6.4. Turbidity and Sediment

Turbidity is a measure for the water clarity. Measurements are obtained using a sensor which emits light and measures the scattering of that light by particles suspended in the water column. Turbidity measurements are expressed in Nephelometric Turbidity Units (NTU).

Naturally, high turbidity is primarily caused by fine sediment that enters the water way from surrounding land surfaces, either in the form of slips or removed from stream and river banks due to the erosive action of flowing water. Removal of vegetation along the edges of water ways can significantly increase erosion of the banks. A lack of dense vegetation on adjacent land surfaces can result in high sediment input during rainstorms. Heavy animals can also cause damage to stream banks, generating increased bank erosion. Another source of increased turbidity are construction works in and around streams and rivers when water is still flowing in the channel.

Prolonged periods of high turbidity have a negative effect on aquatic life. Many fish are visual feeders, which means they need to see their prey in order to feed. Extremely high concentrations of fine sediment in the water column can also cause abrasive injuries to aquatic animals and potentially lead to a premature death.

Once sediment has entered the water, it will be deposited onto the stream bed if water velocities are relatively low. Large amounts of fine sediment can smother the stream bed and reduce quality and availability of habitat for aquatic insects, which are the main food source for fish. Additionally, fine sediment cover decreases the amount of suitable spawning habitat for fish.

Apart from ecological effects, high turbidity also affects the aesthetic value of water ways. The guideline of 5.6 NTU used for this report is the trigger level for lowland rivers suggested by the ANZEEC 2000 Guidelines based on recreational and amenity values [1].

State of the Environment and other sampling of Doctors Creek upstream of the Taylor River carried out since 1996 show exceedances of the turbidity guideline were and still are a regular occurrence (Figure 38). Trend analysis did not detect any significant increase or decrease in turbidity since 1997. There is no clear seasonal pattern and higher values occur during rainfall events as well as during dry periods.

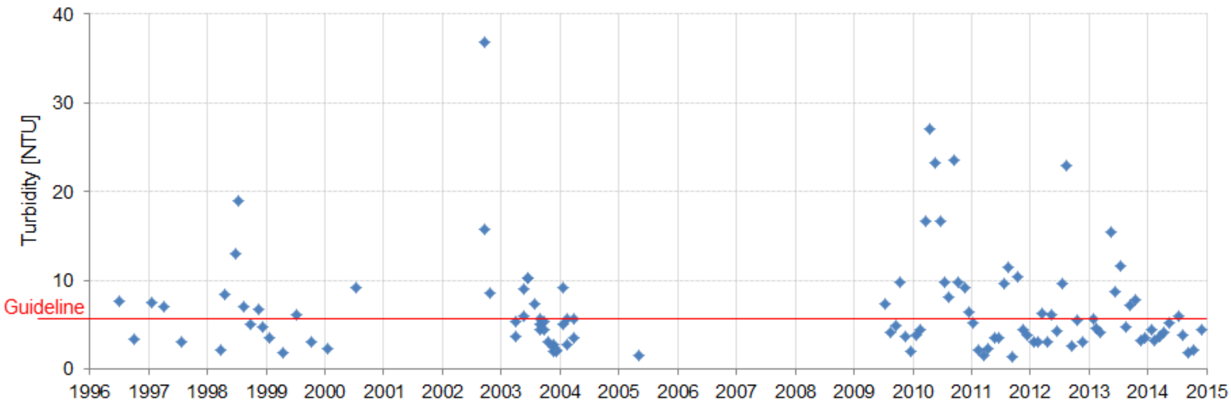

Figure 38: Turbidity in Doctors Creek upstream Taylor River since 1996.

Figure 39 shows the turbidity in the lower Doctors Creek catchment, based on samples taken as part of the investigations for this report. In the majority of Doctors Creek and its tributaries, turbidity was below or only slightly above the guideline value. The highest turbidity was observed in some small drains, particularly the road drain along Ben Morven Road. This drain is an example for the impact of regular spraying of bank vegetation with the aim to keep the drain ‘clean’. Drains of similar size and form that are not sprayed have relatively clear water in comparison. Examples are the road drains along the western side of Bells Road (Figure 40).

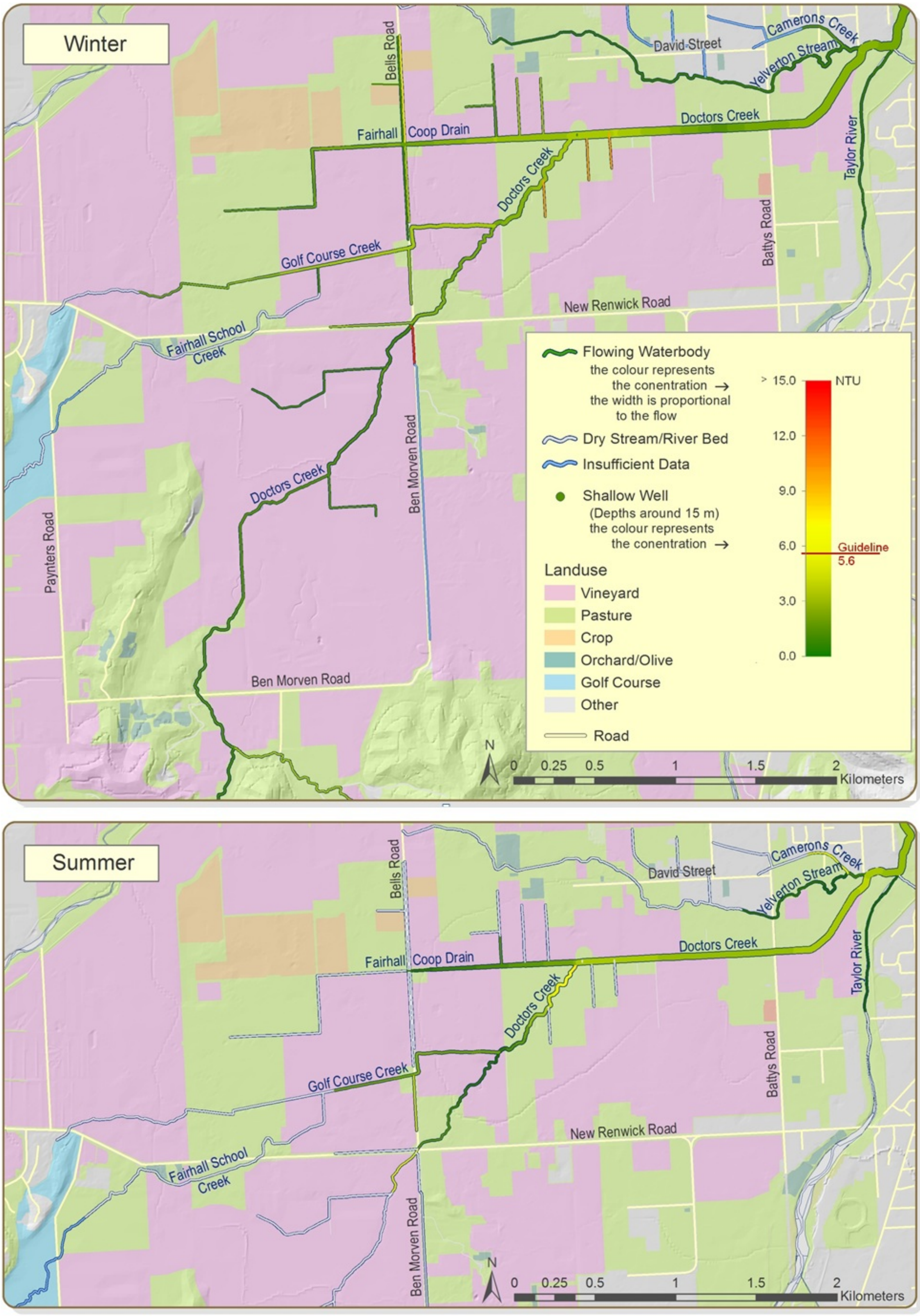

Figure 39: Turbidity in the Lower Doctors Creek catchment based on measurements taken in winter 2014 and summer 2013/14. Also shown is the land use at the time.

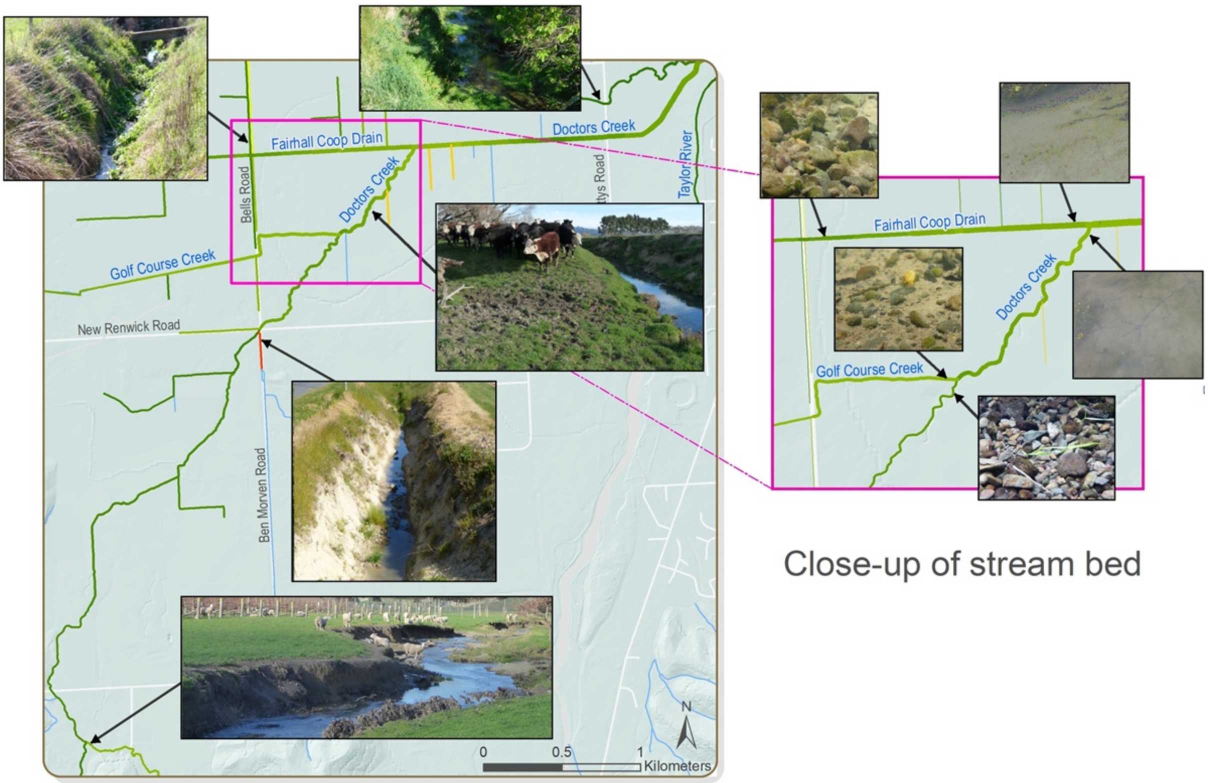

Figure 40: Examples of differences in bank vegetation and stability. The right side shows the variation in fine sediment cover for the area around the confluence between Fairhall Coop Drain and Doctors Creek compared to sites located upstream.

The Taylor River and Yelverton Stream had some of the clearest water, with turbidity values generally below the guideline. The only exception was a sample taken from Yelverton Stream at Battys Road at a very low flow.

In general, turbidity was higher during the summer months and values usually increased in a downstream direction in Doctors Creek, Fairhall Coop Drain and Golf Course Creek. The sample with the highest turbidity of 39 NTU was taken from Doctors Creek, just upstream of Fairhall Coop Drain in April, when flows were very low. Generally, there was a noticeable increase in turbidity in Doctors Creek between the confluence of Golf Corse Creek and Fairhall Coop Drain. This is one of the few areas were cattle have direct access to the creek. Cattle are attracted to waterways and due to their relatively heavy weight, the animals can cause significant damage to stream banks and subsequently move soil into the waterway. Additionally, the few mature trees remaining in this area are located close to the creek providing the additional attraction of shade. The confluence of Doctors Creek with Fairhall Coop Drain is also an area where most of the stream bed is covered in a thick layer of fine sediment (Figure 40). Disturbances of this fine material can easily move it back into the water column where it causes an increase in turbidity. Cattle and foraging wildfowl were seen moving in the creek, creating plumes of fine sediment that reduced the clarity of the water for some distance downstream. Waterfowl have a greater impact on turbidity during the summer months, because the lower water levels allow the birds easier access to the stream bed. More than 30 ducks and a number of Pukekos were frequently seen in and around Fairhall Coop Drain and Doctors Creek, downstream of Golf Course Creek.

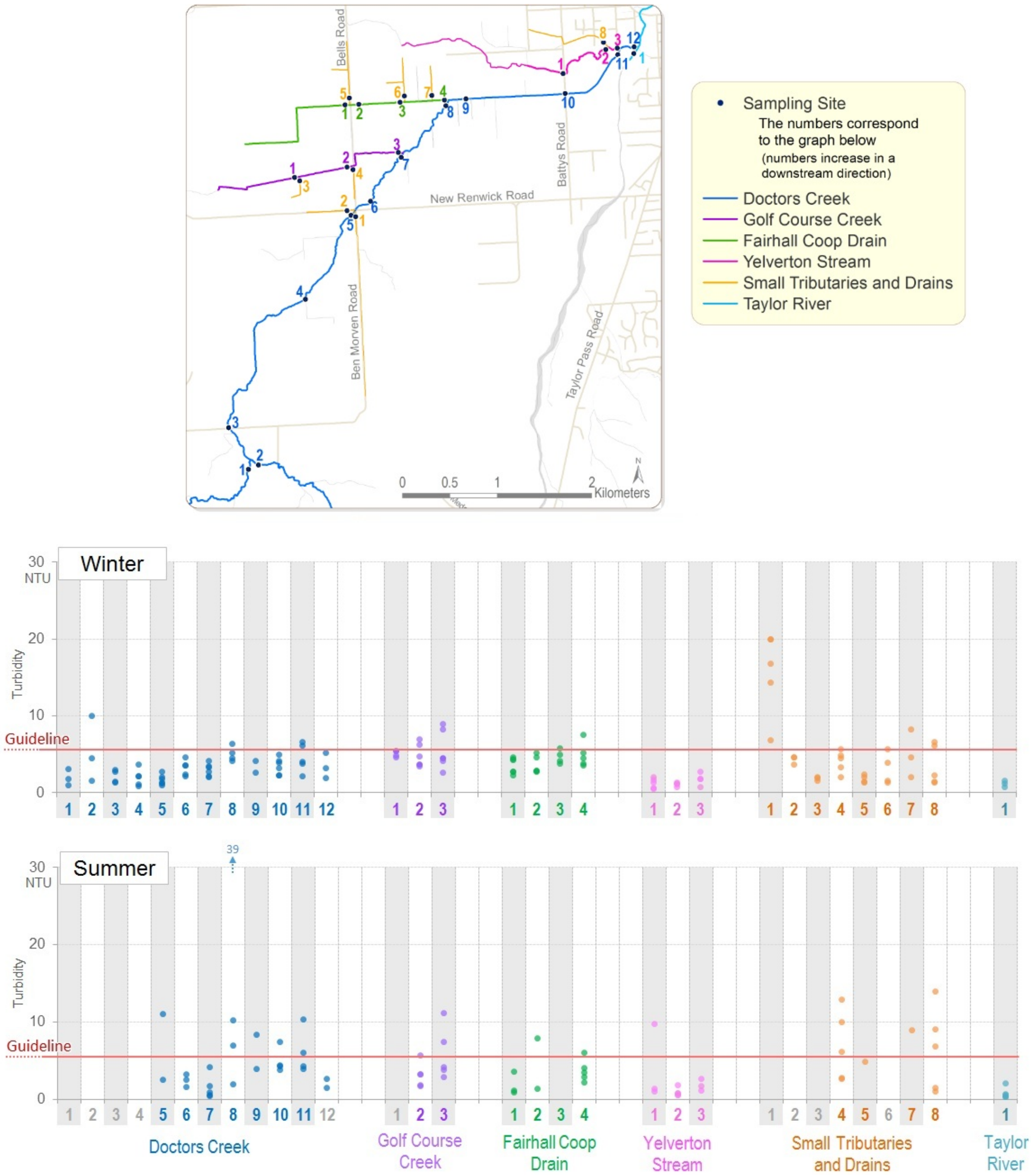

Figure 41: Turbidity measurements at core sites of the 2013/14 investigation.

At times wind induced turbulences also caused re-suspension of fine bed sediment, but this was observed on very few occasions and appears to play a minor role.

Overall, during low flows, water of higher turbidity originated in areas where large parts of the stream bed were covered with fine sediment. Once a substantial amount of fine sediment has accumulated on the stream bed, it can act as a nearly continuous cause for a reduction in water clarity downstream. The amount of fine sediment cover varied significantly throughout the catchment. For this reason the source of the fine sediment as well as the reason for the variability in fine sediment cover became a focus for the study.

One potential source is sediment carried into the system during heavy rainfall as a result of surface run-off or bank erosion due to increased flows. To assess sediment loads during such an event, samples were taken on two consecutive days following a small flood event in June 2014 (Figure 42 top left). Two weeks before this smaller flood event a larger flood had occurred. The time period between these two floods was not long enough to allow vegetation to establish and stabilize erosion scars created by the larger flood event. This meant that sampling captured erosion sources from both the larger and smaller flood event. During peak flows deposition of sediment onto the stream bed is unlikely as water velocities are too high to allow settling. The sampling was chosen to coincide with flows that would allow the first settling of sediment onto the stream bed.

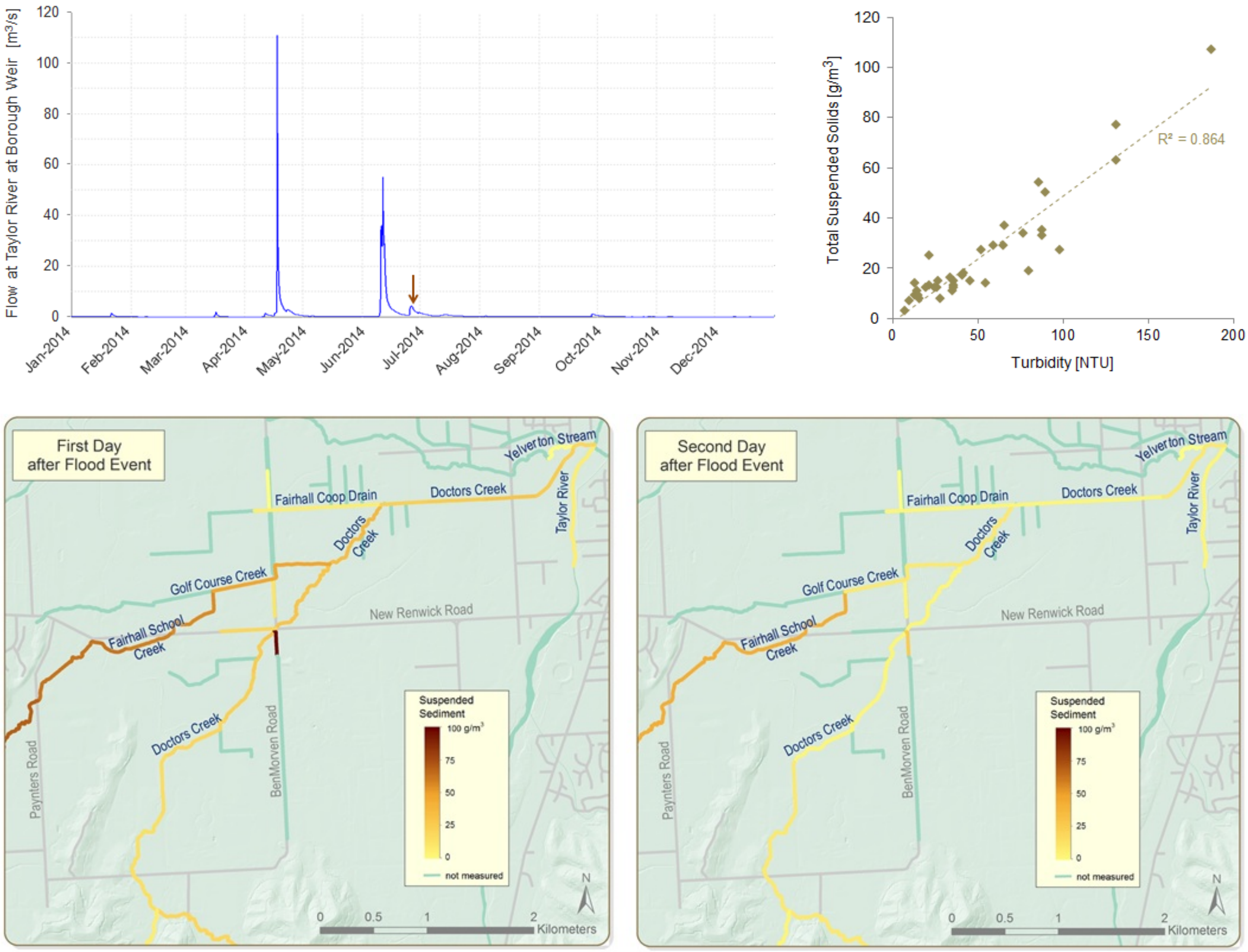

Figure 42: Results of Flood Sediment sampling. Top left: Flows of the Taylor River at Borough Weir – the timing of the sampling is indicated by the arrow. Top right: relationship between Total Suspended Solid concentration and Turbidity for the samples taken. Bottom: Modelling of the Suspended Sediment concentrations on the first and second day following the small flood event.

The bottom maps in Figure 42 show the concentration of Suspended Solids measured on the two days following the rainfall event. Total Suspended Solid concentrations give a better measure of the actual mass of fine sediment transported and correlate well with turbidity measurements (Figure 42 – top right).

The results show most of the sediment originated from Fairhall School Creek with some contributions from the road drain along Ben Morven Road and the upper Doctors Creek catchment. High sediment loads in Fairhall School Creek are most likely caused by a lack of vegetation cover on the banks of the main channel, as well as drains flowing into the creek. Upstream of Paynters Road the banks of waterways are regularly sprayed to remove vegetation, which increases erosion.

Notably less sediment originated from Fairhall Coop Drain and Yelverton Stream, which was particularly clear. Field observations made during the preceding larger flood revealed that Yelverton Stream remained clear during both flood events. The banks of this waterway are densely vegetated with long grass, shrubs and occasional trees. The areas were bank vegetation is removed by spraying is very limited and instream vegetation is not removed at all.

Whether the pattern of sediment loads observed during the June rainfall event is typical for most floods in the Doctors Creek catchment could not be investigated, as no significant flood flows have occurred since (Figure 42 – top left).

If it is assumed that this pattern is representative, most of the fine sediment should have been found along the Fairhall School Creek, Golf Course Creek and most of Doctors Creek, but not in Fairhall Coop Drain. However, this is not the case. Although most of the stream bed of Golf Course Creek has a comparatively high fine sediment cover, the cover in parts of Fairhall Coop Drain and Doctors Creek is substantially greater. Measurements of sediment depth in Fairhall Coop Drain in the three meters upstream of the confluence with Doctors Creek showed an increase from an average of 89mm in August 2013 to an average of 197mm in February 2014[7]. No significant flood events had occurred during this period. This further suggests, that the majority of the fine sediment deposited on the bed of Fairhall Coop Drain does not originate from flood flows.

In Doctors Creek fine sediment cover increases particularly in the stretch located between the confluences of Golf Course Creek and Fairhall Coop Drain. Just downstream of Golf Course Creek fine sediment covers some small areas along the water edge; 500 meters further downstream, the entire stream bed is covered in a thick layer of fine sediment. Two main reasons could be identified. Firstly, the flow in Fairhall Coop Drain is larger than in Doctors Creek, which causes the water in Doctors Creek to back up. This results in a reduction of water velocity, which in turn causes suspended sediment to be settled out and deposited onto the stream bed. Secondly, cattle have access to this part of the waterway.

Fine sediment cover also increases in Fairhall Coop Drain in a downstream direction, but the dynamics causing this increase are different from those in Doctors Creek. During the time period sampling was carried out for this report, turbidity in Fairhall Coop Drain was generally low (see Figure 39 and Figure 41). In November, only one month after sampling was completed, the turbidity in Fairhall Coop Drain increased significantly. To investigate the source, turbidity was measured along the length of Fairhall Coop Drain as well as in all tributaries using a portable turbidity sensor. This was done on three separate occasions. In one of these instances, a source was found to be construction work carried out in one of the drains flowing into Fairhall Coop Drain. The works had been going on for a week, potentially causing the deposition of large amounts of fine sediment on the streambed immediately downstream. However, turbidity steadily increased further downstream of the effected drain, which suggested an additional source. On the other two occasions, the same steady increase in turbidity was observed, but no distinct point sources could be identified. Closer investigation revealed filamentous algae were causing the high turbidity values. The generally high nutrient concentration in Fairhall Coop Drain, combined with abundant sunlight due to the lack of larger vegetation on the banks had resulted in the prolific growth of filamentous algae. Due to a prolonged period of low flows, the algae had grown to the extent, that the entire stream bed was covered; the algae had even smothered existing aquatic weed growing in the stream. Algae filaments had grown to a size at which they could no longer withstand the force of the flowing water and small pieces would detach. The algae were covering the entire length of Fairhall Coop Drain and caused a steady increase in the amount of detached material floating downstream. This resulted in a significant increase in turbidity, particularly upstream of Doctors Creek. With the beginning of summer the algae cover in Fairhall Coop Drain reduced; probably because conditions for the algae became less optimal, but also as a result of wildfowl movement, as areas that were frequently traversed by ducks were free of algae growth. The turbidity in Fairhall Coop Drain decrease, but did not reach the low levels observed earlier in the year. Although the algae appeared to have been the main cause of increased turbidity during that period, additional fine sediment was introduced into the system on several occasions when construction works were carried out on surface and subsurface drains as well as some parts of the main channel. These types of works were not confined to Fairhall Coop Drain, but could also be seen in other parts of the Doctors Creek catchment.

[7] Averages are bases on 18 sampling points along transects at 1m and 3m upstream of the confluence

In December 2014 the turbidity in Doctors Creek increased again unexpectedly. There had been no significant rainfall events which could have caused bank and surface erosion. It was found that aquatic weeds in Fairhall Coop Drain had been sprayed and had consequently died. As a result the fine sediment that had accumulated underneath the blanket of aquatic weeds was exposed to higher water velocities. This in turn resulted in the re-suspension of the sediment into the water column.

Figure 43: Two different causes for increased turbidity in the Fairhall Coop Drain; dense filamentous algae cover on the left and spraying of in-stream and bank vegetation on the right.

6.5. Dissolved Oxygen, Water Temperature and pH

Dissolved Oxygen

Like us, plants and animals living in streams and rivers need oxygen to breath. The amount of oxygen dissolved in the water changes in a distinct pattern over a 24 hour cycle. During the day aquatic plants release oxygen into the water as part of their photosynthetic activity. At night this oxygen supply is gone and oxygen is used up by the respiration of animals, plants and the activity of microorganism. For this reason, oxygen concentrations are usually lowest in the early morning, just before the sun rises. Oxygen also enters the water through the water surface from the air above it, but this process is relatively slow. In areas of a stream where the water surface is broken by turbulences (i.e. riffles and rapids), air bubbles are forced into the water. This increases the surface area through which the oxygen can move from the air into the water, which means significantly more oxygen is exchanged.

The amount of oxygen that can be dissolved depends on the temperature of the water, as warmer water can carry less oxygen than cooler water. Because of this dependency on water temperature the dissolved oxygen “saturation” instead of the dissolved oxygen concentration is often used. 100% dissolved oxygen saturation represents the amount of oxygen that can physically be dissolved into a water body at a given temperature. The photosynthetic activity of aquatic plants can increase the dissolved oxygen saturation significantly above 100%.

Low dissolved oxygen concentrations effect the growth and survival of aquatic invertebrates and fish [2, 9]. Studies have shown that Trout become effected if dissolve oxygen saturation decreases to values below 70% [9].

Water Temperature

The water temperature of rivers is naturally quite variable as it changes over the course of the day and with the season. The water is cooler during the night, warming during the day with temperatures usually reaching a maximum around mid-afternoon. Water temperatures are particularly high in streams where the vegetation along the banks has been removed or is kept short, thereby allowing the sun to directly heat the water. Groundwater inflow, on the other hand, can keep the water temperature quite stable, even reducing the seasonal variability.

High temperatures have a negative impact on the survival of stream invertebrates and fish. Some mayflies (Ephemeroptera) are not found in streams with water temperatures above 21.5^{o}C [37] and native fish like the Banded Kokopu (*Galaxias fasciatus*) are also effected by long term maximum temperatures above this value [2].

pH

The pH is a measure for the acidity or alkalinity of the water, ranging between 0 (strong acid) and 14 (strong alkaline). Pure water has a neutral pH of 7. Photosynthetic activity by aquatic plants increases the pH of the water, resulting in daily variations similar to those in Dissolved Oxygen with a maximum around mid-afternoon. Discharges of decomposing organic material can lower the pH and many heavy metals are more toxic at a lower pH.

The optimal range for trout is between 6.7 and 7.8 [16]. Although trout can tolerate a pH ranging from 5 to 9.5, growth and reproduction of the fish will be impaired. It is assumed that guidelines protecting trout will also be sufficient for native fish.

Figure 44 shows the measurements of dissolved oxygen saturation, water temperature and pH taken at 15-min intervals in Doctors Creek just upstream of the confluence with the Taylor River over a period of three days. In winter none of the measurements exceed the guideline values and there is only a small variability over the course of a day. In summer, on the other hand, all three measurements exceed the guidelines on a regular basis. Extremely high dissolved oxygen saturation and pH values during the day are a result of photosynthetic activity of excessive amounts of aquatic weeds and algae growing in the stream. Their growth is fuelled by high nutrient concentrations. The lack of larger vegetation along most of the banks of Doctors Creek and its tributaries also aid the growth of aquatic plants, as the lack of shade results in an abundance of sunlight reaching into the water column. At night, the same plants remove oxygen out of the water through respiration and the dissolved oxygen saturation decreases to values of 50%. Only physical input of oxygen as a result of turbulences and through the water surface prevent further reduction and result in the plateauing of the oxygen concentration during the night.

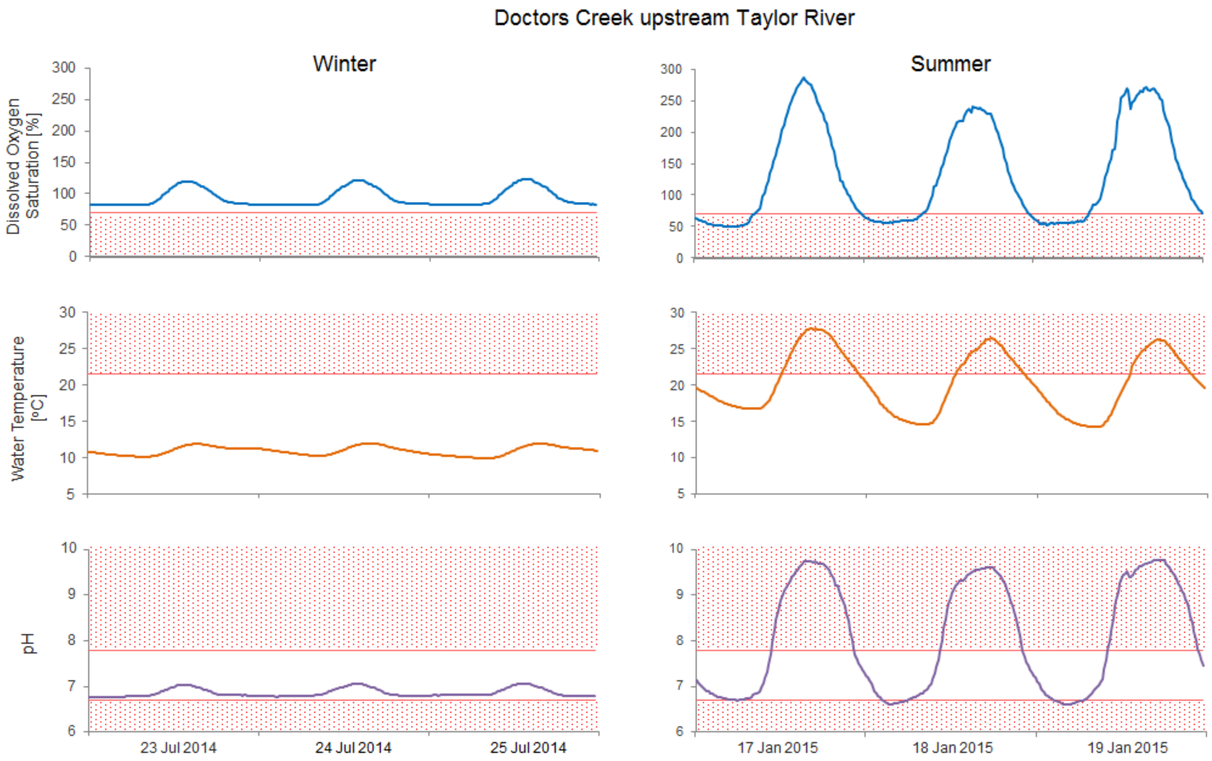

Figure 44: Continuous measurements of Dissolved Oxygen Saturation (blue), Water Temperature (orange) and pH (purple) in Doctors Creek upstream of the Taylor River over a period of three days, during the middle of winter (left) and summer (right). The range outside guideline values is shaded red.

As most of the flow in Doctors Creek originates from cool groundwater, the water temperature should be relatively constant. However, the already mentioned lack of tall bank vegetation allows the water to be heated by the sun during the daylight hours. This results in water temperatures in excess of 27^{o}C, well above the guideline of 21.5^{o}C.

In late spring, after a long period of stable flows, continuous measurements were taken from Doctors Creek and the Fairhall Coop Drain at their confluence (Figure 45). Dissolved oxygen saturation in both waterways was similar and fell only slightly below the guideline during the night. The variation in water temperature was slightly greater in Doctors Creek and spot measurements showed that the guideline value was exceeded during the height of summer. PH values above the guideline were already observed in late-spring and were likely to reach even higher values in summer. The pH of the water in the Fairhall Coop Drain was significantly lower than in Doctors Creek. PH measurements in water from a nearby shallow well had values of around 7.3, well above the values seen in the Fairhall Coop Drain. This points to processes in the water column or direct inputs as the cause. Low pH values in streams are usually associated with the decomposition of organic matter. E. coli concentrations in the Fairhall Coop Drain were comparatively low, which excludes faecal matter as a major source. During the monitoring most of the stream bed was overgrown with aquatic weeds. The water current would constantly rip off parts of the weed, which would float down the waterway and collect along the banks or on other aquatic plants. It is possible that the decomposition of this material caused the lowered pH values.

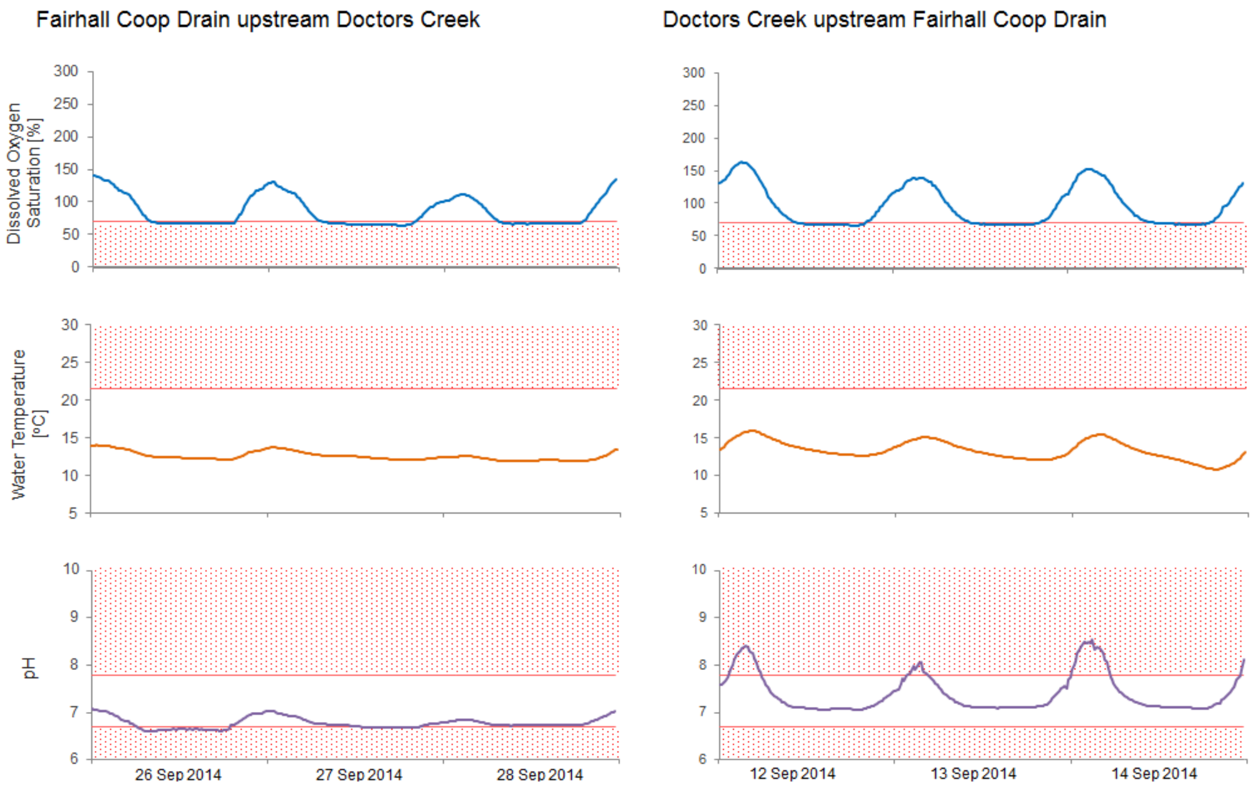

Figure 45: Continuous measurements of Dissolved Oxygen Saturation (blue), Water Temperature (orange) and pH (purple) in the Fairhall Coop Drain (left) and Doctors Creek (right) just upstream of their confluence.

Generally, conditions for aquatic animals are not very favourable in some parts of Doctors Creek, particularly in the lower reaches. This means that sensitive species cannot survive or are confined to areas like parts of the Fairhall Coop Drain where conditions are better.

Figure 46: The 'Sonde' used for the continuous monitoring deployed in Fairhall Coop Drain. The screen to the right prevents floating aquatic weed to accumulate on the instrument.

6.6. Ecology

Macroinvertebrates are the community of insects, worms and crustaceans living in a waterway. Together with fish, they are a good indicator of long term water quality. The animals are exposed to persistent water quality degradation as well as short term events of high contaminant concentrations that might not be picked up by spot sampling. Habitat quality also influences the abundance of macroinvertebrates and fish.

The diversity and abundance of macroinvertebrates collected from a stream can be summarised into a single number or score that is based on the sensitivity of the individual species found. One such score is the MCI (Macrinvertebrate Community Index). The MCI is commonly used and allows the categorization of water quality as 'poor', 'fair', 'good' or 'excellent'.

Several macroinvertebrate and fish surveys have been carried out in the Fairhall Coop Drain and the lower parts of Doctors Creek. Habitat conditions are generally not suitable for sensitive species. Most channels are straightened with steep banks, retaining little of their original morphology. Introduced aquatic weeds dominate most of the waterways in the lower Doctors Creek catchment. Fine sediment covers large areas of the stream bed, forming thick layers in some parts. Most aquatic insects require larger substrate, i.e. cobbles, and limited aquatic plant growth in order to thrive. In summer, water temperatures are higher than most sensitive species can endure and large variations in dissolved oxygen concentration and pH are additional stressors. An ecological assessment of the spring-fed streams on the Wairau Plain classified the Fairhall Coop Drain, the lower Doctors Creek and Yelverton Stream as of medium ecological value.

The results of macroinvertebrate monitoring of Doctors Creek upstream of the Taylor River reflects the limited ecological value of this waterway. MCI scores are usually indicating poor or fair water quality and particularly in recent years MCI scores have been consistently in the poor category (Figure 47).

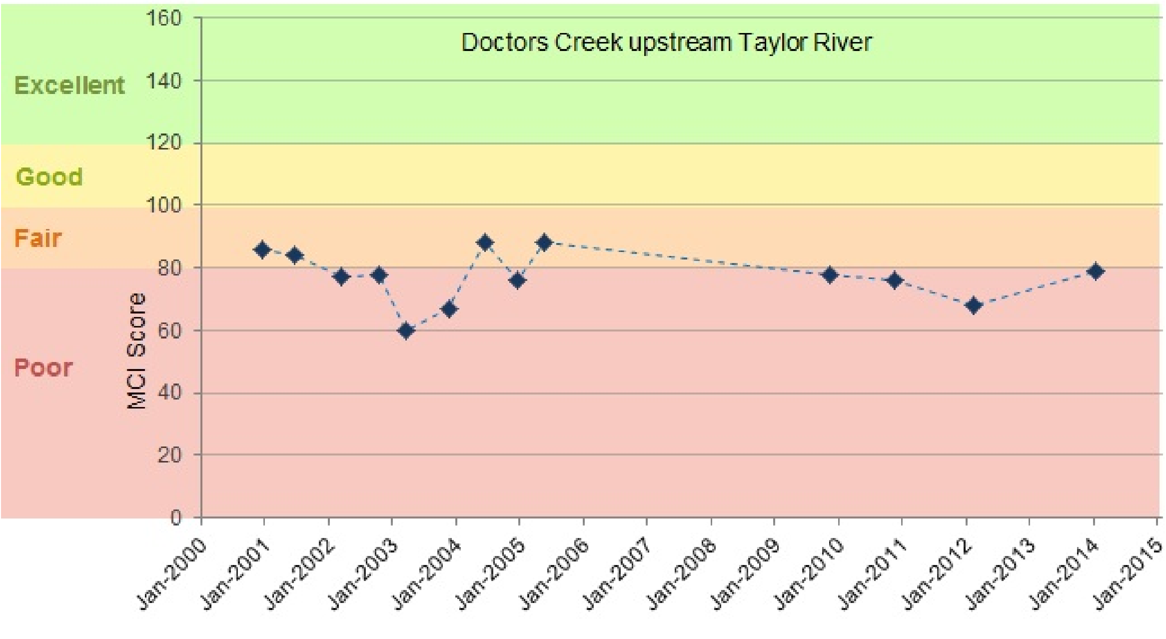

Figure 47: Macroinvertebrate Community Index (MCI) scores for Doctors Creek upstream of the confluence with the Taylor River.

Occasional Macroinvertebrate monitoring of sites further upstream, in the Fairhall Coop Drain and lower Doctors Creek in 2002 and 2008, showed similar MCI scores ranging from 69 to 82 [42, 43].

Some sites have also been monitored for the abundance of fish (Figure 48). The fish fauna found as part of these surveys is limited to four or five species. Eels made up the majority of fish found at all of the sites. Shortfin Eels were most common, but Longfin Eels were also present, although in much lower numbers (4-34% of the Eels). The Common Bully was comparatively rare and totally absent in Fairhall Coop Drain. Inanga and Brown Trout number were very low at all of the sites.

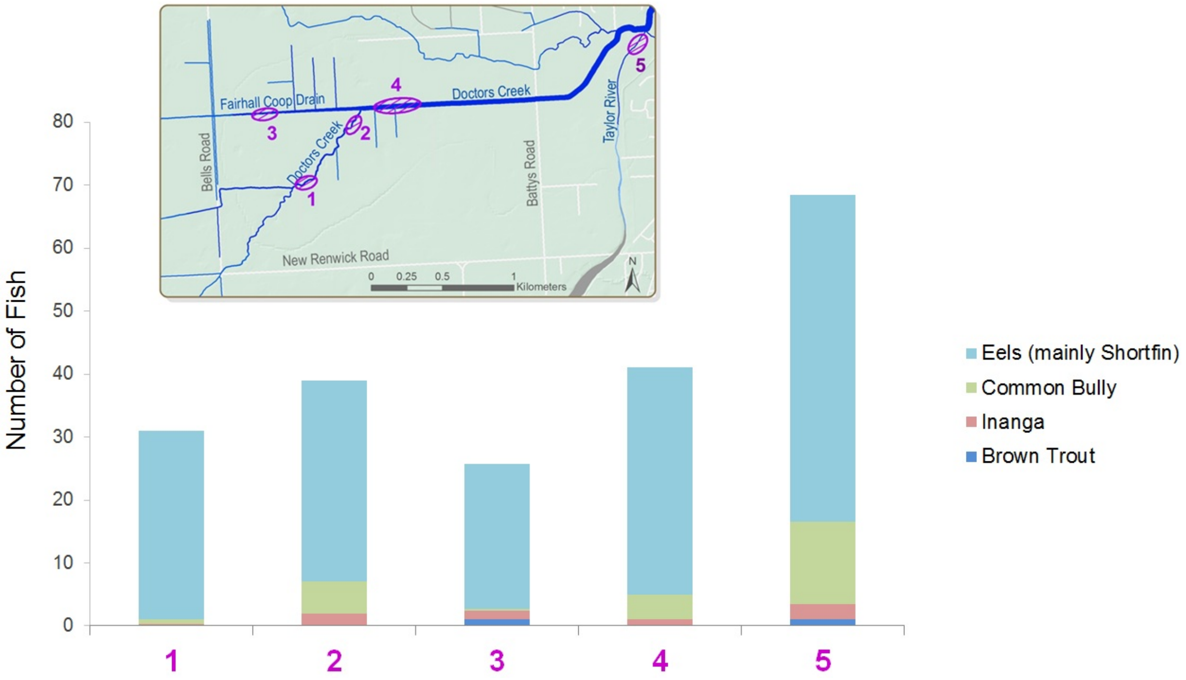

Figure 48: Average fish numbers found in several sites in the lower Doctors Creek catchment and in the Taylor River upstream of Doctors Creek [21, 42, 43].

The greatest number of fish was found in the Taylor River upstream of the confluence with Doctors Creek, but the actual species composition was similar to that in Doctors Creek. A qualitative survey of fish in the lower Doctors Creek from Batty's Road to the Fairhall Coop Drain downstream of Bells Road was carried out in late January 2015. This survey found a similar fish species composition as the previous studies. Fish numbers were low and the fauna was again dominated by Eels. Small schools of Inanga were found in stretches that were shaded by tall bank vegetation. A small number of adult trout lived in upper parts of the Fairhall Coop Drain, where cool water from inflowing tile drains and groundwater would keep water temperatures low.

6.7. Heavy Metals and Agricultural Chemicals

Heavy Metals

Naturally, Heavy Metals are present in very small concentrations. Some agricultural chemicals contain small quantities of these metals as impurities. For example many NPK fertilisers contain zinc, cadmium, arsenic or lead originating from the mineral ores that were used in the production [11]. Frequent fertilizer application can result in the accumulation of these heavy metals in the soil. If soil is shifted into the water way due to erosion during rainfall or stock access, the water way can also become contaminated with heavy metals. Some heavy metals, including zinc and copper originate from machinery and roofing iron. These sources usually only contribute significant amounts during rainfall events when the contaminants are washed off roof and road surfaces.

High heavy metal concentrations are toxic to aquatic life. The trigger levels provided by the ANZECC Guidelines [1] allow the application of different degrees of species protection. For most water ways, the default trigger limit is the 95% Species Protection limit. A higher 80% Species Protection trigger can be applied to impacted waterways. The trigger values apply to median concentrations not the results of individual samples.

Pesticides

Insecticides, Fungicides and Herbicides are widely used as part of the primary production industry. The components of some pesticides are persistent, degrading very slowly. Repeated application of these pesticides can result in elevated concentrations in the soil. Depending on the mobility of the pesticide in the environment, groundwater and surface water can also become contaminated. Spray drift from application too close to a waterway can also lead to contamination of surface water. Limits for acceptable pesticide concentrations in water can be found in the Drinking Water Quality Standards [30].

Copper, Arsenic and Zinc concentrations are measured in Doctors Creek upstream of the Taylor River as part of the State of the Environment program. Additionally, lead concentrations were measured at the same site as part of the Taylor River stormwater investigation in 2013 and 2014. Arsenic concentrations were consistently very low, but copper, zinc and lead concentrations were occasionally elevated (Figure 49). The majority of samples with elevated heavy metal concentrations were taken during and shortly after rainfall. Soils samples from the Doctors Creek catchment had heavy metal concentrations well below the limits suggested by NZWWA (see Section 4). This suggests that heavy metal contaminations in soils are not a concern in regard to the water quality of Doctors Creek. The occasionally elevated concentrations in Doctors Creek associated with rainfall events are likely a result of run-off from roads, yards, tracks and roofs. Overall, the median concentrations of the heavy metals monitored in Doctors Creek are all well below the 95% Species protection trigger values.

To investigate potential contamination with pesticides, three samples were taken from Doctors Creek upstream of the Taylor River in October 2014. The timing was chosen so that application of pesticides had begun while most of the waterways in the catchment were still carrying surface water before increasingly drying out later in the year. This allowed capture of the greatest extent of possible contamination sources. Additionally, plant growth was still slow, which potentially resulted in lower absorption by the vegetation.

In all three samples, only one pesticide, Terbuthylazine was found to be above the detection limit, but concentrations were well below the maximum acceptable value for drinking water [30]. Terbuthylazine is a selective herbicide that can be used on a wide range of crops, including vines and maize. This pesticide is used for long-term weed control, because it degrades very slowly. However, this also means that it can be a potential source of contamination well after the application, if used in close proximity to water ways. The banks of a number of waterways in the Doctors Creek catchment are frequently sprayed to remove vegetation.

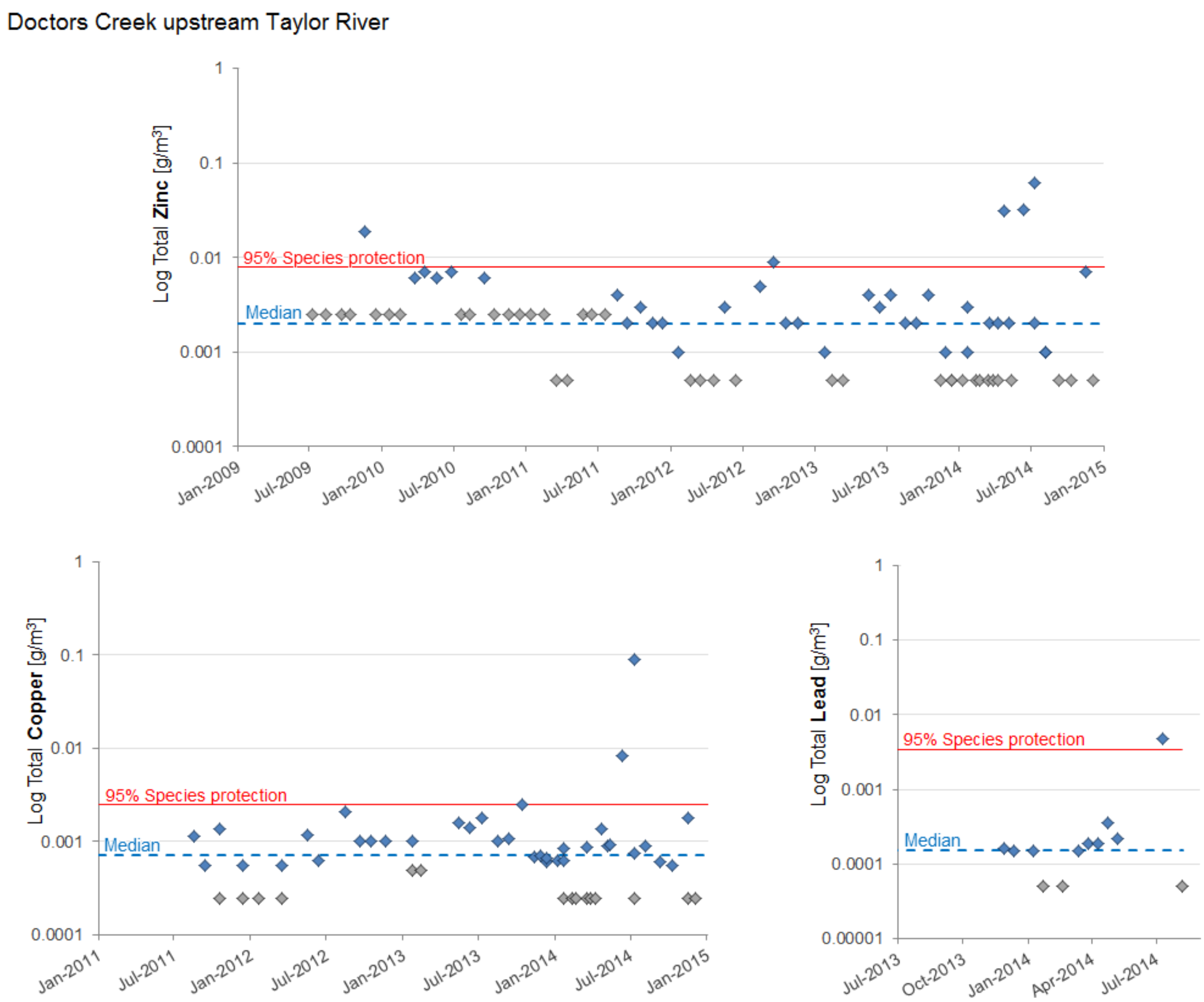

Figure 49: Total Zinc, Copper and Lead concentrations measured in Doctors Creek upstream of the Taylor River. Note that the metal concentrations are presented on a logarithmic scale. Values below detection limit are shown in grey.

The Marlborough District Council also carries out 4-yearly pesticide sampling of 20 wells across the region. Shallow groundwater, as it is found in the Doctors Creek catchment is especially susceptible to contamination with pesticides. Pesticide concentrations have been found to be minimal and are not increasing [7].

7. Summary and Discussion

The Taylor River and the associated river reserve are an important feature of Blenheim and are used for a number of recreational activities, including rafting, cycling, running, dog-walking and swimming. Doctors Creek is one of the main tributaries of the lower Taylor River. During prolonged dry periods, Doctors Creek and Murphys Creek supply the majority of surface flow into the Taylor River. These two tributaries are part of a belt of springs that emerge west and north of Blenheim. Most of these springs have a comparatively small surface catchment. This means during rainfall events, surface-runoff contributes a small amount to the overall flow of the springs when compared to waterways not predominantly fed by groundwater. However, Doctors Creek is one of the few spring-fed streams that have a substantial surface catchment area. Consequently, direct inputs have a greater potential to impact on the overall water quality of the creek. Nearly the entire area of the Doctors Creek catchment is dedicated to primary production with only a small part flowing through residential Blenheim at the bottom of the catchment.

Monthly sampling of Doctors Creek as part of the State of the Environment program had shown the water quality of this waterway to be degraded. This had a follow-on effect on the water quality of the Taylor River, which is also monitored as part of the program. A number of the water quality parameters measured, were found to exceed guidelines based on ecological and recreational values. In 2012 Council decided to investigate the sources causing the degradation in water quality.

One of the parameters consistently exceeding the guideline values was soluble inorganic nitrogen, which is predominantly in the form of nitrate. The investigative sampling carried out in 2013 and 2014 found that nearly all of the nitrate originates from the groundwater emerging in Doctors Creek. Generally all primary production activities cause the leaching of nitrate into groundwater. However, the amount leached varies for different soil types and land uses. For similar soils the greatest amount of nitrate is generally lost under irrigated cattle pasture and cropping, while dryland sheep farming and vineyards lose comparatively small amounts to groundwater. The State of the Environment data for Doctors Creek show a downward trend for nitrate concentrations, which might be a result of the large-scale conversion of pasture into vineyards that occurred on the Wairau Plain in recent years. Results from the 2013/14 investigation showed that the nitrate concentrations in the southern part of the catchment are very low. The groundwater emerging in this area is comparatively old and probably originated from a time before the catchment was used agriculturally. Further to the north, particularly around New Renwick Road, nitrate concentrations are very high. In this area most of the groundwater flows in from the west. Sampling of shallow wells in the Fairhall River valley several years ago, in 2000, revealed nitrate concentration there to be considerably higher than those observed in Doctors Creek in 2013/14. Unfortunately, these wells were not sampled recently, but it can be assumed that nitrate concentrations are still relatively high.

Groundwater flowing into the Doctors Creek system further north (i.e. Fairhall Coop Drain) originates from the Wairau aquifer. Nitrate concentrations are slightly lower, but still significantly elevated. The aquifer contains considerably more water, which also moves at a greater speed, compared to the aquifers supplying water to Doctors Creek further to the south. This might explain the difference in nitrate concentrations. The slower moving groundwater from the west is picking up more nitrate leachate before emerging as surface water in the Doctors Creek catchment. It is unclear how old this water is, which means it is difficult to link nitrate concentrations to land use activities. The majority of the Doctors Creek water flowing into the Taylor River originates from the northern part of the catchment. This means the high nitrate concentrations in groundwater from the Wairau aquifer and from the Fairhall River valley (potentially also from the Omaka River valley), are the sources of the nitrate influx into the Taylor River from Doctors Creek.

Measurement and modelling of the cumulative nitrate leachate under the different land use activities on the Wairau Plain and the Southern Valleys would allow better management of the water resources for the area, for both, groundwater and surface water.

Future plans to convert more pastures into vineyards and the time-lag introduced by the age of the groundwater mean that a further reduction of nitrate concentrations in Doctors Creek is likely.

Another major plant nutrient that is generally elevated in Doctors Creek is phosphorus, measured as DRP (Dissolved Reactive Phosphorus). Most of the DRP originates again from groundwater, but an additional source was found to effect DRP concentrations in winter. A combination of the removal of stream bank vegetation by spraying and grazing sheep in vineyards resulted in the shifting of soil into waterways by the hoofs of the sheep, when they moved down the stream banks to take a drink. Although the amount of soil input was not large enough to cause a significant reduction of the water clarity it did result in a notable increase in DRP due to the release of soil-bound phosphorus into the water column. During the summer months, phosphorus was also released from fine sediment covering the bed of some of the small, slow flowing parts of the Doctors Creek system. However, these made a very small contribution of the overall flow and therefore did not significantly impact on the DRP concentration in the lower Doctors Creek.

The lower flows during the dryer summer months result in a reduced dilution of other contaminants, including faecal matter. In the rural areas of the Doctors Creek catchment, contamination with faecal matter is predominantly the result of livestock access and wildfowl. In Yelverton Stream, which flows through residential areas, source tracking identified several sources of human effluent. While these sources will be eliminated relatively soon, the reduction of faecal inputs from farm animals will require long-term cooperation with land owners. The fencing off of cattle access is a priority, as these animals have a natural affinity for waterways. The significant impact of a relatively small number of animals upstream of the confluence of Doctors Creek and Fairhall Coop Drain shows that fencing regulation based on stocking rates[8] would not lead to the required improvements of water quality in Doctors Creek. Additionally, many small seeps and springs carry animal faeces into the water way from paddocks where the animals already have no direct access to the main stream channel. This means that livestock should also be excluded from these small tributaries.

The exclusion of stock animals from the waterways would also result in a significant reduction of sediment input into Doctors Creek and its tributaries. Not only is this sediment a source of phosphorus, but more importantly, it is the main cause for increased turbidity. Particularly when water levels are low, wildfowl and livestock frequently remobilise fine sediments that have been deposited onto the stream bed. The resulting higher turbidity of the water not only degrades aesthetic values, but also affects many fish. Many species need to see their prey in order to feed. The deposited sediment also limits suitable habitat for many aquatic species. Stream bed dominated by larger substrate (i.e. cobbles) in some parts of Doctors Creek and Fairhall Coop Drain suggest that fine sediment cover would naturally be quite low.

In late 2014, the removal of aquatic weeds with herbicides increased water velocities close to the stream bed after the plants had died. This also resulted in the re-suspension of fine sediment for several days after the treatment. The management plan for the control of aquatic weeds in the Doctors Creek catchment might need be reviewed.

Another source of fine sediment are drainage works in and around water ways that still carry surface water. During the investigation for this report, a number of drains were turbid for several days, resulting in the deposition of significant amounts of fine sediment on the stream bed downstream. During drainage works, the amount of time spent in the flowing part of the water way should be kept to a minimum. It is important to recognized that any discharge of fine sediment effects water clarity for quite some distance downstream while the work is carried out, but also for quite some time after works have stopped.

A portion of the fine sediment deposited on the stream bed in Doctors Creek and its tributaries originates from flood flows, when heavy rainfall erodes land surfaces close to water ways and washes soil and subsoil into the water. Input from this sediment source is again exacerbated by human activity. In some vineyards, vegetation on the vineyard and particularly along stream banks is frequently removed by spraying leaving exposed soil that is easily eroded. Although pesticide sampling found only small amounts of spray residue in the water, the sediment input can be quite substantial. The removal of bank vegetation also increases the risk of severe erosion that can result in the loss of productive land. Leaving bank vegetation to grow, stabilizes the stream banks and planting of shrubs would also increase the shading of the water ways. The current lack of taller bank vegetation results in very high water temperatures during the summer months, but it also aids the excessive growth of aquatic weeds and algae which in turn results in large dissolved oxygen and pH fluctuations. All this is detrimental to most

[8] Number of stock units per hectare

aquatic animal. Macroinvertebrate sampling and fish surveys confirm the currently limited ecological value of Doctors Creek.

Improvement of the water quality in Doctors Creek requires a combined effort, but considering the significant influence this water way has on the water quality of the highly valued Taylor River, the enhancement of Doctors Creek is potentially highly beneficial to the community.

Figure 50: The Taylor River at Riverside. Improvements of water quality in Doctors Creek would have a follow-on effect on the Taylor River.

References

1. ANZECC (2000) Australia and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council. Agriculture and Resource Management Council of Australia and New Zealand

2. Ausseil O and Clark M (2007) Recommended Water Quality Standards for the Manawatu-Wanganui Region: Technical Report to Support Policy Development. Report No. 2007/EXT/806 Horizons Regional Council

3. Biggs B (2000) New Zealand Periphyton Guideline: Detecting, Monitoring and Managing Enrichment of Streams. Prepared for Ministry for the Environment

4. Close M (2008) Review of Deep Wairau Aquifer – Groundwater Chemistry Aspects. Report prepared for Marlborough District Council. Client Report CSC0806

5. Close M and Skinner A (2011) National Survey of Pesticides in Groundwater 2010. Report prepared for Marlborough District Council. ESR Report No: CSC1102.

6. Davidson P and Wilson S (2011) Groundwaters of Marlborough. Marlborough District Council

7. Davidson P and Pamment A (2011) Groundwater Factsheet – Pesticides

8. Davidson P (2014) Groundwater Quality State and Trends 2014. Marlborough District Council Technical Report No. 14-005

9. Dean T and Richardson J (1999) Responses of seven species of native freshwater fish and shrimp to low levels of dissolved oxygen. New Zealand Journal of Marine and Freshwater Research. Vol. 33:99-106

10. Edmeades D, Metherell A, Waller J, Roberts A and Morton J (2006) Defining the relationships between pasture production and soil P and the development of a dynamic P model for New Zealand pastures: a review of recent developments. New Zealand Journal of Agricultural Research, 49, 207-222.

11. EPA (1999) Background Report on Fertilizer Use, Contaminants and Regulations. Report prepared by BATTELLE for US Environmental Protection Agency, Contract No. 68-D5-0008

12. Gabzdylova B, Raffensperger JF and Castka P (209) Sustainability in the New Zealand wine industry: driver, stakeholders and practices. Journal of Cleaner Production 17, 992-998

13. Gray C (2012) Survey of soil properties at some sites receiving winery wastewater in Marlborough. Marlborough District Council Technical Report No: 12-002

14. Gray C (2013) Soil Quality in Marlborough 2007-2012. Marlborough District Council Technical Report No. 13-004

15. Green S, Agnew R and Greven M (2014) Monitoring nitrate loss under vineyard soil on the Wairau Plains, Marlborough. Plant & Food Research report prepared for the Marlborough District Council, PFR SPTS No. 10328

16. Hay J, Hayes J and Young R (2006) Water Quality Guidelines to Protect Trout Fishery Values. Cawthron Report No. 1205 for Horizons Regional Council

17. Henkel S (2013) Investigation into High E. coli Concentrations in the Taylor River during Low Flows. Marlborough District Council – Technical Report No. 13-007

18. Henkel S (2013) State of the Environment Surface Water Quality Monitoring Report, 2013. Marlborough District Council – Technical Report No. 13-011

19. Henkel S (2014) Recreational Water Quality Report 2013-2014. Marlborough District Council – Technical Report No. 14-002

20. Henkel S (2014) State of the Environment Surface Water Quality Monitoring Report, 2014. Marlborough District Council – Technical Report No. 14-006

21. Hamill, PF (2007) Evidence for Hearing of the Resource Consent Application U071180. Marlborough District Council (unpublished)

22. Hill R and Sparling G (2009) Soil Quality Monitoring. In: Land Monitoring Forum. Land and Soil Monitoring: A guide to SoE and regional council reporting. Hamilton: Land Monitoring Forum, pp 27 – 88

23. Laurenson S and Houlbrooke D (2011) Winery wastewater Irrigation- the effect on sodium and potassium on soil structure

24. Lilburne L, Webb T, Robson M and Watkins N (2013) Estimating nitrate-nitrogen leaching rates under rural land uses in Canterbury (updated) Environment Canterbury Report No. R14/19

25. Lynn IH (2004) Soil map of the Wairau Plain. Scale 1:50,000. Landcare Research

26. MCB (1987) Wairau Valley Regional Wind Erosion Control Scheme Review 1977-1987. Marlborough Catchment Board (unpublished)

27. McDowell RW, Cox N, Daughney CJ, Wheeler D and Moreau M (2014) A national assessment of the potential linkage between soil, and surface and groundwater concentrations of phosphorus. 2014 Water Symposium, Blenheim, New Zealand

28. MCWB (1977) Taylor – Opawa River Water Quality Survey 1976-77. Marlborough Catchment and Regional Water Board

29. MfE (2003) Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas. Ministry for the Environment.

30. MfE (2008) Drinking-water Standards for New Zealand 2005 (Revised 2008). Ministry for the Environment.

31. Morgenstern U, van der Raaij R, Trompetter V and McBeth K (2008) Deep Wairau Aquifer Sustainability Review 2008 – Isotopic Indicators. Report prepared for Marlborough District Council. GNS Science Report 2008/33

32. NMRC (1987) Water and Soil Resources of the Wairau. Volume One, Water Resources. Nelson-Marlborough Regional Council

33. NMRC (1990) Water and soil resources of the Wairau. Volume three, Land and Soil resources. Nelson-Marlborough Regional Council

34. NZWWA (2003) Guidelines for the safe application of biosolids to land in New Zealand. New Zealand Water and Wastes Association, Wellington

35. Phreatos (2005) Hydrogeological Investigation of the Southern Springs, Wairau Plains. Report prepared for Marlborough District Council

36. Quinn J, Steele L, Hickey C and Vickers M (1994) Upper thermal tolerances of twelve New Zealand stream invertebrate species. New Zealand Journal of Marine and Freshwater Research. Vol. 28:391-397

37. Quinn J and Hickey C (1990) Characterisation and classification of benthic invertebrate communities in 88 New Zealand rivers in relation to environmental factors. New Zealand Journal of Marine and Freshwater Research, Vol. 24:387-409

38. Richardson J, Boubée J and West D (1994) Thermal tolerance and preference of some native New Zealand fish. New Zealand Journal of Marine and Freshwater Research. Vol. 28: 399-407

39. Ritchie H and Donnison A (2010) Faecal Contamination of Rural Waikato Waterways – Sources, Survival, Transport and Mitigation Opportunities. Environment Waikato Technical Report 2010/38

40. Roberts AHC and Morton JD (2009) Fertiliser use on New Zealand dairy farms. New Zealand Fertiliser Manufacturers' Research, Auckland

41. Sparling GP, Rijkse W, Wilde RH, van der Weerden T, Beare MH and Francis G (2001) Implementing soil quality indicators for land: Research report for 1999/2000, Landcare Research Contract Report 0001/059 for the Ministry for the Environment and various regional councils (unpublished)

42. Taylor M (2008) Ecological monitoring of Fairhall- Co-op Drain: 1st round. AEL Report No. 61

43. Taylor M (2010) Ecological monitoring of Fairhall- Co-op Drain: Round three. AEL Report No. 78

44. Taylor MD (2011) Towards developing targets for soil quality indicators in New Zealand: Findings of a review of soil quality indicators workshop. 6th May 2011. Unpublished report, Land Monitoring Forum.

45. Wilkes A (2000) Review of Water Quality in the Taylor/Omaka/Opawa River System. Report prepared for Marlborough District Council

46. Williman EB and Sutherland RD (1992) Wairau Catchment River Management – Interim Note on Main Issues. Nelson-Marlborough Regional Council (unpublished)