The Watershed Water Quality Report Card Series

Background and Calculation of the PEI Water Quality Indicator

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Introduction

The PEI Department of Environment, Water and Climate Change (EWCC) has a responsibility to report to Islanders on the health of water in Prince Edward Island. As part of this responsibility EWCC makes public an overview of water quality on a watershed basis.

A watershed is an area of land that drains groundwater and surface water into a single estuary, river or stream. Almost all human activities can have a negative effect on water quality. To understand both our water resources and the activities that can impact them it is important to think about them in the context of a watershed

In the past water quality has been reported on using single parameters as in the State of the Environment (PDF) (SOE) reports or as in the nitrate trend report. Although these efforts provide valuable information on the quality of our water resources they miss the mark of reporting on a watershed basis as they represent either an Island-wide roll-up of results or the results for a discrete sample site. These efforts mostly consider only a single parameter, such as fecal coliforms or nitrates, at a time. The use of single parameter reporting means that many individual parameters have to be considered to get an overall picture of water quality.

An alternative is to use a data roll-up or index to report on water quality in Island watersheds. There are many examples of water quality indexes in use around the world and within Canada. PEI already participates in national reporting on fresh water quality in the Canadian Environmental Sustainability Indicators (CESI) initiative. The PEI calculations for the CESI water quality indicator uses a roll-up of results of the results of eight water quality parameters from eleven sample sites, each representing a single stream or river, over a 3 year index period. Although useful to water quality managers in understanding water quality the CESI approach dies not fulfill the requirement for watershed reporting. Using a roll-up of discrete results from several chemical parameters also does not include some information that Islanders may consider relevant when considering water quality in the province. This may include issues such as siltation, anoxic events, and contaminants which may be difficult to capture in a grab sample based monitoring program.

The ***PEI Water Quality Score (PEI WQS)*** bridges these gaps by including both estimates of parameters and observations of water quality which are of relevance to Islanders.

This document provides detailed information about the calculation of the ***PEI WQS***. This score is calculated using 5 issues:

- Nitrate concentration in streams.
- Anoxic events in estuaries
- Fish kills related to run-off
- Siltation events
- Other factors (e.g. blue-green algae blooms, high temperature, high nitrate in drinking water, etc.).

Calculation of the PEI WQS

The ***PEI WQS*** is represented by a simple dashboard (speedometer) graphic. The possible scores of 0 – 12 relate to 4 water quality categories:

- Excellent (score 0)
- Good (score 1-4)
- Fair (Score 5- 8)
- Poor (9-12)

The arrow of the speedometer indicates both the total score and the related water quality category.

Figure 1. Appearance of the ***PEI WQS*** graphic. This example shows a score of 2 and an overall water quality category of *Good*.

Water Quality Issues used in the PEI WQC Calculation

Watershed Nitrate Concentrations

Islanders are concerned about nitrates in the environment. In PEI exceedances of Health Canada's Drinking Water Guidelines for nitrate in drinking water are common. Nitrate concentrations in many Island streams and ponds may also exceed the Canadian Water Quality Guideline for the protection of Aquatic Life for nitrate. Excess nitrates in our surface waters are also known to cause issues with eutrophication in many of our ponds and estuaries.

Modelled nitrate concentrations were used in the initial reporting of the Watershed Water Quality Report Card series (2016) to determine the score for the watershed nitrate component. This was because not all Island watersheds had recently collected nitrate data available and because only a modelling approach could produce a concentration that is representative of the entire watershed. In subsequent discussion with community-based watershed groups it was determined that an approach where data collected by these groups is used in the calculation was preferred.

Modelled nitrate concentrations represent an average nitrate concentration for the entire watershed. The model that is used produces a watershed concentration that, for PEI, is also analogous to the baseflow (the portion of streamflow that comes from groundwater) nitrate concentration. In order to use measured nitrate data in the place of modeled nitrate data in the calculation of water quality scores, measured nitrate and modelled nitrate concentrations need to be as comparable as possible.

Since Island streams are known to be predominately groundwater during low flow, mean nitrate results from data collected during the summer months (June – September) is used. In order to account for inter-annual variation at least 2 – 3 years of sampling results is needed. Since the goal of the Watershed Water Quality Report Card series is to provide a timely assessment of water quality, recent data, from the current year of the assessment plus the 1 or 2 previous years, is preferred. If recent data is unavailable older data is used as long as there is no reason to suspect that the nitrate concentrations are changing significantly over time.

Variability within a dataset is often observed. To account for variability a minimum of five samples are used in calculating a mean for a particular watershed. If less than five samples exist for a particular watershed, the measured values can still be used however the range of the nitrate results and the number of samples is provided in the report card data rather than the watershed mean.

Data that is highly variable can have a large influence on the sample means, especially if the number of samples is small (i.e. < 30). In order to reduce the influence of variation on the data extreme outliers (observations that lie an abnormal distance from other values in a particular set of results) are removed from the data (Figure 2) using the following method.

Due to the small amount of data used for the watershed nitrate calculations a normal distribution of the data is unlikely. Due to this non-normal distribution assumption outliers are identified using the inter-quartile distance rather than the standard deviation approach. Excel is used to calculate values for the lower quartile (or 1st percentile) above which 75% of the data is found and the lower quartile (or 3rd percentile) above which 25% of the data is found. The inter-quartile range (IQR), or range which represents the central 50% of the data, is determined by subtracting the lower quartile from the upper quartile. Extreme outliers were identified as being more than 3x the IQR above the upper quartile (upper outlier value) or being less than 3x the quartile range below the lower quartile (lower outlier value) (Figure 2).

Individual stream results also may not represent the entire watershed. The nitrate results from each individual stream site will reflect concentrations that are influenced by land use in the drainage area of that site only. Local land use can vary quire significantly from stream to stream and even from site to site in the same stream. The latter are offset by using results from sites that are the farthest downstream in each watershed as they will be more representative of the overall land in the drainage area.

Many watersheds also do not have a single stream that can be sampled at a single downstream location as many have two to several tributaries. Where multiple tributaries exist, their results are averaged in an area-weighted approach that produces a result more analogous with a modelled concentration for the whole watershed (Figure 2). Of course any tributaries or stream areas which are downstream of a given measurement site are not accounted for in these nitrate measurements. Neither will any areas which have direct drainage to a downstream estuary. If land use is in these areas is dissimilar to that of the drainage area represented by a monitoring site or combination of monitoring sites the nitrate value produced from the monitoring results will not truly represent the entire watershed. An indication of this is conveyed in the ***Status*** portion of the Water Quality Report Card page by indicating the proportion of the watershed represented by the measured result. The inference being that the smaller the proportion the less likely it is to represent the entire watershed.

Tryon River Calculation of Average Measured Watershed Concentration

SSWA001/MSC 96

Station Drainage Area (ha)	1466
Proportion of total	0.40

Date	Watershed Group Nitrate Result (mg N/L)	CLE Nitrate Result (mg N/l)
	Data Source	
6/30/2015		3.40
7/10/2015		3.70
7/21/2015		3.60
8/11/2015	3.57	
8/19/2015		3.60
8/25/2015	3.21	
9/1/2015	1.56	
9/3/2015		3.50
9/15/2015	2.36	
9/22/2015	2.44	
6/9/2016	3.81	
6/16/2016	4.00	
6/30/2016	3.50	
7/21/2016	6.01	
8/4/2016	3.77	
8/12/2016	4.22	

Number of Samples	16
Average (all data) (mg N/l)	3.52
Median (mg N/l)	3.59
Standard Deviation (mg N/l)	0.92
3rd Quartile (mg N/l)	3.78
1st Quartile (mg N/l)	3.35
InterQuartile Distance (mg N/l)	0.43
Upper Outlier (mg N/l)	5.06
Lower Outlier (mg N/l)	2.07
Average (Outliers removed) (m	**3.48**
Area Weighted Average (mg N/	**1.40**

SSWA019/MSC 97

Station Drainage Area (ha)	2168
Proportion of total	0.60

Date	Watershed Group Nitrate Result (mg N/L)	CLE Nitrate Result (mg N/l)
	Data Source	
6/30/2015		4.5
7/10/2015		4.80
7/21/2015		4.80
8/19/2015		5.00
9/3/2015		5.00
6/30/2016	6.14	
7/21/2016	8.92	
8/12/2016	6.11	

Number of Samples	8
Average (all data)	**5.66**
Median	5.00
Standard Deviation	1.36
3rd Quartile	6.12
1st Quartile	4.80
InterQuartile Distance	1.32
Upper Outlier	10.07
Lower Outlier	0.85
Area Weighted Average	**3.38**

Total Area Sampled (ha)	3634
Watershed Nitrate (mg/l) (Area Weighted Average of All Sampled Areas)	**4.78**
Total Watershed Area	5204.98
Proportion of Watershed Measured	0.70

red text indicates A statistical Outlier

Outliers are determined as 3X the interquartile distance from the 1st and 3rd quartiles.

Figure 2. Example calculation of watershed nitrate concentration. This example demonstrates the area weighted approach for multiple streams in watershed, with determination of outliers in the data.

Often multiple agencies (e.g. local community watershed groups, researchers, provincial government, and federal government) collect data from the same sites. All available sources of measured nitrate data will be used in this assessment as they are identified (Figure 2).

Even with the sampling coverage provided by EWCC, community watershed groups and other agencies it is anticipated that watersheds exist for which there are no measured nitrate results. The alternative approach for these sites is to use a model. Virtually all island watersheds are now modelled for average nitrate-nitrogen concentration using a land-use area weighted approach (Jiang *et al*. 2015). The model produces a watershed concentration that, as discussed above, is also analogous to the baseflow contribution to surface water flow for PEI.

The measured or modelled concentrations are used for the calculation of the watershed nitrate score portion of the PEI WQS. Nitrate scores are assigned as follows:

- Concentration < 0.5 mg/N/l. Score is 0 - very low range.
- Concentration < 1.5 mg N/l. Score is 0 – low range.
- Concentration 1.5 to <3 mg N/l. Score is 1- moderate range.
- Concentration 3 to < 5 mg N/l. Score is 2 – high range.
- Concentration >5 mg N/l. Score is 3 – very high range.

Three threshold values are utilized in the scoring for this part of the ***PEI WQS***. The concentration chosen as the low threshold is 1.5 mg N/l because it is a concentration considered to reflect a relatively low level for nitrate in PEI watersheds. A concentration of 3 mg N/l is the CCME WGQ for aquatic life and stream concentrations that exceed this level represent an alert level above which there may be some impact on aquatic life. Watershed nitrate concentrations at or above 5 mg N/l are considered high for PEI.

These threshold concentrations are not related to eutrophication and/or anoxic events in ponds or estuaries (see below).

Frequency of Anoxic Events in Estuaries

Unfortunately Islanders have become very familiar with the occurrence of anoxic events in PEI estuaries. Anoxia is the end result of a process in which excess primary productivity results in degraded water quality. Most Islanders would place anoxic events high on a list of environmental concerns for PEI. Although related to nitrate loading (loads are a function of both concentration and flow volume) in watersheds the occurrence of anoxic events in island estuaries is also related to flushing rates in these bodies of water. That is why some relatively low nitrate concentrations stream/groundwater concentrations can result in anoxia in some systems while other much higher concentrations do not result in anoxia in other systems. Since flushing rates differ from system to system the loading that can cause anoxic events also differs from watershed to watershed.

Currently the occurrence of anoxia is being used as an endpoint in determining the reductions in nitrate loading that would be needed to address estuarine water quality in

PEI. As an important endpoint, the occurrence of anoxic events in the downstream estuary is used in the calculation the ***PEI WQS***. Scores for the occurrence of anoxia are assigned as follows:

- No anoxic events reported in an estuary in the last 5 years or no downstream estuary. Score is 0
- 1 anoxic event reported in an estuary in the last 5 years. Score is 1
- 2-3 anoxic events reported in an estuary in the last 5 years. Score is 2
- 4 – 5 anoxic events reported in an estuary in the last 5 years. Score is 3.

Frequency of Fish Kills

Fish kills are also an issue of great concern to Islanders. Fish kills can occur for a variety of reasons including natural causes (e.g. disease), anoxic events, the presence of contaminants in water due to spills and run-off, as well as some other environmental factors (e.g. high temperature).

The fish kills considered here are the result of events such as run-off and contaminant spills. This information is drawn from a list of documented fish kills maintained by the province. No fish kills related to spills have been recorded for more than 10 years so in recent years all fish kills on this list are related to contaminants borne in run-off. Scores for fish kills are assigned as follows:

- No fish kills recorded in the last 10 years. Score is 0
- 1 fish kill recorded in the last 10. Score is 1.
- Two or more fish kills recorded in the last 10 years. Score is 2.

Fish kills associated with anoxic events and certain other environmental factors are included in the anoxic event scoring as all anoxic events are likely to result in the death of some aquatic life due to very low oxygen levels in the water. Fish kills which are the result of environmental factors such as high temperature are rare and are captured under the ***Occurrence of Other Issues*** below. Fish and shellfish kills associated with natural causes such as disease or post-spawning mortality, are not included as the ***PEI WQS*** is intended to highlight issues that are of human origin.

Occurrence of Siltation Events

Siltation is also an issue of concern for water quality in PEI. Siltation is a difficult issue to measure adequately at the watershed level. Although the province is continuing to pilot an automated method to monitor siltation it is unlikely that there would be sufficient resources available to ever implement such a monitoring effort in all Island watersheds.

In lieu of data on siltation a qualitative assessment of the occurrence of sediment laden run-off (red water) events in watersheds is used in the calculation of the ***PEI WQS***. Since this is a factor for which there is little or no actual data the information comes from local observation of the occurrence of run-off in these watersheds. Scores are assigned as follows:

- Infrequent (occurring only in the biggest run-off events where there is significant rainfall or snow-melt) red water events. Score is 0.
- Frequent red water events (occurring in most but not all rainfall or snowmelt events which result in run-off from surrounding land to streams). Score is 1.
- Very ***F***requent red water events (occurring in virtually all rainfall or snowmelt events which result in run-off from surrounding land in streams). Score is 2.

Occurrence of Other Issues

Although using just nitrate concentration, frequency of anoxic events and the occurrence of fish kills and siltation events as factors in the calculation of the ***PEI WQS*** would provide a reasonable picture of water quality in Island watersheds, there are other issues that occasionally occur that are also considered in the calculation of the ***PEI WQS***. Examples of such issues include events such as high surface water temperatures, cyanobacteria blooms, anoxia in freshwater ponds and high drinking water nitrate. Since these issues can differ from watershed to watershed assigning a specific category for each possible type of other issue is not a reasonable approach. Instead all other issues with a possible negative effect on water quality are considered collectively in the "Other" category.

As is the case for siltation "Other" encompasses factors for which there may be little or no available measurement data. Instead qualitative information for such factors may come from local observation of the occurrence of incidents in these watersheds.

Some quantitative data may also be available for use in the calculation of the "Other" category score. Summary groundwater (well) results for nitrate by watershed is available online. Summary nitrate data from the last 5 years are used, with small sub-watersheds aggregated into larger ones as necessary. An average value of 3 mg N/l for groundwater nitrate is considered to keep most drinking water wells in PEI watersheds below the Health Canada Drinking Water Guideline.

Some community-based watersheds collect surface water temperature data using water temperature and/or water level (which also record temperature) data loggers which collect water temperatures at frequent intervals during the year. For the purposes of this assessment data from the May to September period, generally the warmest months in PEI, are used for sites with a minimum of 100 continuous records. Thresholds of 20° and 25° C are used as indicators of stress to aquatic species, particularly brook trout.

Scores in the “Other” category are assigned as follows:

- No other issues. Score is 0.
- Infrequent other issues (e.g. occurring in only one or scattered years, occurring in only a few discrete or logged samples, having the 5 year average groundwater nitrate value > 3 mg N/l, etc.). Score is 1.
- Frequent other issues (e.g. occurring in more than a few discrete samples, occurring in more than 5% of logged samples, occurring in more than one year, having the 5 year average groundwater nitrate value > 5 mg N/l, etc.). Score is 2.

Scores are additive in the “Other” category. For example the occurrence of infrequent anoxia in a freshwater pond accompanied by an average groundwater nitrate concentration of > 3 mg N/l (but less than 5 mg N/l) would result in an ”Other” score of 2, however “Other” scores will never exceed 2. For example the occurrence of temperatures recorded in a freshwater pond 10% of the time accompanied by an average groundwater nitrate concentration of > 5 mg N/l would result in an ’Other” score of 2 not 4.

Calculation of the PEI WQS and Assigning of Water Quality Categories.

The calculation of the final ***PEI WQS*** involves summing the 5 individual issue scores. This results in possible scores of 0 to 12 (Table 1).

Table 1. Thresholds and scoring for calculation of the PEI WQS.

Score	N03-N	Anoxic Events	Fish Kills	Siltation	Other Events	Category Range	Category
0	<1.5 mg/l	0 in last 5 years or no estuary	0 in last 10 years	Infrequent red water events	no other events	0	EXCELLENT
1	1.5 - <3 mg/l	1 in last 5 years	1 in last 10 years.	Frequent red water events	Infrequent other events. Average GW nitrate > 3 mg N/l	1-4	GOOD
2	3- < 5 mg/l	2 or 3 in last 5 years	2 or more in the last 10 years	Very frequent red water events	Frequent other events, Average GW nitrate > 5 mg N/l.	5-8	FAIR
3	>5 mg/l	4 or 5 in last 5 years				9-12	POOR

Scores for the ***PEI WQS*** were calculated for the 41watersheds included in the 2017 Water Quality Report Cards series (Table 2). To test the precision of the ***PEI WQS*** calculation WQS categories were compared to expert opinion of water quality in each watershed (Table 2). Although there was good agreement between the assigned categories and expert opinion, some watersheds differed (Table 2). Seven watersheds had categories that were worse than expert opinion and two watersheds were better than expert opinion. This was not unexpected as roll-ups of this type often result in some degree of disparity with other local knowledge. It should be noted that the categories are rather broad and in most cases (6 of 9) the disparaging scores are close to the category assigned by the water quality expert (Table 2).

Comparison to the 2016 WQS Results

As discussed the methodology for the calculation of the ***PEI WQS*** changed slightly for both the 2017 and 2018 versions of the Water Quality Report Cards. In both newer versions measured surface water nitrate concentrations rather than modelled nitrate concentrations were used for the calculation of watershed nitrate score. Average watershed groundwater nitrate concentrations were also used in the "Other" scores to approximate drinking water nitrate concerns in the 2017version. In the 2018 version surface water temperature data collected by community-based watershed groups using loggers were also added to the calculation. These changes resulted in some differences in the ***PEI WQS*** and categories between the three versions published so far. As an example of this a comparison of the ***PEI WQS*** results for the 30 watersheds that were included in both the 2016 and 2017 versions of the Report Cards is shown in Table 3.

This comparison shows that 8 of the 30 watersheds had the ***PEI WQS*** decline in the 2017 Water Quality Report Card series (Table 3). This decline in scores in these watersheds was generally due to the measured surface water nitrate concentration being higher than the modelled concentrations and/or the inclusion of the average groundwater nitrate values under ”Other” issues (Table 3). Better ***PEI WQS*** scores were recorded in 2017 than in 2016 in 3 watersheds (Table 3). These were all due to the measured surface water concentration being lower than the modelled concentration (Table 3). Despite these differences in the ***PEI WQS*** between the 2016 and 2017 Water Quality Report Card series only one watershed had a difference in water quality category (Table 3). This confirms that the roll-up or index approach used for the report cards is not being heavily influenced one parameter or another.

Use of the *PEI WQS*

The purpose of the ***PEI WQS*** is to provide Islanders with an easy to understand overview of water quality on a watershed basis so that Islanders can see the general health of water and compare it to that in other PEI watersheds using data or information that is currently available and relevant.

The Watershed Report Card Series is updated on an regular basis and made available as a report on the EWCC website

It is hoped that the ***PEI WQS*** will be a valuable tool that will assist Islanders in understanding the current threats to the quality our surface water resources and underline the need for management activities that will serve to protect or restore them.

Table 2. Comparison of PEI WQS results to expert opinion of watershed water quality for the 41 watersheds in the 2017 Water Quality Report Cards

Watershed	Measured N03-N	NO3 Score	Years with Anoxia in Last 5	Anoxia Score	Run-off Related Fish Kills Last 10 Years	Fish Kill Score	Siltation Events	Other Events	Total Score	Category	Expert Opinion Category	Other Category Description
Augustine Cove	4.2	2	0	0	0	0	1	2	5	Fair	Good	Infrequent issues with stream DO. Average GW nitrate > 3.0. mg/l.
Bear River	0.3	0	0	0	0	0	0	0	0	Excellent	Excellent	
Boughton	0.4	0	4	3	0	0	1	0	4	Good	Good	
Brudenell	2.0	1	1	1	0	0	1	1	4	Good	Good	Average GW nitrate > 3.0 mg/l.
Cape Traverse	5.0	2	0	0	0	0	2	2	6	Fair	Good	Average GW nitrate > 5.0 mg/l.
Cardigan	0.7	0	0	0	0	0	1	0	1	Good	Good	
Covehead/Brackley	2.8	1	4	3	0	0	2	1	7	Fair	Fair	Average GW nitrate > 3.0 mg/l.
Desable	1.4	0	0	0	0	0	1	2	3	Good	Good	Frequent complaints of odors from decaying sea lettuce.
Dunk	3.5	2	0	0	1	1	2	2	7	Fair	Fair	Average GW nitrate > 5.0 mg/l.
Enmore River	0.4	0	0	0	0	0	0	0	0	Excellent	Excellent	
Grand	0.9	0	1	1	0	0	1	0	2	Good	Good	
Hillsborough	0.4	0	0	0	0	0	2	2	4	Good	Good	Anoxic event in a freshwater pond 2012. Average GW nitrate > 3.0 mg/l.
Hunter/Clyde	1.1	0	5	3	0	0	2	0	5	Fair	Poor	
Jacques	0.5	0	0	0	0	0	0	1	1	Good	Excellent	Average GW nitrate > 3.0 mg/l
Kildare	4.5	2	5	3	1	1	2	2	10	Poor	Poor	High temperatures in pond at the head of tide. Average GW nitrate > 3 mg/l.
MacLaurins	2.9	1	0	0	0	0	0	0	1	Good	Excellent	
Mill	3.0	1	5	3	2	2	2	2	10	Poor	Poor	Average GW nitrate > 5.0 mg/l.
Montague/Valleyfield	1.5	1	1	1	0	0	2	1	5	Fair	Fair	Average GW nitrate > 3.0 mg/l.
Morell	0.9	0	1	1	0	0	0	1	2	Good	Good	Average GW nitrate > 3.0 mg/l.
Murray River	0.1	0	0	0	0	0	1	1	2	Good	Good	Occasional cyanobacteria blooms.
North Lake	1.3	0	0	0	0	0	0	1	1	Good	Excellent	Average GW nitrate > 3.0 mg/l.
North River	2.9	1	0	0	1	1	2	0	4	Good	Good	
Orwell/Vernon	1.8	1	0	0	0	0	2	1	4	Good	Good	Average GW nitrate > 3.0 mg/l.
Ox/Sheep	0.7	0	0	0	0	0	1	0	1	Good	Good	
Percival	0.7	0	0	0	0	0	0	0	0	Excellent	Excellent	
Pinette	1.1	0	0	0	0	0	1	1	2	Good	Good	Average GW nitrate > 3.0 mg/l.
Souris	2.2	1	1	1	0	0	1	1	4	Good	Good	Average GW nitrate > 3.0 mg/l.
Southwest	5.0	3	5	3	0	0	2	2	10	Poor	Poor	Anoxic event in a freshwater pond 2016. Average GW nitrate > 3.0 mg/l.
St. Chrystostome	1.2	0	0	0	0	0	0	0	0	Excellent	Excellent	
St. Peter's	0.4	0	2	2	0	0	1	1	4	Good	Good	Average GW nitrate > 3.0 mg/l.
St. Philip	3.5	2	0	0	0	0	0	2	4	Good	Good	Frequent reports of issues of fish and habitat conditions in stream.
Tracadie/Desroches	0.8	0	0	0	0	0	1	0	1	Good	Good	
Trout River (Coleman)	1.7	1	5	3	3	2	2	1	9	Poor	Poor	Average GW nitrate > 3.0 mg/l.
Trout/Stanley	2.3	1	5	3	0	0	2	1	7	Fair	Poor	Average GW nitrate > 3.0 mg/l.
Tryon	4.8	2	0	0	1	1	2	2	7	Fair	Fair	Infrequent issues with stream DO. Average GW nitrate > 5.0 mg/l.
Tyne Valley/Bideford	0.5	0	1	1	0	0	1	1	3	Good	Good	Release from peat mining facility.
Westmoreland	2.6	1	0	0	0	0	1	2	4	Good	Good	Infrequent issues with stream DO. Average GW nitrate > 3.0 mg/l.
West River	1.6	1	0	0	1	1	2	2	6	Fair	Good	Turbid water, low light limited growth of macro-algae and marine plants in estuary. Average GW nitrate > 3.0 mg/l.
Wheatley	3.0	2	5	3	0	0	2	1	8	Fair	Poor	Average GW nitrate > 3.0 mg/l.
Wilmot	6.1	3	0	0	0	0	2	2	7	Fair	Fair	Average GW nitrate > 5.0 mg/l.
Winter River	1.4	0	5	3	0	0	2	2	7	Fair	Fair	High temperature in ponds.

Better than Expert Opinion
Worse than Expert Opinion

Table 3. Comparison of the ***PEI WQS*** results for the 30 watersheds covered in the 2016 and 2017 Water Quality Report Card series.

Watershed	Measured/ Modelled N03-N	NO3 Score	Years with Anoxia in Last 5	Anoxia Score	Fish Kills Last 10 Years	Fish Kill Score	Siltation Events	Other Events	2017 Series Score	2016 Series Score	2017 Category	2016 Category	Reason for Change
Bear River	0.3	0	0	0	0	0	0	0	0	0	Excellent	Excellent	
Boughton	0.4	0	4	3	0	0	1	0	4	3	Good	Good	Higher anoxia score
Brudenell	2.0	1	1	1	0	0	1	1	4	3	Good	Good	GW nitrate score included in Other.
Cardigan	0.7	0	0	0	0	0	1	0	1	1	Good	Good	
Covehead/Brackley	2.8	1	4	3	0	0	2	1	7	6	Fair	Fair	GW nitrate score included in Other.
Dunk	3.5	2	0	0	1	1	2	2	7	7	Fair	Fair	
Grand	0.9	0	1	1	0	0	1	0	2	3	Good	Good	Lower watershed nitrate score
Hillsborough	0.4	0	0	0	0	0	2	2	4	3	Good	Good	Lower watershed nitrate score
Hunter/Clyde	1.1	0	5	3	0	0	2	0	5	6	Fair	Fair	Lower watershed nitrate score
Kildare	4.5	2	5	3	1	1	2	2	10	9	Poor	Poor	
Mill	3.0	1	5	3	2	2	2	2	10	9	Poor	Poor	Lower watershed nitrate score. GW nitrate score included in
Montague/Valleyfield	1.5	1	1	1	0	0	2	1	5	5	Fair	Fair	Lower anoxia score. GW nitrate score included in Other.
Morell	0.9	0	1	1	0	0	0	1	2	1	Good	Good	Lower nitrate score offset by a reported anoxia event in a FW
Murray River	0.1	0	0	0	0	0	1	1	2	2	Good	Good	
North Lake	1.3	0	0	0	0	0	0	1	1	0	Good	Excellent	GW nitrate included in Other.
North River	2.9	1	0	0	1	1	2	0	4	4	Good	Good	
Orwell/Vernon	1.8	1	0	0	0	0	2	1	4	3	Good	Good	
Percival	0.7	0	0	0	0	0	0	0	0	0	Excellent	Excellent	
Pinette	1.1	0	0	0	0	0	1	1	2	2	Good	Good	Lower watersehd nitrate score. GW nitrate
Souris	2.2	1	1	1	0	0	1	1	4	4	Good	Good	Lower anoxia score. GW nitrate score included in Other.
Southwest	5.0	3	5	3	0	0	2	2	10	9	Poor	Poor	Higher watershed nitrate score
St. Peter's	0.4	0	2	2	0	0	1	1	4	3	Good	Good	GW nitrate scire included in Other.
Tracadie/Desroches	0.8	0	0	0	0	0	1	0	1	1	Good	Good	
Trout River (Coleman)	1.7	1	5	3	3	2	2	1	9	9	Poor	Poor	Lower watershed nitrate score. GW nitrate score included in
Trout/Stanley	2.3	1	5	3	0	0	2	1	7	6	Fair	Fair	GW nitrate included in Other.
Tyne Valley/Bideford	0.5	0	1	1	0	0	1	1	3	4	Good	Good	Lower watershed nitrate score
West River	1.6	1	0	0	1	1	2	2	6	5	Fair	Fair	Higher fish kill score
Wheatley	3.0	2	5	3	0	0	2	1	8	6	Fair	Fair	Higher watershed nitrate Score. GW nitrate score included in
Wilmot	6.1	3	0	0	0	0	2	2	7	7	Fair	Fair	
Winter River	1.4	0	5	3	0	0	2	2	7	7	Fair	Fair	Lower watershed nitrate. GW nitrate included in Other.

Higher Score/category
Lower Score/Category

References

Jiang, Y., P. Nishimura. M.R. van den Heuvel, K.T.B MacQuarrie, C.S. Crane, Z. Xing, B.G. Raymond and B.L. Thompson, 2015. Modeling of land-based nitrogen loads from groundwater dominated agricultural watersheds to estuaries to inform nutrient reduction planning. Journal of Hydrology 529 (213 – 230),