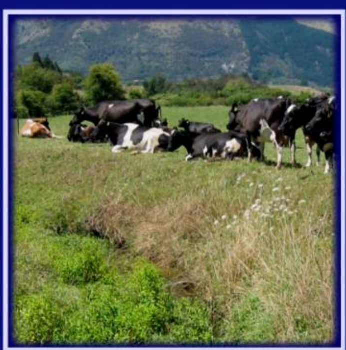
State of the Environment Report

# River Water Quality in Tasman District

# 2015



## State of the Environment Report

# River Water Quality in Tasman District 2015

**Document Status:** Final

A technical report presenting results of the Tasman District Council's 'State of the Environment' River Water Quality Monitoring Programme and additional data from the National River Water Quality Network. Indicators measured include: physical, chemical, and bacteriological characteristics of the water, macroinvertebrate indices and periphyton cover. The report highlights water quality condition and trends, from the Waimea, Motueka, Takaka, Aorere and Buller water management areas.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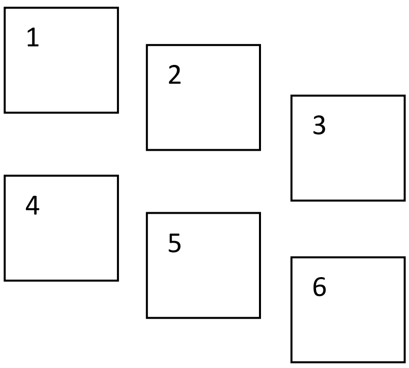
**Cover photos:**

1. Claire Webster at the Aorere River
2. Koura from Dall Ck, Golden Bay
3. Jimmy Lee Ck, Washbourne Gardens
4. Mouth of the Motueka River
5. McConnon Ck, Golden Bay
6. Bathers at the Lee River Reserve

Photos taken by Trevor James and Jonathan McCallum.



# Contents

# Aorere Water Management Area

This area covers the whole of the Aorere catchment, Parapara, and north to Puponga and west to Westhaven Inlet south to Kahurangi Point (Figure 1). As of 2015, a 'Freshwater Management Unit' (FMU) under the 'National Policy Statement for Freshwater Management' has not yet been formally set up for this area. Like the Takaka and Waimea FMU's that have been operating from 2014, there will be a collaborative governance group from the community tasked with making recommendations for limits on water quality and quantity.

There were five core River Water Quality sites monitored between 2010 and 2014 (Figure 1). There was one reference site at the Kaituna River, 500 m up stream of the start of the Track.

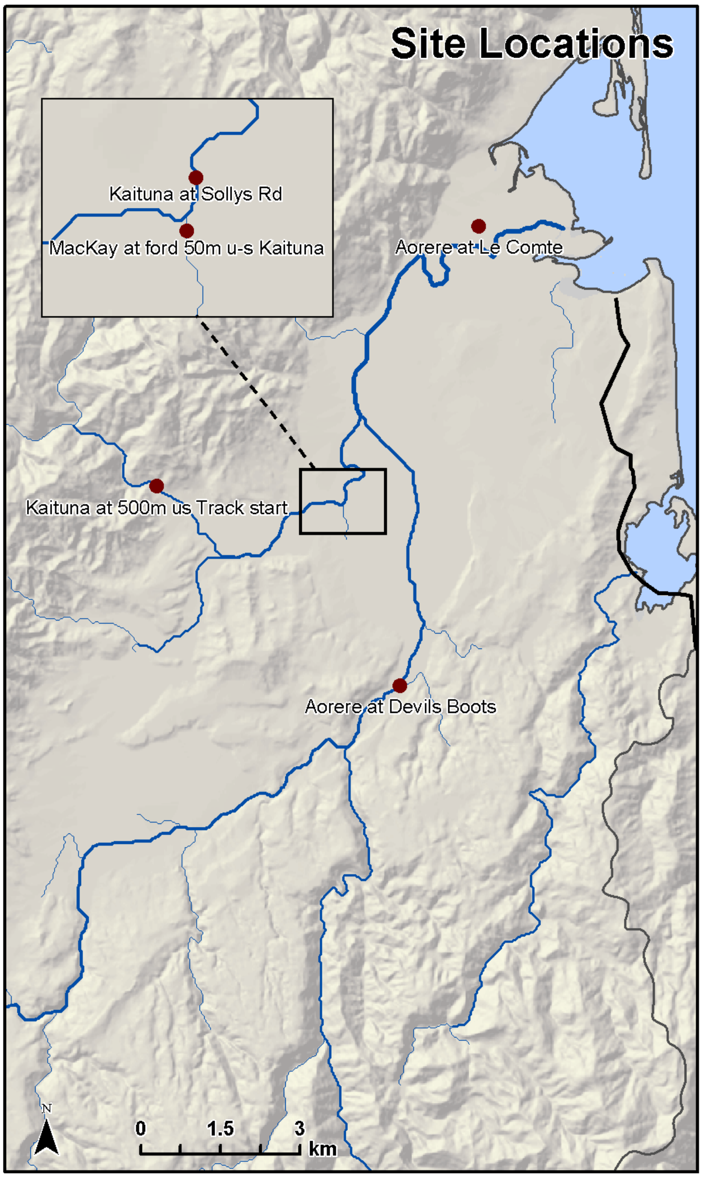



**Figure 1. River Water Quality sites in the Aorere Water Management Area**

## Discussion of Specific Catchments/Areas

This section describes the more **notable aspects of water quality in a given catchment, actions taking place, and recommendations** for further action.

The key to the colour-coding for each water quality attribute state (A to D) is shown to the right. The cut-offs used for each attribute are shown in Table 1.

The dataset used to determine the attribute states was collected at base-flow over the period from 2010-2014 unless a comment is made otherwise. White (no colouring) indicates there are no data available to determine the attribute state.

| **Attribute State** |
|---|
| A (Excellent) |
| B |
| C |
| D (Poor) |

Trends in water quality attributes are reported if they are statistically significant (p-value<0.05) and ecologically meaningful (RSKSE>1%). An increasing trend can have a positive or negative effect on the stream ecosystem, depending on the attribute. To indicate the ecosystem effect of the trend, we have used a smile symbol (☺) for improving trends and a frown symbol (☹) for degrading trends.

**Table 1. Numerical attribute states for each water quality attribute for the protection of river ecosystem health, aesthetics, and human health. Attributes highlighted in blue are included in the National Policy Statement for Freshwater Management (NPSFM 2014).**

| Attribute | Statistic | Units | Attribute State | | | | Source |
|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | |
| Water clarity | Single measurement | m | ≥5 | 3 - 5 | 1.6 - 3 | <1.6 | - |
| Turbidity | Single measurement | NTU | ≤5.6 | >5.6 | N/A | N/A | ANZECC & ARMCANZ (2000) |
| Resuspendable solids | Shuffle score (1 to 5) | N/A | 1 | 2 | 3 | ≥4 | - |
| Dissolved oxygen concentration | 7-day mean minimum | $g/m^3$ | ≥8 | 7 - 8 | 5 - 7 | <5 | NPSFM (2014) |
| | Lowest 1-day minimum | $g/m^3$ | ≥7.5 | 5 - 7.5 | 4 - 5 | <4 | |
| Water Temperature | Midpoint of daily mean and daily maximum | °C | ≤18 | 18 - 20 | 20 - 24 | >24 | Davies-Colley et al. (2013) |
| pH | Single measurement | N/A | 6.5 - 8.5 | 5 - 6.5, 8.5 - 9 | >5 or >9 | N/A | - |
| Ammonia-N | Annual median | $g/m^3$ | ≤0.03 | 0.03 – 0.24 | 0.24 - 1.3 | >1.3 | NPSFM (2014) |
| | Annual maximum | $g/m^3$ | ≤0.05 | 0.05 - 0.4 | 0.4 - 2.2 | >2.2 | |
| Nitrate-N | Annual median | $g/m^3$ | ≤1.0 | 1.0 - 2.4 | 2.4 – 6.9 | >6.9 | NPSFM (2014) |
| | Annual 95$^{th}$ percentile | $g/m^3$ | ≤1.5 | 1.5 - 3.5 | 3.5 - 9.8 | >9.8 | |
| Dissolved reactive phosphorus | Single measurement | $g/m^3$ | <0.01 | ≥0.01 | N/A | N/A | ANZECC & ARMCANZ (2000) |
| E. coli | Annual median | CFU/100 ml | ≤260 | 260 - 540 | 540 - 1000 | >1000 | NPSFM (2014) |
| | 95$^{th}$ percentile | CFU/100 ml | ≤260 | 260 - 540 | 540 - 1000 | >1000 | |
| Macroinvertebrates | MCI | N/A | ≥120 | 100 - 120 | 80 - 100 | <80 | Stark & Maxted (2007) |
| | SQMCI | N/A | ≥6 | 5 - 6 | 4 - 5 | <4 | |
| Phormidium | Percentage cover | % | <20 | ≥20 | N/A | N/A | MfE (2009) |
| Filamentous green algae | Percentage cover | % | <10 | 10-19 | 20-29 | >30 | Biggs and Kilroy (2000) |
| Periphyton | Periphyton score (1 to 10) | N/A | ≥8 | 6 - 8 | 5 - 6 | < 5 | - |

## How to read a site summary

The site summaries in this report are based on data collected quarterly (monthly for selected sites) from 2010-14, with two exceptions: (1) macroinvertebrate community index values were from 2011-2015 and (2) dissolved oxygen measurements were taken over several days in a summer period from 2005-2015.

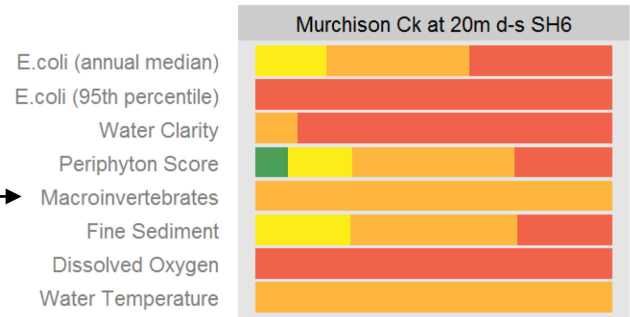
The rows of a site summary represent water quality attributes. The colours indicate attribute states **A** (very good), **B** (good), **C** (fair) **D** (poor).

Proportion of periphyton scores in each attribute state.

Proportion of water clarity measurements (m) in each attribute state.

Attribute state for the 95th percentile *E. coli* concentration. Minimum 10 samples.

Attribute states for the annual median *E. coli* concentration. No minimum sample size.




Proportion of macroinvertebrate community index (MCI) values in each attribute state.

Attribute state for the highest midpoint of daily mean and daily maximum temperature from a continuous record.

Attribute state for the mean minimum dissolved oxygen concentration over 3 or more days during summer. For sites with fewer than 3 days of continuous measurements, the 1-day minimum value was used.

Proportion of resuspendable solids (fine sediment) scores in each attribute state.

## Water Clarity

Over the five-year reporting period, approximately 75% of water clarity records at the two Aorere River sites were 'excellent' (Figure 2). In contrast, Kaituna at 500 m u-s Track start had less than 25% of water clarity records in the 'excellent' state. Even though this site has no human land use upstream (i.e. a good reference site) it has relatively poor water clarity due to natural tannin staining from the leaf litter. Approximately 25% of water clarity records at this site were in band C (1.6 to 3 m). Also in band C were more than 30% of water clarity records for at Kaituna at Sollys Rd and MacKay at ford 50 m u-s Kaituna.

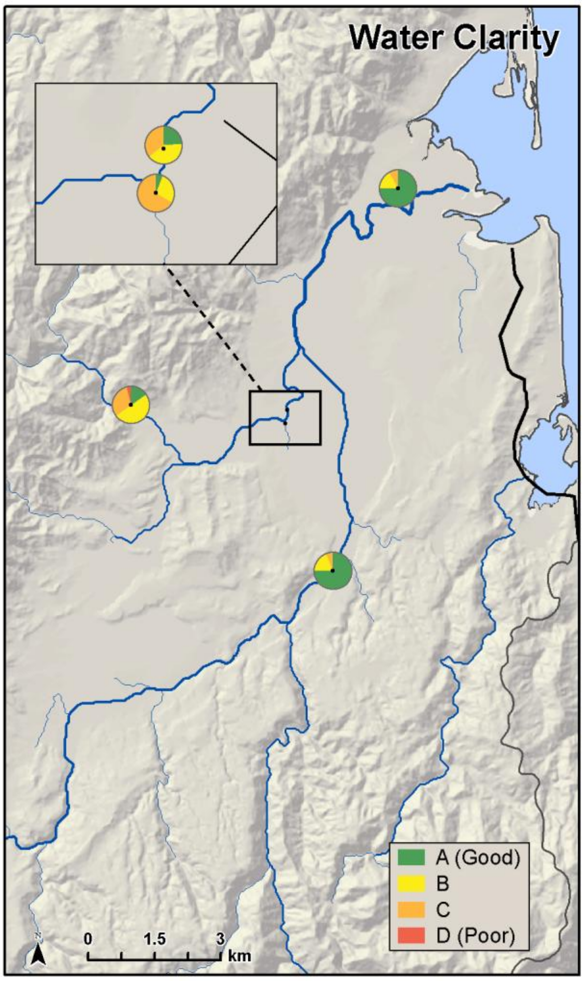



**Figure 2. Proportion of water clarity records in each attribute state (A to D) for river water quality sites in the Aorere Water Management Area (sites shown have a minimum of 10 records).**

## Disease-causing organisms

For all core sites, annual median *E. coli* concentrations were better than the National Bottom Line of 1000 *E. coli* per 100 ml (NPSFM, 2014; Figure 3). However, some tributaries investigated in the catchment have recorded annual medians over this bottom line (e.g. Clay Creek). In 2014, MacKay at ford 50 m u-s Kaituna had a median *E. coli* concentration exceeding the guideline value for contact recreation (540 *E. coli*/100 ml). While this site is not known as a contact recreation (swimming) site, swimming is an important local value for the Kaituna River not far downstream from the confluence of Mackay Creek.

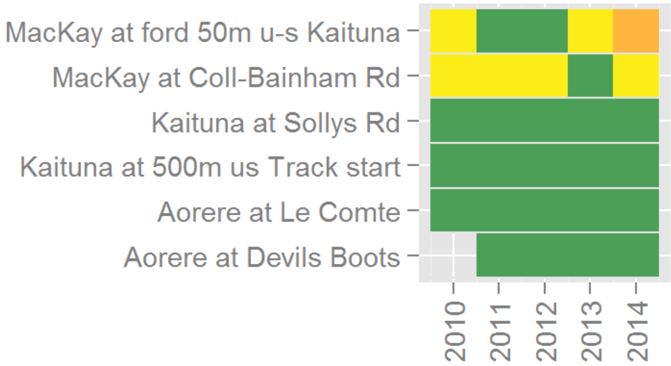



**Figure 3. Tile plot of annual median *E. coli* values for sites in the Aorere Water Management Area. Colours indicate attribute states A (green), B (yellow), C (orange) and D (red). Annual median values were calculated for sites with three or more records in a given year.**

## Filamentous Green Algae Cover & Periphyton Score

With a few exceptions, sites in the Aorere Water Management Area had A scores for filamentous green algae cover (less than 10% cover; Figure 4). Kaituna at Sollys Rd had three records of filamentous green algae in the D band (greater than 50% coverage). Aorere at Le Comte had high cover of filamentous green algae only on one occasion (during Spring 2013 after a period of dry weather). A similar pattern was seen in the periphyton scores[1] (Figure 4). That is, most sites had periphyton scores above 7 (in the A or B bands) but Kaituna at Sollys Rd and Aorere at Le Comte recorded two periphyton scores less than 5 (band D). These two findings, high filamentous green algae cover and low periphyton scores, indicate poorer water quality at Kaituna at Sollys Rd and Aorere at Le Comte compared to the other sites in the Aorere catchment.

Macro-algae cover in the Ruataniwha Inlet is low (Stevens and Robertson, 2015).

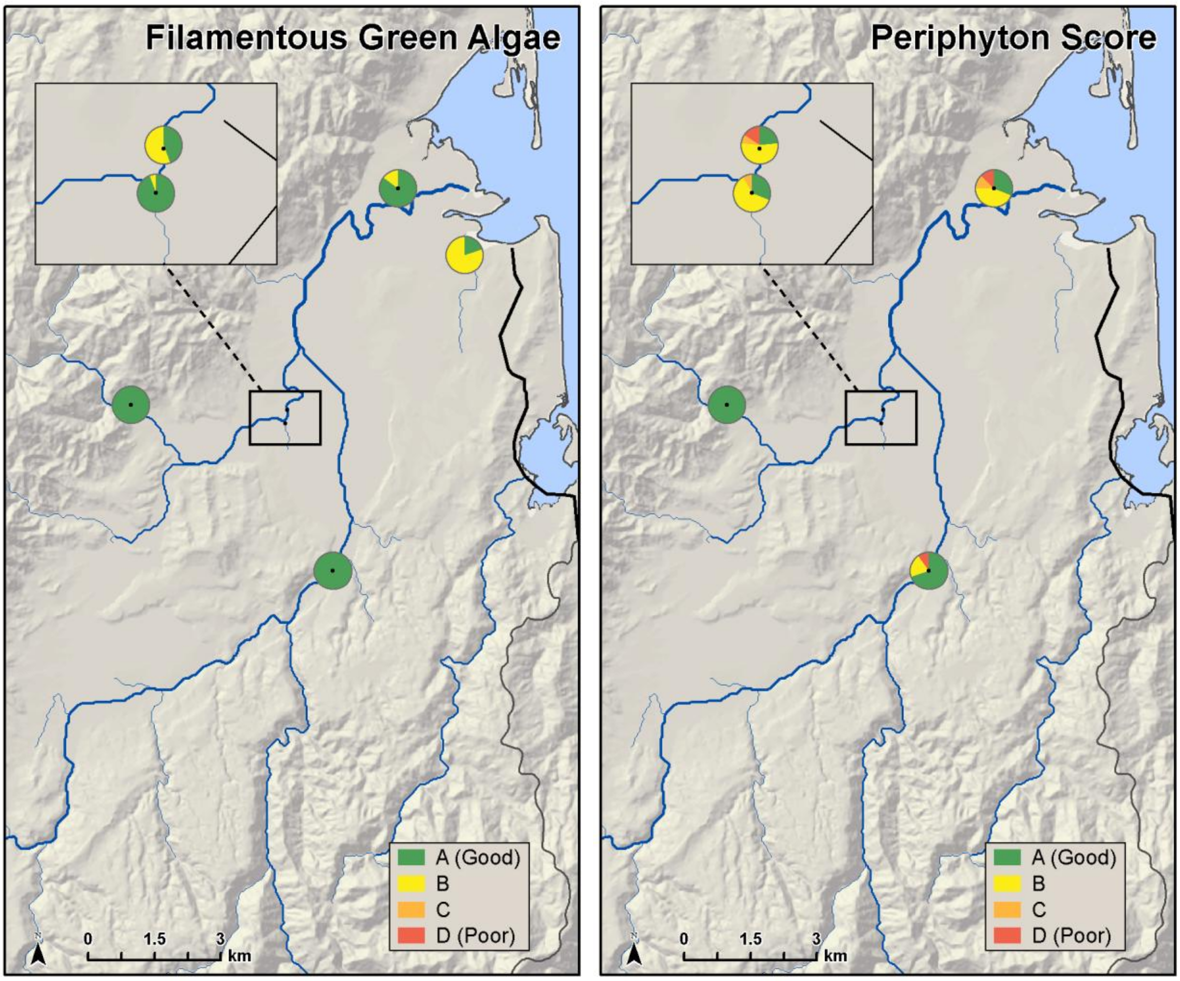



**Figure 4. Coverage of filamentous green algae greater than 2cm in length (left) and periphyton community score (right) for sites in the Aorere Water Management Area. Pie charts show the proportion of estimates in each attribute state (A to D) for sites with 10 or more observations (2010 to 2014 data).**

[1] Rapid Assessment Method 2, NZ Periphyton Monitoring Manual, 2000.

## Nutrients

For the 2010-15 monitoring period nutrient data, apart from ammonia, were only available for Aorere at Le Comte (this is considered the 'sentinel site' for the catchment and to determine loading to the coast; other sites aren't sampled as nutrients are so seldom an issue in the catchment). **Nutrient concentrations were low** at the **Le Comte site,** (annual median nitrate concentrations and annual median ammonia concentrations were consistently in the A band (less than 1 $g/m^3$ and less than 0.03 $g/m^3$, respectively; Figure 5)). Dissolved reactive phosphorus concentrations were satisfactory at Le Comte (less than 0.01 $g/m^3$) except for one record in Winter 2014 (0.02 $g/m^3$; Figure 6). The only streams where nutrients have been found to be a concern are those draining catchments with large proportions in pakihi soils such as **Burton Ale and James Cutting Creeks** where there were consistently **dissolved reactive phosphorus concentrations five times guidelines**. The mass load of nutrients from the Aorere to the coastal marine area is only 10% of that coming from Cook Straight. This means that the load from the Aorere would have to be 5-10 times higher and sustained to make much of a difference (Paul Gillespie, pers.com.).

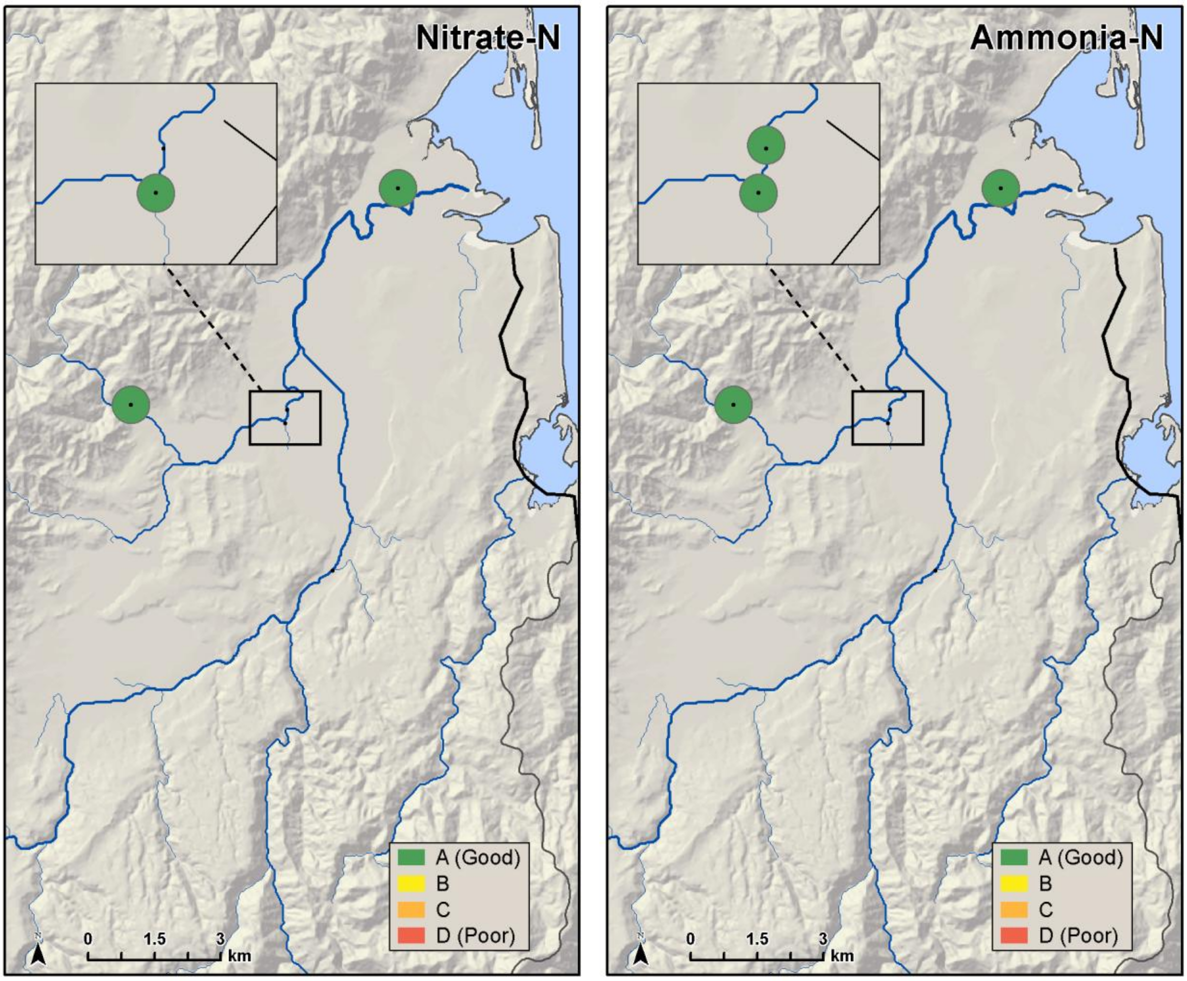



**Figure 5. Nitrate (left) and ammonia (right) concentrations for sites in the Aorere Water Management Area. Pie charts show the proportion of annual medians in each attribute state (A to D) for 2010-15.**

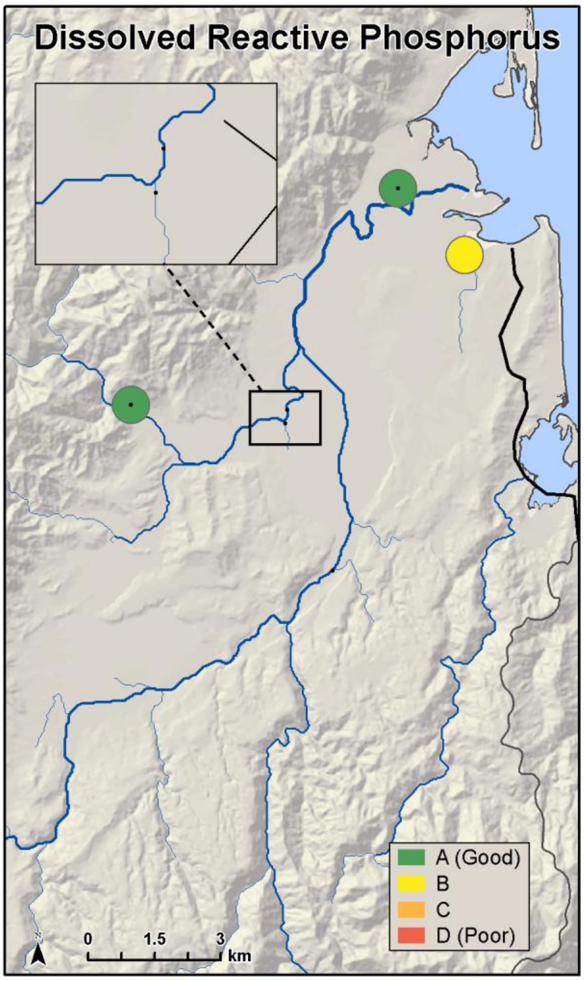



**Figure 6. Dissolved reactive phosphorus concentrations for sites in the Aorere Water Management Area. Pie charts show the proportion of records in each attribute state (A to D) for 2010-15.**

## Resuspendable sediment

At least 75% of resuspendable solids scores were in attribute state A for four out of five sites (Figure 7). The remaining site was MacKay at ford 50 m u-s Kaituna. This site had resuspendable solids scores in attribute states A to C. Data were not collected for volumetric SBSV in this catchment. The soft mud coverage of the Ruataniwha Inlet appeared to have increased from 12.9% to 18.5% between 2000-2015 with the 700 ha area of unvegetated intertidal habitat (Stevens and Robertson, 2015).

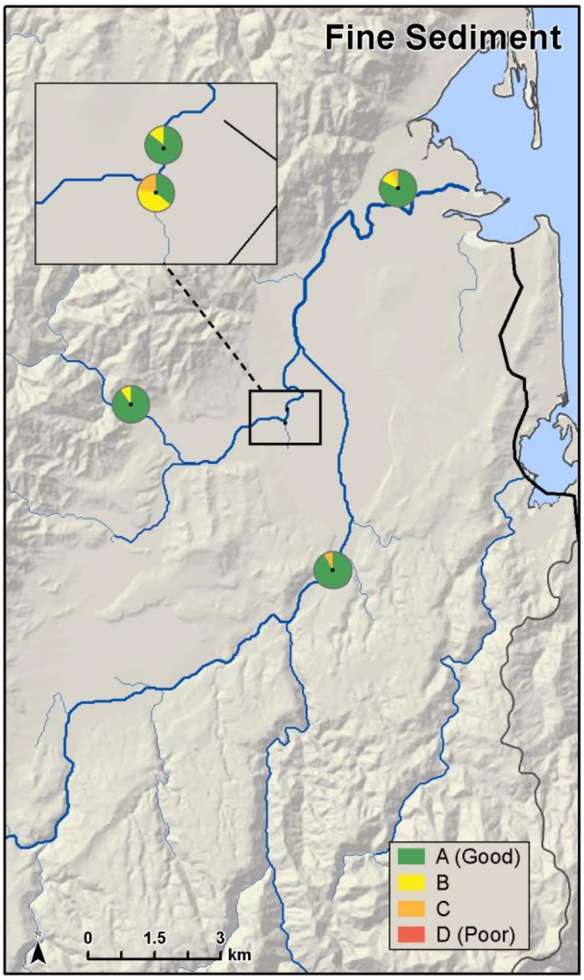



**Figure 7. Proportion of resuspendable solids scores in each attribute state (A to D) for sites in the Aorere Water Management Area.**

## Macroinvertebrate Community

Based on MCI scores, the **invertebrate community was 'excellent' at Aorere at Le Comte and Kaituna at Sollys** (MCI greater than 119); Note: these are the only two sites in the Aorere Water Management Area with at least three recorded macroinvertebrate samples; Figure 8). The SQMCI scores, however, shifted from 'excellent' to 'poor' for Aorere at Le Comte and 'excellent' toward 'fair' for Kaituna at Sollys Rd in recent years. After 2005 at the Kaituna site there were notable reductions in sensitive macroinvertebrate taxa (particularly *Deliatidium* and *Helicopsyche*) while there were marked increases in pollution-tolerant taxa (snails (*Potamopyrgus*), true flies (*Orthoclad* and *Aphrophila*), axe-head caddisflies (*Oxythira*)).

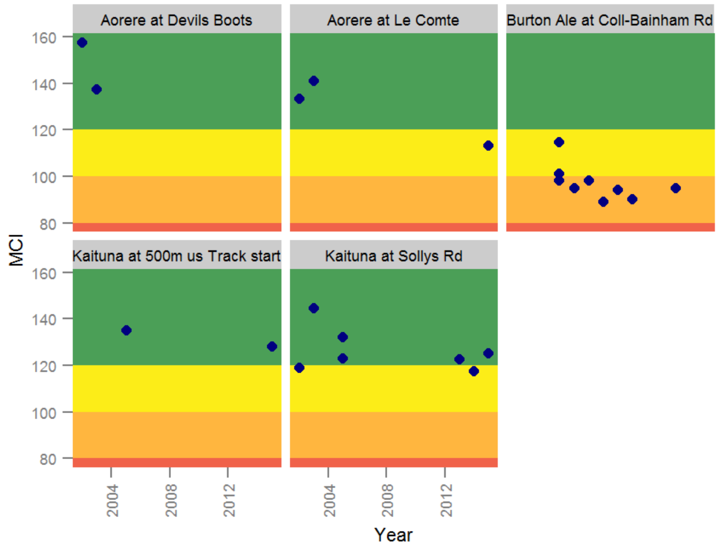
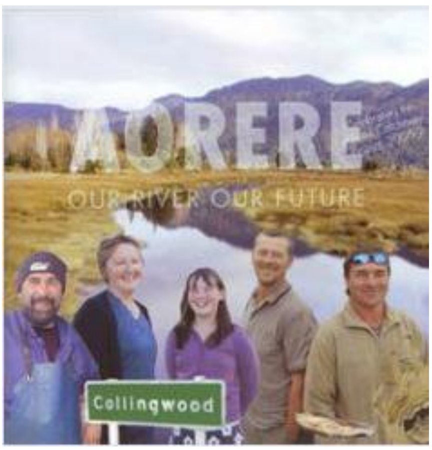



**Figure 8. Macroinvertebrate community index (MCI) scores between 2001 and March 2015 for sites in the Aorere Water Management Area (blue dots). The background colours indicate these quality classes: excellent (green), good (yellow), fair (orange) and poor (red).**

**The Aorere Catchment Project**
**One of the biggest efforts to improve water quality in Tasman**

The Aorere catchment project was a community-led initiative supported by Landcare Trust that began in 2005. Farm environmental plans were developed for 24 farms of the 35 farms in the catchment. These plans provide advice on the appropriate actions for a particular farm and prioritise them in order to maximise the benefits of actions in the initial phases. Fencing off dairy cows from streams was completed in the catchment by 2013 and between 2006 and 2014 over 23,000 plants were established by the Golden Bay Streamcare Group. Over $1.6 million was invested in on-farm best management practices (www.landcare org.nz/ArorereProject).



## Paired Site Differences

*This section compares the difference (increase or decrease) between two sites on a particular waterway on a particular day. The differences are then averaged to get the “mean difference”. It is not the difference of the mean from each site calculated from the whole record for one site with the mean from the whole record from other site.*

Kaituna at Sollys Rd was paired with Kaituna at 500 m u-s Track start (reference site). Comparisons between these sites revealed two main differences (Figure 9). First, *E. coli* concentrations at Sollys Rd were higher than the reference site (mean increase = 148 *E. coli*/100 ml, SD = 195, n = 19, comparing each site on each sampling event). This difference would be expected even with best practice followed on each farm. The concentration of *E. coli* was more than 50 times higher on three sampling occasions. Second, the resuspendable solids scores were higher at Sollys Rd compared to the reference site (mean increase = 0.7, SD = 0.6, n = 10). A higher resuspendable solids score indicates higher fine sediment deposition.

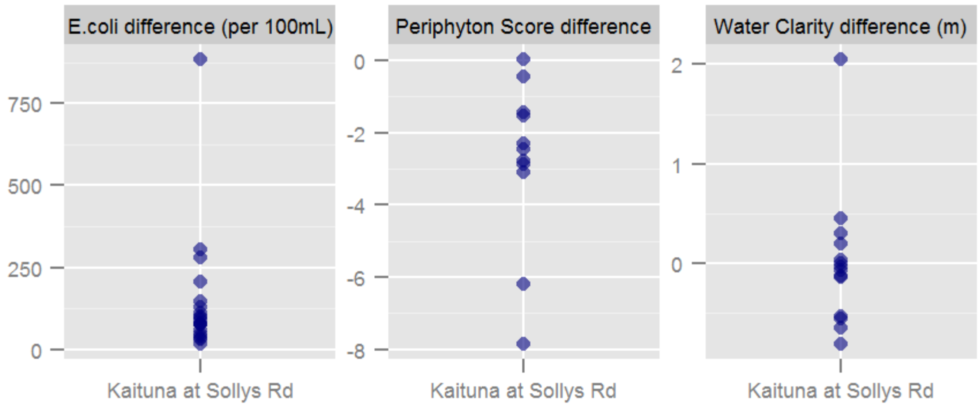



**Figure 9. Difference between Kaituna at 500 m u-s Track start (upstream) and Kaituna at Sollys Rd (downstream) for water quality data collected at both sites on the same day. A positive difference means the downstream site had a higher value than the upstream site.**

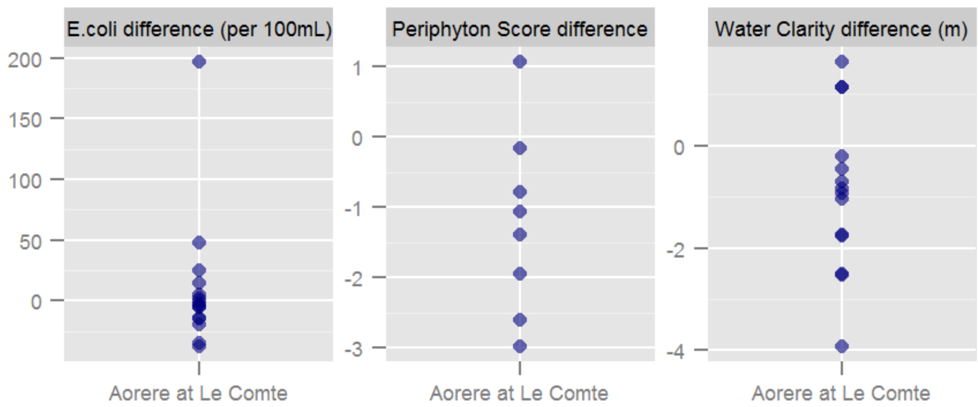



**Figure 10. Difference between Aorere at Devils Boots (upstream) and Aorere at Le Comte (downstream) for water quality data collected at both sites on the same day. A positive difference means the downstream site had a higher value than the upstream site.**

## Trends in the Aorere Water Management Area

For sites in the Aorere Water Management Area, there were no trends in *E. coli* or water clarity over the past 10 years or over the full record. There was an improvement in dissolved reactive phosphorus and Ammonia-N concentrations at the Aorere at Le Comte site. At the same site, however, there was an indication of degrading Nitrate-N concentrations (Table 2).

**Table 2. Water quality trend results for sites in the Aorere Water Management Area over the 10-year period 2005 to 2014 (highlighted in blue) and over the full record (from 15 to 26 years depending on the site). Seasonal Kendall trend tests were used for *E. coli* concentrations, water clarity measurements and nutrient concentrations (Ammonia-N, Nitrate-N and DRP). The trends shown are significant ($p < 0.05$), meaningful (RSKSE > 1% per year) and the change in value between the start and end of the trend line is greater than the detection limit for the attribute (refer to the Methods sections for the detection limits). Statistics are shown in the Appendices.**

| Site name | Attribute | Effect ☺ ☹ | N obs | N years |
|---|---|---|---|---|
| Aorere at Le Comte | Ammonia-N | ☺ | 62 | 15 |
| Aorere at Le Comte | DRP | ☺ | 61 | 15 |
| Aorere at Le Comte | Nitrate-N | ☹ | 45 | 10 |
| Kaituna at Sollys Rd | Ammonia-N | ☺ | 36 | 10 |

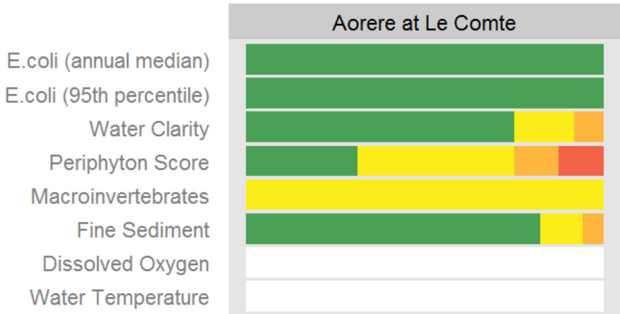
## Aorere Catchment, near Collingwood

### Main Stem Aorere River

There are two long-term monitoring sites on the Aorere River, Le Comte (which is near the bottom of the catchment, just upstream of the saline influence) and Devils Boots (which is influenced by about half the farmed area compared to Le Comte). The river exits into the Ruataniwha estuary (1610 ha) which is listed as being nationally important.

**Aorere Rv at Le Comte (February 2005).**

A large amount of effort to improve water quality has been undertaken, particularly by dairy farmers in this catchment. This effort has been acknowledged nationally.




**Site data summary plot. Colours indicate attribute states from A (good) to D (poor).**
**Refer to the interpretation guide for full details.**

With 80% of the Aorere catchment in native forest there is a lot of clean water to provide dilution for any contaminants running off the remaining land. Despite this, the level of **faecal indicator bacteria during rainfall events** can be **moderate to high**. However, base flow concentrations of faecal indicator bacteria are low (median for 2011-15: 32 *E. coli*/100 ml; compared to 39 *E.coli*/100 ml for the previous 10 years). Just over 10% of samples exceeded the 260 *E.coli*/100 ml alert guideline for contact recreation. The trend in *E.coli* is not statistically significant (p=0.18) (Figure 11).

In 2005 faecal contamination became a significant issue for the shellfish farming industry. This may have been the case since the marine farms were established but increased monitoring showed this more definitely. The bathing area near the Collingwood boat ramp also relatively frequently breached guidelines (for contact recreation).

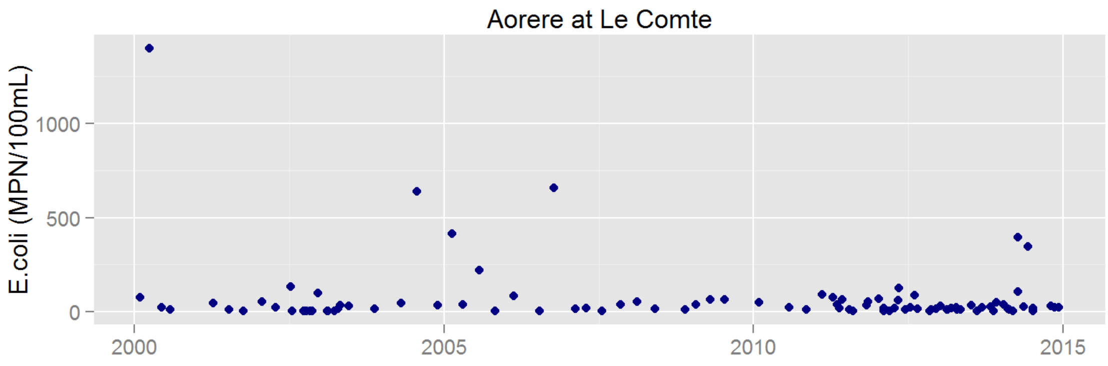



**Figure 11. Concentration of *E. coli* from 2000 to 2015 at Aorere at Le Comte**

In a flood in September 2000 *E.coli* concentrations were shown to peak about five hours prior to the flow peak with a total loading over the 10 hour flood of over 40,000 *E.coli* (Figure 12). The separation of the *E.coli* and flow peak also indicates a contaminant source within 5-10 kilometres of the monitoring site. Given the rainfall intensity was less than 10mm/hour during this storm it is unlikely that much of the contribution of *E.coli* was from paddock run-off, but more likely to be run-off from hard surfaces such as races and yards as well as re-suspension of fine sediment in the stream bed. Although this data is relatively old it is still provides relevant information on the impacts expected in Golden Bay today. This is because land use and cow numbers have remained similar (Robertson & Stevens 2008). However, it would be expected that peak concentrations and total loading will be reduced through excluding stock from waterways via improved base flow water quality and a reduced reservoir of disease-causing organisms in stream beds.

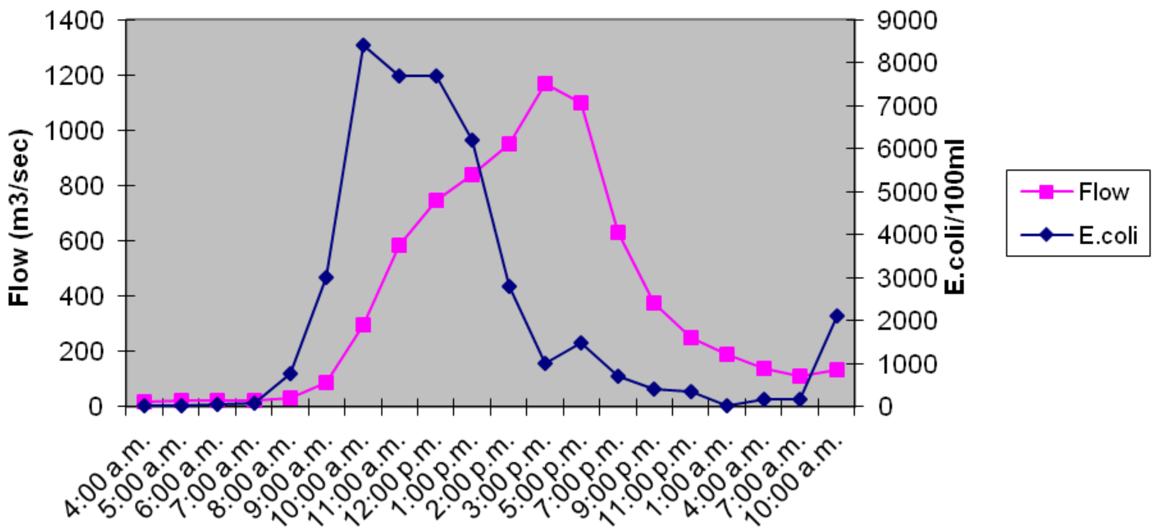



**Figure 12.** ***E.coli*** **versus flow at Aorere River at Devils Boots (28 – 29 Sep 2000). Nottage 2001.**

Dairying was identified as a significant contributor (53%) to faecal contamination with an estimated annual total load of faecal coliforms of 2 x $10^{16}$/year (Robertson & Stevens 2008). Sheep and beef farming were estimated to contribute 42% of faecal load (assuming this land use covers the same area as dairying). Black swan contribute a faecal bacteria load estimated at 0.9% (based on 10,000 swans resident all year round) with human sewage 0.09%. It would be useful to repeat this survey now that there has been so much improvement in farm practice.

The dairy farming community responded very proactively and with Landcare Trust formed the Aorere Catchment Group. This was largely in response to mussel farms in the coastal area only a few kilometres off the river mouth. Mussel farm harvesting rates have ranged from 60% to 95% (check with MSQP) of the time over the past 5 years, compared to as low as 28% of the time in 2005 (Figure 13). Despite the improvements in farm management practices in the Catchment, trends in *E.coli* are not apparent at the Aorere at Le Comte site since 2000 when monitoring started at quarterly frequency (at base flows) or since monthly sampling began in 2011 (all flows). Quarterly sampling during baseflow conditions (which occurs at all sites, except Le Comte since 2011) does not capture storm related events, where most contaminants would be liberated and where the greatest improvements are most likely to be observed.

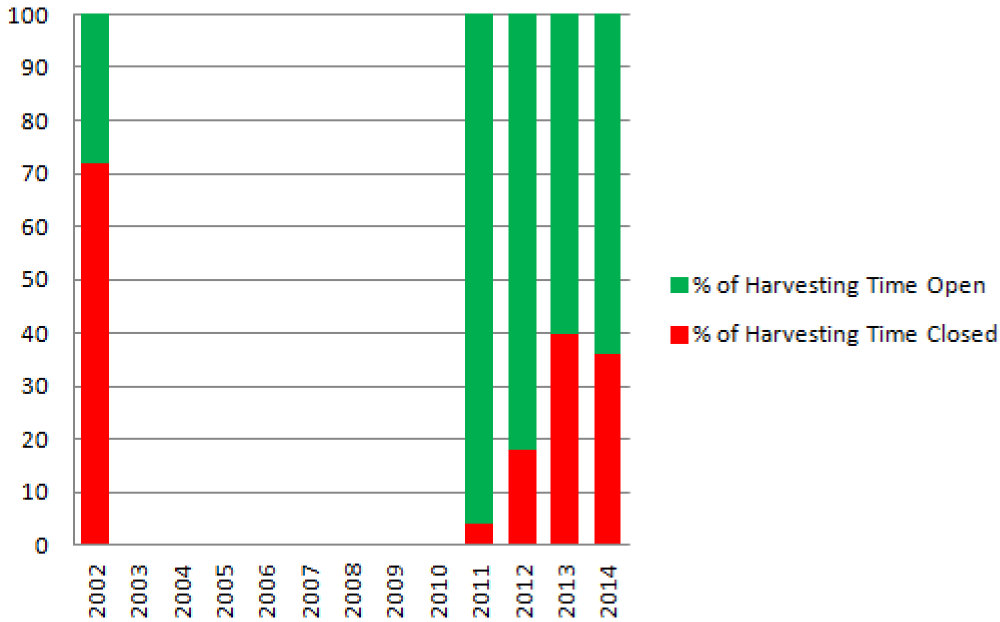



**Figure 13. Proportion of harvesting time that the Collingwood mussel farms are closed due to water quality issues.**

Over this period there has be significant focus on dairy effluent treatment systems, particular with respect to increasing effluent storage to allow disposal in more suitable weather. **Rainfall in the Aorere Valley is high** (2.5-3.0 m annually in the lower valley and up to 5 m during some years in the upper valley). This makes intercepting and treating effluent discharged to pasture difficult.

The **total suspended solid load** from the Aorere River to the coast is considered low-moderate when compared across New Zealand (measured at 46,876 tonnes SS/yr) but the specific yield of suspended solids is around average for NZ rivers (607 kg/ha/yr) (Nottage 2001). A moderate flood over the period 28 – 29 September 2000 saw 2430 tonnes of sediment pass the Devils Boots monitoring site in just 28 hours (compared to 9 ton for stable low flows).

The Aorere River currently has moderately low levels of nutrients. However, nitrate concentrations are increasing (Figure 15). With dissolved reactive phosphorus at Le Comte decreasing (Figure 14), it suggests that sediment discharges from farms are improving. **Nutrient loads to Golden Bay are relatively low** (total nitrogen load to the coast is predicted to be low (440T/year) (Robertson and Stevens, 2007).

Sampling by Nottage in 2000 showed **very good macroinvertebrate condition** at Le Comte (MCI 140, QMCI 7.8, # taxa 9; mean of 3 samples) and 11 other sites around the catchment (MCI range: 158-139, QMCI range: 8.3-6.8, # taxa range: 8.7-15.6). This compared well to the reference site on the Aorere at 900 m downstream Brown River (MCI 158, QMCI 8.0, # taxa 9.6; mean of 3 samples). The limited macroinvertebrate sampling in the Aorere River at Le Comte as part of the RWQMP also shows good water quality (the most recent sample is an exception and further sampling is required to confirm if this is a downward trend. The sampling frequency has been lower at this site because it was felt that land uses in the catchment are less likely to adversely affect the river given the high dilution, allowing resources to be diverted to other sites.

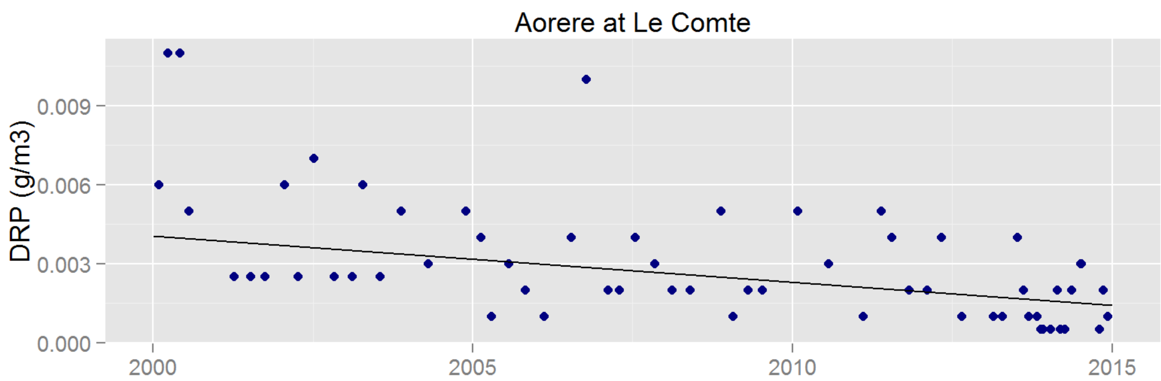



**Figure 14. Aorere at Le Comte dissolved reactive phosphorus (DRP) concentration data with 15-year trend line (p < 0.0001, RSKSE = -7.0% per year). There was no significant meaningful trend over the most recent 10 years of the record.**

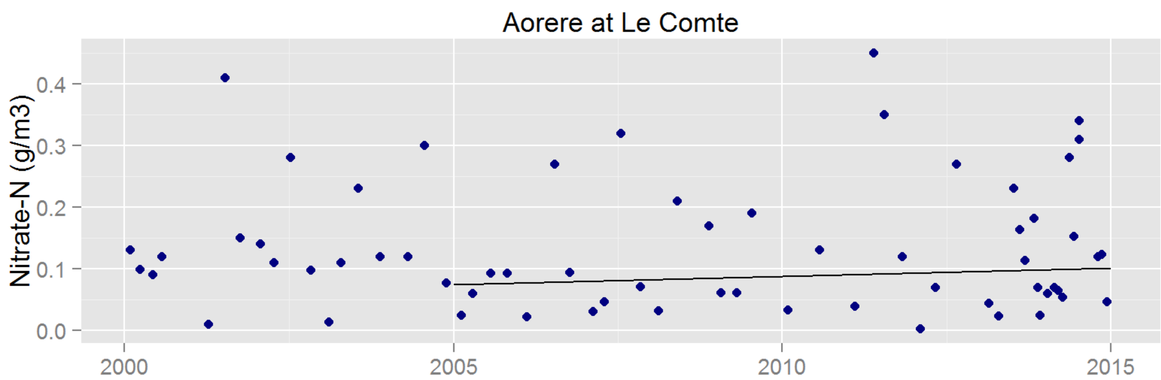



**Figure 15. Aorere at Le Comte Nitrate-N concentration data with 10-year trend line (p = 0.0245, RSKSE = 2.9% per year). There was no significant meaningful trend over the full record (15 years).**

**Aorere Rv at Devils Boots (February 2005)**

| | **Devils Boots** | **Le Comte** |
|---|---|---|
| **River Environment Class** | Cool Extremely Wet<br>Hard sedimentary<br>Indigenous forest<br>Low gradient | Cool Extremely Wet<br>Hard sedimentary<br>Indigenous forest<br>Low gradient |
| **Catchment area ($km^2$)*** | 561 | 681 |
| **Predominant land use upstream** | | 80% native forest<br>16 % agriculture (11,000-13,500 dairy cows in the catchment)<br>3 % scrub<br>1 % exotic forestry |
| **Mean annual rainfall (mm)** | 2490 | |
| **Mean flow (l/sec)** | 69,274 | |
| **Median flow (l/sec)** | 31,816 | NA |
| **7-day Mean Annual Low Flow (l/sec)** | 11,300 | NA |
| **Lowest recorded flow (l/sec)** | 5,969 | NA |
| **Highest recorded flow (l/sec)** | 3,560,550 (one of the highest specific discharges in NZ) | NA |
| **Water quality record** | 2000-present | Quarterly: 2000-present<br>Monthly: 2011 - present |

* Estimate from WRENZ 2013. NA = not available

## Clay Creek, Bainham

This small creek flows into the Aorere River about 1.1 km downstream of James Bridge. Over 90% of the catchment land use is in intensive dairy farming. The flow in the middle reaches (around Mackay Pass Rd) and upper reaches regularly dry up in summer but flows are permanent in the lower 600-700 m (lowest recorded flow of 50 L/sec. The creek flows into a large recirculating pool in the Aorere River that is used for swimming.

**Concentrations of disease-causing organisms are generally very high** (median 3100 *E.coli*/100 ml).

Daily **dissolved oxygen** minima were **below standard** for ecosystem health at around 53-55% (continuous sampling March 2015) (Figure 16). However, it is likely that it won't take much effort to improve this (to bring it up to over 60%) by further removing dairy effluent discharges from raceways to the stream and more riparian planting. The relatively flat bottom to the daily dissolved oxygen curves shows that there is reasonable re-aeration – in this case from turbulent flow over riffles in the lower reaches. The low daily maxima are consistent with this creek having reasonable shading and therefore less extensive aquatic plant coverage. Water temperatures were very suitable for aquatic ecosystem protection (daily maxima: 18$^{o}$C).

**Above: Clay Ck 30 m upstream Aorere Rv. Below: Clay Ck 550 m upstream Aorere Rv. Both photos taken in February 2015.**

**Macroinvertebrate metrics indicate this creek is in relatively poor condition** (MCI 93, SQMCI 3.88, snails very abundant; based on one sample in February 2014). However, there was relatively high number of taxa (20) and a 'satisfactory' proportion of sensitive taxa in the sample (%EPT: 55%), mostly cased caddisflies.

The source of faecal contamination and the reason for low dissolved oxygen could be discharges of dairy cow effluent from stand-off areas and a raceway in the mid-upper catchment. Effluent runoff from this raceway will be treated from August 2015. All creeks in the catchment are fenced and stock crossings are bridged or culverted.

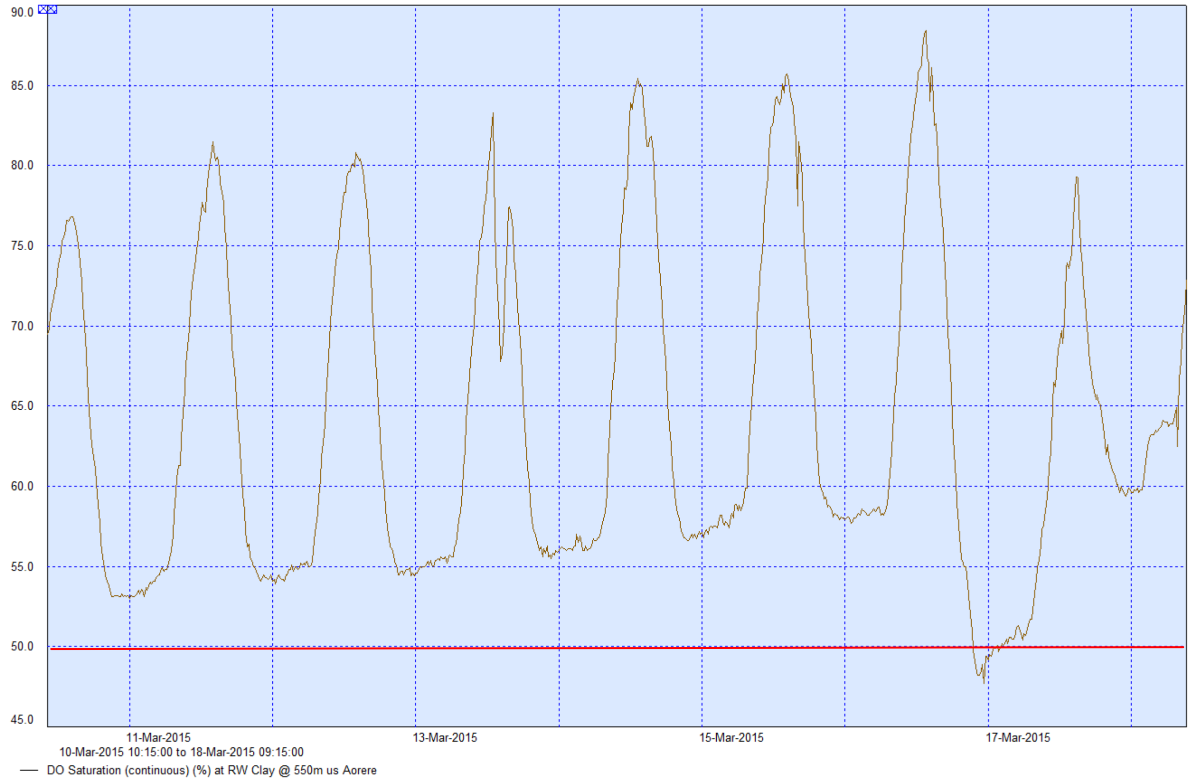


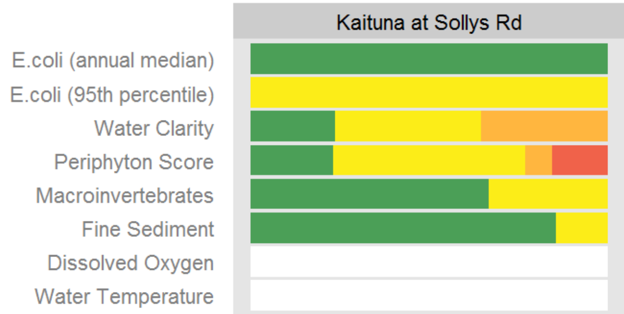

**Figure 16. Dissolved oxygen saturation at Clay Creek about 500 m upstream Aorere River measured continuously from 10-18 March, 2015. The national proposed bottom line for the daily 1-day minimum is shown by the red line.**

## Kaituna River

There are two long-term sampling sites on this river. One upstream of the start of the Kaituna Track (upstream of "The Naked Possum") which has a catchment entirely in native forest, much of which is dominated by podocarp and rata. The site at Solly Rd is downstream of several dairy and beef farms and Bonny Doon Creek, a significant tributary. Local farming families use the Kaituna River for swimming.

There is a significant difference in levels of base-flow **faecal indicator bacteria** between the upstream (reference site) and the lower reaches (Sollys Rd) (median 5 *E. coli* /100 ml upstream reference site compared to 92 *E. coli* /100 ml at Solly Rd, 2010-2014; median at Solly Rd 2001-2009: 150 *E. coli* /100 ml). Alert level guidelines are exceeded over 15% of the time. Mackay Creek, a tributary that joins the Kaituna upstream Solly Rd, is likely to be a contributor to this condition.

**Kaituna Rv 200 m upstream Track Start (February 2015)**




**Site data summary plot. Colours indicate attribute states from A (good) to D (poor).**
**Refer to the interpretation guide for full details.**

From 2007 until present the percent cover of **filamentous green algae** on the bed of the river at the Solly Rd site each summer has been well above nuisance levels (75% cover in each of 2007 and 2010). It is obvious that Mackay Creek is the cause of this, as there are very low (<10% cover) levels upstream of this stream confluence. The mixing profile is also very visually apparent from the presence of bright green algae (i.e. the algae spreads across the streambed as the waters of the two streams progressively mix downstream of the confluence), with almost complete mixing downstream of the stock bridge and complete mixing downstream of the next riffle. The original source of the problem was traced to **dairy effluent** treatment pond sludge that was placed near the stream and ran off into MacKay Creek. This issue has been resolved by removing the sludge as it is not an acceptable practice. In 2000, Nottage also noted sporadic accumulation of filamentous green algae at the Solly Rd site.

**Water clarity** is often naturally low in this stream (median: 3.5 m, 25th percentile 2.2 m) due to dissolved colour from water percolating through the leaf and bark litter on the podocarp forest floor. At the Solly's Rd site water clarity is similar to the upstream site (median: 3.3 m, 25th percentile 2.1 m).

**Good or excellent macroinvertebrate condition** was found in the **lower Kaituna River** (MCI generally greater than 119). The SQMCI scores, however, shifted from excellent toward fair for Kaituna at Sollys Rd in recent years. Sampling by Nottage in 2000 showed at Solly Rd (MCI 141, QMCI 6.9, # taxa 14.3; mean of 3 samples). This was not much less than the reference site on at Kaituna at Track Start (MCI 149, QMCI 8.3, # taxa 15.6; mean of 3 samples).

**Kaituna Rv at Sollys Rd (June 2010)**

| | Kaituna u-s track start | Kaituna at Sollys Rd |
|---|---|---|
| River Environment Class | Cool Extremely Wet<br>Soft sedimentary<br>Indigenous forest<br>Lowland-fed<br>Low gradient | Cool Extremely Wet<br>Soft sedimentary<br>Indigenous forest<br>Lowland-fed<br>Low gradient |
| Catchment area ($km^2$)+ | 44.6 | 79 |
| Predominant land use upstream | 100% native forest | 73% native forest |
| Mean annual rainfall (mm) | 3621* | NA |
| Mean annual flow (l/sec) | 2,274* | 4,277 |
| Lowest recorded flow | NA | 519 (Mar 2003) |
| Water quality record | Monthly: 2000-01 and 2013-present<br>Quarterly: 2005-present | 2000-present |

* Estimate from WRENZ 2013. NA = not available

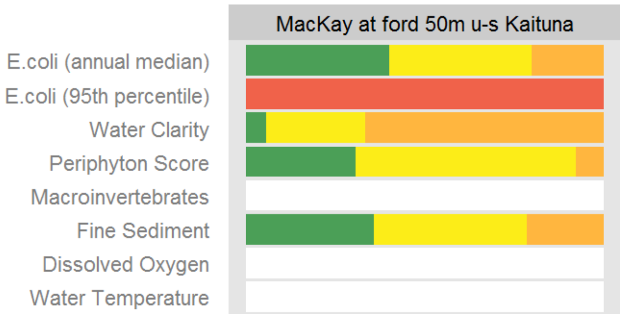

**Kaituna Rv at Sollys Rd taken from stock bridge. Left: Filamentous green algae cover at 75% cover (April 2007) Right: View upstream with filamentous green algae cover at 50% (February 2013). Note there are very little filamentous algae on the true left side of the river (right side of the photo).**

## Mackay Creek, Rockville

While this creek is too small to be used for swimming, it can affect the Kaituna River which is used for this purpose. Giant kokopu are found in the deep pools in the lower reaches where there is ecologically significant riparian podocarp forest enclosing the stream. With over **80% of the catchment in intensive pastoral land use**, it consequently is likely going to struggle to meet water quality guidelines. Monitoring of this creek began in 2007 because of the effect the creek had on the Kaituna River, particularly the filamentous green algae coverage. The flow in this creek can be as little as 1-2 L/sec in the driest summers.

The **level of disease-causing organisms is moderately high** at base flows at the 50 m upstream Kaituna site (median 280 *E. coli*/100 ml (2010-2015), and exceed the guideline for contact recreation more than half the time. Stock drinking water and secondary contact guidelines are exceeded just over 20% of the time. Compared to a site in the upper catchment on mostly sheep and beef farmland (1 km upstream Collingwood-Bainham Rd) the *E. coli* concentration at Collingwood-Bainham Rd was on average 1.8 times greater (comparing samples collected from the sites within hours of each other). Only 15% of samples were lower at the downstream site. Two results in 2014 were particularly concerning (13,000 *E. coli*/100 ml on 14 April and 20,000 *E. coli*/100 ml on 21 October with results 2.2x and 75x less upstream). In late 2014 another site on Mackay Creek downstream of a tributary above Gillies Rd was sampled and found to have levels on average 1.5x lower than the Collingwood-Bainham Rd site (average difference of each sampling event over 8 events).

**Above: Mackay Creek 30 m upstream Kaituna Rv showing high filamentous green algae coverage (January 2009). Below: 50 m upstream Kaituna Rv (February 2007).**




**Site data summary plot. Colours indicate attribute states from A (good) to D (poor).**
**Refer to the interpretation guide for full details.**

In 2011 the source of faecal contamination was determined as ruminant e.g. cows, with no other animal faecal material. Initially it was thought that the cause was dairy effluent sludge oozing into the creek after being removed from the effluent ponds and stockpiled in the riparian area in 2006. However, almost 10 years after the material was pulled back from the creek *E.coli* concentrations still spike high at base flows. Dairy effluent ponds appear to be functioning well with no overflows or leaks evident. While the stream has been mostly fenced for the monitoring period, a small amount of fencing was completed in the area upstream of Gillies Rd in 2015.

Daily **dissolved oxygen** minima measured over 5 days in February 2010 was **very low** in the mid reaches (Collingwood-Bainham Rd; Figure 18 and Figure 19), at 35-40% saturation, but improved to about 60% saturation near the confluence of the Kaituna River (Figure 17). The irregular spike at 2-4am on 11/2/2010 could suggest a discharge or a water take. The reduced peak at mid-afternoon on 13/2/2010 at the site close to the Kaituna in the dissolved oxygen trace could be due to heavy cloud cover. The sonde deployment in 2015 at Collingwood-Bainham showed dissolved oxygen levels less variable and with considerably higher daily minima than in 2010.

**Median water clarity is fair** (median 2.9 m 2010-2015), but just over 5% of records in base flow have been below the 1.6 m guideline for contact recreation.

**Filamentous green algae** at the site 30 m upstream of the Kaituna River is high at times (40 and 50% cover have been recorded; see photo at top of previous page) but due to shading by tree cover at this site is on average is likely to be lower than other sites.

In 2015 a source of high nitrate was found coming from a drain from the true right about 920 m downstream of Collingwood-Bainham Rd. The origin for this has not been found but may be due to something buried within the paddock.

**Above: Mackay Ck at Collingwood-Bainham Rd, looking downstream (Left: April 2005, Right: February 2015)**

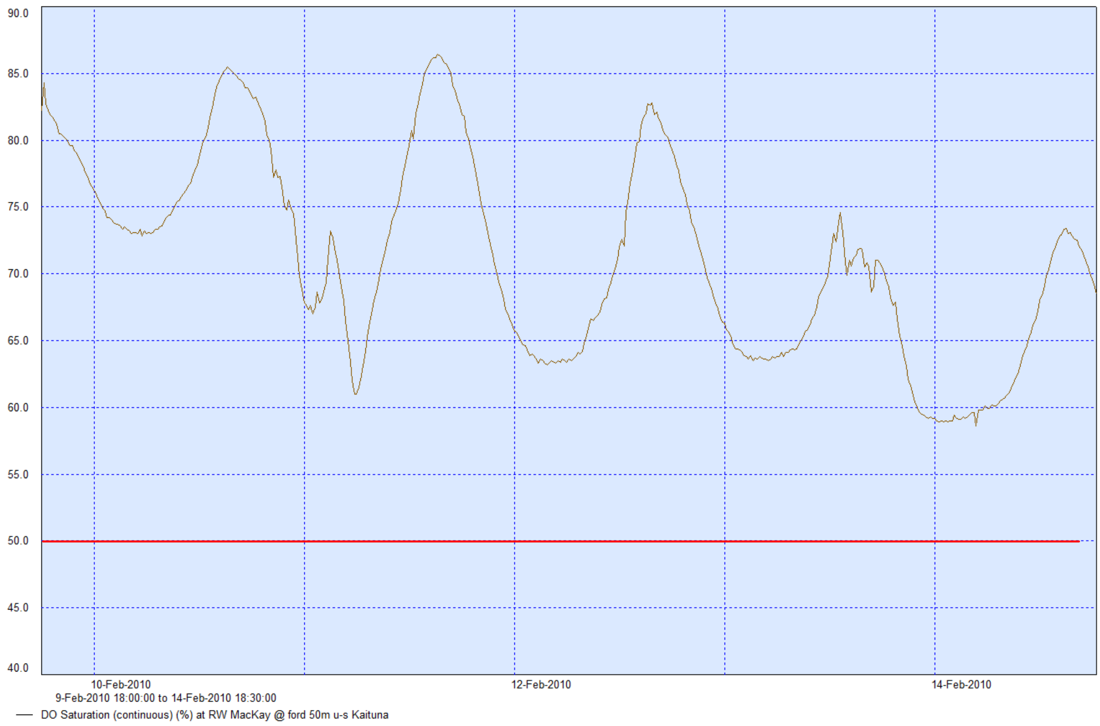



**Figure 17. Dissolved oxygen saturation at Mackay Creek 50 m upstream Kaituna River measured continuously from 9-14 February, 2010. The national proposed bottom line for the daily 1-day minimum is shown by the red line.**

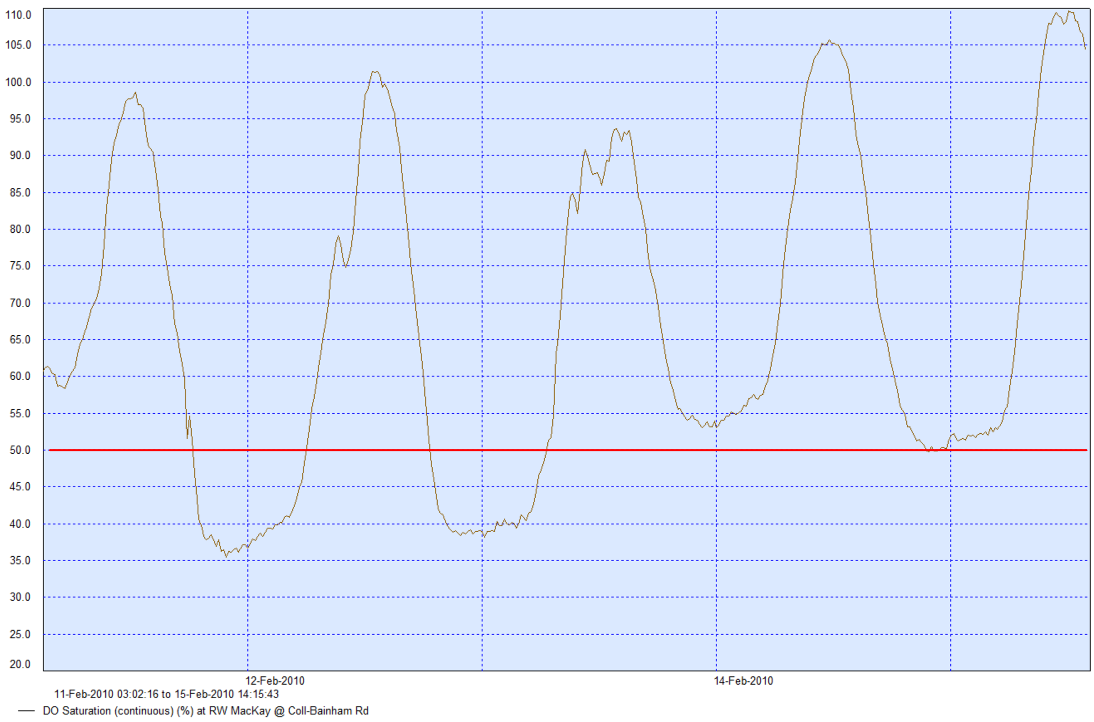



**Figure 18. Dissolved oxygen saturation at Mackay Creek at Collingwood-Bainham Rd measured continuously from 11-15 February, 2010. The national proposed bottom line for the daily 1-day minimum is shown by the red line.**


**Figure 19. Dissolved oxygen saturation at Mackay Creek Collingwood-Bainham Rd measured continuously from 17-23 February, 2014. The national proposed bottom line for the daily 1-day minimum is shown by the red line.**

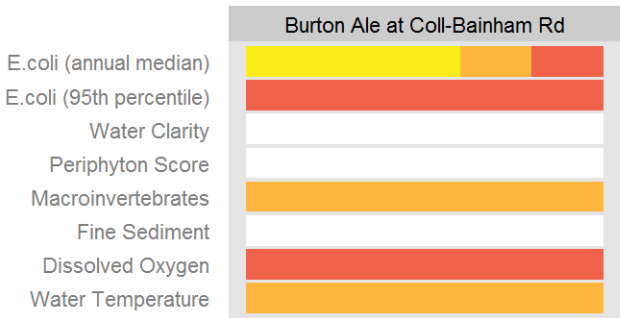
## Burton Ale Creek

Burton Ale Ck 60 m downstream Collingwood-Bainham Rd, looking downstream (Left: February 2005)

This creek, and the neighbouring James Cutting Creek, are unique in that their catchments are dominated by farmland on pakihi soils. Phosphorus retention in these soils is extremely low (1%) leading to high rates of leaching of this nutrient. The land use in this catchment is dominated by dairy and sheep farming. **Stream habitat is generally good** i.e. natural meander, water depth variety, cobbly/bouldery bed and regenerating riparian scrub overhanging the stream. Reasonable numbers of native fish reside in this stream where the habitat is good, including short-jaw kokopu and red-fin bully. Because of the limited mixing of water from this creek with the Aorere River at the mouth, and that swimming and other contact recreation occurs in the area near the mouth, this creek has been assessed against the contact recreation guidelines. The total area of this catchment is 802 ha with 247 ha in sheep and beef, 450 ha in dairy farming and about 65 ha in scrub and forest. The flow in this creek can be as little as 5 L/sec in the driest summers.

This stream receives tertiary treated **effluent from the Collingwood wastewater treatment plant** (WWTP) and diffuse discharges from dairy farmland.

In 2010-12 this catchment was the subject of an investigation to determine the source of high levels of disease-causing organisms and high cover of filamentous green algae (James and Mullis 2012).




**Site data summary plot. Colours indicate attribute states from A (good) to D (poor).**
**Refer to the interpretation guide for full details.**

**High concentrations of faecal indicator bacteria are found** in this stream, as measured monthly over all flows as part of resource consent monitoring of the WWTP (Figure 20; 2014 annual median = 475 *E.coli*/100 ml). A failure of the wetland tertiary treatment system of the WWTP resulted in a temporary failure (subsequently fixed) to comply with the discharge consent in 2009. The concentrations of faecal indicator bacteria are usually very similar upstream of the WWTP discharge, compared to downstream. This suggests the likely cause of this situation is activities on dairy farms, such as regular stock crossings, upstream in the catchment. It is understood that bridging these regular crossings is imminent.

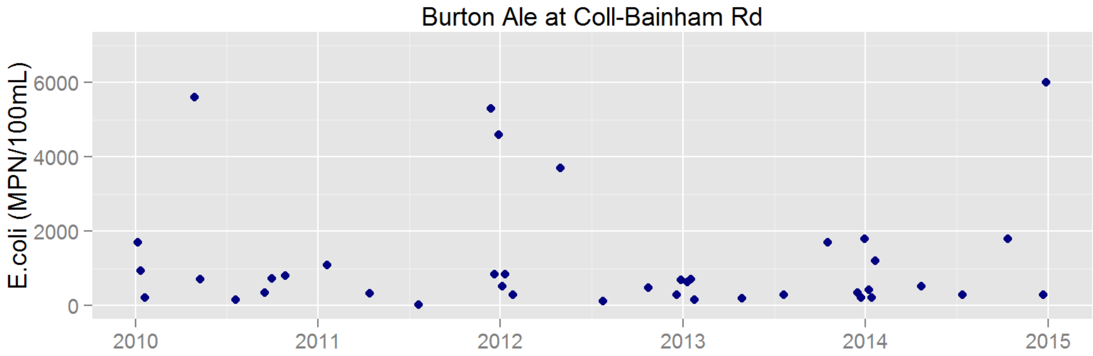



**Figure 20. Concentration of *E. coli* downstream of the Collingwood wastewater treatment plant discharge into Burton Ale Ck from 2010 to 2015. Two samples greater than 7000 E. coli/100ml excluded (from 2010 and 2013).**

**Filamentous green algae cover is high at times during summer** (median summer: 25% cover, 5 of 15 samples over 30% cover and 2 of 15 samples over 90% cover at Collingwood-Bainham Rd). There was often a marked difference between filamentous green algae cover in tributaries dominated by dairy (e.g. Southern tributary) versus those dominated by sheep farming (Northern tributary) (see photos below).

**Dissolved reactive phosphorus concentrations were very high** in this stream (in dry weather typically 0.1-0.2g/$m^3$; 10-20 times guidelines) even during dry periods as a result of farming on pakihi soils with very low phosphorus retention. The ANZECC guidelines are 0.01 g/$m^3$ and excessive algal growth usually occurs when dissolved reactive phosphorus concentrations are over 0.015-0.03g/$m^3$ in the presence of sufficient nitrogen. Wet weather phosphorus concentrations were 2-3 times higher than dry weather. A tributary of Burton Ale Creek that is dominated by sheep farming has dissolved reactive phosphorus concentrations less than half that of tributaries dominated by dairy farming. At lower catchment sites increases in phosphorus concentrations were often matched by increases in dissolved nitrogen ($r^2$=0.47). **Nitrate-N concentrations are relatively low** (typically around 0.1-0.3g/$m^3$ except for two sites on two southern tributaries where they cross Plain Rd where they were 0.4-0.6 g/$m^3$).

**Above left: Northern tributary Burton Ale Ck (9 February 2012). Above right: Southern tributary Burton Ale Ck (9 February 2012)**

Macroinvertebrate metrics indicate moderate pollution (MCI 90-100; Cawthron reports related to sewage treatment plant consent monitoring).

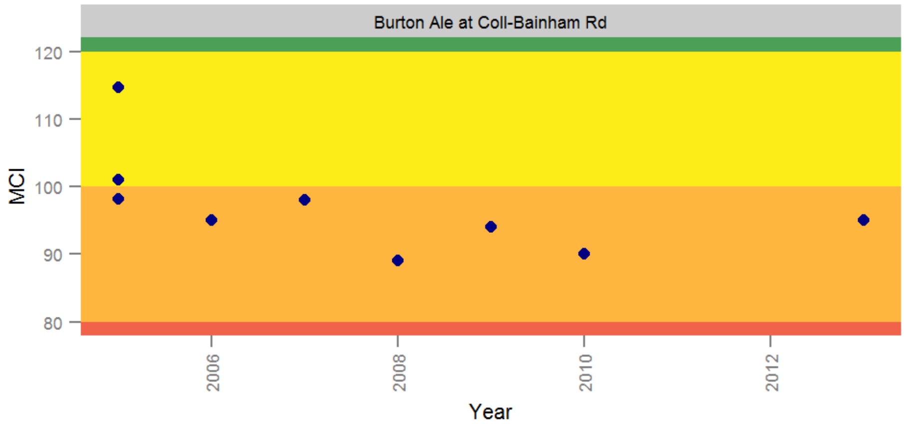



**Figure 21. Macroinvertebrate community index (MCI) results for Burton Ale at Coll-Bainham Rd. Data from sewage treatment plant consent monitoring.**

**Burton Ale Ck at Collingwood-Bainham Rd, looking downstream (Left: January 2009, Right: February 2015).**

**Dissolved oxygen levels get very low in summer** in the lower part of the catchment (daily minima of about 40% saturation over a week in March 2015; Figure 22). There appears to be very little re-aeration in this stream at this site as shown by the deep 'V' shape at the bottom of the daily curve. This shows that this stream is vulnerable to discharges with high biological oxygen demand in these lower reaches. Spot measurements in earlier years have occasionally recorded a low result.

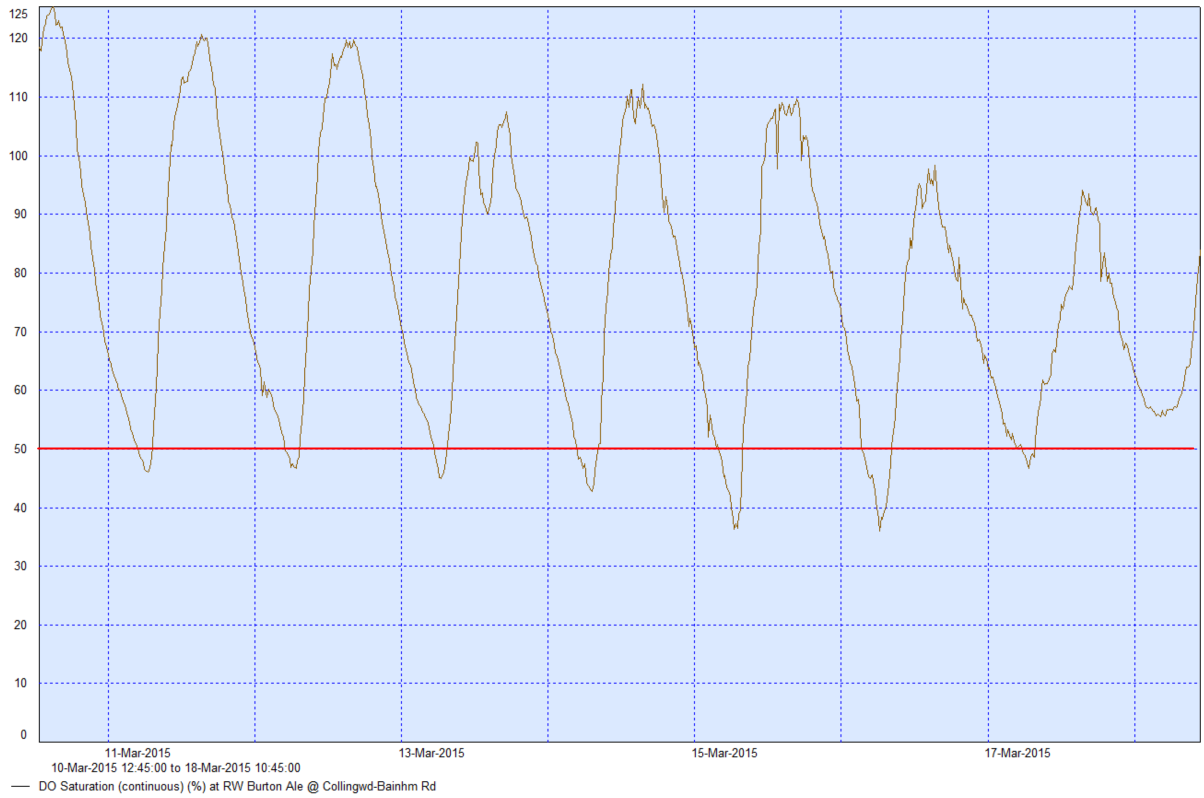
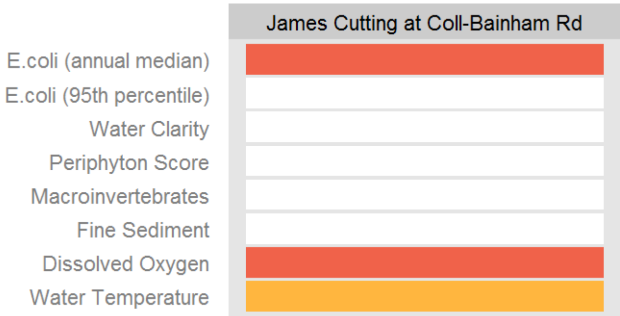



**Figure 22. Dissolved oxygen saturation at Burton Ale Creek Collingwood-Bainham Rd measured continuously from 10-18 February, 2014. The national proposed bottom line for the daily 1-day minimum is shown by the red line.**

## James Cutting Creek

This small creek flows through a catchment comprising, almost entirely, **dairy farmland.** The flow in this creek can be as little as 1 L/sec in the driest summers.

The creek has **high concentrations of faecal indicator bacteria** (median: 900 *E.coli*/100 ml and ~40% of samples above stock drinking guidelines at base flow). The few high flow samples recorded levels of faecal indicator bacteria over 10,000 *E. coli* /100 ml.




**Site data summary plot. Colours indicate attribute states from A (good) to D (poor).**
**Refer to the interpretation guide for full details.**

This creek has **extensive cover of filamentous green algae,** indicating high nutrient concentrations. Like Burton Ale Creek, dissolved reactive phosphorus concentrations are high in this creek. In 2008 the riparian zone upstream of Collingwood-Bainham Rd was fenced and planted, which has improved habitat greatly. However, water quality would particularly benefit from the installation of wetlands in key parts of the catchment, to act as filter strips. In 2014-15 further planting was carried out after the diversion of the creek for the 800 m reach downstream of Collingwood-Bainham Rd.

Riparian planting began in 2007 and by 2015 the shading and habitat in the stream was greatly improved and is a credit to those involved in restoring in stream habitat and overland flow interception (see photo sequence below).

**James Cutting Ck viewing upstream of Collingwood-Bainham Rd (from left October 2005, January 2009, and February 2015 right).**

Daily minimum dissolved oxygen concentrations in the creek measured over eight days in March 2015 were consistently very low (Figure 23), and indicate either significant groundwater influence or high biological demand within the waterway. Given the high daily maxima it is likely that aquatic plants in the unshaded parts of the waterway (upstream of the area planted) are the cause.

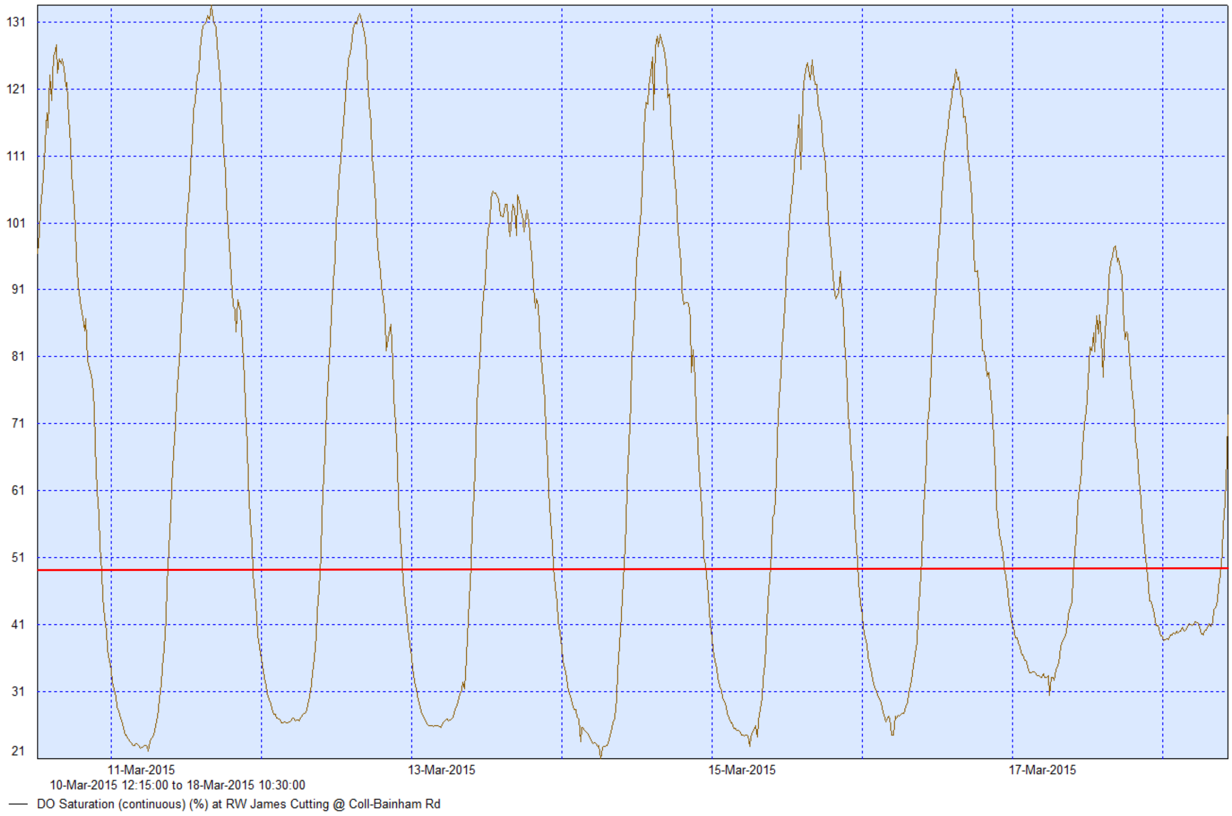


**Figure 23. Dissolved oxygen saturation at James Cutting Creek at Collingwood-Bainham Rd measured continuously from 10-18 March, 2015. The national proposed bottom line for the daily 1-day minimum is shown by the red line.**

**Water temperatures** (midpoint of daily maxima and daily mean) were **within guidelines** (Figure 24) and appear to be similar to the few spot sample records available (no semi-continuous data has been collected other than shown here).

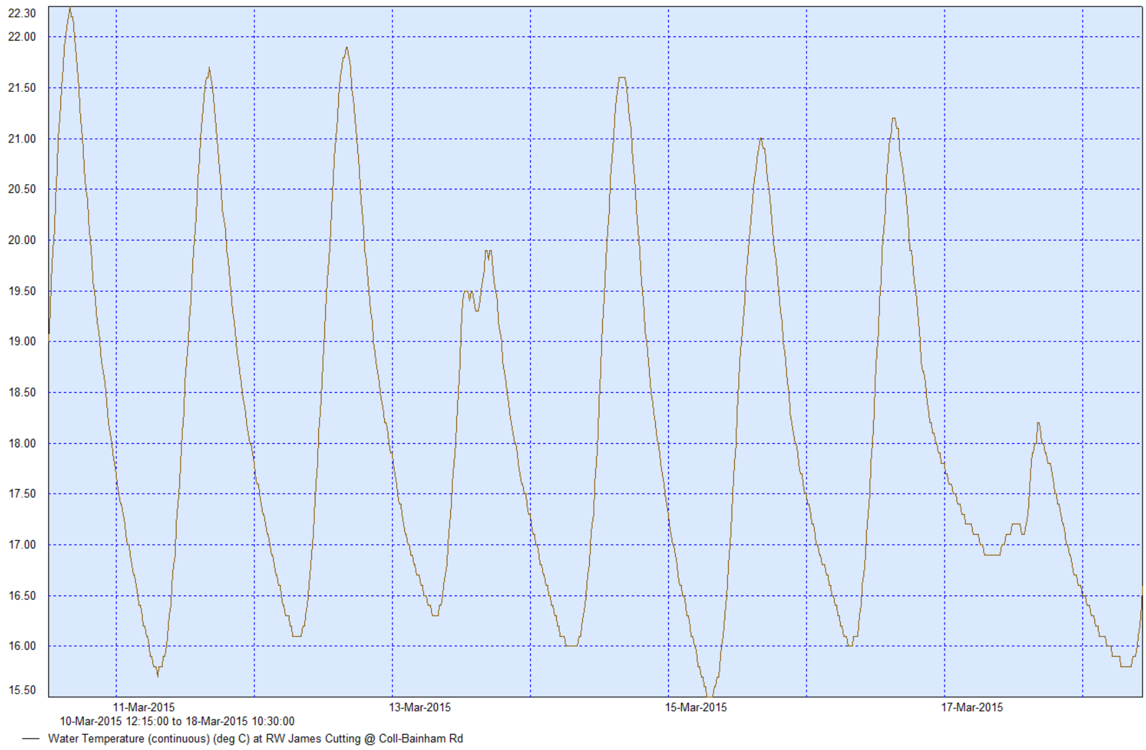



**Figure 24. Water temperature at James Cutting Creek at Collingwood-Bainham Rd measured continuously from 10-18 March, 2015.**

Conductivity peaked regularly late in the evening and again in the morning (Figure 25).


**Figure 25. Conductivity at James Cutting Creek at Collingwood-Bainham Rd measured continuously from 10-18 March, 2015.**

## Pakawau (Yellow Pine) Creek, Pakawau Inlet

Yellow Pine Creek is the largest stream flowing into the Pakawau Inlet and has a catchment with over 3.5 $km^2$ in native bush (total catchment area of 4.4 $km^2$ catchment). Exotic forestry makes up most of the remaining land use. A natural waterfall about 900 m upstream of the estuary is most likely a barrier to all non-climbing fish, however Koaro, banded kokopu, eel and koura are abundant in the catchment upstream of the waterfall.

Yellow Pine Creek ~1.2 km upstream estuary (Sept 2013)

Historic coal mining occurred in this catchment and there is heavy iron-oxide precipitate where old adits (horizontal mining tunnels) discharge and a light iron oxide coating on the bed of 'Culvert 15 Creek' a small tributary (second creek up from the mouth on the true right). The pH of the discharges from the adits into this creek ranged from 5.3-6.7 so are mildly acidic.

A heavy discharge of fine sediment (estimated at least 50 $m^3$) to Yellow-Pine Creek occurred in 2012 as a result of logging and tracking operations causing slips and erosion into 'Culvert 15 Creek' (James, Sept 2013). Sampling the effects of this discharge took place in February 2013. Fine sediment volumes in Yellow Pine Creek were much higher downstream of Culvert 15 Creek (7.5 $m^3$/100 m reach), compared to upstream (0.2 $m^3$/100 m reach). This activity resulted in a prosecution for the company involved.

It would appear from the results of macroinvertebrate samples that the effects of mining masked that of any affect of the forestry operation. No mayfly, stonefly or caddisfly taxa were found in the sample downstream of mining but were found upstream of the mining and forestry. The acid mine drainage index showed a marked difference between the upstream reference site (above known mining discharges) and downstream of the mining discharges. The macroinvertebrate community index (MCI) also showed this trend but not to a degree considered significant. Four koura were caught upstream of forestry and mining but not in any of the downstream samples.

Overall the results from macroinvertebrate samples collected in February 2013 show an adverse effect on Yellow Pine Creek from the Culvert 15 Stream, but these effects are not considered large. Downstream of the Culvert 15 Stream confluence compared to upstream there was a 30% reduction (14 compared to 20) in the pollution sensitive taxa (mayflies, stoneflies, and caddisflies) and a macroinvertebrate community index (MCI) of 10 points lower.




**Above left: Yellow Pine Creek tributary ('Culvert 15 Ck') showing the effect of mine drainage. Above right: 'Culvert 15 Ck' showing a sediment depth of about 300 mm. Middle: Yellow Pine Ck downstream of Culvert 15 Ck sediment depths 100-200 mm.**

## Pakawau-Puponga Creeks

Extremely **low dissolved oxygen** was found in several streams (flowing out of culverts 74-80) on the Pakawau-Puponga Road (about half way between these settlements; 3.5-4 km north-west of Pakawau Hall) in summer. Anoxic or near anoxic conditions were found at some of these sites. Bubbles of **Methane** were observed in the area and a white precipitate was noticed on the cobbles and sand at the mouth which is likely to be caused by a natural methane discharge related to coal deposits in the area. These bubbles may be a symptom of anoxia (i.e. produced by methanogenic bacteria living under anoxic conditions). Summer flows in most of these streams are low but not stagnant (0.5-2 L/sec).

The streams are fully fenced and the stream's headwaters are in native bush. A large-scale riparian planting programme was initiated in 2009 (see photos below).

**Unnamed stream north of Pakawau, Culvert 78 (Top left: October 2006, Top right: February 2010, Left: February 2011).**