Hutt Valley water quality and ecology

This memo details the current state of water quality and ecology for streams within the Hutt Valley (Lower and Upper Hutt). Although this memo is primarily focused on water quality and ecology in the urban areas, it also covers the rural areas in the Valley such as upper Belmont Stream. These streams drain primarily into Te Awa Kairangi and eventually to Wellington Harbour (Figure 1), which are discussed in another summary. General effects assessments will be applied to smaller streams and tributaries, and where appropriate, larger streams will be described in more detail (for example, the Waiwhetu and Korokoro Streams). This memo should be read in conjunction with the place based memo on Te Awa Kairangi, which focusses primarily on the main river and various pressures that affect its water quality and quantity.

The urban footprint is significant within the Hutt Valley, with >150,000 people based on 2018/19 estimates. This coverage starts from Te Marua in Upper Hutt and extends to Petone and Seaview foreshore at Wellington Harbour. Most of the urban footprint, which ranges from housing to industry and parks to roads, is located in Te Awa Kairangi's flood plain. As a result there have been significant modification of the valley floor streams and Te Awa Kairangi through stop banks and channel engineering, which has enabled protection of surrounding suburbs, but in doing so has changed both the natural river processes (i.e. meandering) and affected infiltration and runoff through greater impervious surfaces. SH2 runs alongside Te Awa Kairangi through-out the valley. Local and regional rail infrastructure (from Wairarapa) also pass through the cities connecting to Wellington City. The Western Hills (including Korokoro) are a mixture of urban development in the foothills, rural land dominated primarily by lifestyle blocks and regenerating scrubland and native bush. Short and often steep streams drain these catchment.

Many of the small streams within the urban area are considered to be poor quality, graded E attribute state for pathogens (indicated by *E.coli* concentrations). High levels of metal and sediments exist in some urban streams and the Awa Kairangi estuary, such as Waiwhetu Stream and Seaview. These are primarily the result of legacy effects from decades of industrial, commercial and residential development absent of any water quality treatment.

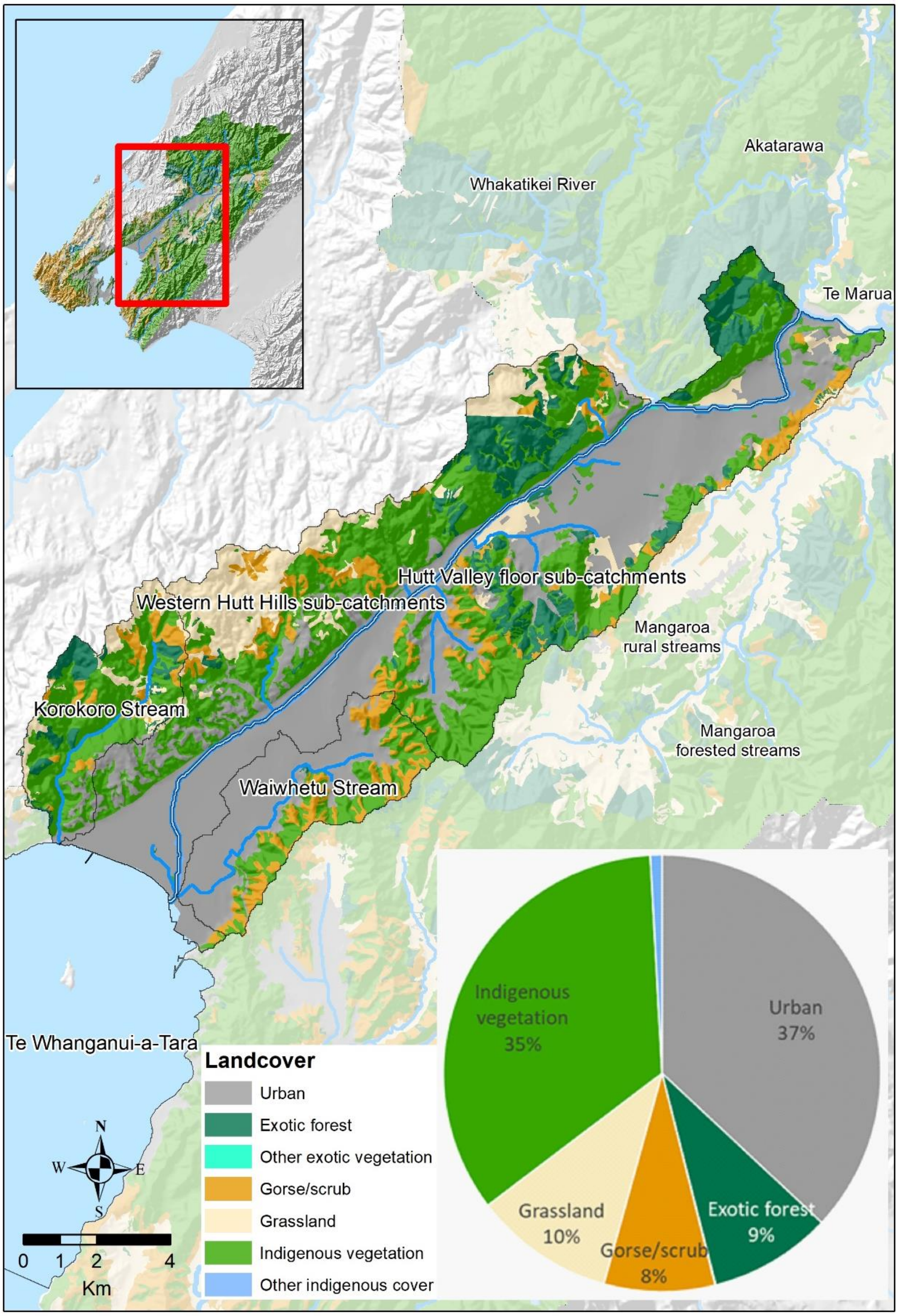

Figure 1. Overview of the Hutt Valley catchments and their land cover.

The Hutt Valley catchments

The Hutt Valley catchments considered in this memo includes the urban 'Hutt Valley Floor' group of catchments, Waiwhetu Stream (draining to Seaview), Korokoro Stream (draining to Korokoro Estuary and Wellington Harbour) and the Western Hutt Hills group of catchments (mixed urban and rural, draining to Te Awa Kairangi).

Hutt Valley Floor sub-catchments

The urban Hutt Valley begins at Te Marua in the north and extends to Petone in the South. Streams in this catchment include; Hulls, Stokes Valley, Pinehaven, Mawaihakona and Te Mome Stream. The majority of this sub-catchment, including the surrounding hills, has been developed. While an expansive green belt of regenerating scrub exists around much of the Hutt Valley protecting steep and erodible land, such as around Stokes Valley, Silverstream and Pinehaven, and Naenae through to Waiwhetu, any land suitable for development has been used. Many of the small streams draining the bush areas have good quality water and ecological health, however this declines substantially as the streams move into urban environments where large sections of stream are piped and culverted, cleared and affected by various urban contaminants (including wastewater).

The Hutt River Valley Floor urban catchments area is 59 km^2, of which ~25% is indigenous forest and 5.9% plantation forest. Only a small amount of pastoral farming is located within these catchments (~4%), although 8% of the area is made up of scrubland which may include retired farmland. While the urban environment could be mistaken as being primarily impervious surfaces, there is a large network of parks and sport fields within this catchment (including along the river), covering ~28% of the total area. Impervious residential houses, roads and paved surfaces cover ~22% of the catchment. The remaining impervious area is made up of SH2 and commercial/industrial land-uses (including roads and paved areas) making up ~5.5.% of the catchment (King 2020).

Waiwhetu Stream sub-catchment

Waiwhetu Stream headwaters originate from the regenerating native bush hills near the residential suburb of Naenae and drains through Waiwhetu and the industrial/commercial Seaview area before discharging into Te Awa Kairangi near the river mouth to Wellington Harbour. This stream is heavily modified from urban development; it is chanellised, void of meaningful ecological habitat for large stretches and wastewater discharges occur at constructed overflow locations. However significant investment (>$5M) has been spent on improving wastewater overflows and leakage since 2008.

The Waiwhetu catchment area is 18 km^2 and the stream ~10 km long. Approximately 45% of the catchment is covered in native indigenous forest and scrubland. The remaining land-use (53%) is dominated by an entirely urban footprint, incorporating heavy industry and commercial land-uses. Some small blocks of plantation forestry are also present (Greer & Aussiel 2018).

Korokoro sub-catchment

This sub-catchment originates from Belmont Park, and drains approximately 8 km to the South West towards Wellington Harbour, under SH2 and through a small estuary. The headwaters are primarily forested scrublands and indigenous forest with some limited mixed rural landuse activities and urban development along the foothills in the suburb of Korokoro.

Korokoro Stream catchment is 16.4 km^2 and is dominated by native indigenous forest (54%), gorse and broom (11.7%) and forestry (12.4%). This provides a canopy cover of ~78% of the catchment, with the remaining land-use made up of pastoral grazing (~17%) and urban (<5%) (Greer & Aussiel 2018).

Western Hutt Hills sub-catchments

While many hydrologically distinct smaller sub-catchments (draining numerous small streams, including Belmont and Speedys streams) are present, the area was assessed as two groups based primarily on having similar rural and urban land-uses and pressures which are affecting water quality and ecology. The grouping extends from the Riverstone Terraces (overlooking Trentham in Upper Hutt) to Maungaraki and Normandale in Lower Hutt. It encompasses other suburbs such as Belmont and Kelson. Most of the western hills have a developed urban environment along the foothills, which primarily transitions to mixed rural and lifestyle blocks in the headwaters. Large tracts of regenerating scrub are present in many catchments and help improve ecological health of small streams impacted from urban and agricultural runoff (for example, Speedys Stream near Kelson).

The Western Hills catchments comprise a mixture of urban land-uses on the foothills including scrubland, forest and rural activities. The total catchment area is ~60.4 km^2. Indigenous forest accounts for 35% of the catchment with ~12% scrubland (and retired farmland) and 12% exotic forestry. This provides a canopy coverage of ~59% of the total catchment area. The remaining land-uses are dominated by pastoral agriculture mainly in the form of lifestyle blocks (~19% of area) and urban parks and grasslands (~10%). The impervious urban footprint is relatively small, with residential roads, roofs and paved surfaces covering 9% of the catchment, and commercial/industrial accounting for another 1.5%. The remaining land-use in the catchment is from SH2, with >50,000 vehicles per day covering ~0.7% of the catchment (King 2020).

Current state, threats and opportunities

This section helps us look at the current state, pressures and possible trajectories of water quality and ecology under different assumptions about catchment management. Water quality and ecological indicators can help us understand different types of stresses in our aquatic environments. These include ecological toxicants, nutrients (and the algae growth they support), sediment, insects and fish in the stream, and *E. coli*.

We have used a number of tools, including monitoring, modelling and expert assessments to help us understand the current state of these indicators and how they are currently or expected to change based on different assumptions about urban development and climate change. Each tool has advantages and limitations to help us in different ways.

Table 1 below details the current state of water quality and ecological indicators from monitoring (where available) and modelled data, and presents the possible changes assessed by the Freshwater Expert Panel for each scenario (Business as Usual, Improved and Water Sensitive).

Some considerations to help understand this table are:

1. Monitoring current state data is presented where present within a catchment. This gives us a high confidence assessment of the conditions in that area, and is generally a good indication of water quality indicators throughout the catchment. However, it may not represent some of the expected variation throughout the catchment for ecological or sediment indicators so well.
2. An arrow next to the current monitored state indicates whether the attribute has an improving (↑) or deteriorating (↓) trend, while a (NT) indicates no trend.
3. Model current state (or range of states) is based on at least 75% of stream reaches in the catchment for order 2[1] and larger rivers and streams unless indicated. This helps to illustrate

[1] **Stream ordering** is a method for identifying and classifying types of **streams** based on their numbers of tributaries; an **order 2** stream has at least 1 tributary (order 1) which flows in to it, an order 3 stream has at least 2 tributaries (i.e., one tributary flows in to another tributary before flowing in to the stream of interest.

the conditions of catchments we don't have monitoring for and some of the patterns within catchments. These are generally good for illustrating catchment scale conditions and may be less reliable for sub-catchment or reach scale conclusions.

4. Changes are based on expert panel indications of scenario change applied to the modelled current state (Greer, 2020). An arrow indicates an improvement (↑) or deterioration (↓) within an attribute state. Because there is no modelled current state for copper and zinc, two arrows indicate an attribute state change for those attributes.
5. The BAU scenario gives us information about the expected trajectory of environmental outcomes based on current understanding of urban development, the application of current policy settings in the proposed Natural Resources Plan and the likely effects of climate change.
6. The improved and water sensitive scenarios help us understand how doing urban development and catchment management differently might change the expected trajectory of environmental outcomes.
7. Confidence in expert panel scenario changes are indicated
   a. Regular font – low confidence
   b. **Bold font** – moderate confidence
   c. **<u>Bold underline font</u>** – high confidence

Table 1. Current attribute states and expert panel assessments for the three scenarios

Catchment	Scenario	Ecological toxicity				Sediment	
		Copper	Zinc	Nitrate	Ammonia	Clarity	Deposited
Valley floor streams	Model			A	A	D/A	D/B/A
	BAU	**↓**	**↓**	**A**	**A**	D/A	
	Improved	**↑**	**↑↑**	**A ↑**	**A ↑**	D/A ↑	
	WS	**↑↑**	**↑↑**	**A ↑**	**A ↑**	D/A ↑	
Western hills rural streams	Model			A	A	D	A/C/B
	BAU			**<u>A</u>**	**<u>A</u>**	D ↓	
	Improved			**<u>A ↑</u>**	**<u>A</u>**	D ↑	
	WS			**<u>A ↑</u>**	**<u>A</u>**	C	
Western hills urban streams	Model			A	A	D/A	D/C
	BAU	**↓↓**	**↓↓**	**<u>A</u>**	**<u>A</u>**	D/A ↓	
	Improved	↓	**↑**	**A ↑**	**A ↑**	D/A	
	WS	↑	↑↑	**A ↑**	**A ↑**	D/A ↑	
Korokoro Stream	Model			A	A	D	A/B/C
	BAU			**<u>A</u>**	**<u>A</u>**	D ↓	
	Improved			**<u>A ↑</u>**	**<u>A</u>**	D ↑	
	WS			**<u>A ↑</u>**	**<u>A</u>**	C	
Waiwhetu Stream	Monitoring	C	D	A	B	A	D
	Model			A	A	A	D/C
	BAU	**↓**	**↓**	**A**	**A**	A ↓	
	Improved	**↑**	**↑↑**	**A ↑**	**A ↑**	A	
	WS	**↑↑**	**↑↑**	**A ↑**	**A ↑**	A ↑	

Catchment	Scenario	Nutrients for growth			Dissolved oxygen*	Ecology		Human health	
		Phosphorus	Nitrogen	Periphyton		Macro-invertebrates	Fish	*E. coli*	Primary contact
Valley floor streams	Model	C	B/C	C/D		C/D/B	A/B/C	E/D	
	BAU	C	**B/C**	C/D ↓		C/D/B ↓	**<u>A/B/C</u>**	**E/D**	
	Improved	**C ↑**	**B/C ↑**	C/D		C/D/B	**<u>A/B/C</u>**	**C/B**	
	WS	**C ↑**	**B/C ↑**	C/D		B/A	**<u>A/B/C</u>**	**C/B**	
	Model	C/D	B/C	C		B	A	D/C	

Catchment	Scenario	Nutrients for growth			Dissolved oxygen*	Ecology		Human health	
		Phosphorus	Nitrogen	Periphyton		Macro-invertebrates	Fish	*E. coli*	Primary contact
Western hills rural streams	BAU	**C/D**	**B/C**	C ↓		B ↓	**A**	**D/C**	
	Improved	C/D ↑	**B/C ↑**	C ↑		B ↑	**A**	**D/C ↑**	
	WS	**B/C**	**B/C ↑**	C ↑		A	**A**	C/B	
Western hills urban streams	Model	C	C/B	C/D		B/C	A	E/D	
	BAU	C	**C/B**	C/D ↓		B/C ↓	**A**	**E/D**	
	Improved	**C ↑**	**C/B ↑**	C/D		B/C ↑	**A**	**C/B**	
	WS	**C ↑**	**C/B ↑**	C/D ↑		B/C ↑	**A**	**C/B**	
Korokoro Stream	Model	C	B	C		B	A	D	
	BAU	**C**	**B**	C ↓		B ↓	**A**	**D**	
	Improved	C ↑	**B ↑**	C ↑		B ↑	**A**	**D ↑**	
	WS	**B**	**B ↑**	C ↑		A	**A**	C	
Waiwhetu Stream	Monitoring	D			B	D		E	
	Model	C	C	C/D		D/C	B	E/D	
	BAU	**C**	**C**	C/D ↓		D/C ↓	**B**	**E/D**	
	Improved	**C ↑**	**C ↑**	C/D		D/C ↑	**B**	**C/B**	
	WS	**C ↑**	**C ↑**	C/D ↑		C/B	**B**	**C/B**	

* based on minimum from spot sampling and benchmarked to one day minimum thresholds

Ecological toxicants

Metals such as copper and zinc, and nutrients such as nitrate and ammonia can be toxic to aquatic life. These effects can occur from either longer-term exposure to moderate/high concentrations or shorter-term exposure to very high concentrations.

Monitoring data for copper and zinc are limited across these catchments. Longer-term monitoring in Waiwhetu indicates elevated concentrations (Table 1), and very preliminary monitoring results in Stokes Valley and Hulls Creek also indicate elevated levels, though perhaps not to the degree of Waiwhetu. We don't have trend or modelling data for these indicators.

Metals can accumulate in sediments and living organisms, meaning that toxicity effects build up over time. During rainfall, copper and zinc are washed from impervious surfaces into urban streams through the stormwater network and the 'first flush' has the most acute effects on aquatic life with the highest concentrations. Copper typically comes from paved surfaces (generally, ~75% of the load across the catchment from areas such as car parks) and roads (12%). The primary sources of zinc are roofs (66%) and paved surfaces (27%). The mixed rural, pastoral and forest land present across the catchments contribute very little metal loads to the environment.

The expert panel assessments were moderately confident that metal concentrations are likely to deteriorate, assuming that around 6,000 additional residential dwellings are accommodated within these catchments. This is a result of expected urban development generating more contaminants and with climate change exacerbating this through longer dry periods for contaminant accumulation and greater mobilisation of these during higher intensity rainfall.

Adopting water sensitive design principles to new and re-development areas are likely to mitigate these effects to some extent, but major gains are made, particularly for zinc, from capturing and treating road and commercial/industrial surface runoff and painting or replacing existing high zinc yielding roofs. The amount of these areas in this catchment suggest moderate uptake might allow a one attribute state improvement and extensive uptake might provide two attribute state improvements.

Monitoring in Waiwhetu Stream is graded A for nitrate toxicity and B for ammonia toxicity (Table 1). Modelling predicts that all streams across these catchments are an A attribute state for ammonia and nitrate toxicity (Table 1). However, the modelling, and to a lesser extent the monitoring, do not detect short term peak concentrations of ammonia and nitrate toxicity at isolated locations (i.e. at a point source discharge, such as a sewage leak). This means they may be underestimating the attribute state of these catchments.

The main source of ammonia and nitrate to urban streams is from sewage. This generally occurs during rainfall and is most often the result of cross connections between the stormwater and wastewater network. However, dry weather spikes can also occur as result of groundwater ingress and/or broken pipes.

Other sources of ammonia and nitrate can come from fertilisers applied in gardens and parks, although infrequently applied and often at low quantities compared to rural applications. Whilst agriculture is present within the catchment, this is primarily from lifestyle blocks and it could generally be assumed low fertiliser inputs are occurring on these farms. There will, however be some agricultural inputs of nitrogen through urine deposition and leaching, and seepage/runoff from rural septic tanks, which are plentiful within Te Awa Kairangi catchment (>650 septic tanks).

The expert panel were moderately confident that reductions in dry and wet weather wastewater contributions to streams would likely have a detectable improvement on ammonia concentrations in streams.

Sediment

Sediment has effects on stream ecology through both its effects on the clarity of the water, and when it deposits on the stream bed which can smother aquatic organisms and their habitat. It's also a very visual contaminant, which can affect our enjoyment and sense of connection to a stream.

It is very difficult to make an overall assessment of the sediment conditions in the streams throughout these catchments. Monitoring and modelling data both indicate that Waiwhetu Stream is in A state for clarity and D state for deposited sediment. There is no routine monitoring in other catchments, and the models suggest highly variable sedimentation patterns through those catchments.

Alterations to the natural flow regime is one of the largest drivers of sediment input to urban streams. Where streams flow through urban areas, the impervious cover (i.e. from concrete and asphalt) results in rapid surface water runoff during rainfall through the stormwater networks. This results in greater peak flows than would occur under a natural setting (due to soil infiltration and retention by vegetation). Increased peak flows have a greater erosive potential, resulting in increased streambank erosion.

The expert panel were moderately confident that climate change would exacerbate streambank and slip erosion. While some stock exclusion is expected, this was considered unlikely to have an effect on sediment due to the relatively low stock numbers.

Improved sediment management in urban development and in some paved surfaces may offset the detrimental effects of climate change in urban areas. Improved management of erosion prone slopes and limited stock exclusion in rural areas may more than offset the risks of climate change, but not to the extent of an attribute change. Higher degrees of effort with these types of tools in both urban and rural areas may give even more sediment reductions.

Despite considerable research effort attempting to build models to predict the numeric response of deposited fine sediment to catchment management, the expert panel are not aware of any currently available for this purpose. The panel, therefore, cannot make commentary on how deposited sediment attribute states may change in response to catchment sediment reductions.

Nutrients for growth

Nutrients, like nitrogen and phosphorus also affect streams by stimulating the growth of aquatic plants and algae like periphyton. These plants are useful for stream health, but can reach nuisance and problematic levels when too much plant life grows.

Levels of phosphorus are moderate to high, graded D at the SoE monitoring site in Waiwhetu (Table 1) and modelling assessments are reasonably consistent showing C and D states throughout most catchments. Nitrogen hasn't been benchmarked at the monitoring site, and modelling consistently indicates B and C states throughout most catchments. Periphyton isn't benchmarked at the Waiwhetu monitoring site, but again the modelling is consistently indicating Periphyton to be in the C and D states throughout most catchments.

Sources of phosphorus include sediment from exposed earth (i.e., during urban development) and stream bank erosion, as well as from wastewater. Phosphorus can be in particulate and dissolved form, with the particulate form often derived from sediment release. Some soils can be naturally high in phosphorus however erosion can increase the presence of this nutrient in the environment. Nitrogen comes from waste water / sewage, animal inputs and also fertilisers that are applied to gardens, green spaces, golf courses and farmland.

Changes to summer low flows from climate change might increase Periphyton growth through all catchments, but neither of the nutrients are expected to change.

Wastewater improvements are expected to be beneficial for both nutrients in the urban parts of these catchments. However, this is not expected to have a beneficial effect on instream plant growth because of climate change effects and that there is not any changes expected to riparian shading in the urban streams.

In rural parts of these catchments, the relatively modest use of riparian planting and erosion prone land management may have some benefit for nutrients, particularly phosphorus. However, no change is expected for Periphyton growth as these benefits will likely be offset by the effects of climate change, with reductions in summer low flows increasing the risk of periphyton growth.

Ecology

Macroinvertebrates

The combined stressors of contaminants, sediment, habitat disturbance and flow alterations from urban land uses all contribute to the macroinvertebrate conditions seen throughout these catchments.

Monitoring in Waiwhetu Stream indicated macroinvertebrates are in D state (Table 1) and modelling indicated a range of conditions throughout the catchments in this group. Consistent with the Wellington City monitoring, the western hill catchments have more reaches with macroinvertebrates in B states, while the streams of more heavily urbanised catchments have more reaches in the C and D states.

Climate change is expected to have a negative impact on MCI through all catchments in these groups and there is also potential for localised further negative effects in areas of urban development.

Adopting urban management to reduce ecological toxicity are expected to result in improved MCI in urban streams, though gains may be moderated if aspects of the "urban stream syndrome" are not be fully addressed (i.e. habitat modification).

Fish TBC

Habitat

In-stream habitat quality is considered the major issue affecting indigenous biodiversity and ecosystem health**.** Habitat quality is impacted in the following ways:

- Deposited sediment smothers the riverbed while suspended sediment clogs the gills of macroinvertebrates
- Impervious surfaces result in increased peak flows, which erode streams banks in doing so removes vegetation and important habitats, such as undercut banks that are homes for fish.
- Channel modification, such as culverting, channelising and concreting for urban development and erosion protection. Piping is the most extreme form of channel modification.
- Fish barriers prevent fish migration to spawning areas meaning they are unable to complete their life cycles.
- Excess nutrients promotes periphyton growth, which can also smother riverbed habitats used by macroinvertebrates and fish.
- Low summer base flows, which are predicted to reduce further under climate change, results in increased water temperatures and homogenous water velocities.
- Loss of stream bank vegetation reduces shade resulting in increased photosynthetic radiation and water temperatures and supply of organic debris.

E. coli

All stream reaches across the urban catchment and sub-catchments, with the exception of those in the headwaters, are modelled in the E and D states for *E. coli* (Table 1), which is consistent with monitoring in the Waiwhetu stream and the Wellington City urban catchments. Modelling in rural areas indicated slightly better results with D and some C states.

A large contribution to microbial pathogens in the urban freshwater streams is from human wastewater due to leaks (old pipes), overflows (during wet weather events) and direct illegal cross connections (wastewater plumbed into the stormwater network). Wastewater overflows are primarily due to a lack of network capacity, where stormwater runoff enters the wastewater network and the large volumes result in overflow at 'fail safe' locations, primarily linked to the stormwater network. In the Hutt Valley, the greatest volume of wastewater overflow is at Silverstream Storage Tank (accounting for >60% of all wastewater overflows in the Whaitua).

Some of this is due to legacy development, where prior to the building act there was no legal requirement to separate household stormwater runoff from the wastewater network, meaning houses plumbed their downpipes into the wastewater network. Figure 2 shows an overview of monitored wastewater overflows in 2018/19.

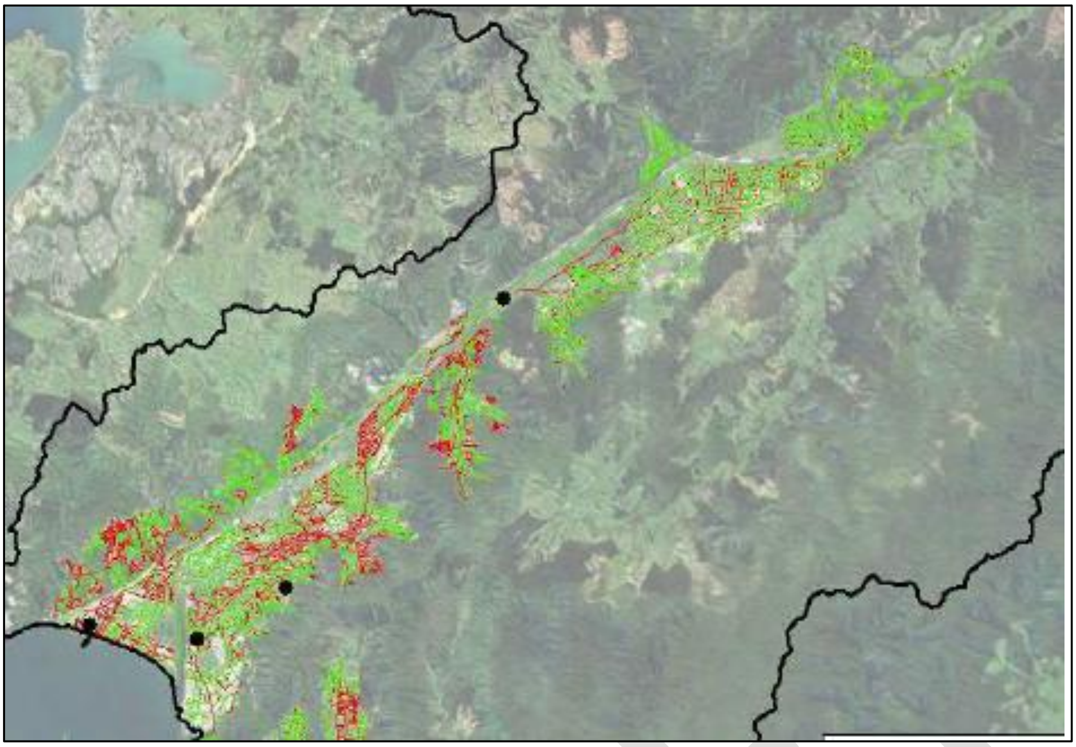

Figure 2. Monitored wastewater overflows in 2018 and 2019 around Hutt Valley (black dots), and wastewater pipe condition (red = poor/very poor condition, green = good to average condition). Adapted from Blyth (2020).

The following is a summary of the wastewater network for each catchment from 2018/19:

- Korokoro Stream - ~47% of network in poor/very poor condition (~7.3 km). No wastewater overflows were recorded in 2018/19.
- Waiwhetu Stream - ~38% of network in poor/very poor condition (~50.3 km) with average wastewater overflows of ~2.5/year across 2 monitored locations
- Hutt River Valley Floor - ~25% of network in poor/very poor condition (~98 km) with average wastewater overflows of ~6/year. This primarily occurs at Silverstream storage tank which discharges >60% of the entire Whaituas wastewater to Te Awa Kairangi.
- Western Hills - ~33% of network in poor/very poor condition (66 km) with no wastewater overflows recorded in 2018/19.

Pathogens can also enter freshwater streams from agriculture (animal effluent), pet faeces and avian inputs, resulting in high counts of *E.coli*. The risk to human health through contact recreation or food gathering is not always directly linked to high levels of *E.coli*, which is used as an indicator of risk, but rather to the presence of pathogens (such as campylobacter or giardia) that may be more prevalent in animal and human waste.

The expert panel expected no change in the attribute states for *E. coli* with current management practices. Removing dry weather leaks and network faults are likely to reduce the input of *E. coli* across all flows to lift the *E. coli* attribute state in urbanised catchments to C and B states.

In rural catchments, stock exclusion and reduced livestock numbers from retirement may improve *E. coli* levels in rural streams by up to an attribute state depending on the level of uptake.

Knowledge gaps, research priorities and actions

There are several knowledge gaps in knowledge, research priorities and actions that are required. Below are a few of these:

- Stream modification and habitat loss, through the likes of culverting, piping, concreting and straightening, have a major impact on aquatic flora and fauna, and ecosystem processes. Research is need to identify restorative approaches in these modified environments. Moreover, opportunities to restore habitat and processes, where they exist, should be identified and implemented.

- Stormwater treatment options and effectiveness: contaminants transported from impervious surfaces through the stormwater network to urban streams is a major issue. Further research is needed on stormwater treatment options (i.e. rain gardens) and their relative effectiveness in different environments.

- The sources of sediment to urban areas are not well understood, and current source controls are often poorly installed.

- Fish passage barriers, both physical and chemical, are a major problem in urban Te Whanganui-a-Tara. Barriers prevent diadromous native fish species from being able to complete their life cycle and access either the marine or freshwater environments. Mapping of fish passage barriers and restorative options need exploring.

- Consideration of whether PNRP permitted take allowance are appropriate offers opportunity to mitigate any unacceptable risk associated with water abstraction where rural land use is present.

Risks, opportunities and unknowns

The scenario packages considered by the expert panel represent a combination of increasing levels of treatment, and assumes 100% adoption and implementation. In reality, different mitigations may be put in place than what has been offered, however this report presents a picture of the level of effort required to improve urban water quality.

A cost assessment for the Improved and WSD scenarios (Blyth 2020), using the cost aggregation model (CAM) applied in Te Awarua-o-Porirua Whaitua, estimated cost to implement both the urban stormwater and wastewater mitigations in the Improved scenario (i.e. excluding rural costs) for the entire whaitua is between $2.6 and $3.4 billion, and the Water Sensitive scenario is between $3.9 and $5.4 billion (over a 30-50 year timeframe). These costs excludes roof replacement, assuming it occurs through attrition but includes the annual maintenance cost estimates for water sensitive devices.

A major assumption to reduce metal loads, particularly zinc, is the replacement of roofs. This could be assumed to occur through attrition over 50 years, paid for by private owners, however if this was to happen faster there would be a large cost involved (over $1B, see Blyth 2020). Furthermore, many of the comprehensive mitigations were applied to greenfield and infill housing. This however represents new loads to the environment, on top of what is already impacting the current state.

Whilst the WSD scenario considers greater treatment of runoff from the existing urban footprint, it does not extensively address retrofitting of devices throughout the Wellington catchment. Potentially, greater improvements in water quality (and flow dynamics) could be achieved than what the panel has assessed, through focussing on the existing environment and setting clear requirements for WSD on any new developments. However this will come at a cost, and there are many implementation barriers that need to be addressed.

Blyth (2020) details some of the barriers to implementing WSD in Wellington region. These include:

- Lack of district level planning guides for WSD infrastructure and tools to help with appropriate devices in different sites, landscapes and climates. Without this information, it is easier for developers to default to BAU stormwater design, which is easier to sign off through clear processes from councils and Wellington Water.
- The design guides released by Wellington Water only cover four devices, even though in Auckland, their design guidelines cover up to 12 types of WSD infrastructure.
- There is no clear ownership and maintenance pathway for WSD in Wellington. Currently this occurs through developer discussions with councils and Wellington Water, as required. WSD assets require ongoing maintenance throughout their life, and this cost (and ownership) needs to be determined clearly at an early stage of any development process.
- Industry standards and compliance needs further development, as the relatively new practice of WSD in Wellington may mean design companies (such as consultants) and contractors building the devices lack the knowledge of their optimal installation for best performance. There are many examples of this causing re-work due to poor design, or lasting legacy issues where a wetland (for example) may not function correctly or is hard to maintain.

While the urban issues span both stormwater and wastewater, the repair of the wastewater network will be a significant challenge. Low confidence estimated costs to fix private laterals, resolve all cross connections, install storage tanks at constructed overflow locations and repair/replace the grade 4 and 5 poor condition wastewater pipes is between $2.08 and $2.58 billion.

Significant investment in Waiwhetu has occurred since 1999 on wastewater and stormwater infrastructure, including private laterals. Stormwater was overloading the wastewater system during storm events, resulting in overflows into the environment, and particularly into the Waiwhetu Stream. Wastewater mains were CCTV inspected and pressure tested. Over $8 m was spent on network improvements between 2004 and 2010, which resulted in the repair and replacement of ~7 km of wastewater pipe. Overflow storage tanks were also installed at a number of locations, to contain some of the wastewater overflow volume during events, which can then gravity feed back into the wastewater network as the flow subsides (Blyth 2020). Repairs of cross connections and broken/damaged private laterals were the responsibility of the owner, who is required to undertake the repairs through a Hutt City Council policy (Blyth 2020).

An assessment of 2,422 properties found that 55% had private laterals that did not pass a basic water pressure test (Blyth 2020). Repairs to these lateral (and associated) costs were the responsibility of the owner and not included in the $8 M network cost mentioned above, although Hutt City Council (HCC) paid for the inspection and arranged contractors where property owners requested. Following completion of these upgrades, assessments in 2009 and 2015 showed that rainfall inflow (from stormwater cross connections) reduced 90% over summer and 60% over winter, significantly reducing wastewater overflows to the environment (with a return period of 5 years and 2 years for summer and winter, respectively) (Blyth 2020).

Subsequently, providing some advice about where to focus efforts first with the limited funds available, may help provide direction to councils and Wellington Water while helping achieve community environmental goals. Roving crews who are working in Ōwhiro Bay are a relatively new approach to inspecting private laterals and identifying cross connections, however would need to be significantly ramped up to cover this catchment and all of urban Te Whanganui-a-Tara. Digging up streets to repair and replace wastewater pipes also has significant disruption to the local communities, albeit the cost and disruption of planned works are always less than unplanned emergency works (such as the Dixon Street wastewater pipe failure).

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Te Awa Kairangi water quality and ecology

Te Awa Kairangi catchment

This report details the current state of water quality and ecology for Te Awa Kairangi main stem, particularly the middle and lower reaches which travel through the floor of the Hutt Valley (Figure 1). It also presents the results that were assessed by both the freshwater and flow expert panels, as well as results for the receiving environment (the wider harbour) that were assessed by the coastal expert panel. Results for rural (Mangaroa and Pakuratahi) and urban (Hutt Valley) areas of the catchment are also presented to illustrate the quality of the water that discharges into Te Awa Kairangi and how this impacts on the health of Te Awa Kairangi.

The Te Awa Kairangi catchment is full of contrasts. It encompasses huge amounts of native vegetation, including Akatarawa Forest and Kaitoke Regional Park to the North, and Pakuratahi Forest to the East. On the eastern side of the river, grassland dominates the Mangaroa Valley. On the western side of the river, the "Western Hills" are an eclectic mix of grassland, exotic forest, native vegetation and urban areas. The entire length of the valley floor is heavily urbanised and two major transport infrastructures, SH2 and a major railway route, shadow the river from Melling in Lower Hutt through to Te Marua at the base of the Remutaka Range. Te Awa Kairangi enters the Harbour via the Hutt Estuary which is surrounded by a heavily industrialised area.

Te Awa Kairangi is widely understood to be the original Te Reo name for the river, used by iwi such as Ngāi Tara. However, later Māori settlers named it Te Wai o Orutu (after Orutu, a Ngāti Mamoe ancestor), and by the time European settlers arrived mana whenua called the river Heretaunga. While the river's name changed often, the uses of its water did not. Te Awa Kairangi was once the largest source of fresh water in the district, and supported a diverse and abundant native fishery resource which was important to the physical and cultural sustenance of mana whenua (Love, n.d.). In addition to sustaining a large variety of native fish populations, the river also provided access to forest birds, watercress, and numerous other food plants.

Te Awa Kairangi was not only important as a mahinga kai but also provided an efficient means of transport for both people and goods between Porirua, the Hutt Valley and Te Whanganui-a-Tara. Te Awa Kairangi provided an important link to Porirua which was positioned strategically as the gateway to, and from, the north. Love (n.d.) states that as mana whenua of Porirua, Ngati Toa maintained control over the northern approaches to the Wellington district, facilitating Ngati Toa's virtual monopoly over trade with foreign settlers in Wellington.

The river's English name is in honour of Sir William Hutt, a chairman of the New Zealand Company. This name was given by Captain Edward Main Chaffers and Colonel William Wakefield while charting Port Nicholson in 1839. The river valley was identified early on as a good site for settlement, and Europeans began settling on the floodplain in the 1840s. By the 1880s the entire floodplain had been deforested to make way for development. Without these forests, which had controlled the river alignment and the processes of erosion and sediment transport, flooding became a major issue. A large flood in 1855 resulted in many settlers moving to Wellington, and another major flood in 1898 that covered the entire valley floor became the catalyst for constructing the first major stop banks. Some of these are still in use today.

Land use in the catchment area

Nearly two thirds of the catchment is covered in indigenous vegetation, primarily in the northern headwaters of the catchment area, but also in the far eastern part of the catchment where several tributaries of Te Awa Kairangi originate (Figure 1).

Pasture or grassland makes up approximately 10 percent of the catchment area, most of which is on the eastern side of the Hutt River (in the Pakuratahi and Mangaroa sub-catchments). Plantation forestry covers 12 percent of the area, with large patches on the western side of the river in the Whakatikei and Akatarawa sub-catchments, and smaller patches on the eastern side in marginal hill country backing onto the Pakuratahi and Wainuiomata forests.

Ten percent of the area is urbanised, which is concentrated on the valley floor from just south of Te Marua through to where the Hutt River enters the harbour.

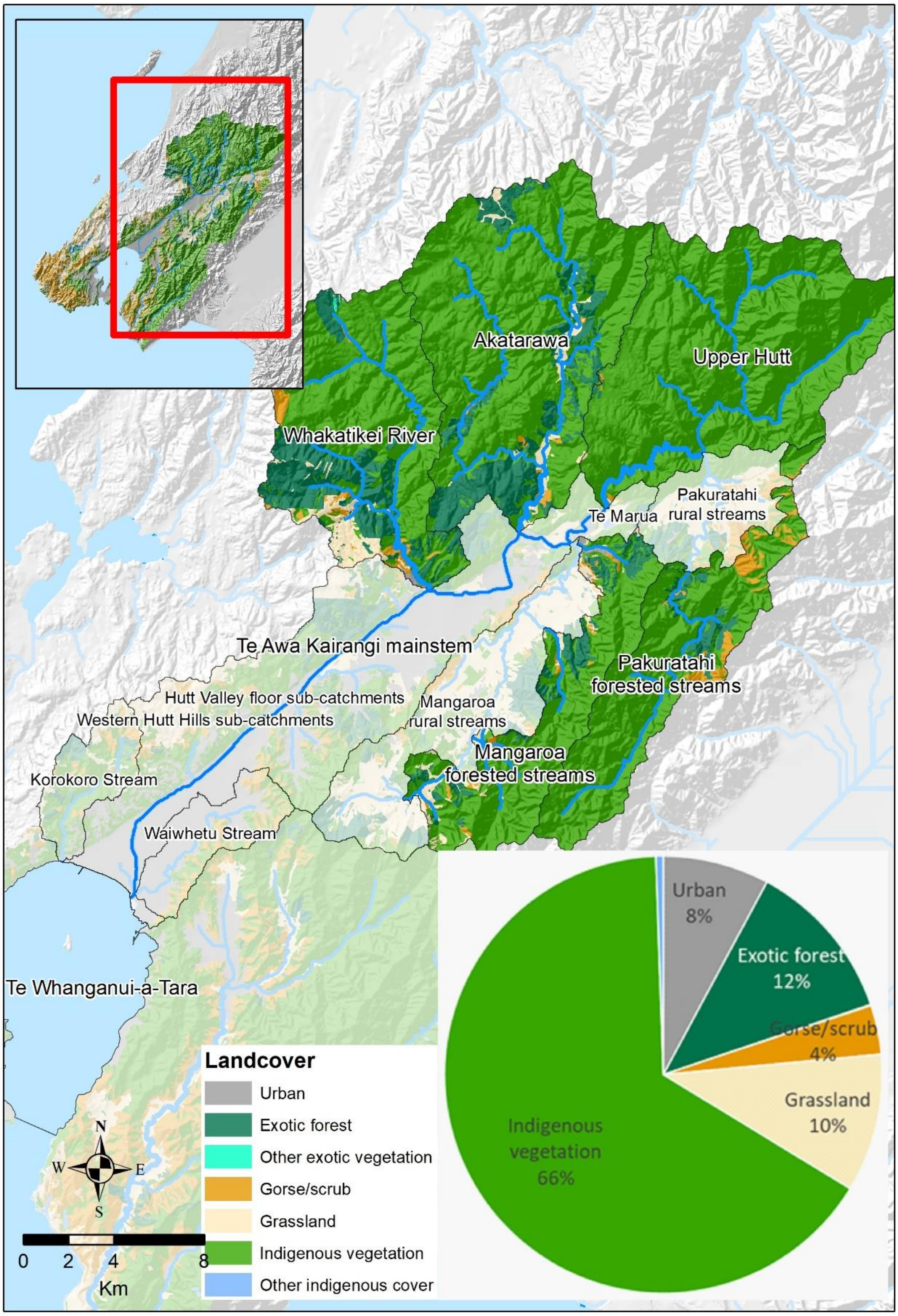

Figure 1. Te Awa Kairangi catchment land use map.

Note: Land cover presented here is for the whole Te Awa Kairangi catchment, including forested headwaters, the Mangaroa and Pakuratahi valleys, and Hutt Valley sub-catchments flowing into the mid and lower main stem.

Toxic algae and Te Awa Kairangi

The issue of toxic algae in Te Awa Kairangi has been written up into a Draft Narrative by the Whaitua Committee Small Group. SharePoint link here.

In summary, the small group accepted that the drivers of toxic algal blooms are complicated and that the causal cyanobacterium is a good competitor in low nutrient environments (Heath and Greenfield 2016). Despite the uncertainty, the small group decided that a holistic all-of-catchment approach to reducing probable drivers of algal growth was the best approach to manage the frequency and mangnitude of blooms. Key actions included taking every opportunity, where they exist in the wider catchcment, to reduce river sediment, nutrients (nitrogen and phosphorus) and water temperature, and increase flow, water levels and shade.

Current state

This section summarises the current state of water quality and ecology using indicators of ecological toxicants, nutrients (and the algae growth they can support), sediment, insects and fish in the stream, and *E. coli* (an indicator of faecal contamination).

Table 1 below details the current state of water quality and ecology from monitoring data (where available). Results are presented for three different sites in Te Awa Kairangi – one in the upper reaches (Te Marua), one in the middle reaches (Manor Park) and one in the lower reaches (Boulcott Street).

Table 1. Current attribute states for the three monitoring sites on Te Awa Kairangi

Monitoring site	Ecological toxicity				Sediment	
	Copper	Zinc	Nitrate	Ammonia	Clarity	Deposited
Te Marua	A	A	A	A	A	A
Manor Park	A	A	A	A	A	A
Boulcott Street	A	A	A	A	B	A

Monitoring site	Nutrients for growth			Ecology		Human health	
	Phosphorus	Nitrogen	Periphyton	Macro-invertebrates	Fish	*E. coli*	Primary contact
Te Marua	A	A	A	A		A	
Manor Park	A	A	B	B		D	
Boulcott Street	A	A	C	B		D	

Pressures, threats and issues

This section looks at the pressures and threats posed from human modification and contaminants entering the river, and issues related to the abstraction of water from Te Awa Kairangi (mainly for municipal water supplies).

For the urban environment of the Hutt Valley to exist as it does today (in such close proximity to Awa Kairangi), permanent modification of the river course has occurred through development of stop banks (to prevent flooding up to a 100-year event based on current design, and up to 440 years once Riverlink has been completed) and flood control works such as river straightening, channel stabilisation and willow planting to reduce bank erosion.

The large amount of native forest in the catchment headwaters ensures protection of a critical water supply area (Kaitoke), as well as good water quality and excellent ecosystem health in the upper reach of the river, while providing some buffering for contaminant concentrations downstream (dilution). Downstream of Kaitoke, human impacts on water quality and the health of the river become increasingly prevalent, with:

- Large expanses of exotic forestry (primarily *pinus radiata*) most of which is located in the four major tributary catchments (Akatarawa, Whakatikei, Pakuratahi and Mangaroa), the harvesting of which can have significant impacts (primarily relating to sediment) on the freshwater environment for five to seven years (out of a total cycle of 27+ years) before replanted land establishes.
- Low/moderate intensity farming in the Mangaroa and Pakuratahi sub-catchments that contributes nutrients, sediment and pathogens into these rivers and streams before draining into Te Awa Kairangi.
- An expansive urban footprint on the valley floor which contributes a variety of contaminants to the river via stormwater networks, including metals (from roofs, cars and industry), nutrients (from fertiliser used in parks and gardens, residential lawns and vegetable gardens, and on golf courses) and pathogens (from wastewater overflows and leaks, but also other sources such as birds and pet animals). In addition, hydrocarbons, paint, herbicides and other chemicals can also enter Te Awa Kairangi through stormwater networks.
    - Stormwater inputs to the river occur during rainfall events. Significant acute (short-term) effects on aquatic life are unlikely, as Te Awa Kairangi is a large river and localised stormwater inputs are quickly diluted. However long-term chronic effects cannot be ruled out.
    - Near Silverstream, a large wastewater tank exists for temporary storage of wastewater during rainfall events. Approximately six times per year this tank has insufficient storage space, which results in excess wastewater being discharged into Te Awa Kairangi during high flows (see **Figure 2.**). Over 2018 and 2019 this accounted for over 60 percent (~195,000m^3) of the total recorded wastewater overflow in the Whaitua.
- The Western Hills (Belmont, Kelson and Maungaraki) contain a mixture of urban and rural environments, in addition to significant infrastructure such as the Belmont Quarry. This contributes a range of contaminants including sediment, nutrients, metals and pathogens through a number of small tributaries to the Hutt River.
- Septic tanks can also be a source of pathogens and nutrients, and are abundant in the wider valley primarily due to the large number of lifestyle blocks (Agribase identifies over 650 rural properties in the area).
    - Recent survey data showed, from 130 respondents, that 40-50% had septic tanks that were greater than 25 years old, many of which are likely to be the original from when the dwelling was built. A similar number of respondents did not have their discharge fields inspected or maintained, likely relating to the fact many old tanks did not incorporate discharge fields like modern day designs. However, cleaning regimes of septic tanks were likely good for approximately two thirds of respondents.

In saying all this, the large flows coming from the headwaters offer a high degree of buffering/resilience to the main stem of the river. So while the lower reaches are subject to many pressures, their effects may be somewhat muted due to the “dilution factor”.

Figure 2. Silverstream weir and constructed wastewater overflow discharge point (see Blyth 2020)

What about water abstraction?

Te Awa Kairangi is a critical water source for the majority of the metropolitan Wellington Region, with water abstracted from the river itself at Kaitoke and from groundwater in the Waiwhetu aquifer. Public water supply accounts for the vast majority (≥95%) of all consented water taken from the river and aquifer.

The Waiwhetu aquifer lies beneath Lower Hutt, and is recharged directly from the river bed, essentially creating a fully connected surface and groundwater system. Over summer, the aquifer can supply up to 80 percent of Wellington's water (includes the Hutt Valley and Porirua), when Te Awa Kairangi supply becomes restricted due to minimum flow conditions.

Recent modelling has found that the current use of water does not remove any of the fundamental components of the rivers natural flow regime, ie, floods/freshes retain their natural frequency, timing and size, and there is still natural seasonal variation (high flows in winter and low flows in summer).

However, there are substantial changes during low base flow periods (primarily in summer) and this is likely having moderate to strong negative impacts on ecosystem health depending on the river section. In particular:

- Aquatic life is likely to be under significant stress during low flow periods because of reduced physical space for organisms to live, greater competition for food, reduced dilution of pollutants and elevated water temperatures;
- This stress will increase the likelihood of degradation of ecological communities (e.g. reductions in abundance and diversity, impaired growth of organisms, proliferation of algae), but also reduces the resilience of these communities to other possible stressors.

While Wellington is blessed with a large water supply close to the city, it is facing growing pressure from increased demand due to population growth, an aging network resulting in poor performance (~22% of the abstracted water is lost through leaks) and a lack of storage to buffer through dry periods (see Blyth & Williams 2020).

In addition, the Waiwhetu aquifer may not always be able to pick up supply shortfalls when the river take is restricted because rising sea levels will gradually increase the frequency with which aquifer takes are also restricted to avoid salt water intrusion.

We also have to take into account the fact that, comparatively, Wellington has fairly limited water storage capacity. Further, Wellingtonians currently have a high water use per person (estimated at ~220 L/pp/day). Education campaigns by Wellington Water and local councils, coupled with fixing leaking infrastructure, are aiming to reduce demand by 10 percent by 2026. This is likely to defer construction of any new storage lakes until 2043, however at some point in the future, more water will be needed to meet demand and increase resilience to climate change (which will cause longer and more extreme dry periods).

Apart from public water supply, there are about 35 other consents which make up a very small proportion (3-5%) of the total water take. “Permitted takes” (water that can be taken without a consent) are also likely to account for a very small amount of the total water take. A recent survey identified that only 4 out of 141 respondents knew of and were using the permitted abstraction allocation on their properties. Nearly 59% of people did not know or were uncertain about the Natural Resources Plan having any rules around water use, showing an apparent disconnect between regulation and engagement with the rural/lifestyle community.

Future predictions

This section helps us look at the potential impacts on Te Awa Kairangi under a range of different catchment management scenarios, and is divided into three parts:

1. Insights from the Freshwater Expert Panel,
2. Insights from the Coastal Expert Panel, and
3. Insights from the Flow Expert Panel.

Three scenarios were considered by both the Freshwater and Coastal expert panels. These scenarios were *Business as Usual*, *Improved* and *Water Sensitive Design*. The assessments of the Coastal Expert Panel took into account the predicted outcomes from the Freshwater Expert Panel when assessing impacts on the receiving environments.

However, abstraction effects (assessed by the Flow Expert Panel) were considered independently of other pressures, such as contaminants entering the river. The Committee will therefore need to take into account the potential effects from BOTH water quality pressures AND abstraction when making decisions.

Insights from the Freshwater Expert Panel

Table 2 below details the current state of water quality and ecological indicators from monitoring (Te Awa Kairangi at Boulcott site in the lower reaches) and modelled data, and presents the possible changes assessed by the Freshwater Expert Panel for each scenario (Business as Usual, Improved and Water Sensitive). Unlike, other place based memos, this memo only presents current state of Te Awa Kairangi main-stem and not the other tributaries and streams in the catchments. The latter have been mostly captured in the Pakuratahi and Mangaroa Valleys and Hutt valley placed based memos.

Note however that Akatarawa and Whakatikei catchments were not assessed by the expert panels because they are predominately native forested catchments. Nevertheless, in the context of Te Awa Kairangi, there are some influences from these catchments on the main stem that will need to be considered (for example, significant areas of plantation forestry). A brief place based memo for the Akatarawa and Whakatikei catchments may need to be considered.

Some considerations to help understand Table 2 are:

1. Monitoring current state data is presented where present within a catchment. This gives us a high confidence assessment of the conditions in that area, and is generally a good indication of most water quality indicators throughout the catchment. However, it may not represent some of the expected variation throughout the catchment for ecological or sediment indicators so well.
2. An arrow next to the current monitored state indicates whether the attribute has an improving (↑) or deteriorating (↓) trend, while a (NT) indicates no trend.
3. Modelled current state (or range of states) is based on at least 75% of stream reaches in the catchment for order 2[1] and larger rivers and streams unless indicated. This helps to illustrate the conditions of catchments we don't have monitoring for and some of the patterns within catchments. These are generally good for illustrating catchment scale conditions and may be less reliable for sub-catchment or local reach scale conclusions.
4. Changes are based on expert panel indications of scenario change applied to the modelled current state. An arrow indicates an improvement (↑) or deterioration (↓) within an attribute state. Because there is no modelled current state for copper and zinc (see table 2), two arrows indicate attribute state change for those attributes.
5. The BAU scenario gives us information about the expected trajectory of environmental outcomes based on current understanding of urban development, the application of current policy settings in the proposed Natural Resources Plan and the likely effects of climate change.
6. The improved and water sensitive scenarios help us understand how doing urban development and catchment management differently might change the expected trajectory of environmental outcomes.
7. Confidence in expert panel scenario changes are indicated
    a. Regular font – low confidence
    b. **Bold font** – moderate confidence
    c. <u>**Bold underline font**</u> – high confidence

[1] **Stream ordering** is a method for identifying and classifying size of **streams** based on their numbers of tributaries; an **order 2** stream has at least 1 tributary (order 1) which flows in to it, an order 3 stream has at least 2 tributaries (i.e., one tributary flows in to another tributary before flowing in to the stream of interest.

Table 2. Current state and expert panel assessments of three different scenarios for Te Awa Kairangi. NB, assessment is of Te Awa Kairangi main-stem current state only.

	Ecological toxicity				Sediment	
	Copper	Zinc	Nitrate	Ammonia	Clarity	Deposited
Boulcott monitoring site (lower reach)	A	A	A↑	A↑	B↑	A
Model	*	*	A	A	C/D	A/B
BAU	↓	↓	**A**	**A**	C/D	
Improved	↑	↑	**A↑**	**A↑**	C/D↑	
WS	↑	↑	**A↑**	**A↑**	C/D↑	

* No model for copper and zinc current state currently exist.

	Phosphorus	Nitrogen	Periphyton	Macro-invertebrates	Fish	*E. coli*
Boulcott St monitoring site (lower reach)	A↑	A	C	B		D↑
Model	A/B	B	B/C	B	A/B	D/B
BAU	A/B	**B**	B/C↓	B↓	**A/B**	**D/B**
Improved	**A/B↑**	**B↑**	B/C	B	**A/B**	**C/A**
WS	**A/B↑**	**B↑**	B/C	B	**A/B**	**B/A**

One of the key messages to take from the expert panel findings is that climate change is expected to bring a number of negative effects for water quality and ecology in Te Awa Kairangi, as a result of reduced minimum flows, increased temperatures and increased flood intensities.

Further, with an increasing population, the management approaches under the BAU scenario are not enough to offset the negative effects of climate change. Accordingly, better than BAU management effort is generally necessary just to 'hold ground' against climate change and maintain current levels of water quality and ecological health.

Some specific comments for the three scenarios are as follows.

Business as Usual: The copper and zinc attributes are predicted to get worse due to an increase in impervious surface cover from further urban development, ie, the urban design measures under the BAU scenario are insufficient to mitigate the effects of further urban development.

No attributes improved under the BAU scenario, despite there being some slight improvements in some of the sub-catchments that sit within the wider Te Awa Kairangi catchments. For example, stock exclusion in the Mangaroa and Pakuratahi resulted in slight improvements for phosphorus, sediment, *E. coli* and overall suitability for recreation. However these improvements are either not large enough to have a "flow-on" effect in Te Awa Kairangi or to offset degradation occurring in other parts of the catchment.

Improved: The Improved scenario brings better urban management including better stormwater treatment and mitigations such as rain tanks, rain gardens and wetlands, reduced leakage from the wastewater network, fewer wastewater overflows and better roof materials. It also incorporates better rural management such as more extensive stock exclusion, riparian planting and retirement of the steepest erosion-prone land into native woody vegetation.

These measures are predicted to offset the negative effects of climate change and many attributes show an improvement. Some further detail regarding the predicted improvements include:

- Zinc and copper concentrations improvements are driven by stormwater capture/treatment and replacing 50 percent of existing zinc roofs.
- Sediment and nutrients will likely improve as a result of extensive stock exclusion, greater riparian planting and retirement of steep erosion prone in the Mangaroa, Pakuratahi and western hills, as well as reductions in wastewater contamination from urban areas. Reductions in sediment and nutrients may also decrease the frequency and magnitude of cyanobacterial (toxic algae) blooms, **however this is by no means certain**.
- *E. coli* loads are substantially reduced, meaning all river reaches will likely be 'swimmable' (ie, in the A, B or C state). **Currently, only 42 percent of reaches are predicted to be swimmable** (noting that those currently not classified as swimmable fail based on *E. coli* concentrations during rainfall events). This improvement is driven by a combination of better urban and rural management.

Water Sensitive Design: This scenario takes a further step up in urban management measures including comprehensive water sensitive urban design and stormwater treatment, as well as further reduced wastewater overflows. Rural management measures include even greater stock exclusion, wider riparian planting buffers and retirement of both moderate and steep erosion-prone land into native woody vegetation.

The improvements gained through this scenario are largely of the same magnitude as for the Improved scenario. The exceptions are *E. coli* and overall suitability for recreation which both improve a step further.

There is predicted to be no change in periphyton growth. The predicted nutrient reductions are unlikely to noticeably reduce periphyton growth, especially when taking into account the effects of climate change. As noted above reduced nutrient concentrations could reduce the frequency and magnitude of cyanobacterial blooms, but perversely, may favour their establishment over other types of algae (as cyanobacteria tend to have a competitive advantage in low nutrient environments).

There is predicted to be no change in macroinvertebrates or overall ecosystem health. The expert panel considered that, on balance, the reductions in sediment, nutrients and metals will only be enough to offset the negative effects of climate change. However, the panel did note that moderate improvements may occur near stormwater outlets and the Silverstream overflow.

Insights from the Coastal Expert Panel

Table 3 below presents a summary of the current state of various coastal indicators and the changes predicted by the Coastal Expert Panel for each scenario (Business as Usual, Improved and Water Sensitive). These assessments take into account current knowledge of these coastal environments as well as the predicted outcomes from the Freshwater Expert Panel.

Table 3. Current attribute states and coastal expert panel assessments for the Wider Harbour

Catchment	Scenario	Metals in sediment		Mud content	Ecology			*Enterococci*
		Zinc	Copper		Macro-algae	Phyto-plankton	Macro-invertebrates	
Wider Harbour	Current state	A	A	D	A	A	B	C
	BAU	A↓	A↓	D↓	A	A	B↓	C
	Improved	A	A	D	A	A	B	B
	WS	A↑	A↑	D	A	A	B	B

Impacts on the receiving environment of the Wider Harbour

Water quality in the Wider Harbour (excludes the Inner Harbour waters around the port and east to Miramar Peninsula) is generally of good quality except during rain events when big plumes from the Hutt River carry sediment and other contaminants into harbour waters.

Harbour plants and animals have been affected by urbanisation, however biodiversity is still relatively high in the remaining habitats. Mud content is the major issue and is higher in subtidal depositional zones of the central harbour basin and subtidal areas of the Hutt Estuary. Metal contaminants in the central harbour basin are generally low because of the distance from the port and Wellington City.

The intertidal sediments of the Hutt Estuary are in good health, with metal levels well below those that might be expected. The two key issues for the Hutt Estuary are:

1. Extensive macroalgal growths both in the intertidal and subtidal zones (current state is rated as being a ‘C’), and
2. A significantly degraded subtidal macroinvertebrate community (the deeper, dredged areas of the estuary have very poor sediment quality with high organic enrichment and low oxygenation).

Korokoro is expected to be in a similar state and have similar issues to the Hutt Estuary, but there is very limited data available.

Under the BAU scenario, subtidal depositional zones in the central harbour basin are expected to continue to degrade as they continue to accumulate sediment.

Under the Improved and Water Sensitive scenarios, a significant improvement in infrastructure is likely to result in improvement in state (from a C to a B) for *Enterococci*. However, mud content in the subtidal depositional zones of the central harbour basin and subtidal areas of the Hutt Estuary are not expected to change in the short to medium term due to legacy effects.

Insights from the Flow Expert Panel

The commentary below summarises the effects of lesser or greater water abstraction on flows and ecosystem health in each of three different parts (upper, middle and lower) of Te Awa Kairangi (see Figure 3) as assessed by the Flow Expert Panel.

The expert panel's assessments were informed by hydrological and ecological modelling undertaken for each of the scenarios, and compared against both the existing water use regime and a naturalised (or no abstraction) scenario.

This was coupled with an infrastructure assessment of the scenarios (Blyth and Williams, 2020) to provide context on costs and constraints, and identify challenges to future water supply.

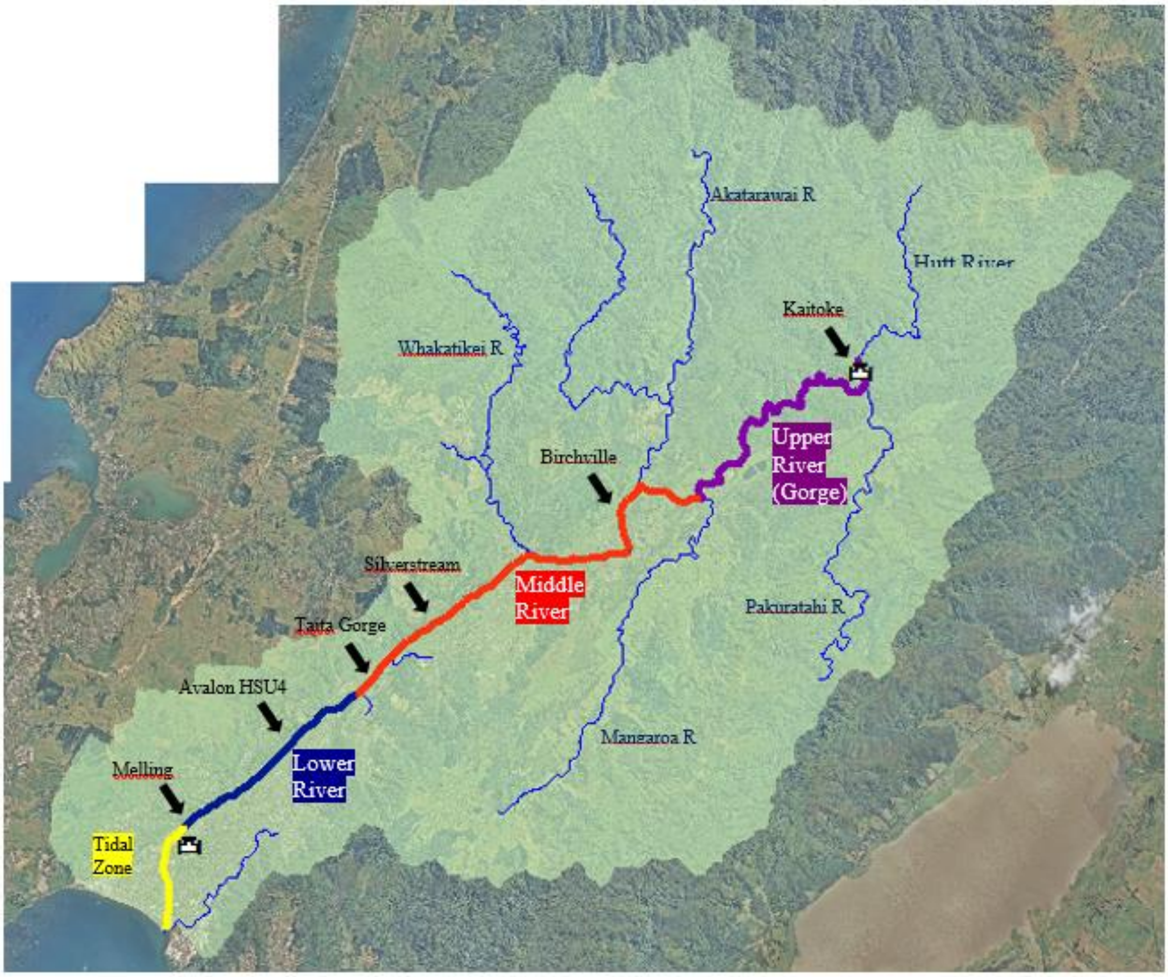

Figure 3. The Te Awa Kairangi catchment showing the assessment units (Upper, Middle and Lower river) and key modelling locations

One of the key findings of the expert panel is that the ecological impacts of our existing water use regime are considered to range from moderate in the middle reaches of the river, to strong in the upper and lower reaches. Compared with this shift that has already taken place, increasing or decreasing water abstraction within the ranges tested is predicted to have relatively minor/incremental further effects on ecosystem health, noting that:

- Additional (even minor) negative effects on top of stress conditions already created by existing use may not be desirable.
- Large decreases in abstraction (i.e. large increases in the minimum flow at Kaitoke) would likely be needed to result in substantial positive effects on ecosystem health throughout the river.

The **lower part** of the river is considered especially vulnerable to the effects of abstraction, as it is subjected to the combined effects of river and groundwater takes as well as other cumulative catchment stressors.

In future, climate change is likely to bring warmer baseline temperatures, more ‘hot’ days (days where the temperature exceeds 25°C) and longer dry spells in summer/autumn. However this will be a gradual process and over time a “shifting baseline” in key measures such as mean annual low flow (MALF) is expected. Even so, the reasonable conclusion is that climate change will generally shift the expert panel assessments further towards negative outcomes for ecosystem health.

Further interpretation of the Expert Panel results in the context of the NPS-FM and possible allocation regime management responses was provided in a paper for the 17 December 2020 workshop.

Some specific comments for the three main scenarios assessed by the expert panel are as follows.

Maximum Use under the PNRP: This scenario assumes maximum use of current water allocations (ie, full theoretical use under existing consents and plan policies).

Compared with the large shift that has already taken place from a naturalised scenario to the existing use regime, further flow alterations are modest and ecosystem health effects only incrementally more negative.

The key change is that greater volumes of water are abstracted through the mid to low-flow ranges where, currently, demand does not require it. This manifests as both a reduction in mid-range flows and an increase in the length of low-flow durations (although the magnitude of extreme low flows is not substantially affected as water use at these times is generally already maximised). **Although the ecological effects (on top of the effects already incurred by the existing use regime) would probably not be measureable or readily apparent to a casual observer, they could still be significant given current background stress conditions.** The Lower river is most vulnerable as it is the most sensitive to further change (with the combined effects of surface water and aquifer pumping), and also subject to the maximum cumulative stress of all other land use pressures acting in the catchment.

Infrastructure implications of this scenario shows abstraction would be sufficient to meet the projected population growth until approximately 2070, but would still require a 20 percent decline in water demand and a new storage lake (ie, a third Macaskill Lake) estimated to cost $250M. With a 10 percent demand reduction, construction of the new lake could be deferred from 2030 to 2043.

Decreased Allocation (raising the minimum flow from 600 to 800 L/s at Kaitoke): This scenario assumes reducing river abstraction by increasing the minimum flow at Kaitoke by a third.

It resulted in modest reductions in flow-associated effects, largely constrained to the Upper River (Kaitoke). **Changes and negative effects would remain moderate in the Middle River and large in the Lower River (ie, not significantly improved by this scenario) due to continued groundwater pumping.**

Raising the minimum flow would have significant and immediate effects on the ability to meet current water demand. Upgrades at the Te Marua water treatment plant and reducing leakage would help offset this in short term. However, even with a third storage lake (which would need to be constructed very soon) and 10 percent demand reductions, this would only meet demand until ~2048.

Increased Allocation (lowering the minimum flow from 600 to 400 L/s at Kaitoke and increasing groundwater abstraction): This scenario assumes increasing abstraction (beyond the maximum use scenario) by reducing the minimum flow at Kaitoke and increasing groundwater abstraction.

Again, changes and ecological effects are likely to be incrementally worse rather than a significant step change from the current regime or maximum use scenario. However it is important to reiterate that the current regime already represents a large alteration in which effects are considered moderate to strongly negative.

Average summer flows will reduce throughout the length of the river and low flows of a given magnitude will occur more often and last longer, with impacts being more pronounced in the uppermost and lowermost reaches. Under such conditions, algae has a longer accrual period to grow, macroinvertebrate production and consequently feeding opportunities for fish (and river birds) will decrease, while physical habitat constraints will add further stress to aquatic life.

Ultimately, it can only be concluded that the risk of detrimental effects on ecosystem health will increase with greater abstraction. Further, this risk compounds in the Lower River where some of the predicted flow and habitat losses become very large and other stress factors (cumulative effects) are pronounced.

Lowering the minimum flow has minimal gains for water supply (an extra 5 years at best), however extra abstraction from the aquifer would help meet population demands for an additional 10-15 years. In saying that, the bore field would need to be upgraded and potentially relocated to reduce salt water intrusion risks. This scenario would allow for population growth and demand to be met until ~2073 if it was supported by a 20 percent demand reduction. Beyond this additional storage or water sources would be necessary.

Opportunities and cost of improvements

Under the **Improved scenario**, improvements are generally small (except for *E. coli* and overall suitability for recreation). This is partly because the benefits of the mitigations in this measures are somewhat offset by the negative effects of climate change and an increasing population.

The significant improvements in *E. coli* and overall suitability for recreation are due primarily to improvements in wastewater network leakage and reduced wastewater overflows in urban areas, and greater stock exclusion, riparian buffers and retirement of steep erosion-prone land in rural areas.

- Cost estimates for the entire whaitua to implement **stormwater mitigations** under this scenario are between $645 and $865 million over a 50-year lifecycle. The **wastewater mitigations**[2] are estimated to cost between $2.1 and $2.6 billion.
- Supposing a total cost of $3 billion for the stormwater and wastewater mitigations assumed under the Improved scenario and 145,000 dwellings, this equates to an annual cost of **$413/dwelling/year (note this is for indicative purposes only)**.
- Mitigations relating to roof replacements are excluded as they are assumed to be covered privately. These costs also exclude all potable network improvements.

[2] These include fixing cross-connections, repairing/replacing private laterals, reducing overflows to 1 event per year on average and replacing/repairing grade 4 & 5 pipes.

The **Sensitive scenario** does not result in any further improvements over the Improved scenario, with the exception of *E. coli* and overall suitability for recreation where an additional attribute state improvement is predicted.

- Cost estimates for the entire Whaitua to implement **stormwater mitigations** under this scenario are between $1.9 and $2.8 billion over a 50-year lifecycle. The w**astewater mitigations**[3] are estimated to cost between $2.1 and $2.6 billion.
- Supposing a total cost of $5 billion for the stormwater and wastewater mitigations assumed under the Sensitive scenario and 145,000 dwellings, this equates to an annual cost of **$690/dwelling/year (note this is for indicative purposes only)**.
- Mitigations relating to roof replacements are excluded as they are assumed to be covered privately. These costs also exclude all potable network improvements.

Blyth (2020) details some of the barriers to implementing Water Sensitive Design including:

- Lack of district-level planning guides for WSD infrastructure and tools, resulting in developers defaulting to "BAU" stormwater designs that are easier to get signed off.
- No clear ownership and maintenance pathway for WSD in the Wellington Region. WSD assets require ongoing maintenance, therefore asset ownership and maintenance costs needs to be determined clearly at an early stage of any development process.
- Industry standards and compliance needs further development. WSD in Wellington is a relatively new practice, meaning designers and contractors building the devices can lack the knowledge and experience for gaining optimal results.

In terms of water conservation, to achieve a low leak network[4] a number of technical interventions are suggested including active leak detection, pressure management and water metering. Wellington Water estimates this would cost **$260-330 million over a 30-year period**, and help contribute to a reduction in leakage from an estimated 22% to less than 11%. After this point, the cost for additional gains in leakage start to become uneconomical. Note that water meters can also help with demand management by helping educate people about their water use.

To achieve the bulk of leakage reductions, pipe renewals will be necessary on aging infrastructure at locations identified from the technical interventions, and is estimated to cost an additional **$1.9–2.4 billion** for the current public water supply network.

In addition to the above, new infrastructure will also be necessary to meet population demands to 2100, potentially including:

a. A new storage lake at Te Marua to buffer summer demand (~$250 million)
b. Relocation of the aquifer borefield to reduce saline intrusion risk (no estimate available).

The costs and benefits of additional infrastructure (such as rainwater tanks, desalinization plants or other storage reservoirs) would require further investigation.

[3] These include fixing cross-connections, repairing/replacing private laterals, reducing overflows to 1 event per year on average and replacing/repairing grade 4 & 5 pipes.
[4] As per McCormack, C. & Penfold, A. 2020. Achieving a low leak network. A report for Whaitua te Whanganui-a-Tara. Wellington Water Limited.

Knowledge gaps and unknowns

Freshwater quality and ecology

- There is limited information on the impacts of septic tanks on small tributaries and consequently Te Awa Kairangi. Greater than 650 rural properties exist within this catchment, with many on the lowland pastoral areas. There is a good chance most septic tanks are original from when a dwelling was built (ie, older than 25 years). A water quality monitoring study on the impacts of septic tanks would be of interest.
- Many of the scenario mitigations were applied to green-field and in-fill housing meaning this is about *new* loads to the environment, not existing loads. Whilst the Water Sensitive scenario considers greater treatment of runoff from the existing urban footprint, it does not address retrofitting of devices throughout the catchment. Potentially, greater improvements in water quality (and flow dynamics) could be achieved through focussing on retrofitting in the existing environment while setting clear requirements for WSD on any new developments, however this will come at a cost and there are many implementation barriers that need to be addressed.

Flows and abstraction

- Modelling suggests a significant modification to river health is likely to have occurred when we moved from a naturalised flow (before any major abstraction) to the current state. Scenarios of increased and decreased abstraction suggest comparatively modest further, impacts or improvements could be expected (beyond the current state) unless fairly substantial/fundamental changes to the abstraction regime are made.
- Impacts on river health are spatially highly variable. The uppermost and lowermost reaches have probably been modified the most by the current regime and are the most sensitive to further change.
- Even with substantial changes to abstraction regime, there is insufficient information currently available to adequately assess likely benefits. For example, it is not known how much we would need to modify the abstraction regime in order to see a noticeable increase in ecological health in the river (for example, reduced aquifer abstraction *and* an even higher minimum flow).
    - The infrastructure constraints of the above would be significant as it would require additional storage (for example, from winter harvesting) and an additional summer supply (such as desalinisation). The community's appetite and willingness to pay for such schemes is not yet well understood. The longer any such schemes are deferred, the better likelihood new technology will become available to increase their viability.
- Flow abstraction effects are considered independent of other pressures, such as contaminants entering the river. The Committee will need to take into account the potential effects from BOTH water quality pressures and abstraction on the health of the river when making decisions.

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Mangaroa and Pakuratahi water quality and ecology

This report details the current state of water quality and ecology for rivers and streams in the Mangaroa and Pakuratahi river catchments[1] (Figure 1). It also presents the scenario testing results as assessed by the freshwater expert panel.

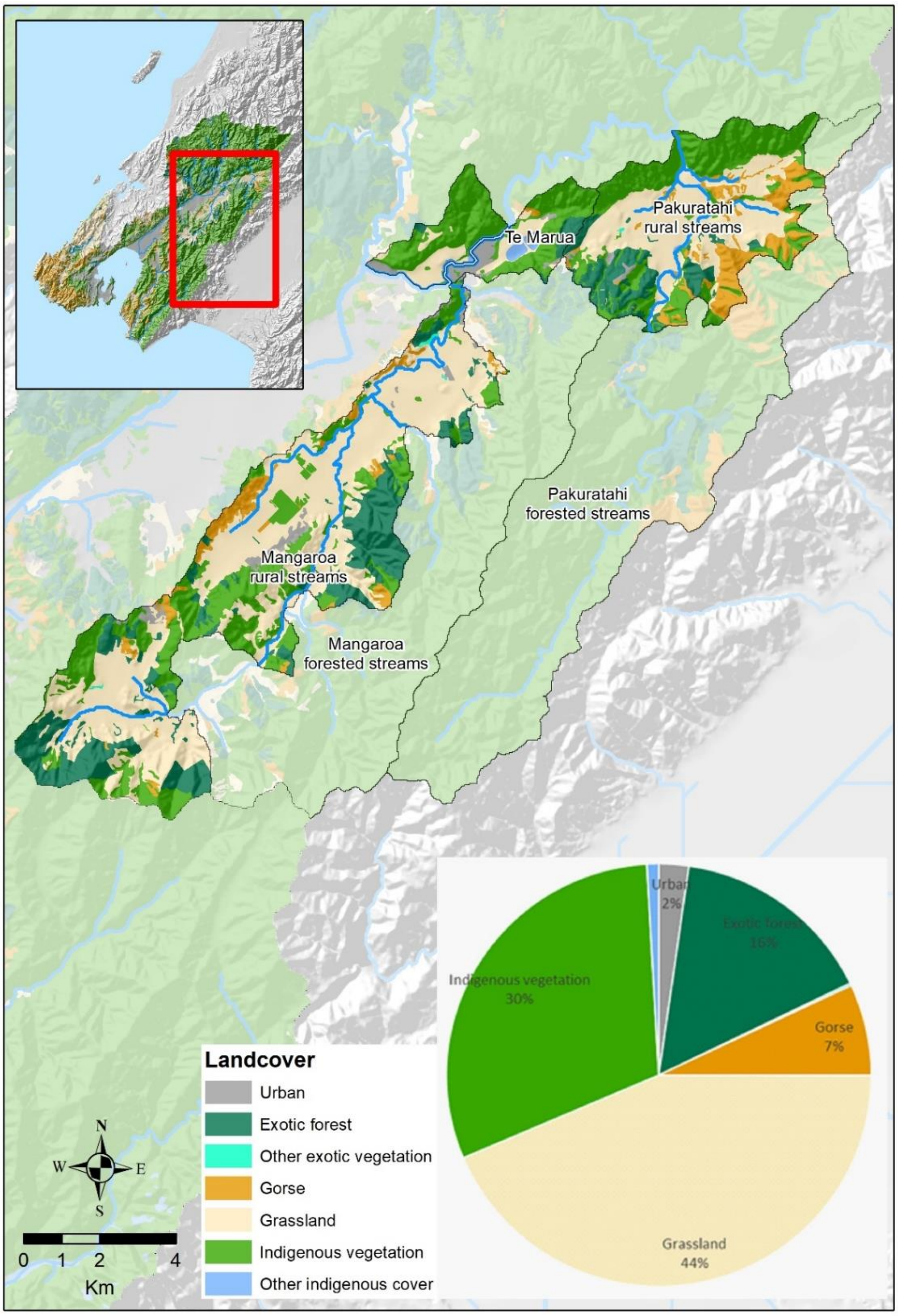

Figure 1 - Overview of the Mangaroa and Pakuratahi catchments and their land cover

[1] Excludes the areas where indigenous vegetation dominates, this has been included in the Te Awa Kairangi memo

Environmental condition summary

The Mangaroa and Pakuratahi catchments both encompass native forested streams in their headwaters, extensive wetlands (Mangaroa catchment only), large areas of exotic forest and low to moderate intensity farming in their lower catchments (Figure 1). Both rivers discharge into Te Awa Kairangi above Upper Hutt City.

The Mangaroa and Pakuratahi rivers are predominantly in a good to moderate state. However, water quality does deteriorate in the lower valleys of both catchments where pastoral land use (agriculture and lifestyle blocks) dominate. Urban land use is also a contributing factor to poorer water quality and ecology at the bottom of the Mangaroa Catchment.

The Mangaroa at Te Marua monitoring site (located at the Te Awa Kairangi confluence) is in the D state for both the *E. coli* and suspended sediment (clarity) attribute and C state for periphyton, all other attributes are either B state or better. High concentrations of tannins from the Waipango Peatlands in the valley floor is the key factor resulting in poor water clarity in the lower reaches of Mangaroa River, although suspended fine sediment is also likely to be having an effect. Elevated *E. coli* is a major concern in this catchment and monitoring indicates that concentrations exceeds safe swimming guidelines in both wet and dry weather. Cattle, waterfowl and septic tanks are the likely sources, however, their relative contributions is unknown. Periphyton biomass is also a concern, at the Mangaroa River at Te Marua monitoring site periphyton is very close to failing the national bottom and will do with one more poor monitoring result. Although nutrients, nitrogen and phosphorus, are both in the B state at this site they are not considered low enough to limit periphyton growth. Poor shading and warm water temperatures are also important contributing factors.

Water quality at the Pakuratahi monitoring site is in an overall good state; all National Objectives Framework attributes are either in the A or B state. National models, however, indicate that some stream reaches in the catchment do have their issues with a number of reaches predicted in the D state for *E. coli* and C state for periphyton biomass. Declining macroinvertebrate community index (MCI) scores at the Pakuratahi River 50m below Farm Creek monitoring site is also an area of concern, so too are the now regular summer toxic algal blooms at the Kaitoke Regional Park camp ground.

The Mangaroa Valley catchment (sub-catchments Mangaroa Valleys and Mangaroa Hills)

The Mangaroa catchment lies on the eastern side of the Hutt catchment and borders the Wainuiomata and Orongorongo catchments to the south and the Pakuratahi catchment to the northeast, and covers an area of 104km^2.

The Mangaroa River is the major waterbody in the catchment, and is a tributary of Te Awa Kairangi. It’s about 18km long and flows in a northerly direction before turning west to converge with the Te Awa Kairangi at Te Marua (Figure 1). The Mangaroa River has number of feeder tributaries, including Blaikie, Mahers, Cooleys, Colletts, Collins, Huia and Narrow Neck streams, most of which originate from the Remutaka Ranges to the East.

The most significant aquatic feature of the Mangaroa Catchment is Waipango Peatland, which is located to the west of Katherine Mansfield Drive. Waipango Swamp is the only peatland of its type in the Whaitua and is responsible for giving the Mangaroa River its tannin stain.

While there are pockets of permeable sands and gravels in places on the valley floor there is no substantial (high yield) groundwater aquifer system.

The Pakuratahi Valley catchment (sub-catchments Pakuratahi Grass and Pakuratahi Native)

The Pakuratahi catchment also lies on the Eastern side of the Hutt catchment and borders the Mangaroa catchment to the west, Wainuiomata and Orongorongo to the South and the Rimutaka ranges that feed the streams of Lake Wairarapa to the East. The catchment covers an area of 81km^2.

The Pakuratahi River is the major waterbody in the catchment, and is a tributary of Te Awa Kairangi. It's approximately 24km long and flows in a Northerly direction before turning west to converge with Te Awa Kairangi at Kaitoke. The Pakuratahi River has number of feeder streams in it lower reaches including Kaitoke, Rimutaka, Puffer and Farm Creek.

The majority of the Pakuratahi catchment remains in native forest and is reserved as a future water collection area. In its lower reaches South-West of State Highway two moderate intensity pastoral land use dominates. It is these lower reaches that this memo focuses on.

The most significant aquatic feature of the Pakuratahi catchment is the Pakuratahi forks located in Kaitoke Regional Park, which was one of the film locations for Peter Jackson's Lord of the Rings and the home to Rivendell. This stunning stretch of river is very popular for campers and swimmers who visit from all over the world.

Land use in catchment areas

Indigenous vegetation, which makes up the majority of land use in both the Mangaroa and Pakuratahi catchments, will be covered in the Te Awa Kairangi memo. In the lower valleys of both catchments pastoral grazing land is the largest land use; 51% and 37% in the Mangaroa and Pakuratahi catchments, respectively, and 44% collectively across both catchments. Exotic forestry (16%) and gorse (7%) land use dominate the marginal hill country not in indigenous vegetation (Figure 1). In the lower Mangaroa River, there is a small amount of urban land use (including the Mangaroa School and Wallaceville Church), as well as smaller lifestyle blocks. Further residential development in the Mangaroa valley is constrained by both natural hazards and ecological sensitives surrounding the Mangaroa Peatlands[2]. There is no planned urban development in Kaitoke (Pakuratahi Valley).

Visualisation of the Agribase farms (2019) database show that both the Pakuratahi and Mangaroa valleys are dominated by sheep and /or beef farming and forestry enterprises. Dairy, horse and deer farming operations also occur. According to Agribase there are four active dairy farms in the Mangaroa Valley and two in the Pakuratahi Valley. In dispersed among the pastoral farming and forestry operations, which represent the over 70% of the land use in both catchment, are a large number of smaller lifestyle blocks.

Current state, threats and opportunities

This section helps us look at the current state, pressures and possible trajectories of water quality and ecology under different assumptions about catchment management. Water quality and ecological indicators can help us understand different types of stresses in our aquatic environments. These include ecological toxicants, nutrients (and the algae growth they can support), sediment, insects and fish in the stream, and *E. coli*.

[2] Upper Hutt City Council (2020), Rural Issues and Opportunities Public Engagement, p 15-18.

We have used a number of tools, including monitoring, modelling and expert assessments to help us understand the current state and trend of these indicators and how they are currently or expected to change based on different assumptions about rural land use and climate change. Each tool has advantages and limitations to help us in different ways.

Table 1 below details the current state of water quality and ecological indicators from monitoring (where available) and modelled data, and presents the possible changes assessed by the Freshwater Expert Panel for each scenario (Business as Usual, Improved and Water Sensitive).

Some considerations to help understand this table are:

1. Monitoring current state data is presented where present within a catchment. This gives us a high confidence assessment of the conditions in that area, and is generally a good indication of water quality indicators throughout the catchment. However, it may not represent some of the expected variation throughout the catchment for ecological or sediment indicators so well.

2. An arrow next to the current monitored state indicates whether the attribute has an improving (↑) or deteriorating (↓) trend, while a (NT) indicates no trend.

3. Model current state (or range of states) is based on at least 75% of stream reaches in the catchment for order 2[3] and larger rivers and streams unless indicated. This helps to illustrate the conditions of catchments we don't have monitoring for and some of the patterns within catchments. These are generally good for illustrating catchment scale conditions and may be less reliable for sub-catchment or reach scale conclusions.
4. Water quality scenario assessments were not made in Wellington central catchments as they were uncertain how changing management would affect environmental outcomes in such heavily modified (predominantly piped) catchments.
5. Changes are based on expert panel indications of scenario change applied to the modelled current state. An arrow indicates an improvement (↑) or deterioration (↓) within an attribute state. Because there is no modelled current state for copper and zinc, two arrows indicate an attribute state change for those attributes.
6. The BAU scenario gives us information about the expected trajectory of environmental outcomes based on current understanding of urban development, the application of current policy settings in the proposed Natural Resources Plan and the likely effects of climate change.
7. The improved and water sensitive scenarios help us understand how doing urban development and catchment management differently might change the expected trajectory of environmental outcomes.
8. Confidence in expert panel scenario changes are indicated
    a. Regular font – low confidence
    b. **Bold font** – moderate confidence
    c. **<u>Bold underline font</u>** – high confidence

[3] **Stream ordering** is a method for identifying and classifying types of streams based on their numbers of tributaries; an **order 2** stream has at least 1 tributary (order 1) which flows in to it, an order 3 stream has at least 2 tributaries (i.e., one tributary flows in to another tributary before flowing in to the stream of interest.

Table 1. Current attribute states and expert panel assessments for the three scenarios

Catchment	Scenario	Ecological toxicity				Sediment	
		Copper	Zinc	Nitrate	Ammonia	Clarity	Deposited
Pakuratahi rural streams	Monitoring	NA	NA	A↑ trend	A↑ trend	A↑ trend	A
	Model			A	A	A/B/C	A
	BAU			**A**	**A**	A/B/C ↑	
	Improved	↑	↑	**A ↑**	**A**	A/B	
	WS	↑	↑	**A ↑**	**A**	A/B	
Mangaroa rural streams	Monitoring	NA	NA	A (NT)	A↑ trend	D↑ trend	A
	Model			A	A	D	D/A
	BAU			**A**	**A**	D ↑	
	Improved			**A ↑**	**A**	C	
	WS			**A ↑**	**A**	C	

Catchment	Scenario	Nutrients for growth			Dissolved oxygen*	Ecology		Human health	
		Phosphorus	Nitrogen	Periphyton		Macro-invertebrates	Fish	*E. coli*	*Primary contact*
Pakuratahi rural streams	Monitoring	A↑ trend	A↑ trend			B↓ trend		B↑ trend	
	Model	B/C	A/B	C/B/A		A/B	A	B/A/D	
	BAU	**B/C** ↑	**A/B**	C/B/A ↓		A/B	**A**	**B/A/D** ↑	
	Improved	**A/B**	A/B ↑	C/B/A ↑		**A/B** ↑	**A**	A/C	
	WS	**A/B**	**A**	**A/B**		**A**	**A**	**A**	
Mangaroa rural streams	Monitoring	B↑ trend	B↑ trend	C		B(NT)		D(NT)	
	Model	C/B	B/C	C		C/B	B	D/E	
	BAU	**C/B** ↑	**B/C**	C ↓		C/B	**B**	**D/E** ↑	
	Improved	**B/A**	B/C ↑	C ↑		**C/B** ↑	**B**	C/D	
	WS	**B/A**	**A/B**	**B**		**A**	**B**	**B/C**	

* based on minimum from spot sampling and benchmarked to one day minimum thresholds

Ecological toxicants

Metals such as copper and zinc, and nutrients such as nitrate and ammonia can be toxic to aquatic life. These effects can occur from either longer-term exposure to moderate/high concentrations or shorter-term exposure to very high concentrations.

Monitoring data for copper and zinc are unavailable across these catchments. With the exception of State Highway two, there are few high risk sources of these contaminants in these catchments and they are likely to be at low levels in these streams.

The expert panel were highly confident that metals are unlikely to change from these low levels with no urban development expected in most catchments. The lower reaches of Pakuratahi Stream may experience small improvements with improved management of runoff from the state highway.

Monitoring of the Pakuratahi and Mangaroa rivers shows levels of nitrate and ammonia to be in the A attribute states for toxicants, which is consistent with the national model assessments (Table 1).

Rural-land use practices are not expected to change much in these catchments and, given the existing state, the expert panel are highly confident of no change in the toxicity states. Increasing levels of stock exclusion and retirement are expected to further reduce nitrate concentrations within the A attribute state under the Improved and Waster Sensitive scenarios. Reductions in wastewater leaks and overflows in the small urban area at the bottom of the Mangaroa River will also help to reduce in nitrate and ammonia concentration at this location. The contribution of septic tanks to river nitrate and ammonia concentrations at a localised scale is unknown, but at the river scale contribution from these sources are likely to be minimal.

Sediment

Sediment has effects on stream ecology through both its effects on the clarity of the water, and when it deposits on the stream bed which can smother aquatic organisms and their habitat. It's also a very visual contaminant, which can affect our enjoyment and sense of connection to a stream.

Suspended (clarity) and deposited sediment are both in the A state at the Pakuratahi River Monitoring site. Similarly, national models indicate that suspended and deposited sediment are predominantly in the A state throughout the rural streams in the Pakuratahi catchment (Table 1).

Suspended sediment at the Mangaroa monitoring site is currently in the D attribute state and failing the national bottom line. Tannin staining, as a result of the Mangaroa Rivers connection with the Waipango Peatland, is the key driver of poor clarity in the lower reaches of the Mangaroa River. While tannin staining is the key drive of poor water clarity, suspended fine sediment is also believed to be having an effect. National models indicate that most rural stream reaches, including those not connected to the Waipango Peatland, in the Mangaroa catchment are predominantly in the D state. Deposited sediment at the Mangaroa monitoring site at Te Marua is in the A state, but national modelling indicates there are also number of stream reaches in the D attribute state.

Mangaroa streams are considered be at risk of sedimentation due to erodible soils, steep topography and lack of vegetated cover. The extent to which sediment losses from these risks are realised is influenced by management at the property scale, particularly around activities such as stock access to and planting of stream banks, winter grazing, vegetation clearance and forest harvesting, access tracks and earthworks. It is difficult to characterise and describe many of these at a large scale, so these discussions are generalised on typical risks and practices.

Streambank erosion is expected to be a large contributor to sediment losses through these catchments. These catchments have high proportions of pasture and the absence of vegetation can contribute to runoff changes and flow modification in streams, which can exacerbate stream bank erosion risks lower in the catchments. These can be exacerbated where livestock have access to streams, the streambanks don't have established vegetation and where roads run adjacent to streams.

Despite considerable research effort attempting to build models to predict the numeric response of deposited fine sediment to catchment management, the expert panel are not aware of any currently available for this purpose. The panel, therefore, cannot make commentary on how deposited sediment attribute states may change in response to catchment sediment reductions.

Nutrients for growth

Nutrients, nitrogen and phosphorus, affect streams by stimulating the growth of aquatic plants (macrophytes) and periphyton (algae). Periphyton at low levels is important for overall stream health, but high levels of nuisance periphyton and aquatic plants can be detrimental.

Nutrient concentrations at the Mangaroa River at Te Marua monitoring site, while in the B attribute state for both nitrogen and phosphorus, are not considered lower enough to limit periphyton growth. Nuisance periphyton blooms are a common occurrence in the lower reaches of the Mangaroa. In the Pakuratahi River both nitrogen and phosphorus are in the A attribute state and periphyton, other than toxic algae, is generally at low levels. National models indicate that the majority of stream reaches in the Mangaroa catchment are in the B and C attribute states for both nitrogen[4] and phosphorus, while the majority of reaches in the Pakuratahi catchment are in the A and B state for nitrogen and B and C state for phosphorus (Table 1).

Toxic algal blooms have become a regular occurrence in the lower reaches of the Pakuratahi River, especially at the popular Kaitoke campground. Low water column phosphorus concentrations have been linked to toxic algae blooms across New Zealand rivers. In these conditions toxic algae are able to out compete other algal species by acquiring phosphorus from sediment and organic material.

Of the four major Te Awa Kairangi tributaries, the Mangaroa and Pakuratahi have been identified as the two biggest contributors of nitrogen load to Te Awa Kairangi, contributing approximately 22 and 17 % of the nitrogen load as measured at Manor Park, respectively. Nitrogen from both tributaries has been linked to toxic algal (cyanobacteria) blooms in Te Awa Kairangi. In a 2015 investigation, Pakuratahi River nitrogen concentrations were found to increase six-fold in a 2.8km reach between State Highway 2 and the Farm Creek monitoring site (Heath and Greenfield 2016). Similarly, nitrogen loads were found to increase approximately 10 times in the lower reaches of the Mangaroa River between Hill Road Bridge and Blaikie Stream. In both catchments groundwater upwelling is believed to be a key source of nitrogen as well as small tributary streams.

Agricultural land use and the Waipango Swamp (Mangaroa catchment only) are the two main nutrient sources in these catchments. Mitigation measures such as stock exclusion, riparian planting and retirement of marginal hill country will help to reduce nutrient inputs from agriculture. Improving the health of the Waipango Swamp will also help to improve water quality outcomes in the lower Mangaroa River by reducing the leaching of organic, nutrient rich, material.

Ecology

The Mangaroa River and its tributaries are not currently recognised in the Proposed Natural Resources Plan (PNRP) as supporting ecosystems and habitats with significant indigenous biodiversity. Macroinvertebrate health is currently in the B state at the Te Marua monitoring site, and modelling shows this to be in the B and C state elsewhere in the catchment.

Indigenous fish diversity and abundance are not considered as being high in the Mangaroa River, but this assessment is based on limited data. Only three reaches in the Mangaroa catchment have been surveyed for indigenous fish, and these three reaches are in the A, B and C states, respectively.

The Pakuratahi River, including its tributaries, is identified in the PNRP as supporting ecosystems and habitats with significant indigenous biodiversity. Macroinvertebrate health is in the B state at the Pakuratahi monitoring site and modelling indicates that the majority of stream reaches are in the A and B attribute states elsewhere in the catchment. The Pakuratahi River and its tributaries are known to support at least eight indigenous fish species (Bluegill bully, Crans bully, dwarf galaxias, koaro, longfin eel, redfin bully, shortfin eel and upland bully).

Both the Mangaroa and Pakuratahi Rivers are important for trout spawning as identified in Schedule I of the Natural Resources Plan.

In-stream habitat quality in Mangaroa and Pakuratahi rural streams is considered the major stressor affecting indigenous biodiversity and ecosystem health. Habitat quality is impacted in the following ways:

- Deposited sediment smothers the riverbed while suspended sediment clogs the gills of macroinvertebrates,

[4] Note: This is dissolved inorganic nitrogen which has been removed as an attribute from the most recent NPS-FM (August 2020).

- Stock access pugs and compacts stream margins which results in the loss of undercut banks that are homes for fish as well as providing shelter from the sun,
- A lack of riparian vegetation reduces in-stream habitat (and prevents some insects from completing their life cycle) and increases the amount of direct sunlight and water temperature (which together increases fish and macroinvertebrate stress, and promotes algal growth),
- Fish barriers prevent fish migration to spawning areas and being able to complete their life cycles,
- Excess nutrients promotes periphyton growth, which can also smother riverbed habitats used by macroinvertebrates and fish.

E. coli

Over 83% of river and stream reaches in the Mangaroa catchment are modelled to be in the D and E state for *E. coli*, while only 15% of stream reaches are modelled in the D and E in the Pakuratahi catchment. Faecal contamination is both these catchments is from a combination of ruminant, avian and human (septic tanks) sources. How much each of these sources contributes is hard to quantify without undertaking a faecal source tracking study, however similar studies in the Waitohu Stream (near Otaki) have shown that while avian inputs can be large, the most dangerous pathogens are associated with ruminant and human waste.

There are an estimated 550-580 septic tanks in Mangaroa River Valley, of various age classes (see Figure 2). A recent survey on rural water use and septic tanks has found that ~50 percent of respondents don't inspect their discharge fields, however nearly 80 percent of respondents clean their tanks at least every 10 years (best practice is considered every 5-7 years). Discharge fields help treat wastewater that overflows from the tank, through the subsoil, into the environment. The degree to which septic tanks overflows affect instream *E. coli* concentrations in both the Pakuratahi and Mangaroa catchments is unknown.

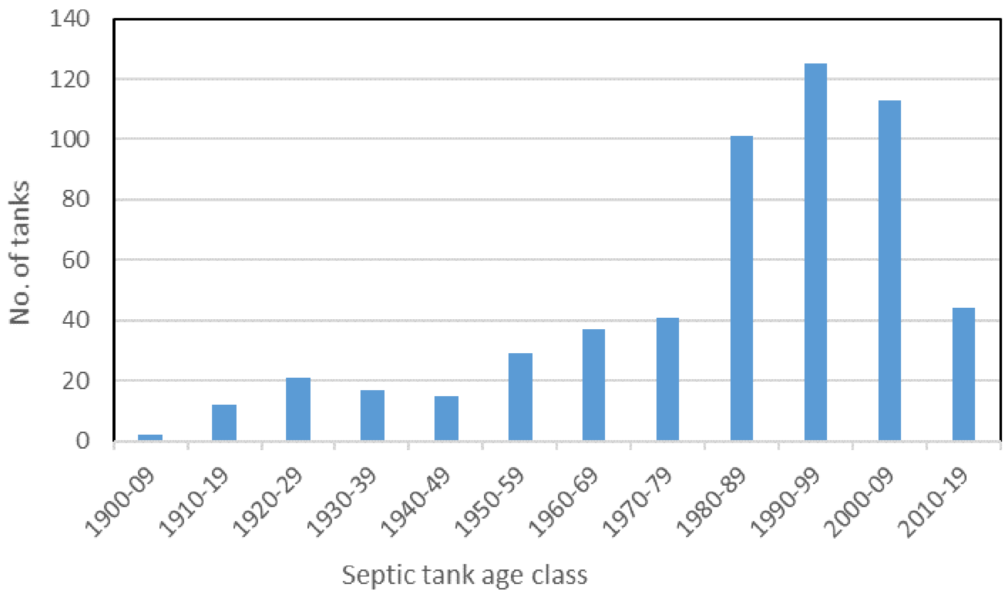

Figure 2. Mangaroa Valley septic tanks by age class (estimated from a building age database)

Consented water use is almost non-existent in the Mangaroa and Pakuratahi river catchments (there is one very minor groundwater take in the Mangaroa catchment). The only other abstraction occurs under RMA and regional rules that permit use for stock and domestic water needs and minor other consumptive uses. Total volumes taken under these rules are not known (as these takes do not require meters) but a recent rural land owner survey suggested low usage and therefore unlikely to present a significant risk.

Expert panel findings

Three scenarios were considered by an expert panel for water quality and ecology outcomes. These scenarios were *Business as Usual*, *Improved* and *Water Sensitive Design*. No specific water abstraction scenarios were considered for this catchment, however comment on the potential effects of the Business as Usual Scenario (which assumes maximum usage under the PNRP) are provided.

Business as Usual: Only slight improvements are predicted in phosphorus, sediment and *E. coli* (and hence suitability for recreation), due to the stock exclusion assumed under this scenario[5]. However these improvements are not sufficient to improve a whole attribute state. A key reason for this is the negative effects of climate change. In particular, increased flood intensities will result in increased sediment and sediment-bound phosphorus loss from erosion (Table 1).

As main tributaries of Te Awakairangi, consented water use directly from the Pakuratahi and Mangaroa rivers is controlled by the Te Awa Kairangi allocation limit. Therefore they are both considered fully allocated. There is no groundwater allocation limit listed in the NRP for either catchment as groundwater is not a substantial resource. Minor groundwater allocation could still be available but would be assessed on a case by case basis through a resource consent process with the main considerations (directed by the regional plan) being that the groundwater sought is not directly connected to any rivers or streams, can be sustained by local recharge and use of it would not cause significant drawdown for other users or local natural features like wetlands.

The potential for permitted take growth in the Pakuratahi catchment is low but significantly higher in the Mangaroa catchment. However even if the potential for permitted takes under the PNRP was fully realised, the combined effect of maximum consented and permitted use would still likely be below and therefore would not present an unduly high risk[6]. Nevertheless, this theoretical maximum use scenario suggests that if consented allocation were to increase in the Mangaroa catchment in the future in some unanticipated way (e.g. current allocation from somewhere within the wider Te Awa Kairangi catchment was surrendered and available for re-allocation), the burden of increased consented take plus fully exercised permitted take could become concerning.

Improved: Under this scenario stock are excluded from a greater proportion of streams[7]. Further, it is assumed that 5m riparian management margins are in place, moderate erosion risk hill country is space-planted and steep, erosion-prone land is retired in native vegetation. These mitigations result in a one attribute state improvement in phosphorus, sediment and *E. coli*. Nitrogen concentrations are also expected to decrease, however an attribute state change is not expected.

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[5] It is important to note that stock exclusion in the Mangaroa under the BAU scenario is the result of being classified as Category 2 surface waterbody in the PNRP.

[6] Based on comparing volumes against a default allocation limit applied to small streams/rivers in other parts of the Wellington region (the limit is a volume equating to 30% of MALF)

[7] All order 2 streams and above with grassland land cover and catchment slopes less than 10 degrees, as well as category 2 surface waterbodies which is required under BAU.

These reductions, in concert with stream habitat improvements (through riparian management) result in significantly enhanced ecosystem health and suitability for recreation outcomes (i.e., a one attribute state improvement).

Water Sensitive: This scenario assumes even greater stock exclusion, wider riparian margins (10m) and retirement of both moderate and steep erosion-prone land. These measures are predicted to produce further environmental improvements and push all attributes into the A or B state for the overall catchment.

What is interesting is when we look at the proportion of reaches within the catchment and how they change, for example:

- All reaches in both the Mangaroa and Pakuratahi catchments swimmable compared to <20% under BAU.
- For periphyton, 85% of Mangaroa catchment reaches are expected to be in the B state (up from 10% in BAU)
- For macroinvertebrates, most river reaches (85 and 93% for the Pakuratahi and Mangaroa, respectively) shift from the B or C state to the A state.

Key mitigations and effects: Stock exclusion when coupled with 5m riparian margin (Improved scenario) was identified by the expert panel as an important mitigation to reduce sediment (and sediment-bound phosphorus) entering waterways. It was also the panel's assessment that this would have commensurate, and cumulative, benefits for ecosystem health.

Extensive riparian management was also identified by the panel as being very effective at reducing nitrogen loads, however it is noted that streams in the Mangaroa are already in the A or B state.

The panel acknowledged that reductions in nitrogen and phosphorus would help to reduce periphyton in the catchment, but it was only when this was coupled with extensive riparian management (Improved for small streams and Water Sensitive for the Mangaroa River) that the panel believed an attribute state reduction would be achieved.

The incidence of stock defecating into surface water reduces under the under BAU as a result of stock exclusion requirements. However, this only reduces *E. coli* concentrations in dry weather and as a result stock exclusion alone is not expected to result in streams being classified as swimmable. Riparian management, space-planting and retirement under the Improved and Water Sensitive scenarios is expected to result in large reductions in *E. coli* concentrations during wet weather and therefore swimmable streams.

Climate change is expected to bring several negative effects for water quality and ecology (e.g. adverse effects of reduced minimum flows and increased flood intensities). In the Mangaroa the stock exclusion under BAU is necessary just to 'hold ground' against climate change and maintain current levels of water quality and ecological health. It is not until riparian management, space-planting and retirement that water quality and ecology outcomes significantly improve.

Consideration of whether PNRP permitted take allowance are appropriate offers opportunity to mitigate any unacceptable risk associated with water abstraction.

Waipango swamp

The Waipango Swamp (also known as Mangaroa peatland) is a unique ~300ha area located in the Mangaroa catchment (Figure 3).

Over the last 100 years the Waipango swamp has been drained and cleared, mainly for agriculture. This is believed to have resulted in a reduction in peat thickness and the swamp turning from a carbon sink to a carbon source. Urban expansion in the area also poses a risk to the future of the swamp.

Before drainage and vegetation removal, Waipango Swamp would have supported a rich and regionally unique biodiversity. Any potentially rare peat-adapted aquatic flora and fauna still extant in Waipango swamp and Black Stream remains unknown and requires investigation.

The influence the Waipango swamp has on Mangaroa River water quality and ecosystem health also requires further attention. A recent investigation showed Black Stream, which drains Waipango swamp, is a large source of nutrients.

Wetland restoration is no easy task, especially where a network of cut drains exist, but improving the health of the Waipango Swamp area would result in improved water quality outcomes for the Mangaroa River.

Figure 3. a. Mangaroa river at Russel Road, b. Mangaroa River at Hill Road Bridge, c. Black Stream at Gorrie Road and d. Mangaroa River at Maymorn

Knowledge gaps and research priorities

- The impact of plantation forestry in the Mangaroa Valley on water quality, and in particular sediment loads, are not well understood.
- The drivers of toxic algal blooms in the Pakuratahi River
- Interactions between the Waipango Swamp, Mangaroa River and groundwater is not well understood. In particular, the influence of the Waipango Swamp on downstream Mangaroa River water quality requires further investigation.
- The Mangaroa River system is the only major tributary of the Hutt River not listed as 'significant' for indigenous ecosystems in the Natural Resources Plan (Schedule F). This classification is not necessarily because significant indigenous ecosystems don't exist, but a symptom of a lack of monitoring, in particular fish monitoring, in the catchment.
- The unique Waipango Swamp peatland system, including Black Stream (which drains the wetland) and the Mangaroa River are likely to harbour regionally rare and significant biodiversity.
- The impact of septic tank overflows and leakage are not well understood, as no appropriate monitoring data (on or near a tank) or case study information exists.

Kei te pūtake o te whaitua o te Whanganui-a-Tara tōna mauri mana motuhake… hei oranga mō te katoa.

The mauri of Whaitua te Whanganui-a-Tara and the communities who live within it is nurtured, strengthened and able to flourish.

Our kawa are an immutable injunction to provide for te wai mouri – the essence of life that is water, te wai ora – the water that nourishes life.

Our kaupapa is Te Mana o te Wai – to restore the dignity and esteem of water as a life giver and to have respect and regard for water bodies as living entities. We put the wellbeing of water and waterbodies first. Te Mana o te Wai will be achieved through the integrated management of water including its physical and spiritual properties which are fundamental to providing for its wellbeing and the wellbeing of all who rely upon it for existence

Our tikanga implement Te Mana o te Wai - Ki uta ki tai; He taonga te wai; Mana whakahaere; Mana tangata; Mana kaunihera

Whakapapa of Te Awa Kairangi

Te Awa Kairangi is born from our Tupua – Whātaitai and Ngake who sought to break through the land locked lake and out into Te Moana Nui a Kiwa. On their journey out, Ngake flicked up his tail and created Te Awa Kairangi. Ngake is the great creator of our Harbour and Te Awakairangi, giving life, shape and form to life as we know it.

Historically within the whaitua, Māori settlements were concentrated at the mouth of rivers and streams. These estuarine areas provided many resources such as fish and birds which were easily found on forest margins, as opposed to the inhospitable forests further upstream. Te Awa Kairangi/ Hutt River was a significant freshwater fishery, where flat fish (patiki/flounder), mullet/kanae, piharau/korokoro/lamprey, kokopu (giant and banded), inanga and tuna/long-finned eels were abundant. The flood plains of Te Awa Kairangi/ Hutt River provided fertile land for gardens.

Taranaki Whānui ki Te Upoko o Te Ika travelled in the Hutt Valley largely by waka. Prior to 1855, Te Awa Kairangi/ Hutt River was navigable by waka up to the Pakuratahi River. There were few trails through the heavy forest of the valley. Many Taranaki Whānui ki Te Upoko o Te Ika Kainga and Pā were close to the Awa Kairangi/ Hutt River and the Waiwhetu Stream.

The relationship of Ngāti Toa Rangatira to the Hutt Valley and Te Awa Kairangi/ Hutt River is not one defined by concentrated settlement and physical presence. Rather it is based on the powerful leadership of Te Rauparaha and Te Rangaihaeata – particularly due to the relationship that they had with the iwi residing in Harataunga who had been placed there by Ngāti Toa in the 1830s. For some years these iwi in the Hutt Valley paid tribute of goods such as canoes, eels and birds to Te Rauparaha and Te Rangihaeata.

In 1855, the Wairarapa earthquake caused uplift of the Hutt estuary by 1.8 to 2.1 metres. It also raised the bed of Te Awa Kairangi/ Hutt River, which made the river less navigable and the estuary of the Waiwhetu stream was much reduced in size.

Sources:

Draft River Link Kaitiaki Strategy 2020
Raukaura Consultants (Love, Morrie) 2019, Cultural Values Report Te Whaitua Te Whanganui a Tara Te Awakairangi, Wainuiomata River, Akatarewa River, Hutt River Tributaries, West Coast Stream and Harbour Streams.
Statements of Association from the Taranaki Whānui ki te Upoko o te ika Deed of Settlement: Documents Schedule
Statements of Association from the Ngati Toa Rangatira Deed of Settlement: Documents Schedule

Values

See accompanying memo of values and outcomes from Ros and Project team

Following committee discussions on 17 December 2020, the original values and outcomes have been updated to reflect the outcomes of that discussion. See the meeting notes for full discussion.
The updated values are as follows:

- The river and tributaries are an inherent part of the identity of the Hutt Valley. It is recognised as having importance above and beyond its provision of habitat or its utility to humans.
- The river, tributaries, riparian margins, and wetlands provide a thriving environment for native fish, insects and aquatic plants.
- Water is of high enough quality to provide for trout fisheries, which are protected where they do not conflict with native fish.
- The river and immediate surrounds provide a healthy and safe space for people and their pets to relax, exercise, learn, forage and build a connection with nature.
- Toxic algal blooms are controlled along the river’s length and do not pose a risk to people and their pets.
- Development focus should be on living with the natural environment, with the river being given more room to flow naturally.
- The river and aquifers supply people with water to drink, for hygiene, for rearing plants and animals, for recreation and for economic opportunities.
- Small streams off the main stem are suitable for recreational use, including full immersion.
- The connection between human activity and water quality is acknowledged and mitigated as far as possible/practicable [through reducing our water demand, taking care of what is disposed to stormwater and investing in reticulated and on-site wastewater management].
- The river and tributaries can be easily viewed and accessed and the way it looks, sounds, and smells provides amenity and a sense of place to the people of the Hutt Valley and visitors.
- Communities living in the vicinity of the river have a vision for improving the river and its surrounds and an expectation that it can and will get better.

Desired outcomes

Mana Whenua Values and environment outcomes:

- Te Awa Kairangi main stem mana whenua environmental outcomes
- Draft Te Awa Kairangi Valley Floor mana whenua environmental outcomes
- Draft Te Awa Kairangi small urban streams mana whenua environmental outcomes

Indigenous forested catchments remain as current.

Flood management

Te Awa Kairangi/Hutt River Environmental Strategy Action Plan contains the following vision for the management of the Hutt River corridor "River management that meets community aspirations of enhancing the natural environment and recreational activities of the Hutt River, its margins and the wider river corridor, whilst enabling flood protection objectives and operations to be achieved."

Current conditions

Current state assessments are made based on a nominated monitoring site that is considered to be a representative proxy for each of these groups of catchments.

Te Awa Kairangi mainstem

	Ecological toxicity				Mahinga Kai			Sediment		Wāhi Tapu & Kōrero tuku iho			Nutrients for growth		Kaitiakitanga	Dissolved oxygen	Community connection	Intergenerational knowledge exchange	Natural character	Ecology		Mana whenua decision-making	Human health	
	Copper	Zinc	Nitrate	Ammonia	Taonga species	Access	Kai safe to harvest	Clarity	Deposited	Protection	Access	Mātauranga	Phosphorus	Periphyton						Macro-invertebrates	Fish		*E. coli*	Primary contact
Current state	A	A	A	A					B				A	C		A				C			D	D
Recent trend			Imp. trend	Imp. trend				Imp. trend					Imp. trend	No trend						No trend			Imp. trend	
BAU future state	A ↓	A ↓	A	A									A	C ↓						C ↓			D	D ↓

Proxy site is Te Awa Kairangi at Boulcott

The wider harbour (Wellington Harbour excluding the inner harbour which stretches from Kaiwharawhara across to Miramar Peninsula)

Harbour

	Metals in sediment		Mud content	Ecology			*Enterococci*
	Zinc	Copper		Macroalgae	Phytoplankton	Macroinvertebrates	
Current state	A	A	D	A	A	B	C
BAU future state	A↓	A↓	D↓	A	A	B↓	C

This strawthing focuses on the mainstem of Te Awa Kairangi from Te Marua (at the water storage lakes) to Te Whanganui a Tara. Although this framework focuses on mainstem issues, the source of the issue (i.e., wastewater gets into Te Awa Kairangi at all flows) will mostly be the result of cumulative impacts from the wider Te Awa Kairangi catchment. Most of these issues will have been covered and addressed to some degree in the rural and urban workshops and issues sessions. Please see Pakuratahi and Mangaroa and Hutt Valley urban place-based memos. The only Te Awa Kairangi sub-catchments not yet covered in a place-based memo are the predominantly forested catchments, Akatarawa and Whakatikei. The main potential issues in the these two catchments are exotic forestry (sediment) and small amount of pastoral landuse, but these are likely to be minor. For completeness a place based memo for these two catchments will be prepared at a later date.

Issues and barriers to implementation

Insights from the expert panel assessments and small group discussions - freshwater

Issues

- Improving habitat values in a constrained river environment
- Waste water get into Te Awa Kairangi at all flows
- Toxic algae prevents recreational pursuits during the summer months
- Lack of swimming pools in lower reaches of Te Awa Kairangi
- Barriers preventing fish migration
- Toxicants are transported to Te Awa Kairangi through Stormwater
- Mud content in the harbour smother benthic communities reducing subtidal biodiversity
- E. *coli* and *Enterococci* concentrations prevent swimming in Te Awa Kairangi and the harbour, respectively from time to time.

	Barriers to implementation (Sci and Policy) • Landowners are often unaware that their private wastewater pipes are broken (Whaitua Committee meeting 7 December 2020).Councils can only place something on a Land Information Memoranda (LIM) if it is a known problem (Whaitua Committee meeting 20 Jan 2021). • Landowners may not have the money to fix their pipes (Whaitua Committee meeting 7 December 2020). • Currently there are no Council or central government funding mechanisms to help private landowners fix their broken pipes (Whaitua Committee meeting 7 December 2020). • WWL, and councils have not undertaken proactive prioritisation exercises to develop and implement a programme that strategically works across the Te Awa Kairangi catchment to identify and repair cross connections or asset failures (Whaitua Committee meeting 7 December 2020). • Resourcing to investigate the drivers of toxic algae growth • Identifying ownership of fish passage barriers and resourcing their remediation *Insights from the expert panel assessments and small group discussions – coastal* For the harbour, mud content is the major issue and is higher in subtidal depositional zones of the central harbour basin and subtidal areas of the Hutt Estuary. Action (over and above what is expected under the BAU scenario) is required to ensure that ongoing sediment loads to do not further impact sediment quality and macroinvertebrate health. However, it is noted that even under the "water sensitive" scenario, mud content is not expected to significantly improve in the short-medium term due to legacy effects, i.e., improving coastal outcomes is a long term game.		
Our whāinga	**Immediate actions (2020-2030)** Stop further degradation Take measurable actions that improve water within 5 years Lock in any expected improvements from actions in train Begin actions that contribute towards longer term water quality improvements	**Generational change (2030-2050)** Reverse past damage to bring our waterways and ecosystems to a healthier state Achieve the national bottom lines Achieve the types of improvements associated with the 'water sensitive' scenario	**Long-term outcomes (2050-2100)** Achieve the desired environmental outcomes.
Our journey – strategies, policies and actions to achieve our whāinga	Short term (0-10 years) improvements – high level description of methods (incl reg and non-reg) drawn from detail in issues summaries. **Flood management** • Continue to ensure large flood management works in Te Awa Kairangi consider habitat restoration, stormwater treatment and mitigation of effects (Flood management memo 9 Sept 2020). (short, medium and long-term) • GWRC to seek opportunities to carry out wetland restoration through ongoing projects, to encourage positive impacts on habitat. These need to take into account lifecycle costs including maintenance costs (Flood management memo 9 Sept 2020). (short, medium and long-term) • GWRC to support ongoing public involvement in restoring biodiversity and habitat values in Te Awa Kairangi river corridor (Flood management small group 10 Sept 2020) (short, medium and long-term) **Stormwater** – • Increase work programmes to identify Inflow and Infiltration (I & I) faults across all urban suburbs, which contributes stormwater and groundwater ingress to the wastewater network leading to overflows. • Increase work programme to support repair of identified I & I faults, targeting repair of 90% of identified inflow faults within 10 years. • Co-design with nature to make water sensitive design (WSD) and green infrastructure (GI) solutions to stormwater the default for all new development within the city • Work with Wellington Water, TA's, Developers, NZTA and GWRC to identify opportunities to retrofit WSD and GI into the existing built environments	**Medium term/ Generational change (2030-2050)** **Flood management** • Te Awa Kairangi natural character is enhanced with Greater community connection as a result of co-design between nature, while incorporating flood management objectives through Riverlink **Stormwater** • Target repair of 90% of identified infiltration faults within a generation • WSD is the default for all developments and active retrofits are occurring on existing built infrastructure across Te Awa Kairangi FMU as opportunities arise (such as at asset replacement/end of life) **Wastewater** • Reduction of wastewater overflows at the Silverstream weir (medium term), which is strongly driven by I & I recommendations relating to stormwater (Wastewater summary paper 1 December 2020) (wastewater overflows are reduced) • All cross connections have been identified and repaired. • Over 50% of leaky wastewater laterals have been repaired or replaced.	**Long-term (2050-2100)** **Wastewater** • Elimination of all wastewater overflows in Te Awa Kairangi main stem (long-term) • Repair and replacement of all leaking laterals and cross connections **<u>Stormwater</u>** • A built environment that integrates seamlessly with natural features, fully adopting WSD and GI to connect communities with the environment and mitigate our effects on freshwater ecosystems

- Retain, restore and enhance existing elements of the natural drainage system through WSD, and integrate these elements into the urban landscape to connect communities with their water bodies.
- Support WCC Mayoral Taskforce recommendations 6-14 – when implemented will help break down the barriers to water sensitive urban design.

Wastewater

- HCC, UHCC and WWL to develop a road-map to prioritise the reduction of wastewater overflows in Te Awa Kairangi main stem to protect values listed above e.g. swimming holes, and cultural significance of Te Awa Kairangi.(Wastewater summary paper 1 December 2020 (Any potential prioritisation of infrastructure upgrades in the short term to be determined).
- HCC and UHCC to adopt recommendations 22 and 23 to address illegal cross – connections (wastewater to stormwater) and broken private laterals. (Short term) – 7 December 2020 Committee meeting – identify and fix cross connections; and Wastewater issue summary paper – identify private drainage faults and increase monitoring and compliance).

Nutrient management

- GWRC to work with HCC and UHCC to manage green spaces in way that reduces the impact on water quality (short-term)
- Further investigations of Te Awa Kairangi nutrient sources, in particular:
  - Nitrogen inputs from tributaries and groundwater in Pakuratahi and Mangaroa river catchments
  - Nitrogen inputs to the shallow unconfined Upper Hutt aquifer
  - Sediment bound phosphorus inputs from forestry, agriculture, streambank erosion, instream river works and stormwater and wastewater inputs.

Habitat

- GWRC to work with owners of fish passage barriers to investigate and prioritise their remediation
- GWRC to work with HCC and UHCC to identify and restore spawning habitats of Mahinga Kai species (I.e., Inanga spawning habitat)

Draft target attribute states

(Whole of lower mainstem from Te Marua to Harbour)

	Ecological toxicity				Mahinga Kai			Sediment		Wāhi Tapu & Kōrero tuku iho			Nutrients for growth		Kaitiakitanga	Dissolved oxygen	Community connection	Intergenerational knowledge exchange	Natural character	Ecology		Mana whenua decision-making	Human health	
	Copper	Zinc	Nitrate	Ammonia	Taonga species	Access	Kai safe to harvest	Clarity	Deposited	Protection	Access	Mātauranga	Phosphorus	Periphyton						Macro-invertebrates	Fish		*E. coli*	Primary contact
BAU future state	A ↓	A ↓	A	A				A/B	A				A/B	B/C ↓		A#				B ↓			D	D ↓
Immediate actions	A	A	A	A				A/B	A				A/B↑	B/C		A#				B			C/A	C/A
Generational change	A	A	A	A				A	A				A/B↑	B/C		A#				B			B/A	B/A
Long-term																								

Not assessed by the expert panel, assessment made by project team.

*Succinct summary collection of ideas from TKT, Small groups and project team. This won't capture all of your ideas for a change. What other ideas would act on both immediate and systemic actions for changes?

Te Awa Kairangi monitoring sites

	Ecological toxicity				Sediment		Nutrients for growth			Dissolved oxygen	Ecology	Human health	
	Copper	Zinc	Nitrate	Ammonia	Clarity	Deposited	Phosphorus	Nitrogen	Periphyton		Macro-invertebrates	*E. coli*	Primary contact
Hutt River at Te Marua Intake	A*	A	A	A	A	A	A	A	A	A	A	A	Poor
Hutt River at Manor Park	A	A	A	A	A	A	A	A	B*	A	A	D	Poor
Hutt River at Boulcott	A	A	A	A	B	A	A	A	C	A	B	D	Poor
Pakuratahi 50m below Farm Creek	A*	A*	A	A	A	A	A	A	A*	A	B	B	Poor*
Mangaroa River at Te Marua	A*	A*	A	A	D	A	B	B	C	A	B	D	Poor*
Akatarawa at Hutt confluence	A*	A*	A	A	A	A	A	A	A*	A	B	B	Poor*
Whakatikei River at Riverstone	A*	A*	A	A	A	B	B	A	A*	A	B	A	Good*
Waiwhetu at Whites Line East	C	D	A	B	A	D	D	C	D**	A	D	E	Poor*

Modelling

Scenario and /or monitoring site	Ecological toxicity				Sediment		Nutrients for growth			Dissolved oxygen	Ecology		Human health	
	Copper	Zinc	Nitrate	Ammonia	Clarity	Deposited	Phosphorus	Nitrogen	Periphyton		Macro-invertebrates	Fish	*E. coli*	Primary contact
Hutt River at Boulcott (GWRC monitoring site)	A	A	A↑	A↑	B↑	A	A↑	A	C	A	B		D↑	Poor
Current state (based on models for lower TAK mainstem)	*	*	A	A	C/D	A/B	A/B		B/C		B	A/B	D/B	
BAU (as assessed by expert panel for lower TAK mainstem)	↓	↓	A	A	C/D		A/B		B/C↓		B↓	A/B	D/B	
Improved (As assessed by expert panel for lower TAK mainstem)	↑	↑	A↑	A↑	C/D↑		A/B↑		B/C		B	A/B	C/A	

Water Sensitive (As assessed by expert panel for lower TAK mainstem)	↑	↑	A↑	A↑	C/D↑		A/B↑		B/C		B	A/B	B/A	

Draft target attributes states (based on Boulcott monitoring site)

	Ecological toxicity				Sediment		Nutrients for growth		Dissolved oxygen	Ecology		Human health	
	Copper	Zinc	Nitrate	Ammonia	Clarity	Deposited	Phosphorus	Periphyton		Macro-invertebrates	Fish	*E. coli*	Primary contact
BAU future state	A	A	A	A	B	A	A	C ↓	A#	B ↓		D	Poor ↓
Immediate actions	A	A	A	A	B	A	A	C	A#	B		D	
Generational change	A	A	A	A	A	A	A↑	C	A#	B		B	
Long-term													

*Replacement of draft attribute states table in Te Awa Kairangi template