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Water quality trends in rivers of Tasman

Analyses of data ending in 2021

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1 At a Glance

This report presents the results of trend assessments for Tasman rivers over 5 years and 15 years up to June 2021. Water quality was assessed using water chemistry (Total Ammonia, Nitrate-N, Dissolved Reactive Phosphorus), levels of faecal indicator bacteria (*E. coli*) and visual water clarity data. All long-term river water quality monitoring sites with sufficient data were included in the assessments.

The trend assessment methods account for the increase in sampling frequency from four times per year to 12 times per year and the shift from dry weather sampling (waiting at least three days after rain) to all-weather sampling which occurred in 2016. The trend results are interpreted with reference to the current state of water quality at the river sites. Trends were assessed in terms of trend direction, from **very likely improving** to **very likely degrading**, and trend rate, the rate of change in the water quality attribute per year.

There were a mix of improving and degrading trends across all water quality attributes. For the Nitrate-N and Water Clarity attributes, the proportion of monitoring sites in each trend category were similar over five years and 15 years. For the Total Ammonia, DRP and *E. coli* attributes, however, there were considerable differences in the proportion of monitoring sites with degrading trends between the five and 15 year time periods.

Over the five year time period, there were more degrading trends in water chemistry and water clarity than there were improving trends. For Total Ammonia and Dissolved Reactive Phosphorus, this pattern was reversed over the 15 year time period where most sites were improving. There were a similar number of improving and degrading trends for faecal indicator bacteria levels over five years, but more sites with degrading trends over 15 years.

For the majority of **very likely degrading** trends, the trend rate was low (the 95% confidence interval for Sen slope included 0). There was a general pattern that higher trend rates occurred at monitoring sites with higher median nutrient concentrations.

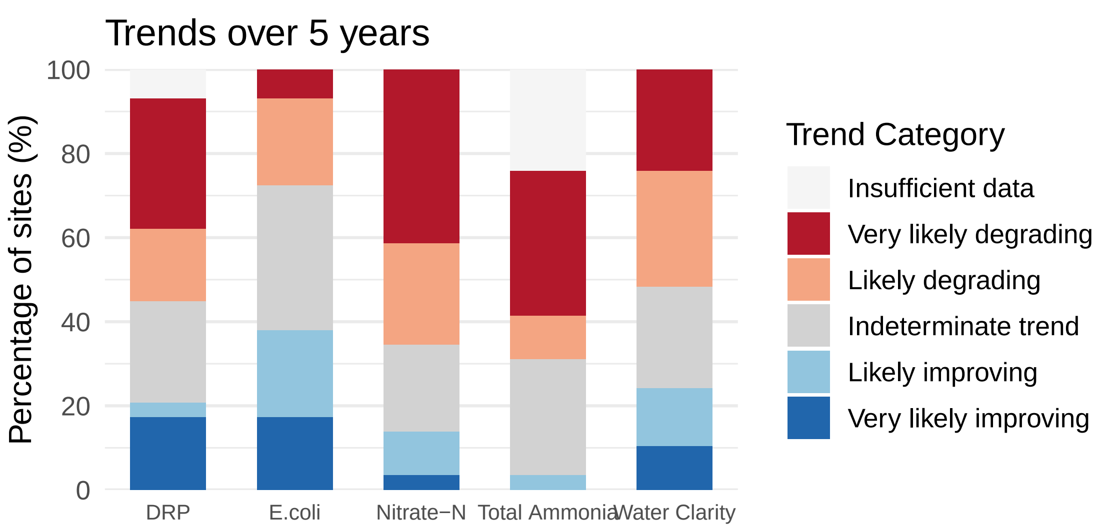

Figure 1: Percentage of sites in each trend category for the five year time period, July 2016 to June 2021

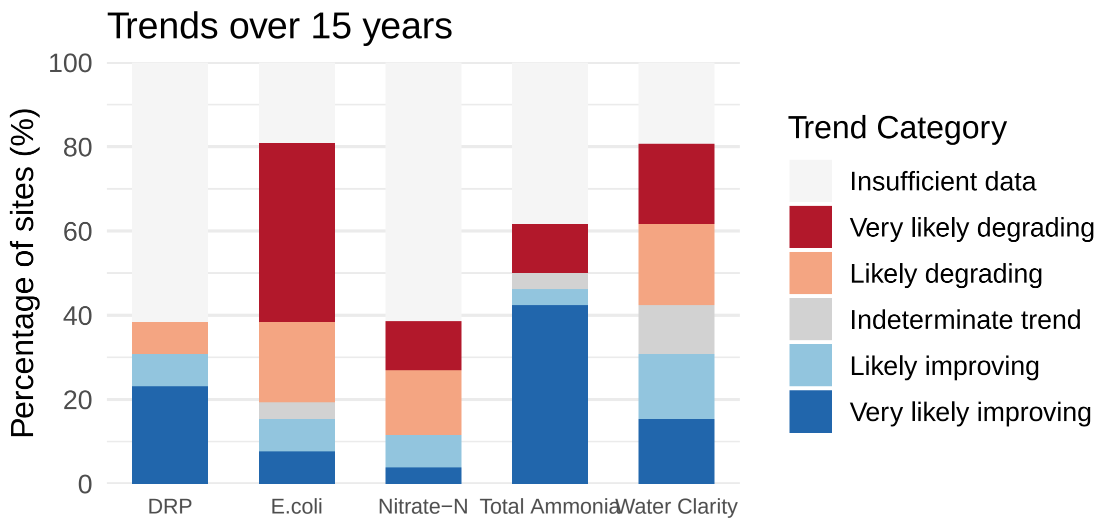

Figure 2: Percentage of sites in each trend category for the 15 year time period, July 2006 to June 2021

1.1 Disclaimer

In accordance with data access agreements, Tasman District Council and NIWA make no representations or warranties regarding the accuracy or completeness of the data collected through the Tasman River Water Quality Monitoring Programme (RWQMP) or National Rivers Water Quality Network (NRWQN). Both parties accept no liability for any loss or damage (whether direct or indirect) incurred by any person through the use of or reliance on these data.

1.2 Acknowledgements

Tasman District Council would like to thank all the people and organisations who have assisted with river water quality monitoring in the Tasman District.

Thank you to the landowners who provide access to river monitoring sites, cooperate with efforts to identify contaminant sources and invest in measures to improve the health of waterways.

A big thank you to the staff and students involved in the collection of river water quality information. Your teamwork and individual efforts add enormously to the quality of this long-term monitoring dataset.

A special thanks to Anette Becher for assistance with data wrangling and input into the calculation of water quality state. Thanks also to Caroline Fraser for conducting a peer review of this report.

We acknowledge the ongoing contributions to environmental monitoring by the following organisations:

- Hill Laboratories and Cawthron Institute for sample analysis
- NIWA and the Ministry for the Environment for data from the National River Water Quality Network sites

2 Introduction

Rivers and streams are a vital part of Tasman's landscapes, forming an integral part of our lifestyles and livelihoods. Wai-māori (freshwater) provides a home for aquatic plants and animals and resources we consume. Wai-ora (pure water) is a source of life and wellbeing. Over 14,000 kilometers of rivers and streams weave through the landscapes of Tasman, from small streams to large rivers, from intermittently flowing to raging in flood.

Tasman District is fortunate to have relatively few water quality issues compared to other parts of New Zealand, assisted by the District's large rivers having a significant proportion of indigenous forest in their headwaters. In these large rivers, any inputs of contaminants from developed land are substantially diluted by the large volume of high quality water from upstream. The main problems with water quality are found in small streams whose catchments contain a large proportion (>50%) of intensively developed land. Previous river water quality reports for Tasman show sites with pastoral and urban land cover have higher concentrations of disease-causing organisms, greater quantities of deposited fine sediment and lower water clarity than sites with indigenous forest or exotic forest land cover (Young et al. 2005; Young et al. 2010; James and McCallum 2015).

Under the National Policy Statement for Freshwater Management (NPS-FM), regional councils including Tasman District Council are required to monitor freshwater and respond to degradation (Ministry for the Environment 2020). An important component of this work is to assess and report on trends in water quality over time. Where rivers and streams are degraded or degrading, Tasman District Council must then investigate the causes and take action to halt or reverse the degradation.

Data on water quality in Tasman is collected by long-term monitoring programmes operated at the national and regional level. The National River Water Quality Network (NRWQN) began operation in January 1989 (Davies-Colley et al. 2011) and has maintained a monthly sampling schedule. The NRWQN includes three river sites in Tasman. The TDC river water quality monitoring programme started a decade later, in 1999, with a quarterly schedule (four times per year). At present, 27 river water quality sites are monitored by TDC.

An internal review of the TDC river monitoring programme was carried out in 2016. Changes to the programme were made to better align with national level reporting requirements and increase the ability to detect trends in the long term. As a result of this review, the frequency of sampling at river water quality sites was increased from four times per year (quarterly sampling) to 12 times per year (monthly sampling). There was also a shift from dry weather sampling (waiting at least three days after rain) to all-weather sampling. These changes in sampling design must be considered when assessing trends in Tasman District Council river water quality data.

The sampling design changes in 2016 introduce confounding factors when assessing long-term trends in water quality. In particular, by switching to all-weather sampling, there is a greater chance of rainfall-induced runoff influencing water quality. Rainfall increases runoff, where contaminants (faecal matter, nutrients or fine sediment) are delivered to waterways from paddocks and hard surfaces. At the same time, rainfall has a dilution effect, where increasing river flows reduce the concentration of a contaminant (Helsel et al. 2020). The combination of these two processes, runoff and dilution, leads to different patterns between river flow and water quality at different monitoring sites. For the same water quality parameter, the relationship with river flow may be positive, negative or non-monotonic (positive for some flow values then switching to negative, for example).

A statistical method called 'flow adjustment' can be used to remove some of the influence of river flow on water quality observations. Flow adjustment involves fitting a statistical model describing the relationship between river flow and water quality at a particular monitoring site (Larned et al. 2018). Flow adjustment can theoretically increase the statistical power of the trend assessments (Helsel et al. 2020).

Land Air Water Aotearoa (LAWA) collate and analyse environmental monitoring data from New Zealand regional and unitary councils, including Tasman District Council. On an annual basis, LAWA releases summary statistics describing the current state and trends in water quality at each monitoring site. To date, the LAWA trend assessment methods do not include flow adjustment (Cawthron Institute 2022a).

There are many drivers of water quality trends, across the catchment scale and broader spatial scales. Within a catchment, a trend may be the direct result of human activity (for example, increased urbanisation, a shift in land-use, removal of point-source discharges). At this scale, biological or geological processes may also be important (for example, increased abundance of waterfowl, increased sediment inputs from a landslide). At a broader, oceanic scale, water quality trends may result from climate variability, with cycles over years, decades or longer (Scarsbrook et al. 2003; Helsel et al. 2020).

2.1 This report

This report presents the results of trend assessments for Tasman rivers over five years and 15 years up to June 2021. Water quality was assessed using water chemistry (Total Ammonia, Nitrate-N, Dissolved Reactive Phosphorus), levels of faecal indicator bacteria (*E. coli*) and visual water clarity data. All long-term river water quality monitoring sites with sufficient data were included in the assessments.

The trend assessment methods account for the increase in sampling frequency from four times per year to 12 times per year and the shift from dry weather sampling (waiting at least three days after rain) to all-weather sampling which occurred in 2016. The trend results are interpreted with reference to the current state of water quality at the river sites. The results quantify overall trends in water quality in rivers across the Tasman District.

3 Methods

River water quality data for assessing trends in Tasman were compiled from the TDC River Water Quality Monitoring Programme (26 monitoring sites) and the NIWA National River Water Quality Monitoring Network (3 monitoring sites; Figure 3).

3.1 Attributes Assessed

To limit the scope of this report, only attributes listed in the National Objectives Framework of the National Policy Statement for Freshwater Management (NPS-FM) were assessed (Ministry for the Environment 2020). The TDC River Water Quality Monitoring Programme includes additional attributes not presented here.

Table 1: River water quality attributes assessed

Attribute	Units	NPS-FM Metrics
Total Ammonia	g/m3	Median, maximum
Nitrate-N	g/m3	Median, 95th percentile
Dissolved Reactive Phosphorus (DRP)	g/m3	Median, 95th percentile
E. coli	cfu/100ml	Median, 95th percentile, proportion > 260, proportion > 540
Water Clarity	m	Median

Notes on attributes listed in the NPS-FM but not included in this report:

- Deposited fine sediment (SAM2). Deposited fine sediment data is collected at TDC monitoring sites, but not using the SAM2 protocol specified by the NPS-FM.
- Dissolved oxygen. TDC has data from short-term (three to five day) deployments. To date, dissolved oxygen data is not collected at the same sites each year.
- Freshwater fish. To date, freshwater fish data are not collected at the same sites each year.
- Periphyton. Monitoring of periphyton occurs at TDC monitoring sites, but not using the chlorophyll-a method specified by the NPS-FM.
- Macroinvertebrate Community Index (MCI). Macroinvertebrate samples are collected annually, during Summer, when river flows are low. Trends in MCI are available on the LAWA website (lawa.org.nz).

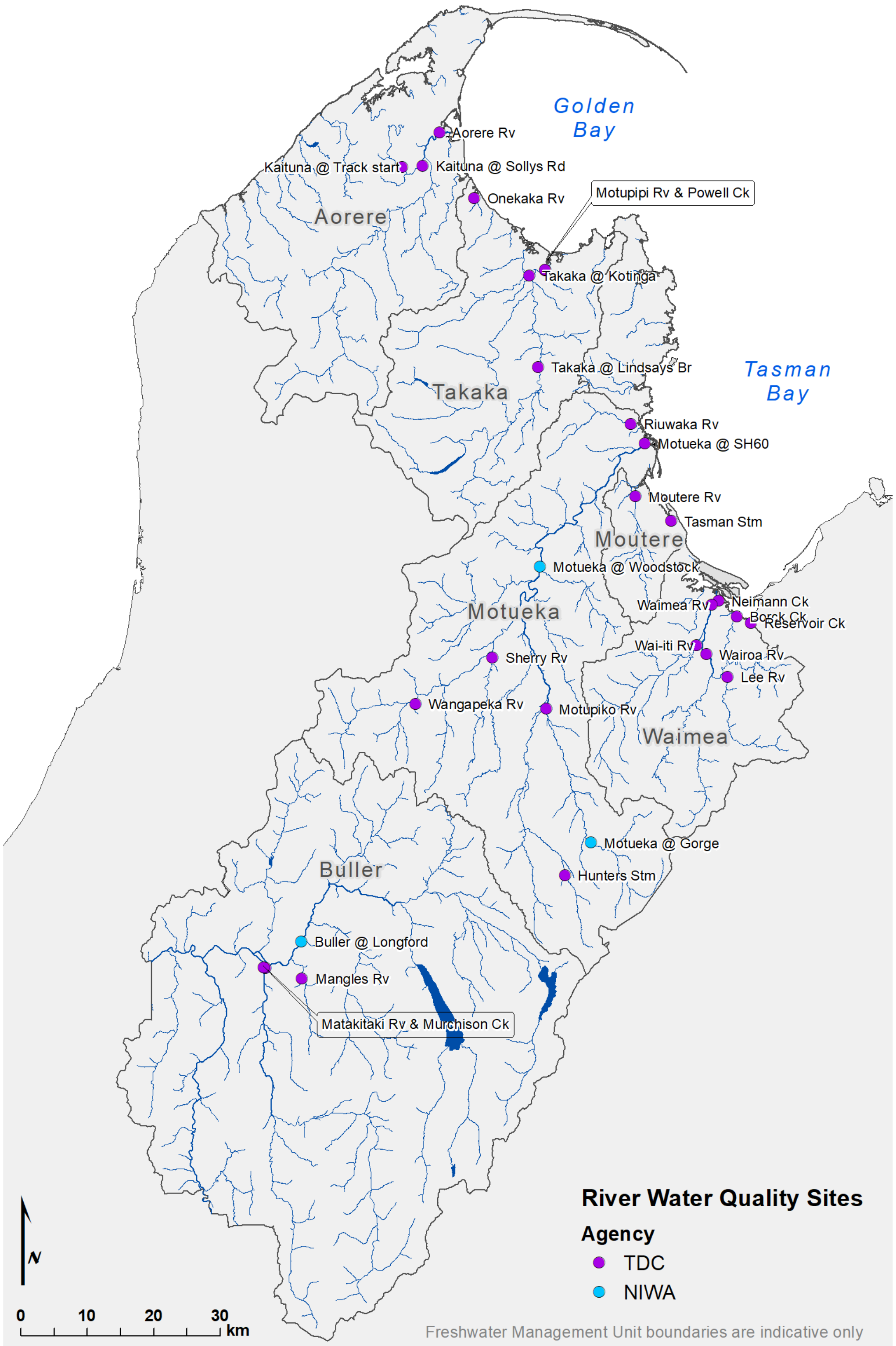

Figure 3: River water quality monitoring sites in Tasman District

3.2 River water quality state

The current state of water quality at the river sites was evaluated using the National Objectives Framework of the NPS-FM (Ministry for the Environment 2020). Under this framework, each combination of river site and water quality attribute is assigned to an attribute band. Attribute bands are named **A** through **D** (or **A** through **E** for the (*E. coli* attribute) with the **D** (or **E**) band representing poor water quality.

The water quality state statistics and attribute bands in this report are from LAWA (Cawthron Institute 2022b), using five years of monitoring data (July 2016 to June 2021). For the ammonia attribute band, pH adjustment of the Total Ammonia data was undertaken.

3.3 River water quality datasets

Two time periods were chosen to assess trends: five years covering the period since monthly monitoring began at TDC river water quality sites, and 15 years to show longer-term trends. The majority of river sites had at least 15 years of monitoring data available.

The **p5m** dataset contains five years of monthly monitoring data (July 2016 to June 2021)

The **p15q** dataset contains 15 years of quarterly monitoring data (July 2006 to June 2021)

To construct the **p15q** dataset, the part of the record with a monthly sampling frequency was converted to a quarterly frequency. This 'downsampling' was done by keeping the observation closest to the midpoint of each quarter/season. The midpoints of each season were: Summer, 14-Feb; Autumn, 16-May; Winter, 16-Aug and Spring, 15-Nov. Using the median value to convert the monthly data to quarterly was avoided because this may introduce a trend in the variance of the water quality data, invalidating the trend statistics (Helsel et al. 2020).

Four monitoring sites were sampled at a monthly frequency during the entire analysis period (Sherry @ Blue Rock plus the three NIWA sites). These sites were assessed separately.

In July 2016, TDC began monitoring at three sites, Takaka @ Lindsays Br, Mangles @ 5km u-s Buller and Wai-iti @ 400m d-s Waimea W Rd. Due to the shorter period of monitoring at these sites, they are included in the **p5m** dataset only.

Two monitoring sites were moved during the time period that this analysis covers. The monitoring data from these pairs of sites were combined:

- Kaituna @ Track start and Kaituna @ 500m us Track start (500m upstream)
- Wairoa @ SH6 and Wairoa @ Irvines (3 km upstream)

Given the sites were moved a short distance (3km or less) and no tributaries were located between them, we assume no change in water quality results due to the change in monitoring location.

One site, Sherry @ Blue Rock, had *E. coli* data from both the TDC and NIWA monitoring programmes. These data were combined by taking the median value within months containing more than one observation.

Total Oxidised Nitrogen (nitrate nitrogen + nitrite nitrogen) data were used as a proxy for nitrate-N data at the three NIWA sites. The difference between these two monitoring parameters is small (less than 0.05 g/m3), based on inspection of data collected from Motueka @ SH60 bridge, a TDC monitoring site downstream of the NIWA sites.

3.4 River flow dataset

River flow data were from several sources, depending on the river water quality site. The flow data sources were (1) a flow gauging carried out on the same day as the river water sampling, (2) a flow value from a hydrometric station on the same waterway or (3) a flow derived from a correlation between a nearby hydrometric station on a different waterway. Flow values taken from hydrometric stations were matched to the river water quality datasets using the nearest timestamp.

3.5 Trend assessment steps

Trends in water quality were assessed following recent guidance documents on trend analysis in New Zealand (Snelder and Fraser 2018; McBride 2019; Snelder, Fraser, et al. 2021). For each combination of monitoring site and water quality attribute, the steps taken to produce a trend result were:

1. Join river water quality and flow data
2. Apply flow adjustment procedure
3. Divide into seasons (months or quarters) and test for seasonality
4. Evaluate trend direction (positive or negative) and confidence in trend direction
5. Evaluate trend rate (rate of change in the water quality attribute per year)
6. Categorise trends into five classes (from **very likely improving** to **very likely degrading**)

All trend assessments were carried out using R software (R Core Team 2021) and relied on functions from the LWP trends library v2101 (Snelder and Fraser 2021).

Trends were not assessed if less than 80% of season-year combinations contained data. In the LAWA trend assessment procedure, this threshold was set at 90% of season-year combinations (Cawthron Institute 2022a). We relaxed this threshold to permit a higher proportion of monitoring sites to be included in the assessments, acknowledging the fact that flow adjustment requires both a water quality value and a flow value.

3.6 Censored values

Water quality attributes have associated detection limits, that is, minimum and maximum values that can be reliably measured. Data outside the detection limits are ‘censored’ by setting them equal to the detection limit. In the raw data, this censoring is indicated by a less-than “<” or greater-than “>” symbol.

In the flow adjustment step, raw values less than the detection limit were halved and raw values greater than the detection limit were multiplied by 1.1.

For some water quality attributes, the detection limits have changed over time. To account for these changes, the ‘HiCensor’ option was used in the LWP Trends functions which modifies the raw data by (1) identifying the maximum censored value that is below the detection limit and (2) setting all values below the max censored value to the max censored value. For example, in the four values “<2,”“<2,”19,“<5,” the maximum censored value is “<5.” Applying rule (2) to these four values gives “<5,”“<5,”19,“<5.”

Changes in detection limits:

- For Dissolved Reactive Phosphorus, the lower detection limit was 0.001 g/m3 for most of the record, except for March to November 2018 when the lower detection limit was 0.004 g/m3.

3.7 Flow adjustment

Flow adjustment is the process of removing the influence of river flow on water quality data (Larned et al. 2018). This was done by fitting models relating the water quality data with river flow then adjusting the data with respect to flow using the best model.

Models used to relate water quality attributes with river flow were:

- Log-log models
- Locally estimated scatterplot smoothing (LOESS)
- Generalised additive models (GAMs)

Of the three families of models, log-log models are the simplest in terms of model structure. Log-log models are monotonic, meaning the fitted line either consistently increases in value or consistently decreases in value. A monotonic relationship between flow and water quality attributes is physically realistic (Snelder, Fraser, et al. 2021). By contrast, LOESS and GAM models can produce fitted lines with changes in direction (increasing then decreasing then increasing again, for example) which often do not have a clear physical explanation. However, LOESS models have been used for flow adjustment (Ballantine 2012; Snelder 2018) and may be appropriate where log-log models fit the data poorly. Our approach, following Larned et al. (2021), was to choose the simplest model that captures large-scale patterns in the data.

Log-log, LOESS and GAM models were fitted using the LWP trends library (Snelder and Fraser 2021). LOESS models were fitted with a span of 75%. For each combination of site and water quality attribute, the raw data from the **p5m** dataset were plotted with fitted lines from each model. The most suitable model was chosen using professional judgement, based on model goodness of fit and plausibility of the shape of the fitted line. This process was repeated for the **p15q** dataset. The residuals (difference between the observed values and the fitted values from the best model) were used in the trend tests except where the corresponding R-squared statistic was less than 0.2 (that is, less than 20 percent of the variance in the water quality attribute was explained by flow). In that case, flow adjustment was deemed unnecessary and the unadjusted values were used in the trend tests.

3.8 Seasonality test

Seasonality was estimated using the Kruskal Wallis test (non-parametric ANOVA with season as the predictor). For the monthly datasets, each month of the year was treated as an season, giving 12 seasons. For the quarterly dataset, seasons were defined as Summer (Jan, Feb, Mar), Autumn (Apr, May, Jun), Winter (Jul, Aug, Sep) and Spring (Oct, Nov, Dec). The data were classified as seasonal when the p-value of the Kruskal Wallis test was less than 0.05.

3.9 Trend tests

The **Kendall S** statistic provides an estimate of trend direction. Kendall S is derived by calculating the difference between all pairs of water quality observations (Snelder, Fraser, et al. 2021). The number of positive pairs (increasing with time) and the number of negative pairs (decreasing with time) are tallied up. The Kendall S statistic is the number of positive pairs minus the number of negative pairs. The seasonal version of Kendall S is derived by applying the same procedure to the water quality observations within each season. The Kendall S values from each season are then added together to give the final seasonal Kendall S statistic. Kendall S values less than 0 indicate a negative trend and values greater than 0 indicate a positive trend.

To calculate the non-seasonal Kendall S statistic, at least three unique values and at least five non-censored values were required. A stricter rule applied to the seasonal Kendall S statistic, with at least three unique values required within each season. If this stricter rule was not met, preventing the calculation of the seasonal Kendall S statistic, a second attempt was made using the non-seasonal version. When there was insufficient variability in the data, the trend statistics were not calculated and the trend was categorised as "insufficient data."

Confidence in the trend direction (**C**) was calculated from the p-value associated with Kendall's S statistic. **C** ranges from 0.5 to 1 where a value of 0.5 indicates the trend direction is equally likely to be positive or negative while a value close to 1 indicates high confidence in the trend direction.

Confidence that the trend was decreasing (**C decreasing**) was derived from **C** and the sign of Kendall S (positive or negative). **C decreasing** ranges from 0 to 1 (Snelder and Fraser 2021).

For each trend result, a **trend category** was assigned, using the same categories as on the LAWA website (Cawthron Institute 2022a).

Trend Category	Confidence that the trend was decreasing
Very likely degrading	Less than 0.1
Likely degrading	Between 0.1 and 0.33
Indeterminate trend	Between 0.33 and 0.67
Likely improving	Between 0.67 and 0.9
Very likely improving	Greater than 0.9

Sen slope provides an estimate of trend rate. It is expressed in terms of the change in the monitored parameter per year. Sen slope is the median of all possible inter-observation slopes (Hirsch et al. 1982). In brief, the calculation steps are:

1. Take all possible pairs of data points and calculate the slope for each pair (difference in measurement divided by difference in time)
2. Rank the slopes in ascending order
3. Return the median slope

The seasonal version of sen slope estimator is modified to give the median of all possible inter-observation slopes within each season.

4 Results

4.1 Water quality data

The number of river water quality sites with sufficient data to carry out trend assessments differed between the five year and 15 year time periods (Table 3). For the nutrient attributes, fewer sites had sufficient data to carry out trend assessments over the 15 year time period. This was because, prior to 2016, nutrients were not monitored at selected river sites.

Table 3: Number of sites with trend results

Attribute	**5 years**	**15 years**
DRP	27	10
E.coli	29	21
Nitrate-N	29	10
Total Ammonia	22	16
Water Clarity	29	21

There were a high proportion of censored values, less than the lab detection limit, in the ammonia data compared to the other water quality attributes (Figure 4). Three sites in the **p5m** dataset had 100% of ammonia values censored (Takaka @ Lindsays Br, Waimea @ SH60 Appleby and Wairoa @ SH6) preventing trend assessments from being performed.

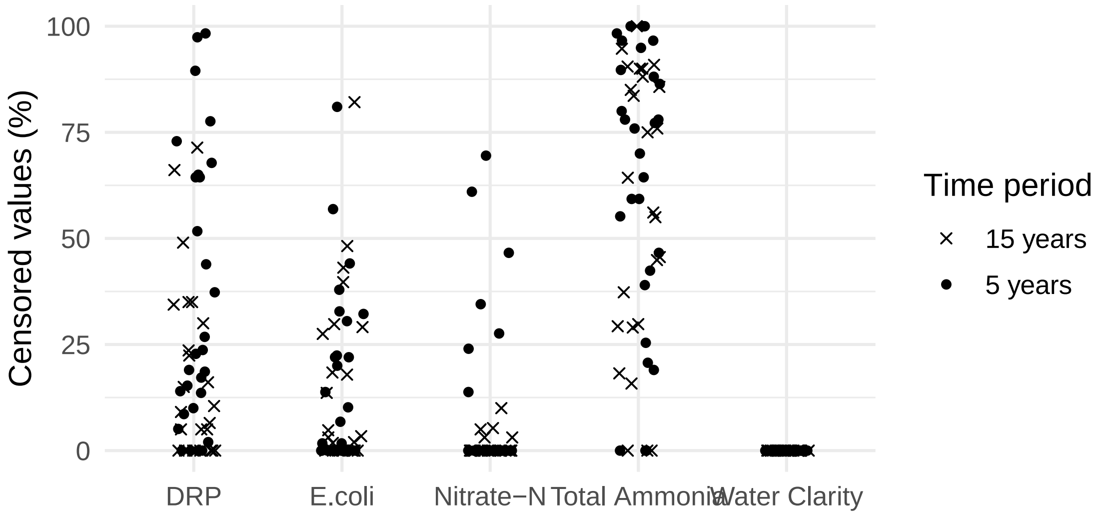

Figure 4: Percentage of censored values at each river monitoring site

4.2 Flow adjustment

The availability of flow data varied by site. In general, sites with a paired hydrometric station had a more complete flow record than sites requiring a flow gauging to be carried out on the same day as the river water sample collection. Overall, however, the vast majority of water quality values had a corresponding flow value. For the **p5m** and **p15q** datasets, 98.5% and 95.8% of water quality values had a corresponding flow value, respectively.

The models used for flow adjustment were Log-log, LOESS and GAM. Plots of the fitted lines from each model were inspected before choosing a model for each site, parameter and time period (plots shown in the Appendices for the five year time period).

For the *E. coli* and nitrate attributes, flow adjustment was unnecessary at the majority of sites (Table 4). For Total Ammonia, flow adjustment was unnecessary at all sites. This was because flow explained only a small proportion of the variation in the water quality data (R2 less than 0.2). Instead, for these attributes, the unadjusted values were used in the trend tests.

4.3 Total Ammonia

There were consistently low levels of ammonia across the majority of monitoring sites in Tasman (median Total Ammonia less than 0.01 g/m3). All sites were in the A or B attribute bands except Powell Ck which fell in attribute band C, below the National Bottom Line of the NPS-FM.

Over the five year time period, trends in total ammonia were degrading at most sites assessed. This pattern was reversed over the 15 year time period where most sites were improving (Table 5).

Of the trends that were **very likely degrading**, the trend rate was small (Sen slope less than 0.001 g/m3 per year) for all monitoring sites other than Powell Ck, Murchison Ck, and Tasman Valley Stream over the five year time period, with the steepest degrading trend observed at Powell Ck (Sen slope 0.003 g/m3 per

Table 4: Number of sites where flow adjustment was applied, for each water quality attribute and time period assessed

Attribute	Time period	Not applied	Log-log	LOESS	GAM
DRP	5 years	6	21	0	0
DRP	15 years	1	9	0	0
E.coli	5 years	24	5	0	0
E.coli	15 years	13	8	0	0
Nitrate-N	5 years	10	0	19	0
Nitrate-N	15 years	3	0	7	0
Total Ammonia	5 years	22	0	0	0
Total Ammonia	15 years	16	0	0	0
Water Clarity	5 years	4	23	0	2
Water Clarity	15 years	6	14	0	1

year, 95% CI 0.002 to 0.006). Of the trends that were **very likely improving**, the trend rate was small, or very close to 0, for all sites (Figure 5).

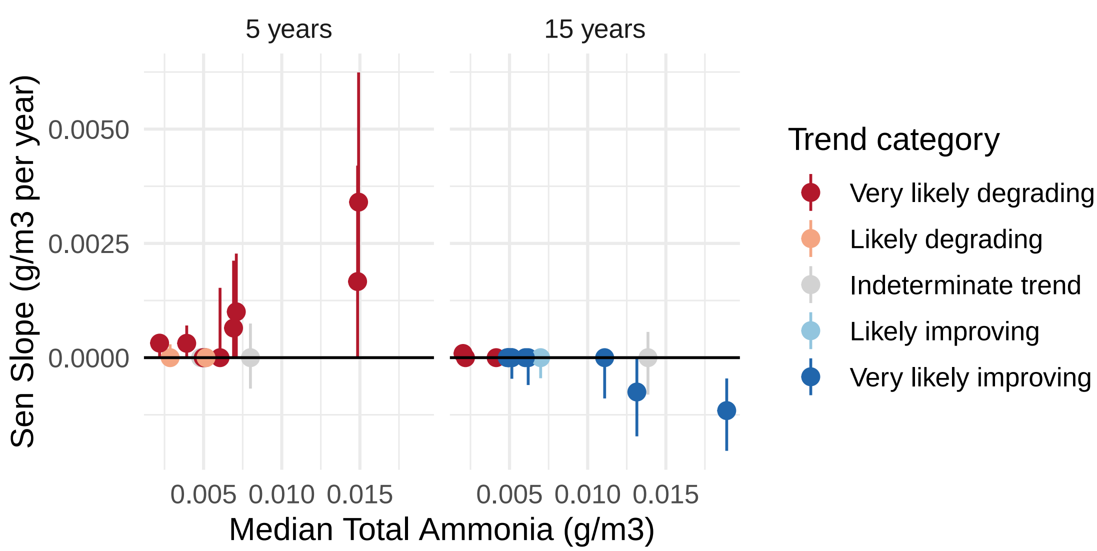

Figure 5: Median Total Ammonia concentration (g/m3) and trend rate (Sen slope with 90 percent confidence interval) at river monitoring sites in Tasman over five years and 15 years. Colours indicate trend category. The raw, unadjusted, values were used in the trend assessments because flow explained only a small proportion of the variation in Total Ammonia.

Table 5: Number of sites in each trend category for Total Ammonia

Trend category	5 years	15 years
Insufficient data	7	10
Very likely degrading	10	3
Likely degrading	3	0
Indeterminate trend	8	1
Likely improving	1	1
Very likely improving	0	11

4.4 Nitrate-N

Most sites were in the A attribute band for nitrate toxicity under the NPS-FM. Three sites fell below the National Bottom Line (Neimann Ck, Borck Ck and Murchison Ck), all in band C.

Nitrate-N was **very likely improving** at the Wangapeka Rv over 15 years (Sen slope -0.001 g/m3 per year, 95% CI -0.001 to 0) and at Neimann Ck over five years (Sen slope -0.579 g/m3 per year, 95% CI -0.75 to -0.365).

Over the five year time period, Nitrate-N was **very likely degrading** at 12 monitoring sites. Of these, eight were in the A attribute band and three were in the B attribute band (Wai-iti Rv, Reservoir Ck and Motupipi Rv). Sites with higher median Nitrate-N tended to have higher trend rates (Figure 7).

Over the 15 year time period, the trend in Nitrate-N was **very likely degrading** at three monitoring sites (Buller @ Longford, Motueka @ Gorge and Motueka @ Woodstock), all in the A attribute band.

The percentage of sites in each trend category was similar with or without flow adjustment (Figure 6), though the confidence in trend direction increased for some sites.

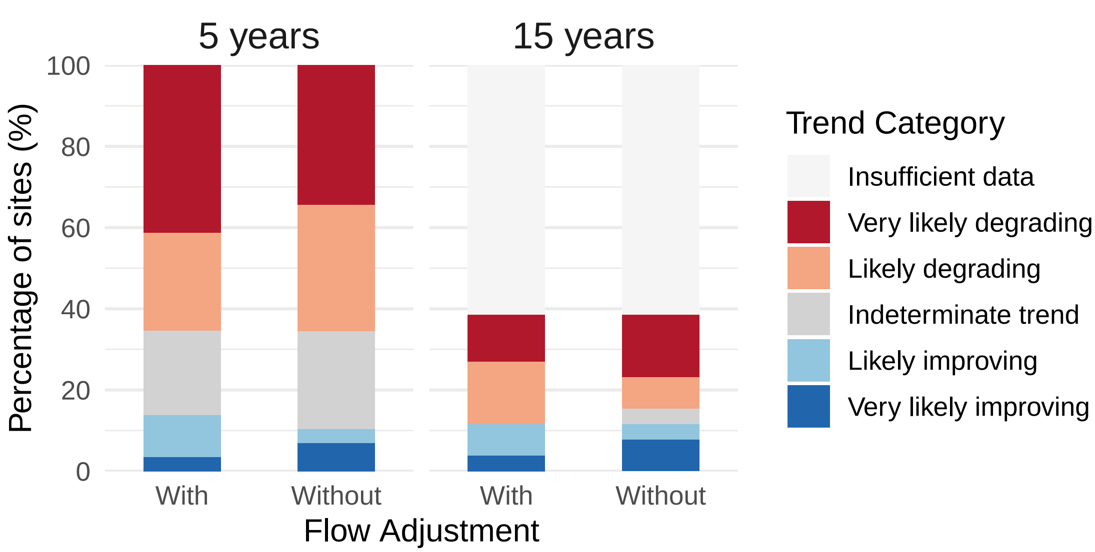

Figure 6: Percentage of sites in each trend category for Nitrate-N, with and without flow adjustment.

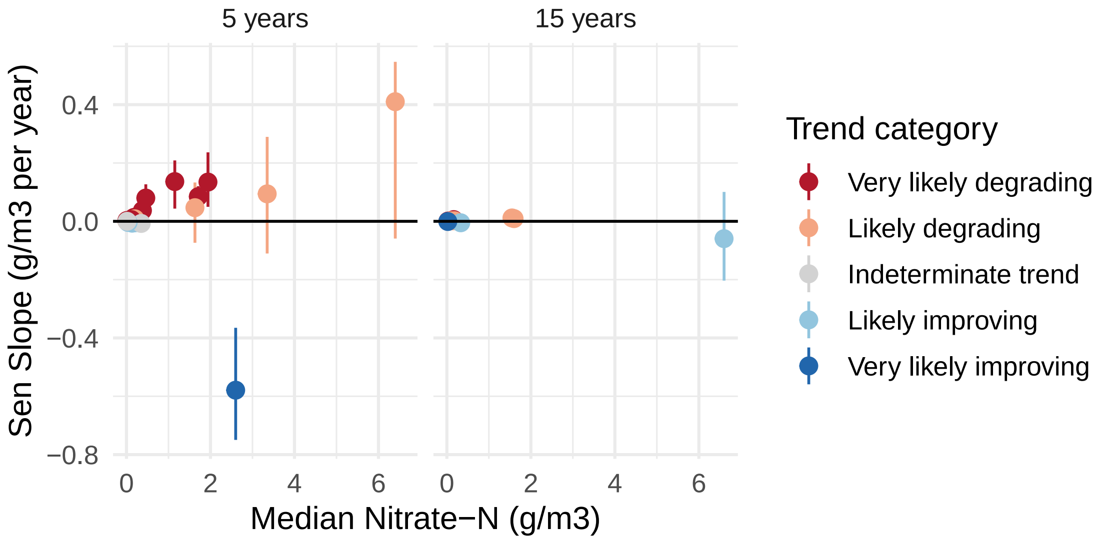

Figure 7: Median Nitrate-N concentration (g/m3) and trend rate (Sen slope with 90 percent confidence interval) at river monitoring sites in Tasman over five years and 15 years. Colours indicate trend category. The trend assessments included flow adjustment.

4.5 Dissolved Reactive Phosphorus (DRP)

Most monitoring sites had consistently low levels of DRP (five year median value less than 0.006 g/m3). DRP was substantially elevated at two monitoring sites, Tasman Stm and Powell Ck, both in attribute band D.

Over five years, there were more degrading trends in DRP than improving trends. Less than half the monitoring sites had sufficient data to assess trends over 15 years. Flow adjustment resulted in a higher percentage of degrading trends over five years but not 15 years (Figure 8).

Of the nine sites with **very likely degrading** trends in DRP over five years, four were in the A attribute band, three were in the B attribute band and two were in the C attribute band (Hunters Ck and Reservoir Ck). Reservoir Ck had the highest trend rate (Sen slope 0.003 g/m3 per year, 95% CI 0.002 to 0.004). There were no **very likely degrading** trends in DRP over 15 years and the trend rates were lower, relative to the five year period (Figure 9).

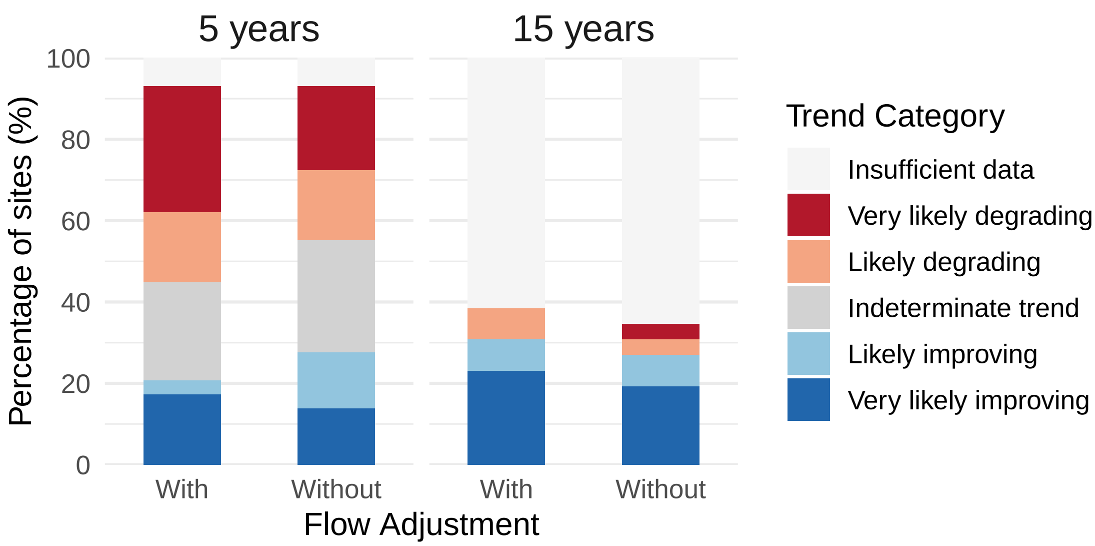

Figure 8: Percentage of sites in each trend category for DRP, with and without flow adjustment.

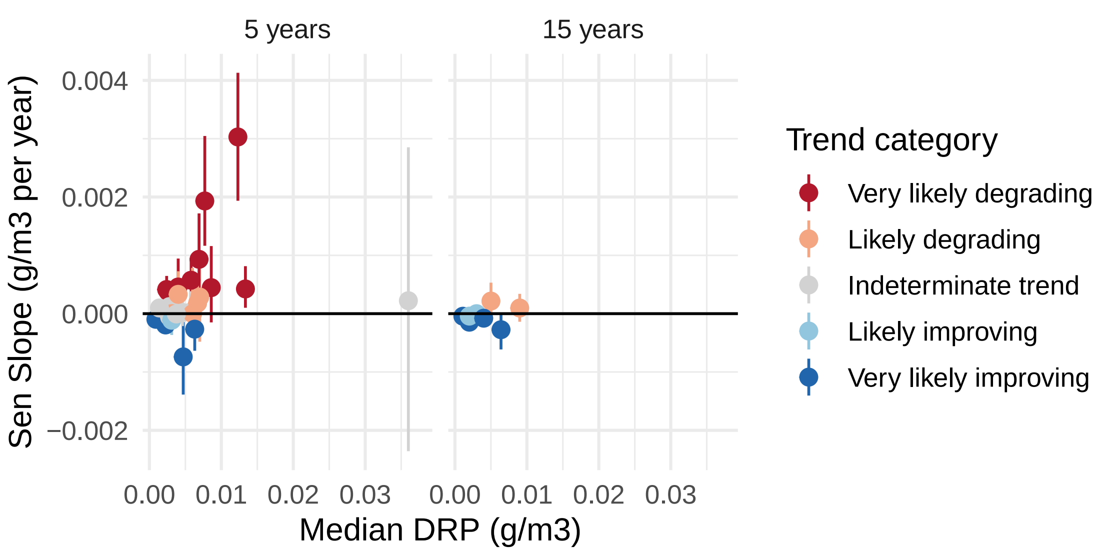

Figure 9: Median DRP concentration (g/m3) and trend rate (Sen slope with 90 percent confidence interval) at river monitoring sites in Tasman over five years and 15 years. Colours indicate trend category. The trend assessments included flow adjustment.

4.6 Escherichia coli (*E. coli*)

The *E. coli* attribute bands range from A (average infection risk 1%) to E (average infection risk greater than 7%). The monitoring sites were spread across the *E. coli* attribute bands, with 10 sites in the A band, seven in the B band, six in the D band and six in the E band (Neimann Ck, Borck Ck, Powell Ck, Tasman Stm, Powell Ck, Motupipi Rv).

Over five years, there were a mix of degrading and improving *E. coli* trends . Over 15 years, more sites had degrading trends than improving trends. The percentage of sites in each trend category was similar with or without flow adjustment (Figure 10).

Of the 11 *E. coli* trends that were **very likely degrading** over 15 years, four sites were in the A attribute band, three sites were in the B attribute band and four sites were in the E attribute band (Motupipi, Powell, Borck Ck and Reservoir Ck). Borck Ck had the highest trend rate over 15 years (Sen slope 36 cfu/100ml per year, 95% CI 10 to 57).

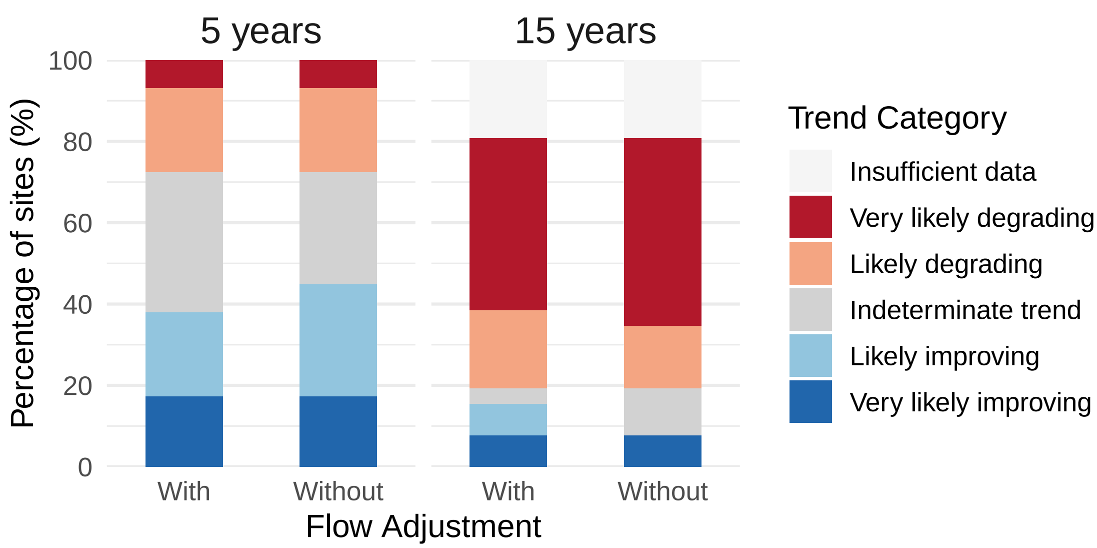

Figure 10: Percentage of sites in each trend category for *E. coli*, with and without flow adjustment.

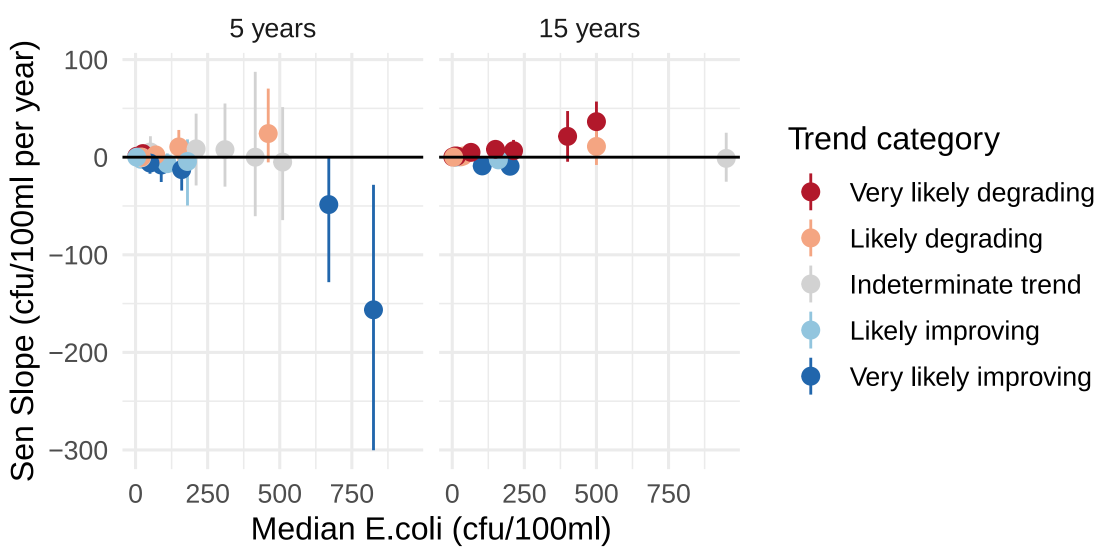

Figure 11: Median *E. coli* concentration (cfu/100mL) and trend rate (Sen slope with 90 percent confidence interval) at river monitoring sites in Tasman over five years and 15 years. Colours indicate trend category. The trend assessments included flow adjustment.

4.7 Water Clarity

Under the NPS-FM, all except two monitoring sites were in the A attribute band for water clarity. The exceptions were Murchison Ck in the C band and Matakitaki Rv in the D band (median water clarity 2.1 m).

There were a mix of improving and degrading trends in water clarity. Over the five year time period, water clarity was **very likely improving** at three sites (Kaituna @ Sollys Rd, Murchison Ck @ 20m u-s SH6, Powell @ 40m u-s Motupipi Rv) and **very likely degrading** at seven sites (all sites in the A attribute band except for Matakitaki @ SH6 Murchison in band D). Over the 15 year time period, a similar number of sites were improving as were degrading.

Looking at both five year and 15 year time periods, water clarity was **very likely degrading** at two sites (Matakitaki @ SH6 Murchison and Motueka @ Gorge) and **very likely improving** at two sites (Kaituna @ Sollys Rd and Powell @ 40m u-s Motupipi Rv).

The flow adjustment procedure influenced the trend results substantially for the five year time period. Without flow adjustment, more sites had improving trends and fewer sites had degrading trends. For the 15 year time period, however, the flow adjustment procedure had a minimal influence on the percentage of sites in each trend category (Figure 12).

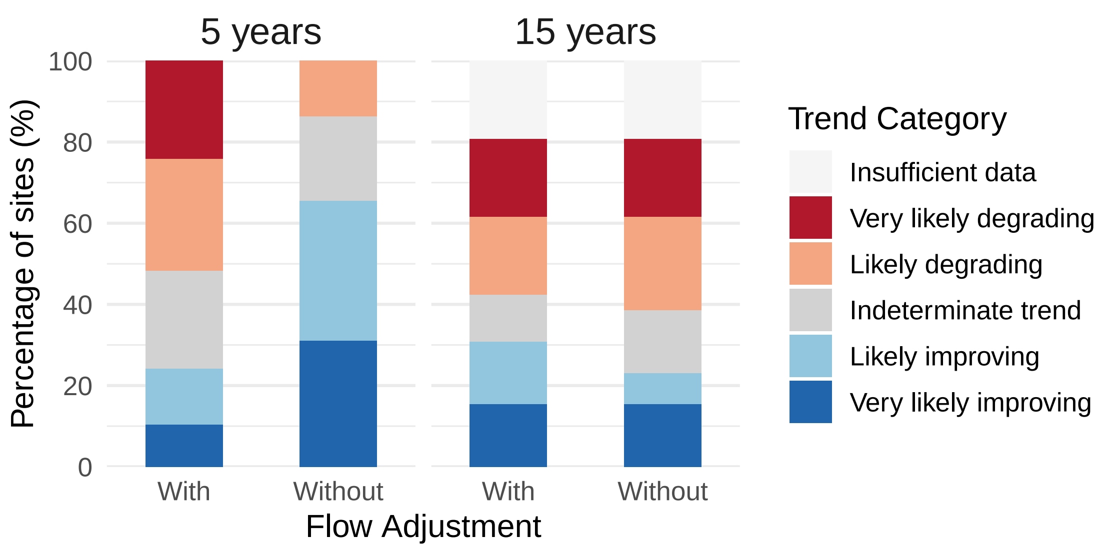

Figure 12: Percentage of sites in each trend category for Water Clarity, with and without flow adjustment.

Of the trends that were **very likely degrading**, the trend rate was highest for Wangapeka @ 5km u-s Dart over five years (Sen slope -0.835 m per year, 95% CI -1.33 to -0.477). The trend rate for Motueka @ Gorge was small (95% confidence interval for Sen slope included 0 for both time periods).

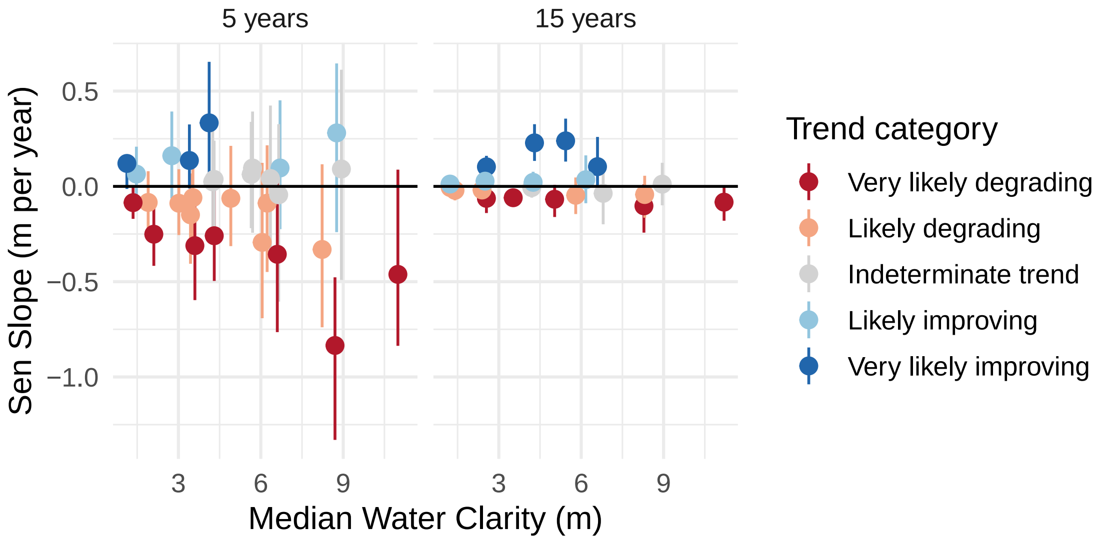

Figure 13: Median water clarity (m) and trend rate (Sen slope with 90 percent confidence interval) at river monitoring sites in Tasman over five years and 15 years. Colours indicate trend category. The trend assessments included flow adjustment.

5 Discussion

Sound resource management decision-making requires information on trend direction, trend rate, and the current state of water quality. The trend categories used in this report (such as **likely improving** or **very likely improving**) indicate the level of confidence in the trend direction. It is important to interpret these trend categories with trend rate. There can be a high confidence in the trend direction but a very small trend rate (Sen slope and annual change close to 0). Examining the Nitrate-N trend results over five years, for example, 12 sites were **very likely degrading** but only five sites had high confidence that the magnitude of the trend was greater than zero (Reservoir Ck, Wai-iti Rv, Sherry Rv, Riuwaka Rv and Motupipi Rv).

In a previous report (James and McCallum 2015), we categorised trends as ‘meaningful’ if the change in the median value of the water quality parameter was greater than 1% per year. This approach has the disadvantage that, for an identical trend rate, sites with very low median values have a much higher annual percentage change. In other words, sites with very good water quality are more likely to have ‘meaningful’ trends than sites with poor water quality. In this report, trend rate is instead plotted against the median value of the water quality parameter. By combining estimates of trend rate (using Sen slope) and water quality state (using the median value), the management importance of different sites can more easily be compared.

Detecting a large number of trends was expected for two reasons: (1) there is always an underlying trend in water quality, as no trend rate is ever precisely zero (Snelder, Fraser, et al. 2021) and (2) the changes to the design of the monitoring programme in 2016 were intended to increase the ability to detect trends at river sites. However, the detected trends may not be persistent. That is, a trend detected over one time window (2016 to 2021, as used in this report) may not be detected in the next time window (2017 to 2022, for example).

For the Total Ammonia, DRP and *E. coli* attributes, there were considerable differences in the percentage of monitoring sites with degrading trends between the five and 15 year time periods. Focusing on DRP, while half the trends were degrading over the five year time period, less than 25% of trends were degrading over the 15 year time period. These differences are likely due to a combination of factors, including the fact that fewer monitoring sites had sufficient data to assess trends over the 15 year time period.

A large proportion of the trend results for Total Ammonia had a sen slope of 0, meaning it was not possible to resolve the trend rate. The smallest trend rate that can be resolved (non-zero Sen slope) is approximately the detection limit of the water quality parameter divided by time period of the trend assessment. For Total Ammonia over five years, for example, that equates to 0.001 g/m3 per year. From a management perspective, trends categorised as **very likely degrading** but with a small trend rate are less important than those with a higher trend rate. There are however, no widely accepted thresholds for deciding whether a trend is important based on trend rate.

Comparing the trend results with and without flow adjustment, two general patterns emerged. First, flow adjustment changed the trend direction from improving to degrading at more sites over the five year time period than the 15 year time period. In total 9 trend results showed this pattern over five years (7 for Water Clarity, 1 for DRP, 1 for Nitrate-N). Only one trend result switched from improving to degrading over 15 years after flow adjustment was applied (Motupiko Rv water clarity). Second, the trend rate over the 15 year time period tended to decrease (become more negative) after flow adjustment. This effect was more pronounced for *E. coli* and Nitrate-N than other water quality attributes.

Climate patterns may explain part of the variation in water quality over time, and therefore influence trend results. This has been shown for New Zealand rivers using the Southern Oscillation Index (SOI), a way of quantifying the El Nino-Southern Oscillation climate pattern (Snelder, Larned, et al. 2021). The influence of the SOI on water quality trends was found to decline for trends assessed over longer time periods. This implies that trends over five years are more prone to influence by climate patterns than trends over 15 years.

Trends in the SOI may amplify or counteract trends in water quality parameters. The influence of the SOI at a particular monitoring site depends on (1) the correlation between the water quality parameter and the SOI and (2) the magnitude of the trend in the SOI over the time period of the trend assessments. Quantifying the influence of the SOI should be part of the process to develop action plans in response to degrading trends.

5.1 Comparison with NIWA trend results

NIWA carried out trend analyses using 10, 20 and 30 year time periods, ending in December 2020 (Whitehead et al. 2022). The trend results for the three NRWQN sites were compared with the trend results from the present study.

Over the 30 year time period (1990 to 2020), nitrogen concentrations were **very likely degrading** at the three NRWQN sites. The trend rate was greatest for Motueka @ Woodstock (Sen slope 0.004 g/m3 per year, 95% CI 0.003 to 0.005). At this site, the rate of degradation was higher for the shorter time periods.

Though there were **very likely degrading** trends in Total Ammonia at the three NRWQN sites, the trend rate was small (Sen slope less than 0.0005 g/m3 per year) for all time periods.

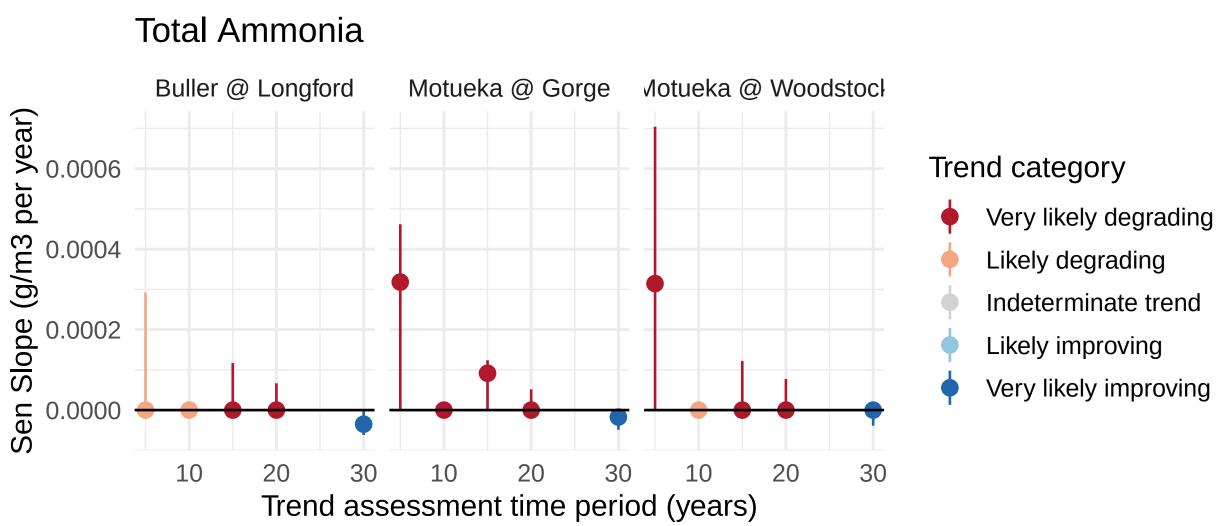

Figure 14: Total ammonia trend results at NRWQN sites for each trend assessment time period. Trend results for 10, 20 and 30 year time periods from Whitehead et al 2022 without flow adjustment. Error bars are 90 percent confidence intervals around Sen slope.

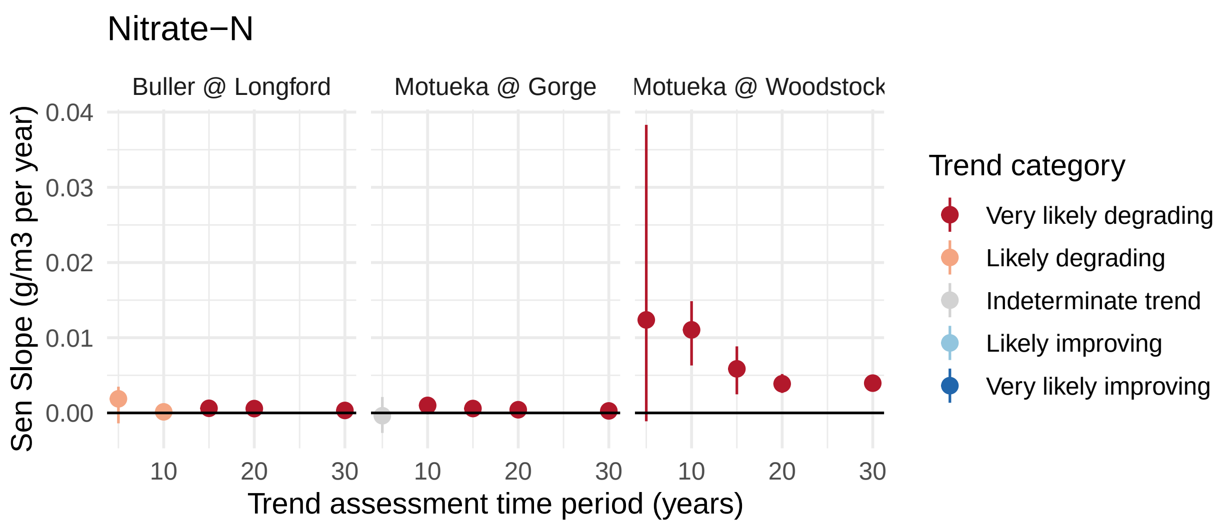

Figure 15: Total oxidised nitrogen trend results at NRWQN sites for each trend assessment time period. Trend results for 10, 20 and 30 year time periods from Whitehead et al 2022 without flow adjustment. Error bars are 90 percent confidence intervals around Sen slope.

Dissolved Reactive Phosphorus was **very likely improving** over time periods of 15 years or less. The trend direction was less certain over the 20 and 30 year time periods.

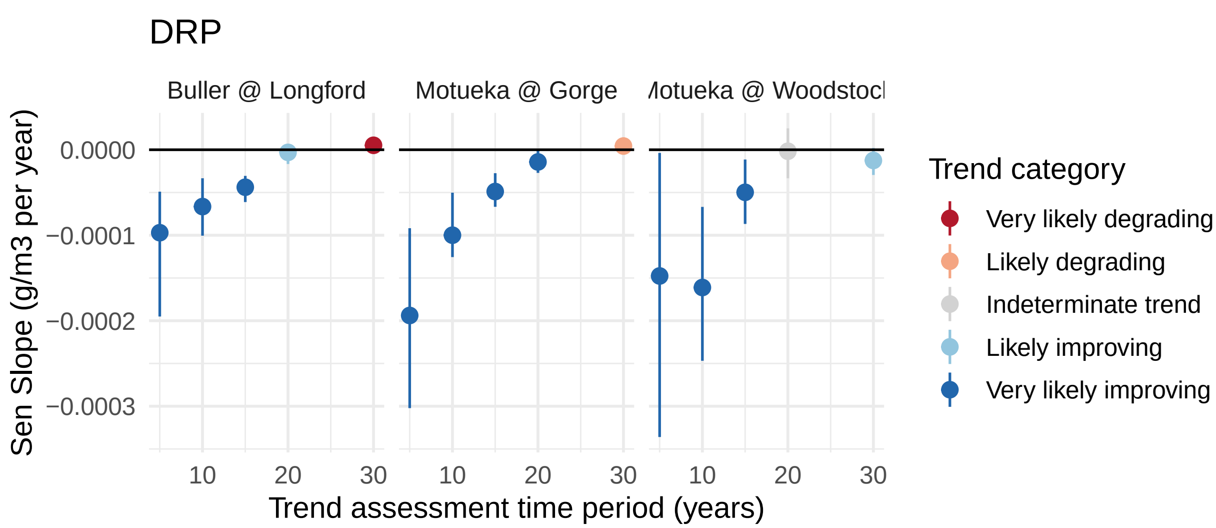

Figure 16: DRP trend results at NRWQN sites for each trend assessment time period. Trend results for 10, 20 and 30 year time periods from Whitehead et al 2022 without flow adjustment. Error bars are 90 percent confidence intervals around Sen slope.

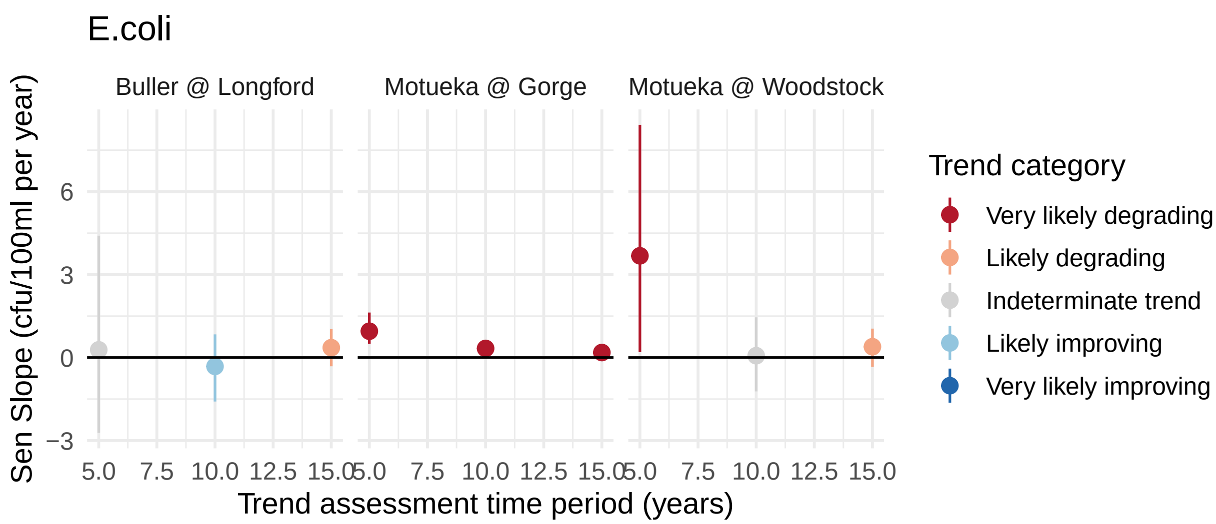

Figure 17: E. coli trend results at NRWQN sites for each trend assessment time period. Trend results for 10 year time period from Whitehead et al 2022 without flow adjustment (20 and 30 year trends were not available for this attribute). Error bars are 90 percent confidence intervals around Sen slope.

For the water clarity trends at NRWQN sites, there was no consistent pattern in water quality trend direction across the trend assessment time periods.

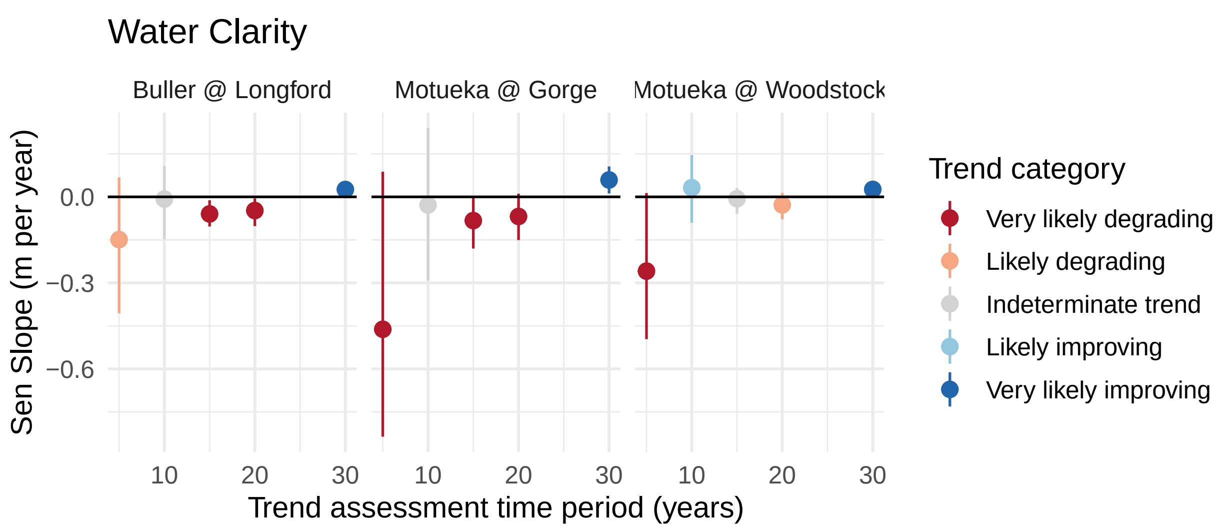

Figure 18: Water clarity trend results at NRWQN sites for each trend assessment time period. Trend results for 10, 20 and 30 year time periods from Whitehead et al 2022 without flow adjustment. Error bars are 90 percent confidence intervals around Sen slope.

Across all parameters, the width of the confidence intervals around Sen slope tended to narrow with increasing time period. This pattern is due to the larger number of data points included in the trend assessments over the longer time periods.

5.2 Prioritising trend results for further investigation

Under section 3.19 of the NPS-FM, Tasman District Council 'must (a) investigate the cause of the trend and (b) consider the likelihood of the deteriorating trend, the magnitude of the trend, and the risk of adverse effects on the environment' (Ministry for the Environment 2020). To fulfill this responsibility, an approach is needed to prioritise trend results for further investigation. One such approach is outlined here.

1. Prioritise **very likely degrading** trends. Trends classified as **very likely degrading** have greater than 90% confidence in trend direction, compared to **likely degrading** trends which have greater than 67% confidence in trend direction. For sites with both flow-adjusted and non flow-adjusted trend results, use the trend category of the flow-adjusted trend result. Prioritising trend results that were **likely degrading** or **very likely degrading** over both five and 15 year time periods was considered. However, such a rule would exclude monitoring sites with insufficient data to calculate 15 year trends.

2. Set a minimum trend rate - the rate of change in the water quality attribute per year. This is because **very likely degrading** trends can have a trend rate close to zero. In fact, where the proportion of censored values is very high, the trend rate is calculated as zero (Snelder and Fraser 2021). By setting a minimum trend rate, these less informative trend results can be filtered out.

To choose a minimum trend rate, knowledge of the data collection methods is required. For the water quality attributes measured in a laboratory, the precision of the results (number of decimal places reported) and lower detection limits provide a guide.

The measurement precision, lower detection limits and proposed minimum trend rates are shown in the table below.

Attribute	Precision	Detection limit (2022)	Minimum trend rate
Total Ammonia	0.001 g/m3	0.005 g/m3	0.001 g/m3 per year
Nitrate-N	0.001 g/m3	0.001 g/m3	0.001 g/m3 per year
DRP	0.0001 g/m3	0.001 g/m3	0.001 g/m3 per year
E. coli	1 cfu/100ml	1 cfu/100ml	1 cfu/100ml per year
Water Clarity	0.01 m	0 m	-0.1 m per year

3. Focus on the B band or lower. In general, the risk of adverse effects on the environment is lowest for waterways in the A band of the NPS-FM. Waterways with attribute bands of 'B' or lower should have higher priority when investigating water quality trends. Waterways with one or more attributes below the National Bottom Line of the NPS-FM have the highest priority for further investigation.

This three-part process is a first attempt at prioritising the large number of trend results that could be investigated. Alternative methods of prioritisation should be considered before allocating resources for investigation work.

Table 7: High priority trend results for further investigation. These trend results were Very Likely Degrading, with a trend rate greater than chosen thresholds and the associated attribute band was B or lower.

FMU	Site	Degrading trend	Band
Buller	Matakitaki @ SH6 Murchison	Water Clarity (5 yrs)	D
Buller	Murchison Ck @ 20m u-s SH6	Total Ammonia (5 yrs)	B
Motueka	Motueka @ Woodstock	E.coli (5 yrs)	B
Motueka	Riuwaka @ Hickmotts	E.coli (15 yrs)	B
Takaka	Motupipi @ 1.2km u-s Abel Tasman Dr	E.coli (15 yrs)	E
Takaka	Motupipi @ 1.2km u-s Abel Tasman Dr	Nitrate-N (5 yrs)	B
Takaka	Powell @ 40m u-s Motupipi Rv	DRP (5 yrs)	D
Takaka	Powell @ 40m u-s Motupipi Rv	E.coli (15 yrs)	E
Takaka	Powell @ 40m u-s Motupipi Rv	Total Ammonia (5 yrs)	C
Waimea	Borck @ 400m ds Queen St	E.coli (15 yrs)	E
Waimea	Reservoir Ck @ 20m d-s Salisbury Rd	DRP (5 yrs)	C
Waimea	Reservoir Ck @ 20m d-s Salisbury Rd	E.coli (15 yrs)	D
Waimea	Reservoir Ck @ 20m d-s Salisbury Rd	Nitrate-N (5 yrs)	B
Waimea	Wai-iti @ 400m d-s Waimea W Rd	Nitrate-N (5 yrs)	B

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7 Appendix

7.1 Ammonia

7.1.1 Takaka & Aorere

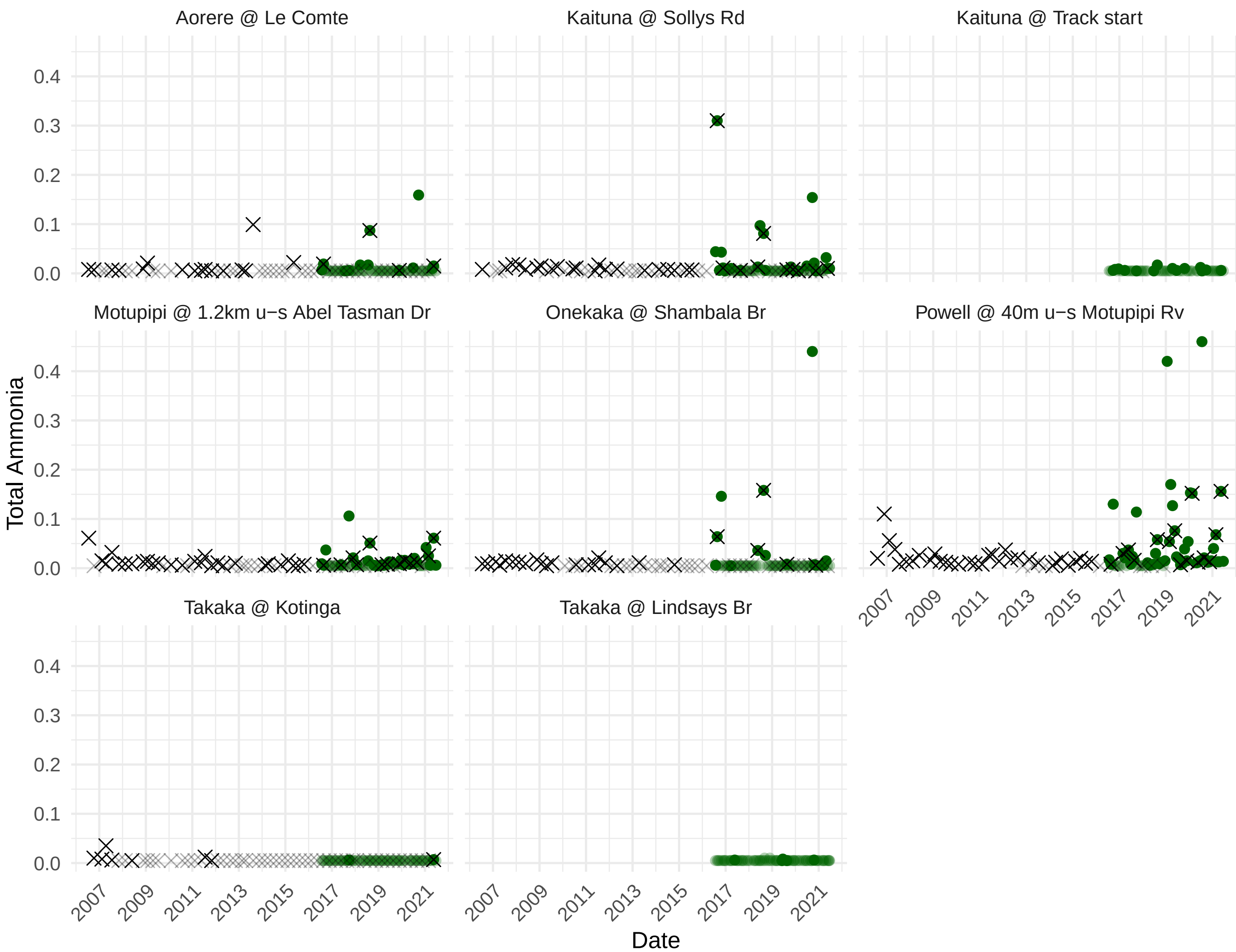


Figure 19: Total Ammonia data (g/m3) sampled monthly over 5 years (dots) and quarterly over 15 years (crosses). Values below detection are lighter in colour. To limit the size of the y-axis, one high value from Powell Ck is not shown (Total Ammonia 2.4 g/m3 on 22/09/2020).

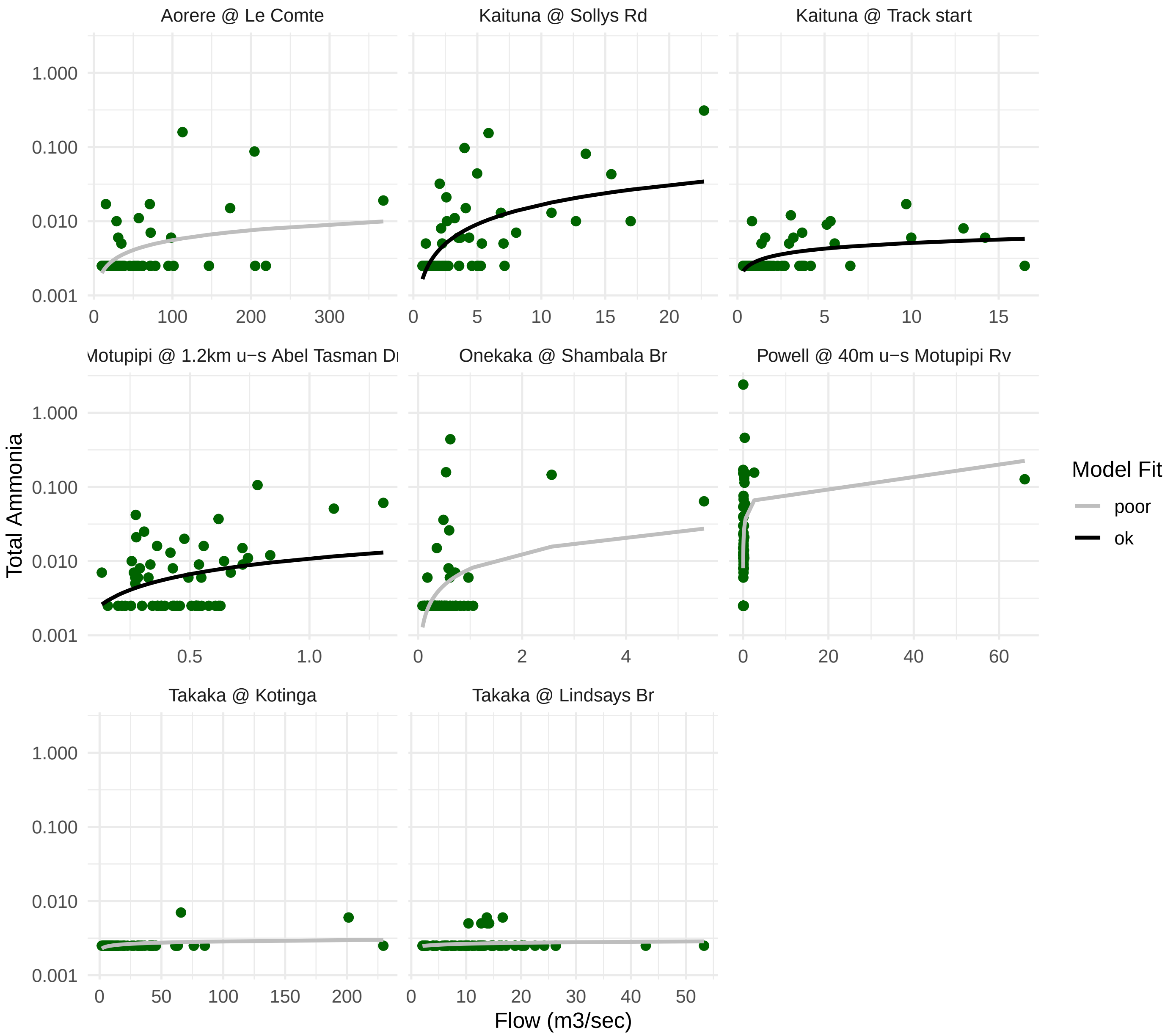


Figure 20: Total Ammonia data (g/m3, log10-transformed) and river flow (m3/sec) over 5 years with LogLog fitted line. Model fit = *poor* when less than 20 percent of the variation in Total Ammonia was explained by flow.

Table 8: Total Ammonia trend results for Takaka and Aorere sites

Site	Band	Years	Flow adj	Trend category	Median	N	Sen slope	90% CI
Aorere @ Le Comte	B	15	none	Very likely improving	0.005	56	0	0 to 0
		5	none	Indeterminate trend	0.005	59	0	0 to 0
Kaituna @ Sollys Rd	B	15	none	Very likely improving	0.005	57	0	0 to 0
		5	none	Indeterminate trend	0.005	59	0	0 to 0
Kaituna @ Track start	A	15	none	Insufficient data				
		5	none	Indeterminate trend	0.005	57	0	0 to 0
Motupipi @ 1.2km u-s Abel Tasman Dr	B	15	none	Likely improving	0.007	57	0	0 to 0
		5	none	Very likely degrading	0.006	58	0	0 to 0.002
Onekaka @ Shambala Br	B	15	none	Very likely improving	0.005	57	0	0 to 0
		5	none	Indeterminate trend	0.005	57	0	0 to 0
Powell @ 40m u-s Motupipi Rv	C	15	none	Indeterminate trend	0.014	57	0	-0.001 to 0.001
		5	none	Very likely degrading	0.015	58	0.003	0.002 to 0.006
Takaka @ Kotinga	A	15	none	Very likely improving	0.005	56	0	0 to 0
		5	none	Insufficient data				
Takaka @ Lindsays Br	A	5	none	Insufficient data				

Band = attribute band (NPSFM 2020), Flow adj = type of model used for flow adjustment, Median in g/m3, Sen slope and 90% confidence interval in g/m3 per year

7.1.2 Motueka & Buller

Figure 21: Total Ammonia data (g/m3) sampled monthly over 5 years (dots) and quarterly over 15 years (crosses). Values below detection are lighter in colour.

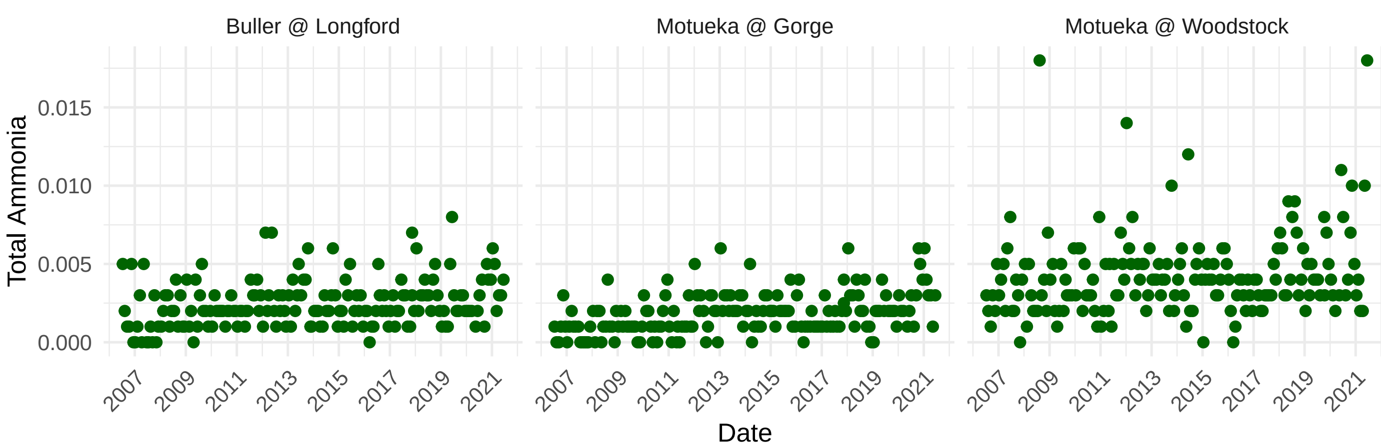


Figure 22: Total Ammonia data (g/m3) at sites monitored by NIWA, showing monthly data over 15 years (July 2006 to June 2021).

Figure 23: Total Ammonia data (g/m3, log10-transformed) and river flow (m3/sec) over 5 years with LogLog fitted line. Model fit = *poor* when less than 20 percent of the variation in Total Ammonia was explained by flow.

Table 9: Total Ammonia trend results for Motueka and Buller sites

Site	Band	Years	Flow adj	Trend category	Median	N	Sen slope	90% CI
Buller @ Longford	A	15	none	Very likely degrading	0.002	179	0	0 to 0
		5	none	Likely degrading	0.003	59	0	0 to 0
Hunters @ Kikiwa	A	15	none	Insufficient data				
		5	none	Indeterminate trend	0.005	58	0	0 to 0
Mangles @ 5km u-s Buller	A	5	none	Very likely degrading	0.005	59	0	0 to 0
Matakitaki @ SH6 Murchison	A	15	none	Insufficient data				
		5	none	Insufficient data				
Motueka @ Gorge	A	15	none	Very likely degrading	0.002	179	0	0 to 0
		5	none	Very likely degrading	0.002	59	0	0 to 0
Motueka @ SH60 bridge	A	15	none	Insufficient data				
		5	none	Likely degrading	0.005	59	0	0 to 0
Motueka @ Woodstock	A	15	none	Very likely degrading	0.004	178	0	0 to 0
		5	none	Very likely degrading	0.004	58	0	0 to 0.001
Motupiko @ 250m u-s Motueka Rv	A	15	none	Insufficient data				
		5	none	Indeterminate trend	0.005	59	0	0 to 0
Murchison Ck @ 20m u-s SH6	B	15	none	Very likely improving	0.019	55	-0.001	-0.002 to 0
		5	none	Very likely degrading	0.015	59	0.002	0 to 0.004
Riuwaka @ Hickmotts	A	15	none	Very likely improving	0.005	55	0	0 to 0
		5	none	Likely improving	0.005	59	0	0 to 0
Sherry @ Blue Rock	A	15	none	Very likely improving	0.006	58	0	0 to 0
		5	none	Very likely degrading	0.005	59	0	0 to 0
Wangapeka @ 5km u-s Dart	A	15	none	Insufficient data				
		5	none	Insufficient data				

Band = attribute band (NPSFM 2020), Flow adj = type of model used for flow adjustment, Median in g/m3, Sen slope and 90% confidence interval in g/m3 per year

7.1.3 Waimea & Moutere

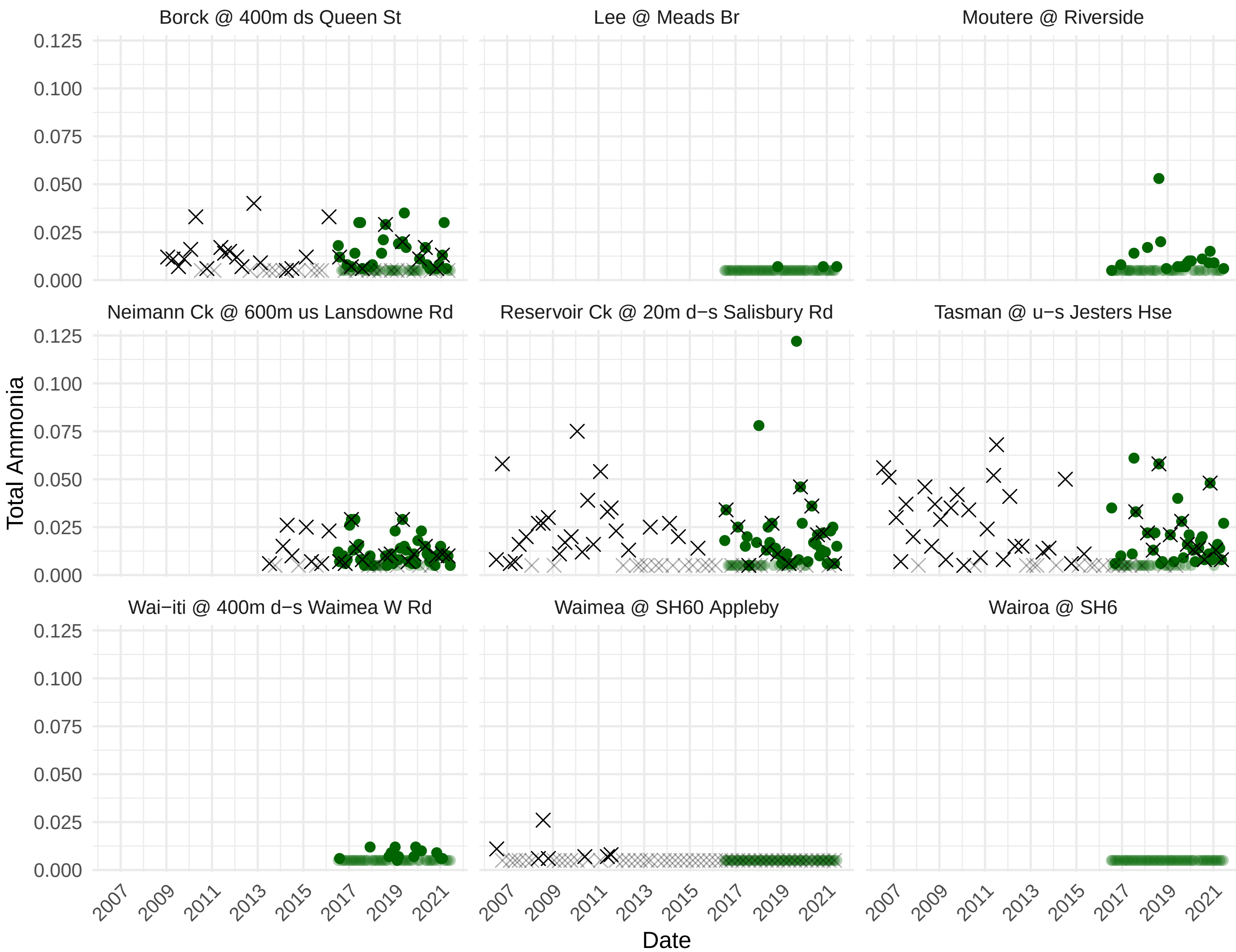


Figure 24: Total Ammonia data (g/m3) sampled monthly over 5 years (dots) and quarterly over 15 years (crosses). Values below detection are lighter in colour.

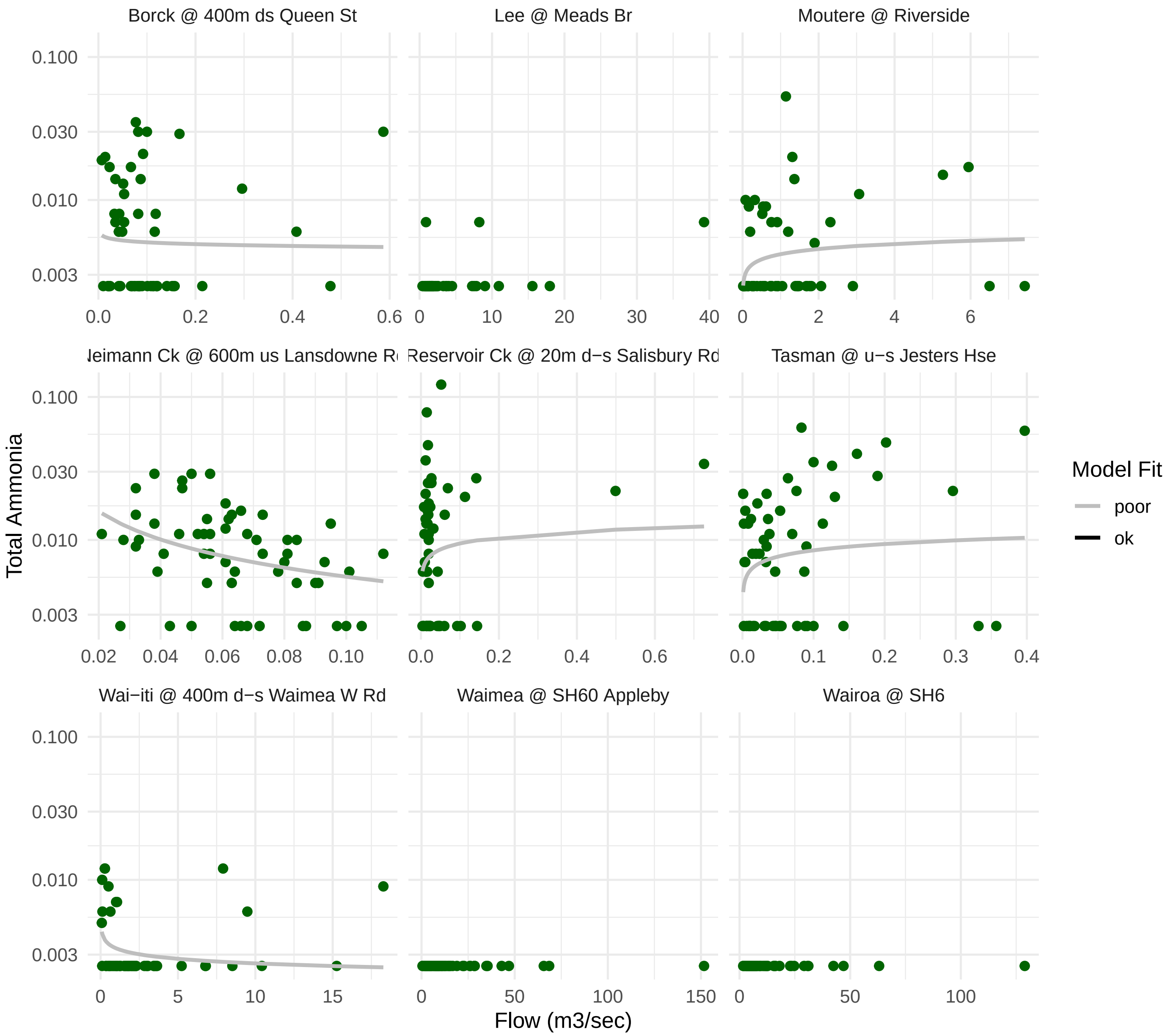


Figure 25: Total Ammonia data (g/m3, log10-transformed) and river flow (m3/sec) over 5 years with LogLog fitted line. Model fit = *poor* when less than 20 percent of the variation in Total Ammonia was explained by flow.

Table 10: Total Ammonia trend results for Waimea and Moutere sites

Site	Band	Years	Flow adj	Trend category	Median	N	Sen slope	90% CI
Borck @ 400m ds Queen St	A	15	none	Very likely improving	0.006	49	0	-0.001 to 0
		5	none	Indeterminate trend	0.005	58	0	0 to 0
Lee @ Meads Br	A	15	none	Insufficient data				
		5	none	Insufficient data				
Moutere @ Riverside	A	15	none	Insufficient data				
		5	none	Very likely degrading	0.005	59	0	0 to 0
Neimann Ck @ 600m us Lansdowne Rd	A	15	none	Insufficient data				
		5	none	Indeterminate trend	0.008	58	0	-0.001 to 0.001
Reservoir Ck @ 20m d-s Salisbury Rd	B	15	none	Very likely improving	0.011	59	0	-0.001 to 0
		5	none	Very likely degrading	0.007	59	0.001	0 to 0.002
Tasman @ u-s Jesters Hse	A	15	none	Very likely improving	0.013	58	-0.001	-0.002 to 0
		5	none	Very likely degrading	0.007	59	0.001	0 to 0.002
Wai-iti @ 400m d-s Waimea W Rd	A	5	none	Likely degrading	0.005	59	0	0 to 0
Waimea @ SH60 Appleby	A	15	none	Very likely improving	0.005	59	0	0 to 0
		5	none	Insufficient data				
Wairoa @ SH6	A	15	none	Insufficient data				
		5	none	Insufficient data				

Band = attribute band (NPSFM 2020), Flow adj = type of model used for flow adjustment, Median in g/m3, Sen slope and 90% confidence interval in g/m3 per year

7.2 Nitrate

7.2.1 Takaka & Aorere

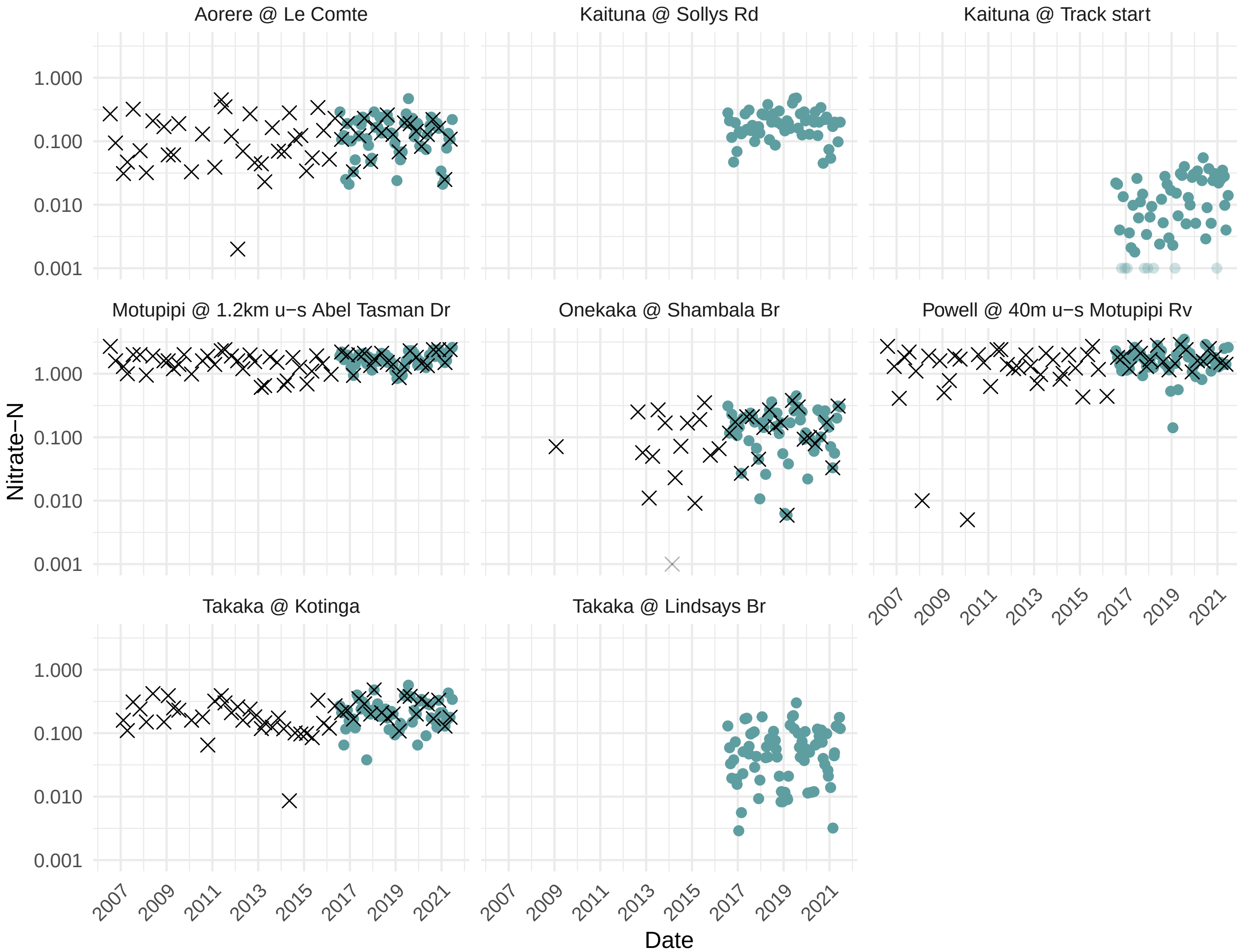


Figure 26: Nitrate-N data (g/m3, log10-transformed) sampled monthly over 5 years (dots) and quarterly over 15 years (crosses). Values below detection are lighter in colour.

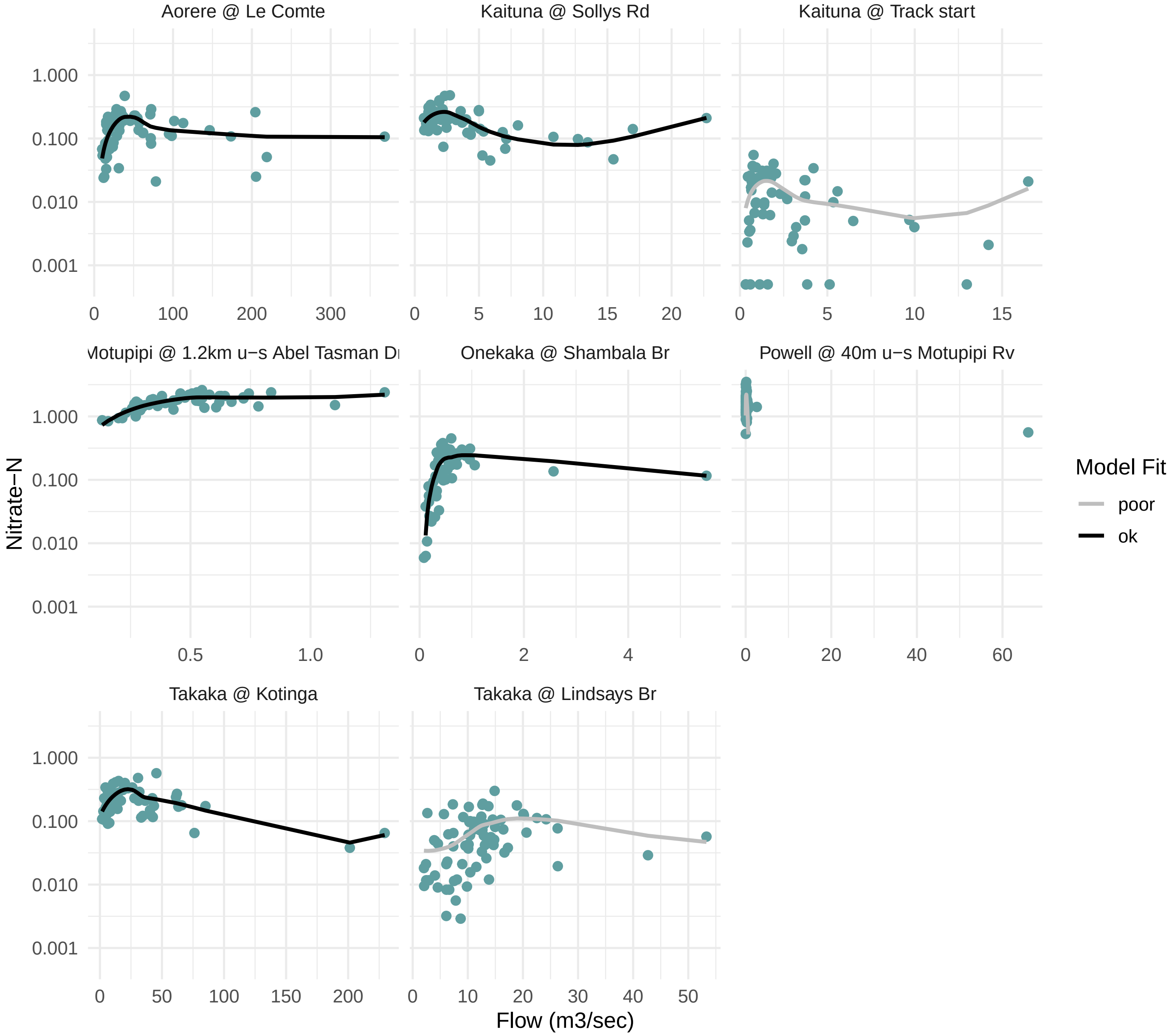


Figure 27: Nitrate-N data (g/m3, log10-transformed) and river flow (m3/sec) over 5 years with LOESS fitted line. Model fit = *poor* when less than 20 percent of the variation in Nitrate-N was explained by flow.

7.2.2 Motueka & Buller

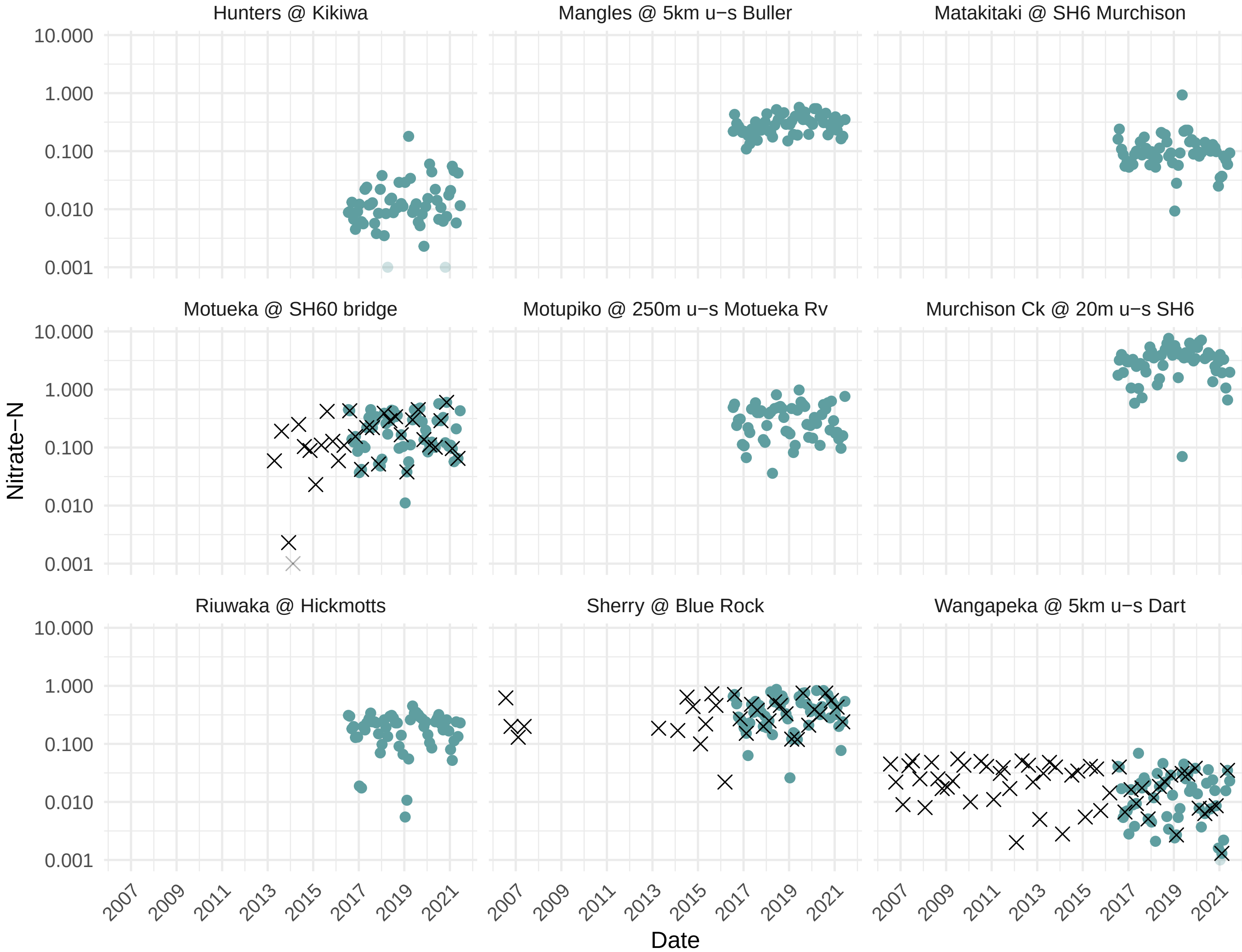


Figure 28: Nitrate-N data (g/m3, log10-transformed) sampled monthly over 5 years (dots) and quarterly over 15 years (crosses). Values below detection are lighter in colour.

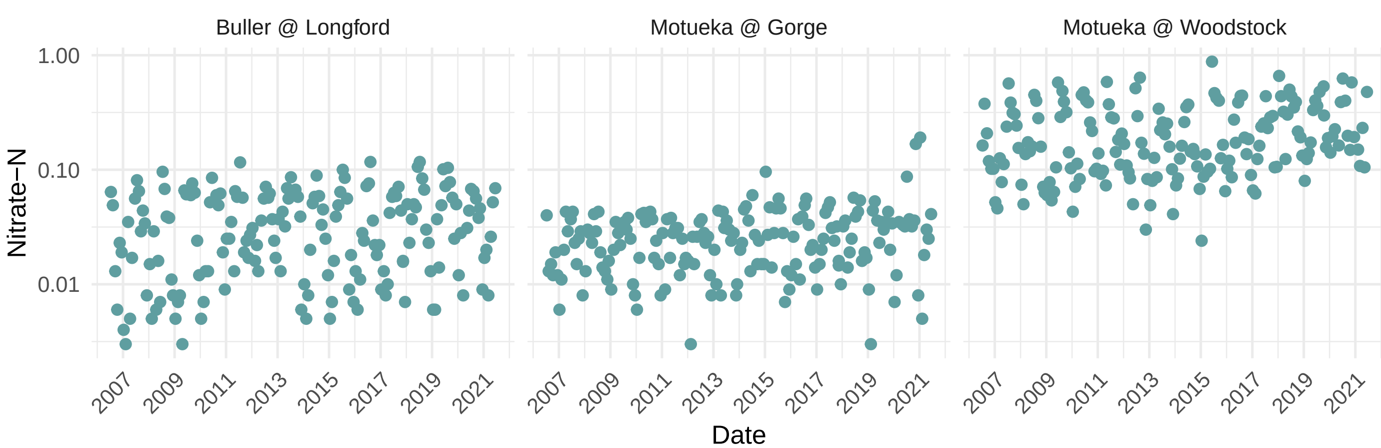


Figure 29: Nitrate-N data (g/m3, log10-transformed) at sites monitored by NIWA, showing monthly data over 15 years.

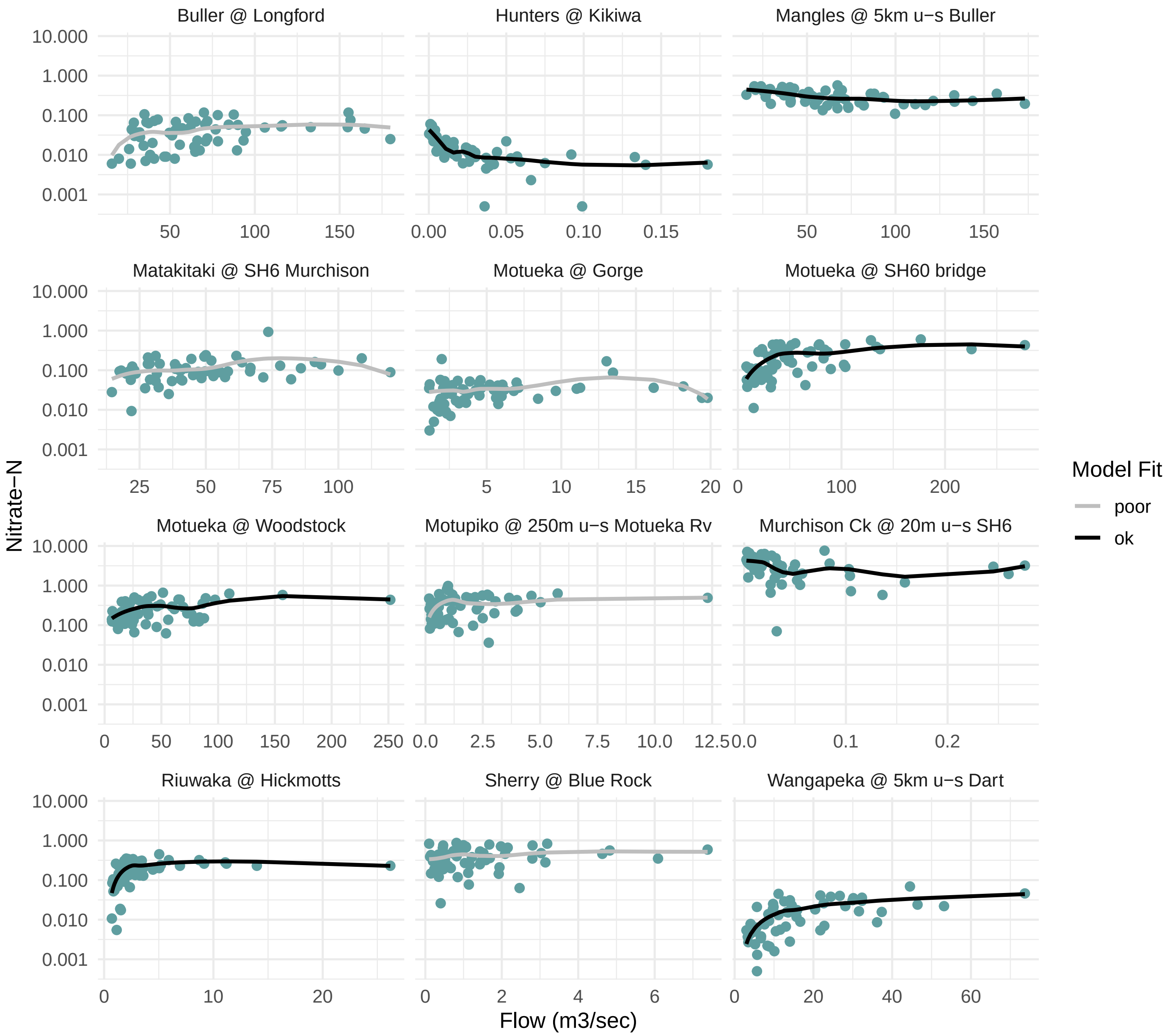


Figure 30: Nitrate-N data (g/m3, log10-transformed) and river flow (m3/sec) over 5 years with LOESS fitted line. Model fit = *poor* when less than 20 percent of the variation in Nitrate-N was explained by flow.

7.2.3 Waimea & Moutere

Figure 31: Nitrate-N data (g/m3, log10-transformed) sampled monthly over 5 years (dots) and quarterly over 15 years (crosses). Values below detection are lighter in colour.

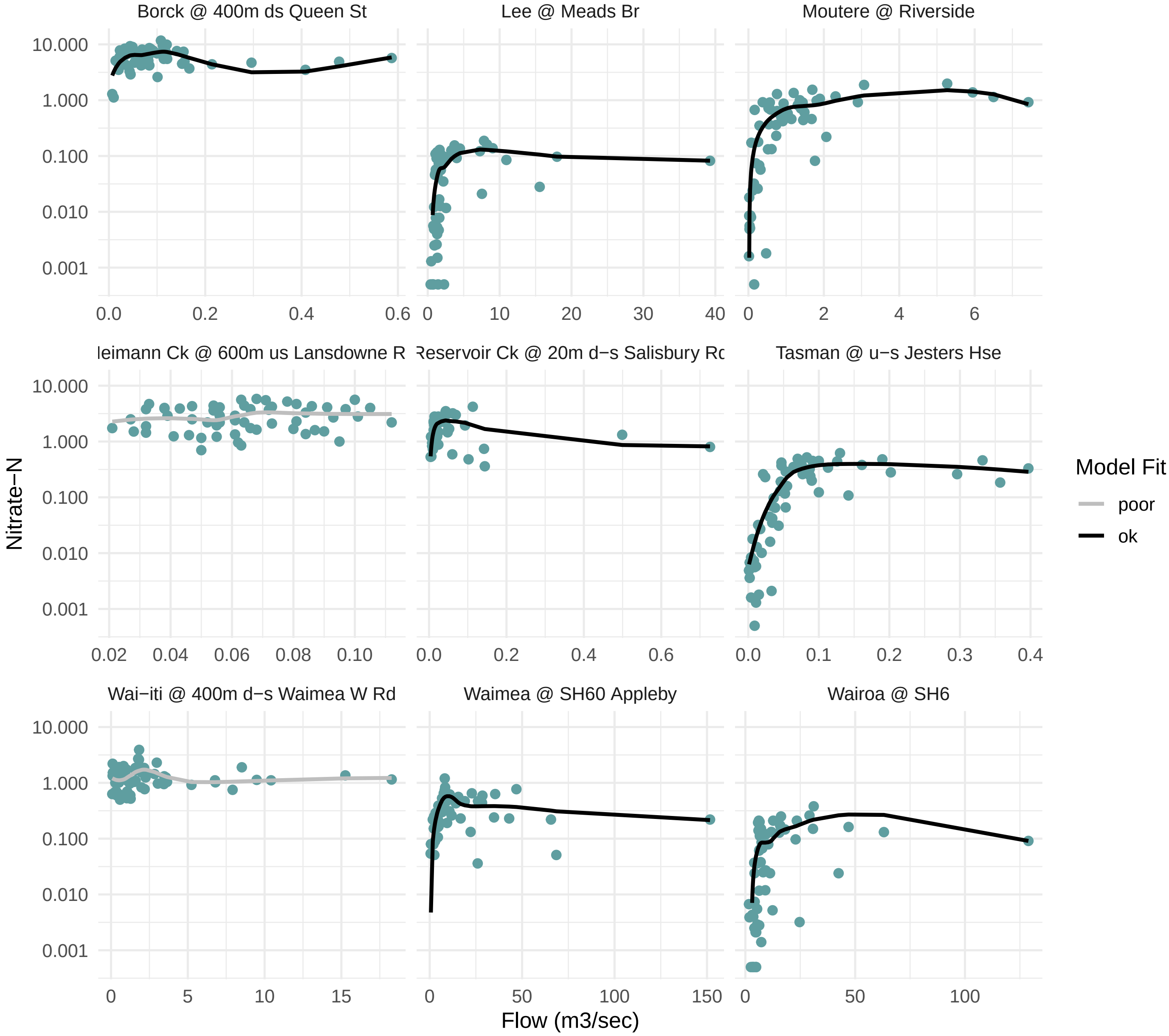


Figure 32: Nitrate-N data (g/m3, log10-transformed) and river flow (m3/sec) over 5 years with LOESS fitted line. Model fit = *poor* when less than 20 percent of the variation in Nitrate-N was explained by flow.

flow adjustment using LOESS with span 0.75. This model allows for a rise in nitrate concentration with flow followed by a flattening, and at some sites a reduction, of nitrate concentration as flows increase further. Onekaka @ Shambala Br is one of the clearest examples of this pattern.

7.3 Dissolved Reactive Phosphorus (DRP)

7.3.1 Takaka & Aorere

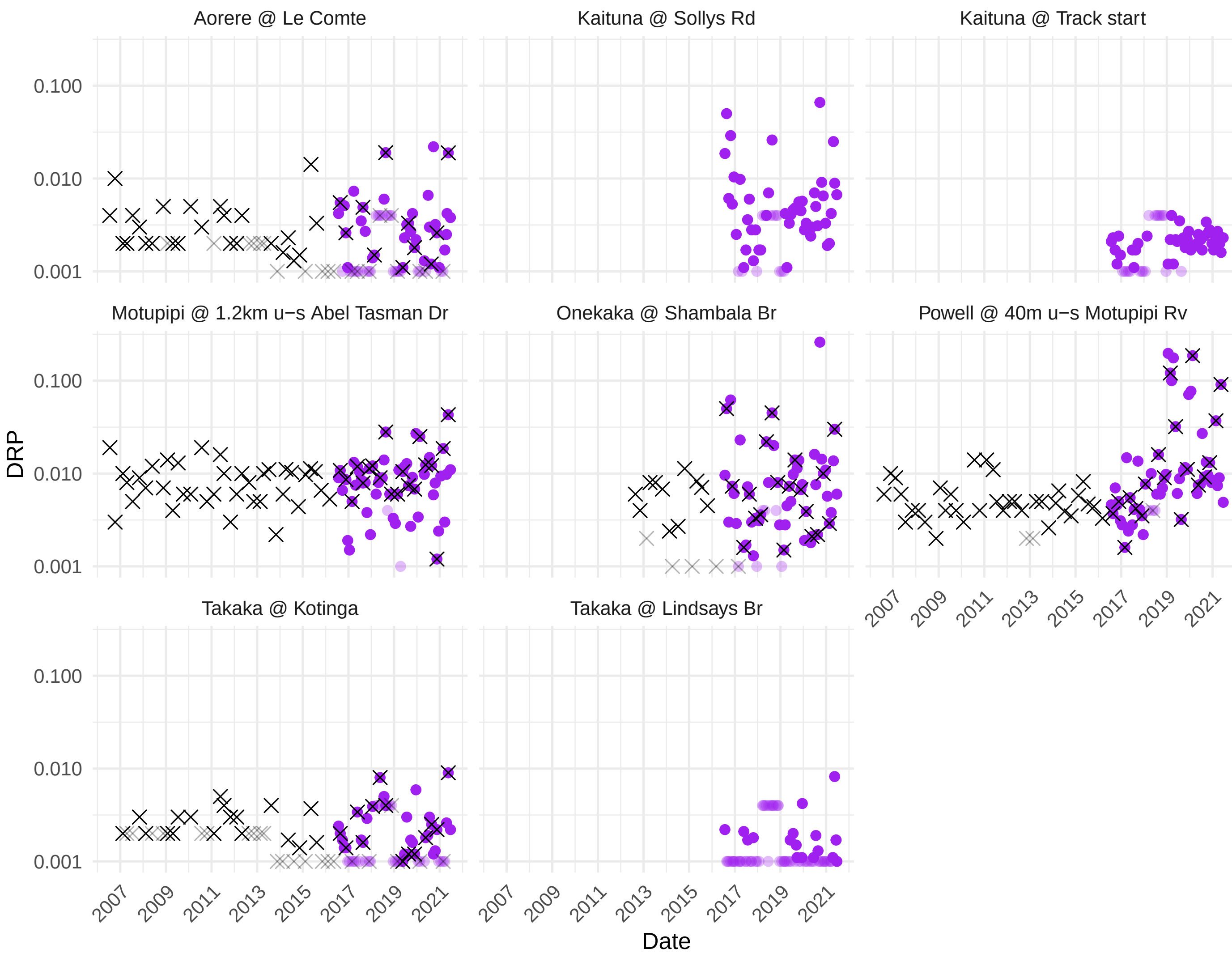


Figure 33: Dissolved Reactive Phosphorus data (g/m3, log10-transformed) sampled monthly over 5 years (dots) and quarterly over 15 years (crosses). Values below detection are lighter in colour.

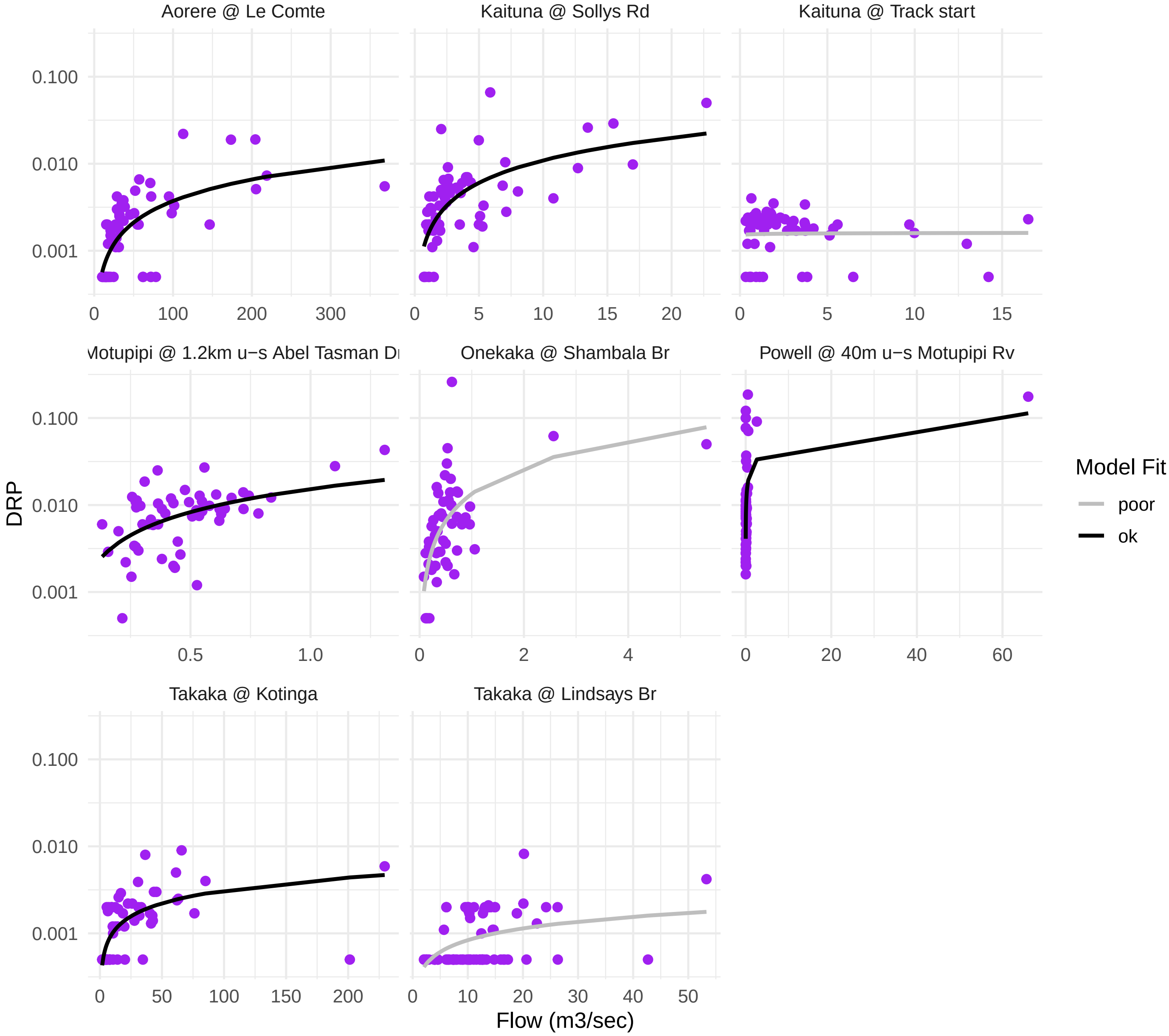


Figure 34: Dissolved Reactive Phosphorus data (g/m3, log10-transformed) and river flow (m3/sec) over 5 years with LogLog fitted line. Model fit = *poor* when less than 20 percent of the variation in DRP was explained by flow.

7.3.2 Motueka & Buller

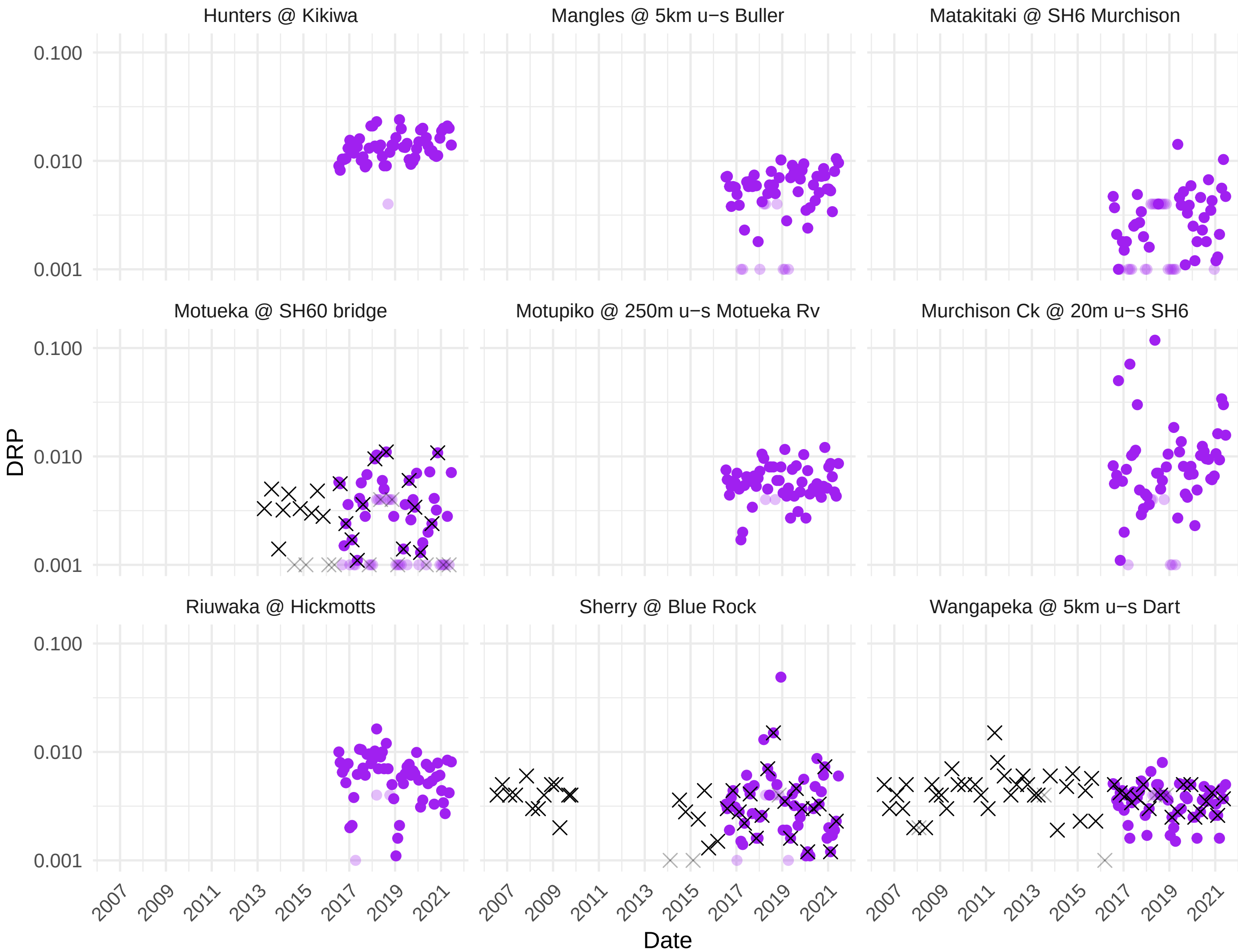


Figure 35: Dissolved Reactive Phosphorus data (g/m3, log10-transformed) sampled monthly over 5 years (dots) and quarterly over 15 years (crosses). Values below detection are lighter in colour.

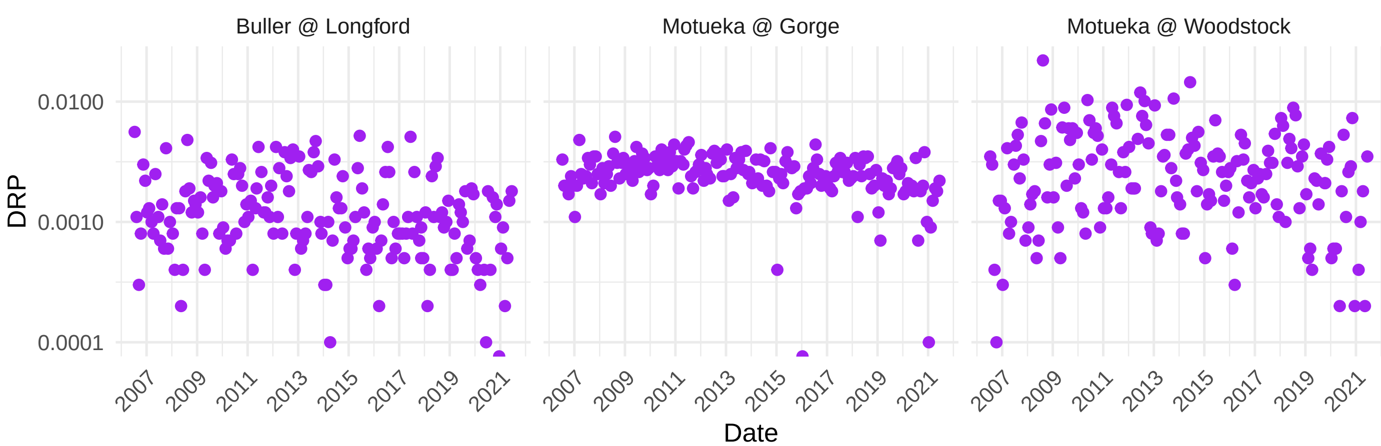


Figure 36: Dissolved Reactive Phosphorus data (g/m3, log10-transformed) at sites monitored by NIWA, showing monthly data over 15 years.

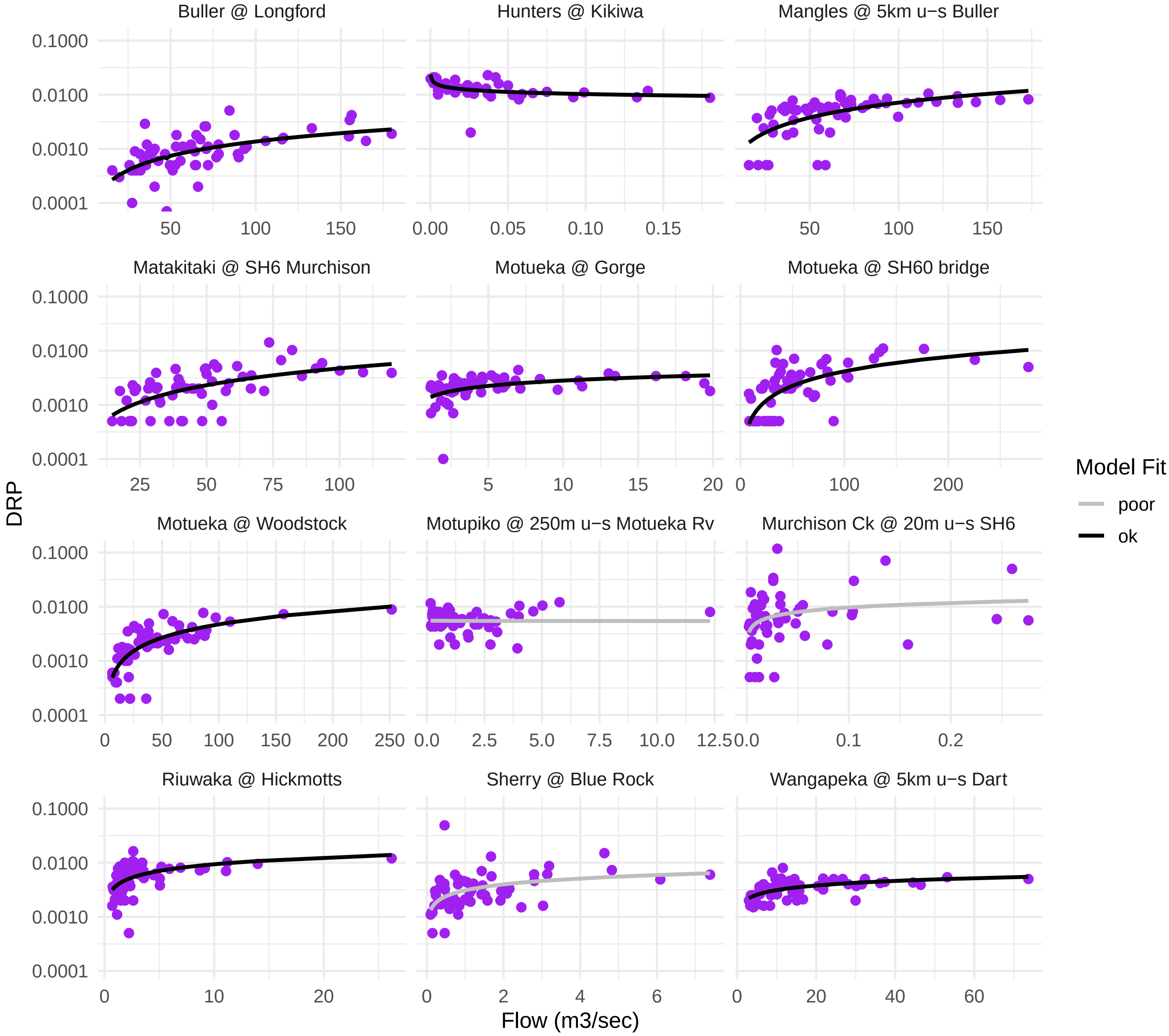


Figure 37: Dissolved Reactive Phosphorus data (g/m3, log10-transformed) and river flow (m3/sec) over 5 years with LogLog fitted line. Model fit = *poor* when less than 20 percent of the variation in DRP was explained by flow.

7.3.3 Waimea & Moutere

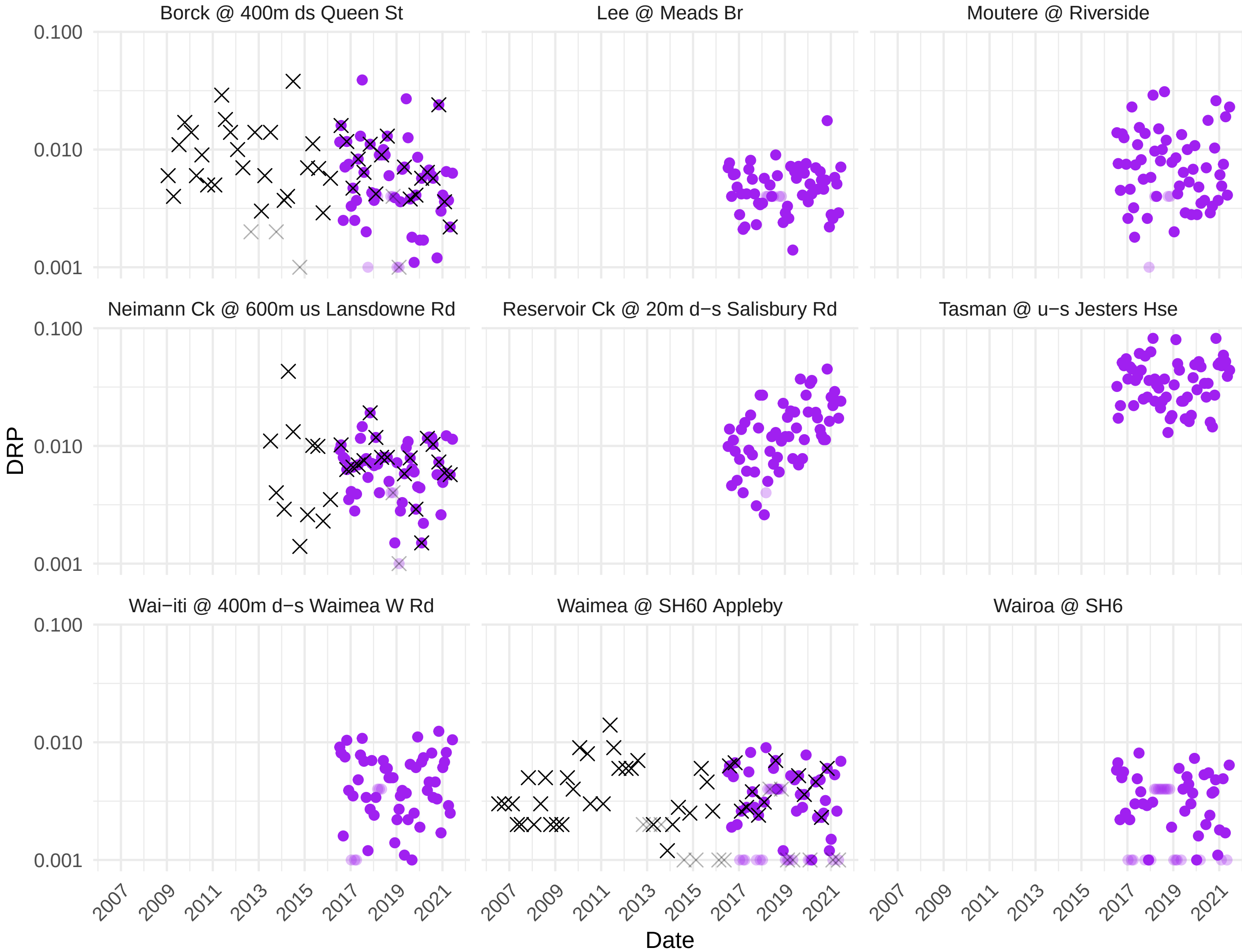


Figure 38: Dissolved Reactive Phosphorus data (log10-transformed) sampled monthly over 5 years (dots) and quarterly over 15 years (crosses). Values below detection are lighter in colour.

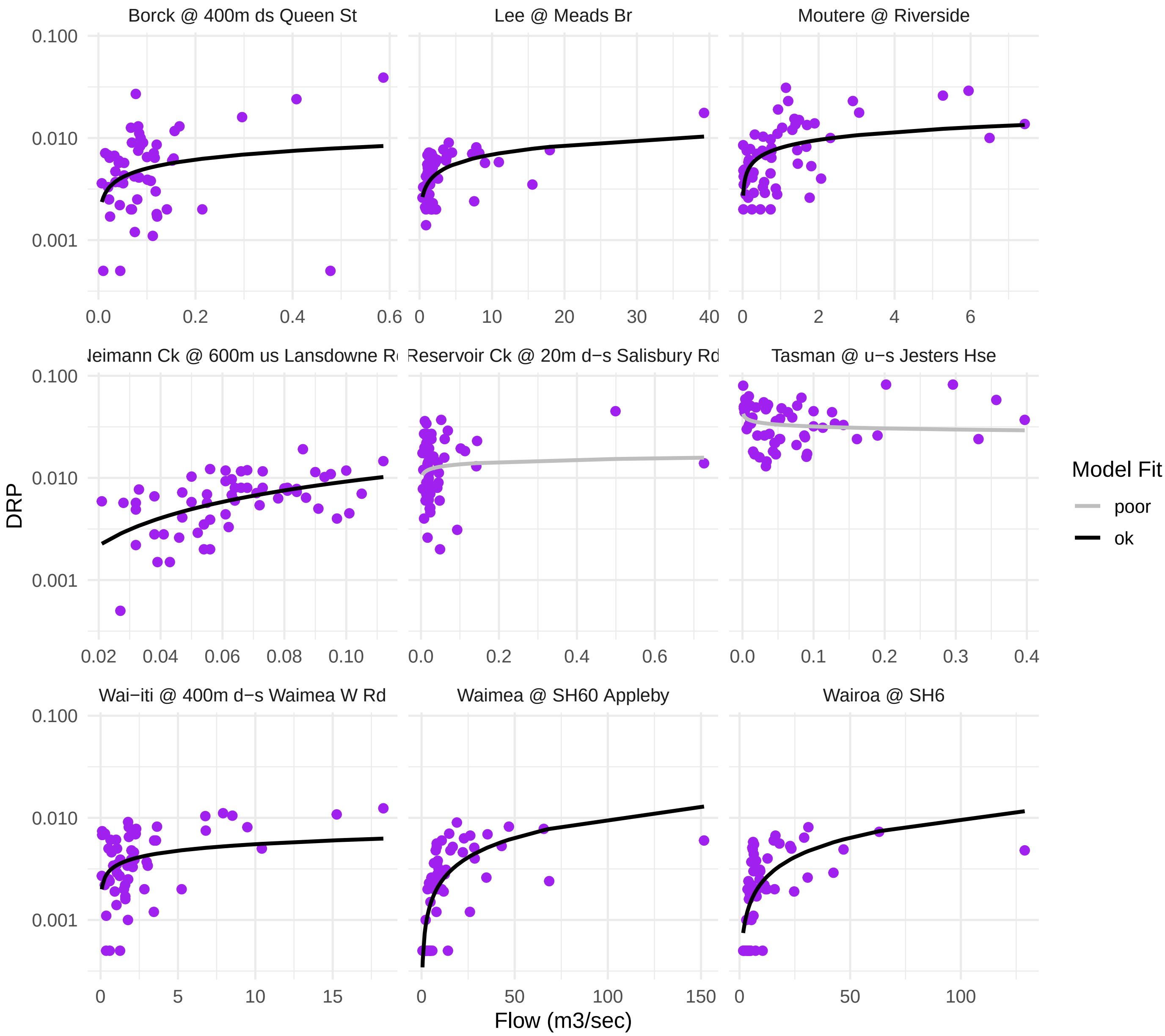


Figure 39: Dissolved Reactive Phosphorus data (g/m3, log10-transformed) and river flow (m3/sec) over 5 years with LogLog fitted line. Model fit = *poor* when less than 20 percent of the variation in DRP was explained by flow.

Flow-adjust using log-log models. There tends to be a monotonic increase in DRP as flow increases.

7.4 Escherichia coli (*E. coli*)

7.4.1 Takaka & Aorere

Figure 40: E. coli concentration (cfu/100ml, log10-transformed) sampled monthly over 5 years (dots) and quarterly over 15 years (crosses). Values below detection are lighter in colour.

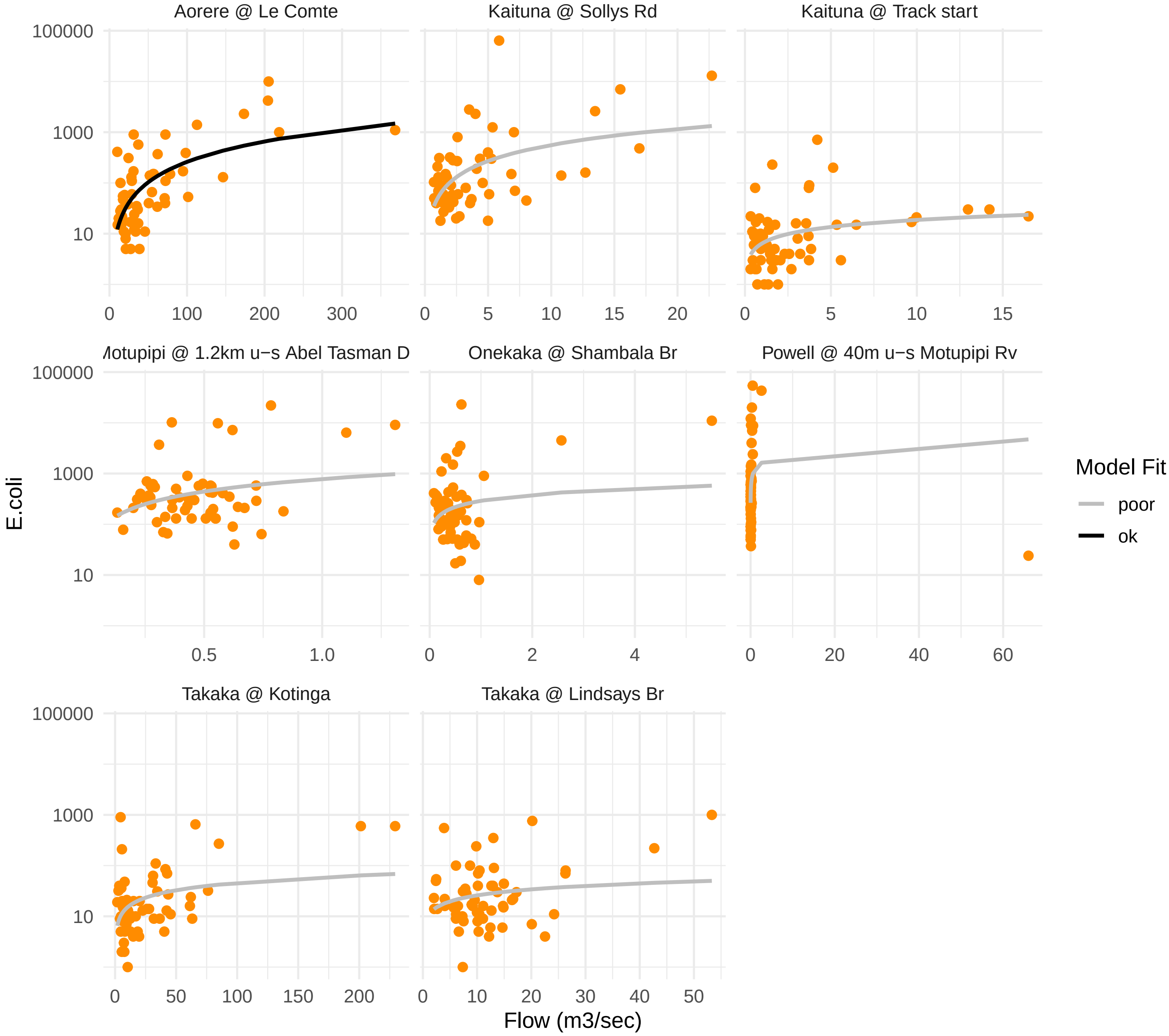


Figure 41: E. coli concentration (cfu/100ml, log10-transformed) and river flow (m3/sec) over 5 years with LogLog fitted line. Model fit = *poor* when less than 20 percent of the variation in E. coli was explained by flow.

7.4.2 Motueka & Buller

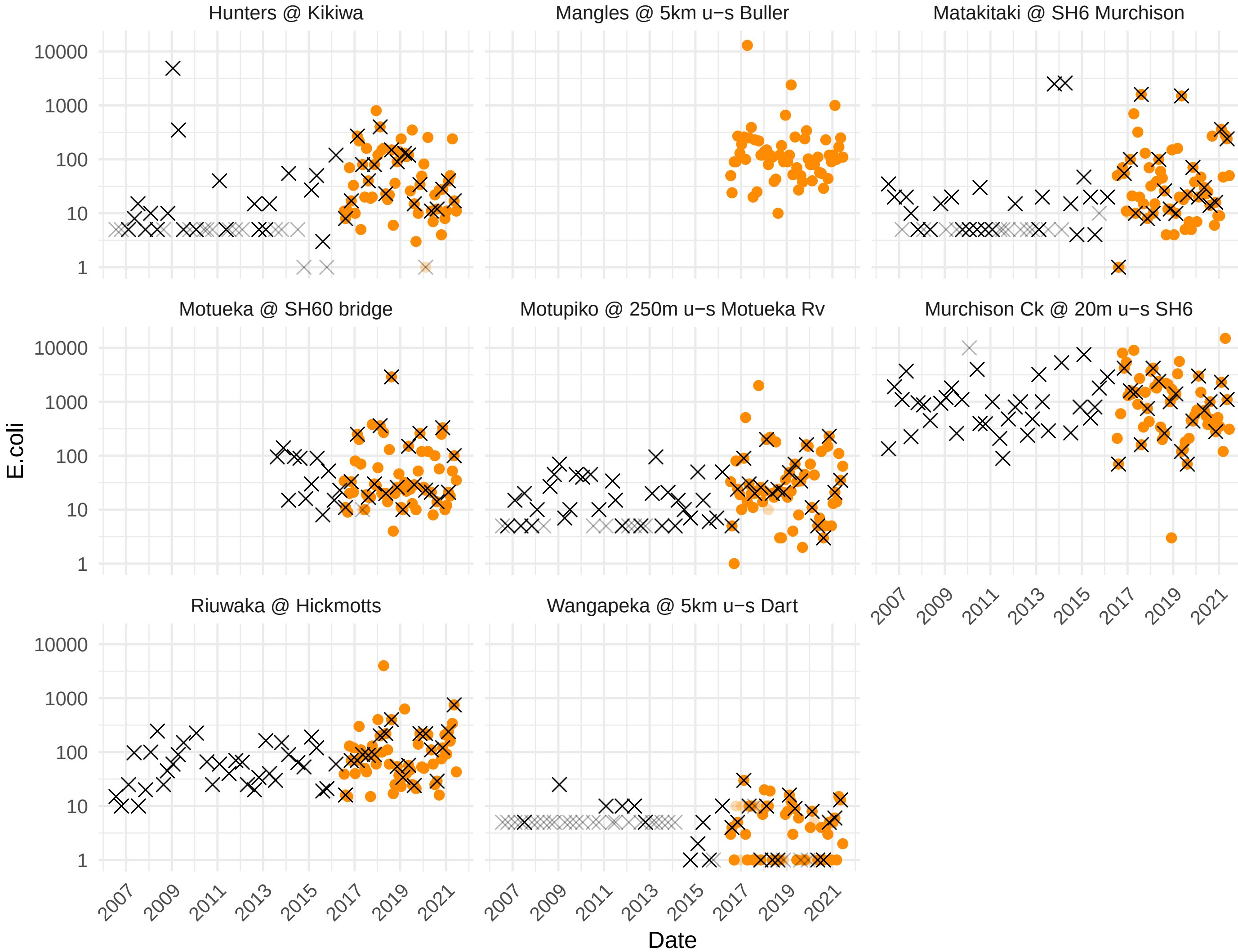


Figure 42: E. coli concentration (cfu/100ml, log10-transformed) sampled monthly over 5 years (dots) and quarterly over 15 years (crosses). Values below detection are lighter in colour.

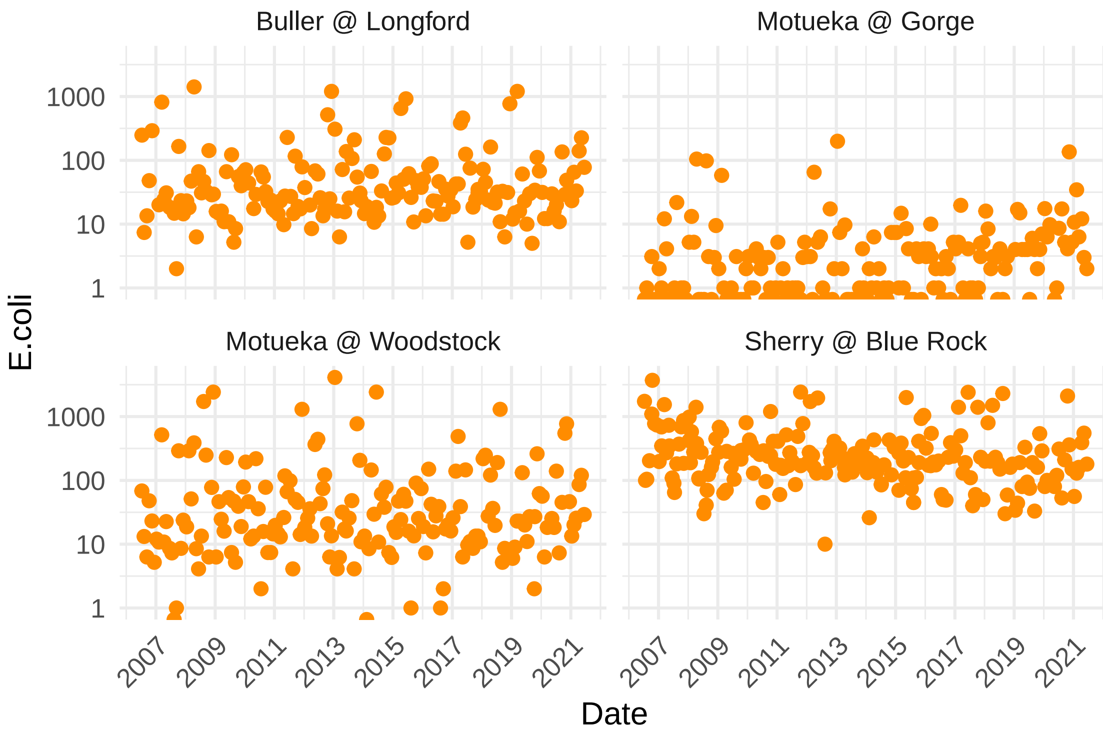


Figure 43: E. coli concentration (cfu/100ml, log10-transformed) at sites with monthly data over 15 years.

Figure 44: E. coli concentration (cfu/100ml, log10-transformed) and river flow (m3/sec) over 5 years with LogLog fitted line. Model fit = *poor* when less than 20 percent of the variation in E. coli was explained by flow.

7.4.3 Waimea & Moutere

Figure 45: E. coli concentration (cfu/100ml, log10-transformed) sampled monthly over 5 years (dots) and quarterly over 15 years (crosses). Values below detection are lighter in colour.

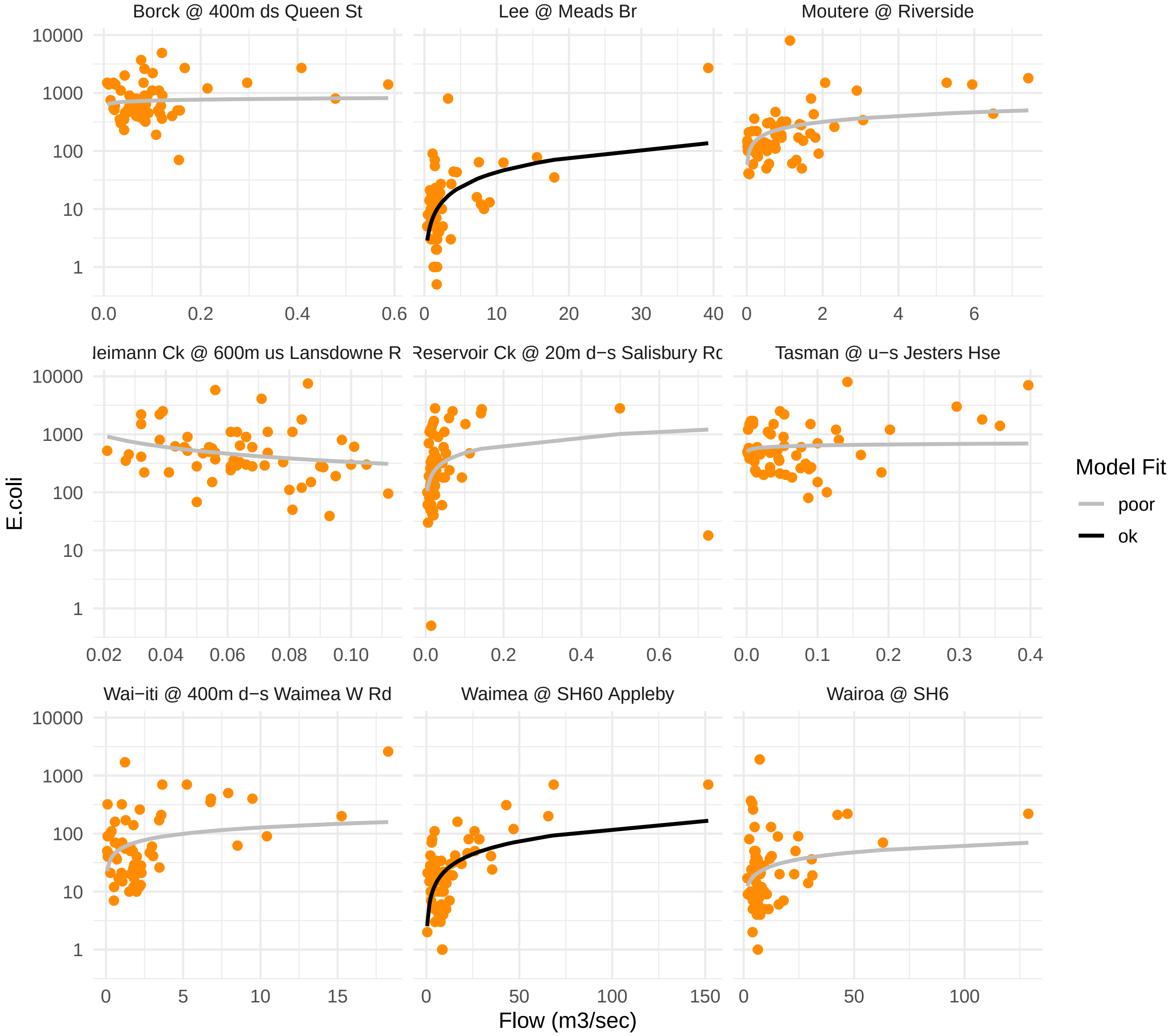


Figure 46: E. coli concentration (cfu/100ml, log10-transformed) and river flow (m3/sec) over 5 years with LogLog fitted line. Model fit = *poor* when less than 20 percent of the variation in E. coli was explained by flow.

Flow-adjust using log-log models. Where there is a relationship between flow and *E. coli*, this tends to be a monotonic increase.

7.5 Water Clarity

7.5.1 Takaka & Aorere

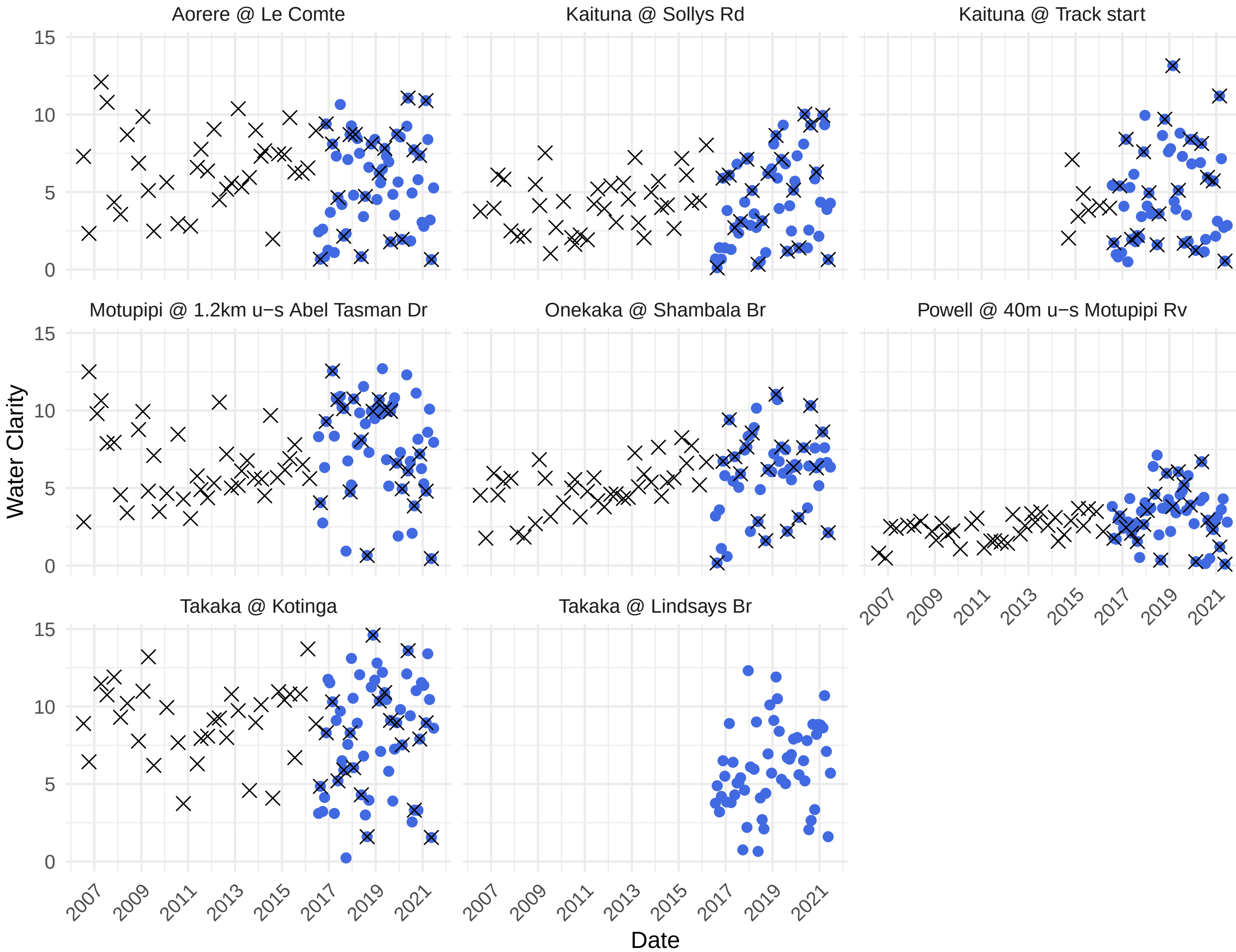


Figure 47: Visual water clarity (m) sampled monthly over 5 years (dots) and quarterly over 15 years (crosses)

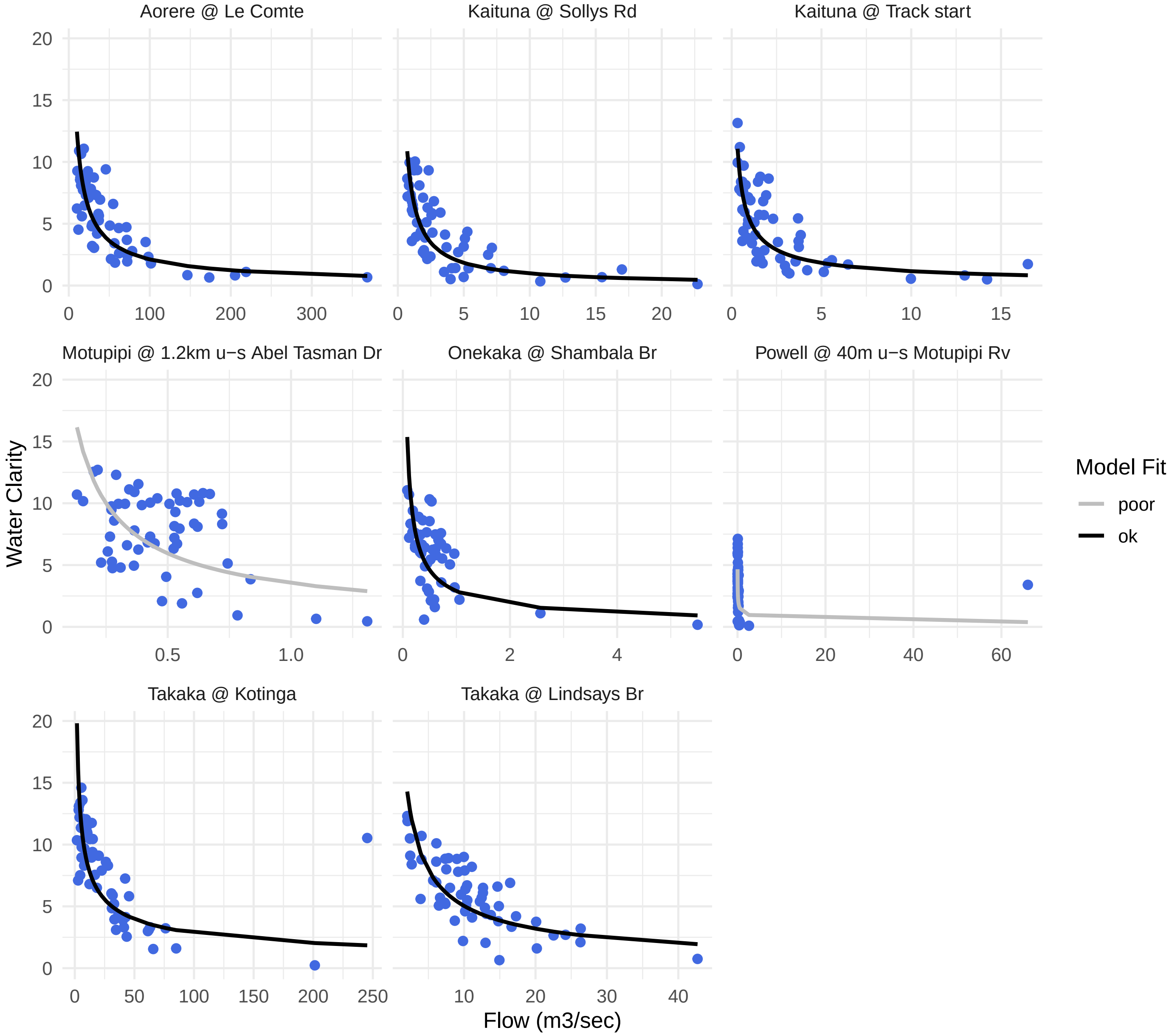
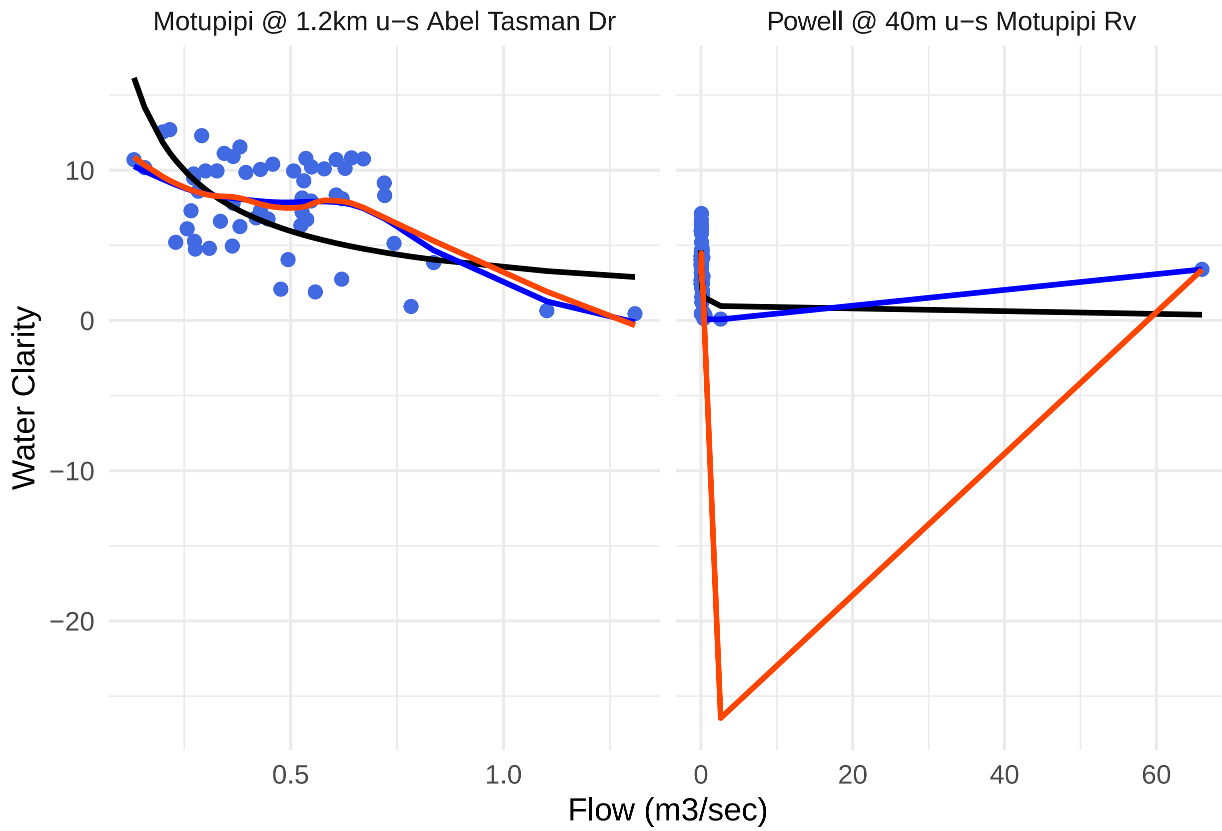


Figure 48: Visual water clarity (m) and river flow (m3/sec) over 5 years with LogLog fitted line. Model fit = *poor* when less than 20 percent of the variation in water clarity was explained by flow.


Motupipi @ 1.2km u−s Abel Tasman Dr
Powell @ 40m u−s Motupipi Rv
Water Clarity
10
0
−10
−20
0.5
1.0
0
20
40
60
Flow (m3/sec)

7.5.2 Motueka & Buller

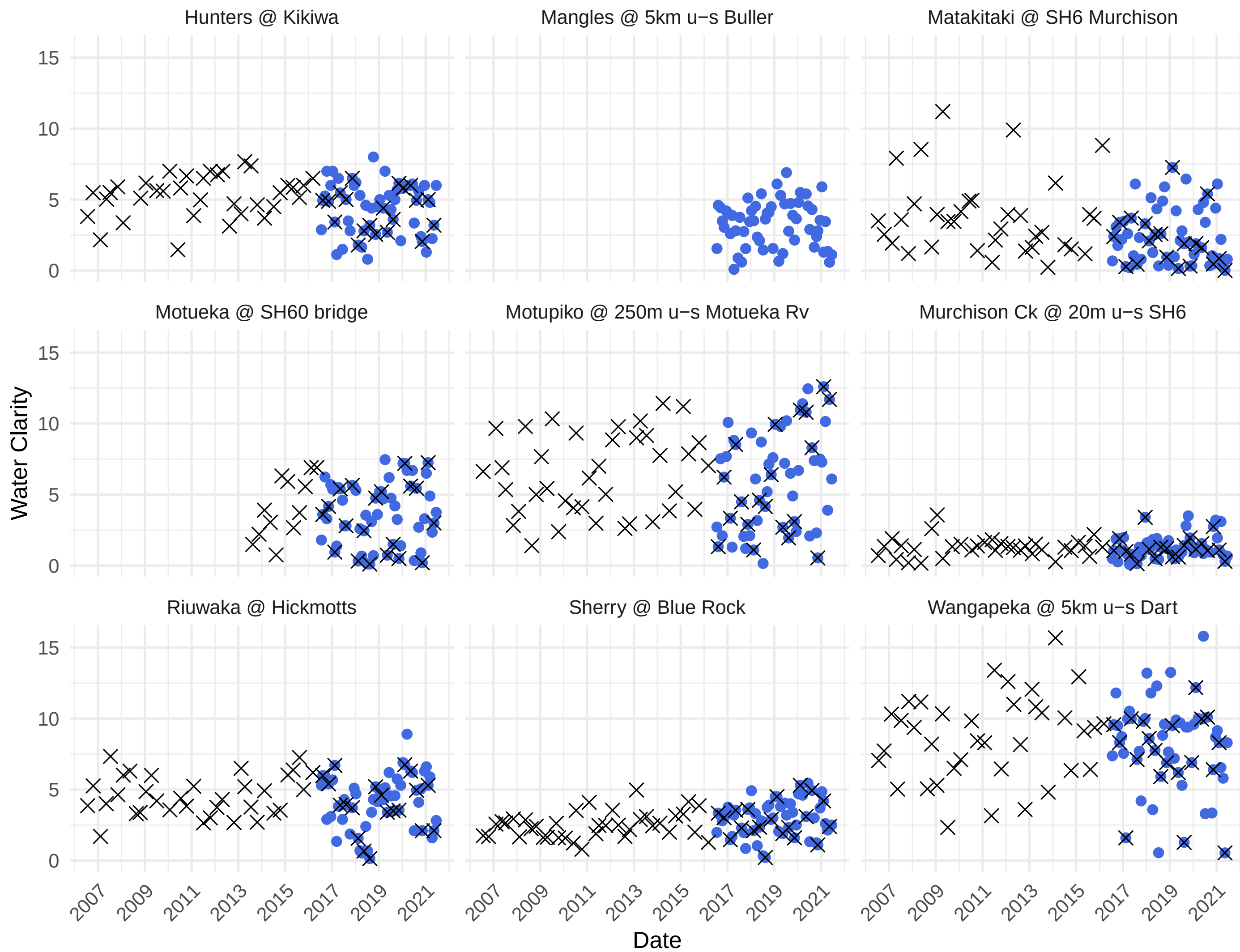


Figure 49: Visual water clarity (m) sampled monthly over 5 years (dots) and quarterly over 15 years (crosses). Values below detection are lighter in colour.

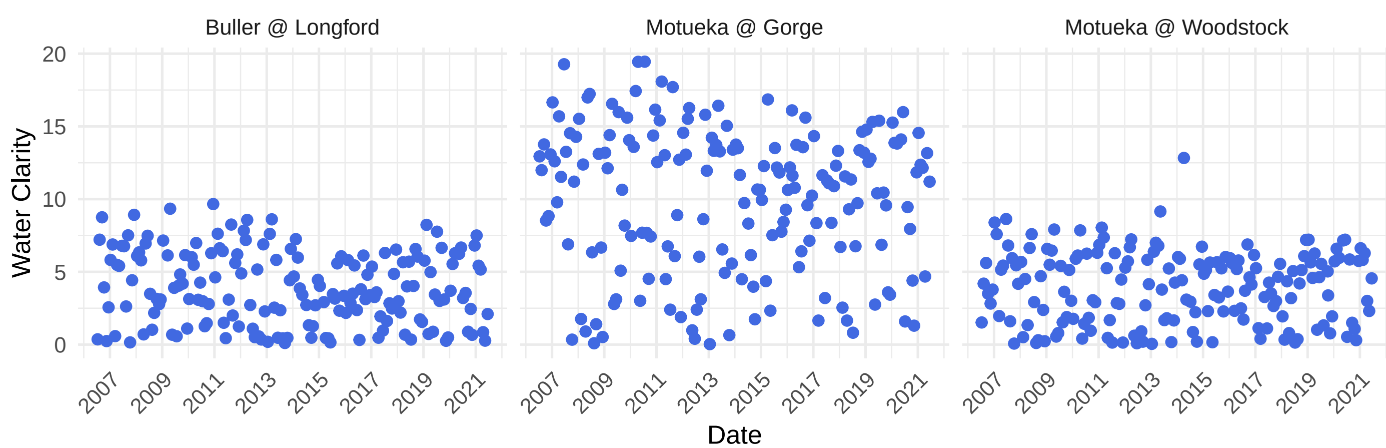


Figure 50: Visual water clarity (m) at sites monitored by NIWA, showing monthly data over 15 years.

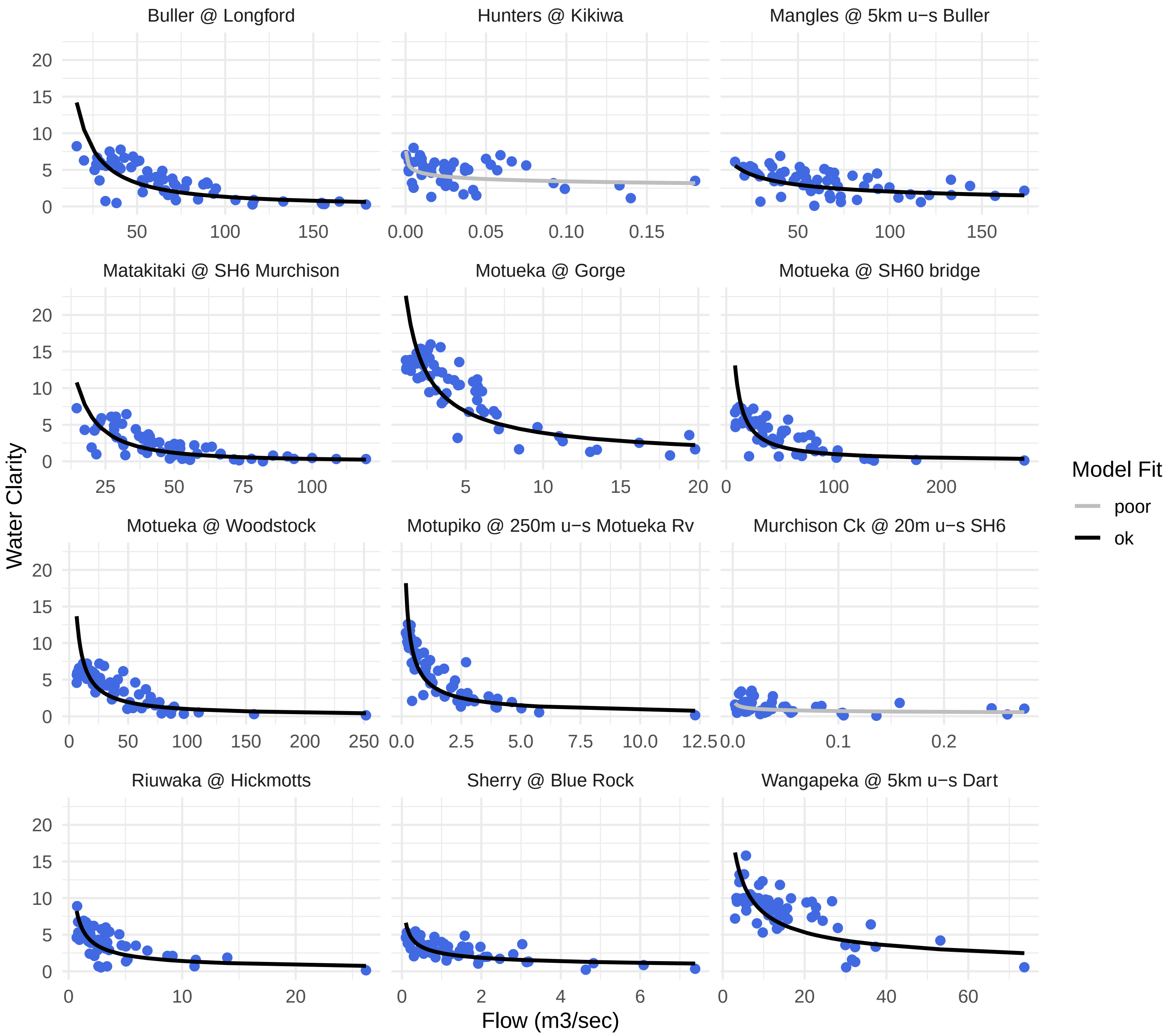


Figure 51: Visual water clarity (m) and river flow (m3/sec) over 5 years with LogLog fitted line. Model fit = *poor* when less than 20 percent of the variation in water clarity was explained by flow.

7.5.3 Waimea & Moutere

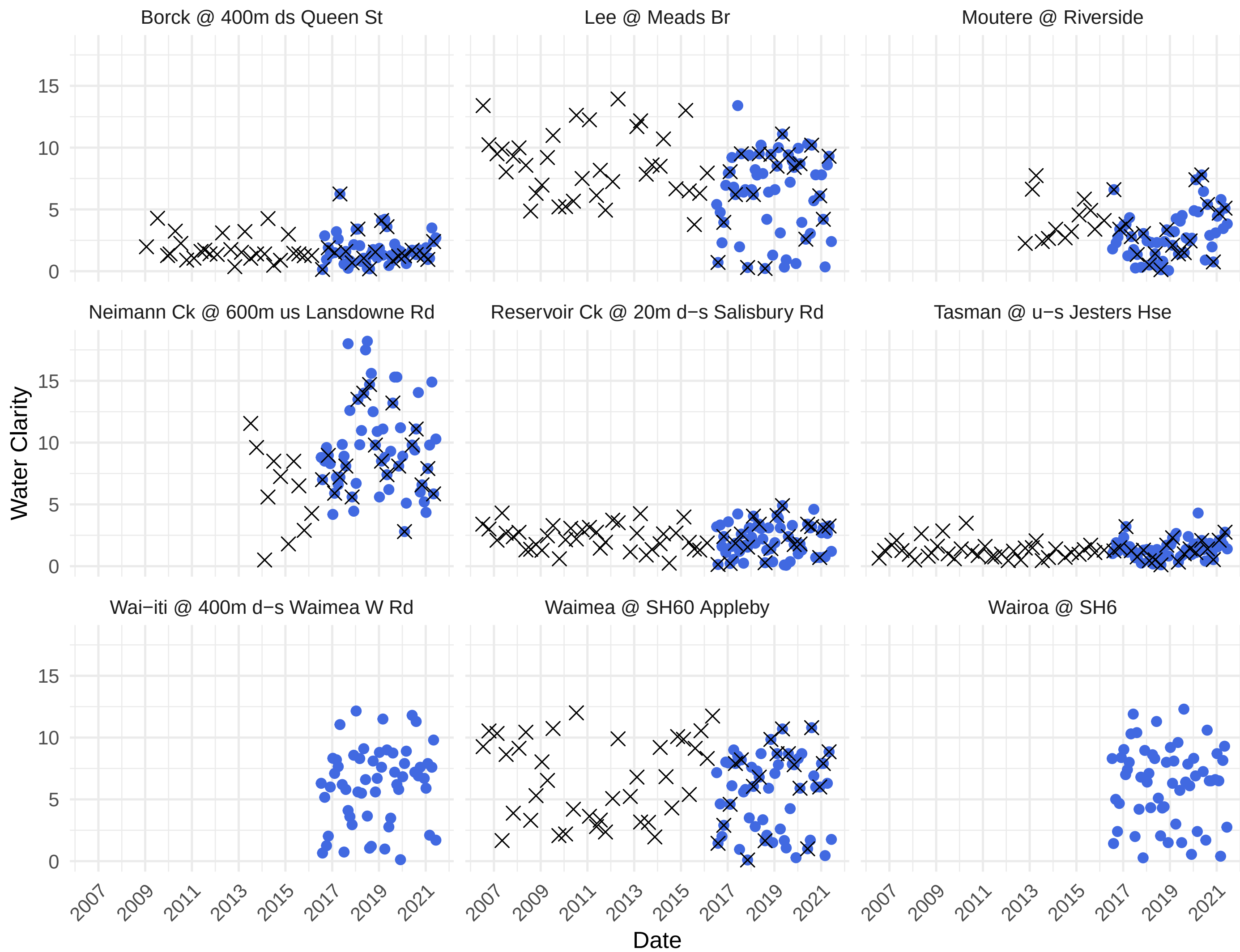


Figure 52: Visual water clarity (m) sampled monthly over 5 years (dots) and quarterly over 15 years (crosses). Values below detection are lighter in colour.

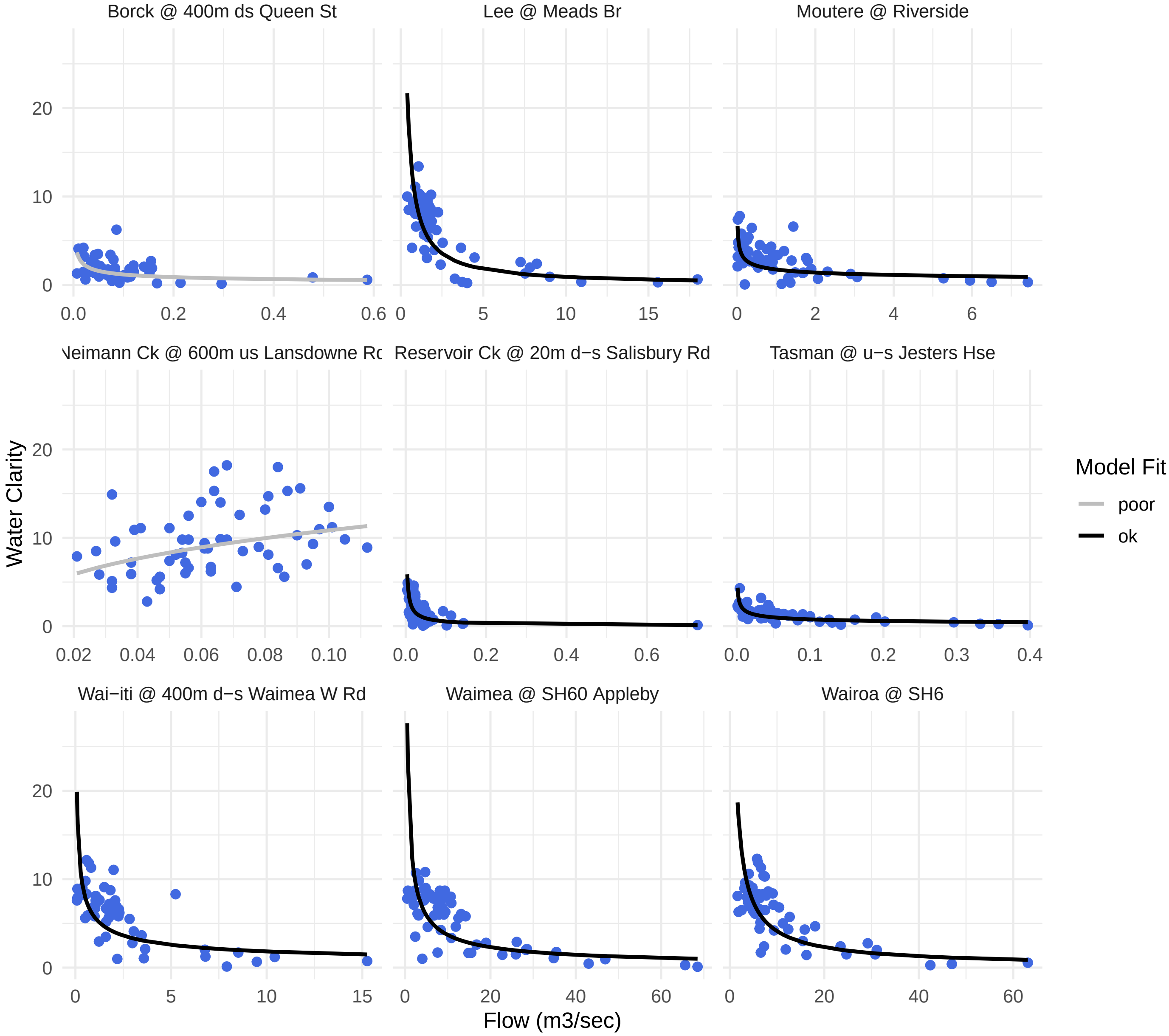


Figure 53: Visual water clarity (m) and river flow (m3/sec) over 5 years with LogLog fitted line. Model fit = *poor* when less than 20 percent of the variation in water clarity was explained by flow.

The log-log model was chosen for all sites except Powell and Motupipi. The GAM fitted values appear more reasonable for these sites. The fitted values from the LOESS model drop below zero for Powell - not sensible water clarity values.

Table 11: Nitrate-N trend results for Takaka and Aorere sites

Site	Band	Years	Flow adj	Trend category	Median	N	Sen slope	90% CI
Aorere @ Le Comte	A	15	loess	Likely degrading	0.108	51	0.002	-0.001 to 0.005
		15	none	Likely degrading	0.121	56	0.002	-0.001 to 0.004
		5	loess	Likely improving	0.135	57	-0.006	-0.018 to 0.004
		5	none	Likely degrading	0.134	59	0.006	-0.004 to 0.017
Kaituna @ Sollys Rd	A	15	loess	Insufficient data				
		15	none	Insufficient data				
		5	loess	Likely improving	0.196	58	-0.005	-0.015 to 0.005
		5	none	Likely degrading	0.196	59	0.006	-0.008 to 0.018
Kaituna @ Track start	A	15	loess	Insufficient data				
		15	none	Insufficient data				
		5	none	Very likely degrading	0.01	57	0.003	0.001 to 0.005
Motupipi @ 1.2km u-s Abel Tasman Dr	B	15	loess	Likely degrading	1.6	55	0.009	-0.008 to 0.024
		15	none	Likely degrading	1.6	57	0.011	-0.013 to 0.037
		5	loess	Very likely degrading	1.71	57	0.085	0.047 to 0.12
		5	none	Very likely degrading	1.73	58	0.093	0.049 to 0.113
Onekaka @ Shambala Br	A	15	loess	Insufficient data				
		15	none	Insufficient data				
		5	loess	Indeterminate trend	0.147	53	0.002	-0.011 to 0.016
		5	none	Likely degrading	0.169	57	0.009	-0.007 to 0.016
Powell @ 40m u-s Motupipi Rv	B	15	loess	Likely degrading	1.55	55	0.012	-0.008 to 0.033
		15	none	Very likely degrading	1.55	57	0.033	0 to 0.056
		5	none	Likely degrading	1.63	58	0.047	-0.074 to 0.133
Takaka @ Kotinga	A	15	loess	Likely degrading	0.181	49	0.002	-0.002 to 0.007
		15	none	Indeterminate trend	0.2	55	0.001	-0.005 to 0.006
		5	loess	Likely degrading	0.2	57	0.009	-0.004 to 0.021
		5	none	Likely degrading	0.205	58	0.008	-0.015 to 0.017
Takaka @ Lindsays Br	A	5	none	Very likely degrading	0.054	59	0.003	-0.001 to 0.007

Band = attribute band (NPSFM 2020), Flow adj = type of model used for flow adjustment, Median in g/m3, Sen slope and 90% confidence interval in g/m3 per year

Table 12: Nitrate-N trend results for Motueka and Buller sites

Site	Band	Years	Flow adj	Trend category	Median	N	Sen slope	90% CI
Buller @ Longford	A	15	none	Very likely degrading	0.032	179	0.001	0 to 0.001
		5	none	Likely degrading	0.038	59	0.002	-0.001 to 0.003
Hunters @ Kikiwa	A	15	loess	Insufficient data				
		15	none	Insufficient data				
		5	loess	Likely degrading	0.012	50	0	-0.001 to 0.001
		5	none	Very likely degrading	0.011	58	0.001	0 to 0.003
Mangles @ 5km u-s Buller	A	5	loess	Very likely degrading	0.29	59	0.012	-0.001 to 0.027
		5	none	Very likely degrading	0.29	59	0.021	0.001 to 0.037
Matakitaki @ SH6 Murchison	A	15	none	Insufficient data				
		5	none	Indeterminate trend	0.093	59	0.002	-0.004 to 0.006
Motueka @ Gorge	A	15	none	Very likely degrading	0.026	179	0.001	0 to 0.001
		5	none	Indeterminate trend	0.032	59	0	-0.003 to 0.002
Motueka @ SH60 bridge	A	15	loess	Insufficient data				
		15	none	Insufficient data				
		5	loess	Very likely degrading	0.17	59	0.013	0 to 0.033
		5	none	Likely degrading	0.17	59	0.01	-0.004 to 0.02
Motueka @ Woodstock	A	15	loess	Very likely degrading	0.163	177	0.006	0.002 to 0.009
		15	none	Very likely degrading	0.163	177	0.005	0.003 to 0.007
		5	loess	Very likely degrading	0.221	57	0.012	-0.001 to 0.038
		5	none	Very likely degrading	0.221	57	0.02	-0.002 to 0.03
Motupiko @ 250m u-s Motueka Rv	A	15	loess	Insufficient data				
		15	none	Insufficient data				
		5	none	Likely degrading	0.31	59	0.01	-0.02 to 0.03
Murchison Ck @ 20m u-s SH6	C	15	loess	Insufficient data				
		15	none	Insufficient data				
		5	loess	Likely degrading	3.35	58	0.094	-0.11 to 0.29
		5	none	Likely degrading	3.4	59	0.133	-0.148 to 0.377
Riuwaka @ Hickmotts	A	15	loess	Insufficient data				
		15	none	Insufficient data				
		5	loess	Very likely degrading	0.2	59	0.014	0.002 to 0.02
		5	none	Indeterminate trend	0.2	59	0.003	-0.007 to 0.02
Sherry @ Blue Rock	A	15	loess	Insufficient data				
		15	none	Insufficient data				
		5	none	Very likely degrading	0.38	59	0.037	0.004 to 0.06
Wangapeka @ 5km u-s Dart	A	15	loess	Very likely improving	0.022	57	-0.001	-0.001 to 0
		15	none	Very likely improving	0.022	57	-0.001	-0.002 to 0
		5	loess	Indeterminate trend	0.014	58	0	-0.002 to 0.001
		5	none	Likely improving	0.014	58	-0.001	-0.002 to 0.001

Band = attribute band (NPSFM 2020), Flow adj = type of model used for flow adjustment, Median in g/m3, Sen slope and 90% confidence interval in g/m3 per year

Table 13: Nitrate-N trend results for Waimea and Moutere sites

Site	Band	Years	Flow adj	Trend category	Median	N	Sen slope	90% CI
Borck @ 400m ds Queen St	C	15	none	Likely improving	6.6	49	-0.059	-0.203 to 0.101
		5	loess	Likely degrading	6.4	57	0.41	-0.059 to 0.547
		5	none	Very likely degrading	6.45	58	0.387	0 to 0.678
Lee @ Meads Br	A	15	loess	Insufficient data				
		15	none	Insufficient data				
		5	loess	Indeterminate trend	0.056	59	0.001	-0.004 to 0.005
		5	none	Indeterminate trend	0.056	59	0	-0.003 to 0.002
Moutere @ Riverside	A	15	loess	Insufficient data				
		15	none	Insufficient data				
		5	loess	Very likely degrading	0.46	58	0.08	0.037 to 0.127
		5	none	Indeterminate trend	0.45	59	0.006	-0.03 to 0.082
Neimann Ck @ 600m us Lansdowne Rd	C	15	none	Insufficient data				
		5	none	Very likely improving	2.6	58	-0.579	-0.75 to -0.365
Reservoir Ck @ 20m d-s Salisbury Rd	B	15	loess	Insufficient data				
		15	none	Insufficient data				
		5	loess	Very likely degrading	1.94	59	0.135	0.05 to 0.236
		5	none	Very likely degrading	1.94	59	0.099	0 to 0.23
Tasman @ u-s Jesters Hse	A	15	loess	Insufficient data				
		15	none	Insufficient data				
		5	loess	Very likely degrading	0.12	58	0.006	0 to 0.017
		5	none	Very likely improving	0.117	59	-0.011	-0.038 to -0.001
Wai-iti @ 400m d-s Waimea W Rd	B	5	none	Very likely degrading	1.15	59	0.136	0.044 to 0.209
Waimea @ SH60 Appleby	A	15	loess	Likely improving	0.33	58	-0.005	-0.014 to 0.004
		15	none	Very likely improving	0.31	59	-0.009	-0.018 to 0
		5	loess	Indeterminate trend	0.35	59	-0.007	-0.025 to 0.027
		5	none	Indeterminate trend	0.35	59	-0.013	-0.041 to 0.023
Wairoa @ SH6	A	15	loess	Insufficient data				
		15	none	Insufficient data				
		5	loess	Likely improving	0.038	59	-0.004	-0.011 to 0.004
		5	none	Indeterminate trend	0.038	59	-0.001	-0.008 to 0.002

Band = attribute band (NPSFM 2020), Flow adj = type of model used for flow adjustment, Median in g/m3, Sen slope and 90% confidence interval in g/m3 per year

Table 14: DRP trend results for Takaka and Aorere sites

Site	Band	Years	Flow adj	Trend category	Median	N	Sen slope	90% CI
Aorere @ Le Comte	A	15	loglog	Very likely improving	0.002	51	0	0 to 0
		15	none	Likely improving	0.002	56	0	0 to 0
		5	loglog	Very likely degrading	0.002	57	0	0 to 0.001
		5	none	Indeterminate trend	0.002	59	0	0 to 0
Kaituna @ Sollys Rd	B	15	loglog	Insufficient data				
		15	none	Insufficient data				
		5	loglog	Very likely degrading	0.004	58	0	0 to 0.001
		5	none	Likely degrading	0.004	59	0	0 to 0
Kaituna @ Track start	A	15	none	Insufficient data				
		5	none	Insufficient data				
Motupipi @ 1.2km u-s Abel Tasman Dr	B	15	loglog	Likely degrading	0.009	55	0	0 to 0
		15	none	Likely degrading	0.009	57	0	0 to 0
		5	loglog	Very likely degrading	0.009	57	0	0 to 0.001
		5	none	Likely degrading	0.009	58	0	0 to 0.001
Onekaka @ Shambala Br	C	15	loglog	Insufficient data				
		15	none	Insufficient data				
		5	none	Likely degrading	0.006	57	0	0 to 0.001
Powell @ 40m u-s Motupipi Rv	D	15	loglog	Likely degrading	0.005	55	0	0 to 0.001
		15	none	Very likely degrading	0.005	57	0	0 to 0.001
		5	loglog	Very likely degrading	0.008	56	0.002	0.001 to 0.003
		5	none	Very likely degrading	0.008	58	0.002	0.001 to 0.003
Takaka @ Kotinga	A	15	loglog	Likely improving	0.002	49	0	0 to 0
		15	none	Insufficient data				
		5	loglog	Indeterminate trend	0.001	57	0	0 to 0
		5	none	Likely degrading	0.002	58	0	0 to 0
Takaka @ Lindsays Br	A	5	none	Insufficient data				

Band = attribute band (NPSFM 2020), Flow adj = type of model used for flow adjustment, Median in g/m3, Sen slope and 90% confidence interval in g/m3 per year

Table 15: DRP trend results for Motueka and Buller sites

Site	Band	Years	Flow adj	Trend category	Median	N	Sen slope	90% CI
Buller @ Longford	A	15	loglog	Very likely improving	0.001	179	0	0 to 0
		15	none	Very likely improving	0.001	179	0	0 to 0
		5	loglog	Very likely improving	0.001	59	0	0 to 0
		5	none	Likely improving	0.001	59	0	0 to 0
Hunters @ Kikiwa	C	15	loglog	Insufficient data				
		15	none	Insufficient data				
		5	loglog	Very likely degrading	0.013	50	0	0 to 0.001
		5	none	Very likely degrading	0.013	58	0.001	0 to 0.001
Mangles @ 5km u-s Buller	A	5	loglog	Very likely degrading	0.006	59	0.001	0 to 0.001
		5	none	Very likely degrading	0.006	59	0	0 to 0.001
Matakitaki @ SH6 Murchison	A	15	loglog	Insufficient data				
		15	none	Insufficient data				
		5	loglog	Very likely degrading	0.003	59	0	0 to 0.001
		5	none	Very likely degrading	0.003	59	0	0 to 0
Motueka @ Gorge	A	15	loglog	Very likely improving	0.002	179	0	0 to 0
		15	none	Very likely improving	0.002	179	0	0 to 0
		5	loglog	Very likely improving	0.002	59	0	0 to 0
		5	none	Very likely improving	0.002	59	0	0 to 0
Motueka @ SH60 bridge	A	15	loglog	Insufficient data				
		15	none	Insufficient data				
		5	loglog	Indeterminate trend	0.003	59	0	0 to 0
		5	none	Indeterminate trend	0.003	59	0	0 to 0
Motueka @ Woodstock	A	15	loglog	Very likely improving	0.003	177	0	0 to 0
		15	none	Very likely improving	0.003	177	0	0 to 0
		5	loglog	Very likely improving	0.002	57	0	0 to 0
		5	none	Very likely improving	0.002	57	0	0 to 0
Motupiko @ 250m u-s Motueka Rv	A	15	none	Insufficient data				
		5	none	Indeterminate trend	0.006	59	0	0 to 0
Murchison Ck @ 20m u-s SH6	C	15	none	Insufficient data				
		5	none	Very likely degrading	0.007	59	0.001	0 to 0.002
Riuwaka @ Hickmotts	B	15	loglog	Insufficient data				
		15	none	Insufficient data				
		5	loglog	Very likely improving	0.006	59	0	-0.001 to 0
		5	none	Very likely improving	0.006	59	0	-0.001 to 0
Sherry @ Blue Rock	A	15	loglog	Insufficient data				
		15	none	Insufficient data				
		5	none	Likely degrading	0.003	59	0	0 to 0
Wangapeka @ 5km u-s Dart	A	15	loglog	Very likely improving	0.004	57	0	0 to 0
		15	none	Very likely improving	0.004	57	0	0 to 0
		5	loglog	Indeterminate trend	0.004	58	0	0 to 0
		5	none	Likely improving	0.004	58	0	0 to 0

Band = attribute band (NPSFM 2020), Flow adj = type of model used for flow adjustment, Median in g/m3, Sen slope and 90% confidence interval in g/m3 per year

Table 16: DRP trend results for Waimea and Moutere sites

Site	Band	Years	Flow adj	Trend category	Median	N	Sen slope	90% CI
Borck @ 400m ds Queen St	A	15	loglog	Very likely improving	0.006	49	0	-0.001 to 0
		15	none	Very likely improving	0.006	49	0	-0.001 to 0
		5	loglog	Very likely improving	0.005	57	-0.001	-0.001 to 0
		5	none	Very likely improving	0.005	58	0	-0.001 to 0
Lee @ Meads Br	A	15	loglog	Insufficient data				
		15	none	Insufficient data				
		5	loglog	Indeterminate trend	0.005	59	0	0 to 0
		5	none	Indeterminate trend	0.005	59	0	0 to 0
Moutere @ Riverside	B	15	loglog	Insufficient data				
		15	none	Insufficient data				
		5	loglog	Likely degrading	0.007	58	0	0 to 0.001
		5	none	Likely improving	0.007	59	0	-0.001 to 0
Neimann Ck @ 600m us Lansdowne Rd	B	15	loglog	Insufficient data				
		15	none	Insufficient data				
		5	loglog	Likely degrading	0.007	58	0	0 to 0
		5	none	Indeterminate trend	0.007	58	0	0 to 0
Reservoir Ck @ 20m d-s Salisbury Rd	C	15	none	Insufficient data				
		5	none	Very likely degrading	0.012	59	0.003	0.002 to 0.004
Tasman @ u-s Jesters Hse	D	15	none	Insufficient data				
		5	none	Indeterminate trend	0.036	59	0	-0.002 to 0.003
Wai-iti @ 400m d-s Waimea W Rd	A	5	loglog	Likely degrading	0.004	58	0	0 to 0.001
		5	none	Indeterminate trend	0.004	59	0	0 to 0
Waimea @ SH60 Appleby	A	15	none	Likely improving	0.003	59	0	0 to 0
		5	loglog	Indeterminate trend	0.003	59	0	0 to 0
		5	none	Likely improving	0.003	59	0	0 to 0
Wairoa @ SH6	A	15	loglog	Insufficient data				
		15	none	Insufficient data				
		5	loglog	Likely improving	0.003	59	0	0 to 0
		5	none	Indeterminate trend	0.003	59	0	0 to 0

Band = attribute band (NPSFM 2020), Flow adj = type of model used for flow adjustment, Median in g/m3, Sen slope and 90% confidence interval in g/m3 per year

Table 17: E.coli trend results for Takaka and Aorere sites

Site	Band	Years	Flow adj	Trend category	Median	N	Sen slope	90% CI
Aorere @ Le Comte	D	15	loglog	Likely degrading	38	51	1.23	-1.833 to 4.81
		15	none	Very likely degrading	34	57	1.32	0 to 4.446
		5	loglog	Indeterminate trend	51.5	57	5.37	-8.859 to 21.493
		5	none	Likely improving	51.5	59	-3.25	-17.391 to 5.009
Kaituna @ Sollys Rd	D	15	loglog	Very likely improving	104	55	-8.95	-16.844 to -3.369
		15	none	Very likely improving	104	57	-4.57	-8.318 to 0
		5	none	Very likely improving	89	59	-8.04	-25.421 to 2.08
Kaituna @ Track start	A	15	none	Insufficient data				
		5	none	Indeterminate trend	9	57	0	0 to 0
Motupipi @ 1.2km u-s Abel Tasman Dr	E	15	none	Very likely degrading	212.5	56	6.65	-1.704 to 17.684
		5	none	Indeterminate trend	310	58	7.74	-30.183 to 55.01
Onekaka @ Shambala Br	D	15	loglog	Likely improving	160	51	-2.76	-10.679 to 4.796
		15	none	Indeterminate trend	145	56	-0.248	-7.827 to 5.489
		5	none	Likely degrading	150	57	10.5	-15.02 to 27.898
Powell @ 40m u-s Motupipi Rv	E	15	loglog	Very likely degrading	400	55	21.3	-4.673 to 47.285
		15	none	Very likely degrading	440	57	29.1	4.692 to 59.032
		5	none	Indeterminate trend	415	58	0	-60.483 to 87.483
Takaka @ Kotinga	B	15	none	Very likely degrading	11.5	56	0.652	0 to 1.492
		5	none	Likely improving	14	58	0	-2.511 to 0
Takaka @ Lindsays Br	B	5	none	Likely improving	19	58	-2.21	-6.021 to 0

Band = attribute band (NPSFM 2020), Flow adj = type of model used for flow adjustment, Median in cfu/100ml, Sen slope and 90% confidence interval in cfu/100ml per year

Table 18: E.coli trend results for Motueka and Buller sites

Site	Band	Years	Flow adj	Trend category	Median	N	Sen slope	90% CI
Buller @ Longford	A	15	none	Likely degrading	30.25	173	0.357	-0.314 to 1.03
		5	none	Indeterminate trend	31.35	59	0.279	-2.725 to 4.406
Hunters @ Kikiwa	A	15	none	Very likely degrading	10	57	1.26	0.238 to 2.422
		5	none	Likely improving	30.5	58	-2.51	-9.259 to 1.895
Mangles @ 5km u-s Buller	B	5	none	Likely improving	110	59	-6.65	-13.787 to 3.871
Matakitaki @ SH6 Murchison	B	15	none	Very likely degrading	11	58	0.76	0 to 1.557
		5	none	Indeterminate trend	23	59	0	-3.78 to 4.355
Motueka @ Gorge	A	15	loglog	Very likely degrading	2	177	0.183	0.123 to 0.252
		15	none	Very likely degrading	2	177	0.199	0.088 to 0.252
		5	none	Very likely degrading	4	57	0.953	0.495 to 1.629
Motueka @ SH60 bridge	A	15	loglog	Insufficient data				
		15	none	Insufficient data				
		5	none	Likely degrading	26	59	0.749	-3.007 to 5.047
Motueka @ Woodstock	B	15	loglog	Likely degrading	23.8	176	0.392	-0.337 to 1.047
		15	none	Likely degrading	23.8	176	0.383	-0.224 to 1.023
		5	loglog	Very likely degrading	25.3	56	3.68	0.195 to 8.417
		5	none	Very likely degrading	25.3	56	3.4	0 to 7.808
Motupiko @ 250m u-s Motueka Rv	A	15	none	Very likely degrading	15	59	1.23	0.359 to 2.182
		5	none	Indeterminate trend	22	59	0	-2.659 to 5.358
Murchison Ck @ 20m u-s SH6	**E**	15	none	Indeterminate trend	950	56	-1.22	-25.157 to 25.057
		5	none	Very likely improving	825	59	-156	-300.272 to -28.289
Riuwaka @ Hickmotts	B	15	none	Very likely degrading	65	55	4.96	1.5 to 7.934
		5	none	Likely degrading	70	59	2.33	-2.455 to 7.685
Sherry @ Blue Rock	**D**	15	none	Very likely improving	200.5	167	-9.29	-14.924 to -4.733
		5	loglog	Likely improving	180	59	-4.41	-49.524 to 18.272
		5	none	Likely improving	180	59	0	-22.361 to 0
Wangapeka @ 5km u-s Dart	A	15	none	Likely degrading	5	56	0	0 to 0
		5	none	Likely improving	4	58	0	0 to 0

Band = attribute band (NPSFM 2020), Flow adj = type of model used for flow adjustment, Median in cfu/100ml, Sen slope and 90% confidence interval in cfu/100ml per year

Table 19: E.coli trend results for Waimea and Moutere sites

Site	Band	Years	Flow adj	Trend category	Median	N	Sen slope	90% CI
Borck @ 400m ds Queen St	E	15	none	Very likely degrading	500	49	36.4	10.281 to 57
		5	none	Very likely improving	670	58	-48.5	-128.067 to 0
Lee @ Meads Br	A	15	loglog	Likely improving	10	56	-0.223	-0.702 to 0.278
		15	none	Indeterminate trend	10	58	0	0 to 0
		5	loglog	Likely degrading	11	59	0.08	-1.328 to 1.268
		5	none	Likely degrading	11	59	0	0 to 1.54
Moutere @ Riverside	D	15	none	Insufficient data				
		5	none	Very likely improving	160	59	-12.7	-34.165 to 0
Neimann Ck @ 600m us Lansdowne Rd	E	15	none	Insufficient data				
		5	none	Likely degrading	460	58	24.2	-5.329 to 70.277
Reservoir Ck @ 20m d-s Salisbury Rd	D	15	none	Very likely degrading	150	59	8.03	1.169 to 14.906
		5	none	Indeterminate trend	210	59	8.55	-28.988 to 44.622
Tasman @ u-s Jesters Hse	E	15	none	Likely degrading	500	58	11	-7.979 to 36.26
		5	none	Indeterminate trend	510	59	-5.02	-64.493 to 51.323
Wai-iti @ 400m d-s Waimea W Rd	B	5	none	Very likely improving	50	59	-6.02	-16.949 to 1.086
Waimea @ SH60 Appleby	A	15	loglog	Very likely degrading	15	58	0.902	0.048 to 1.966
		15	none	Very likely degrading	15	59	0.45	0 to 1.503
		5	loglog	Indeterminate trend	21	59	-0.622	-4.205 to 2.742
		5	none	Likely improving	21	59	0	-4.027 to 0.855
Wairoa @ SH6	A	15	none	Insufficient data				
		5	none	Likely degrading	20	59	0	-1.093 to 3.696

Band = attribute band (NPSFM 2020), Flow adj = type of model used for flow adjustment, Median in cfu/100ml, Sen slope and 90% confidence interval in cfu/100ml per year

Table 20: Water Clarity trend results for Takaka and Aorere sites

Site	Band	Years	Flow adj	Trend category	Median	N	Sen slope	90% CI
Aorere @ Le Comte	A	15	loglog	Very likely improving	6.593	55	0.104	-0.028 to 0.259
		15	none	Indeterminate trend	6.593	55	0.031	-0.163 to 0.222
		5	loglog	Indeterminate trend	5.65	55	0.063	-0.219 to 0.339
		5	none	Likely improving	5.625	56	0.309	-0.2 to 0.866
Kaituna @ Sollys Rd	A	15	loglog	Very likely improving	4.3	57	0.228	0.134 to 0.326
		15	none	Very likely improving	4.3	57	0.173	0.035 to 0.302
		5	loglog	Very likely improving	4.12	55	0.333	0.044 to 0.654
		5	none	Very likely improving	4.12	55	0.797	0.3 to 1.221
Kaituna @ Track start	A	15	loglog	Insufficient data				
		15	none	Insufficient data				
		5	loglog	Indeterminate trend	4.25	54	0.024	-0.262 to 0.338
		5	none	Likely improving	4.25	54	0.273	-0.199 to 0.841
Motupipi @ 1.2km u-s Abel Tasman Dr	A	15	gam	Likely improving	6.167	57	0.035	-0.088 to 0.163
		15	none	Likely improving	6.167	57	0.046	-0.111 to 0.183
		5	gam	Likely degrading	8.232	56	-0.331	-0.739 to 0.116
		5	none	Likely degrading	8.232	56	-0.365	-0.836 to 0.096
Onekaka @ Shambala Br	A	15	none	Very likely improving	5.433	57	0.239	0.13 to 0.355
		5	loglog	Indeterminate trend	6.35	51	0.041	-0.36 to 0.424
		5	none	Very likely improving	6.35	51	0.282	-0.02 to 0.733
Powell @ 40m u-s Motupipi Rv	A	15	none	Very likely improving	2.55	56	0.103	0.03 to 0.16
		5	gam	Very likely improving	3.4	55	0.136	-0.011 to 0.325
		5	none	Likely improving	3.305	56	0.09	-0.177 to 0.299
Takaka @ Kotinga	A	15	loglog	Indeterminate trend	8.95	53	0.012	-0.099 to 0.124
		15	none	Very likely degrading	8.95	53	-0.143	-0.285 to 0.023
		5	loglog	Likely improving	8.76	57	0.281	-0.24 to 0.645
		5	none	Indeterminate trend	8.76	57	-0.034	-0.202 to 0.376
Takaka @ Lindsays Br	A	5	loglog	Indeterminate trend	5.7	56	0.097	-0.243 to 0.393
		5	none	Very likely improving	5.7	56	0.425	-0.015 to 0.827

Band = attribute band (NPSFM 2020), Flow adj = type of model used for flow adjustment, Median in metres, Sen slope and 90% confidence interval in metres per year

Table 21: Water Clarity trend results for Motueka and Buller sites

Site	Band	Years	Flow adj	Trend category	Median	N	Sen slope	90% CI
Buller @ Longford	A	15	loglog	Very likely degrading	3.525	176	-0.059	-0.103 to -0.012
		15	none	Very likely degrading	3.525	176	-0.061	-0.149 to -0.002
		5	loglog	Likely degrading	3.44	59	-0.149	-0.406 to 0.068
		5	none	Indeterminate trend	3.44	59	0.08	-0.289 to 0.432
Hunters @ Kikiwa	A	15	none	Very likely degrading	5.033	55	-0.068	-0.161 to 0.008
		5	none	Likely degrading	4.908	56	-0.063	-0.313 to 0.213
Mangles @ 5km u-s Buller	A	5	loglog	Likely degrading	3.528	58	-0.059	-0.272 to 0.126
		5	none	Indeterminate trend	3.528	58	0.016	-0.258 to 0.287
Matakitaki @ SH6 Murchison	D	15	loglog	Very likely degrading	2.55	55	-0.063	-0.14 to -0.005
		15	none	Very likely degrading	2.55	55	-0.165	-0.269 to -0.082
		5	loglog	Very likely degrading	2.105	56	-0.251	-0.417 to -0.081
		5	none	Likely degrading	2.105	56	-0.071	-0.362 to 0.162
Motueka @ Gorge	A	15	loglog	Very likely degrading	11.2	177	-0.083	-0.18 to 0.002
		15	none	Likely degrading	11.2	177	-0.089	-0.225 to 0.051
		5	loglog	Very likely degrading	10.99	58	-0.462	-0.836 to 0.088
		5	none	Likely improving	10.99	58	0.299	-0.416 to 0.963
Motueka @ SH60 bridge	A	15	loglog	Insufficient data				
		15	none	Insufficient data				
		5	loglog	Very likely degrading	3.6	57	-0.311	-0.597 to -0.085
		5	none	Indeterminate trend	3.6	57	0.054	-0.3 to 0.426
Motueka @ Woodstock	A	15	loglog	Indeterminate trend	4.2	176	-0.006	-0.059 to 0.031
		15	none	Indeterminate trend	4.2	176	0.011	-0.055 to 0.064
		5	loglog	Very likely degrading	4.305	57	-0.259	-0.496 to 0.013
		5	none	Very likely improving	4.305	57	0.276	-0.061 to 0.597
Motupiko @ 250m u-s Motueka Rv	A	15	loglog	Likely degrading	5.8	58	-0.047	-0.145 to 0.047
		15	none	Likely improving	5.8	58	0.073	-0.11 to 0.221
		5	loglog	Likely degrading	6.23	55	-0.088	-0.449 to 0.216
		5	none	Very likely improving	6.23	55	0.791	0.233 to 1.334
Murchison Ck @ 20m u-s SH6	C	15	none	Likely degrading	1.232	54	-0.006	-0.037 to 0.019
		5	none	Very likely improving	1.125	56	0.12	-0.013 to 0.168
Riuwaka @ Hickmotts	A	15	loglog	Likely improving	4.25	54	0.021	-0.05 to 0.077
		15	none	Likely degrading	4.25	54	-0.024	-0.12 to 0.055
		5	loglog	Indeterminate trend	4.3	58	0.037	-0.242 to 0.24
		5	none	Likely improving	4.3	58	0.245	-0.078 to 0.537
Sherry @ Blue Rock	A	15	loglog	Likely improving	2.5	53	0.027	-0.018 to 0.076
		15	none	Very likely improving	2.467	58	0.056	-0.003 to 0.109
		5	loglog	Likely degrading	3.017	57	-0.089	-0.255 to 0.09
		5	none	Likely improving	3.017	57	0.141	-0.077 to 0.351
Wangapeka @ 5km u-s Dart	A	15	loglog	Likely degrading	8.31	57	-0.043	-0.164 to 0.056
		15	none	Likely degrading	8.31	57	-0.061	-0.204 to 0.095
		5	loglog	Very likely degrading	8.7	55	-0.835	-1.33 to -0.477
		5	none	Likely degrading	8.7	55	-0.229	-0.669 to 0.111

Band = attribute band (NPSFM 2020), Flow adj = type of model used for flow adjustment, Median in metres, Sen slope and 90% confidence interval in metres per year

Table 22: Water Clarity trend results for Waimea and Moutere sites

Site	Band	Years	Flow adj	Trend category	Median	N	Sen slope	90% CI
Borck @ 400m ds Queen St	A	15	none	Likely degrading	1.405	48	-0.021	-0.073 to 0.023
		5	none	Likely improving	1.472	56	0.064	-0.097 to 0.208
Lee @ Meads Br	A	15	loglog	Very likely degrading	8.283	56	-0.102	-0.243 to 0.011
		15	none	Very likely degrading	8.283	56	-0.147	-0.319 to 0
		5	loglog	Likely improving	6.7	58	0.096	-0.225 to 0.452
		5	none	Likely improving	6.7	58	0.155	-0.332 to 0.613
Moutere @ Riverside	A	15	loglog	Insufficient data				
		15	none	Insufficient data				
		5	loglog	Likely improving	2.76	57	0.161	-0.063 to 0.393
		5	none	Very likely improving	2.76	57	0.421	0.166 to 0.704
Neimann Ck @ 600m us Lansdowne Rd	A	15	loglog	Insufficient data				
		15	none	Insufficient data				
		5	none	Indeterminate trend	8.933	58	0.091	-0.491 to 0.612
Reservoir Ck @ 20m d-s Salisbury Rd	A	15	none	Likely degrading	2.392	58	-0.019	-0.078 to 0.042
		5	loglog	Likely degrading	1.9	57	-0.084	-0.267 to 0.08
		5	none	Likely improving	1.9	57	0.044	-0.138 to 0.258
Tasman @ u-s Jesters Hse	A	15	loglog	Likely improving	1.225	58	0.012	-0.009 to 0.037
		15	none	Indeterminate trend	1.225	58	0.004	-0.03 to 0.036
		5	loglog	Very likely degrading	1.35	57	-0.085	-0.17 to 0.004
		5	none	Very likely improving	1.35	57	0.088	0 to 0.212
Wai-iti @ 400m d-s Waimea W Rd	A	5	loglog	Indeterminate trend	6.65	56	-0.044	-0.605 to 0.326
		5	none	Very likely improving	6.7	57	0.346	-0.073 to 0.836
Waimea @ SH60 Appleby	A	15	loglog	Indeterminate trend	6.8	58	-0.037	-0.199 to 0.112
		15	none	Indeterminate trend	6.8	58	0.029	-0.129 to 0.231
		5	loglog	Likely degrading	6.05	57	-0.294	-0.692 to 0.123
		5	none	Likely improving	6.05	57	0.075	-0.309 to 0.564
Wairoa @ SH6	A	15	none	Insufficient data				
		5	loglog	Very likely degrading	6.6	57	-0.356	-0.765 to 0.054
		5	none	Indeterminate trend	6.6	57	-0.083	-0.558 to 0.386

Band = attribute band (NPSFM 2020), Flow adj = type of model used for flow adjustment, Median in metres, Sen slope and 90% confidence interval in metres per year