Clackamas Watershed Assessment

Summer 2013

Student Watershed Research Project

Portland State University

Abstract

The goal of the Portland State University Clackamas Watershed Assessment is to better understand the quality of the water in the Clackamas River basin and to disseminate information across the watershed and beyond to better bridge the gap between society and this natural resource. This is an ongoing snapshot-monitoring project in its sixth year of qualitative and quantitative analyses of water from the Clackamas River basin. Results from the study convey varying conditions from site to site. Recommendations from the study include the discontinuing of the macroinvertebrate analysis on the mainstem of the Clackamas, the removal of non-native species, and the planting of native vegetation along the streams.

Introduction

The Clackamas River basin is a key natural resource that is heavily utilized in a variety of ways. Not only does it provide drinking water for nearly 400.000 individuals, but the Clackamas River and its tributaries are also utilized for crop irrigation, travel, recreation, and more. To ensure continuous use of this natural resource, it is pertinent that the quality of the water is monitored to detect natural and anthropogenic impacts on the watershed. This is a study of the Clackamas River basin undergone by the Student Watershed Research Project at Portland State University. This study has been going on since the summer of 2008. The purpose of this project is to collect data pertaining to the Clackamas river basin, including water quality and macroinvertebrate data. Tests for water quality include temperature, pH, turbidity, dissolved oxygen, ammonia, phosphorous, nitrate, and macroinvertebrate presence. . Using the results from this study, comparisons between this year and years prior can be undergone to determine whether we have positive or negative trends in water quality. Results will also be used to inform private landowners in the basin about the water that flows through their property.

Methodology

Various analyses were conducted both in the field and in the lab to determine the quality of water for the different portions of the Clackamas River Basin. Field tests included temperature, pH, turbidity, dissolved oxygen (DO). Macroinvertebrate data was also collected and analyzed from six selected field sites. Analyses were done in the lab on water samples collected in the field to determine the concentrations of ammonia, phosphorous, and nitrate.

Temperature has a significant impact on the physical and chemical properties of a stream. Not only do physical and chemical processes of a stream rely on temperature, but aquatic organisms do as well. With narrow temperature thresholds for survival, it is crucial to monitor the temperature of a stream to ensure the continuing presence of the aquatic life and physical and chemical processes that constitute a stream. The impacts of altered stream temperature are perpetual, for instance an increase in

stream temperature leads to a decrease in dissolved oxygen, which then negatively influences aquatic life. Temperatures for the various sites were collected using a non-mercury thermometer in degrees Celsius. For each of the three trials, the bulb of the thermometer was submerged a few inches below the stream for at least one minute.

pH is a measure determining how acidic or alkaline the water is. A range of 6.5 to 8.5 is generally noted as acceptable for aquatic life. Outside of this range, aquatic life is greatly impacted, especially in terms of growth and reproductive cycles. pH can be altered by both natural and anthropogenic processes. It can be lowered by certain byproducts of combustion engines and decomposition of organic matter, while algal blooms and industrial byproducts can raise it. For all of the sites, pH was determined through undergoing three trials utilizing a pH color comparison wheel.

Dissolved oxygen (DO) is the concentration of oxygen that has dissolved in water. Much aquatic life is dependent on DO for respiration. Generally, higher concentrations of DO are favorable. Higher levels of DO are dependent on cooler water temperatures and low levels of salinity. For this study, DO was measured using the Winkler titration method.

For this study, Nitrogen was measured as ammonia (NH3) and nitrate (NO3). Ammonia and nitrate are both crucial parameters to test for in a stream because they are indicative of other happenings in a stream. For instance, high levels of ammonia lead to the deprivation of DO in a stream through the process of Nitrification. Also, above certain concentrations, both of these constituents can be toxic.

Turbidity is a measure of the clarity or haziness of water due to the presence of suspended particles. The more turbid the water, the less clear it is due to higher concentrations of suspended solids. Turbidity is impacted by a number of processes, both natural and human-derived, including agricultural practices (tilling) and the influence of storms carrying sediment from the land to the water. For this study, turbidity was measured using a Hach 2100P Turbidimeter, which measures light scattered at a right angle.

Macroinvertebrate data was gathered in four sub-basins within the Clackamas River Watershed: Clear Creek, Deep Creek, Eagle Creek and Rock Creek. Macroinvertebrate samples were collected using a "three-kick" technique in a single transect in the same stream reach as the chemical sampling. Macroinvertebrate samples were collected using a 500 micron mesh D-framed net at 25, 50, and 75 percent of the stream width across the selected transect. At each sampling location, the D-net was placed on the stream bottom facing upstream and a one-square-foot area in front of the net was visually delineated. The area was stirred by hand clearing and kicking the stream bed substrate for 90 seconds to dislodge benthic macroinvertebrates. All three samples were then examined and combined into one container.

The combined sample for each stream was then placed as evenly as possible into an 18 cell-sampling grid. 5 numbers are randomly generated to select which cells will be used as random samples. All five cells are tallied to complete the sample for that stream. Remaining macroinvertebrates are returned to their collection location.

Lab Analysis:

The macroinvertebrate assemblage data, organized into the four sub-basins, are rated according to EPT index and OWEB Level 2 analysis to estimate stream health. Macroinvertebrate samples were sorted and identified as belonging to Ephemeroptera, Plecoptera, Trichoptera, or other taxonomic orders (Barbour et al., 1999). The number of individuals in each sample belonging to these three generally sensitive taxonomic orders were then added up and then divided by the total number of individuals in the sample to generate an EPT index. This method provides a percentage that represents what percentage of

the overall population sampled fall into the three major orders expected to be found in healthy streams. Higher EPT index percentages are better. The OWEB Level 2 quantifies the population distribution of insects, based on overall taxa richness, Mayfly richness, Stonefly richness, percent Diptera and percent dominance. OWEB has established a scoring system for this method that follows in the tables below.

Table 1: OWEB scoring table where raw score is the total number of each order, found for each metric, in each stream sampled.

Metric	Raw Score	5	3	1	Score (circle one)
Taxa Richness		>18	10 - 18	<10	5 3 1
Mayfly Richness		>4	2-4	<2	5 3 1
Stonefly Richness		>3	1-3	0	5 3 1
Caddisfly Richness		>4	2-4	<2	5 3 1
% Diptera		<15	15-30	>30	5 3 1
% Dominance		<30	30-50	>50	5 3 1
					Sum the Score

Table 2: OWEB table for estimating stream health based on Sum Score from Table 1.

Score Range	Stream Condition
>23	**No impairment**: passes Level 2 assessment. Indicates good diversity of invertebrates and stream conditions with little disturbance. Further sampling will help confirm the site's condition as unimpaired.
17 – 23	**Moderate Impairment**: Evidence of some water quality impairment exists. Requires further study and more detailed analysis.
<17	**Severe Impairment**: Fails level 2 assessment. Evidence of stream disturbance exists. Further study may be warranted to confirm level of impairment and potential causes.

Table 3: Oregon state water quality standards

Parameter	Surface Water	Spawning	Drinking Water
pH	6.5-8.5		6.5-8.5
Temperature (C)	</= 17.8	</=12.8	
DO (mg/L)	>/= 6.0	>/=11.0	
DO (% saturation)	</= 90%	</=95%	
Phosphorus (mg/L)	<0.1		
Nitrate (mg/L)	<10		<10

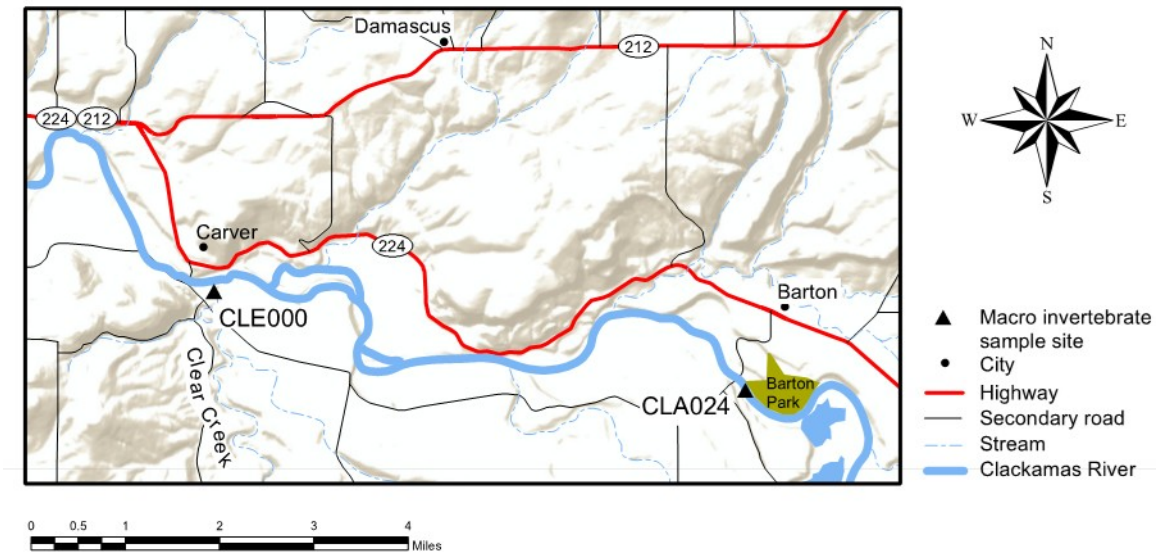
Results

The following results are presented per sub-basin. Graphs for temperature, pH, DO, ammonia, nitrate, phosphorus, and turbidity are provided for comparison of results across the years since the monitoring project was implemented. A macroinvertebrate graph is also included for the sub-basins where macroinvertebrate data was collected and analyzed. Table 3 on page 3 explains water quality standards in accordance with the Oregon DEQ. It is provided for comparative purposes to reveal if any of the streams monitored exceed state standards.

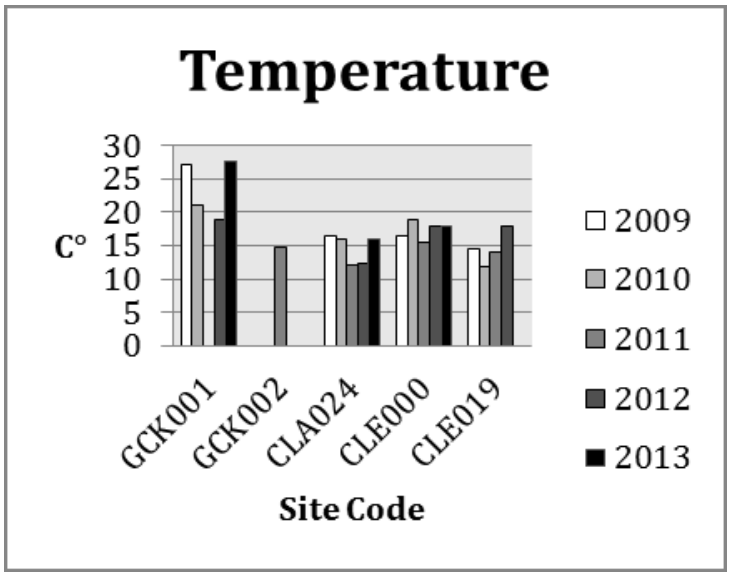
Table 4: Site Legend

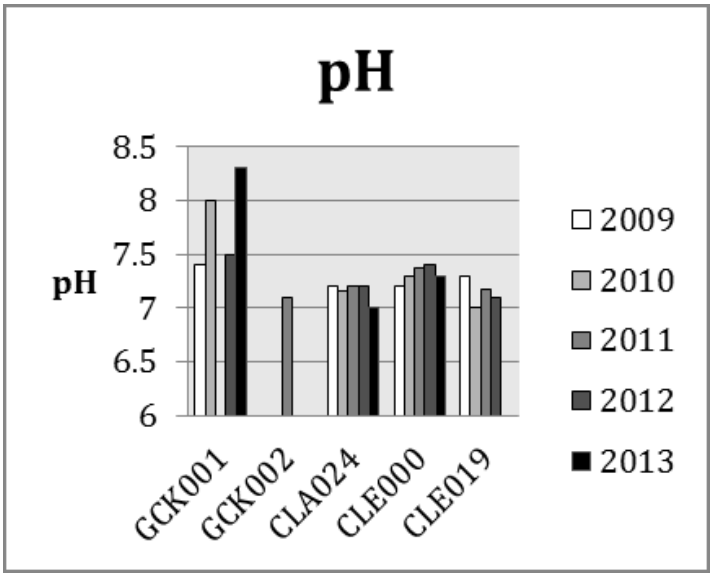
Sub-basin	Site Code	Stream Name	Location
Clear Creek	CLA024	Clackamas River	Barton Park boat ramp
	CLE000	Clear Creek	Carver Park
Deep Creek	DEP002	Deep Creek	Damascus
	GCK001	**Goose Creek**	**Barton Park**
	NFD001	N. Fork Deep Creek	Boring
	NFD002	N. Fork Deep Creek	Boring
	NFD004	N. Fork Deep Creek	Boring
Rock Creek	RCK000	Rock Creek	Damascus
	RCK002	Rock Creek	Damascus
	SEB002	Sieben Creek	Damascus
Richardson Creek	RCH002	Richardson Creek	Damascus
	RCH003	Richardson Creek	Damascus
	RCH004	Richardson Creek	Damascus
	RCH005	Richardson Creek	Damascus
Eagle Creek	EGL001	Eagle Creek	Estacada
	EGL002	Eagle Creek	Estacada
	EGL005	Eagle Creek	Estacada

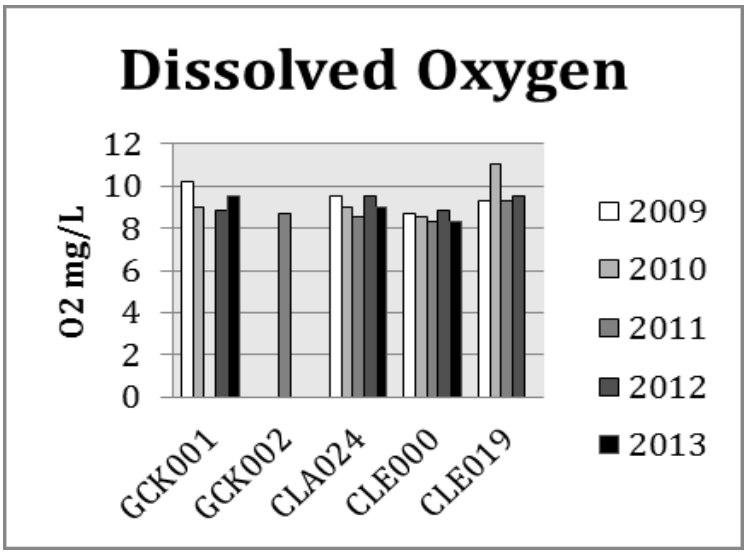
Clear Creek

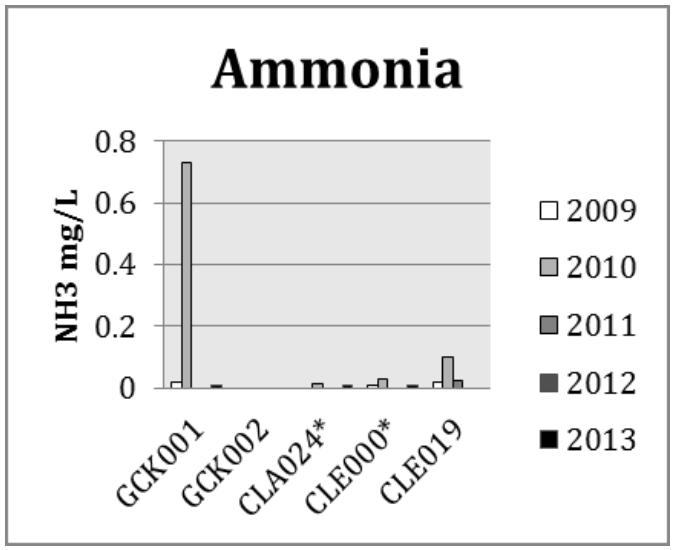


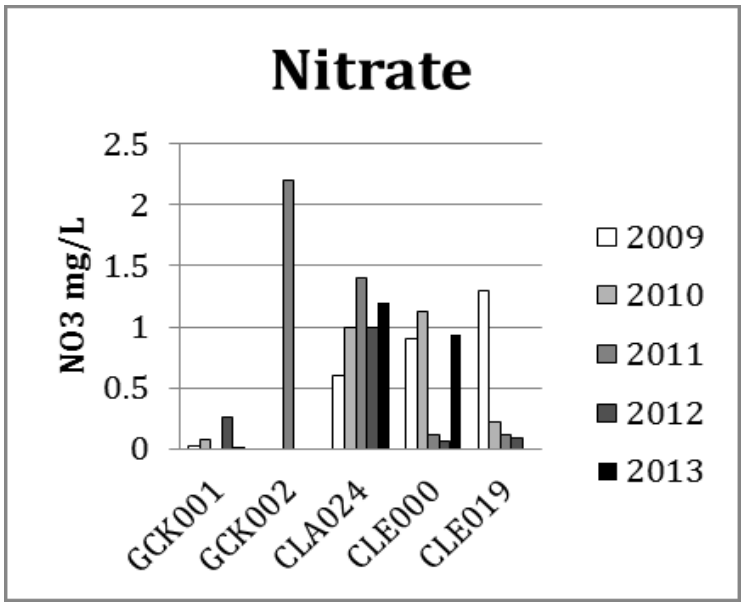
The two sites in the Clear Creek and Clackamas mainstem sub-basin were sampled on different days; CLA024 was sampled during sunny weather conditions and CLE000 was sampled during partly cloudy weather conditions. Both sites had trees as the dominant streamside vegetation and were partially shaded over the stream channel. CLE000 had cobble as its dominant streambed substrate and CLA024 had a substrate composed of cobble, gravel, and sand. Blackberry, English Ivy, and Reed Canary Grass were observed at CLE000 and Japanese knotweed was observed at CLA024. Both sampling sites were shallow and had clear, odor free water. Some algae and some small litter were present at CLA024.

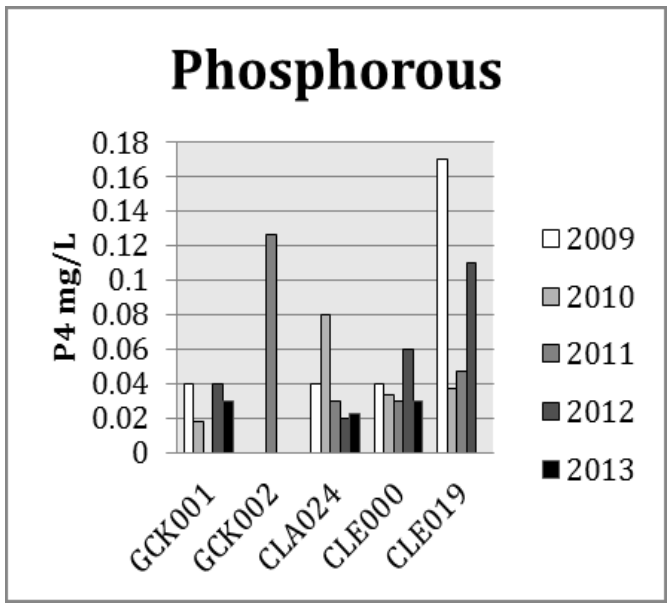


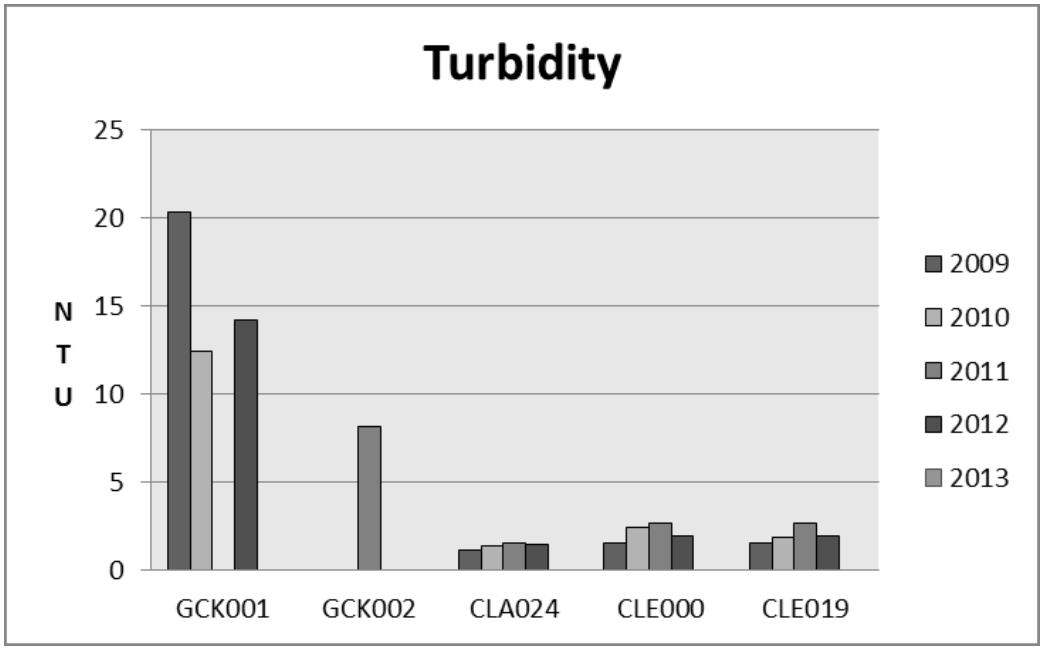


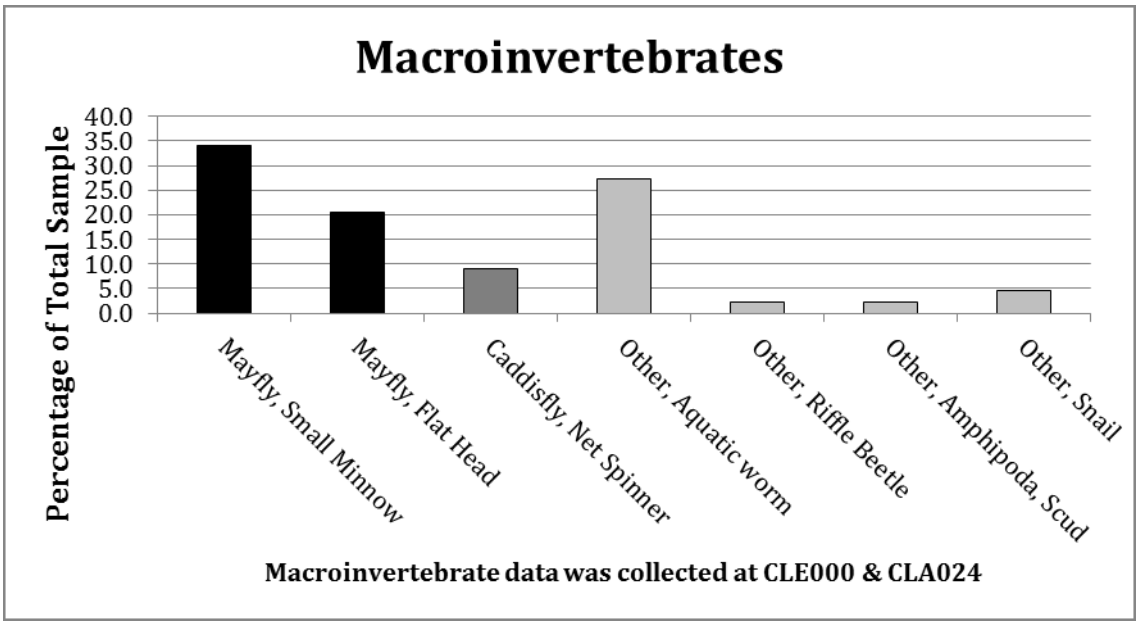

Dissolved Oxygen
O2 mg/L
12
10
8
6
4
2
0
GCK001
GCK002
CLA024
CLE000
CLE019
2009
2010
2011
2012
2013


Ammonia
NH3 mg/L
0.8
0.6
0.4
0.2
0
GCK001
GCK002
CLA024*
CLE000*
CLE019
2009
2010
2011
2012
2013


Nitrate
NO3 mg/L
2.5
2
1.5
1
0.5
0
GCK001
GCK002
CLA024
CLE000
CLE019
2009
2010
2011
2012
2013


Phosphorous
P4 mg/L
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
GCK001
GCK002
CLA024
CLE000
CLE019
2009
2010
2011
2012
2013


Turbidity
NTU
25
20
15
10
5
0
GCK001
GCK002
CLA024
CLE000
CLE019
2009
2010
2011
2012
2013

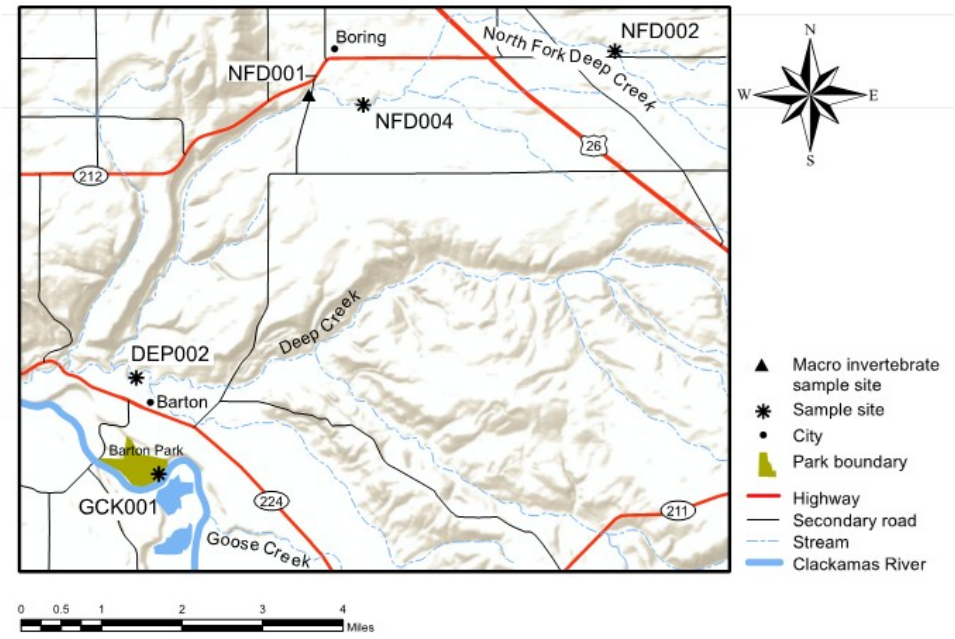


Clear Creek has the lowest richness of benthic invertebrates of the four sub-basins sampled at 7. However, it has an EPT index of 0.64 (Table 5), the highest of the sub-basins sampled here. It holds the lowest score of the four sub-basins in the OBEW level 2 assessment with a score of just 8 (Table 5). A score less than 17 indicate possible severe impairment. Evidence of stream disturbance exists, but requires further study and more detailed analysis to determine the intensity and sources of this disturbance.

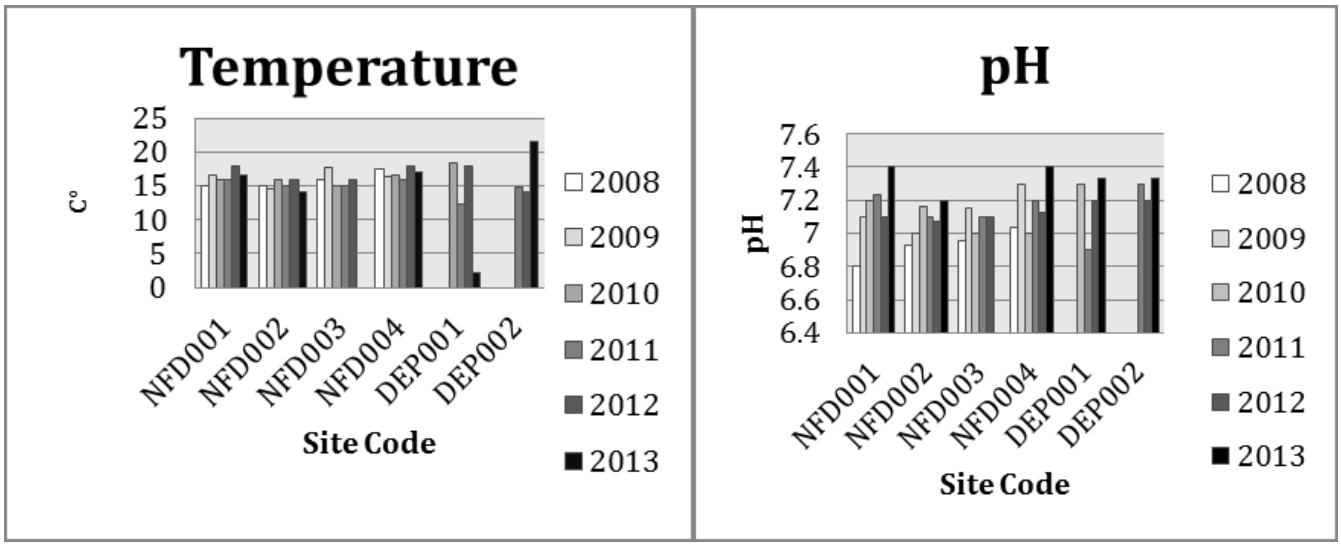
Clear Creek Macroinvertebrate Assessment		
OWEB Assessment	Raw	Ranking
Taxa Richness (# of Families)	7	1
Mayfly Richness	2	3
Stonefly Richness	0	1
Caddisfly Richness	1	1
% Diptera	0	1
% Dominance	81.8	1
Sum total score		**8**
EPT Assessment	0.64	1

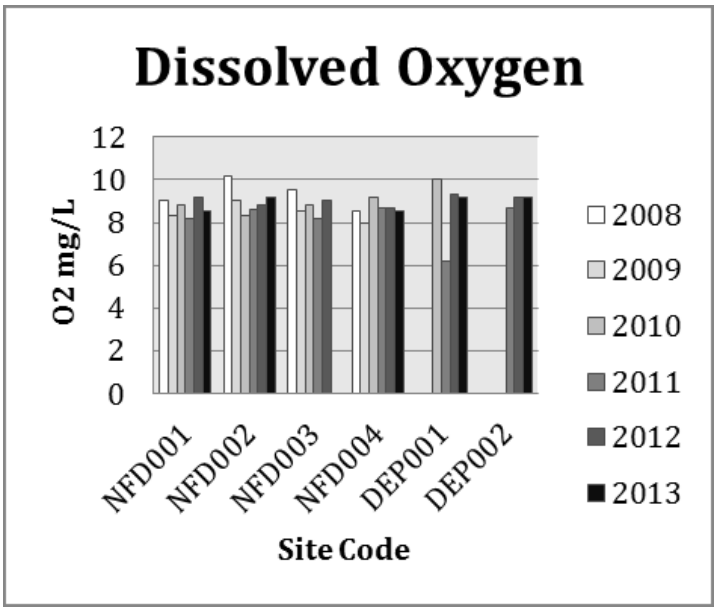
Table 5: OWEB and EPT assessment results. An OWEB score less than 17 indicates severe impairment, evidence of stream disturbance exists. EPT index is moderate to high and rank shows where it falls within the four sub-basins sampled.

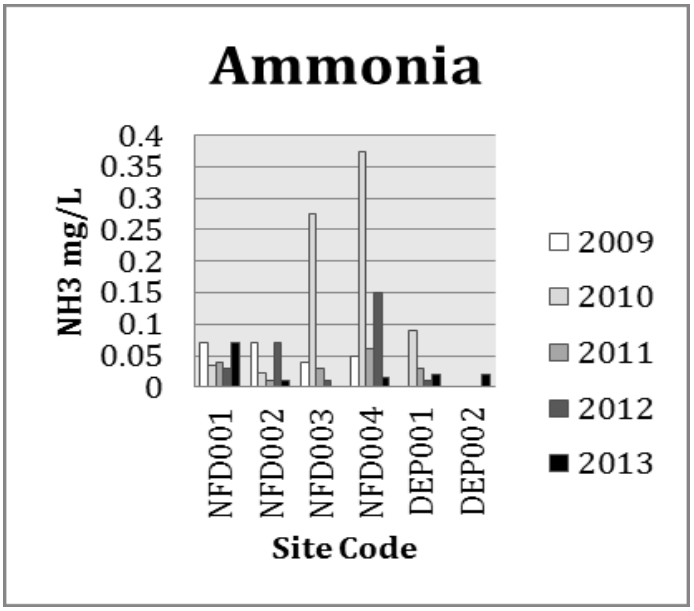
Deep Creek

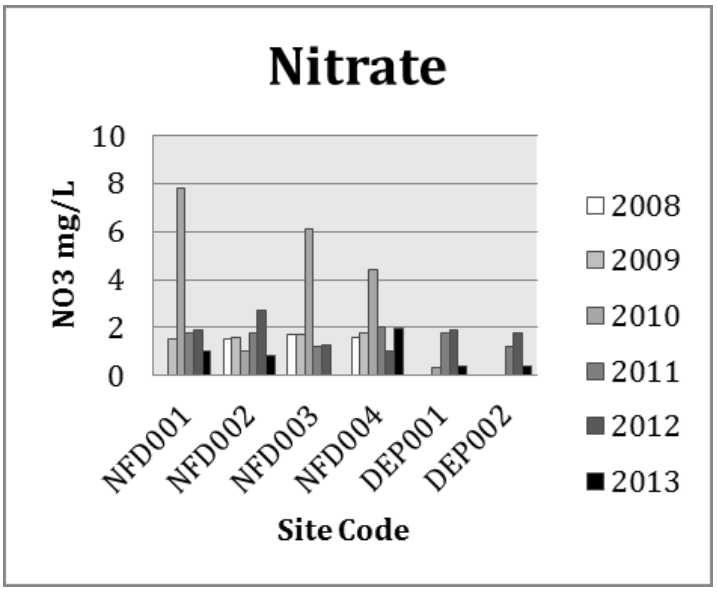


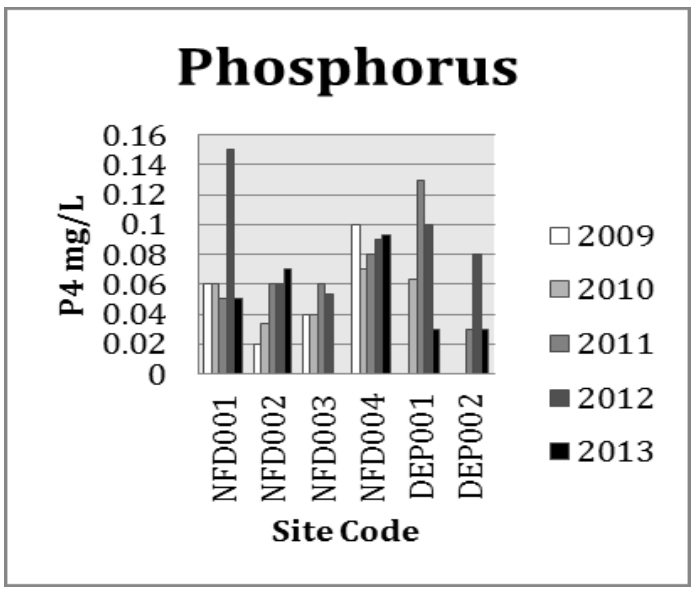
There were five sites where sampling took place along Deep Creek. DEP002 and GCK001 were sampled on 7-2-13 and weather conditions were sunny. NFD001, NFD002, and NFD004 were sampled on 7-27-13 and weather conditions ranged from partly cloudy to sunny. Streamside shade cover ranged from little or none at DEP002 and GCK001 to mostly shaded at NFD001, NFD002, and NFD004. The dominant streamside vegetation consisted of trees, shrubs, and grass. Reed Canary Grass was present at all sites, Himalayan blackberry was observed at NFD002, and Japanese knotweed was observed at GCK001 and DEP002. All of the sites had cobble as the dominant streambed substrate with the exception of GCK001, which had a fishy odor and algae present. NFD001 contained some small and some large litter, and GCK001 contained some small litter.

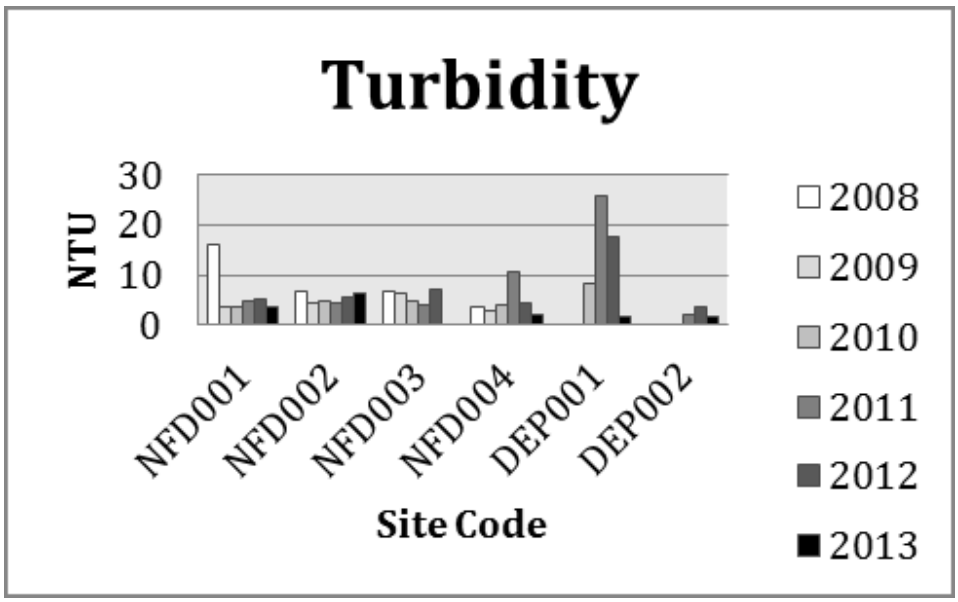


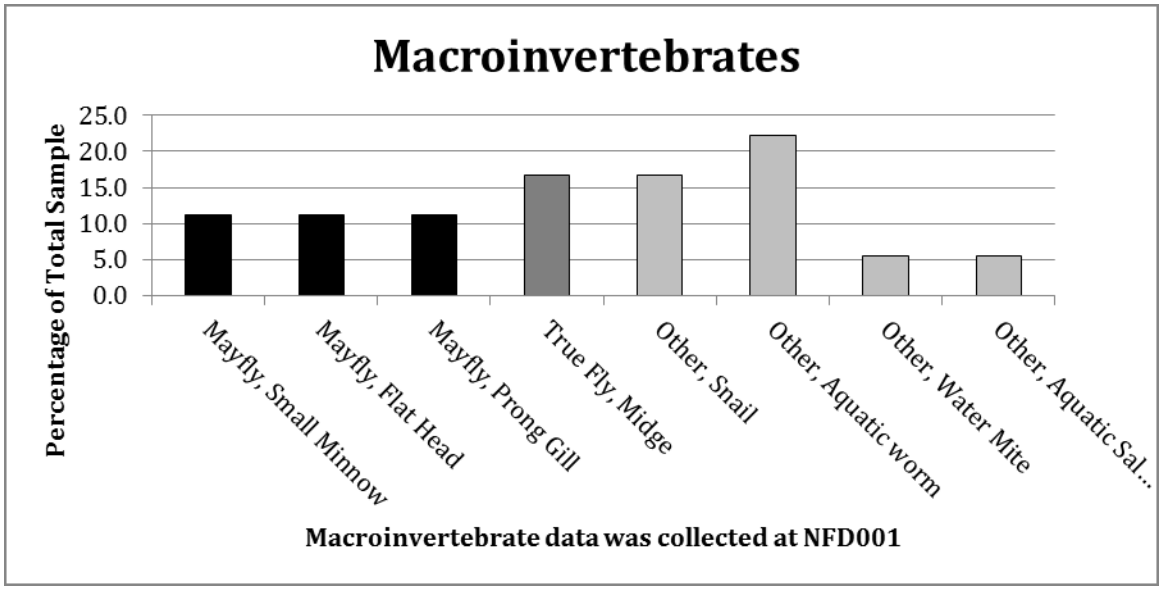

Dissolved Oxygen
O2 mg/L
12
10
8
6
4
2
0
NFD001
NFD002
NFD003
NFD004
DEP001
DEP002
Site Code
2008
2009
2010
2011
2012
2013


Ammonia
NH3 mg/L
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
NFD001
NFD002
NFD003
NFD004
DEP001
DEP002
Site Code
2009
2010
2011
2012
2013


Nitrate
NO3 mg/L
10
8
6
4
2
0
NFD001
NFD002
NFD003
NFD004
DEP001
DEP002
Site Code
2008
2009
2010
2011
2012
2013


Phosphorus
P4 mg/L
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
NFD001
NFD002
NFD003
NFD004
DEP001
DEP002
Site Code
2009
2010
2011
2012
2013


Turbidity
NTU
30
20
10
0
NFD001
NFD002
NFD003
NFD004
DEP001
DEP002
Site Code
2008
2009
2010
2011
2012
2013

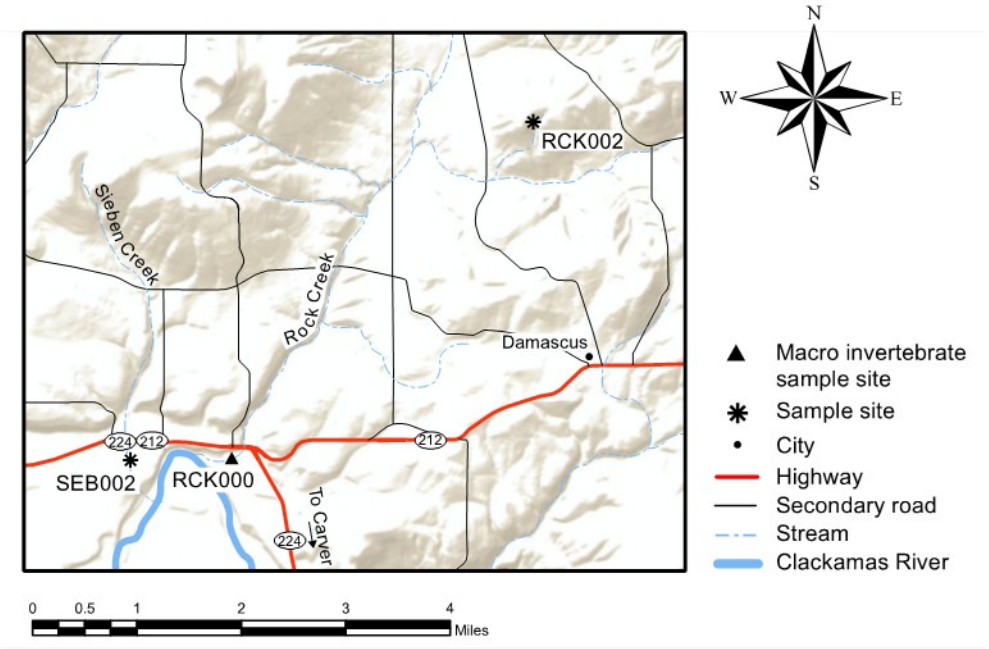


Deep Creek has the second lowest richness of benthic invertebrates of the four sub-basins sampled at 8. It has an EPT index of 0.33 (Table 6), severely low as stream health indicator and lowest of the sub-basins sampled here. It also scores second lowest of the four sub-basins in the OBEW level 2 assessment with a score of just 10 (Table 6). A score less than 17 indicate possible severe impairment. Evidence of stream disturbance exists, but requires further study and more detailed analysis to determine the intensity and sources of this disturbance.

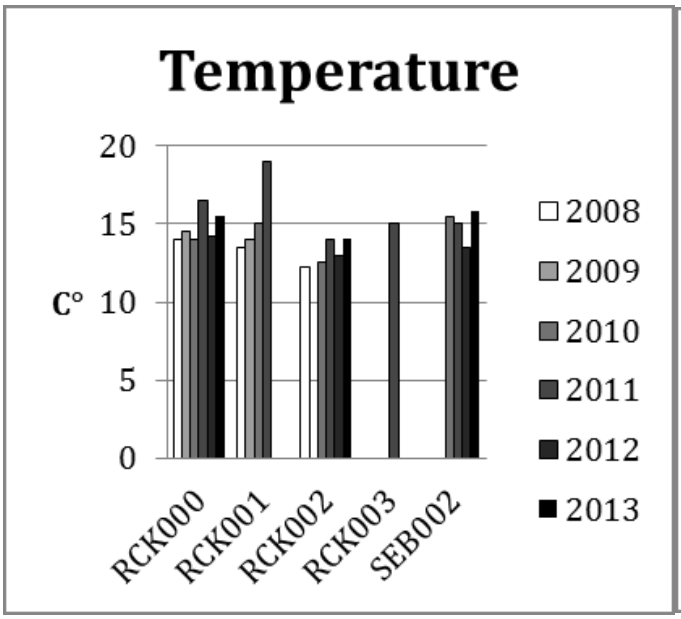
Deep Creek Macroinvertebrate Assessment		
OWEB Assessment	Raw Score	Ranking
Taxa Richness (# of Families)	8	1
Mayfly Richness	3	3
Stonefly Richness	0	1
Caddisfly Richness	0	1
% Diptera	16.7	3
% Dominance	55.6	1
Sum total score		**10**
EPT Assessment	0.33	4

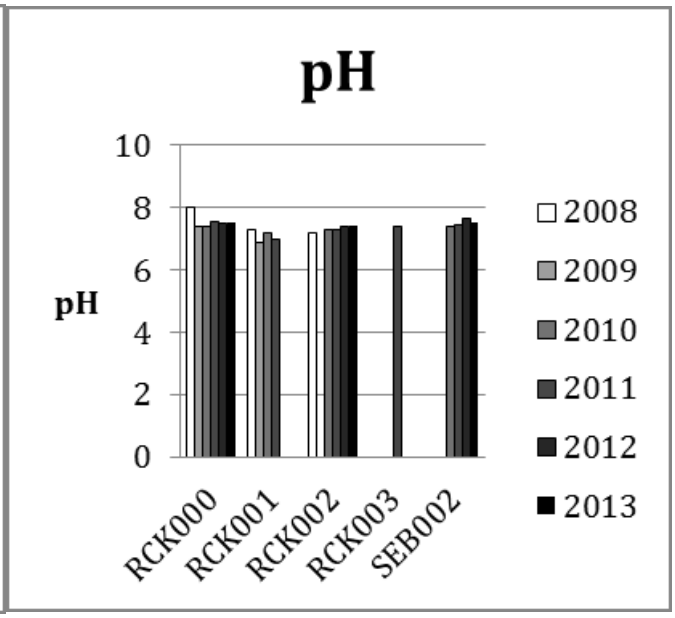
Table 6: OWEB and EPT assessment results. An OWEB score less than 17 indicates severe impair ment, evidence of stream disturbance exists. EPT index is extremely low indicating poor stream health and rank shows where it falls within the four sub-basins sampled.

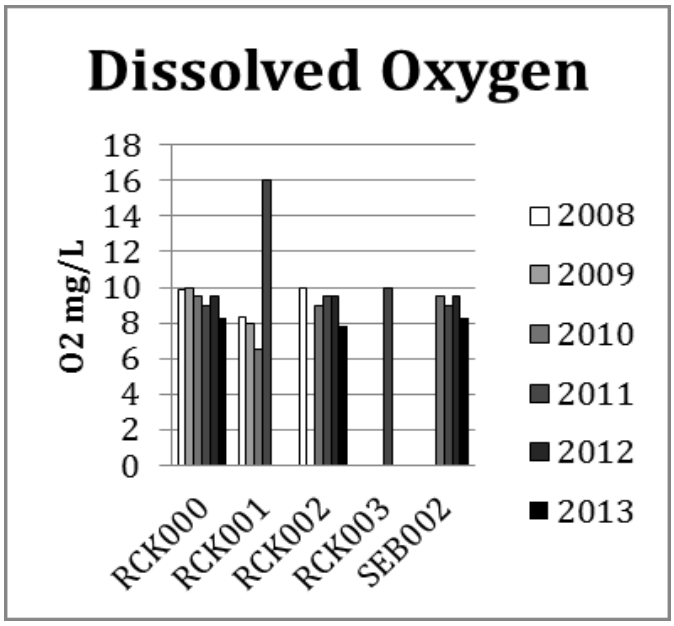
Rock Creek

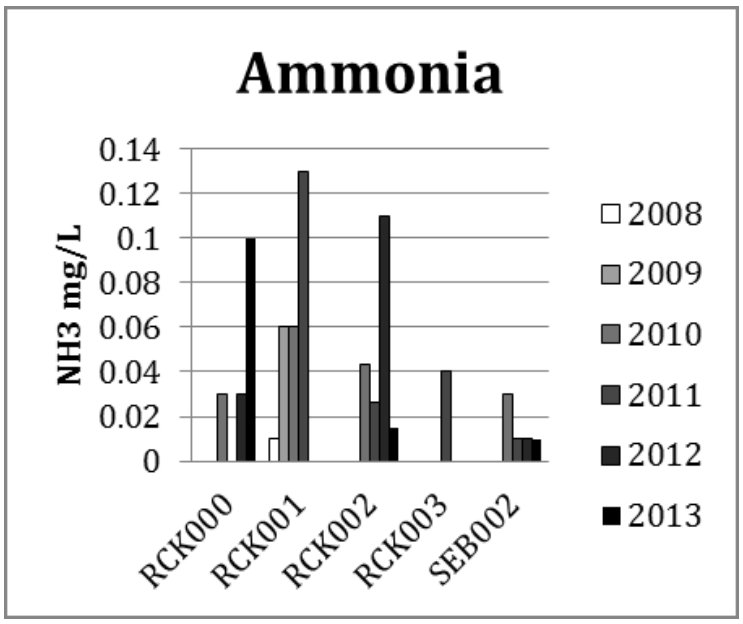


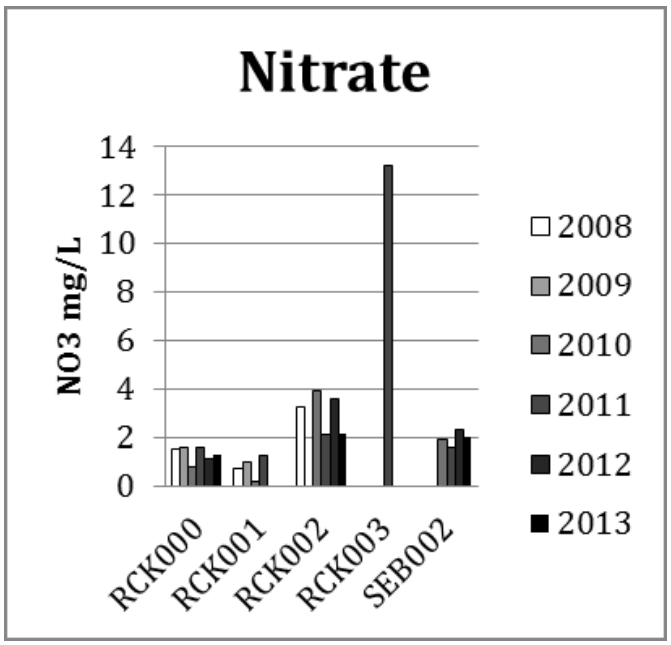
The Rock Creek sites (RCK000, RCK002) tested were shallow, with mud and cobble streambed substrate and medium to fast flow. Sieben Creek (SEB002) was also included in the overall Rock Creek sites, which was shallow with mud and cobble streambed and slow flow. The water was clear at all sites except RCK001 and SEB002 where brown, cloudy water was observed. Shade was full or partial at all sites. Invasive species included Himalayan blackberry, Japanese knotweed and reed canary grass. Weather conditions were cloudy to sunny on the sample days. Litter was not found at the sites except some small litter at SEB002. Some algae was present except RCK002.

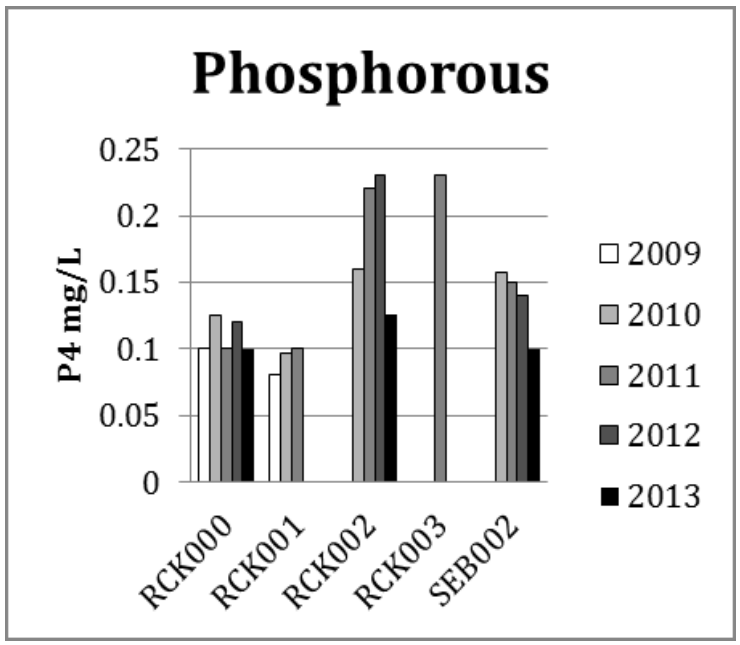


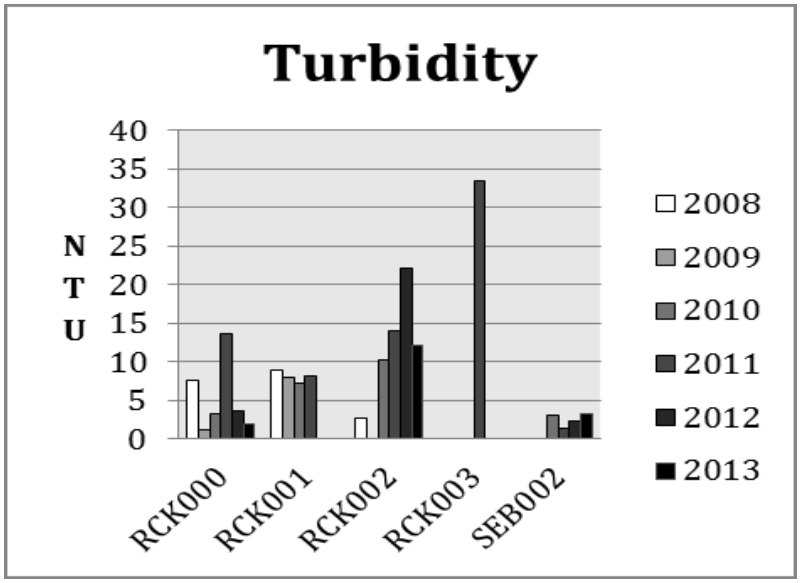


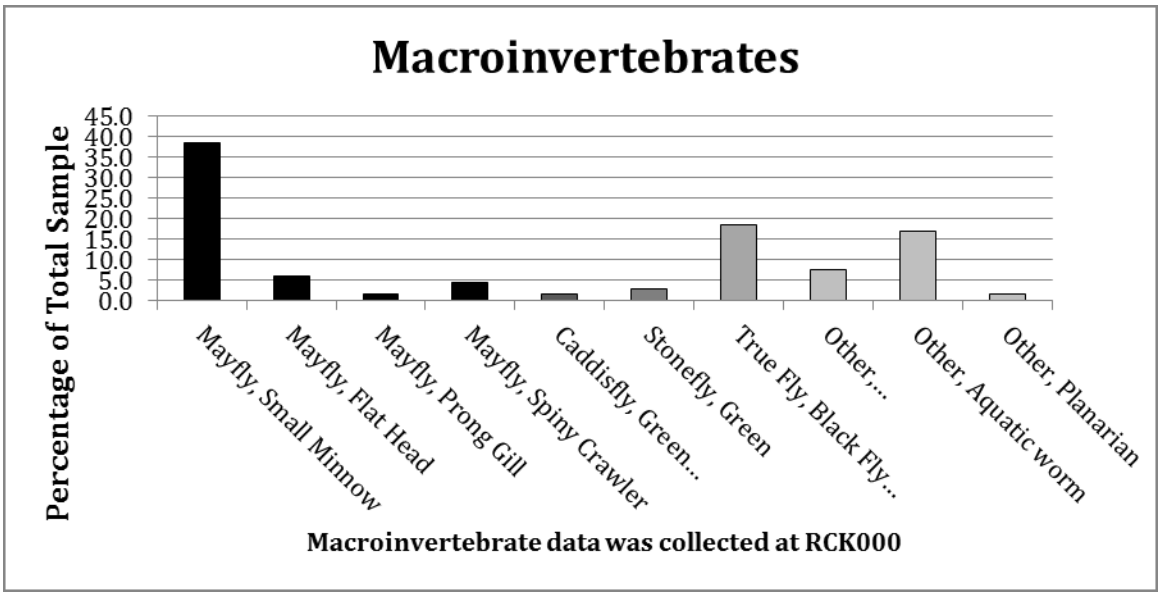

Dissolved Oxygen
O2 mg/L
18
16
14
12
10
8
6
4
2
0
RCK000
RCK001
RCK002
RCK003
SEB002
2008
2009
2010
2011
2012
2013


Ammonia
NH3 mg/L
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
RCK000
RCK001
RCK002
RCK003
SEB002
2008
2009
2010
2011
2012
2013


Nitrate
NO3 mg/L
14
12
10
8
6
4
2
0
RCK000
RCK001
RCK002
RCK003
SEB002
2008
2009
2010
2011
2012
2013


Phosphorous
P4 mg/L
0.25
0.2
0.15
0.1
0.05
0
RCK000
RCK001
RCK002
RCK003
SEB002
2009
2010
2011
2012
2013


Turbidity
NTU
40
35
30
25
20
15
10
5
0
RCK000
RCK001
RCK002
RCK003
SEB002
2008
2009
2010
2011
2012
2013

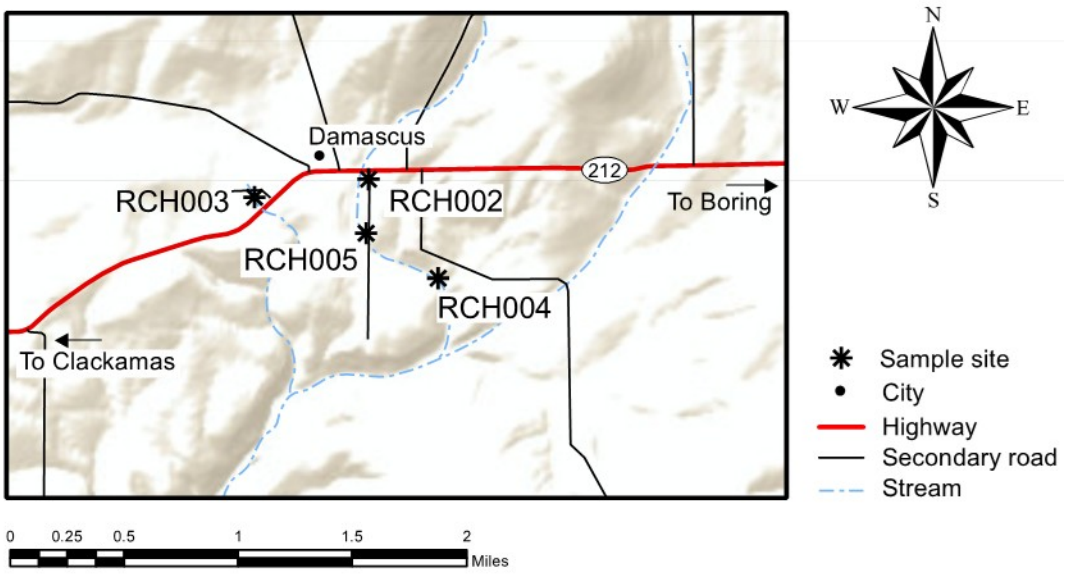


Rock Creek has the second highest richness of benthic invertebrates of the four sub-basins sampled at 10. It has an EPT index of 0.55 (Table 7), about average for the sub-basins sampled here. It scores second of the four sub-basins in the OBEW level 2 assessment with a score of 14 (Table 7). A score less than 17 indicate possible severe impairment: fails levels 2 assessment. Evidence of stream disturbance exists, but requires further study and more detailed analysis to determine the intensity and sources of this disturbance.

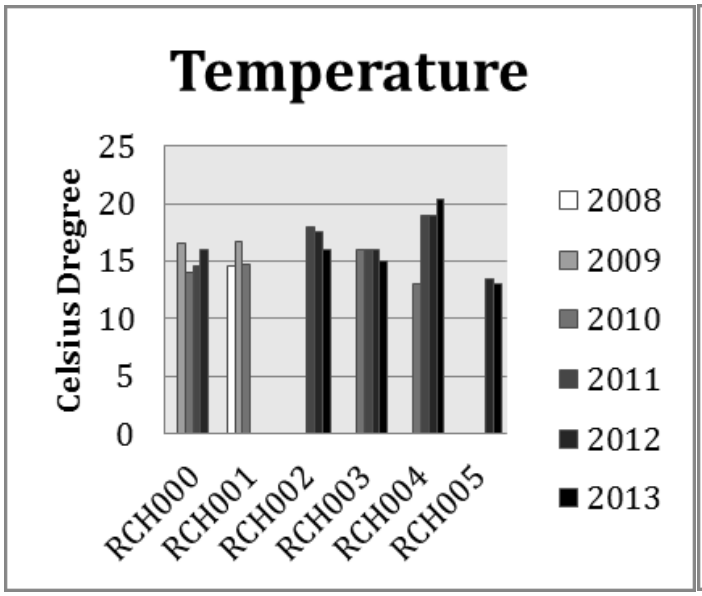
Rock Creek Macroinvertebrate Assessment		
OWEB Assessment	Raw	Ranking
Taxa Richness (# of Families)	10	3
Mayfly Richness	4	3
Stonefly Richness	1	3
Caddisfly Richness	1	1
% Diptera	18.5	3
% Dominance	73.8	1
Sum total score		**14**
EPT Assessment	0.55	3

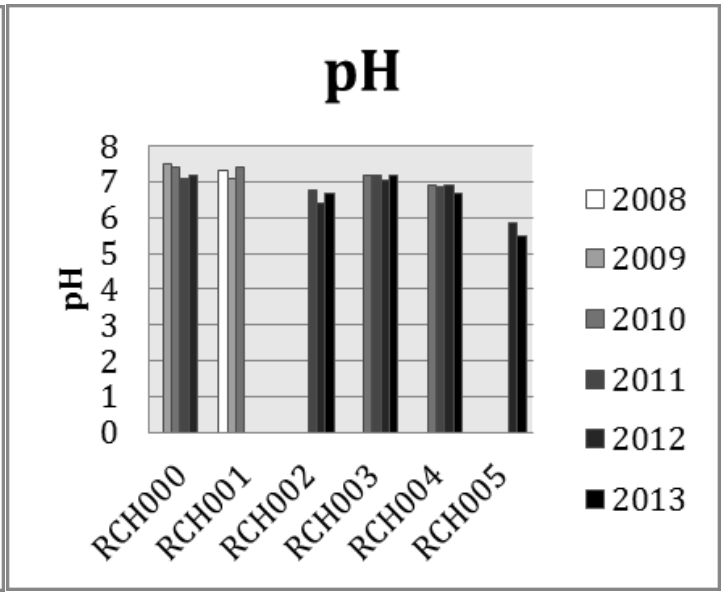
Table 7: OWEB and EPT assessment results. An OWEB score less than 17 indicates severe impairment, evidence of stream disturbance exists. EPT index is also moderate and rank shows where it falls within the four sub-basins sampled.

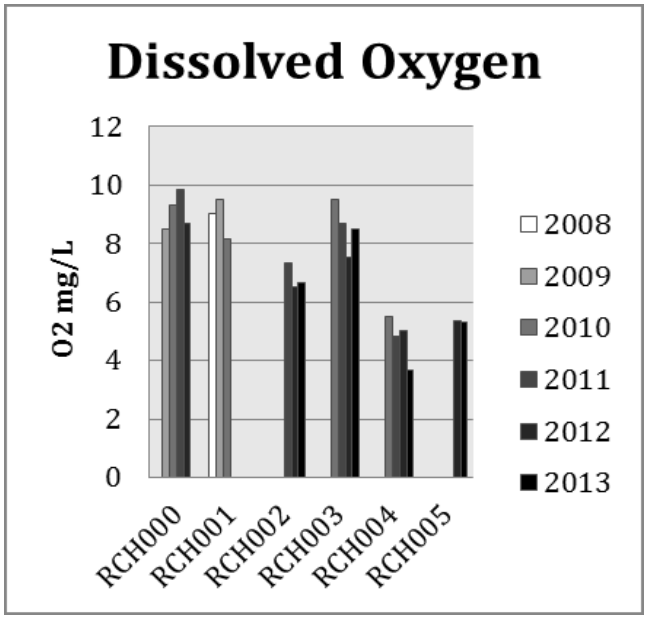
Richardson Creek

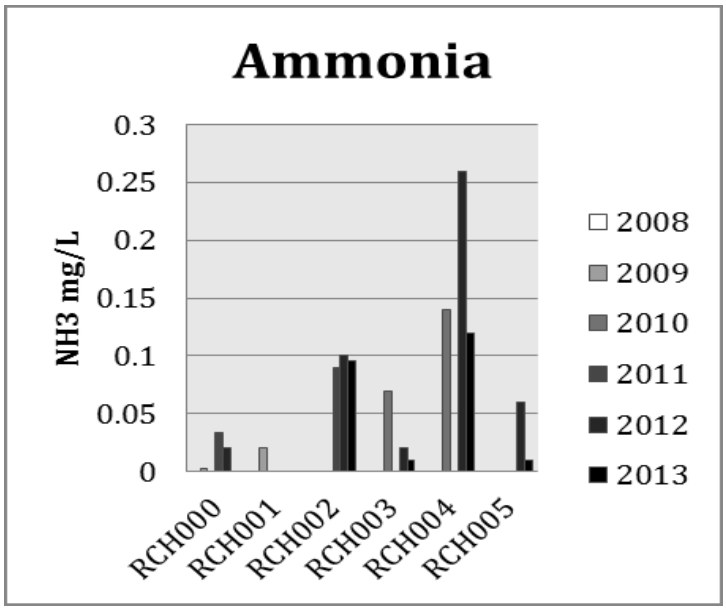


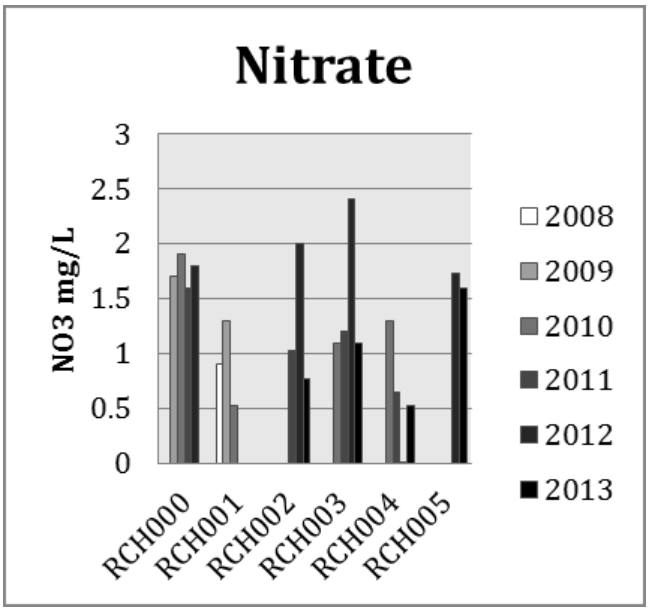
There was great variation of streamside shade cover and vegetation at the Richardson Creek sampling sites. RCH002 was partly shaded and had shrubs and trees as the dominant streamside vegetation. RCH004 and RCH005 were mostly to fully shaded and contained a mixture of grasses and trees. RCH003 was fully shaded with trees as the dominant streamside vegetation. All four sites had mud as their dominant streambed substrate, and RCH002 and RCH004 contained organic material as well. Himalayan blackberry were observed at all sites except RCH004. All sampling sites were shallow and had clear, odor free water with the exception of RCH004, which was deep and brown in color. Algae was present in RCH004 and RCH002. RCH002 contained some large litter and RCH003 contained some small litter. Sites were sampled on the same day and weather conditions ranged from partly cloudy to sunny.

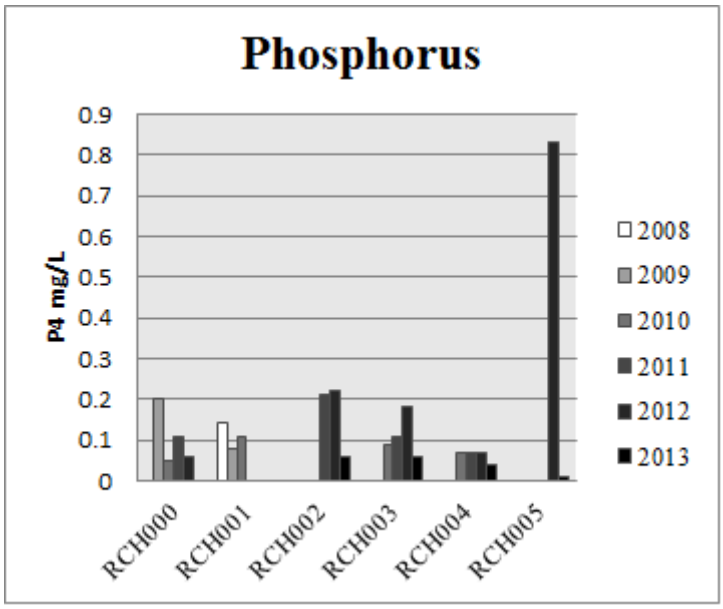


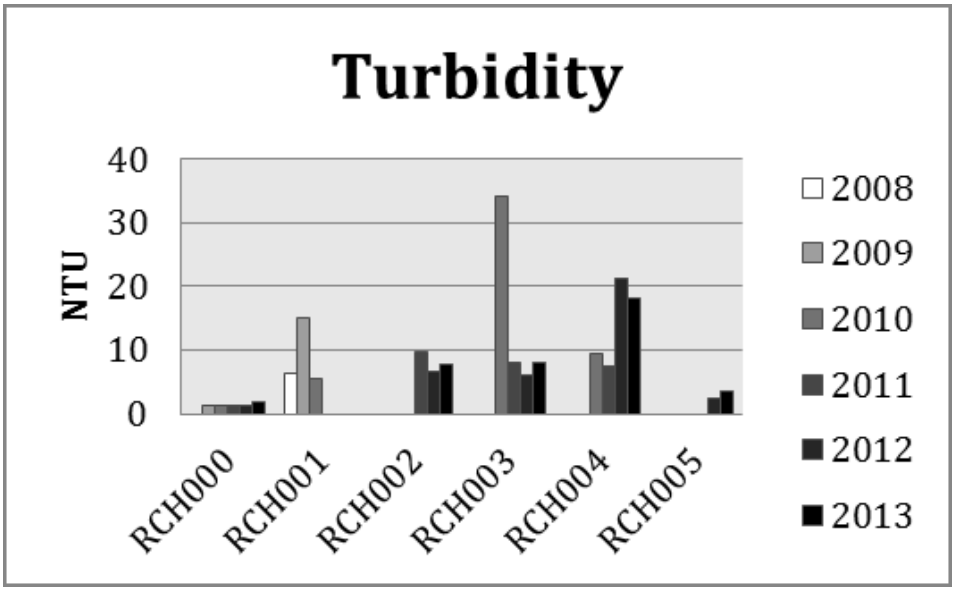



Dissolved Oxygen
O2 mg/L
12
10
8
6
4
2
0
RCH000
RCH001
RCH002
RCH003
RCH004
RCH005
2008
2009
2010
2011
2012
2013

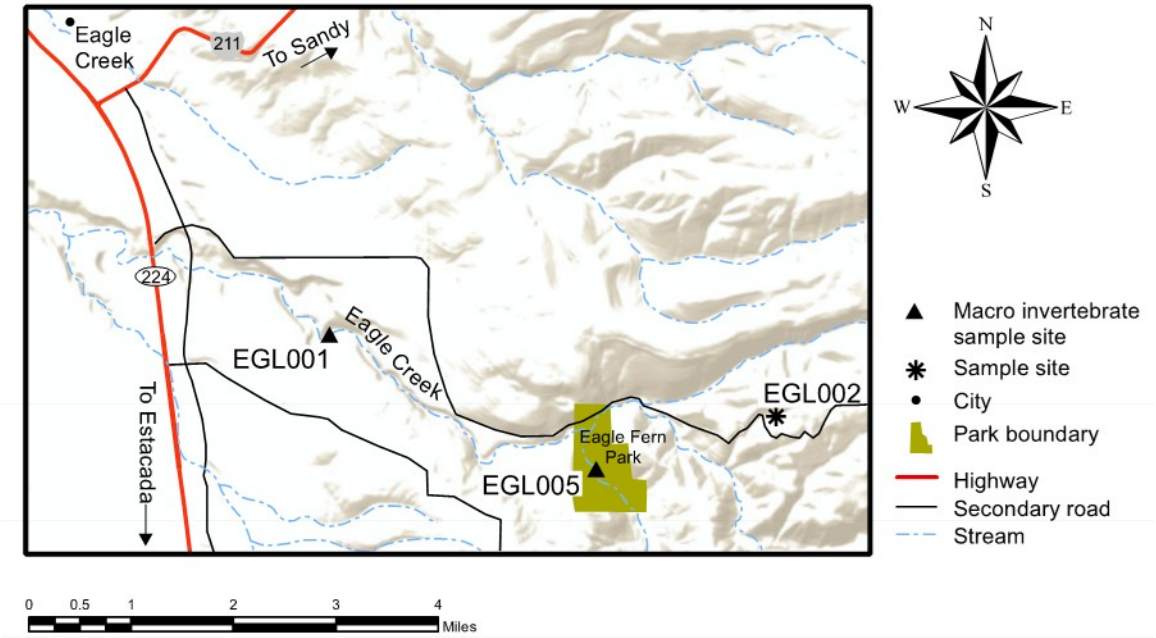

Ammonia
NH3 mg/L
0.3
0.25
0.2
0.15
0.1
0.05
0
RCH000
RCH001
RCH002
RCH003
RCH004
RCH005
2008
2009
2010
2011
2012
2013


Nitrate
NO3 mg/L
3
2.5
2
1.5
1
0.5
0
RCH000
RCH001
RCH002
RCH003
RCH004
RCH005
2008
2009
2010
2011
2012
2013

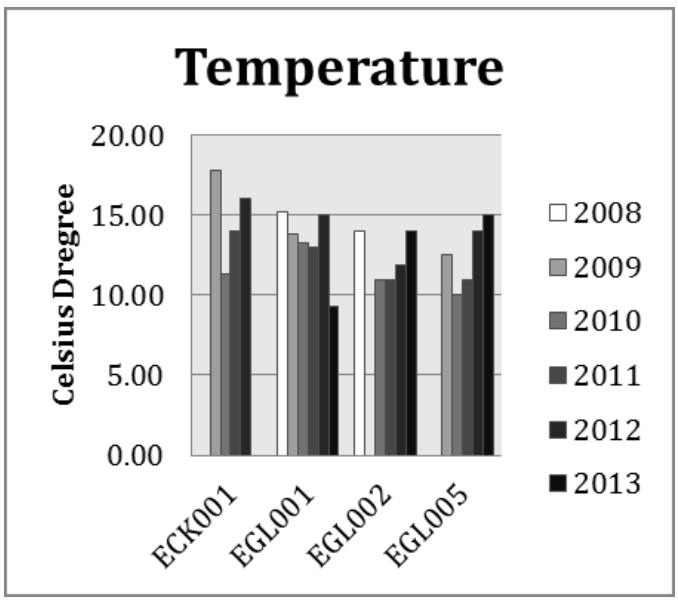

Phosphorus
P4 mg/L
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
RCH000
RCH001
RCH002
RCH003
RCH004
RCH005
2008
2009
2010
2011
2012
2013

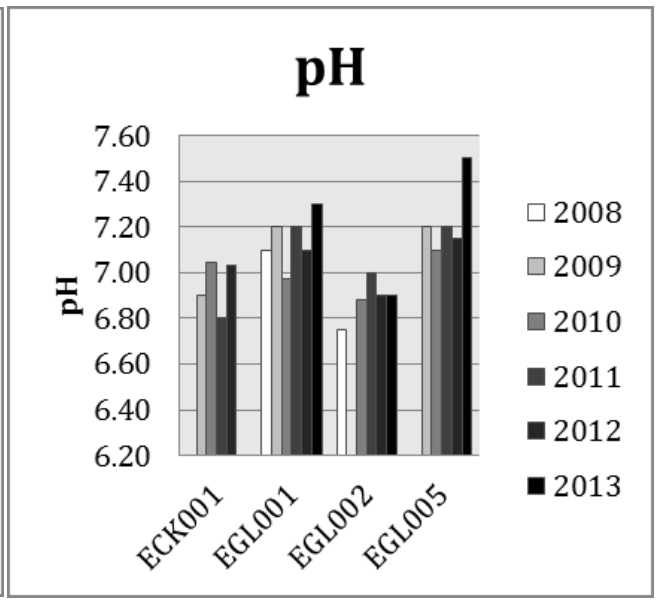

Turbidity
NTU
40
30
20
10
0
RCH000
RCH001
RCH002
RCH003
RCH004
RCH005
2008
2009
2010
2011
2012
2013

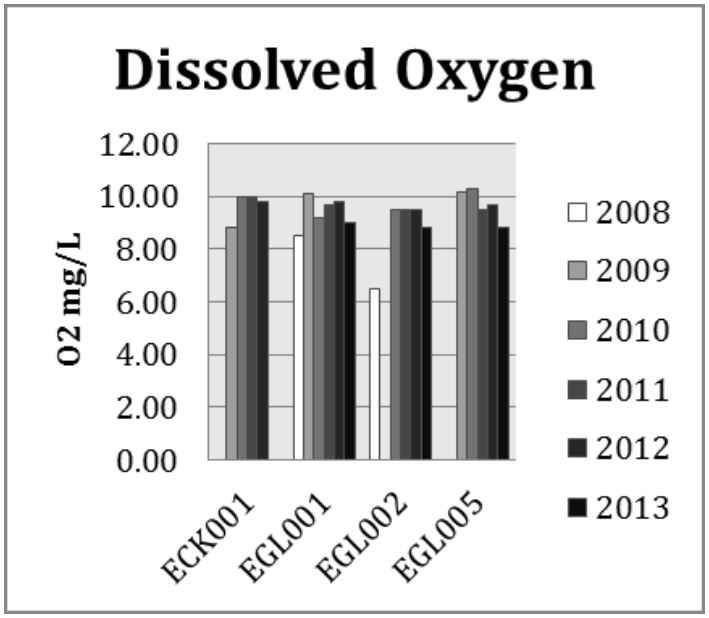
Eagle Creek

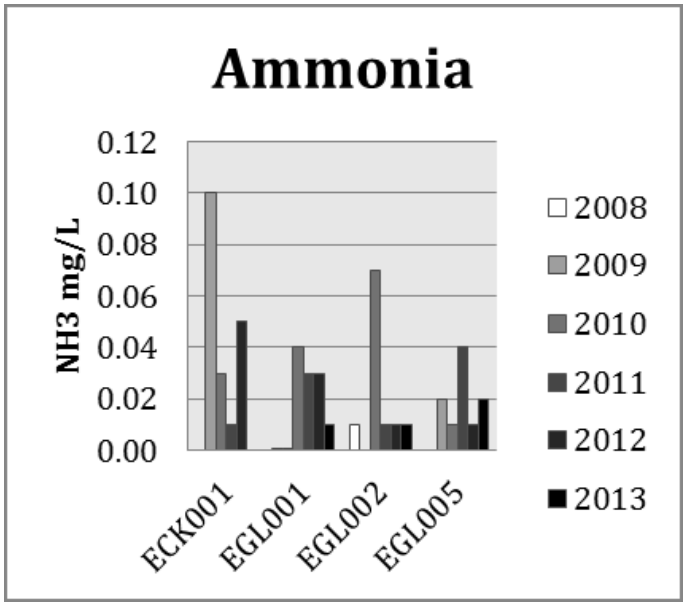


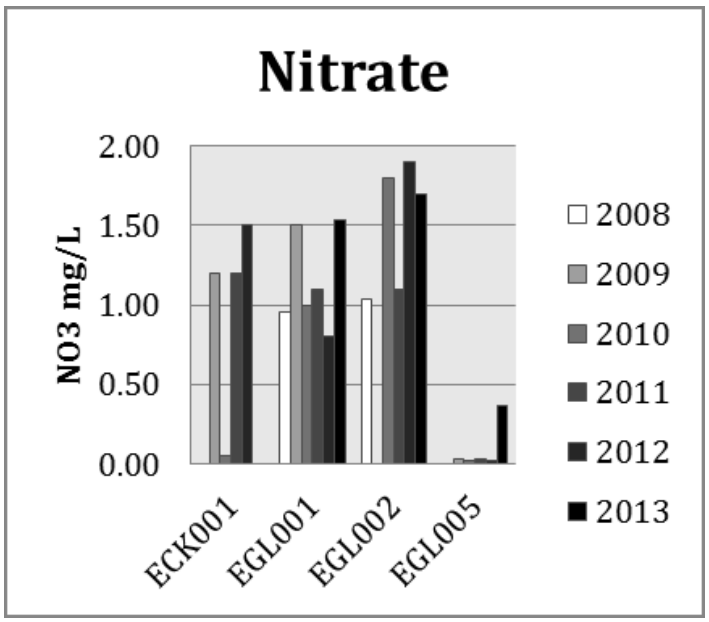
Three sites at Eagle Creek (EGL001, EGL002, EGL005) were sampled on 7/23/13 on a sunny day between the hours of 8:50 am and 11:00 am. All the sites tested were shallow, with cobble and mud streambed substrate and slow to moderate flow. The water color was clear at all sites and odorless except at EGL002 where there was a noted fishy smell. Shade was full or partial at EGL002 and EGL005, and there was no shade at EGL001. Invasive species including Himalayan blackberry and Reed Canary grass were found amongst the tree dominated streamside vegetation. Some small litter was found at sites EGL005 and ECK001. Some algae was present at EGL001 and EGL 002.

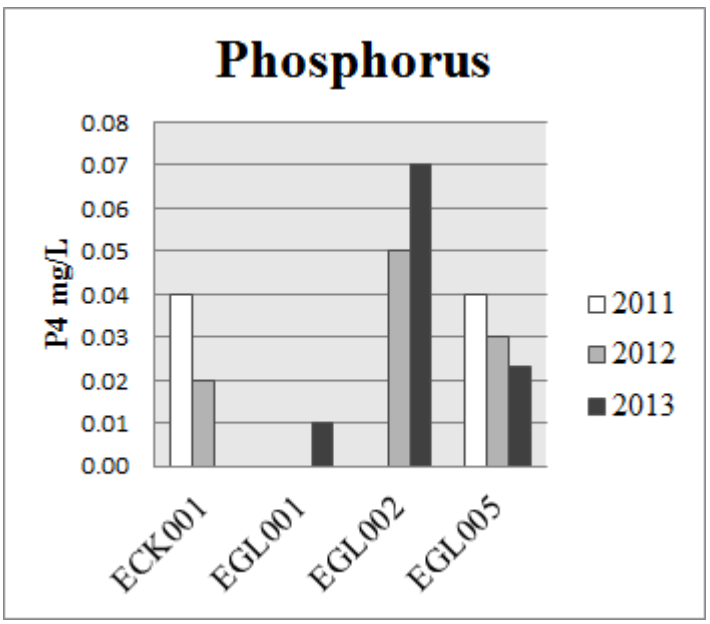


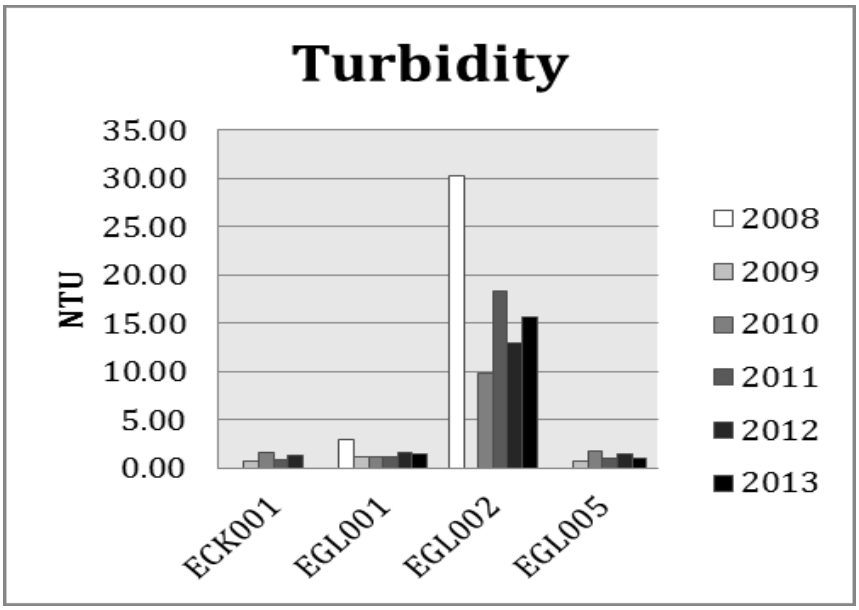


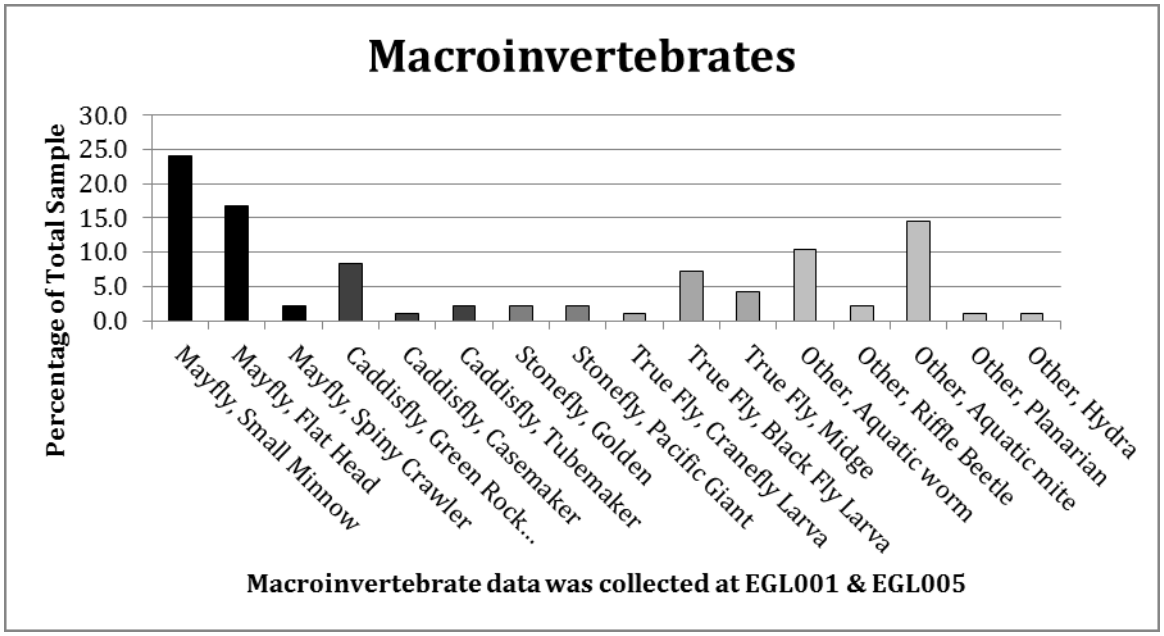

Dissolved Oxygen
O2 mg/L
12.00
10.00
8.00
6.00
4.00
2.00
0.00
ECK001
EGL001
EGL002
EGL005
2008
2009
2010
2011
2012
2013


Ammonia
NH3 mg/L
0.12
0.10
0.08
0.06
0.04
0.02
0.00
ECK001
EGL001
EGL002
EGL005
2008
2009
2010
2011
2012
2013


Nitrate
NO3 mg/L
2.00
1.50
1.00
0.50
0.00
ECK001
EGL001
EGL002
EGL005
2008
2009
2010
2011
2012
2013


Phosphorus
P4 mg/L
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
ECK001
EGL001
EGL002
EGL005
2011
2012
2013


Turbidity
NTU
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
ECK001
EGL001
EGL002
EGL005
2008
2009
2010
2011
2012
2013



Eagle Creek has the highest richness of benthic invertebrates of the four sub-basins sampled at 16. It has a relatively high EPT index of 0.58 (Table 8), above average for the sub-basins sampled here. It scores the highest of the four sub-basins in the OBEW level 2 assessment at 18 (Table 8). An OWEB score of 17-23 indicates moderate impairment; evidence that some water quality impairment exists, requires further study and more detailed analysis to determine the intensity and sources of this disturbance.

Eagle Creek Macroinvertebrate Assessment		
OWEB Assessment	Raw	Ranking
Taxa Richness (# of Families)	16	3
Mayfly Richness	3	3
Stonefly Richness	2	3
Caddisfly Richness	3	3
% Diptera	12.5	5
% Dominance	55.2	1
Sum total score		**18**
EPT Assessment	0.58	2

Table 8: OWEB and EPT assessment results. An OWEB score of 17-23 indicates moderate impairment, evidence of some water quality impairment exists. EPT index is also moderate and rank shows where it falls within the four sub-basins sampled.

Discussion& Recommendations

Phosphorous, nitrate, and pH readings at both sites were within acceptable ranges for Clear Creek and the Clackamas mainstem. CLE000 had a slightly elevated nitrate reading of 0.93 mg/L compared to 0.06 mg/L in 2012, but was still well below the threshold of <10 mg/L. CLE000 had a temperature reading of 18°C, which is the same as the 2012 reading and is slightly over the water temperature threshold of ≤17.8°C. CLA024 had a temperature of 16°C, which is an increase from the 2012 temperature of 12.3°C. The dissolved oxygen parameter of >6.0 mg/L was met by both sites. Both sites had a decrease in dissolved oxygen of 0.5 mg/L from the 2012 levels. Both sites met the turbidity standard of <5 NTU and had readings comparable to previous years.

For Deep Creek, the phosphorous, nitrate, and pH readings from all sites were within acceptable thresholds. DEP002 and GCK001 all had elevated temperatures compared to 2012 and were above the temperature threshold of 17.8°C with water temperatures of 21.5°C and 27.6°C, respectively. NFD001, NFD002, and NFD004 all had temperatures 1-2°C lower than 2012 and were all within the acceptable threshold. The dissolved oxygen parameter of >6.0 mg/L was met by all sites. NFD002 and GCK001 both exceeded the turbidity standard of 5 NTU with readings 6.45 NTU, and 24.03 NTU, respectively. Both showed an increase from the 2012 readings of 5.75 NTU at NFD002 and 14.2 NTU at GCK001. Since there is no clear standard for ammonia levels, the sampling sites were compared to the Willamette Valley stream average of 0.05 mg/L. DEP002, NFD004, and GCK001 were all below the average with readings of 0.01-0.02 mg/L, and NFD001 and NFD002 were above the average with readings of 0.07 mg/L each.

In Eagle Creek, temperature and pH readings at all sites were within the acceptable range though all had increased from 2012 readings except for pH at EGL002 and temperature at EGL001. Nitrate levels met the water quality standard at all sites though levels had increased from 2012 level at EGL001 and decreased at EGL002. Phosphorus levels were generally lower at all sites except EGL002, which increased. Dissolved oxygen met the standard at all sites though had dropped from previous years. There is no clear standard for ammonia levels so the sampling sites were compared to the Willamette Valley stream average of 0.05 mg/L. which all site were lower than. Ammonia levels decreased from 2012 levels at EGL001 had no change at EGL005 and increased at EGL005. Turbidity was almost unchanged from previous years except for EGL002, which was the highest.

Phosphorous and nitrate readings from all sites were within acceptable thresholds for Richardson Creek. The pH readings for all sites were within the acceptable range of 6.5-8.5 with the exception of RCH005, which had a pH of 5.5. RCH004 was above the temperature threshold of 17.8°C with a water temperature of 20.3°C. The dissolved oxygen parameter of >6.0 mg/L was not met by RCH004 and RCH005, which scored 3.67 mg/L and 5.3 mg/L, respectively. RCH002, RCH003, and RCH004 all exceeded the turbidity standard of 5 NTU with readings of 7.81 NTU, 7.9 NTU, and 18.13 NTU, respectively. Since there is no clear standard for ammonia levels, the sampling sites were compared to the Willamette Valley stream average of 0.05 mg/L. RCH003 and RCH005 were below the average with readings of 0.01mg/L each, and RCH002 and RCH004 were above the average with readings of 0.096 mg/L and 0.12 mg/L, respectively.

For Rock Creek, temperature and pH readings at all sites fell within their acceptable ranges with a slight increase in all sites. Phosphorus levels continue to be high at all sites though has dropped to almost acceptable levels. The nitrate level met the standard at all sites. Dissolved oxygen was above the minimum standard at all sites. There is no clear standard for ammonia levels so the sampling sites were compared to the Willamette Valley stream average of 0.05 mg/L, all sites were lower except RCK000, which was much higher. Turbidity was almost unchanged from previous years except for RCK002, which was the highest, as was so in previous years, but also decreased.

Regarding the macroinvertebrate analyses, Eagle Creek was the healthiest of the creeks observed in the watershed and could be used as a benchmark for the other streams in the region. Rock Creek also seems healthy, but was rated severely impaired using the OWEB level two assessment, even though it has a relatively high EPT index. This could be explained by the selection of sampling sites or the sampling method. In all creeks, other species were observed in the overall sample but did not make it into the 5 sampled cells. This may be even more significant in the lower scoring streams and likely makes all streams appear more highly impacted than they actually are. Particularly in Clear Creek, which has a very high EPT rating, indicating a high percentage of easily impacted species present, yet still failing the OWEB level 2 assessment method.

A correlation can found between a lower EPT index, lower OWEB level 2 scores, and increasingly poor water quality by the study conducted here. While there are other potential stressors involved in the overall makeup of stream health, the correlation between poor water quality, anthropogenic activities and lower macroinvertebrate population richness can be observed here. Other confounding factors may contribute to the observed decrease in biodiversity in Deep Creek, Clear Creek and other creeks showing high disturbance. These factors may include canopy cover, increase in impervious surfaces, increased conductivity and other water quality parameters not tested here.

While snapshot monitoring provides data necessary for detecting natural and anthropogenic influences on the watershed, there are several limitations associated with this study. One limitation includes the lack of time, which hinders the ability to perform more analyses and forces analyses to be done quickly. Another limitation includes not incorporating stream flow rates when drawing conclusions on the chemical analyses. One last limitation is that the colorimeters used for the various analyses report concentrations less than 0.01 as 0, so the only way to record the results were no more specific than less than 0.01.

There are various recommendations that were brought to light from this study. One recommendation includes not continuing to perform the macroinvertebrate analysis on the mainstem of the Clackamas. This is because the mainstem Clackamas is not a wadeable stream. As such, it is not possible to collect a representative sample of the macroinvertebrates from the site. Another recommendation includes the removal of non-native vegetation and replanting of native streamside vegetation. This will hinder the spread of non-native species and promote the presence of native species, all while decreasing stream temperature, which will in turn promote a healthy watershed overall.

Special Thanks

Much of this study would not have been possible without our community partner, the Clackamas River Basin Council. Many of the findings would also not have been possible without cooperation from Clackamas River Basin landowners, who permitted access and allowed us to collect water samples throughout the study area.

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