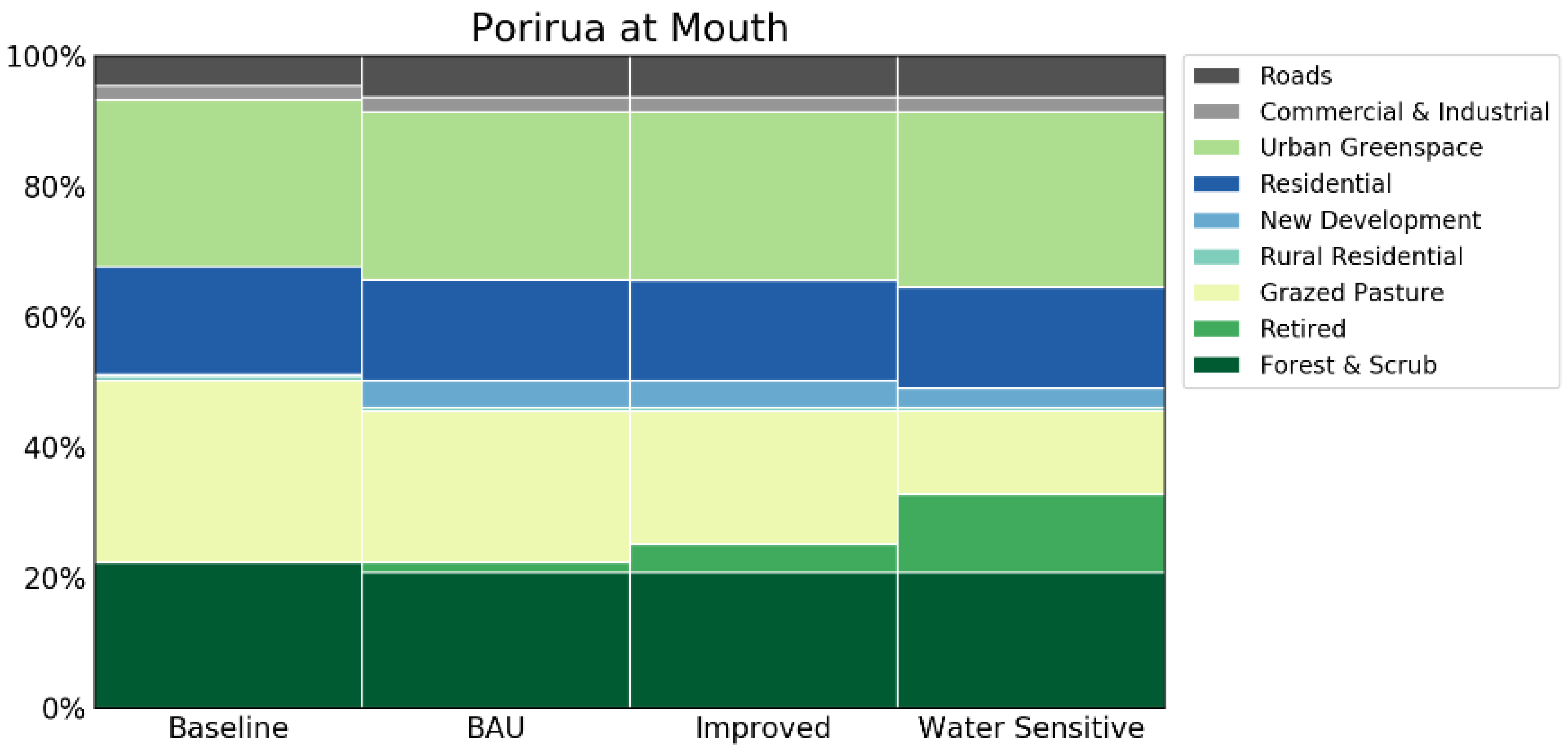

Pauatahanui at Middle reaches
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

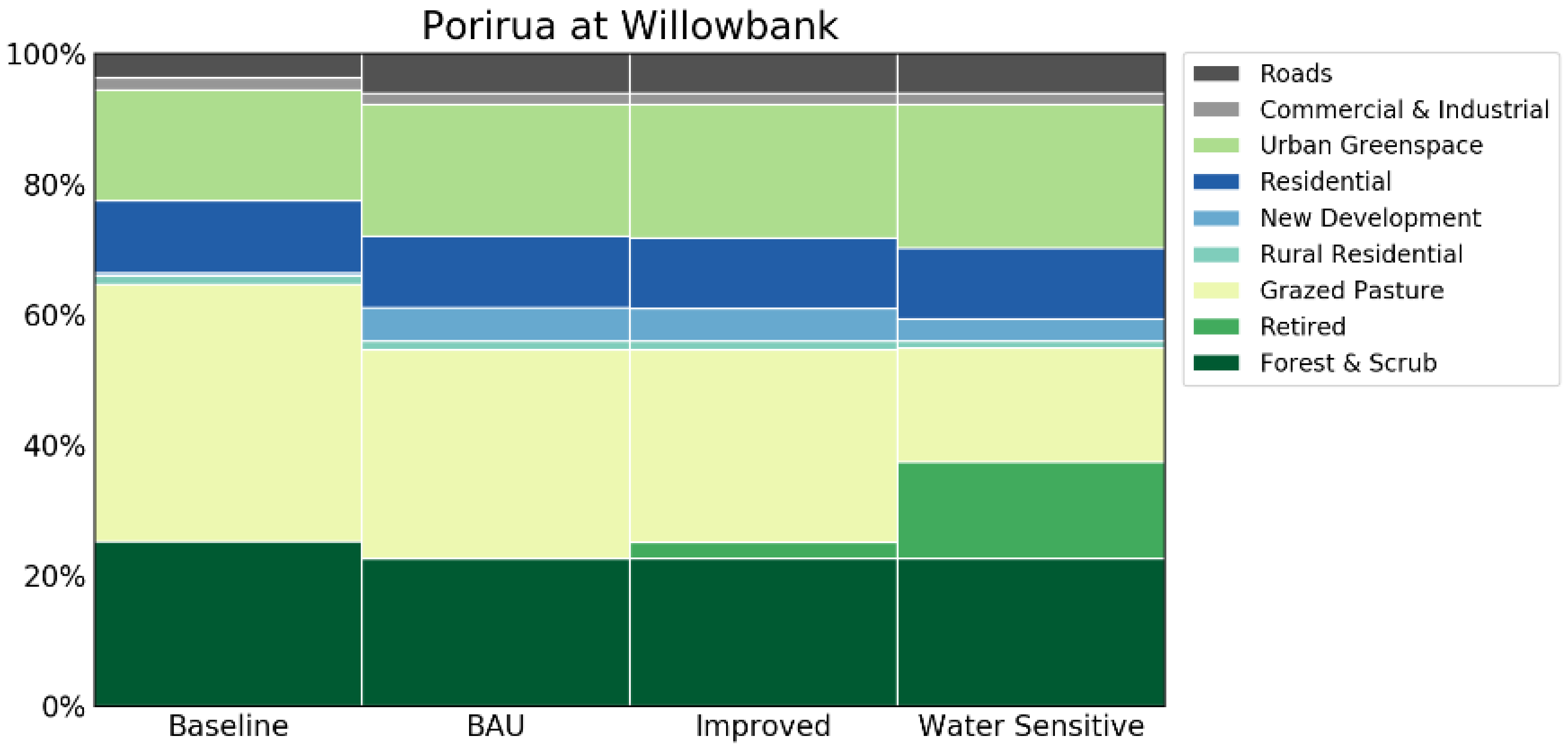

Pauatahanui at Mouth
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

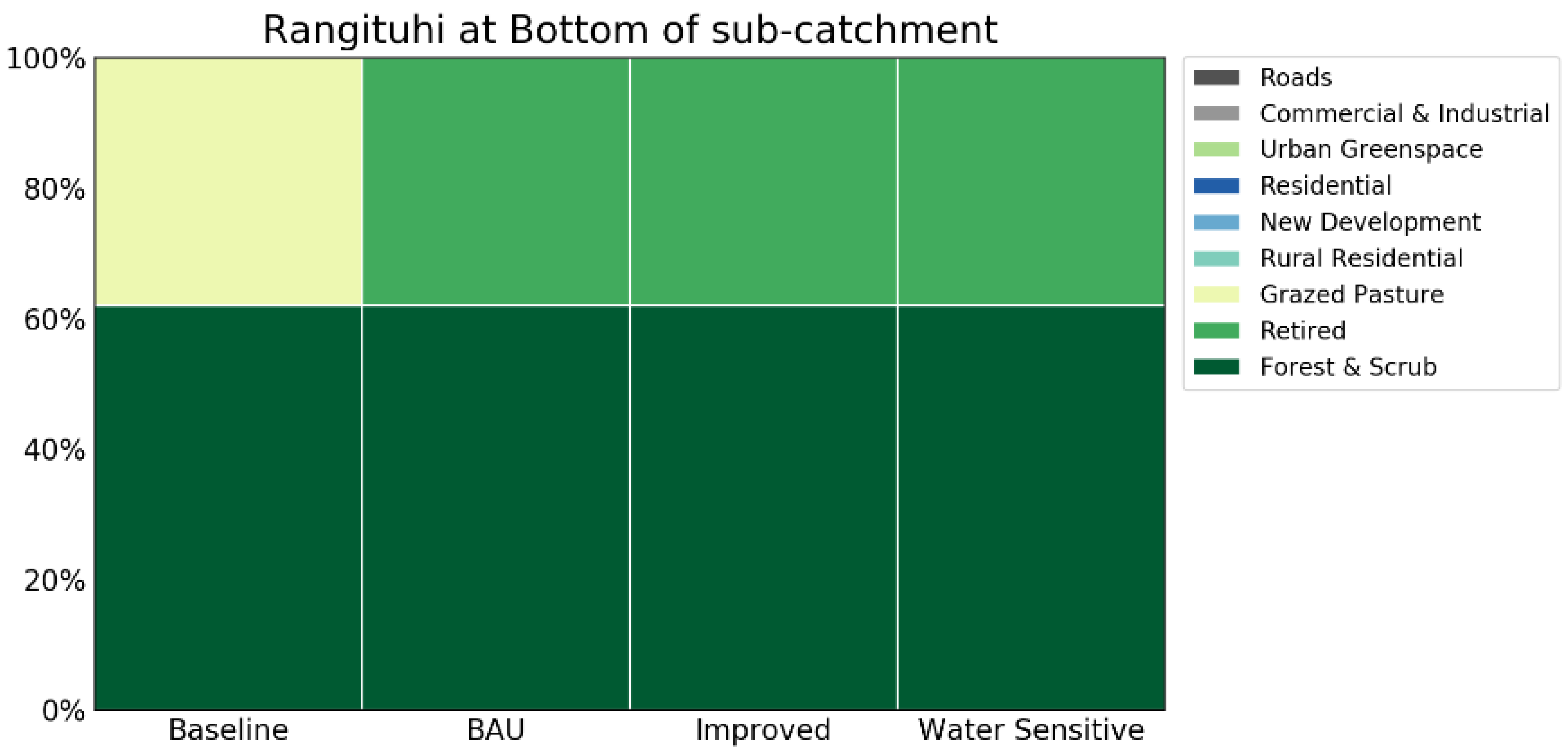

Porirua at Granada North industrial
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

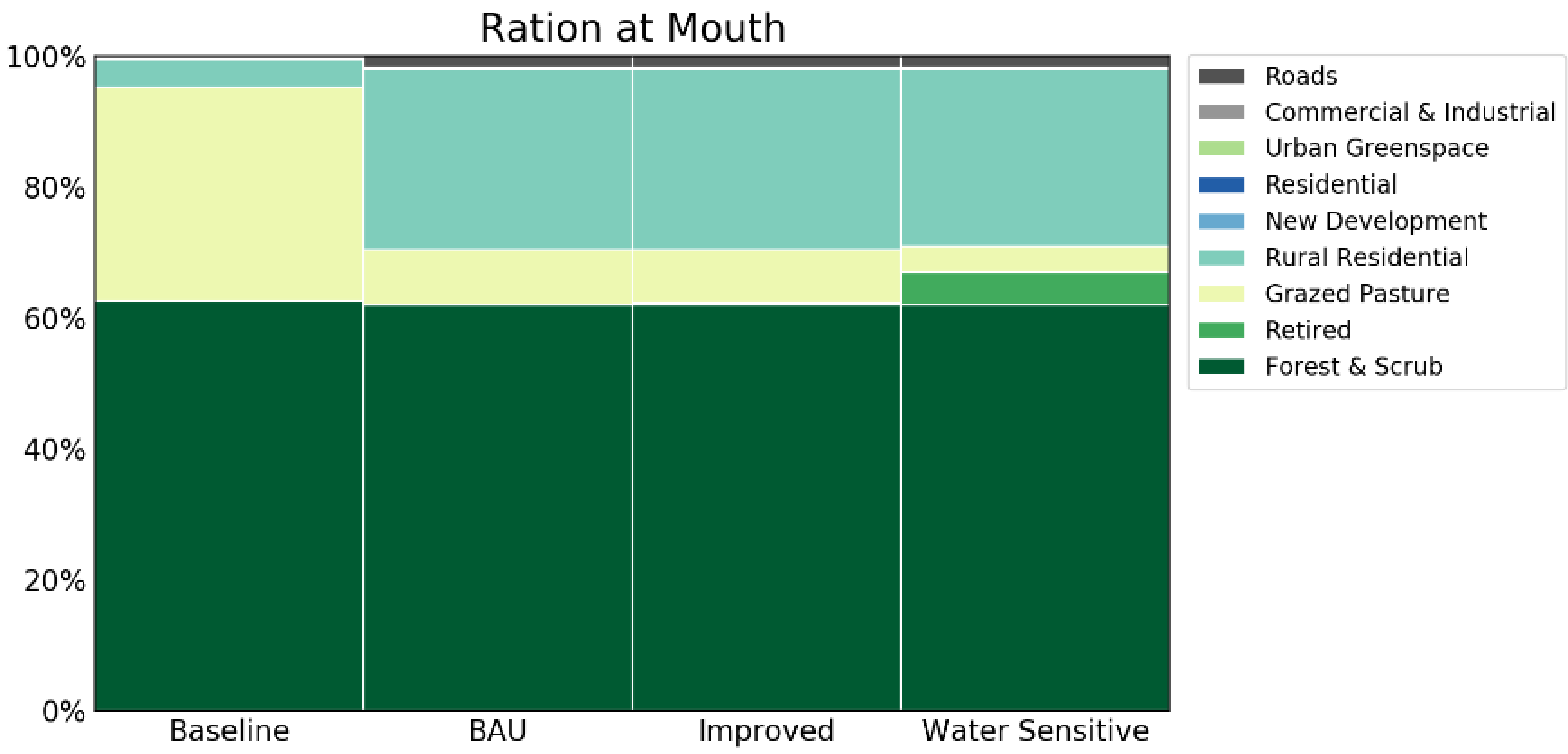

Porirua at Kenepuru Drive
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

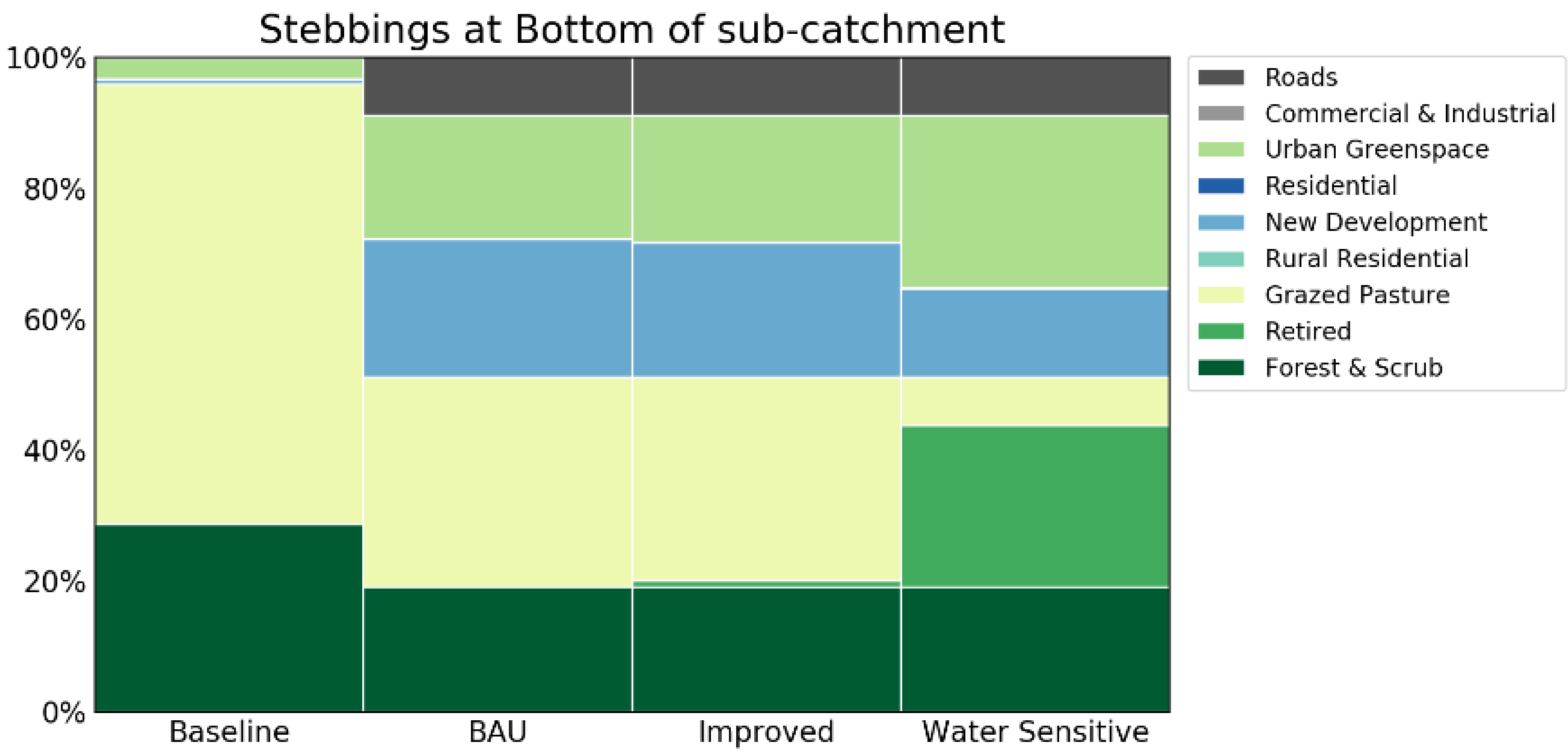

Porirua at Mitchell Stream
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

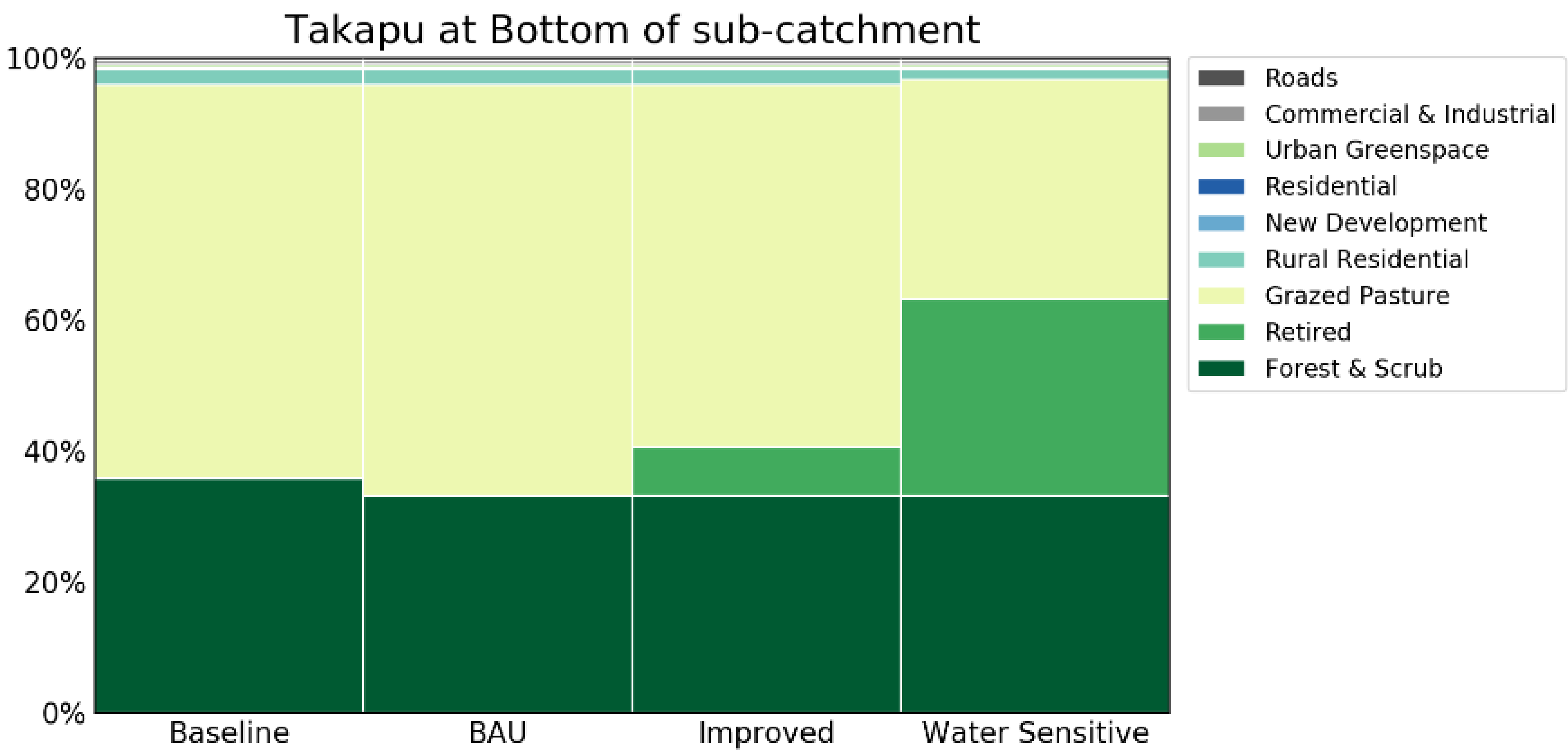

Porirua at Mouth
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

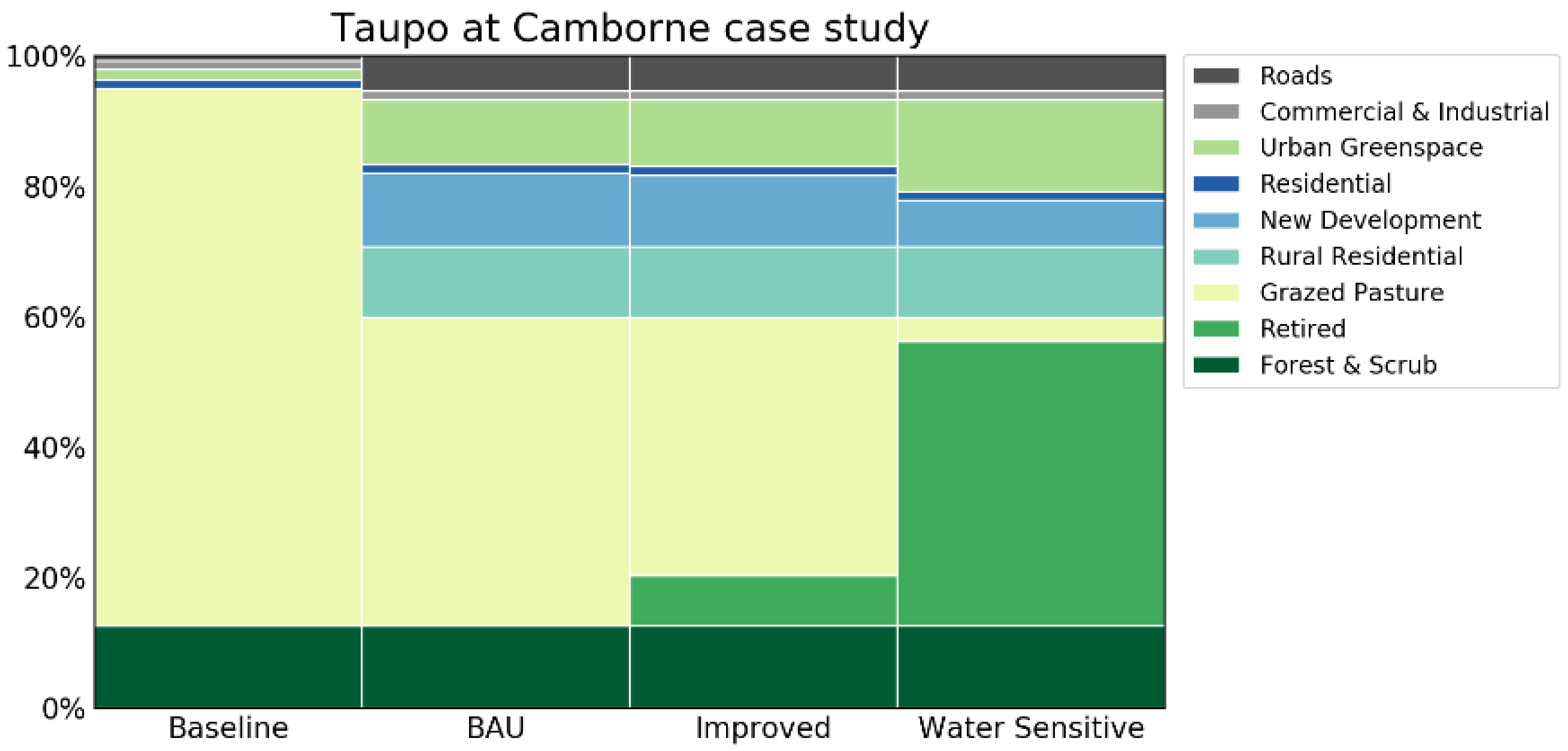

Porirua at Willowbank
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

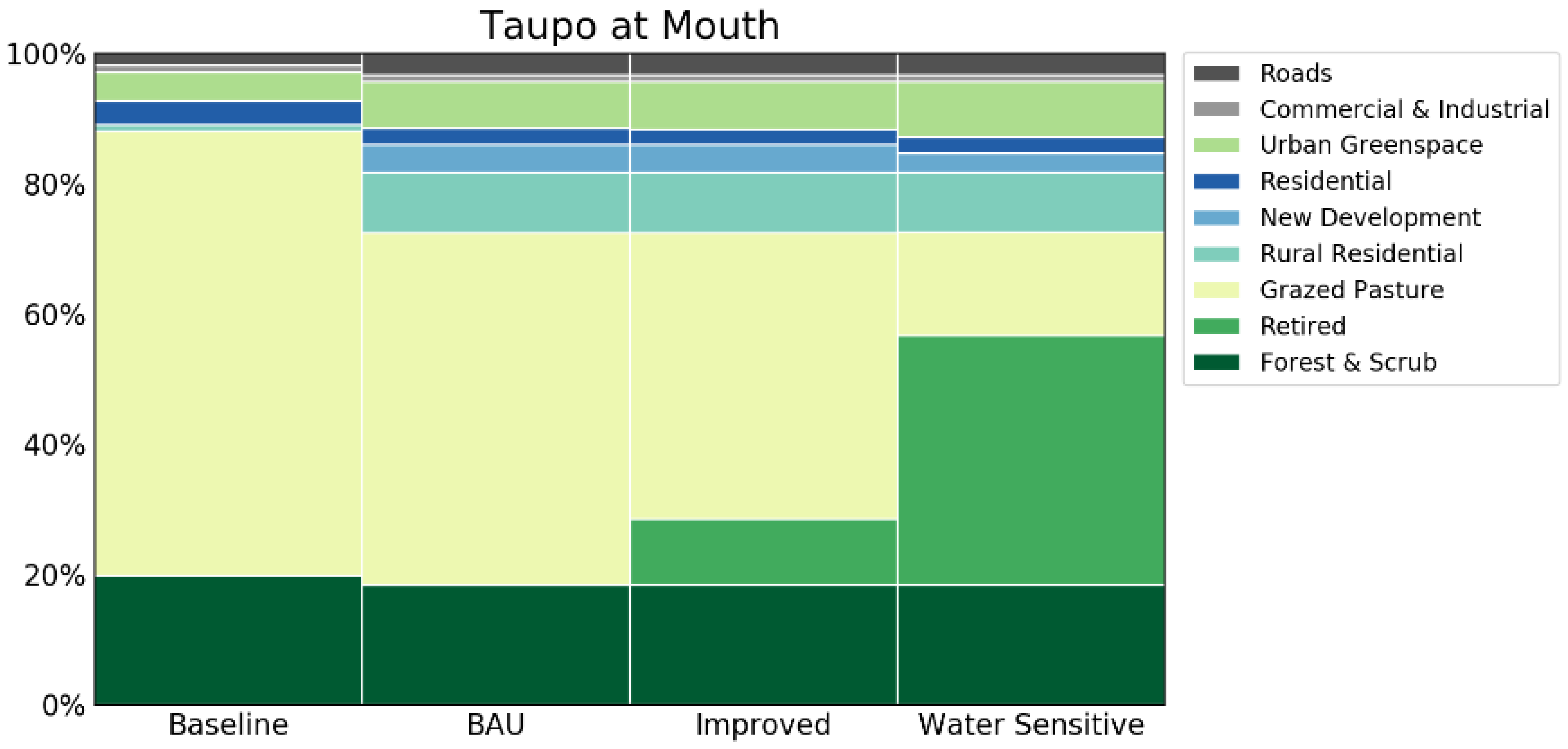

Rangituhi at Bottom of sub-catchment
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

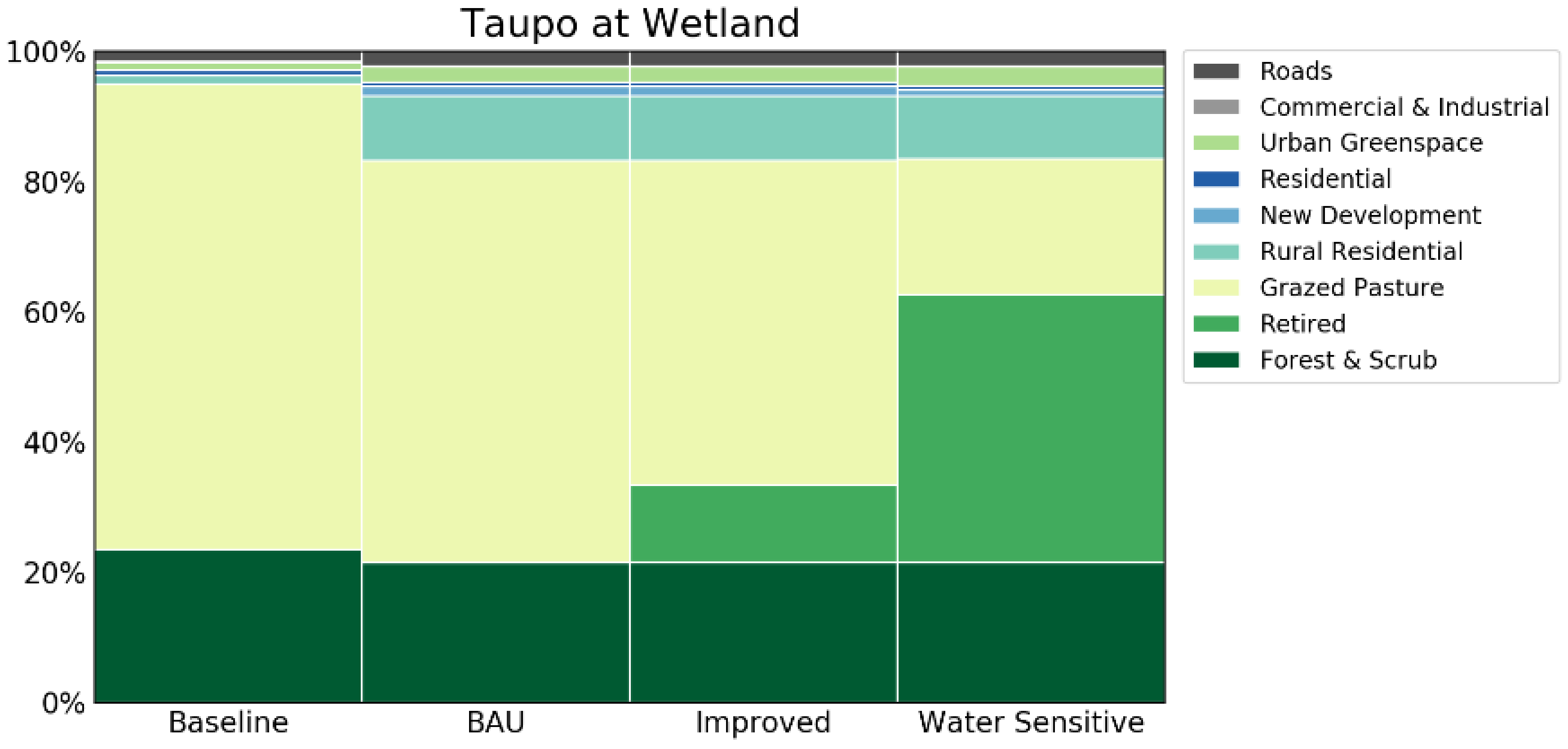

Ration at Mouth
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

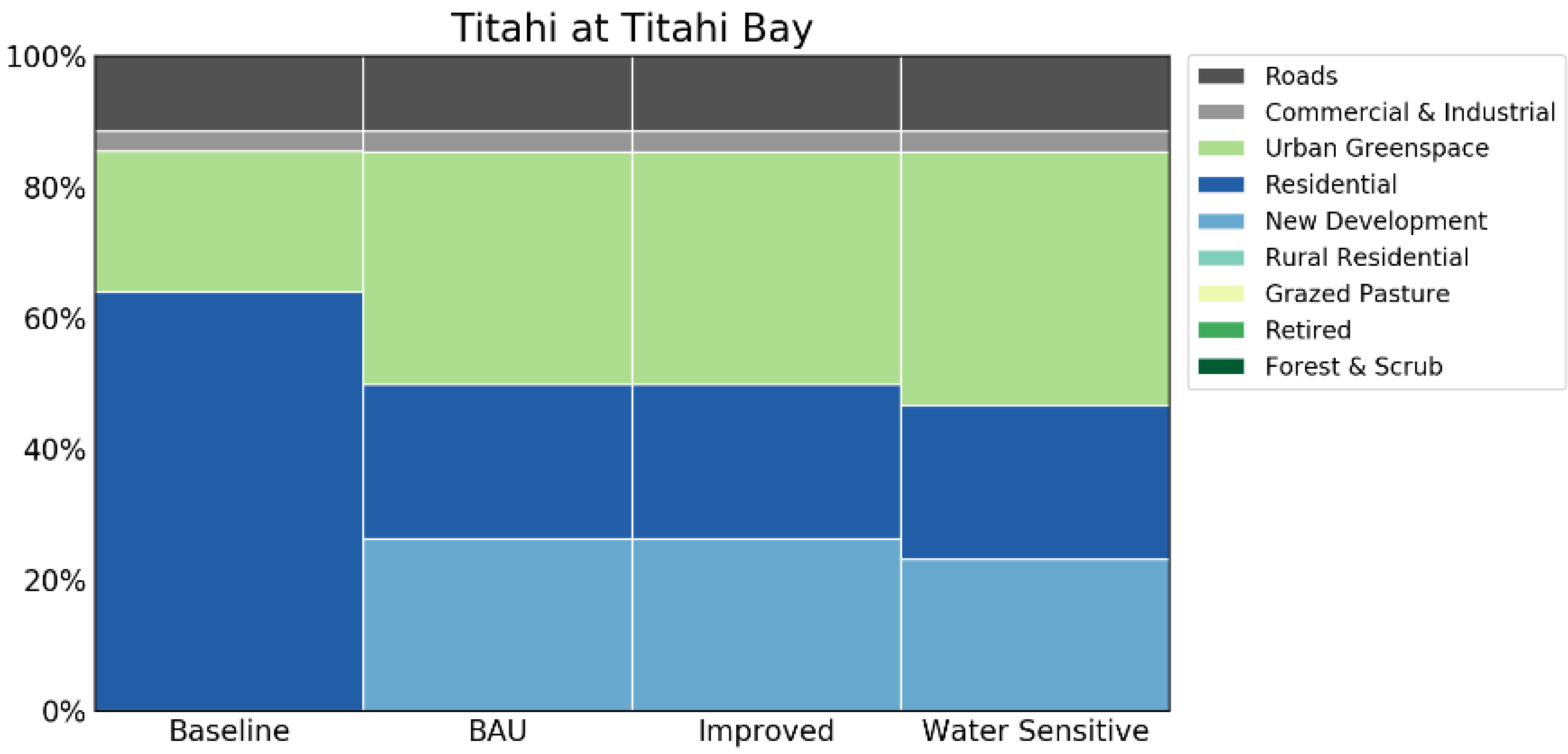

Stebbings at Bottom of sub-catchment
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

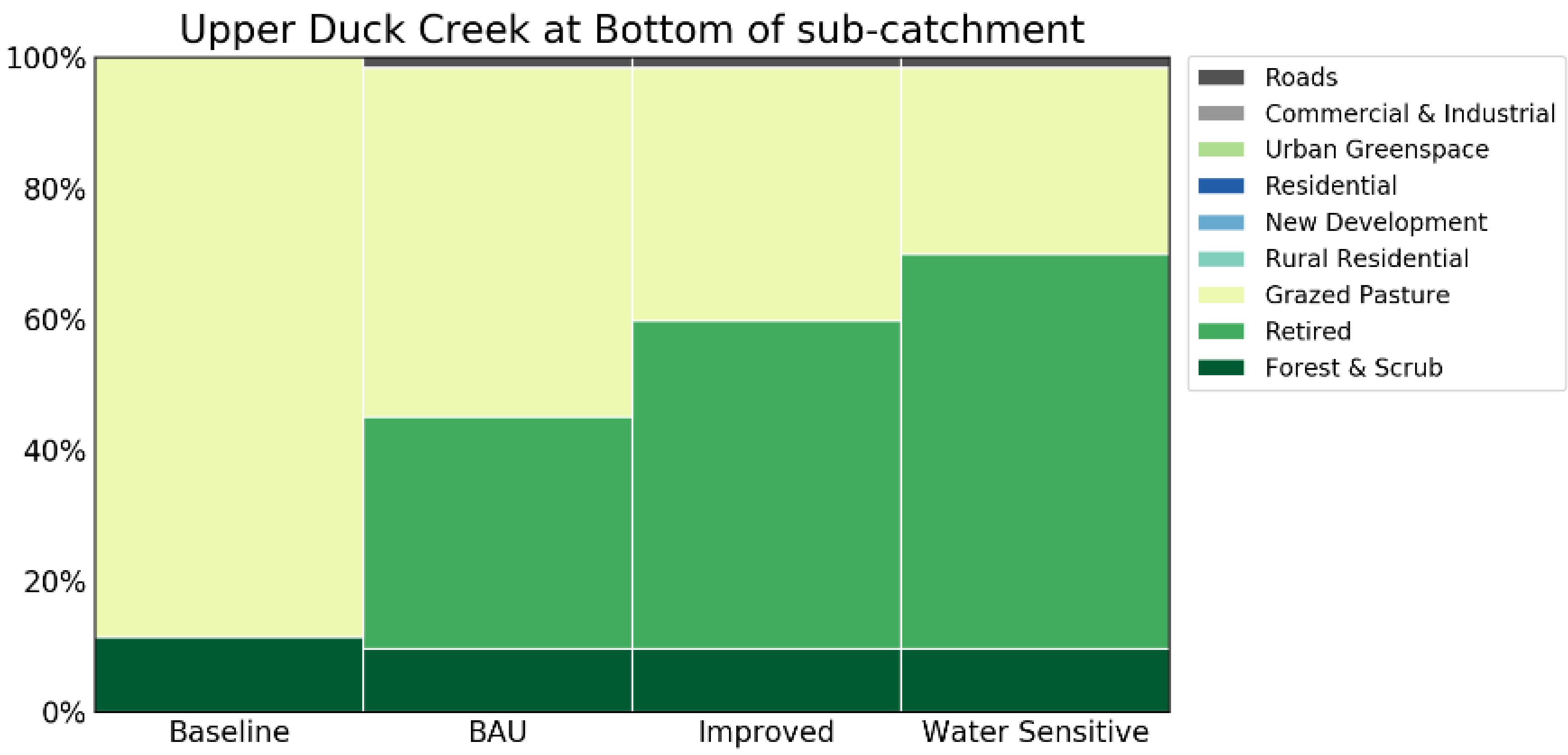

Takapu at Bottom of sub-catchment
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

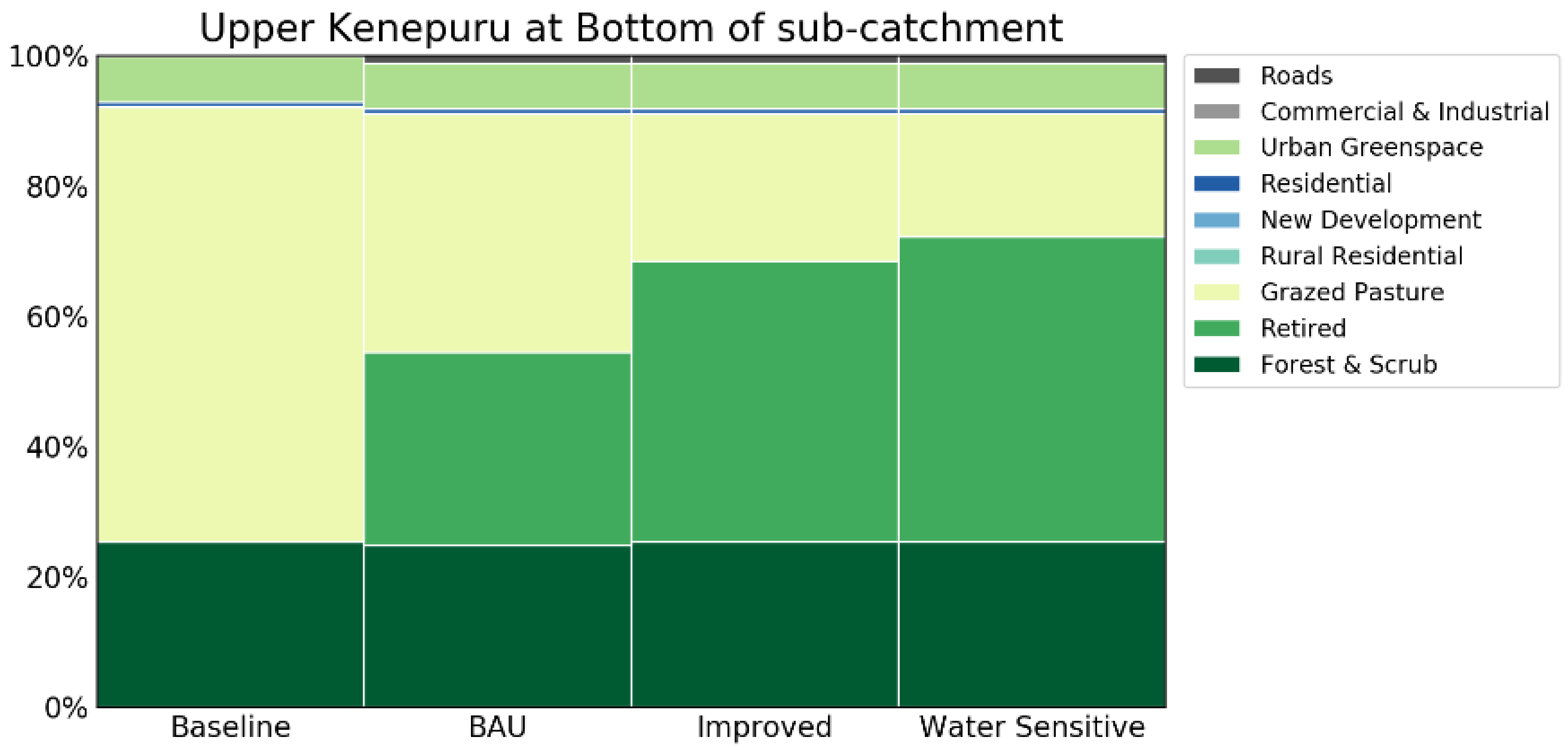

Taupo at Camborne case study
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub

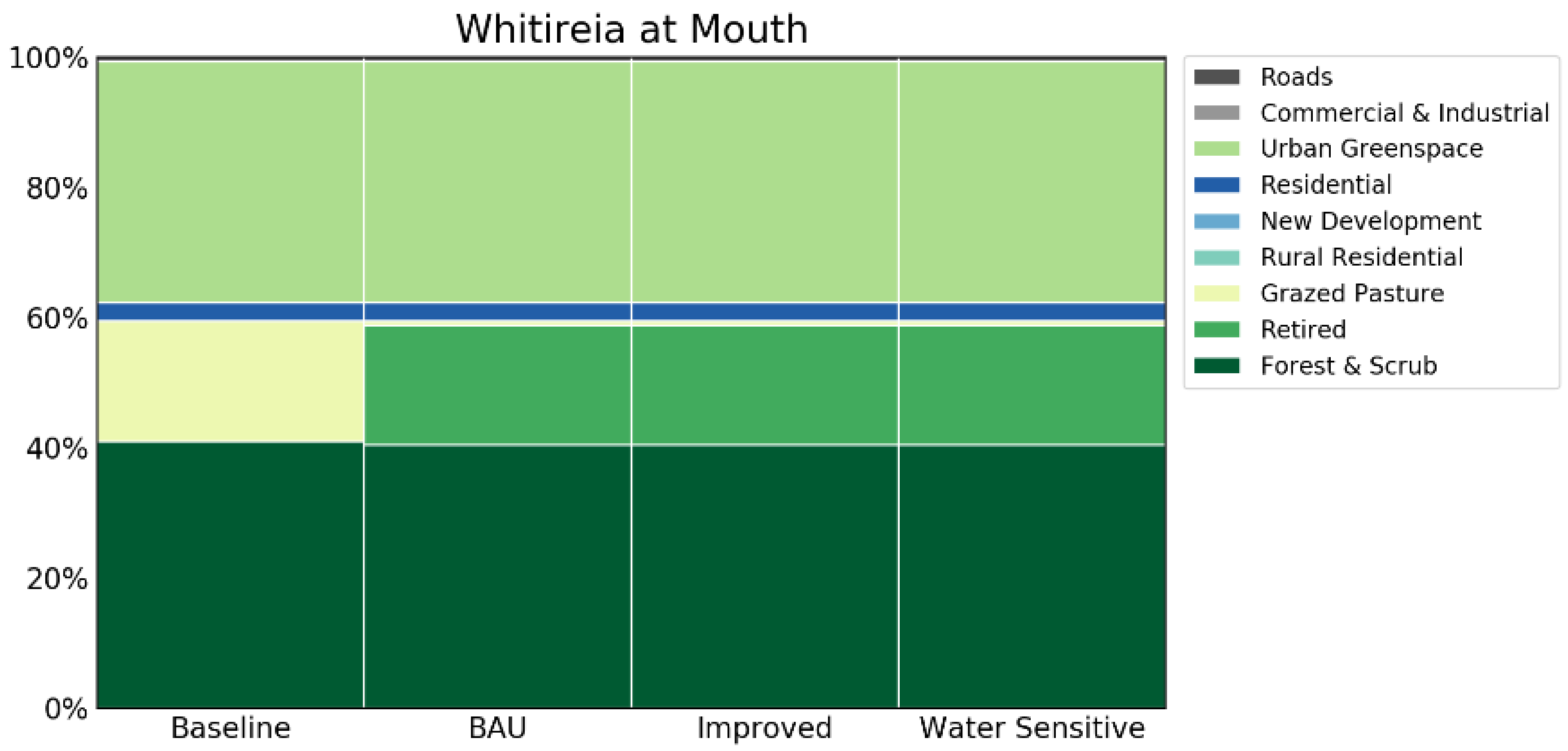

Taupo at Mouth
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub


Taupo at Wetland
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub


Titahi at Titahi Bay
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub


Upper Duck Creek at Bottom of sub-catchment
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub


Upper Kenepuru at Bottom of sub-catchment
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub


Whitireia at Mouth
100%
80%
60%
40%
20%
0%
Baseline
BAU
Improved
Water Sensitive
Roads
Commercial & Industrial
Urban Greenspace
Residential
New Development
Rural Residential
Grazed Pasture
Retired
Forest & Scrub