Regional District of Nanaimo Community Watershed Monitoring Network Three Year Trend Report 2012 - 2014

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Environmental Protection Division
Regional Operations Branch

Acknowledgements

This program would not be possible without the dedication, passion and excellent work of the participating stewardship groups: *Departure Creek Streamkeepers, Island Waters Fly Fishers, Vancouver Island University Fisheries and Aquaculture Department.* Many thanks also to Island Timberlands for provision of safety gear and financial support.

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Executive Summary

This report presents a summary of trends observed in the first three years (2012, 2013 and 2014) of data collected by four groups (Departure Creek Streamkeepers, Island Waters Fly Fishers, VIU Fisheries and Aquaculture and City of Nanaimo) as part of the Regional District of Nanaimo Community Watershed Monitoring Network (CWMN).

This program is a partnership between Ministry of Environment, the Regional District of Nanaimo, Island Timberlands LP and local environmental stewardship groups. The goal of the program in its early stage was to conduct a simple, quick assessment of multiple watersheds to raise watershed health awareness in local communities and obtain a three year dataset for trend analysis. Longer term goals are to use trend data collected in the early stage to determine in which watersheds more detailed monitoring and/or improved watershed management need occur, and to assist in land use planning. In this document, data presented from 19 different sites in 4 different watersheds were compared to existing BC Water Quality Guidelines (BC MOE, 1997) and/or Englishman River Water Quality Objectives (Barlak *et al*., 2010), applicable to other watersheds within the same ecoregion.

Based on water quality guidelines and objectives, an exceedance of one of the measured parameters (temperature, dissolved oxygen or turbidity) occurred at each of the 19 sample locations during at least one of the sample periods. Temperature and dissolved oxygen exceedances tended to be reflective of general summer conditions for most east coast streams, particularly in the lower watershed where the streams are wide, slow moving and have little stream cover. Nine of the sites had exceedances of more than one of temperature, dissolved oxygen or turbidity over more than one year, and were highlighted as priority areas for continued sampling in 2015. As turbidity is associated with higher levels of other contaminants, it was considered the highest priority when determining at which sites more sampling needs to occur. It was recommended that supplementary data be collected to better assess water quality in critical areas. A number of additional recommendations were made for future sample years to maintain data quality and use resources most efficiently.

Program Outline

The purpose of this report is to present a summary of trends observed in the first three years of data collected by the Island Waters Fly Fishers, Departure Creek Streamkeepers, Vancouver Island University (VIU) Fisheries and Aquaculture, and the City of Nanaimo as part of the Community Watershed Monitoring Network (CWMN) partnership.

The CWMN partnership was initiated in 2011 by the Regional District of Nanaimo (RDN) and the British Columbia (BC) Ministry of Environment (MOE) to collect data across the RDN by community environmental stewardship organizations. The goal of the program in its early stage was to conduct a simple, quick assessment of multiple watersheds to raise watershed health awareness in local communities and obtain a three year dataset for trend analysis. Longer term goals are to use trend data collected in the early stage to determine in which watersheds more detailed monitoring and/or improved watershed management need occur, and to assist in land use planning.

The synergistic partnership between environmental stewardship groups, the MOE, the RDN and Island Timberlands is core to the success of this program. At the beginning of each sampling year the MOE, with assistance from the RDN, trained stewardship participants in monitoring protocols. Five stewardship groups within the RDN started participating in the monitoring program in 2011 (Nile Creek Enhancement Society (NCES), Friends of French Creek Conservation Society (FFCCS), Qualicum Beach Streamkeepers (QBS), Mid Vancouver Island Habitat Enhancement Society (MVIHES), Nanaimo & Area Land Trust (NALT) and Parksville-Qualicum Fish and Game Association (PQFG), with safety gear and land access provided by Island Timberlands LP. The results of those groups' first three years of sampling at a total of 25 different sites in 9 different watersheds were summarized in the RDN CWMN Water Quality Trend Report, 2011 – 2013 (Barlak and Fegan, 2014).

Three additional groups were added to the program in 2012: Island Waters Fly Fishers (IWFF), Departure Creek Streamkeepers (DCSK), and Vancouver Island University (VIU) Fisheries and Aquaculture Department. The City of Nanaimo (CoN) assisted with data collection on Northfield Creek in 2014. The results of sampling between 2012 and 2014 at a total of 19 different sites in 4 different watersheds are summarized in this report. Samples were collected weekly according to BC MOE sampling procedures and quality assurance/quality control standards (BC MOE, 2003) between the dates listed in Table 1 below.

Table 1 – 2012, 2013 and 2014 Community Watershed Monitoring Network weekly sample periods

Year	Summer Low Flow (sampling occurred between)	Fall Rains (sampling occurred between)
2012	August 14 and September 11	October 16 and November 13
2013	August 13 and September 10	October 15 and November 12
2014	August 12 and September 9	October 14 and November 12

In this document, data presented were compared to existing BC Water Quality Guidelines (BC MOE, 1997) and/or Englishman River Water Quality Objectives (Barlak *et al*., 2010), applicable to other watersheds within the same ecoregion. Based on these Water Quality Guidelines or Objectives (Table 2), the data were grouped into summer and fall data (Quarter 3 and Quarter 4, respectively, where each quarter included 5 weekly samples in a 30 day period as required to determine if guidelines or objectives are being met per year.) Six comparisons were examined: maximum and average temperature, minimum and average dissolved oxygen, maximum specific conductivity and maximum turbidity. Exceedances in the 2012, 2013 and 2014 data (Barlak, 2012 and 2013; Barlak and Fegan, 2014) are noted and priority areas are indicated. When any turbidity samples were less than 0 NTU, or not a true reading, calibration corrections were

applied to all samples measured with the same instrument on that day and the corrected values presented here.

Table 2 - BC Water Quality Guidelines and/or Englishman River Water Quality Objectives.

Parameter	Guideline or Objective Value	Importance
Turbidity (Englishman River Water Quality Objective)	October to December: 5 NTU maximum January to September: 2 NTU maximum	Measures clarity or cloudiness of water. High values are associated with higher levels of other contaminants (e.g. bacteria).
Temperature (Englishman River Water Quality Objective)	Short Term, at any location in the river ≤ 17°C average weekly temperature. Long Term ≤ 15°C average weekly temperature. *Weekly averages could not be calculated with available data.	If too warm not aesthetically pleasing to drink and can affect health and survival of aquatic organisms.
Dissolved Oxygen (BC Water Quality Guideline for aquatic life)	30 day average 8 mg/L Instantaneous minimum 5 mg/L	If too low affects the health and survival of aquatic organisms.
Conductivity (no guideline)	No guidelines exist; coastal streams generally less than 80 μS/cm but can be more if significant ground water influences.	The more dissolved ions in water, the greater the electrical conductivity. Dilution decreases conductivity but groundwater influences or sediment introduced in water can increase it.

Climate data were reviewed from two Environment Canada weather stations across the RDN: Nanaimo Airport and Ballenas Island, (Environment Canada, 2015). These data helped determine if climate could have been an influencing factor on the measured parameters and to ensure that the fall flush was captured.

In each of the monitoring years reviewed in this report, the large fall flush was captured during sampling (Figures 1, 2 and 3). In 2013 the first moderate rainfall happened during the summer sample period. The amount of rain that fell in the summer of 2012 was less than in 2013 or 2014. In 2014 fall storms brought a relatively large amount of rain over a short period of time. Though there were some missing data points in the climate data, these were usually rare individual (one day) occurrences that occurred when little or no precipitation fell at other stations, thus their absence likely did not change general weekly trends observed.

Figure 1 - 2012 Weekly average precipitation across the southern Regional District of Nanaimo.

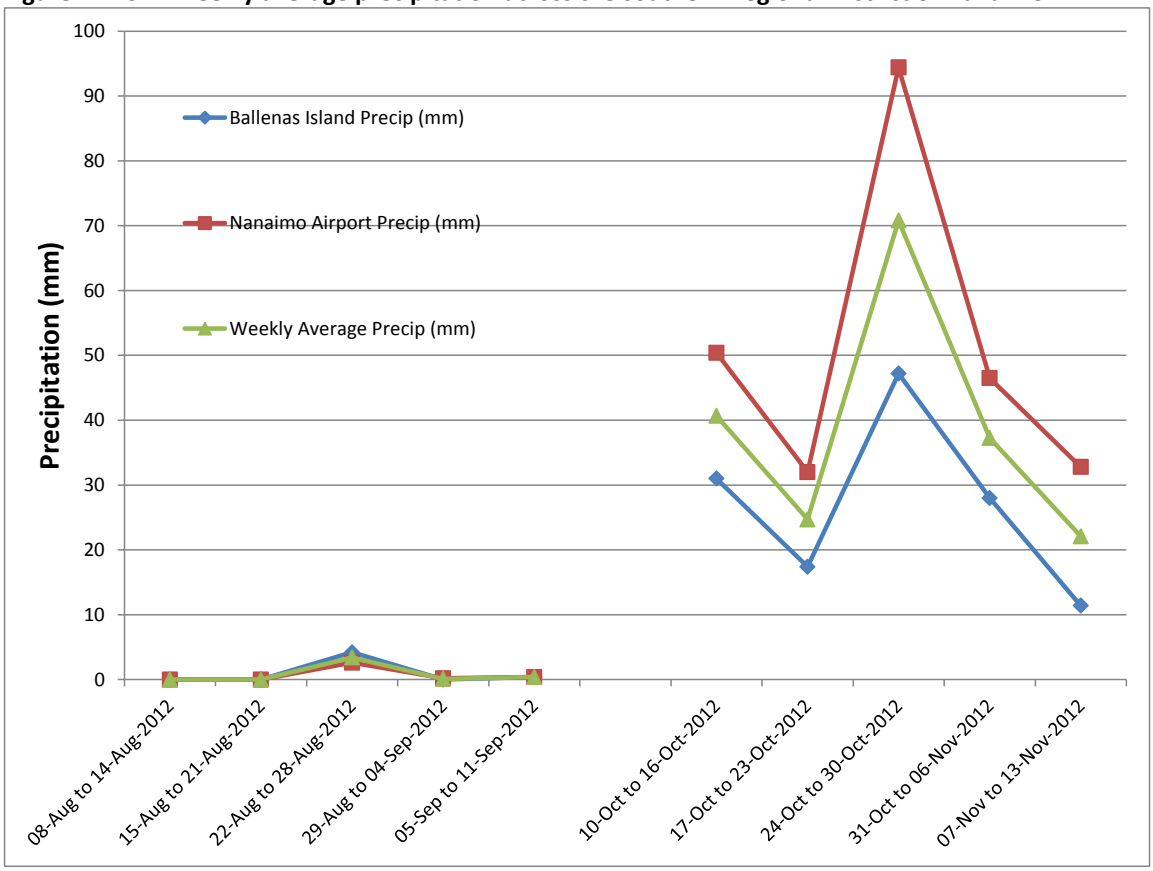


Figure 2 - 2013 Weekly average precipitation across the southern Regional District of Nanaimo.

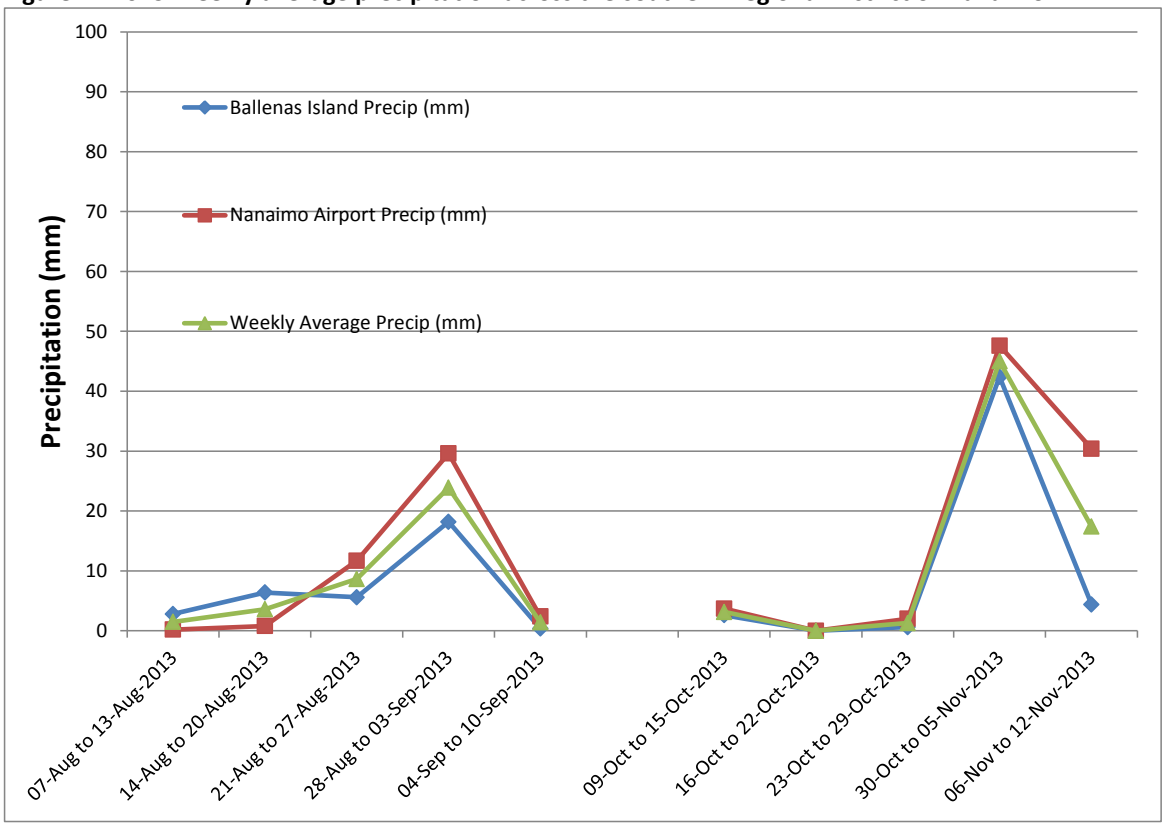
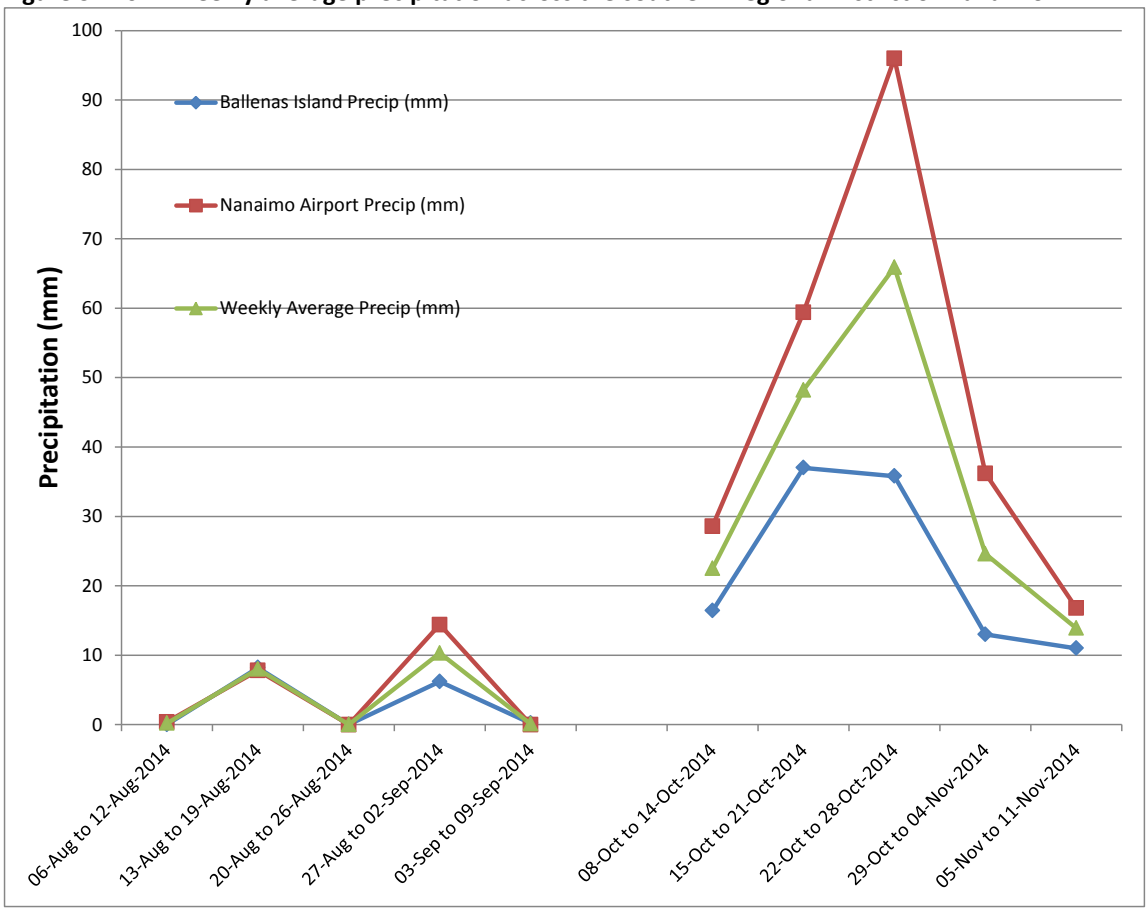
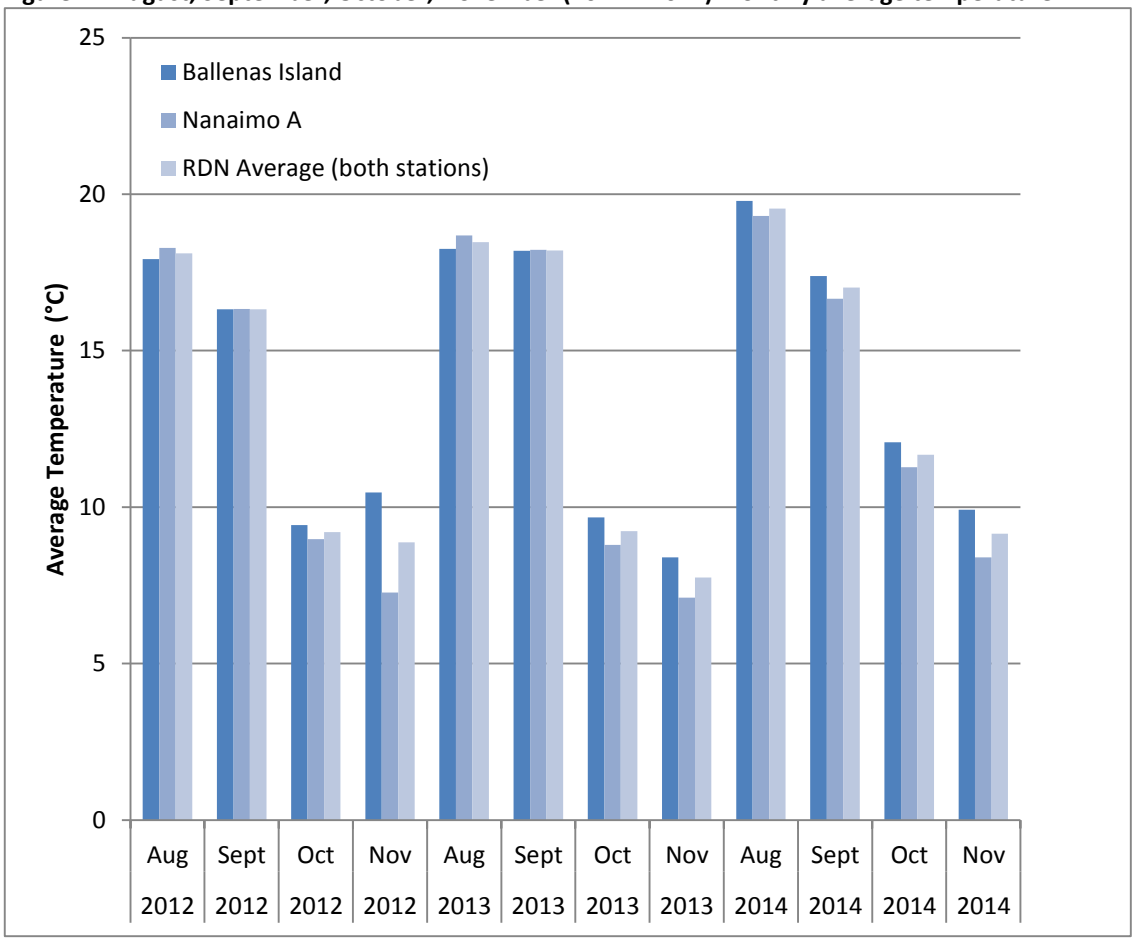


Figure 3 - 2014 Weekly average precipitation across the southern Regional District of Nanaimo.



Air temperature data from these two weather stations were also reviewed for influence on average water temperature. Trends seen in the averages of air temperature for each of the summer quarters (Figure 4) were evident in water temperature values at all of the summer sample sites. Average summer air temperature (for August and September combined) was lowest in 2012 and highest in 2013.

Figure 4 - August, September, October, November (2012 – 2014) monthly average temperature



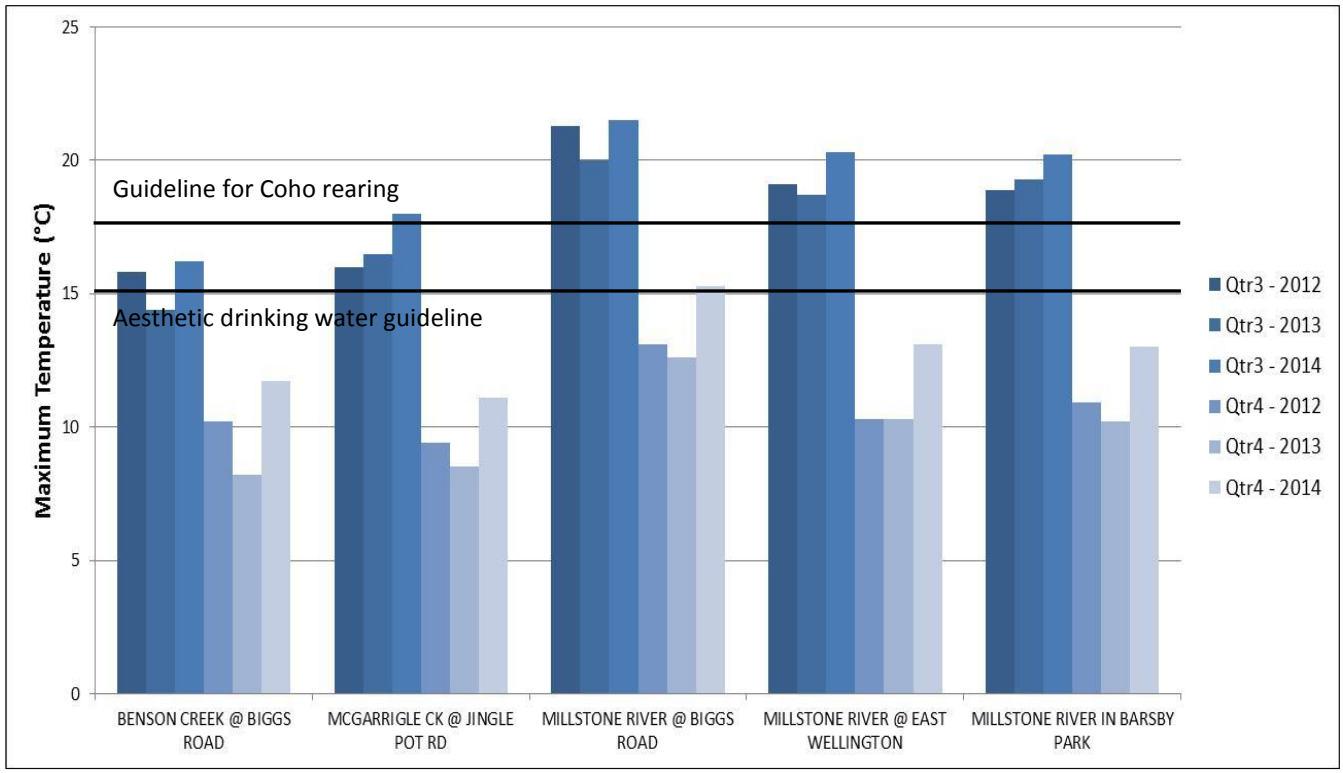
Data Summary

Summer and Fall 2012 - 2014

Island Waters Fly Fishers

The maximum temperature had the potential for exceedances of the aesthetic drinking water guideline (weekly average ≤15°C) at all five sample sites during the summer monitoring periods (Figure 5). The drinking water temperature guideline is used, though there are no drinking water intakes on any of the streams in this report. The maximum summer (Quarter 3) water temperature also had potential to exceed the guideline for Coho rearing (weekly average ≤17°C) at all three sites on the Millstone River for all three years of monitoring, and in McGarrigle Creek in 2014.

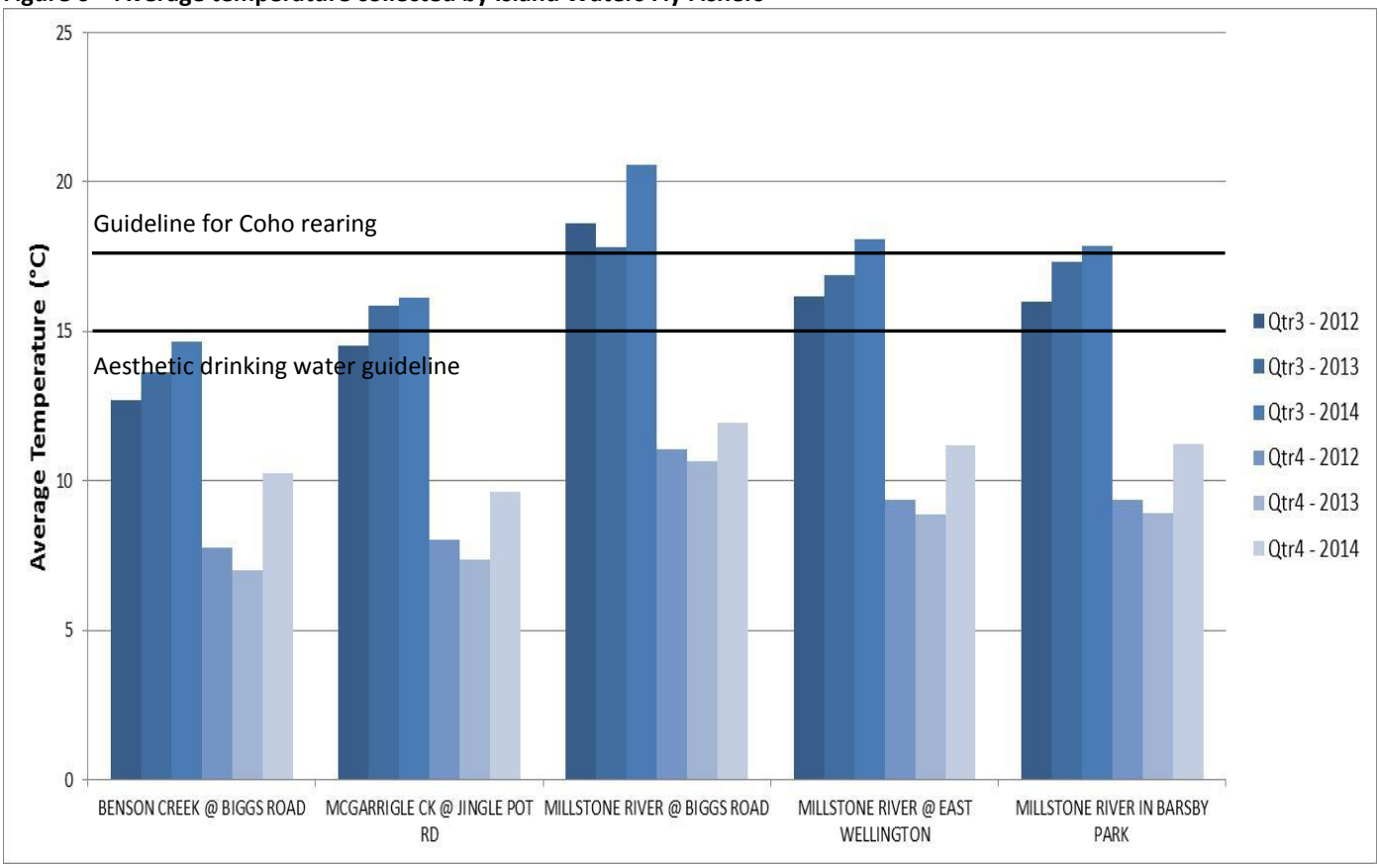
Figure 5 – Maximum temperature collected by Island Waters Fly Fishers



The average temperature showed a potential for exceedance of the aesthetic drinking water temperature guideline (weekly average ≤15°C) in the Millstone River during all summer sample periods in 2012, 2013 and 2014 (Figure 6). This guideline also had the potential for exceedance in McGarrigle Creek in 2013 and 2014. The average temperature also had the potential for exceedance of the guideline for Coho rearing (weekly average ≤17°C) in the upper Millstone River site (Biggs Rd) all summer in each of the three years of monitoring, and in all three Millstone River sites in 2014.

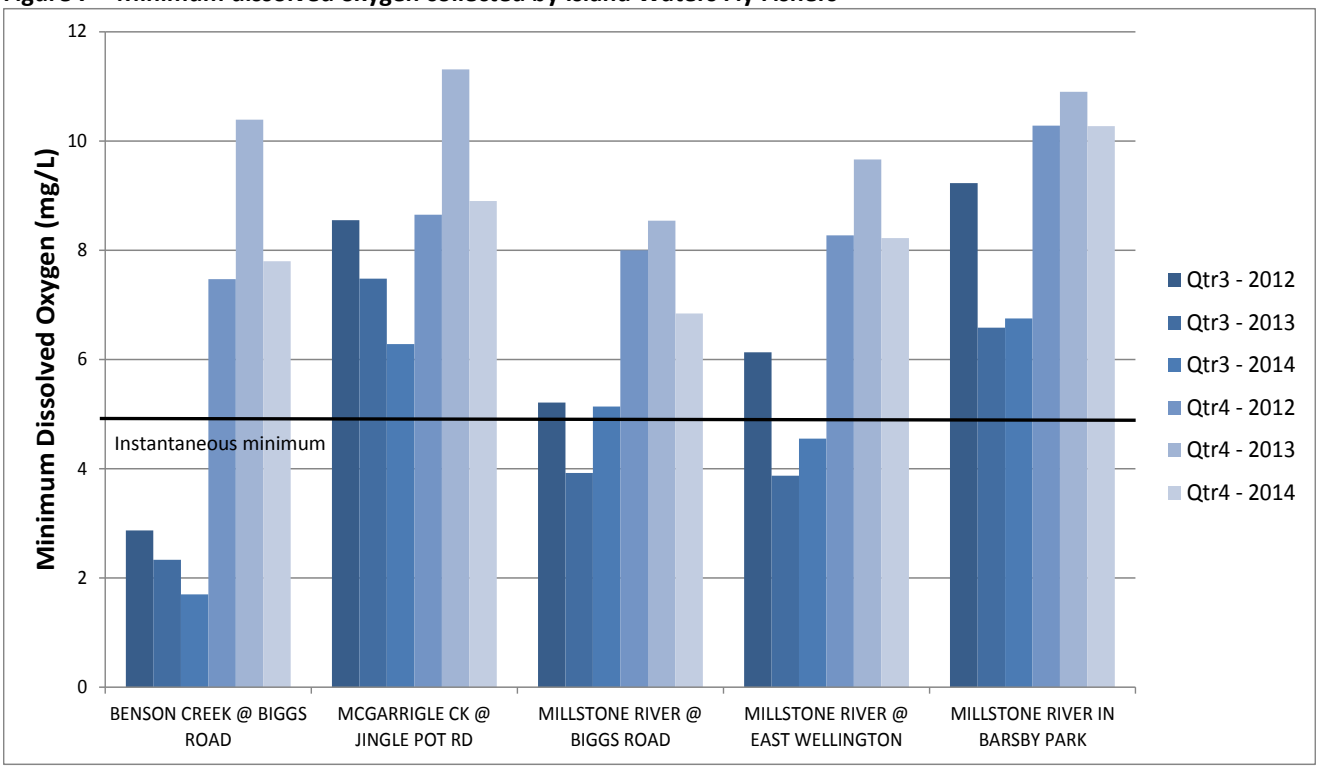
For urban streams, water temperature can be affected by loss of riparian cover. Further assessment would determine if this is the case in the streams monitored by Island Waters Fly Fishers. Temperature exceedances are also typical of many east coast Vancouver Island streams where the lower portions are wide and shallow; as long as refuges remain with lower temperatures, juvenile fish should be able to retreat to these during periods of elevated temperatures.

Figure 6 – Average temperature collected by Island Waters Fly Fishers



The minimum dissolved oxygen (DO) was below the instantaneous minimum aquatic life guideline of 5 mg/L in all of the summer sample periods at the Benson Creek site (Figure 7). Minimum DO also dropped below the instantaneous minimum guideline in the Millstone River at Biggs Rd in summer 2013 and in the Millstone River at East Wellington in summer 2013 and 2014.

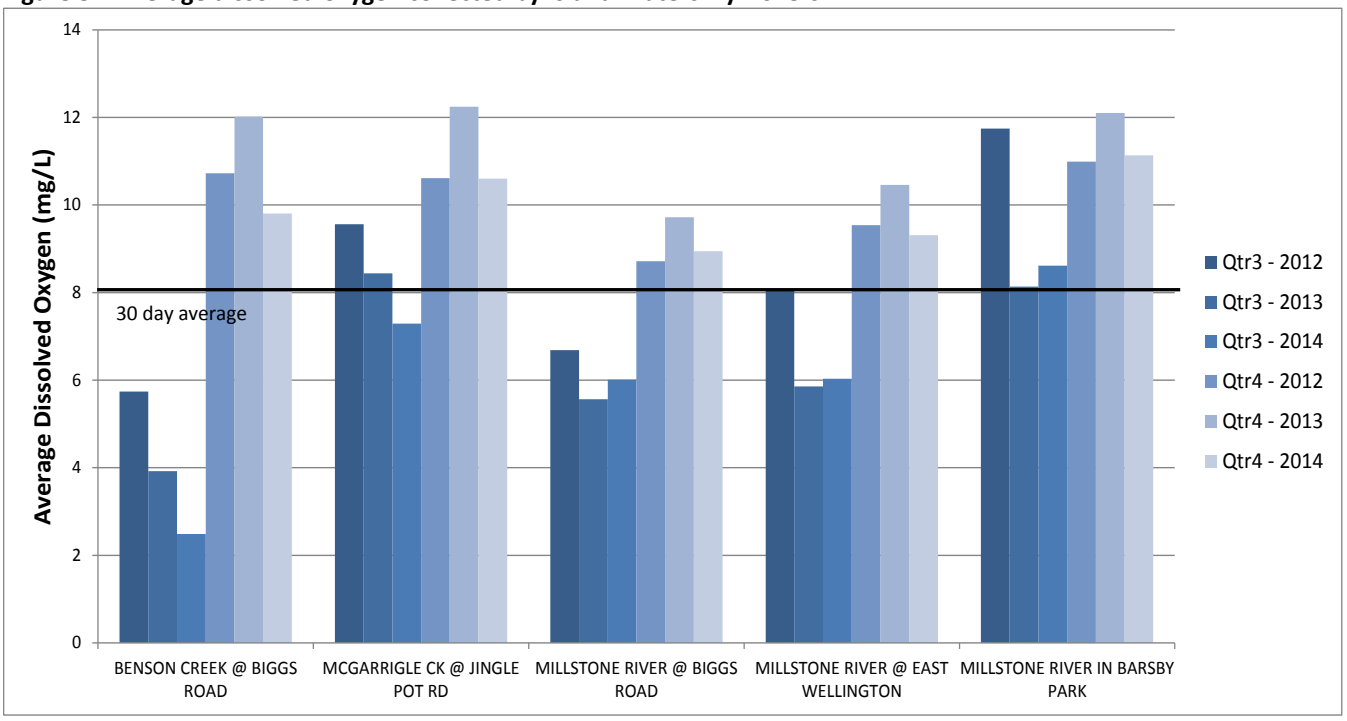
Figure 7 – Minimum dissolved oxygen collected by Island Waters Fly Fishers



The average DO (Figure 8) was below the 30 day average guideline of 8 mg/L for all of the summer sampling periods in Benson Creek at Biggs Road. Values were 5.74 mg/L, 3.92 mg/L, and 2.49 mg/L in 2012, 2013 and 2014 respectively (not shown in figure below).

The average DO (Figure 8) was at or below the 30 day average guideline of 8 mg/L in McGarrigle Creek during the summer of 2014, and in the two upper Millstone River sites for all three summer sampling periods. Average summer DO in McGarrigle Creek was 7.292 mg/L in 2014, and average DO values in the Millstone River at Biggs Rd were 6.67 mg/L, 5.56 mg/L and 6.01 mg/L for 2012, 2013 and 2014, and in the Millstone River at East Wellington were 8.05 mg/L, 5.86 mg/L and 6.03 mg/L for 2012, 2013 and 2014. Low minimum and average DO values may be indicative of very low flow.

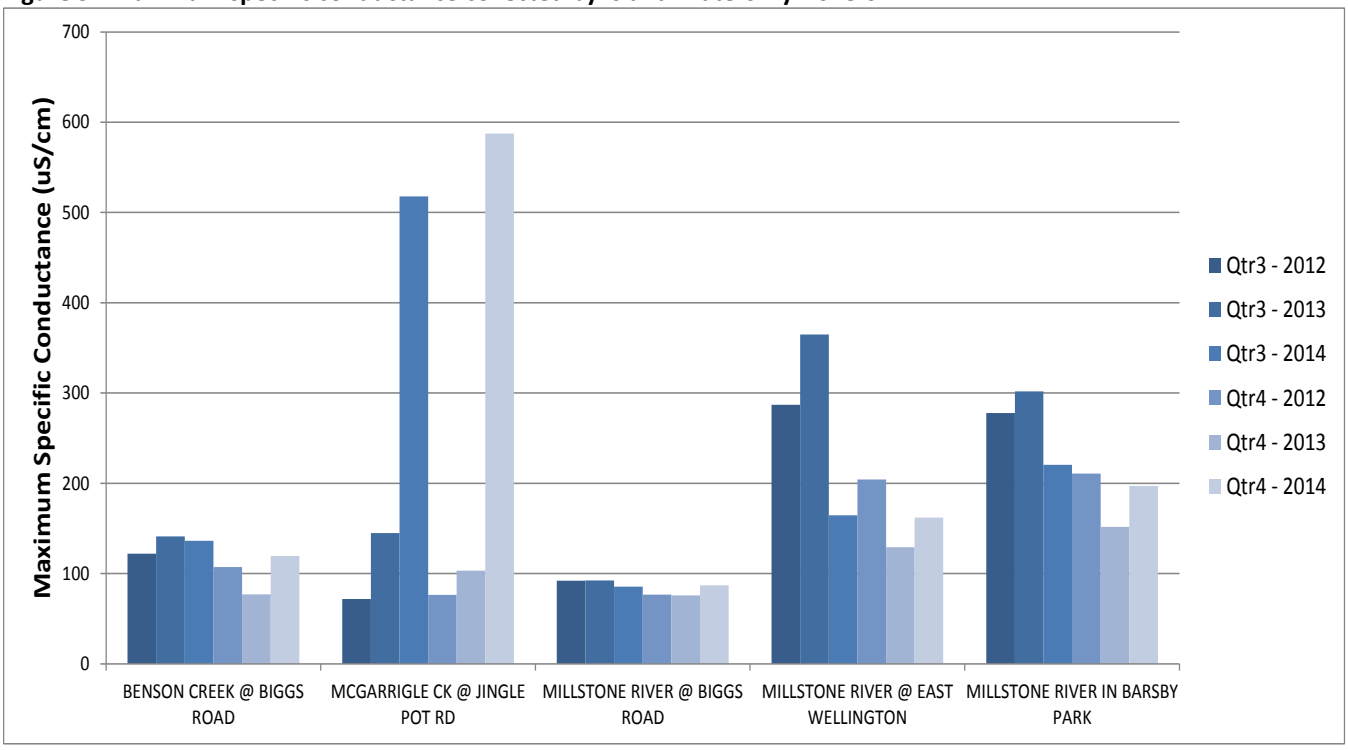
Figure 8 – Average dissolved oxygen collected by Island Waters Fly Fishers.



The maximum specific conductance was higher than levels typical of coastal streams in Benson Creek, and in the two lower Millstone River sites during all sample periods (Figure 9).

Specific conductance was high in McGarrigle Creek in 2014 in both the summer and fall sampling periods compared to previous years. Conductivity did not spike at other monitoring sites in that year as would be expected if the equipment was malfunctioning.

Figure 9– Maximum specific conductance collected by Island Waters Fly Fishers.

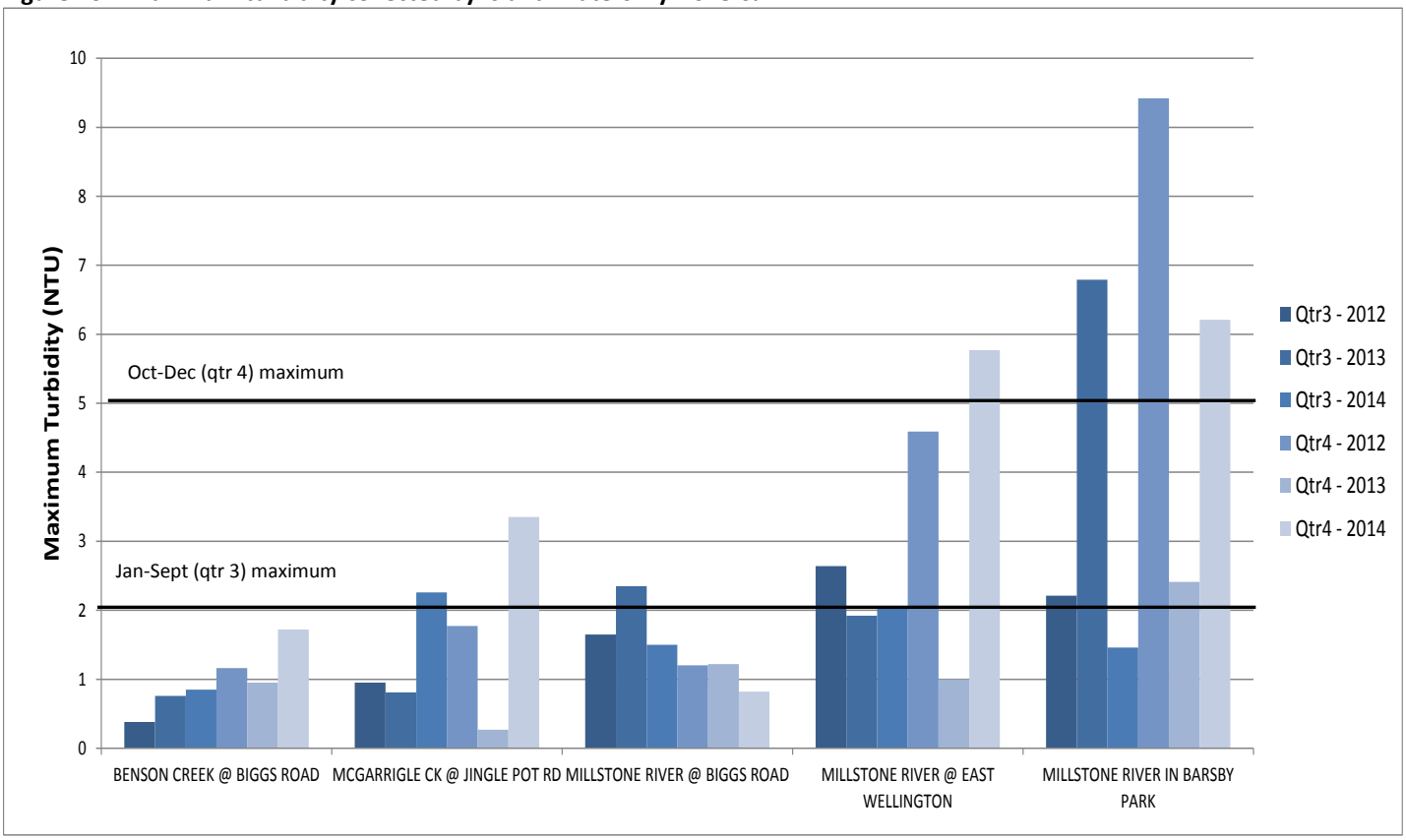


The January through September low flow maximum turbidity objective of 2 NTU was also exceeded in McGarrigle Creek in summer 2014 (Figure 10). Volunteers noted a strong odour of sewage and high specific conductance reading at the sample site in August 2014. Sampling a pool above a residential property upstream of the site on August 19, 2014 yielded a conductivity reading of 39 µs/cm compared with 405 µs/cm at the sample location. It is possible that a failing septic system on the property was contributing contamination to the creek. A referral was made to MOE Environmental Complaints, and Island Health followed up with a site visit.

The January through September low flow maximum turbidity objective of 2 NTU was also exceeded in the Millstone River at Biggs Road in 2013, the Millstone River at East Wellington in 2012 and 2014, and the Millstone River in Barsby Park in 2012 and 2013 (Figure 10). In the Millstone at Barsby Park in summer 2013, turbidity approached 7 NTU. These irregular exceedances suggest local effects of disturbance from sampler error in disturbing the creek bottom, algal growth, isolated weather events or human activity, or potentially a combination of these factors.

During fall sampling (Quarter 4), the October through December turbidity objective of 5 NTU was exceeded in the lower Millstone River site (at Barsby Park) in 2012 and 2014. The proximity of these creeks to residential development areas suggests that increased anthropogenic inputs could account for higher turbidity levels when there was no precipitation. Additional data collection of turbidity at these sites will help discern long term trends.

Figure 10 – Maximum turbidity collected by Island Waters Fly Fishers.



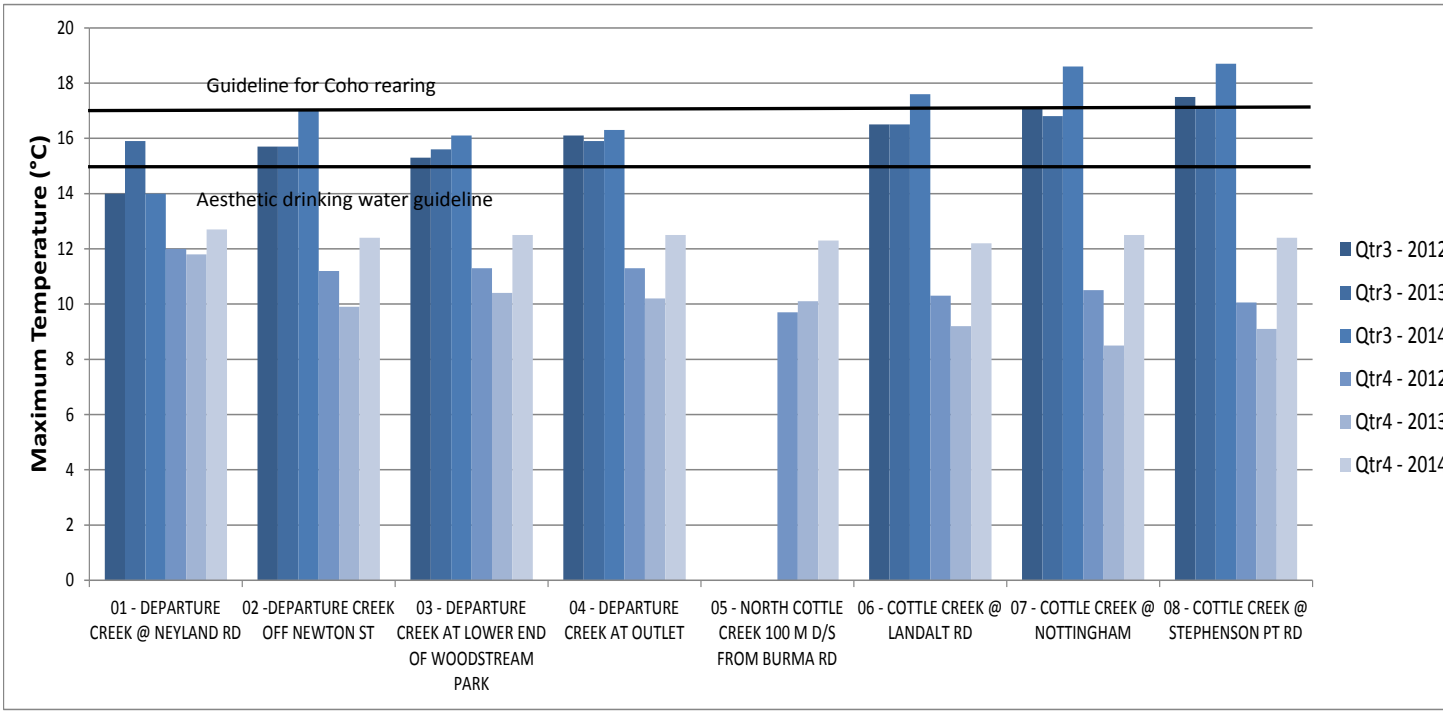
Departure Creek Streamkeepers

The maximum temperature had the potential for exceedances of the aesthetic drinking water guideline (weekly average ≤15°C) at all sites in all summer monitoring periods with the exception of the Departure Creek at Neyland site in 2013 only (Figure 11). The drinking water temperature guideline is used, though there are no drinking water intakes on any of the streams in this report.

No temperature data was collected from North Cottle 100m d/s from Burma Rd in any of the summer monitoring periods as the creek was dry. The maximum summer water temperature also had potential to exceed the guideline for Coho rearing (≤17°C) at Departure Creek off Newton in 2014, and in the three lower sites on Cottle Creek for all three summers of monitoring. This guideline is used, though it is not known if there are salmonids in Cottle Creek. Departure Creek has supported pink salmon since a fish barrier was removed in 2012.

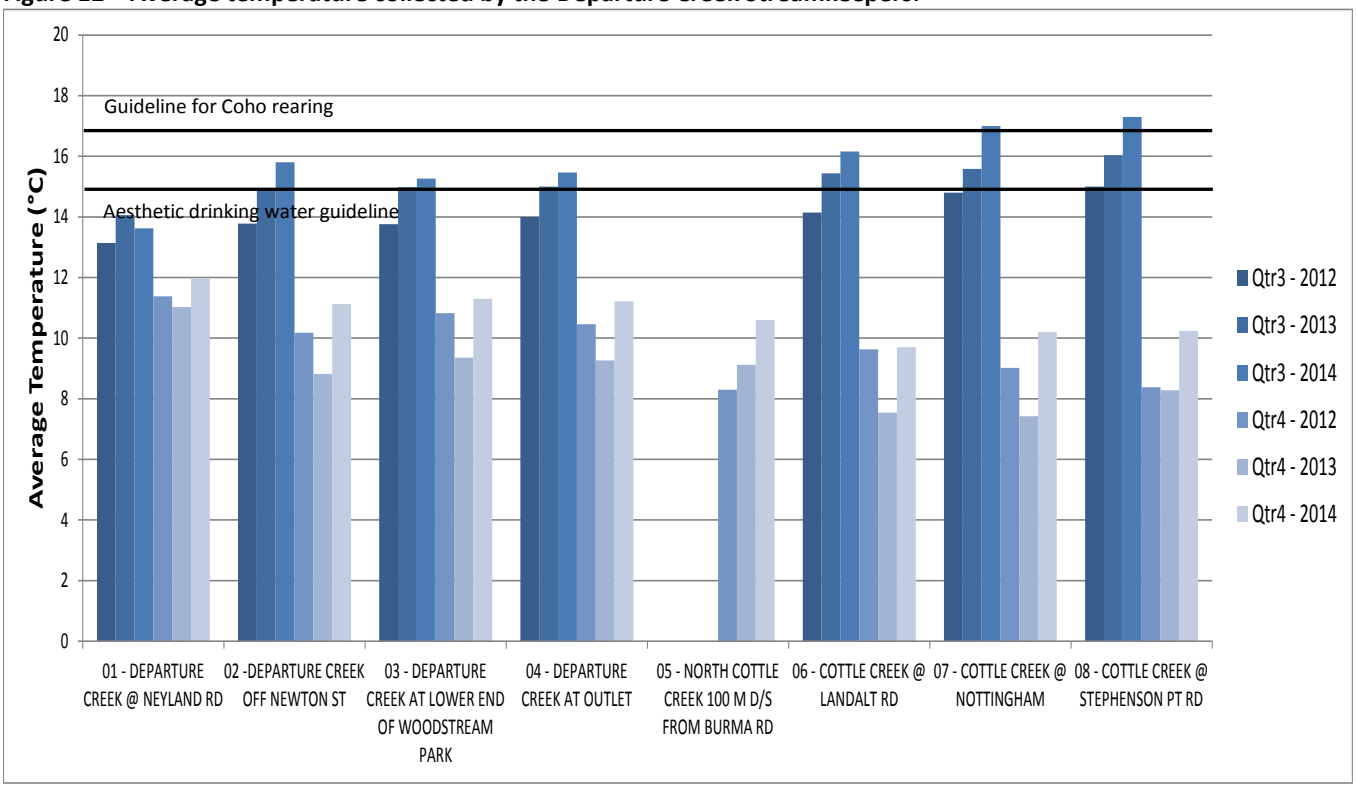
For urban streams, water temperature can be affected by loss of riparian cover. Further assessment would determine if this is the case. Temperature exceedances are also typical of many east coast Vancouver Island streams where the lower portions are wide and shallow; as long as refuges remain with lower temperatures, juvenile fish should be able to retreat to these during periods of elevated temperatures.

Figure 11 – Maximum temperature collected by the Departure Creek Streamkeepers.



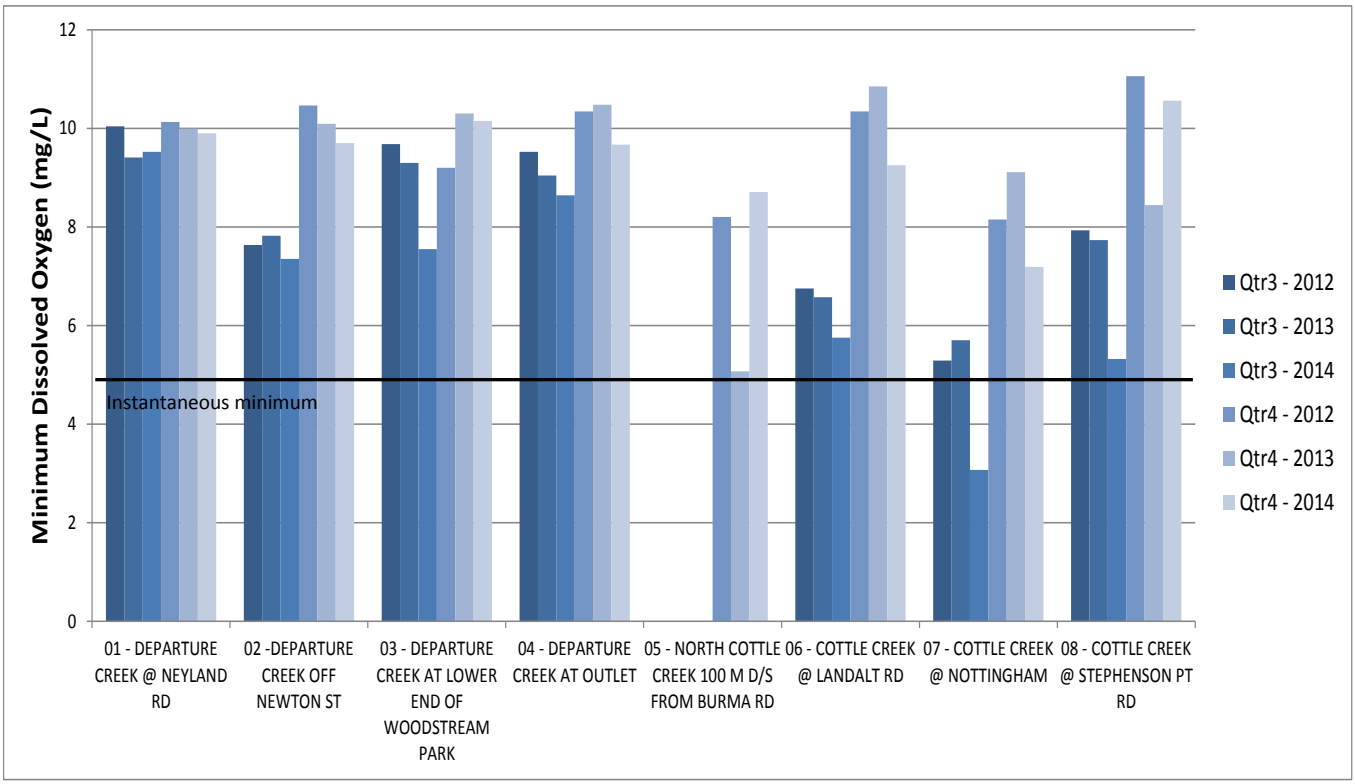
The average temperature had the potential for exceedance of the aesthetic drinking water temperature guideline (weekly average ≤15°C) at all three sites on Departure Creek in 2013 and 2014, and in the three lower sites on Cottle Creek in 2013 and 2014 (Figure 12). There was also the potential for temperatures to exceed the aesthetic drinking water guideline on the two lower sites on Cottle Creek in 2012, as well as 2013 and 2014 as mentioned previously.

Figure 12 – Average temperature collected by the Departure Creek Streamkeepers.



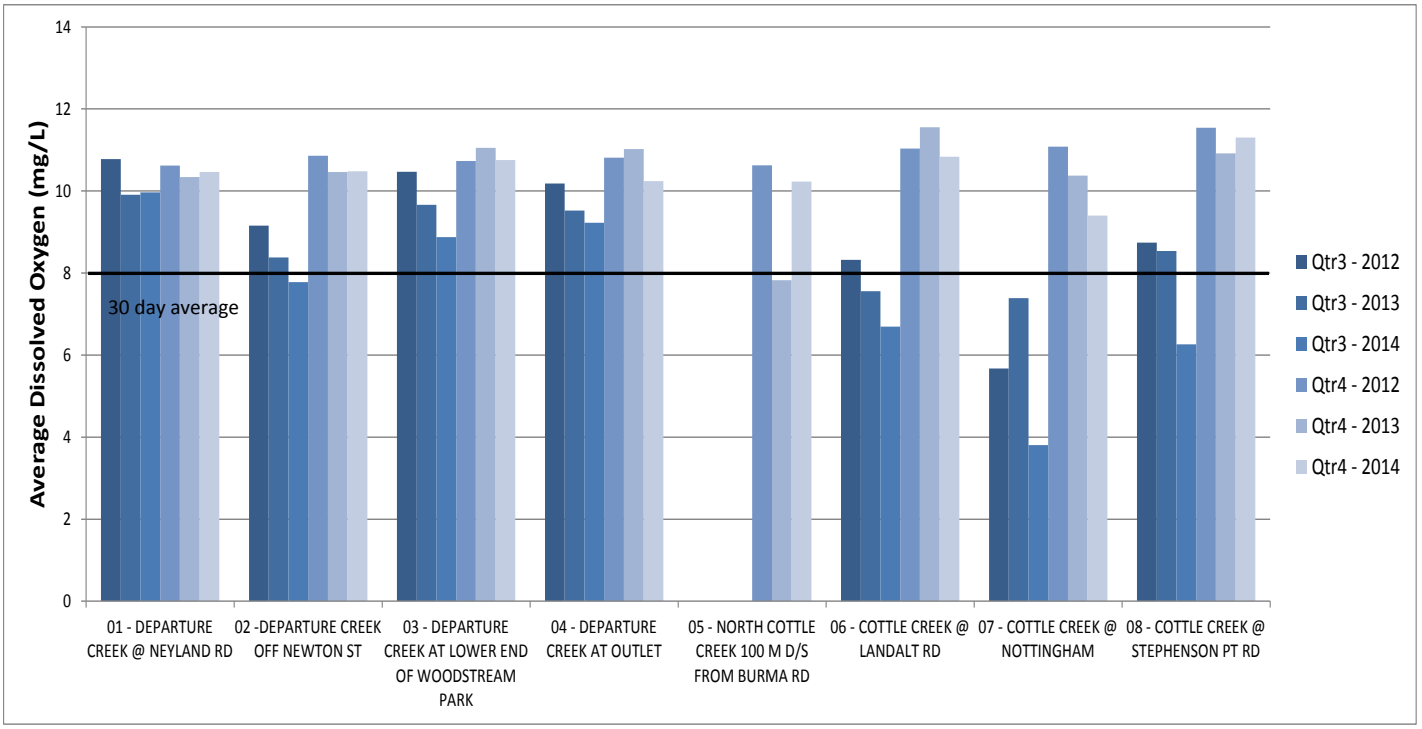
Dissolved oxygen was below the instantaneous minimum aquatic life guideline of 5 mg/L in Cottle Creek at Nottingham in 2014 (Figure 13).

Figure 13 – Minimum dissolved oxygen collected by the Departure Creek Streamkeepers.



Average DO was below the 30 day average guideline of 8 mg/L for the summer sampling periods in Cottle Creek at Landalt in 2013 and 2014, Cottle Creek at Nottingham for all three years of summer sampling, and in Cottle Creek at Stephenson Point in 2014 (Figure 14). The guideline for 30 day average DO was also exceeded in Cottle Creek off Burma in fall 2013 and in Departure Creek off Newton in summer 2014. Low average DO values may be indicative of very low flow.

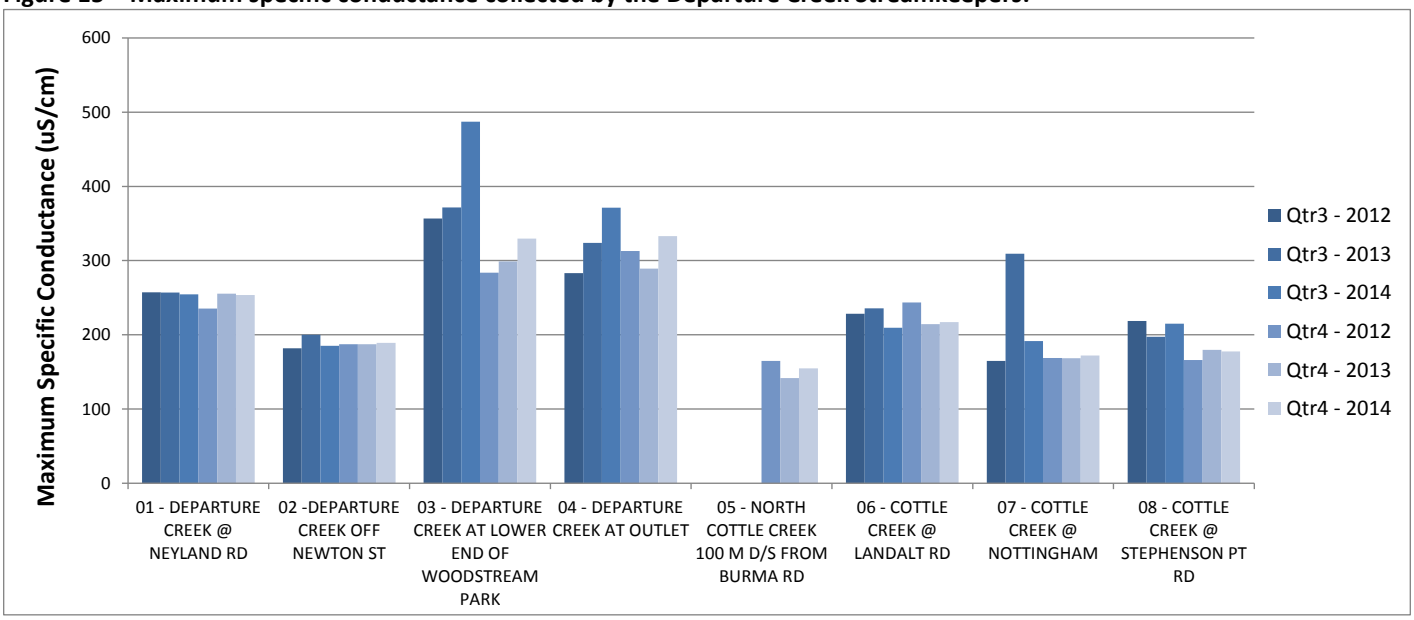
Figure 14 – Average dissolved oxygen collected by the Departure Creek Streamkeepers.



The maximum specific conductance was higher than levels typical of coastal streams in both Departure and Cottle Creeks during all sample periods (Figure 15).

There are high summer values for specific conductance relative to other years in Departure Creek at Woodstream Park in 2014, and in Cottle Creek at Nottingham in 2013. These do not correlate with turbidity exceedances for those sampling periods. These high specific conductance values may be associated with minimum dilution during low flows and possibly groundwater influences.

Figure 15 – Maximum specific conductance collected by the Departure Creek Streamkeepers.

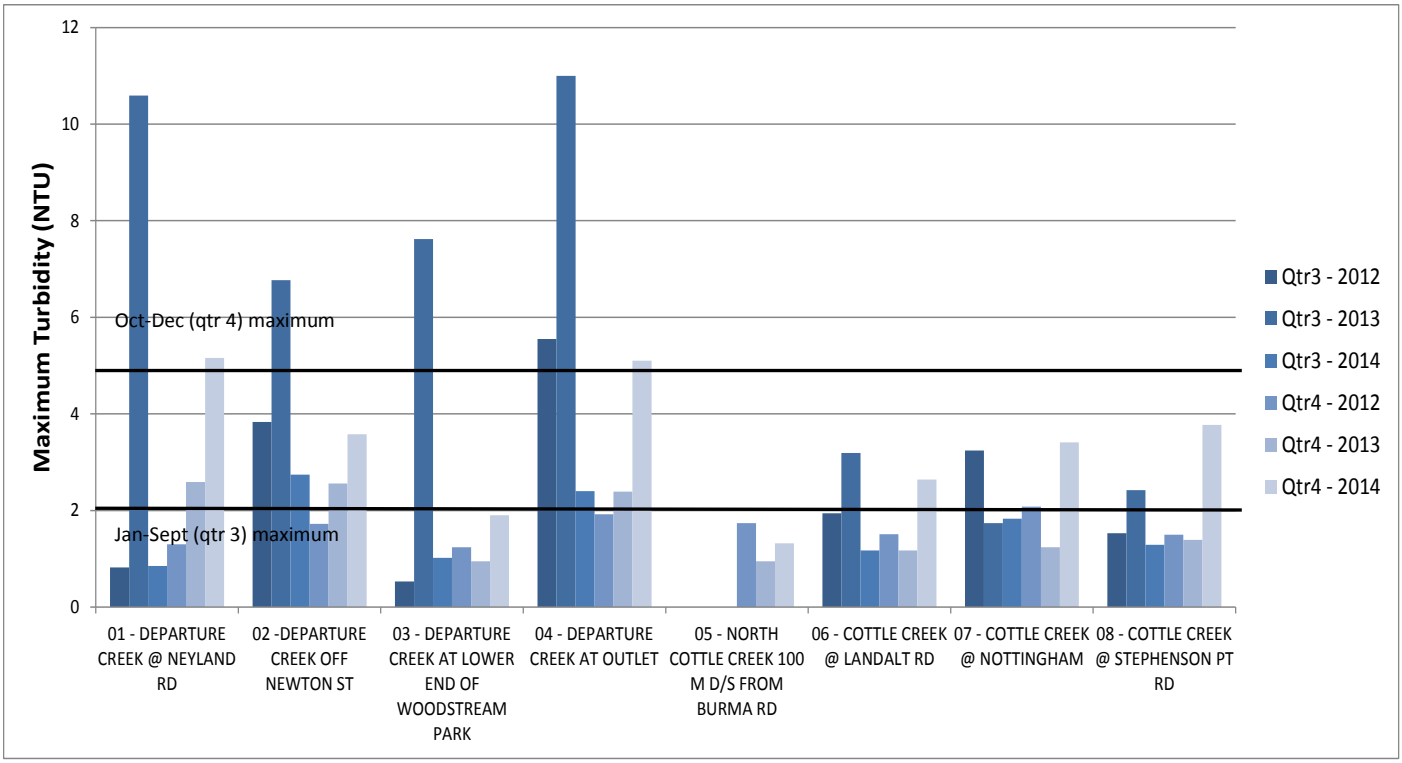


Maximum turbidity values far exceeded water quality guidelines for the summer (Jan. – Sept. 2 NTU) sampling periods in 2013 in Departure Creek (Figure 16). Field notes taken by volunteers at that time state that the water looked murky. There were similar patterns of rainfall in summer 2013 and 2014 that do not explain the difference in turbidity results between those years (Figure 2 and Figure 3).

In addition to the 2013 exceedances noted, maximum turbidity exceeded the Jan. – Sept. 2 NTU objective at Departure Creek off Newton and Departure Creek at outlet in all summer sampling periods. This objective was also exceeded in Cottle Creek at Landalt and at Stephenson Point Rd in 2013, and Cottle Creek at Nottingham in 2012.

During fall sampling (Quarter 4), the October through December turbidity objective of 5 NTU was exceeded in 2014 at the uppermost (Neyland) and lowest (outlet) Departure Creek sampling sites. These irregular exceedances suggest local effects of disturbance from weather or human activity. Lab analysis of water samples is recommended to more clearly pinpoint the cause turbidity exceedances.

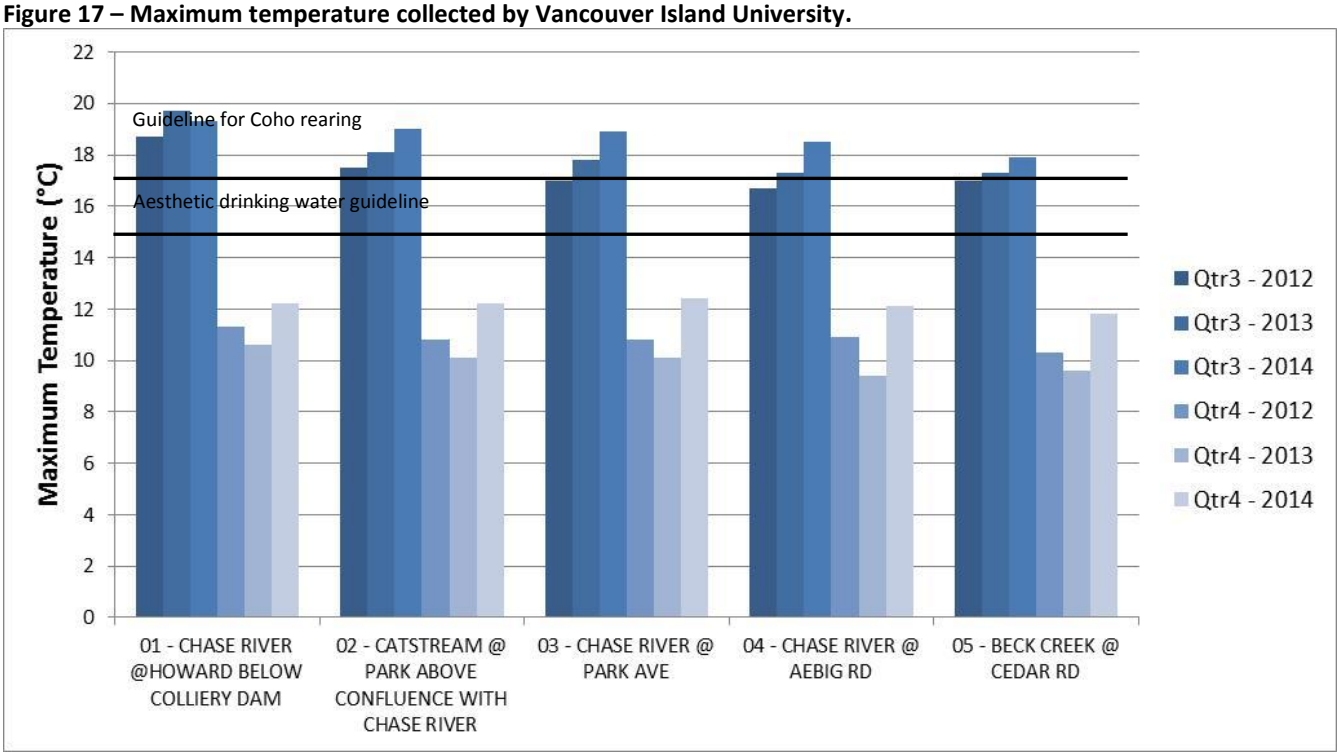
Figure 16 – Maximum turbidity collected by the Departure Creek Streamkeepers.



Vancouver Island University (VIU), Fisheries and Aquaculture Department

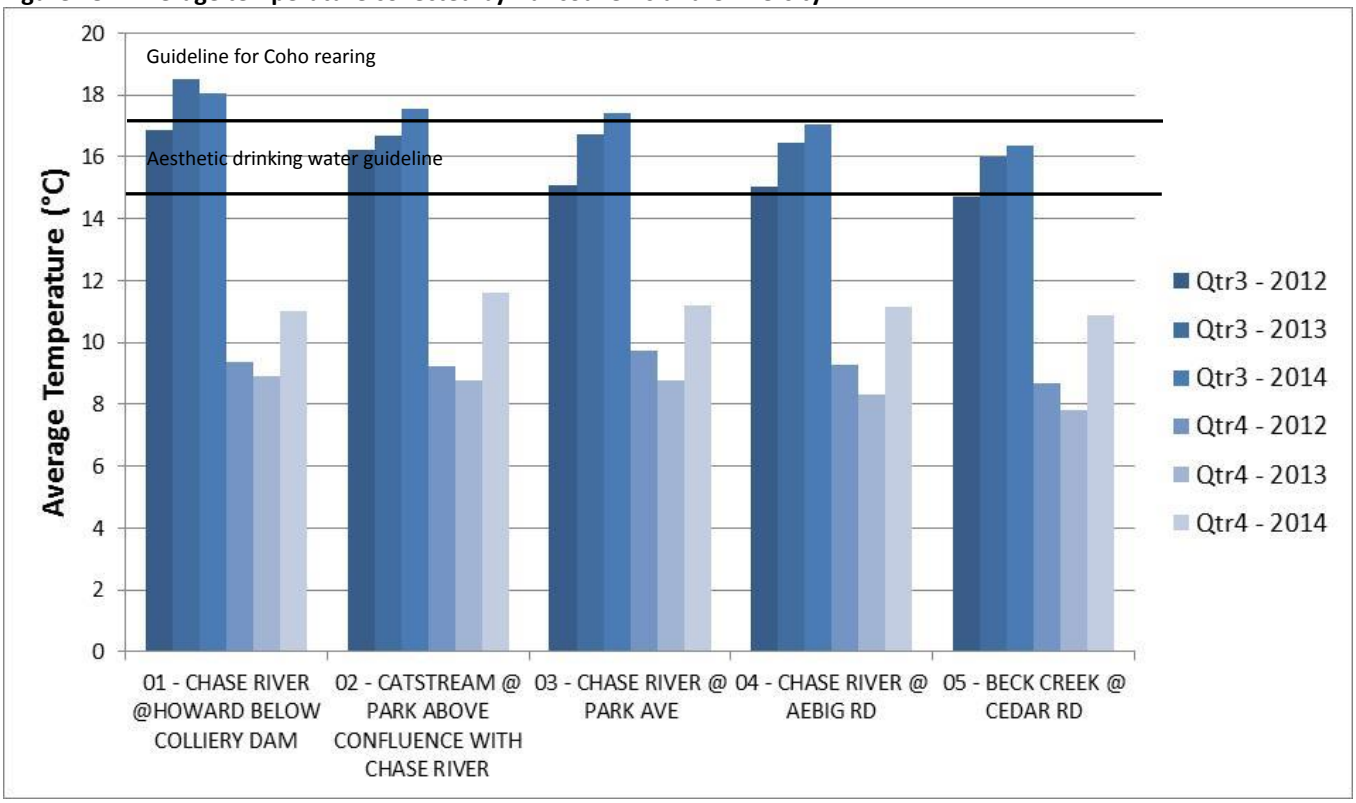
The maximum temperature indicates the potential for exceedance of the aesthetic drinking water temperature guideline (weekly average ≤15°C) in the summer sample periods at all sites (Figure 17). The drinking water temperature guideline is used, though there are no drinking water intakes on any of the streams in this report. Maximum summer water temperatures also had the potential to exceed the guideline for coho rearing (≤17°C) in all sites monitored by VIU between 2012 and 2014.

Figure 17 – Maximum temperature collected by Vancouver Island University.



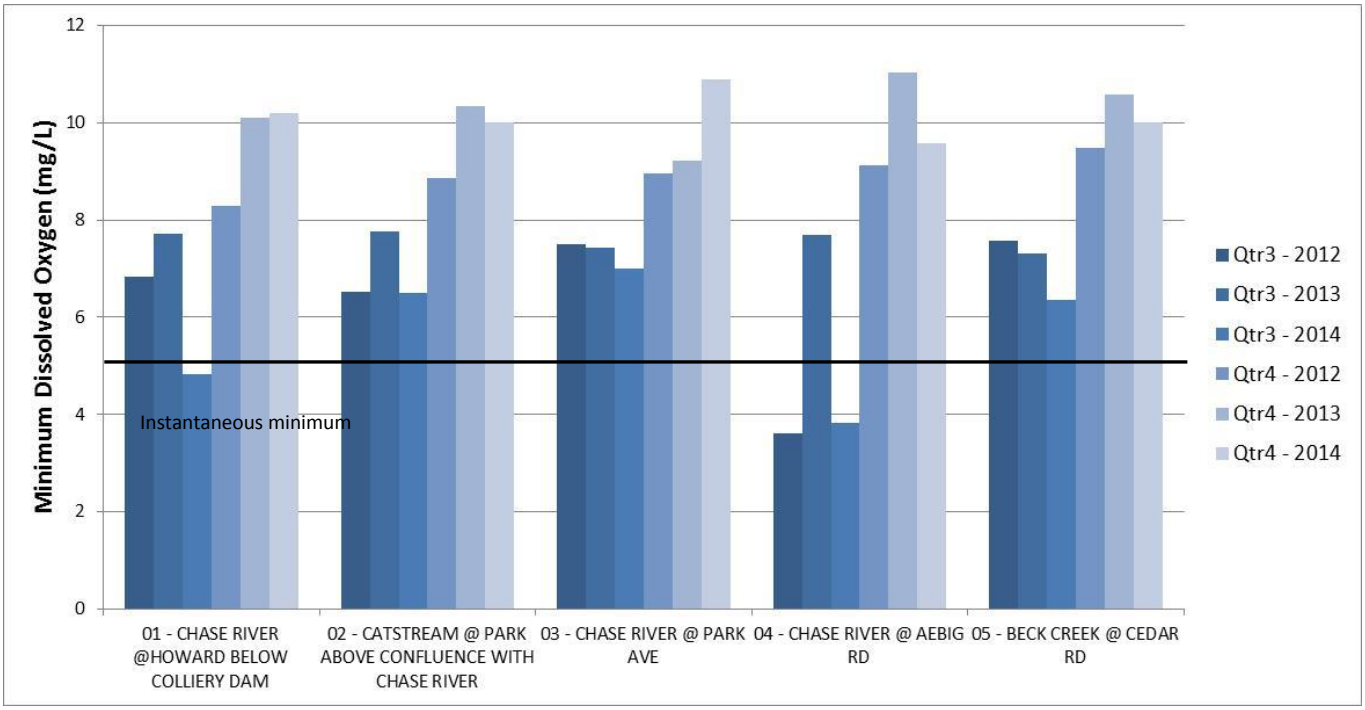
Average temperature values had the potential for exceedances of the aesthetic drinking water temperature guideline (weekly average ≤15°C) in each of the summer sample periods at all sites (Figure 18). This is typical of many east coast Vancouver Island streams where the lower portions are wide and shallow; however, more exposure due to less vegetative cover could also increase maximum and average temperatures. Riparian cover and local hydrology should be evaluated to assess potential influence on temperature trends. This information can then be compared with ongoing temperature monitoring by MOE to understand long-term trends, including impacts from climate change.

Figure 18 – Average temperature collected by Vancouver Island University.



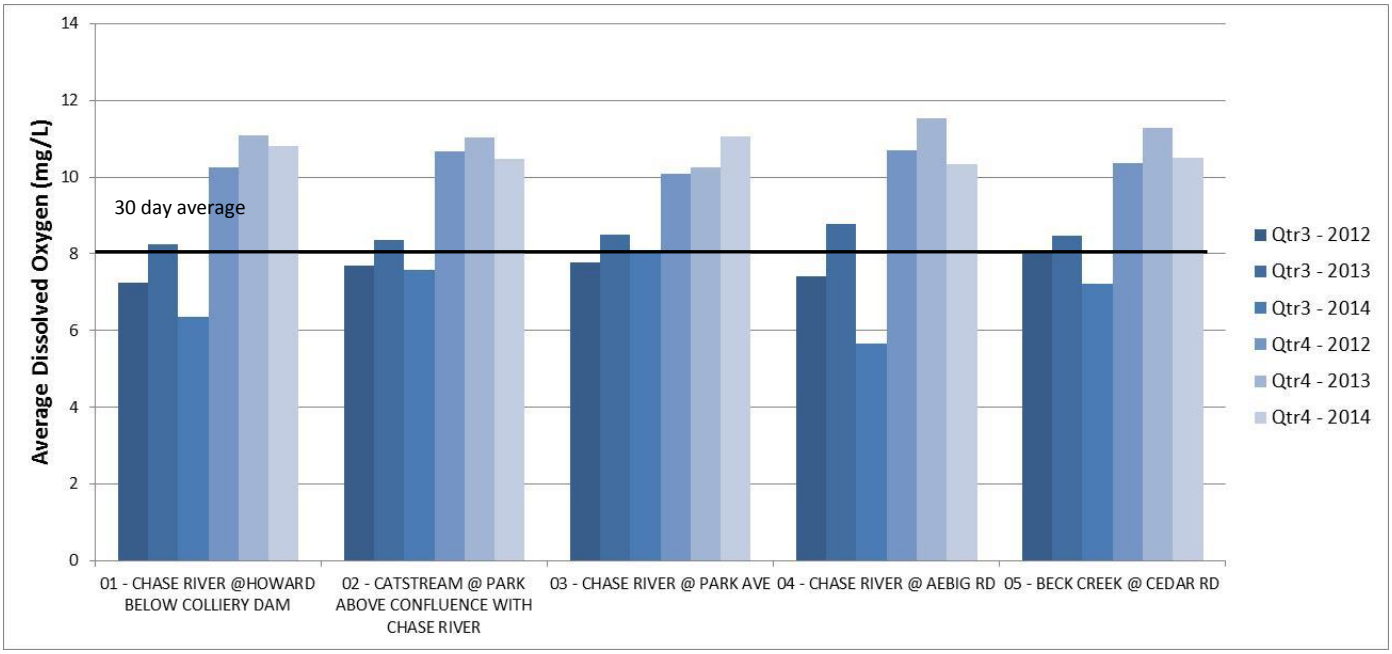
Minimum dissolved oxygen (DO) was below the instantaneous minimum guideline of 5 mg/L in the uppermost Chase River site (Howard) in 2014, and in the lowest Chase River site (at Aebig Rd) in 2012 and 2014 (Figure 19).

Figure 19– Minimum dissolved oxygen collected by Vancouver Island University.



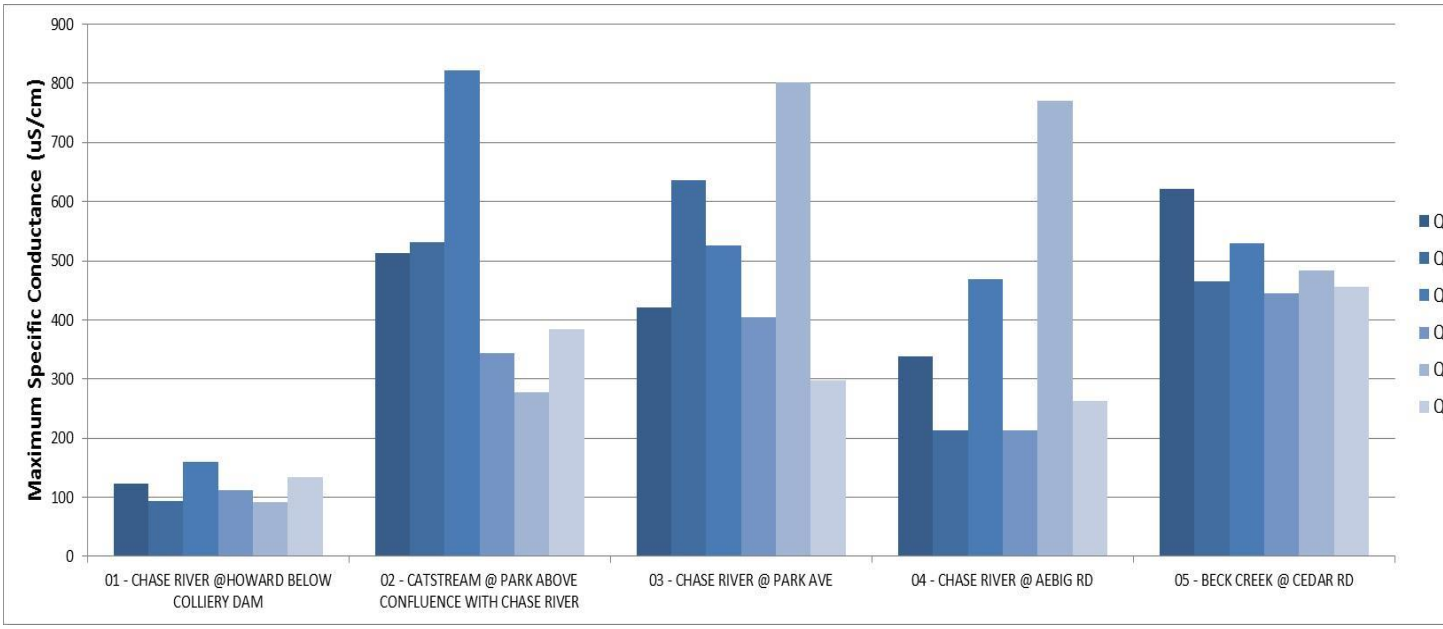
Average DO (Figure 20) was at or below the 30 day average objective of 8 mg/L in the summer sampling periods at all sites in 2012 and 2014. Low DO values may be indicative of very low flow.

Figure 20 – Average dissolved oxygen collected by Vancouver Island University.



The maximum specific conductance was higher than levels typical of coastal streams in the two lower Chase River sampling sites, and in the Cat Stream and Beck Creek, for all sampling periods in all years (Figure 21). This suggests the lower watershed sites appear to be influenced by groundwater inputs. The upper Chase River site demonstrated typical conductivity for all sample dates. There are spikes in conductivity in the two lower Chase River sites during the fall monitoring period in 2013. Conductivity was also unusually high in the Cat Stream in summer 2014.

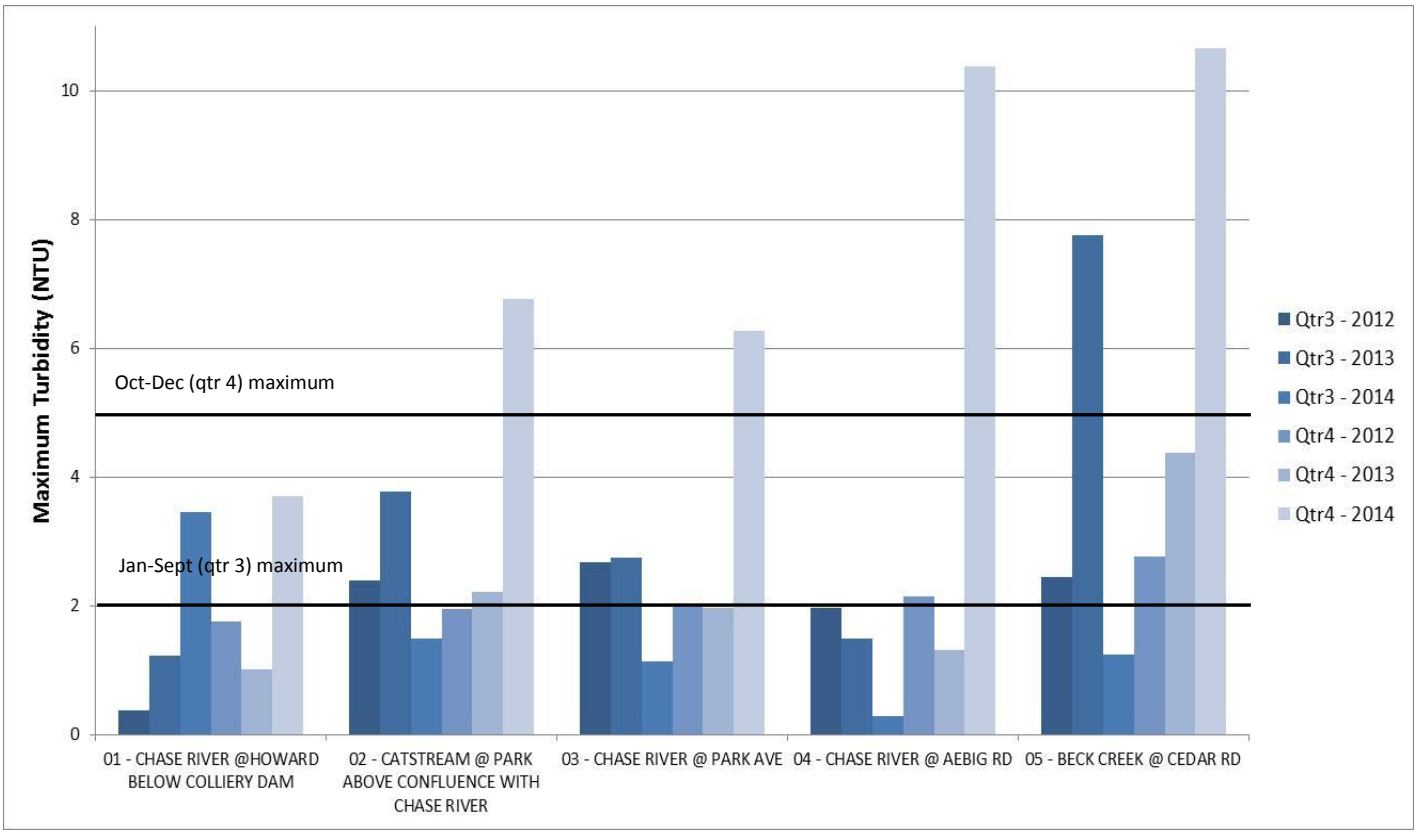
Figure 21– Maximum specific conductance collected by Vancouver Island University.



Maximum summer turbidity levels exceeded the January to September (qtr 3) guideline of 2 NTU in the upper Chase River site (Howard) in 2014, the middle Chase River site (Park Ave) in 2012 and 2013, and the lower Chase River site (Aebig) in 2012 (Figure 22). The summer turbidity objective was also exceeded in the Cat Stream and Beck Creek in 2012 and 2013.

The October to December (qtr 4) 5 NTU maximum was exceeded in the two lower Chase River sites during fall sampling in 2014. The fall turbidity objective was also exceeded in both the Cat Stream and Beck Creek in 2014. Fall turbidity spikes occurred one week after a heavy rainfall in 2014.

Figure 22 – Maximum turbidity collected by Vancouver Island University.

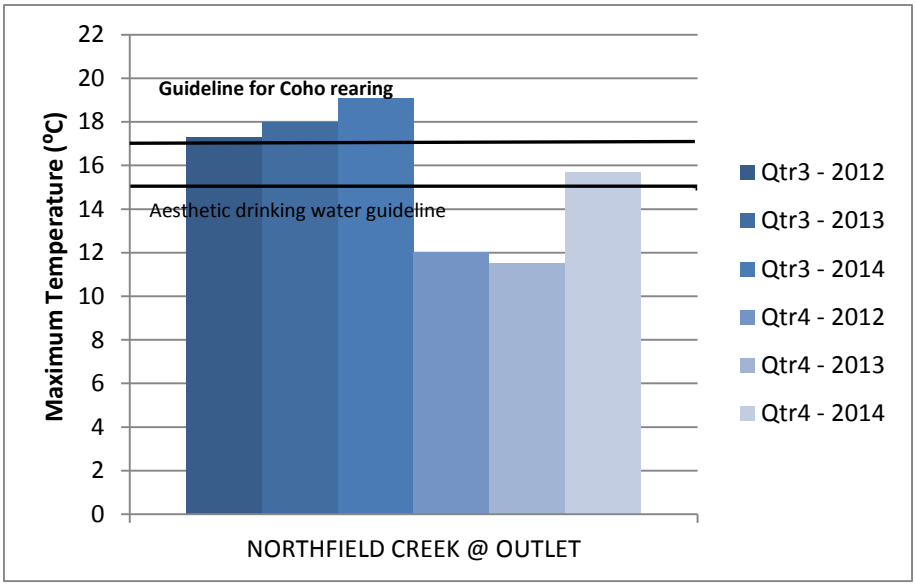


Northfield Creek

Monitoring on Northfield Creek in Nanaimo has been performed by Island Waters Fly Fishers, Harbour City River Stewards, Departure Creek Streamkeepers, and City of Nanaimo staff during the three years it has been included in the CWMN program.

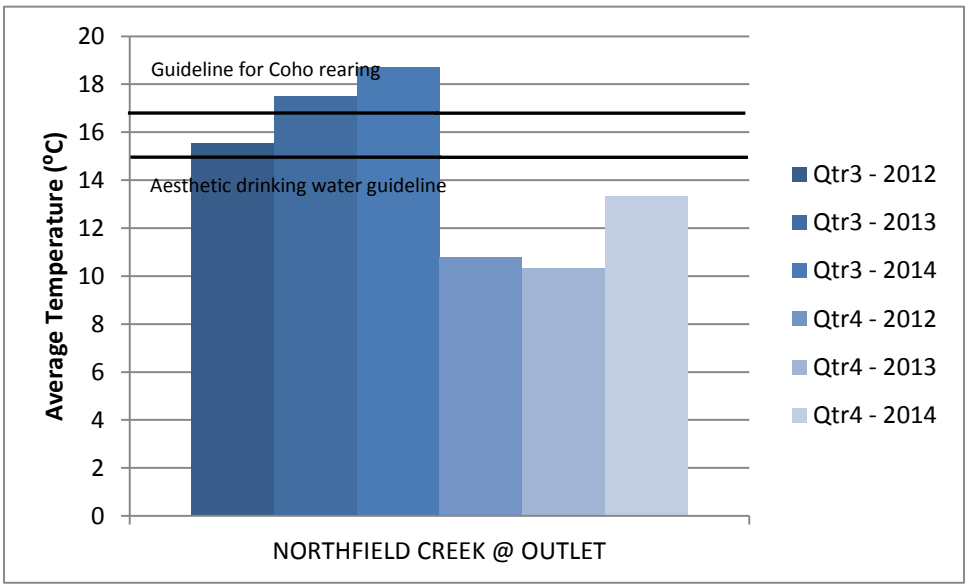
The maximum temperature had potential for exceedance of the aesthetic drinking water temperature guideline (weekly average ≤15°C) during each of the summer sampling periods (Figure 23). The drinking water temperature guideline is used, though there are no drinking water intakes on any of the streams in this report. In each of the summer sampling periods the maximum temperature also had the potential to exceed the guideline for Coho rearing (weekly average ≤17°C).

Figure 23 – Maximum temperature, Northfield Creek



The average temperature also had the potential for exceedance of the aesthetic drinking water temperature guideline (weekly average ≤15°C) in all summer sampling periods in Northfield Creek, and had the potential to exceed the guideline for Coho rearing (weekly average ≤17°C) in 2013 and 2014(Figure 24).

Figure 24 – Average temperature, Northfield Creek.



At the dates and times sampled, dissolved oxygen (DO) did not drop below the instantaneous minimum guideline of 5 mg/L (Figure 25) or the 30 day average guideline of 8 mg/L (Figure 26).

Figure 25 – Minimum dissolved oxygen, Northfield Creek.

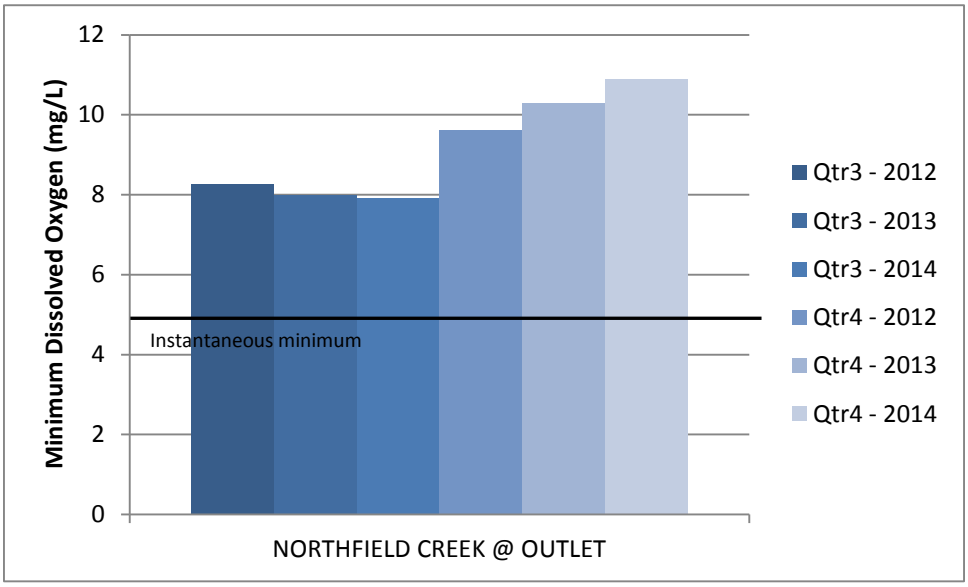
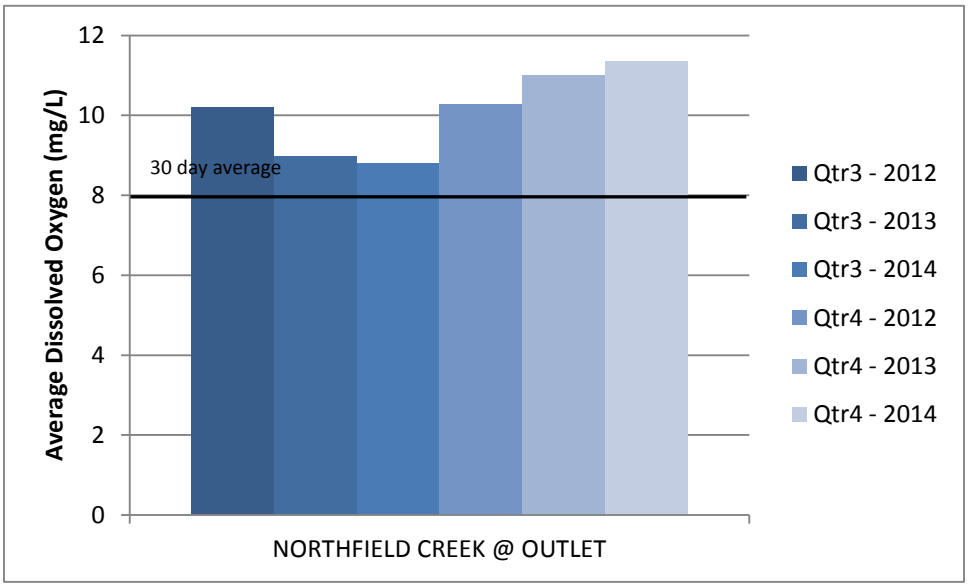
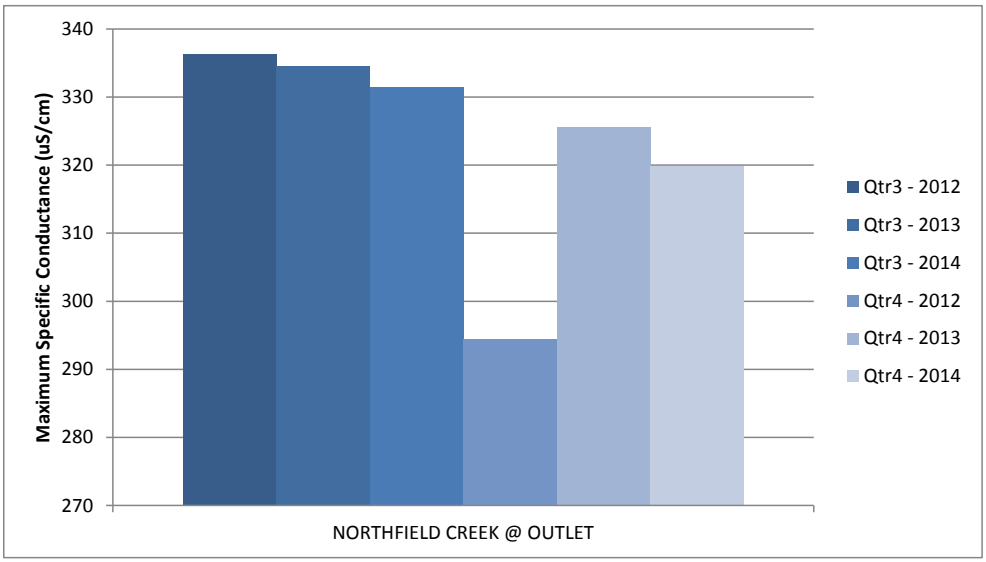


Figure 26 – Average dissolved oxygen, Northfield Creek.



The summer maximum specific conductance was higher than levels typical of coastal streams in each of the sample years (Figure 27).

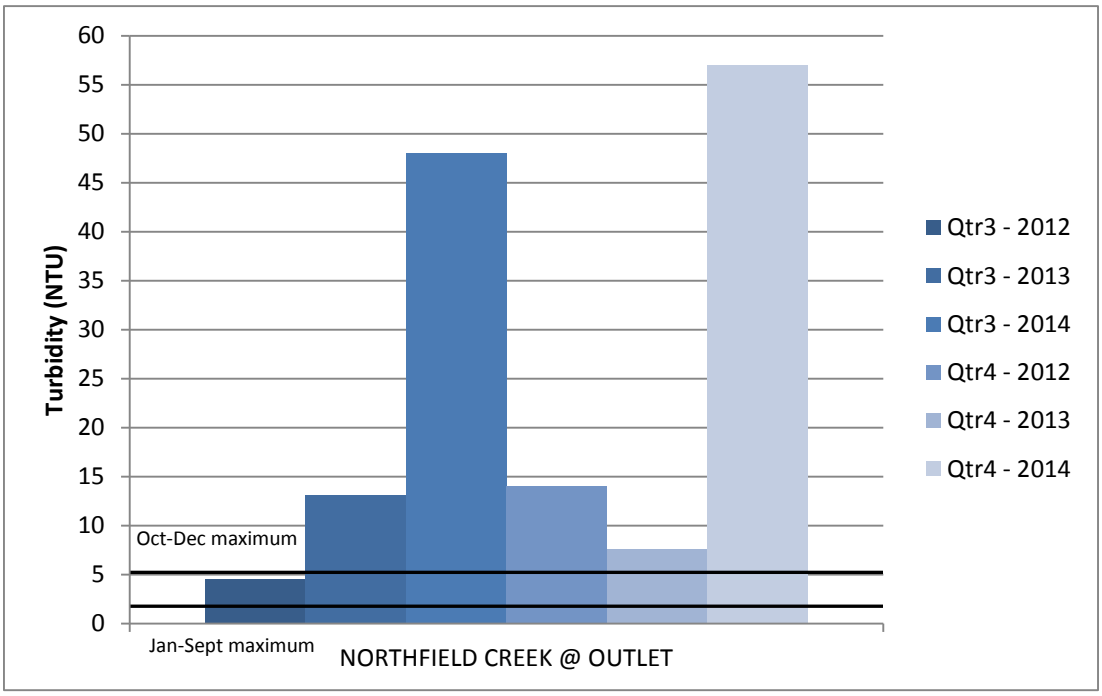
Figure 27 – Maximum specific conductance, Northfield Creek.



Maximum turbidity levels were well above the January to September (Quarter 3) guideline of 2 NTU during summer monitoring in 2012 - 2014 (Figure 28). Turbidity also far exceeded the Oct – Dec (Quarter 4) guideline of 5 NTU for each of the fall monitoring periods in all three years of monitoring.

The higher turbidity levels experienced at this site in 2014 are associated with significant roadwork upstream during that monitoring period. This suggests that ensuring the use of best practices for sediment and erosion control during road construction would be beneficial.

Figure 28 – Maximum turbidity, Northfield Creek.



Recommendations

A summary of the findings of the trend analysis from data collected from 2012-2014 can be seen in Table 3. Exceedances in temperature, turbidity and dissolved oxygen noted; specific conductivity is not included in Table 3 as there are no guidelines or objectives set for this water quality parameter. The yellow highlights indicate where turbidity exceedances were observed at a site for more than one year / period. This serves as our criteria for identifying the priority sites for further sampling, including additional lab analysis for parameters such as total phosphorus, metals and E.coli.

Table 3 – Summary of the 2012-2014 three year trend analysis.

Group	Watershed	Sample Location	Parameter	Guideline	Exceeded Periods
IWFF	Millstone River	at Biggs Road	Temperature	weekly avg. ≤17°C	Summer 2012-2014
			Dissolved Oxygen	Inst. Min 5 mg/L	Summer 2013
			Dissolved Oxygen	30 day avg. 8mg/L	Summer 2012-2014
			Turbidity	> 2 NTU Jan-Sept	Summer 2013
		at East Wellington	Temperature	weekly avg. ≤17°C	Summer 2012-2014
			Dissolved Oxygen	Inst. Min 5 mg/L	Summer 2013, 2014
			Dissolved Oxygen	30 day avg. 8mg/L	Summer 2013, 2014
			Turbidity	> 2 NTU Jan-Sept	Summer 2012, 2014
			Turbidity	> 5 NTU Oct-Dec	Fall 2014
		in Barsby Park	Temperature	weekly avg. ≤17°C	Summer 2012-2014
			Turbidity	> 2 NTU Jan-Sept	Summer 2012, 2013
			Turbidity	> 5 NTU Oct-Dec	Summer 2012, 2014
	McGarrigle Creek	at Jingle Pot Road	Temperature	weekly avg. ≤15°C	Summer 2013, 2014
			Dissolved Oxygen	30 day avg. 8mg/L	Summer 2014
			Turbidity	> 2 NTU Jan-Sept	Summer 2014
	Benson Creek	at Biggs Road	Dissolved Oxygen	Inst. Min 5mg/L	Summer 2012-2014
			Dissolved Oxygen	30 day avg. 8mg/L	Summer 2012-2014
DCSk	Departure Creek	at Neyland	Turbidity	> 2 NTU Jan-Sept	Summer 2013
			Turbidity	> 5 NTU Oct-Dec	Fall 2014
		off Newton	Temperature	weekly avg. ≤15°C	Summer 2013, 2014
			Turbidity	> 2 NTU Jan-Sept	Summer 2012-2014
		Woodstream Park	Temperature	weekly avg. ≤15°C	Summer 2013, 2014
			Turbidity	> 2 NTU Jan-Sept	Summer 2013
		at outlet	Temperature	weekly avg. ≤15°C	Summer 2013, 2014
			Turbidity	> 2 NTU Jan-Sept	Summer 2012-2014
			Turbidity	> 5 NTU Oct-Dec	Fall 2014
	Cottle Creek	at Landalt Road	Temperature	weekly avg. ≤15°C	Summer 2013, 2014
			Dissolved Oxygen	30 day avg. 8mg/L	Summer 2013, 2014
			Turbidity	> 2 NTU Jan-Sept	Summer 2013
		at Nottingham Road	Temperature	weekly avg. ≤15°C	Summer 2013, 2014
			Dissolved Oxygen	Inst. Min. 5mg/L	Summer 2014
			Dissolved Oxygen	30 day avg. 8mg/L	Summer 2012 -2014

			Turbidity	> 2 NTU Jan-Sept	Summer 2012
		at Stephenson Pt Road	Temperature	weekly avg. ≤15°C	Summer 2012-2014
			Dissolved Oxygen	30 day avg. 8mg/L	Summer 2014
			Turbidity	> 2 NTU Jan-Sept	Summer 2013
		North Cottle Creek 100 m d/s from Burma Rd	Dissolved Oxygen	30 day avg. 8mg/L	Fall 2013
VIU	Chase River	below Colliery Dam	Temperature	weekly avg. ≤15°C	Summer 2012-2014
			Dissolved Oxygen	30 day avg. 8mg/L	Summer 2012-2014
			Turbidity	> 2 NTU Jan-Sept	Summer 2014
		at Park Ave	Temperature	weekly avg. ≤15°C	Summer 2012-2014
			Dissolved Oxygen	30 day avg. 8mg/L	Summer 2012, 2014
			Turbidity	> 2 NTU Jan-Sept	Summer 2012, 2013
			Turbidity	> 5 NTU Oct-Dec	Fall 2014
		at Aebig Road	Temperature	weekly avg. ≤15°C	Summer 2012-2014
			Dissolved Oxygen	30 day avg. 8mg/L	Summer 2012, 2014
			Turbidity	> 2 NTU Jan-Sept	Summer 2012
			Turbidity	> 5 NTU Oct-Dec	Fall 2014
	Cat Stream	above conf. w/ Chase	Temperature	weekly avg. ≤15°C	Summer 2012-2014
			Dissolved Oxygen	30 day avg. 8mg/L	Summer 2012, 2014
			Turbidity	> 2 NTU Jan-Sept	Summer 2012, 2013
			Turbidity	> 5 NTU Oct-Dec	Fall 2014
	Beck Creek	at Cedar Road	Temperature	weekly avg. ≤15°C	Summer 2013, 2014
			Dissolved Oxygen	30 day avg. 8mg/L	Summer 2012, 2014
			Turbidity	> 2 NTU Jan-Sept	Summer 2012, 2013
			Turbidity	> 5 NTU Oct-Dec	Fall 2014
Various	Northfield Creek	at Outlet	Temperature	weekly avg. ≤15°C	Summer 2012-2014
			Turbidity	> 2 NTU Jan-Sept	Summer 2012-2014
			Turbidity	> 5 NTU Oct-Dec	Fall 2012- 2014

Based on water quality guidelines and objectives, exceedances of one of the parameters for which guidelines exist (temperature, dissolved oxygen or turbidity) occurred at each of 19 sample locations during at least one of the sample periods. This is a higher ratio of exceedances than in the northern CWMN sample locations analyzed in the RDN CWMN Water Quality Trend Report, 2011 – 2013 (Barlak and Fegan, 2014), in which 17 of 25 sample locations had exceedances during the first three years of monitoring. This may be reflective of the urban context of the streams in this report; urban streams tend to have less riparian cover, more potential anthropogenic inputs, and a greater likelihood of storm water management practices impacting year-round flows.

Temperature exceedances confirm general conditions for all east coast streams, particularly in the lower watersheds where streams are wide, slow moving and have little vegetative cover. Similarly low dissolved oxygen levels in some of the smaller streams are indicative of slow moving or stagnant water. It would be interesting to know what impact this is having on any fish living in these streams. Vancouver Island University (VIU) Fisheries and Aquaculture, and VIU Resource Management Officer Training

program contacts may be able to point to existing reports on which streams are fish bearing within the CWMN program to better understand the impact of water quality exceedances.

Sites with turbidity exceedances should be considered candidates for lab analysis to further determine the cause. Potential sources of increased turbidity (especially in summer) could be disturbance of stream bottom in shallow water, algal growth in the streams, or land disturbance such as land clearing, agricultural or development activities. A review of field notes from the past 3 years of data collection could help identify the cause of turbidity exceedances. It would also be helpful to ask volunteers to take extra care to note disturbance to the stream bottom, presence of algae, or land use activity during future monitoring. For 2015 it is recommended that for those sites with turbidity exceedances identified in Table 4, additional parameters are monitored for to determine potential sources. This includes lab analysis for metals, total phosphorous and E.coli where applicable.

Nine of the monitoring sites had exceedances of more than one parameter over more than one year, and as such are priority areas for continued water quality testing in 2015 (Table 4).

Table 4 – Summary of sites with exceedances in more than one parameter over more than one year during the 2012-2014 sample periods.

Group	Watershed	Sample Location	EMS ID
IWFF	Millstone	at East Wellington	E290480
IWFF	Millstone	in Barsby Park	E290481
DCS	Departure Creek	at Neyland	E290469
DCS	Departure Creek	off Newton	E290470
DCS	Departure Creek	at outlet	E290472
VIU	Chase River	at Park Ave	E290485
VIU	Cat Stream	above conf. with Chase	E290486
VIU	Beck Creek	at Cedar Road	E290487
various	Northfield Creek	at outlet	E290482

To better discern why exceedances occurred at the nine sites listed in Table 4 the following program modifications should be considered:

- Include collection of supplementary data and parameters that can be used to better identify future sites for educational opportunities and restoration work (e.g. E coli, nutrients, metals).
- Sampling at strategic points upstream of these sites to determine possible sources of impacts.
- The addition of parameters such as hydrometric flow measurements, physical structure of the stream and the condition of the stream and riparian habitat upstream of the sample site to better assess the water quality of these areas. Sampling techniques to ensure no disturbance of stream bottom

The following general recommendations are made for future monitoring years:

- Re-training of calibration and sampling procedures should occur at least once each year of the program.
- Quality control samples (e.g. duplicates sent for lab analysis and duplicate meter readings on 10% of samples) should occur and techniques for collecting samples reviewed.
- The importance of getting five samples in 30 days for comparison to objectives should be emphasized.

- Flexibility in the fall sample period to ensure that the fall flush is captured in the fall rains sample period.
- After 2014, some sites will be monitored every second or third year, where no repetitive exceedances were observed over the first three years of monitoring. Trend reports will only be compiled every three years to allow enough time for analysis; data will still be annually entered into MOE database and summaries will be available to all groups and the public.

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