5. Land cover

Figure 18: Original stream channels and stream diversions in the lower Doctors Creek catchment [32].

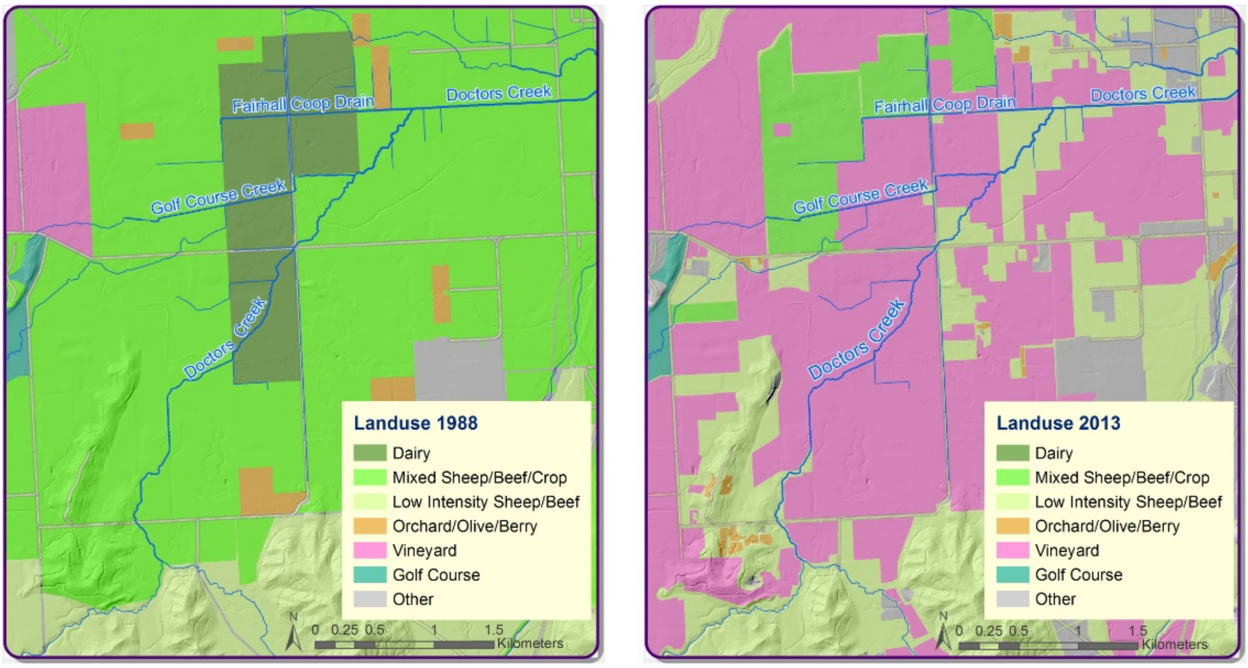

Figure 19: Landuse in 1988 (left) and 2013 (right) in the lower Doctors Creek catchment.

Before human settlement, a large area of the lower Doctors Creek catchment was covered in an extensive swamp. The wetland was dominated by Flax, Raupo, Toitoi and Cabbage trees with patches of Kahikatea, Pukatea and Swamp Maire. On the hills, dryland forest mixed with shrubs and tussock grassland was growing in sunny areas, while gullies and stream margins were covered in Tree Brooms, Kowhai, Maitai and Totara [33].

Maori and European settlers set fire to the original forests. In order to provide land for settlement and primary production, the wetland was drained before the 1930's. Today none of the original native vegetation cover remains.

The channel of Doctors creek was considerably modified over the last 120 years, with many of the waterways now having unnaturally high and steep banks. The Omaka River and Fairhall River, that once flowed into the wetland were diverted to the north into the Opawa River (Figure 18). Extensive networks of surface and sub-surface drains were built to lower groundwater levels and prevent flooding.

In the 1980's most of the land in the lower Doctors Creek catchment was used as pasture for sheep and beef mixed with cropping and a relatively large area along Bells Road and the upper Benmorven Road included dairy pasture. Small orchards could also be found (Figure 19- left). This has changed significantly over the last two decades. Although the low intensity pastures of the hills in the south remained, the landuse in the low lying areas is now very different. By 2013, the majority of the lower catchment had been converted into vineyard and further conversions for some of the remaining pastures is planned (Figure 19).

Figure 20: The Fairhall Coop Drain is the largest of the artificial drainage channels constructed in order to lower the groundwater level.

6. Water Quality

The degraded water quality of Doctors Creek at the confluence with the Taylor River was the main reason for the funding of this report.

Over sixty sites were sampled as part of the investigation into the water quality of Doctors Creek in 2013 and 2014. The number of samples taken at each site varies from one to more than ten. Sites that were sampled nearly every time are referred to as 'Core Sites'. The following sections present the results of this sampling.

Often results were quite different in the drier summer months compared to observations in winter. For this reason measurements are presented separately for the two seasons[4]. Results are generally shown in the form of maps based on the results from all sites and as graphs showing results for the core sites only[5]. Results from earlier studies and the State of the Environment program are also included.

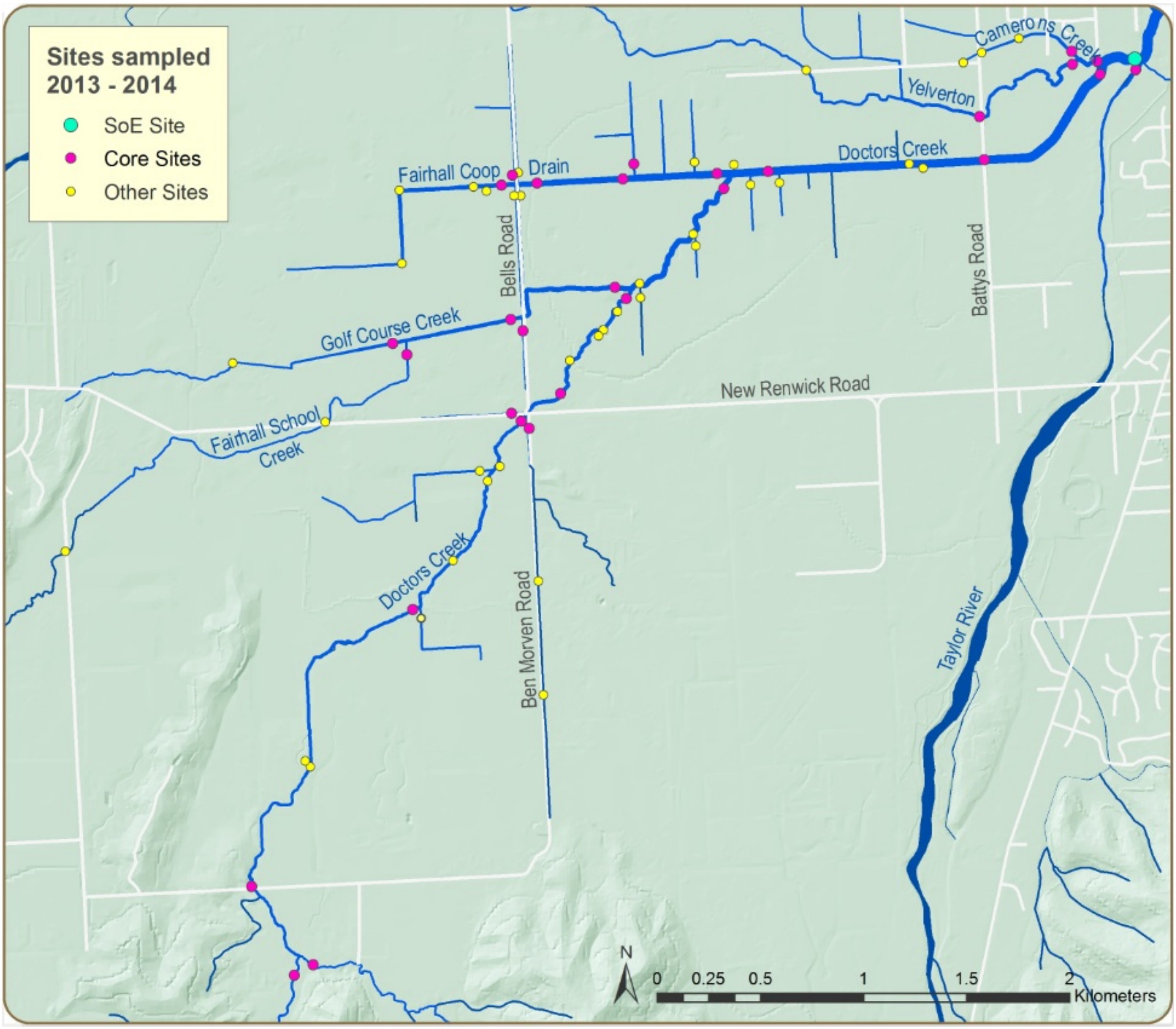

Figure 21: The sites sampled as part of the 2013/2014 investigation for this report.

[4] 'winter' = July – September, 'summer' = December - April

[5] The actual numerical results of the sampling can be obtained on request from the Marlborough District Council

6.1. Nitrate

Nitrate, ammonical nitrogen and nitrite are the forms of nitrogen that are easily taken up by plants. They are collectively referred to as 'Soluble Inorganic Nitrogen'. In surface water and shallow groundwater most of the Soluble Inorganic Nitrogen is in the form of nitrate.

Any nitrogen in animal waste or nitrogen fertilizer applied to land that is not taken up by the vegetation is potentially carried into groundwater by rainfall or irrigation water. Very high nitrate concentrations (> 11.3 g/m^3) can make groundwater unsafe for human consumption as nitrate interferes with oxygen transport in the blood of very young children ('Blue-Baby-Syndrome'). In waterways, high nitrate concentrations can be toxic to some aquatic animals, including fish and koura (freshwater crayfish). The limit of 1.5 g/m^3 for nitrate in the National Policy Statement for Freshwater Management 2014 is based on this toxicity.

At lower concentrations nitrate and the other forms of Soluble Inorganic Nitrogen can cause nuisance algae growth on the stream bed. This is not only visually unpleasing, but it can also cause a reduction of biodiversity as the algae smother available habitat for many aquatic insects which in turn are food for fish. The guideline of 0.165 g/m^3 for Soluble Inorganic Nitrogen used in this chapter is based on this effect and is the guideline value used for State of the Environment reporting [3, 18]. Because more than 96% of the Soluble Inorganic Nitrogen in Doctors Creek is in the form of nitrate, in this report the same guideline is applied to nitrate-nitrogen concentrations.

Figure 22 shows the Soluble Inorganic Nitrogen results from monthly sampling of Doctors Creek carried out as part of the State of the Environment program. Nitrate concentrations were particularly high in 2010. Samples taken in 2010 and early 2011 also had comparatively high nitrite concentrations. Usually nitrite is very quickly converted into nitrate, which means high nitrite concentrations are an indication of a direct input of organic matter, urea fertilizer or effluent close to the sampling point. It is unclear what caused the high nitrite and nitrate concentration. Although very high rainfall in mid-2010 might have resulted in increased run-off from the surrounding land surface, it does not explain similar nitrate and nitrite concentration earlier that year. Concentrations have since reduced significantly. Particularly nitrite has been barely detectable in samples taken since mid-2011.

Trend analysis using the seasonal Kendall trend test show that nitrate concentrations have significantly decreased since monitoring began in 2009. Since 2012 nitrate concentrations have been below the value toxic to aquatic life. Nevertheless, current values are still well above the guideline for nuisance algae growth.

Consistently elevated concentrations suggest nitrate leachate into groundwater and subsurface water rather than direct inputs as the main source. This is common for spring fed streams in Marlborough, including Murphys Creek, Spring Creek and Mill Creek. Different land uses cause varying amounts of nitrate leaching into groundwater. A report by Environment Canterbury estimated that nitrate leaching was highest for dairy and beef farms, followed by cropping. Sheep and deer farms leached comparatively low amounts of nitrate [24]. Depending on stocking rate and soil type, between 9.0 and 132.4 kilograms of nitrogen per hectare is leached from dairy farms per year, compared to 2.3 – 5.2 kilograms of nitrogen per year and hectare on dryland sheep farms. Measurements of nitrate leaching under a vineyard in Marlborough showed that less than 4 kilograms of nitrate per hectare were lost to groundwater for this type of land use [15].

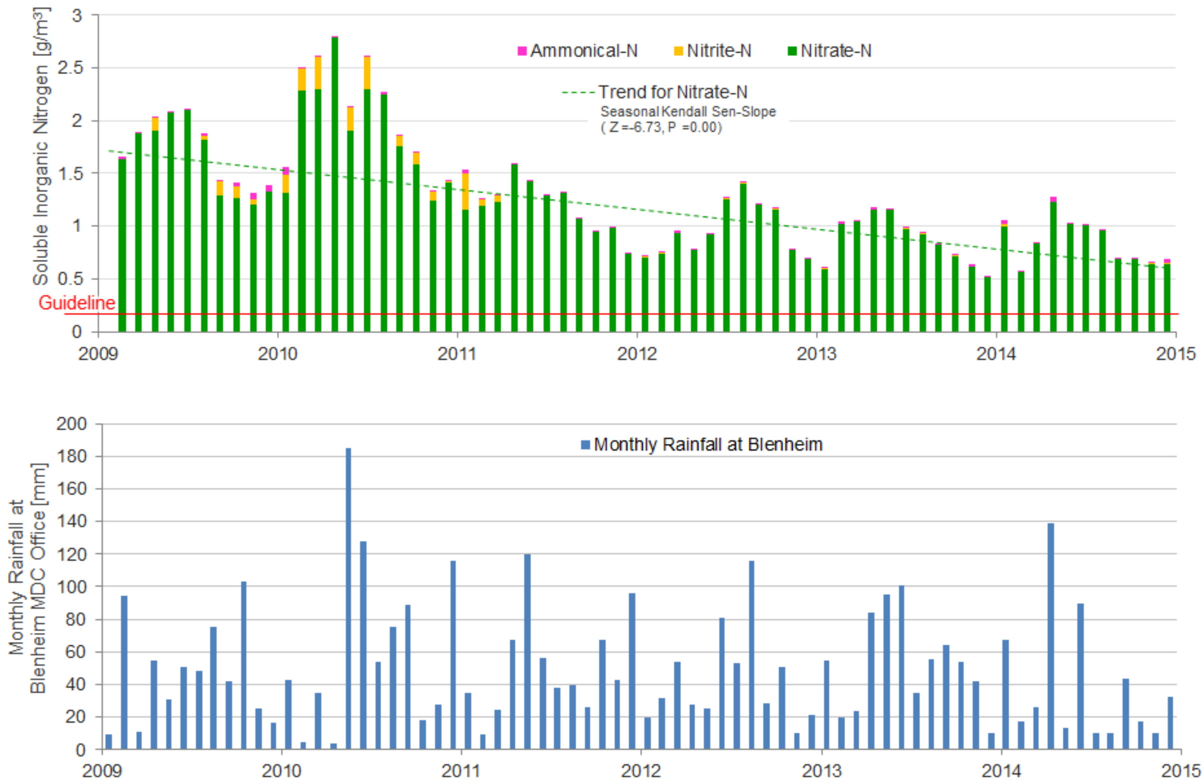

Figure 22: Soluble Inorganic Nitrogen concentration in monthly samples taken from Doctors Creek upstream of the Taylor River. Shown are the contributions of the three main forms of Soluble Inorganic Nitrogen to the overall concentration. The graph below shows the monthly rainfall recorded in Blenheim for the same time period.

A large proportion of the area of the Doctors Creek catchment has been converted from dairy and mixed beef/sheep/cropping farms into vineyards. This would have resulted in a significant reduction of nitrate loss to groundwater over the years and is the likely cause for the reduction in nitrate concentrations observed in Doctors Creek. As groundwater is not bound by the boundaries of surface catchments, some of the water flowing in Doctors Creek originates from areas to the west and north, and water quality is therefore also influenced by land use activities outside the catchment. However, the conversion of pasture into vineyards has been widespread in the whole of the Wairau Plain. The exact age of the groundwater emerging in Doctors Creek and its tributaries is unknown and it is therefore difficult to predict and manage nitrate concentrations in the waterway. Nevertheless, the low nitrate losses measured under vineyards suggest nitrate concentrations in Doctors Creek are likely to further reduce over time.

Nitrate concentrations in Doctors Creek show a distinct seasonal pattern of lower concentrations in summer compared to the winter months. This is common for most waterways. Warmer temperatures and longer days result in more vigorous growth of aquatic plants, which remove nitrate from the water column to incorporate it into their biomass. Terrestrial plants also take up more nutrients during the warmer months and less nitrate is lost into the shallow groundwater and subsequently the spring-fed streams.

Lower concentrations during the summer months were also observed in the investigative sampling carried out in 2013 and 2014 (Figures 23 and 24), but the lowest concentrations were observed in the upper reaches of the catchment (south of New Renwick Road) in the winter. The waterways in this area are fed by groundwater that is potentially very old. Most of the rainfall that produced this groundwater fell at a time before intensive agriculture was established in the area. Occasional higher concentrations of nitrate here are most likely a result of direct input from wildfowl as well as cattle or sheep.

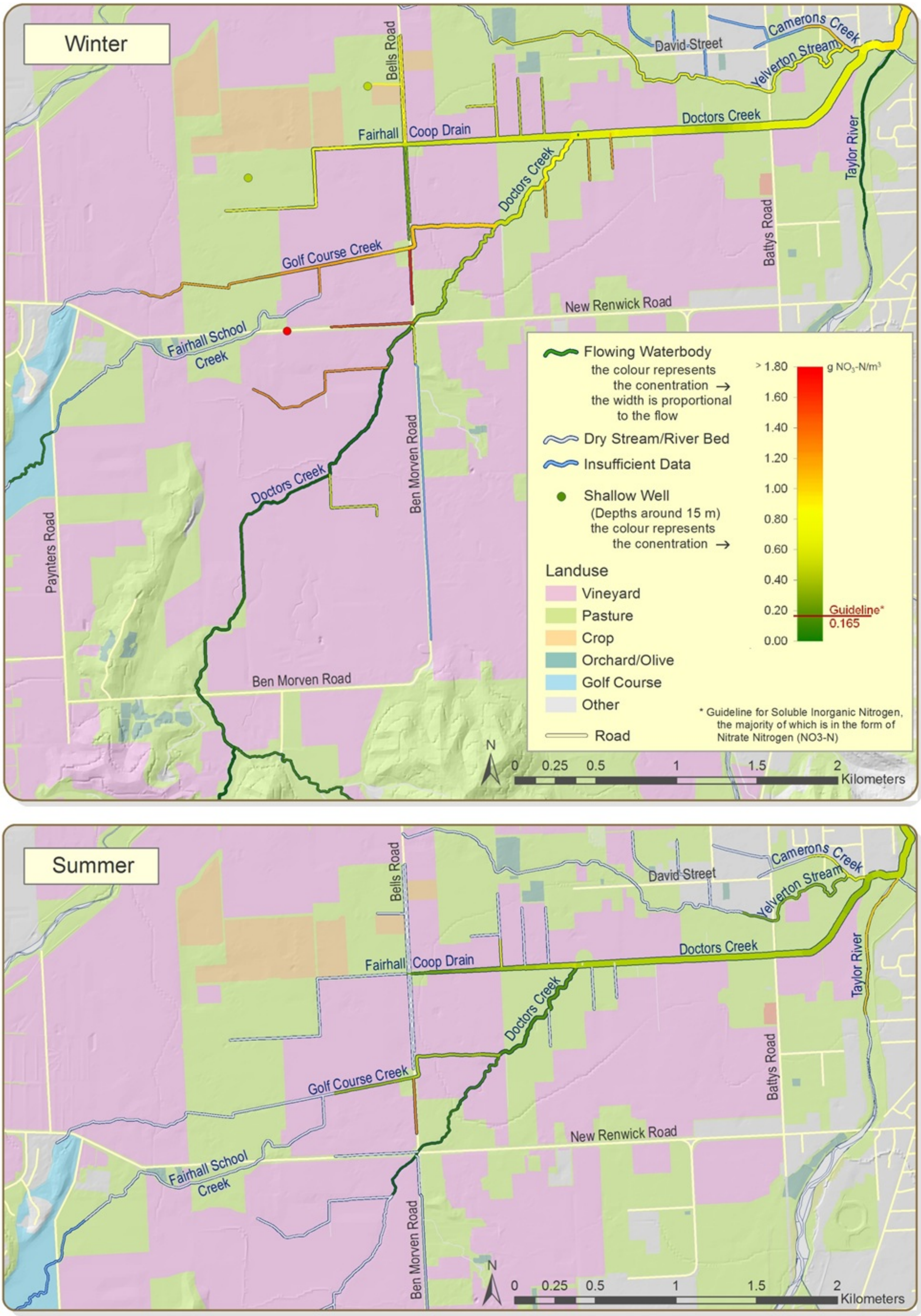

Figure 23: Nitrate concentrations in the Lower Doctors Creek catchment based on measurements taken in winter 2014 and summer 2013/14. Also shown is the land use at the time.

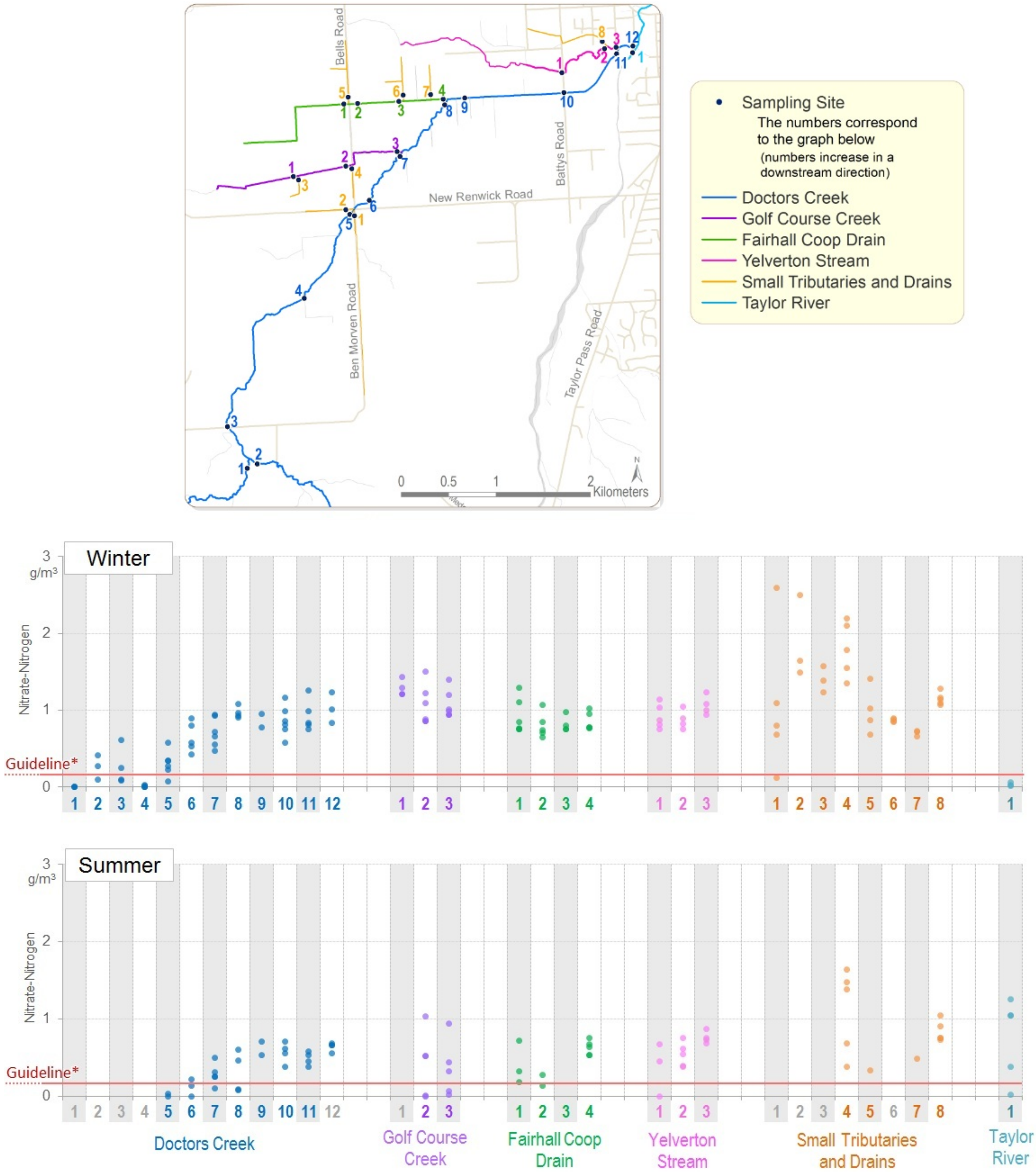

Figure 24: The individual Nitrate-Nitrogen concentrations measured at the core sites of the 2013/214 investigation.

Nitrate concentrations are substantially higher in Golf Course Creek, Fairhall Coop Drain and Yelverton Stream, but the highest values were observed in some of the smaller drains around New Renwick Road and lower Bells Road. Water from shallow wells had similar nitrate concentrations to drains in the same part of the catchment. This further strengthens the theory that most nitrate originates from groundwater inflow. The stretch of Doctors Creek between Golf Course Creek and Fairhall Coop Drain is one of the few parts of the waterway where an increase in nitrate concentrations is not the result of groundwater influences. Instead direct inputs in the form of cattle excrements are the most likely reason, as this is one of the few areas were cattle have direct access to the waterway. Slight increases of nitrate levels observed around Battys Road are potentially also traceable to the impact of cattle grazing. Although the animals have no direct access to the waterway, small surface seeps that originate on some of the paddocks might carry nitrate from faecal matter into the main channel.

Nevertheless, apart from these direct inputs in the form of animal faeces, the majority of nitrate found in Doctors Creek originates from groundwater inflows. The high nitrate concentrations in water emerging in Golf Course Creek, Fairhall Coop Drain and Yelverton Stream have a significant effect on the water quality of Doctors Creek, as these tributaries provide the majority of the flow to the system. A possible source for the high nitrate levels in the groundwater might be leachate from localised land uses. Paddocks located to the east of the golf course are the only areas in the catchment that have winery waste water applied to them. However, the area affected by elevated nitrate concentrations is considerably larger than this localised influence would suggest. Further to the north, the remaining cropping mixed with beef pasture is likely to have an effect on the nitrate concentrations in the Fairhall Coop Drain and possibly Yelverton Stream. Most of the area is to be converted into vineyard. A repeat of the monitoring done as part of this study in the future would show the effects of that land use change.

An earlier investigation of Nitrate concentrations in wells located in the Fairhall River catchment (Brancott Valley), west of Doctors Creek revealed very high nitrate level in shallow groundwater (Figure 25). The investigation was carried out in 2000 and unfortunately none of the wells have been monitored recently. There are no long term records of nitrate concentrations in shallow wells for the Fairhall River catchment or the Doctors Creek catchment. Well 0662 located to the north, close to Middle Renwick Road, has been monitored for a number of years (Figure 25, Figure 26). The well is likely to represents a groundwater source with a greater link to the Wairau aquifer, but measurements can still provide an indication of the changes in nitrate concentrations in shallow aquifers of the area over time. It appears that nitrate levels have dropped in recent years, particularly since 2011. This is also consistent with observations in Doctors Creek (Figure 22). Thus, it is likely that concentrations in the shallow wells in the Brancott Valley have decreased also. However, in 2000 nitrate concentrations in well 0662 were significantly lower than those in the shallow Brancott aquifer. It can, therefore, be assumed that nitrate levels in the Brancott aquifer are still quite high.

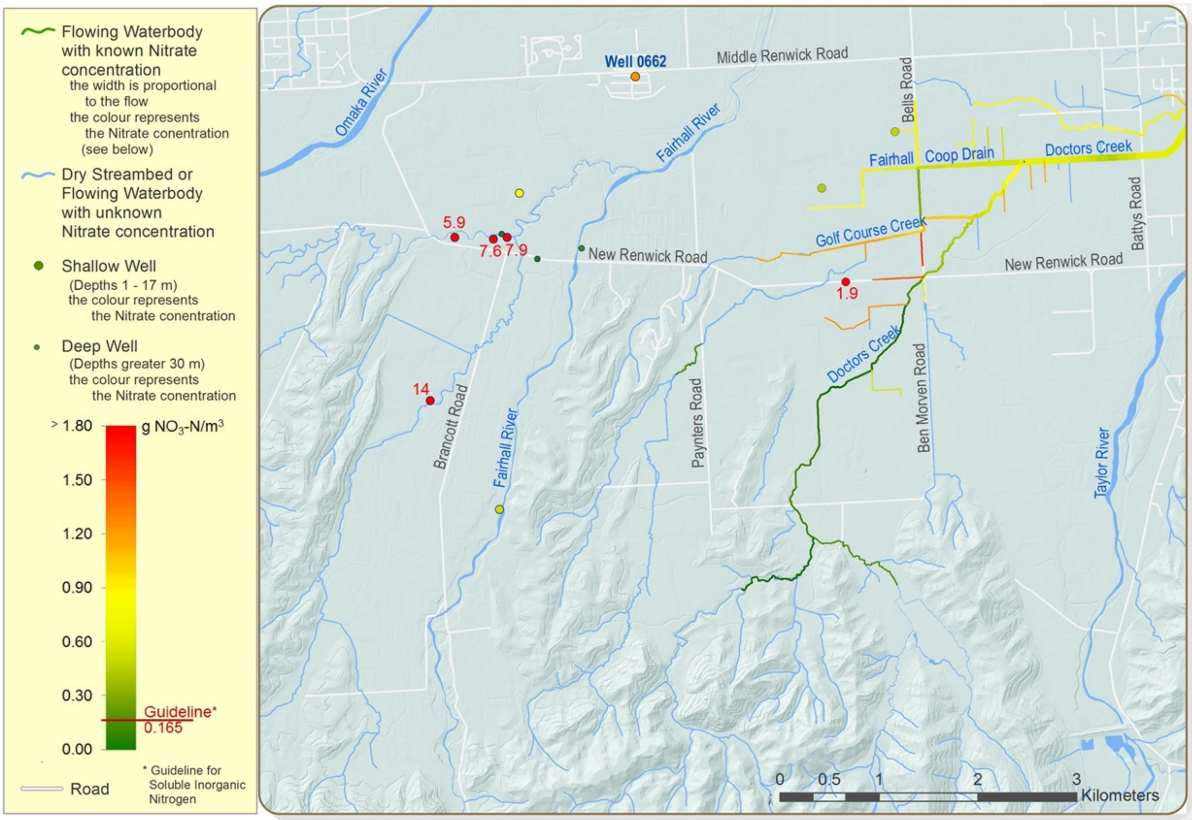

Figure 25: Nitrate concentration measured in the Fairhall River catchment in 2000 and in the Doctors Creek catchment in 2014.

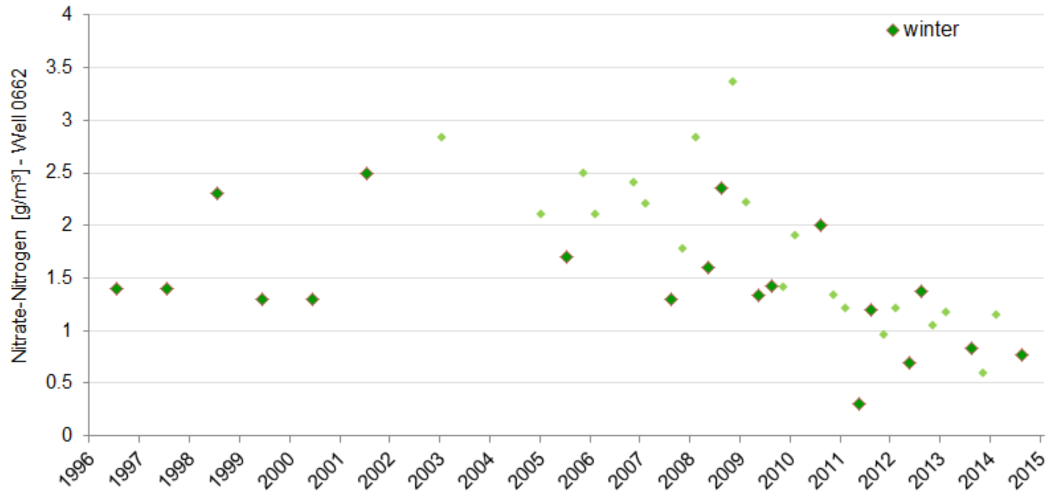

Figure 26: Nitrate concentration in well 0662. Early measurements were only carried out in winter; hence values for the winter months are highlighted to allow easier comparison.

Based on the information above, it is apparent that a significant amount of the nitrate in Doctors Creek originates from areas outside of the catchment, located to the west. Although it is likely that nitrate concentrations will continue to decline, further investigation into age and origin of the groundwater emerging around New Renwick Road and further north would allow a better understanding of the sources. This in turn would permit more effective management of the surface water quality in Doctors Creek.

6.2. Dissolved Reactive Phosphorus (DRP)

Dissolved Reactive Phosphorus (DRP) is a measure for the amount of phosphorus in the water column that can easily be taken up by plants. Together with elevated nitrate concentrations, high levels of DRP can result in excessive growth of algae. These algae can smother the stream bed, which results in the reduction of habitat for fish and aquatic insects. Excessive algae cover also impacts on the amenity and recreational values of a waterway.

DRP concentrations are usually significantly lower than nitrate concentrations, as phosphorus is easily absorbed onto soil particles. It is therefore less mobile than nitrate. Leaching of phosphorus does, however, occur if the soil becomes saturated with phosphorus due to frequent application of phosphorus fertilizer. This has been observed under cropping in some parts of New Zealand [27].

The guideline of 0.015 g/m^3 used in this report is based on limits set by Biggs (2000) to prevent nuisance algae growth in rivers and streams [3]. This is also the guideline used for the State of the Environment reporting.

State of the Environment and other monitoring of DRP in Doctors Creek upstream of the Taylor River shows, that concentrations have not changed significantly since the late 1980s (Figure 27). The majority of samples taken at this site had DRP levels above the guideline. There is a weak seasonal pattern of higher concentrations during winter, but it is not as pronounced as for nitrate concentrations. During the investigations carried out in 2013 and 2014, the DRP concentrations at the site were actually slightly higher during summer compared to levels during the winter months.

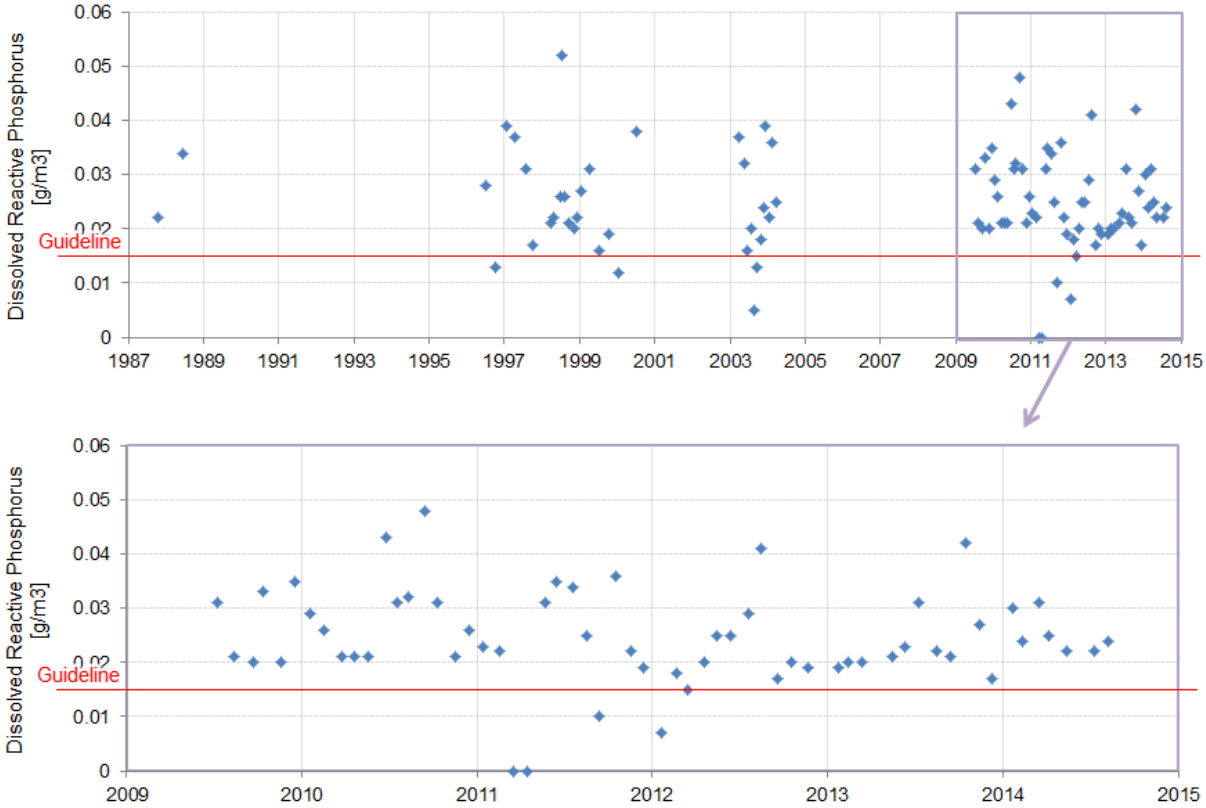

Figure 27: Dissolved Reactive Phosphorus concentrations in Doctors Creek upstream of the Taylor River.

DRP concentrations in Doctors Creek are more than 10 times lower than nitrate concentrations. This reflects the lower concentrations in the sources (i.e. fertilizer, animal droppings), but also the fact that phosphorus is less mobile in the environment as it binds to the soil more readily than nitrate. The difference in binding properties also explains why DRP concentrations are generally not very well correlated to nitrate concentrations (Figure 28).

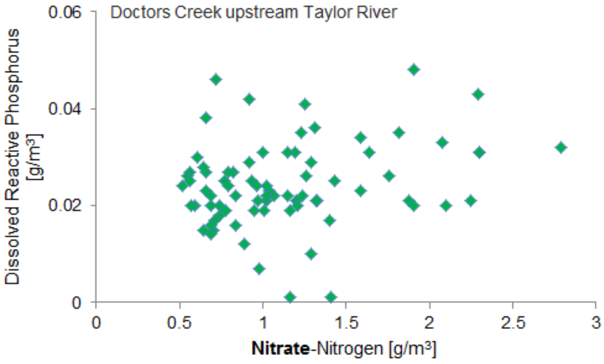

Figure 28: Correlations between Dissolved Reactive Phosphorus concentrations and Nitrate-Nitrogen concentrations in Doctors Creek upstream of the Taylor River.

During the winter months in 2013, the highest DRP concentrations were observed in some smaller tributaries and the western parts of Golf Course Creek, where groundwater begins to emerge (Figure 30). This suggests groundwater is the main source of DRP. The influence of groundwater is reflected in similar DRP concentrations in shallow wells and nearby waterways. Most of the highest concentrations occur around the same areas where very high nitrate concentrations are found. This is not surprising, as the sources of DRP are similar to those for nitrate. This, however, is the only similarity with the distribution of nitrate levels across the catchment. DRP concentrations in Doctors Creek steadily increase from the south to the north until the New Renwick Road Bridge (Figure 30 and Figure 31). In this part of the creek the surrounding land use is dominated by vineyard, which is commonly grazed by sheep during the winter months. While the animals would rarely enter the water, they could frequently be seen along the banks of the creek. In some parts, the stream banks were devoid of any vegetation, a result of intentional removal by spraying combined with trampling by sheep. When the sheep moved down the steep banks in order to take a drink, their sharp hoofs would occasionally shift soil into the waterway. This resulted in the partial release of phosphorus from the soil into the water. The good correlation between DRP concentrations and turbidity for samples taken in winter indicates this to be a major source of DRP during the colder months (Figure 29).

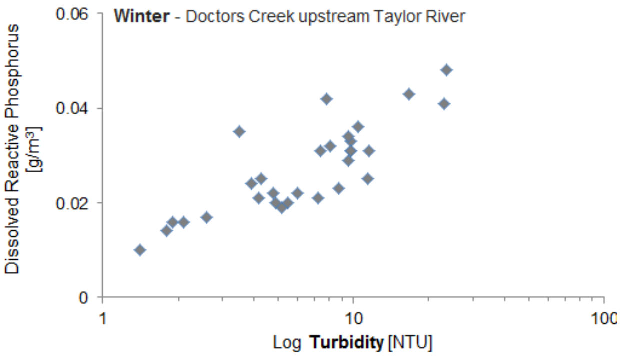

Figure 29: Left: Correlations between DRP concentrations and turbidity in Doctors Creek upstream of the Taylor River for the winter months (There was no clear correlation for samples taken during the summer). Right: Sheep grazing and bare stream banks on a vineyard.

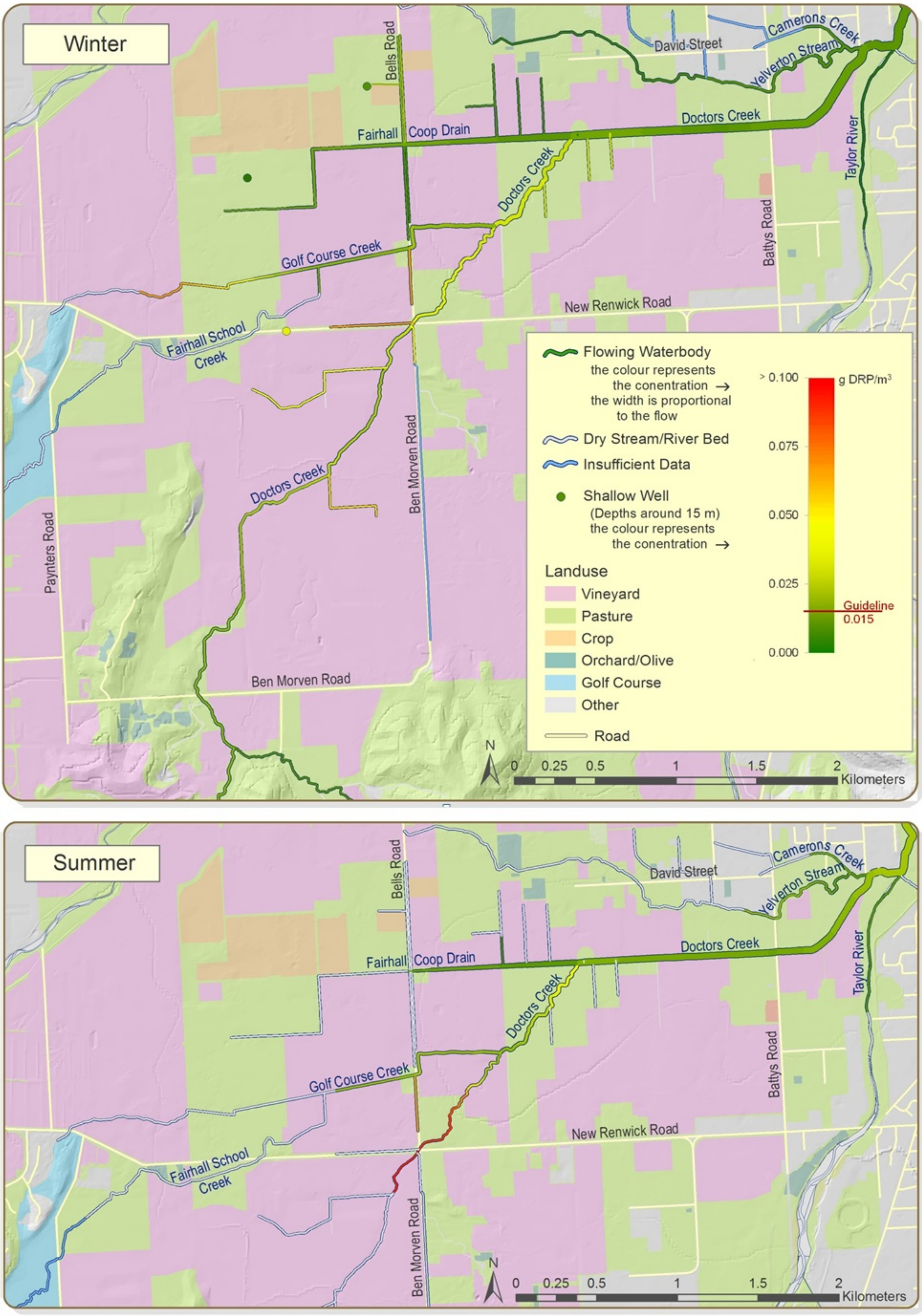

Figure 30: DRP concentrations in the Lower Doctors Creek catchment based on measurements taken in winter 2014 and summer 2013/14. Also shown is the land use at the time.

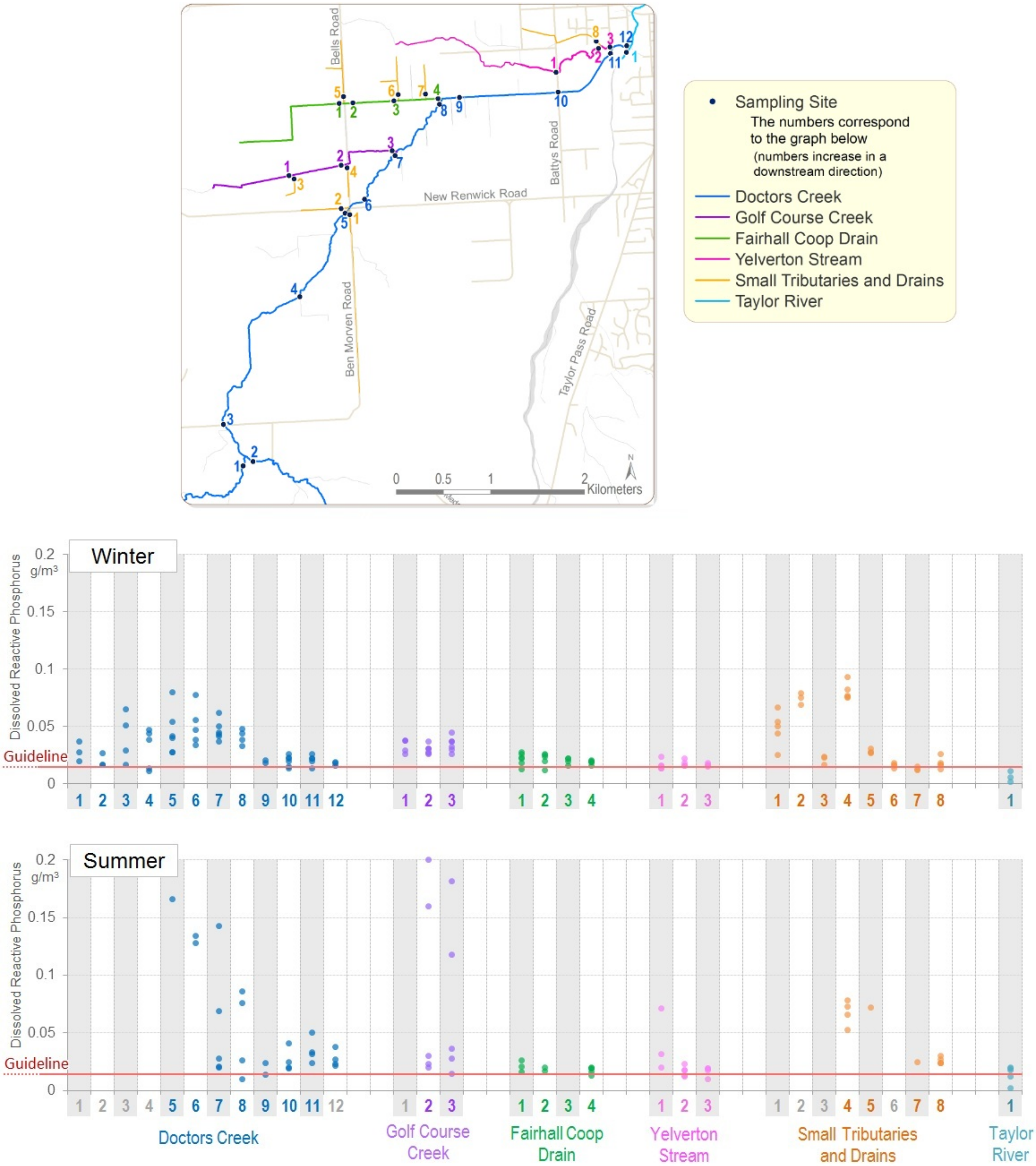

Figure 31: Dissolved Reactive Phosphorus concentrations at core sites of the 2013/14 investigation.

DRP levels in Fairhall Coop Drain are comparatively low and similar to those in Yelverton Stream. Most samples from these tributaries had DRP concentration only slightly above the guideline value. DRP concentrations in the Tayor River upstream of Doctors Creek were below the guideline in winter, but slightly higher in summer.

During very low summer flows, DRP concentrations were extremely high in some of the areas where water would first emerge. Examples are Doctors Creek at New Renwick Road and some samples taken from Yelverton Stream at Battys Road. A possible explanation might be the release of additional phosphorus from sediment. The shallow pool-like areas were chocked with aquatic weeds often overgrown by algae. While this abundance of aquatic plants is oxygenating the upper layers of the water column, water close to the creek bed is potentially oxygen depleted. The dense cover of aquatic plants means that very little light reaches the lower parts of the water column which means oxygen input via photosynthesis is minimized. The slow flow results in a lack of turbulence and consequently, a lack of mixing of the upper, oxygenated water column with water close to the stream bed. At the same time oxygen is constantly removed via respiration by aquatic plants and by microorganisms decomposing dead plant material. Additionally, the groundwater that rises to the surface in these areas is already comparatively low in oxygen. The result is very low oxygen concentrations in the water immediately above the stream bed. During these conditions fine sediment deposited on the bed can release phosphorus into the water column. This is a phenomenon commonly observed for lake sediments during summer stagnation when mixing of the water in some lakes is restricted to the upper water columns, resulting in anoxic conditions in the deeper water.

The same mechanism might also be responsible for some of the very high DRP concentrations observed in Golf Course Creek during summer.

Figure 32: Doctors Creek at the New Renwick Road Bridge in March 2014 at very low flows. The water is nearly stagnant and a dense cover of aquatic weed is growing on the stream bed.

6.3. E.coli

E.coli are bacteria found in the gut of warm-blooded animals and humans. Most E. coli strains are not harmful to human health, but their presence indicates contamination with faecal matter, which might contain harmful organisms like Campylobacter or Cryptosporidium.

The main source of faecal contamination in rural areas is stock access to water ways. Particularly cattle have a high affinity to water. Additionally, animal droppings on land adjacent to a waterway can be washed into the stream or river during rainfall. This can result in very high E. coli concentrations, particularly after long dry periods. For this reason, it is not recommended to swim in rivers for at least 72 hours after rainfall.

In residential areas, leaking effluent systems are the most likely source of high E. coli concentrations. Malfunctioning systems or broken pipes can release large numbers of pathogens into the surrounding soil. Microbiological and absorption processes in the soil are very effective in removing these pathogens, but if the rate of effluent release exceeds the treatment capacity of the soil, pathogens are potentially released into nearby waterways and shallow groundwater. In some residential areas dog droppings are an additional source of faecal contamination.

Large numbers of wildfowl (i.e. ducks, seagulls and Pukekos) can also cause high E. coli concentrations, particularly if flows are low.

If exposed to air and sunlight, E. coli die quickly, but when attached to moist sediment and soil they can survive for a long time period. This is an issue if thick layers of fine sediment are covering stream beds. These sediments can act as a continued source of contamination long after the original source has been removed.

The E. coli guideline of 550 E.coli/100mL used in this document is based on guidelines for water quality of recreational waters released by the Ministry for the Environment and the Ministry for Health in 2003 [29].

Figure 33 shows E. coli concentrations in Doctors Creek just upstream of the Taylor River confluence. From mid-2009 until mid-2010 concentrations appear to have been slightly lower, however, the large gaps in the record make the assessment of possible patterns difficult. In recent years E. coli concentrations have been similar to levels measured in the late 1990s. This indicates that there has been no significant change in E. coli concentrations over the last two decades.

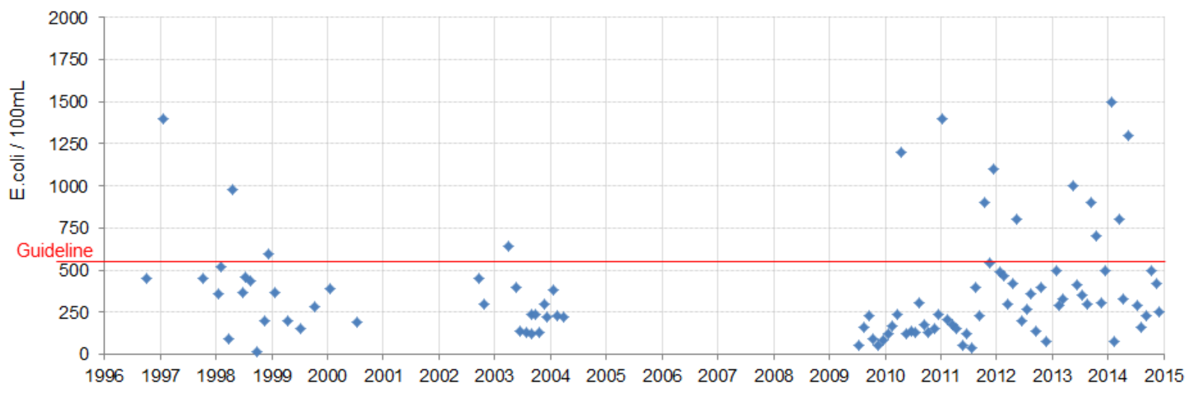

Figure 33: E. coli concentration in Doctors Creek upstream of the Taylor River.

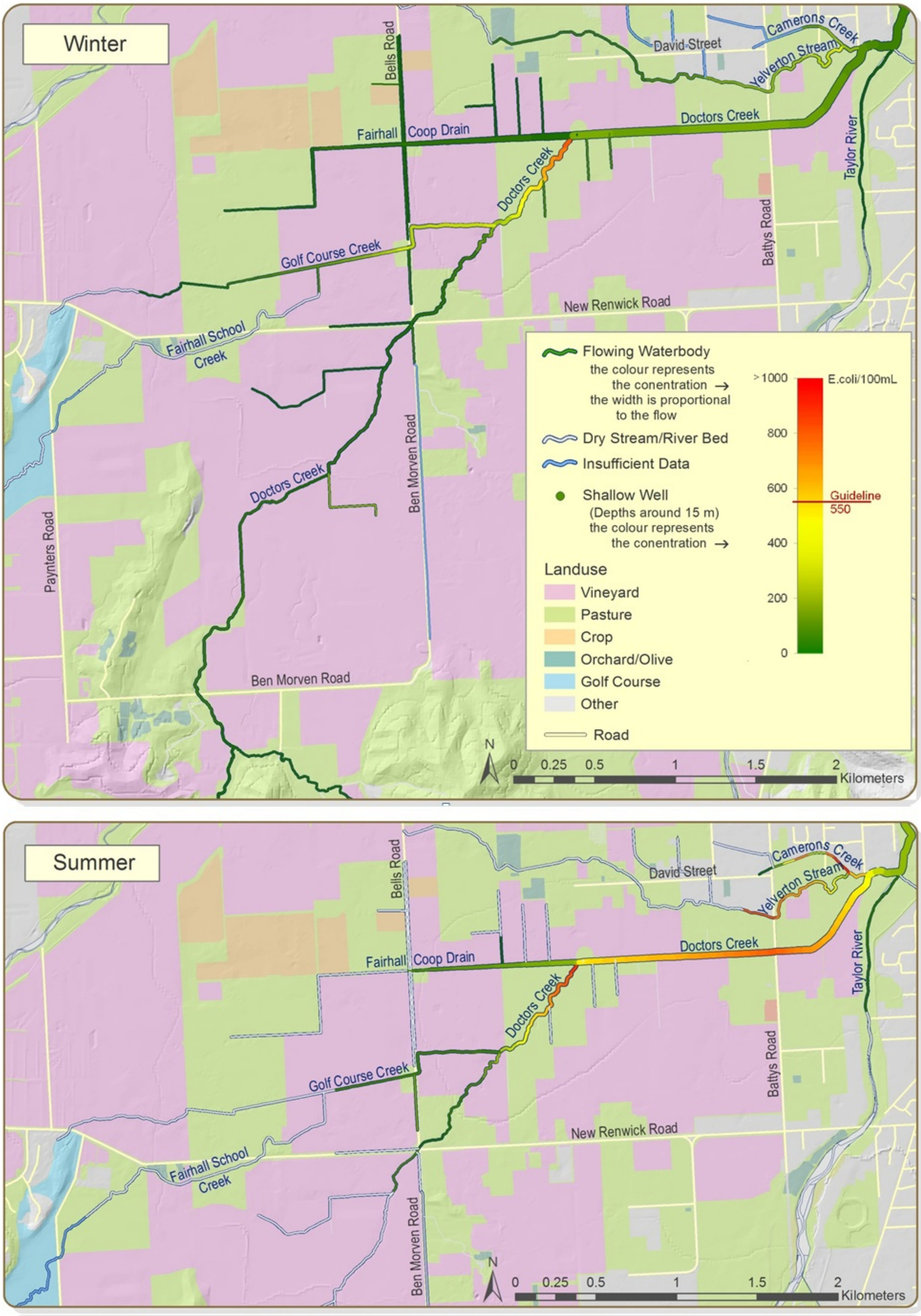

Figure 34: E. coli concentrations in the Lower Doctors Creek catchment based on measurements taken in winter 2013 and summer 2013/14. Also shown is the land use at the time.

There appears to be no seasonal pattern. Concentrations vary substantially throughout the year and levels above the guideline occur during low flow periods as well as during rainfall events.

During the investigation carried out as part of this report, concentrations were generally higher in summer compared to the cooler months (Figure 34). During the warmer months, the lower flows resulted in reduced dilution of inputs and consequently higher concentrations. Samples were taken during base flow only, making this pattern more visible compared to State of the Environment sampling that is carried out independent of flow conditions. Only Golf Course Creek had generally higher levels in winter compared to the summer months. In winter, the creek emerges in paddocks on which cattle have access to the waterway. In summer these upper reaches dry out and the Golf Course Creek emerges further downstream in an area dominated by vineyards. A very high E. coli concentration in a sample taken from Golf Course Creek at Bells Road at the end of summer, is likely the result of wildfowl activity upstream and very low flows.

E. coli concentrations were generally low in the upper reaches of Doctors Creek, the smaller drains and in the Taylor River. Fairhall Coop Drain also had comparatively low E. coli concentrations, but levels were slightly elevated in summer.

Throughout the year E. coli concentrations were comparatively high in Doctors Creek upstream of the confluence with Fairhall Coop Drain. The paddocks in this area are grazed by a small number of cattle (30-40) and a larger number of sheep. This is also one of the few areas where cattle have access to the waterway throughout the year. Despite a comparatively low stocking rate for cattle, the animals were frequently seen in and around the creek (Figure 35).

Figure 35: Cattle aggregating in and around the channel of Doctors Creek upstream of the confluence with Fairhall Coop Drain.

In summer, E.coli concentrations remain high downstream of the Fairhall Coop Drain confluence and only decrease significantly east of Battys Road, probably as a result of dilution from increased groundwater inflow in this area. Despite additional inputs from Yelverton Stream, the concentration in Doctors Creek further reduces downstream. An earlier investigations carried out in the summer of 2012/13 showed that dilution and die-off of E. coli also continues after Doctors Creek flows into the Taylor River. Nevertheless, the consistently high E. coli concentrations in Yelverton Stream were further investigated and three distinct sources were identified. One source appears to be located in the upper Yelverton Stream upstream of David Street and two more sources in Camerons Creek. Microbial Source Tracking showed that the source in Yelverton Stream and at least one in Camerons Creek are of human origin. At the time this report was written, most of Yelverton Stream and Camerons Creek had dried out, which made it impossible to further narrow down the exact location of the contamination. As soon as surface flow returns, efforts to eliminate these sources will continue.

Figure 36 shows results from the investigation in 2013/14 and previous studies. E.coli concentrations observed in earlier studies were of similar magnitude as those found in 2013/14.

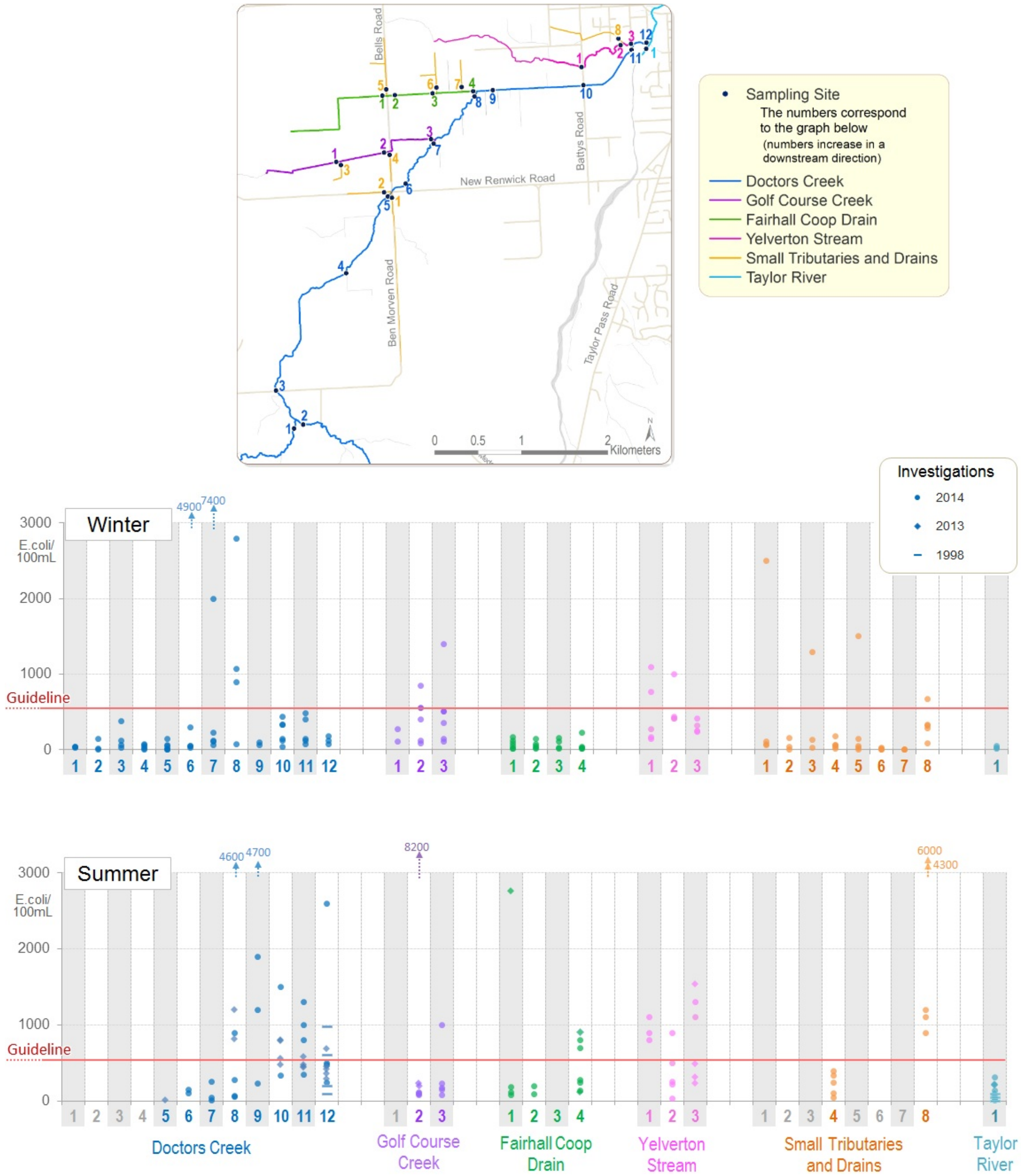

Figure 36: The individual E. coli concentrations measured at the core sites of the 2013/214 investigation and earlier studies.

Although most of Doctors Creek is not used for recreational activities, the creek provides most of the flow to the Taylor River, which has a high recreational value for most residents of Blenheim. Occasionally, children are seen playing in the water at the confluence with the Taylor River. For this reason removal of the sources of faecal contamination is desirable. The human sources in Yelverton Stream will be investigated and eliminated once flows increase. Nonetheless, this is unlikely to be sufficient to decrease faecal contamination in Doctors Creek to an acceptable level, as the flow contribution of Yelverton Stream is relatively small.

For areas upstream of Battys Road, microbial source tracking showed wildfowl sources in all samples and ruminant sources in all but Golf Course Creek[6] samples as the main contributors to faecal contamination. While wildfowl, like Pukekos, are a natural source and difficult to control, fencing off cattle, particularly in the area of Doctors Creek upstream of Fairhall Coop Drain is likely to improve water quality. When fencing waterways, it is vital to also include tributaries and emerging springs. Wet areas in close proximity to Doctors Creek are the possible reason for the increasing E. coli concentrations that were observed around Battys Road. Cattle grazing on the northern banks of the creek are fenced off, but a number of small seepage areas on the paddocks potentially carry polluted water into Doctors Creek.

Figure 37: A small drain on a paddock grazed by beef cattle and sheep.

[6] Sampled during low flows.