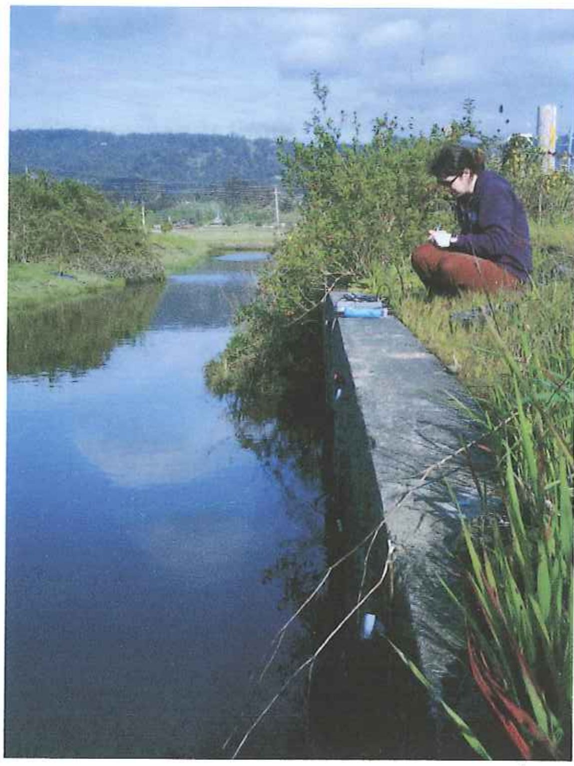
The Gannon Slough Tide Gate Replacement Project



Water Quality Analysis of Campbell Creek, Beith Creek and Gannon Slough

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Problem Background:

Water quality analysis was conducted on Campbell Creek, Beith Creek and Gannon Slough for the City of Arcata to use as a basis for comparison after they replace an existing tide gate at Gannon Slough in Fall 2005. This data was collected and compiled by Environmental Science Practicum (ENVS 410) students from Humboldt State University in cooperation with the City of Arcata Environmental Services Department and local rancher Dean Hunt.

The data collected on Campbell Creek, Beith Creek and Gannon Slough will provide the City of Arcata with the current water quality conditions before the new tide gate is installed. The current tide gate is being replaced because it is leaking and allowing tidal waters upstream. These creeks are also habitat to coastal cutthroat trout, Coho salmon and steelhead. Coho salmon and steelhead are recognized as both federal and state threatened species, requiring protection. Due to the specific requirements for passage of these species, the California Department of Fish and Game has authorized funding for a new tide gate that will allow for proper fish passage and maintenance of tidewater exchange without flooding Bayview Ranch, which all of the streams flow through. The tide gate that will be replaced is just upstream from the Caltrans tide gate nearest to highway 101 (Appendix A of the City of Arcata lab report Appendix C).

The Bayview Ranch is located on the south end of Arcata and east of Highway 101 (Appendix A of the City of Arcata lab report Appendix C). Campbell Creek and Beith Creek run through the ranch where they converge to form Gannon Slough. Campbell Creek begins near Fickle Hill Road and runs through the City of Arcata. It then flows under Highway 101 and resurfaces near the Bayview Ranch, meandering through the field, then converging with Beith Creek, forming Gannon Slough. Beith Creek also begins near Fickle Hill Road, south of Campbell Creek's headwaters. Beith Creek flows through the Sunny Brae and into the Bayview Ranch, merging with Campbell Creek into Gannon Slough. Gannon Slough flows through the tide gate, maintained by Caltrans, into a culvert under Highway 101, and then empties into Humboldt Bay.

Goals and Objectives

- **Goal 1:**

  To collect stream data on Campbell Creek, Beith Creek and Gannon Slough.

  Objectives:

  - Test all three waterways for water quality parameters, including temperature, pH, conductivity, dissolved oxygen (DO), total dissolved solids (TDS) and salinity.

- **Goal 2:**

  To present the City of Arcata with a completed report on the results of water quality analysis as a basis for future comparison.

  Objectives:

  - Provide a completed report to associated parties on the water quality results by 2 May 2005.
  - Provide a basis for comparison in regards to the effectiveness of a new tide being installed fall 2005, pending permits.

Alternatives:

Alternatives Considered:

1. Performing tests twice a week, twice a day during the high and low tides.
2. Performing tests twice a week, one test at high tide and the other at low tide.
3. Perform testing on Campbell Creek in the headwaters to determine the changes in water quality at our testing sites.
4. Performing tests twice a week, both of these tests to occur once a day in the afternoon.
5. Perform tests on three separate sites along Beith Creek, Campbell Creek and Gannon Slough.
6. Perform six separate tests on Beith and Campbell creeks and five tests on Gannon Slough.

Alternatives Rejected:

- Alternative 1 and 2 were rejected due to time constraints.
- Alternative 3 was rejected because headwaters tests have already been conducted.
- Alternative 5 was rejected because three sites would not allow for adequate determination of water quality. This is due to each stream having one or more streams flowing into it, thus more than three testing sites were needed to determine the water quality of the streams being tested.

Alternatives Accepted:

The accepted alternative was a combination of alternative 4 and alternative 6. This combination allowed for adequate time to perform water quality analysis. Water quality analysis on each creek and the slough once a day, twice a week provides variation in stream depth, due to the daily changing tides. Numerous testing sites along each of the creeks and the slough provide sufficient data points for accuracy in analysis results. Increased testing sites along the creeks and slough provide enough data points to get accurate information and measurements of water quality. Each test determines the water quality of Campbell Creek, Beith Creek and Gannon Slough along with the effectiveness of the tide gates separating Gannon Slough from the influent from Humboldt Bay.

Detailed Alternative:

Analytical methods and measurements were taken with portable equipment at each testing site. On-site testing was done between 2:00 and 5:00 pm on Mondays and Wednesdays. Weekly sampling was conducted on water temperature, dissolved oxygen (DO), pH, conductivity, total dissolved solids, and salinity during the study period. At the time of each study period, tide was also considered. Campbell Creek and Beith Creek converged into Gannon Slough, which was tested last in order to allow for adequate water flow throughout both streams. Sites 1 through 5 of Gannon Slough were tested approximately two hours after Campbell Creek and Beith Creek were tested.

Water temperature and DO were both measured on-site using a YSI Incorporated Handheld Dissolved Oxygen and Temperature System (YSI Model 55). Conductivity, pH, and Total Dissolved Solids (TDS) were also measured on-site using a portable HI 9810 pH/EC/TDS Meter by Hanna Instruments. Salinity was measured using a standard hand held salinity meter with a limit of 10 parts per thousand (ppt). Each meter was properly calibrated using techniques derived from both instruction manuals. All sample sites and measurements were given adequate time to stabilize, insuring accurate readings. Measurements on most sampling sites were within 1 to 2 feet below the air-surface interface, which was dependant on the total depth of the stream sites. Different water depths yielded different values and were considered during the sampling of each site. These values were relatively the same for each day, except in the event of rain, which increased the stream volume.

Water quality data was compared with past studies on Campbell Creek, with analysis of creeks adjacent to Beith Creek and Gannon Slough. This information was used primarily for referencing the past water quality of these water systems.

Keeping track of weather conditions would seem important.

Implementation

The goal of the project is to provide the City of Arcata with a baseline for comparison after installation of the new tide gate at Gannon Slough. In order to fulfill this goal our group has set two dates, one as to when we will finish field tests and the other as to when we will have our data compiled and in report form in order to get the information to the City of Arcata.

Timeline:

More details: who gets the equipment?

- All group members will begin field testing March 9, 2005.
- All group members will finish field testing on April 14, 2005.
- All group members will compile all data into report form including graphs and explanations.
- Completed reports will be distributed to Dick Hansis, Dean Hunt, and Julie Neander (City of Arcata) by May 2, 2005.
- A new tide gate will be installed at Gannon Slough by the City of Arcata in early fall of 2005.
- Monitoring will continue on the test sites we have set up after the new tide gate has been installed.

A possible problem that could result from this project is that future monitoring may not occur after installation of the new tide gate. The current monitoring is being conducted by university and future monitoring may or may not be conducted by students. One solution to this problem is future students in Environmental Science 410 practicum would conduct monitoring after the new gates are installed Another possible solution is that the City of Arcata conducts future monitoring on the effectiveness of the tidal gate.

Monitoring and Evaluation:

Future monitoring for this project should be done in compliance with the City of Arcata after they have installed the proposed new tide gates on Gannon Slough. Monitoring should be done on the same test sites as the initial study in order to maintain accuracy. Our recommendation on completing the task of monitoring is to have one of two options be carried out: 1) A future group of students from the Environmental Science 410 class work with the City of Arcata in doing a monitoring project on Campbell Creek, Beith Creek and Gannon Slough in order to inform the city on how effective the new tide gate is or 2) have the City of Arcata use its own staff to perform monitoring on the same sites and compare our data with their own in order determine how well the new tide gate is performing in regards to the City's expectations.

Both monitoring plans would be sufficient in evaluating how well the project is working. Another consideration to take into account would be that all of the future monitoring be carried out by performing the same tests at the original test sites. Also, future testing should be done in accordance with different tide ranges and during the dry season, so only the tide would be considered to affect the water quality.

Results

The results gathered from March 9th to the April 13th indicate the current water quality conditions associated with Beith and Campbell Creeks as well as Gannon Slough. Graphs can be found in Appendix D in the City of Arcata lab report (Appendix C). The results for each parameter are indicated as follows:

3/9/2005						
Beith Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	2:30	2:41	4:00	4:05	4:08	4:14
DO (mg/L)	10	10.27	10.87	11.6	11.05	10.63
Temp (ºC)	12.3	13.2	13.8	13.8	14	15.5
pH	6	6	6.1	5.9	5.9	5.6
TDS (mg/L)	60	60	70	60	65	270
Conductivity(µS/cm)	130	130	130	140	140	170
Salinity (ppt)	0.1	0.1	0.1	0.1	0.1	0.2
Tide	Low tide -0.9 at 5:26 PM					
Weather Observation		sunny, clear, north wind				

Campbell Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	3:05	3:13	3:20	3:28	3:35	3:45
DO (mg/L)	5.3	5.23	6.24	7.8	7.86	8.33
Temp (ºC)	14.7	15.5	15.43	15.7	17.1	17
pH	5.8	5.5	5.3	5.2	5.4	5.1
TDS (mg/L)	150	170	330	1030	1640	4930
Conductivity(µS/cm)	310	350	630	2350	3310	2340
Salinity (ppt)	0.2	0.2	0.3	0.9	1.7	2.3

Gannon Slough	Site 1	Site 2	Site 3	Site 4	Site 5
Time	4:21	4:24	4:30	4:38	4:40
DO (mg/L)	8.85	8.69	8.56	8.06	8.38
Temp (ºC)	16.7	16.8	16.8	16.8	16.7
pH	4.8	5.2	5.1	5.5	5.2
TDS (mg/L)	2870	3210	3420	4040	4420
Conductivity(µS/cm)	5780	6410	6720	8080	8880
Salinity (ppt)	3.3	3.6	3.7	4.8	5.2

3/21/2005			
Beith Creek	Site 1	Site 2	Site 3
Time	2:56	3:05	3:32
DO (mg/L)	9.41	9.68	9.34
Temp (ºC)	11.2	11.2	11.7
pH	5.8	5.6	5.4
TDS (mg/L)	100	110	100
Conductivity(µS/cm)	40	50	50
Salinity (ppt)	0.1	0.11	0.1
Tide	Low tide 0.4 at 3:37 PM		
Weather Observation		High water, overcast and rainy	

No data was recorded for Campbell Creek.

Gannon Slough	Site 1	Site 2	Site 3	Site 4	Site 5
Time	3:36	3:44	3:48	3:52	3:56
DO (mg/L)	8.03	8.05	8.19	8.23	8.34
Temp (ºC)	11.8	11.9	13	12.3	12.2
pH	4.6	5	4.3	4.8	4.6
TDS (mg/L)	140	170	290	230	250
Conductivity (µS/cm)	60	80	140	110	110
Salinity (ppt)	0.1	0.1	0.2	0.1	0.1

3/23/2005						
Beith Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	2:49	2:56	4:20	4:24	4:31	4:36
DO (mg/L)	9.71	9.45	9.45	9.66	9.66	9.45
Temp (ºC)	11-Jan	11.6	11.6	11.6	11.6	12.2
pH	5.5	5.3	7	6.7	6.8	6.9
TDS (mg/L)	50	50	50	60	55	70
Conductivity(µS/cm)	110	110	120	115	120	140
Salinity (ppt)	0	0	0	0	0	0
Tide	Low tide 0.4 at 4:46 PM					
Weather Observation	Overcast, North wind and rainy					

Campbell Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	3:21	3:32	3:38	3:49	3:57	4:05
DO (mg/L)	6.67	6.18	6.84	6.66	7.55	7.34
Temp (ºC)	13.6	13.7	13.1	13.4	13.2	13.3
pH	5.1	6.8	6.7	6.6	6.7	6.9
TDS (mg/L)	120	130	140	170	220	230
Conductivity(µS/cm)	260	260	290	340	450	480
Salinity (ppt)	0.1	0.1	0.1	0.2	0.2	0.2

Gannon Slough	Site 1	Site 2	Site 3	Site 4	Site 5
Time	4:46	4:54	4:59	5:07	5:11
DO (mg/L)	8.15	7.95	7.6	7.02	7.8
Temp (ºC)	12.9	12.8	13.4	13.4	13.2
pH	5.6	6.3	6.1	5.2	6.3
TDS (mg/L)	110	110	860	380	380
Conductivity(µS/cm)	240	380	450	730	780
Salinity (ppt)	0.1	0.2	0.5	0.5	0.5

3/28/2005						
Beith Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	2:40	2:49	2:55	3:03	3:09	3:14
DO (mg/L)	9.19	9.37	9.46	9.47	9.46	9.36
Temp (ºC)	11.2	11.3	11.2	11.3	11.4	12.6
pH	6.3	5.8	5.8	5.5	5.8	6
TDS (mg/L)	130	190	120	120	160	130
Conductivity(µS/cm)	270	440	250	250	330	270
Salinity (ppt)	0	0	0	0	0	0
Tide	High tide 5.7 at 1:48 PM					
Weather Observation		cloudy southwest wind				

Campbell Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	3:32	3:37	3:41	3:46	3:53	3:56
DO (mg/L)	6.29	7.38	7.96	8.28	8.58	9.12
Temp (ºC)	13.7	14.6	18	14.3	14.5	13
pH	5.6	5.9	5.9	5.9	6.3	6.1
TDS (mg/L)	130	130	80	90	80	60
Conductivity(µS/cm)	290	290	180	180	160	120
Salinity (ppt)	0.1	0.1	0.1	0.1	0.1	0

Gannon Slough	Site 1	Site 2	Site 3	Site 4	Site 5
Time	4:08	4:15	4:30	4:34	4:36
DO (mg/L)	9.03	9.2	8.93	9.17	8.94
Temp (ºC)	12.7	12.7	13.4	13	13
pH	5.8	6.1	5.9	5.9	5.9
TDS (mg/L)	50	60	380	490	450
Conductivity(µS/cm)	120	140	820	1030	930
Salinity (ppt)	0	0	0.4	0.6	0.5

3/30/2005						
Beith Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	2:36	2:43	2:50	2:55	3:00	3"06
DO (mg/L)	10.01	9.72	9.86	9.93	9.68	9.61
Temp (ºC)	11.2	11.3	11.3	11.3	11.5	12.4
pH	6.7	6.4	6.7	6.7	6.8	6.7
TDS(mg/L)	40	40	50	50	50	50
Conductivity(µS/cm)	90	90	100	100	100	150
Salinity (ppt)	0	0	0	0	0	0
Tide	High tide at 5.0 at 3:47 pm					
Weather Observation	Sunny, clear north wind					

Campbell Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	3:20	3:25	3:28	3:34	3:38	3:43
DO(mg/L)	7.74	6.48	7.61	7.24	9.17	9.42
Temp(ºC)	13.8	13.4	16	14.9	13.4	12.6
pH	6.6	6.6	6.2	6.2	6.2	6
TDS(mg/L)	110	110	120	140	70	50
Conductivity(µS/cm)	230	230	240	290	160	120
Salinity (ppt)	0.1	0.1	0.1	0.2	0.1	0

Gannon Slough	Site 1	Site 2	Site 3	Site 4	Site 5
Time	3:48	3:52	3:59	4:03	4:04
DO(mg/L)	8.2	8	8.44	7.38	7.63
Temp(ºC)	13.2	16.9	16.7	14.4	14.4
pH	6	5.6	5.5	5.6	5.4
TDS(mg/L)	70	180	160	140	160
Conductivity(µS/cm)	160	370	340	290	330
Salinity (ppt)	0.1	0.2	0.2	0.1	0.2

4/4/2005						
Beith Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	2:17	2:29	2:32	2:36	2:43	2:47
DO (mg/L)	9.92	9.78	9.8	9.97	9.07	9.02
Temp (ºC)	10.9	11	11	11.1	11.4	12.6
pH	7.2	7	6.1	6.6	6.4	5.9
TDS (mg/L)	40	40	40	40	50	50
Conductivity(µS/cm)	90	90	100	90	100	100
Salinity (ppt)	0	0	0	0	0	0
Tide	Low tide -0.3 at 3:37 PM					
Weather Observation		sunny north winds				

Campbell Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	2:57	3:01	3:04	3:09	3:13	3:16
DO (mg/L)	6.91	7.19	6.5	6.93	8.03	7.48
Temp (ºC)	14.2	14.3	13.8	14.1	15.3	14.1
pH	6	5.9	5.7	5.6	5.6	5.3
TDS (mg/L)	80	90	90	100	140	160
Conductivity(µS/cm)	180	190	190	200	290	320
Salinity (ppt)	0.1	0.1	0.1	0.1	0.1	0.2

Gannon Slough	Site 1	Site 2	Site 3	Site 4	Site 5
Time	3:22	3:26	3:30	3:33	3:35
DO (mg/L)	8.34	8.25	8.26	8.47	8.22
Temp (ºC)	13.2	13.3	14.2	14.1	14.1
pH	5.7	5.6	5.3	5.7	5.2
TDS (mg/L)	100	120	660	640	650
Conductivity(µS/cm)	190	240	1570	1300	1320
Salinity (ppt)	0.1	0.1	0.8	0.8	0.7

4/11/2005						
Beith Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	2:37	2:49	2:57	3:03	3:08	3:16
DO (mg/L)	9.64	8.86	9.02	9.06	9.01	8.86
Temp (ºC)	12	12	12.2	12.3	12.4	13.4
pH	7.3	7.5	6.8	6.3	6	6
TDS (mg/L)	40	40	50	50	50	60
Conductivity(µS/cm)	90	100	100	110	110	140
Salinity (ppt)	0	0	0	0	0	0.1
Tide		High tide at 5.6 at 3:10				
Weather Observation		Sunny, light north wind				

Campbell Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	4:20	4:14	4:05		3:55	3:44
DO (mg/L)	5.52	6.72	7.02		7.06	6.83
Temp (ºC)	14.2	16	16.4	NO	15.5	14.5
pH	6.7	6.2	6.4	DATA	7	6.9
TDS (mg/L)	120	200	600		1670	1810
Conductivity(µS/cm)	250	450	1270		3240	3695
Salinity (ppt)	0.1	0.4	7.0		1.8	2.2

Gannon Slough	Site 1	Site 2	Site 3	Site 4	Site 5
Time	3:25	3:32	4:51	4:55	4:57
DO (mg/L)	6.43	6.15	6.87	6.99	6.52
Temp (ºC)	14.9	14.7	15.1	14.9	14.9
pH	6.4	6.6	6.3	6.7	6.8
TDS (mg/L)	2850	4270	3100	4070	4890
Conductivity(µS/cm)	5690	8590	6410	8030	9630
Salinity (ppt)	3.4	5.1	3.5	4.6	5.1

4/13/2005			
Gannon Slough	Site 3	Site 4	Site 5
Time	4:10	4:15	4:16
DO (mg/L)	8.03	7.33	6.8
Temp (ºC)	12.6	12.6	12.7
pH	5.9	6.1	6.2
TDS (mg/L)	1930	1930	1920
Conductivity(µS/cm)	3900	3910	3910
Salinity (ppt)	2.4	2.6	2.4
Tide	High tide at 5.0 at 5:03 pm		
Weather Observation	Overcast, light rain and south winds		

Discussion

Water quality of Campbell Creek, Beith Creek and Gannon Slough was expected to have heavy amounts of brackish water flowing through them, due to the leaking tide gates. The results that were obtained after five weeks of testing did not support the expected results. From the data that was collected, the water quality of Campbell Creek, Beith Creek and Gannon Slough are as follows:

- **Dissolved Oxygen**

Dissolved oxygen (DO), which is measured in mg/L, is the concentration of oxygen in a water column. DO is dependant on temperature, salinity and biotic effects. DO is inversely proportional to temperature, which means that when temperature increases DO decreases. Salinity affects DO minimally by reducing intermolecular space that could be available to oxygen[1] for binding. The Regional Water Quality Control Board (RWQCB) recommends that DO in streams and creeks is no less the 6 mg/L. Beith Creek is well above the recommended value for DO concentration. Campbell Creek's DO values were slightly above the minimum recommendations given by the RWQCB. On March 9th, two of the values for DO were below RWQCB recommendations. The decrease in DO may be a result of the increase in vegetation at sites 1 and 2 and an increase in temperature in the stagnant water, which would prevent any turbulent mixing. Depth also has an effect on DO, which decreases with depth. These results may also be a result of human error. The DO levels for Gannon Slough were consistent and well above the RWQCB recommended level for DO. The high levels of DO indicate an aerobic environment which is preferred for biological agents to break down pollutants and organic matter. All three creeks are well oxygenated and further studies could determine whether fluctuations would occur as temperatures change with seasonal input as well as increase under vegetative cover.

- **Temperature**

Temperature is a measure of the internal energy that a substance contains and is inversely proportional to DO. Temperature is also highly dependant on the amount of shading vegetation present. Many streams are shaded by trees, which considerably reduce solar heating. Clearance of streamside vegetation increases water temperature and,

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[1] Horne, A and Goldman, C.R. Limnology 2nd edition. McGraw Hill Inc. New York.

together with the loss of tree root habitat, can cause dramatic reductions in fish production. Sites 1 and 2 along Beith Creek are the only shaded regions of the stream. Site 1 is located right after the stream resurfaces after passing underground through a culvert. The temperatures at these regions were consistently lower, but there is not a significant temperature change after leaving the shaded regions. The riparian cover aids in regulating stream temperature, keeping it relatively consistent throughout the region. Campbell Creek lacks riparian vegetation and site 1 is located right after the creek resurfaces from under Highway 101. The stream temperature was consistent at site 1, but fluctuated further downstream. Campbell Creek lacks any vegetative cover except for the flora, which includes cattails and marsh grasses, inhabiting the stream. This vegetation helps to regulate temperature, but does not provide adequate coverage to the entire stream. The temperature along Gannon Slough varied more than Beith Creek and Campbell Creek. This could be caused by the influent from the bay, mixing salt water with fresh water. The density difference between freshwater and saltwater can cause temperature gradients to form. Saltwater is denser then freshwater, which would create temperature stratification.

The data for Gannon Slough indicates the occurrence of thermal stratification. Because thermal stratification is depth dependent, temperature changes are proportional to the change in tides and the amount of saltwater flowing back upstream. There is no vegetative cover for Gannon Slough, which prevents any sort of decrease in temperature for that stream. Major fluctuations in temperature were associated with higher flows and high tide.

- **pH**

pH is a term that is universally used to express the intensity of the acid or alkaline condition of a solution. It is a way of expressing the hydrogen-ion concentration, or more precisely, the hydrogen-ion activity. Most lakes range between 6.5 which are slightly acidic to 9 which are basic, with 7 representing a neutral pH. There are several different factors that can affect pH, but most streams have natural buffers that help to prevent any extreme fluctuations in pH. Inorganic and organic chemicals can change the pH significantly as well as anoxic conditions, which are only present when oxygen has been completely removed from the system and anaerobic bacteria are breaking down organic material.

The pH for Beith Creek was below the RWQCB recommended levels for cold water habitats at some of the sites during the monitoring period. The ~~change in~~ pH from site 1 to site 6 did not change drastically. The small fluctuations could be caused by organic decomposition and the introduction of humic acids to the stream, as well as any runoff from the street into Beith Creek. Since there is no buffer zone surrounding Beith Creek the introduction of fecal matter, with the high amounts of nitrogen, could potentially lower the pH of the streams. With time the pH increased to neutral levels, but would slightly increase or decrease due to tributaries merging with Beith Creek.

The pH for Campbell Creek fluctuated between 5 and 6.9 and would fluctuate more with the disturbance of anoxic sediment, which would rise to the surface. This anoxic sediment is high in Hydrogen Sulfide, which would cause the pH to decrease very rapidly to extremely acidic levels. Campbell Creek is deep, with a small amount of vegetation. On consistently windy days, water from the hyplimnion mixes with water from the epilimnion, allowing oxygen to be evenly distributed through the water column, keeping the pH relatively constant. The low pH for Campbell Creek could support salmonids, juveniles, and adult fish, although the fluctuations in pH levels could make spawning unfavorable.

The pH for Gannon Slough was the most inconsistent for the three streams. This could be a result of the numerous tributaries that flow into Gannon Slough. With an increase in sediment, chemical runoff, and animal waste flowing into Gannon Slough, it is assumed that the pH would be lower than the other streams because more variables would be considered. Site 1 of Gannon Slough had a very low pH, 4.3 to 6, which is not consistent with the recommendations for cold water habitats by the RWQCB. In order to identify the cause of pH fluctuations at Gannon Slough, the non-point source that introduces the profusion of hydrogen ions to Campbell Creek and Beith Creek needs to be determined. The pH at Gannon Slough would need to be monitored during high and low tide in winter and summer months in order to determine what effect the large amounts of water that settle in and around the stream sites have on pH. This would be helpful in determining if pH is dependent of stream flow or soil characteristics. The pH of

Beith Creek, Campbell Creek, and Gannon Slough seem to be similar to that of the aquaculture ponds at the wastewater facility. These ponds, a combination of bay water and wastewater, have a pH of 5 to 6, with little fluctuations depending on the tide. Little can be done to change the pH of the streams because soil has naturally low acidity. One option would be to monitor the influents for their contribution to pH values. The pH also can be affected by the amount of total solids present, along with alkalinity and temperature.

- **Total Dissolved Solids**

Total dissolved solids (TDS) are materials in the water that will pass through a 2.0-micron or smaller filter. The amount of dissolved solids present in water determines whether it is suitable for domestic use. In general, water with total-solids content of less than 500 mg/L is most desirable for domestic use. In order to reach this suitable level of total dissolved solids, the water must be treated in some sort of process. Solids can be removed from a water body by the use of settling ponds or increasing the amount of vegetation.

TDS for Beith Creek was consistent, yet dependant on the net flow of the stream. During high precipitation, the TDS increased because the flow rate increased and lifted the sediment from the bottom of the stream. On March 28th, the TDS increased to 190 mg/L, which is approximately double the normal amount. When precipitation increased, the surrounding stream area became weathered and deposited solids into the stream. The influx of sediment increased the TDS, but soon after precipitation occurred the TDS decreased.

The TDS for Campbell Creek was inconsistent. The values ranged from low to high values between sites. The beginning of Campbell Creek has vegetation which helps to remove some solids and acts as a natural settling basin for solids. After the water has passed though this section of stream, those solids that did not settle are transported throughout the rest of the stream. Since Campbell Creek meanders and is very wide and shallowly sloped, sediments can easily deposit into the stream. The TDS at sites 4, 5 and 6 triples the TDS amount found in Beith Creek. This was expected because Beith Creek is long, narrow and straight with steeper slopes. During high precipitation, the stream would increase in volume, in turn increasing the amount of solids in the water system.

This would not necessarily create higher TDS values, although the concentration of solids is higher at the final site.

The TDS values for Gannon Slough changed with the tides and with the amount of water that had settled in the fields. The values for Gannon Slough were expected to be higher than Campbell Creek and Beith Creek since they converge into the slough and the solids from the streams would pass through the first site of the slough. Due to the leaking tidal gates, it was also expected that Gannon Slough would have more solids entering it from the settling basin. The TDS values for Gannon Slough tended to be high because of the leaking tide gate, which allowed freshwater to mix with saltwater. TDS values were greater at high tide than low tide. This shows that high tide is carrying significantly more solids than low tide. Also, since Gannon Slough does not have a buffer around it, the tendency for fecal matter to enter the system is high. This could potentially increase the TDS values. Monitoring needs to be done in order to determine if the tidal gates and the tributaries that flow into Gannon Slough are responsible for the increase in TDS.

- **Conductivity**

The conductivity of a solution is a measure of its ability to carry an electrical current and varies both with the number and type of ions the solution contains. Current is carried by both anions and cations of a salt, but to a different degree. Conductivity can be used to determine the TDS or TDS can be used to determine conductivity.

The conductivity of Beith Creek can be represented by the very small levels of TDS. Beith Creek had consistent values for conductivity, which is expected, due to the consistently low TDS values. The conductivity increased in areas that had metal wires or pipes exposed to water. Metal ions are passed into the water column; increasing conductivity at some stream test sites. Beith Creek had low values for both TDS and conductivity, which is affected by the amount of TDS. The tributaries that flowed into Beith Creek were not monitored. These tributaries could potentially alter the conductivity by adding more dissolved solids or salts from the surrounding soils.

The conductivity of Campbell Creek is twice the amount of TDS that were found in the creek. The data collected shows that the conductivity of Campbell Creek is proportional to TDS values. Campbell Creek has tributaries that were not tested, regardless of the tributaries conductivity; the dissolved solid content remains consistent with the conductivity. The conductivity could be lowered by removing the dissolved solids from the system. The conductivity increase at sites 5 and 6 could be due to the infiltration of salt water from the leaking tidal gate at Gannon Slough.

The conductivity for Gannon Slough is twice the TDS amount. The difference in results between Beith Creek and Campbell Creek and Gannon Slough is that the tidal gate is located directly on the Slough. During high tide, saltwater infiltrates through the leaking tidal gate allowing it to mix with freshwater. Differences in density between the cold seawater and the warmer freshwater, cause chemical stratification to occur in the water column. Depending on the depth placement of the probe in the water and its location, the conductivity could be expected to increase due to the newly added solids. Sites 4, 5 and 6 of Gannon Slough were expected to have very high levels of conductivity, but the values did not change significantly. This could be a result of large amounts of fresh water mixing with the minimal amounts of saltwater. Because the density differences are significant, the depth that the samples were taken at is important. The changes in depth should yield different conductivity values. Depth measurements need to be considered when analyzing the conductivity.

- **Salinity**

Salinity is a measure of the dissolved salts present in 1.0 kg of filtered seawater after oxidation of organics, expressed in parts per thousand (ppt). Salinity is also present in soil. Salts that are abundant in ocean and bay water are Sodium Chloride. Salinity changes with tide and with the seasons. When fresh and salt water meet, the resulting combination is called brackish water, which is defined as having salinity greater than 0.5 ppt.

Beith Creek is considered a freshwater stream because the salinity values do not exceed 0.5 ppt. The leaking tidal gate and the high tide did not have an effect on the salinity of Beith Creek. The only possibility for Beith Creek to change from a freshwater stream to a brackish stream is by anthropogenic influences, which would include road salt.

Campbell Creek would also be considered a freshwater stream because the salinity values do not exceed 0.5 ppt. It was assumed that the salinity of Campbell Creek would be the same as Beith Creek because of the stream length and the residence time of the stream. The leaking tidal gates did not affect the salinity values for Campbell Creek. High tide could affect the amount of saltwater present in the creek, but has not according to the current data. The leaking tidal gates and the amount of water present at the time of high tide could dictate whether or not salt water intrusion occurs at this stream.

Gannon Slough would be considered a brackish stream since the values for salinity range from 0.1 to 5.0 ppt. There are two tidal gates leaking at Gannon Slough, which makes it difficult to prevent saltwater from mixing with freshwater. These gates allow saltwater to flow almost the entire length of Gannon Slough. The increase of salinity was assumed to be most prevelent near the tidal gates as shown by the results. The brackish water stays abundant near sites 4, 5, and 6 and varies at sites 1, 2, and 3. This could be due to the density differences associated with the brackish water. Since brackish water is heavier then freshwater, it takes more energy to travel upstream. If there is a lack of wind and tidal energy, brackish water will not form, but if wind and tidal energy are abundant, mixing of salt and fresh waters to form brackish water is likely.

- **Problems**

There are a number of problems associated with the research and monitoring that was achieved. The calibration of the instruments was completed, but the YSI DO and Temperature Meter have different error correction factors and this was not known until after the research was completed. Certain error corrections were dependant on the concentration of dissolved oxygen in the water column. If the concentration of DO is under 6 mg/L, the meter would read Error 5 and if over 20 mg/L, the meter would read Error 4. These numbers are representative of the correction factor that we would have to multiply by the values attained during sampling.

Various other errors occurred during field analysis. The data that was collected may not be accurate because it was obtained in a narrow five week time frame during the rainy season. Testing over an entire year period, taking into account seasonal changes, may yield more accurate results. Due to daily testing time constraints, there was a limited amount of tidal changes observed. Missing data resulted from high water that caused the streams to be impassable. This data, in combination with the data collected, may have resulted in more accurate results. The missing data during these days may have provided more accurate results.

Conclusion and Future Recommendation:

We expected that the leaking tidal gates would contribute an influx of saltwater into Gannon Slough that would in turn affect the salinity of Campbell Creek and Beith Creek. From the results attained, we can conclude that Gannon Slough was the only creek affected by the leaking tidal gates. The conductivity and TDS of Gannon Slough increased well above expected values, due to the positioning of the tidal gates and the tide. During low tide the conductivity, TDS, and salinity were minimal, but during high tide these parameters were well above the expected values. From our results we can conclude that Beith Creek and Campbell Creek were not affected by the leaking tidal gates.

In order to make a more accurate representation of results, more research would need to be conducted during high tide and during different climatic events. Observations done at these times would help to determine the overall influence that the tidal gate is having on salt water intrusion into Gannon Slough.

Appendix A

May 2, 2005

Dear Julie Neander,

Thank you very much for providing us with an opportunity to work with the City of Arcata on the proposed Gannon Slough tide gate replacement. This was our senior project and we feel it was a great opportunity to begin applying our education into real world scenarios. Thank you for the time spent with us and the information you provided us with.

Sincerely,

Steve Smith

Anne Murray

Jason Soto

Appendix B

May 2, 2005

Dear Dean Hunt,

Thank you very much for letting us perform our senior project on the Bayview Ranch property. This was a very good opportunity for us to begin using our education in an applicable real world scenario. We enjoyed our time out in the field and just want to let you know you were very helpful in the process.

Sincerely,

Steve Smith

Anne Murray

Jason Soto

Appendix C

City of Arcata Lab Report

Table of Contents:

Introduction

Water quality analysis was conducted on Campbell Creek, Beith Creek and Gannon Slough for the City of Arcata to use as a basis for comparison after they replace an existing tide gate at Gannon Slough in Fall 2005. This data was collected and compiled by Environmental Science Practicum (ENVS 410) students from Humboldt State University in cooperation with the City of Arcata Environmental Services Department and local rancher Dean Hunt.

The data collected on Campbell Creek, Beith Creek and Gannon Slough will provide the City of Arcata with the current water quality conditions before the new tide gate is installed. The current tide gate is being replaced because it is leaking and allowing tidal waters upstream. These creeks are also habitat to coastal cutthroat trout, Coho salmon and steelhead. Coho salmon and steelhead are recognized as both federal and state threatened species, requiring protection. Due to the specific requirements for passage of these species, the California Department of Fish and Game has authorized funding for a new tide gate that will allow for proper fish passage and maintenance of tidewater exchange without flooding Bayview Ranch, which all of the streams flow through. The tide gate that will be replaced is just upstream from the Caltrans tide gate nearest to highway 101 (**Appendix A**).

The Bayview Ranch is located on the south end of Arcata and east of Highway 101 **(Appendix A)**. Campbell Creek and Beith Creek run through the ranch where they converge to form Gannon Slough. Campbell Creek begins near Fickle Hill Road and runs through the City of Arcata. It then flows under Highway 101 and resurfaces near the Bayview Ranch, meandering through the field, then converging with Beith Creek, forming Gannon Slough. Beith Creek also begins near Fickle Hill Road, south of Campbell Creek's headwaters. Beith Creek flows through the Sunny Brae and into the Bayview Ranch, merging with Campbell Creek into Gannon Slough. Gannon Slough flows through the tide gate, maintained by Caltrans, into a culvert under Highway 101, and then empties into Humboldt Bay.

Materials and Methods

Analytical methods and measurements were taken with portable equipment at each testing site. On-site testing was done between 2:00 and 5:00 pm on Mondays and Wednesdays. Weekly sampling was conducted on water temperature, dissolved oxygen (DO), pH, conductivity, total dissolved solids, and salinity during the study period. At the time of each study period, tide was also considered. Campbell Creek and Beith Creek converged into Gannon Slough, which was tested last in order to allow for adequate water flow throughout both streams. Sites 1 through 5 of Gannon Slough were tested approximately two hours after Campbell Creek and Beith Creek were tested.

Water temperature and DO were both measured on-site using a YSI Incorporated Handheld Dissolved Oxygen and Temperature System (YSI Model 55). Conductivity, pH, and Total Dissolved Solids (TDS) were also measured on-site using a portable HI 9810 pH/EC/TDS Meter by Hanna Instruments. Salinity was measured using a standard hand held salinity meter with a limit of 10 parts per thousand (ppt). Each meter was properly calibrated using techniques derived from both instruction manuals. All sample sites and measurements were given adequate time to stabilize, insuring accurate readings. Measurements on most sampling sites were within 1 to 2 feet below the air-surface interface, which was dependant on the total depth of the stream sites. Different water depths yielded different values and were considered during the sampling of each site. These values were relatively the same for each day, except in the event of rain, which increased the stream volume.

Water quality data was compared with past studies on Campbell Creek, with analysis of creeks adjacent to Beith Creek and Gannon Slough. This information was used primarily for referencing the past water quality of these water systems.

Results

The results gathered from March 9th to the April 13th indicate the current water quality conditions associated with Beith and Campbell Creeks as well as Gannon Slough. Graphs of results can be found in Appendix D. The results for each parameter are indicated as follows:

3/9/2005						
Beith Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	2:30	2:41	4:00	4:05	4:08	4:14
DO (mg/L)	10	10.27	10.87	11.6	11.05	10.63
Temp (ºC)	12.3	13.2	13.8	13.8	14	15.5
pH	6	6	6.1	5.9	5.9	5.6
TDS (mg/L)	60	60	70	60	65	270
Conductivity (µS/cm)	130	130	130	140	140	170
Salinity (ppt)	0.1	0.1	0.1	0.1	0.1	0.2
Tide	Low tide -0.9 at 5:26 PM					
Weather Observation		sunny, clear, north wind				

Campbell Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
DO (mg/L)	3:05	3:13	3:20	3:28	3:35	3:45
Temp (ºC)	5.3	5.23	6.24	7.8	7.86	8.33
pH	14.7	15.5	15.43	15.7	17.1	17
TDS (mg/L)	5.8	5.5	5.3	5.2	5.4	5.1
Conductivity (µS/cm)	150	170	330	1030	1640	4930
Salinity (ppt)	310	350	630	2350	3310	2340
DO (mg/L)	0.2	0.2	0.3	0.9	1.7	2.3

Gannon Slough	Site 1	Site 2	Site 3	Site 4	Site 5
Time	4:21	4:24	4:30	4:38	4:40
DO (mg/L)	8.85	8.69	8.56	8.06	8.38
Temp (ºC)	16.7	16.8	16.8	16.8	16.7
pH	4.8	5.2	5.1	5.5	5.2
TDS (mg/L)	2870	3210	3420	4040	4420
Conductivity (µS/cm)	5780	6410	6720	8080	8880
Salinity (ppt)	3.3	3.6	3.7	4.8	5.2

3/21/2005			
Beith Creek	Site 1	Site 2	Site 3
Time	2:56	3:05	3:32
DO (mg/L)	9.41	9.68	9.34
Temp (ºC)	11.2	11.2	11.7
pH	5.8	5.6	5.4
TDS (mg/L)	100	110	100
Conductivity (µS/cm)	40	50	50
Salinity (ppt)	0.1	0.11	0.1
Tide	Low tide 0.4 at 3:37 PM		
Weather Observation		High water, overcast and rainy	

No data was recorded for Campbell Creek.

Gannon Slough	Site 1	Site 2	Site 3	Site 4	Site 5
Time	3:36	3:44	3:48	3:52	3:56
DO (mg/L)	8.03	8.05	8.19	8.23	8.34
Temp (ºC)	11.8	11.9	13	12.3	12.2
pH	4.6	5	4.3	4.8	4.6
TDS (mg/L)	140	170	290	230	250
Conductivity (µS/cm)	60	80	140	110	110
Salinity (ppt)	0.1	0.1	0.2	0.1	0.1

3/23/2005						
Beith Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	2:49	2:56	4:20	4:24	4:31	4:36
DO (mg/L)	9.71	9.45	9.45	9.66	9.66	9.45
Temp (ºC)	11.1	11.6	11.6	11.6	11.6	12.2
pH	5.5	5.3	7	6.7	6.8	6.9
TDS (mg/L)	50	50	50	60	55	70
Conductivity (µS/cm)	110	110	120	115	120	140
Salinity (ppt)	0	0	0	0	0	0
Tide	Low tide 0.4 at 4:46 PM					
Weather Observation	Overcast, North wind and rainy					

Campbell Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	3:21	3:32	3:38	3:49	3:57	4:05
DO (mg/L)	6.67	6.18	6.84	6.66	7.55	7.34
Temp (ºC)	13.6	13.7	13.1	13.4	13.2	13.3
pH	5.1	6.8	6.7	6.6	6.7	6.9
TDS (mg/L)	120	130	140	170	220	230
Conductivity (µS/cm)	260	260	290	340	450	480
Salinity (ppt)	0.1	0.1	0.1	0.2	0.2	0.2

Gannon Slough	Site 1	Site 2	Site 3	Site 4	Site 5
Time	4:46	4:54	4:59	5:07	5:11
DO (mg/L)	8.15	7.95	7.6	7.02	7.8
Temp (ºC)	12.9	12.8	13.4	13.4	13.2
pH	5.6	6.3	6.1	5.2	6.3
TDS (mg/L)	110	110	860	380	380
Conductivity (µS/cm)	240	380	450	730	780
Salinity (ppt)	0.1	0.2	0.5	0.5	0.5

3/28/2005						
Beith Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	2:40	2:49	2:55	3:03	3:09	3:14
DO (mg/L)	9.19	9.37	9.46	9.47	9.46	9.36
Temp (ºC)	11.2	11.3	11.2	11.3	11.4	12.6
pH	6.3	5.8	5.8	5.5	5.8	6
TDS (mg/L)	130	190	120	120	160	130
Conductivity (µS/cm)	270	440	250	250	330	270
Salinity (ppt)	0	0	0	0	0	0
Tide	High tide 5.7 at 1:48 PM					
Weather Observation		cloudy southwest wind				

Campbell Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	3:32	3:37	3:41	3:46	3:53	3:56
DO (mg/L)	6.29	7.38	7.96	8.28	8.58	9.12
Temp (ºC)	13.7	14.6	18	14.3	14.5	13
pH	5.6	5.9	5.9	5.9	6.3	6.1
TDS (mg/L)	130	130	80	90	80	60
Conductivity (µS/cm)	290	290	180	180	160	120
Salinity (ppt)	0.1	0.1	0.1	0.1	0.1	0

Gannon Slough	Site 1	Site 2	Site 3	Site 4	Site 5
Time	4:08	4:15	4:30	4:34	4:36
DO (mg/L)	9.03	9.2	8.93	9.17	8.94
Temp (ºC)	12.7	12.7	13.4	13	13
pH	5.8	6.1	5.9	5.9	5.9
TDS (mg/L)	50	60	380	490	450
Conductivity (µS/cm)	120	140	820	1030	930
Salinity (ppt)	0	0	0.4	0.6	0.5

3/30/2005						
Beith Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	2:36	2:43	2:50	2:55	3:00	3"06
DO (mg/L)	10.01	9.72	9.86	9.93	9.68	9.61
Temp (ºC)	11.2	11.3	11.3	11.3	11.5	12.4
pH	6.7	6.4	6.7	6.7	6.8	6.7
TDS (mg/L)	40	40	50	50	50	50
Conductivity(µS/cm)	90	90	100	100	100	150
Salinity (ppt)	0	0	0	0	0	0
Tide	High tide at 5.0 at 3:47 pm					
Weather Observation	Sunny, clear north wind					

Campbell Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	3:20	3:25	3:28	3:34	3:38	3:43
DO (mg/L)	7.74	6.48	7.61	7.24	9.17	9.42
Temp (ºC)	13.8	13.4	16	14.9	13.4	12.6
pH	6.6	6.6	6.2	6.2	6.2	6
TDS (mg/L)	110	110	120	140	70	50
Conductivity(µS/cm)	230	230	240	290	160	120
Salinity (ppt)	0.1	0.1	0.1	0.2	0.1	0

Gannon Slough	Site 1	Site 2	Site 3	Site 4	Site 5
Time	3:48	3:52	3:59	4:03	4:04
DO (mg/L)	8.2	8	8.44	7.38	7.63
Temp (ºC)	13.2	16.9	16.7	14.4	14.4
pH	6	5.6	5.5	5.6	5.4
TDS (mg/L)	70	180	160	140	160
Conductivity(µS/cm)	160	370	340	290	330
Salinity (ppt)	0.1	0.2	0.2	0.1	0.2

4/4/2005

Beith Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	2:17	2:29	2:32	2:36	2:43	2:47
DO (mg/L)	9.92	9.78	9.8	9.97	9.07	9.02
Temp (ºC)	10.9	11	11	11.1	11.4	12.6
pH	7.2	7	6.1	6.6	6.4	5.9
TDS (mg/L)	40	40	40	40	50	50
Conductivity (µS/cm)	90	90	100	90	100	100
Salinity (ppt)	0	0	0	0	0	0
Tide	Low tide -0.3 at 3:37 PM					
Weather Observation		sunny north winds				

Campbell Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	2:57	3:01	3:04	3:09	3:13	3:16
DO (mg/L)	6.91	7.19	6.5	6.93	8.03	7.48
Temp (ºC)	14.2	14.3	13.8	14.1	15.3	14.1
pH	6	5.9	5.7	5.6	5.6	5.3
TDS (mg/L)	80	90	90	100	140	160
Conductivity (µS/cm)	180	190	190	200	290	320
Salinity (ppt)	0.1	0.1	0.1	0.1	0.1	0.2

Gannon Slough	Site 1	Site 2	Site 3	Site 4	Site 5
Time	3:22	3:26	3:30	3:33	3:35
DO (mg/L)	8.34	8.25	8.26	8.47	8.22
Temp (ºC)	13.2	13.3	14.2	14.1	14.1
pH	5.7	5.6	5.3	5.7	5.2
TDS (mg/L)	100	120	660	640	650
Conductivity (µS/cm)	190	240	1570	1300	1320
Salinity (ppt)	0.1	0.1	0.8	0.8	0.7

4/11/2005						
Beith Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	2:37	2:49	2:57	3:03	3:08	3:16
DO (mg/L)	9.64	8.86	9.02	9.06	9.01	8.86
Temp (°C)	12	12	12.2	12.3	12.4	13.4
pH	7.3	7.5	6.8	6.3	6	6
TDS (mg/L)	40	40	50	50	50	60
Conductivity (µS/cm)	90	100	100	110	110	140
Salinity (ppt)	0	0	0	0	0	0.1
Tide		High tide at 5.6 at 3:10				
Weather Observation		Sunny, light north wind				

Campbell Creek	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Time	4:20	4:14	4:05		3:55	3:44
DO (mg/L)	5.52	6.72	7.02		7.06	6.83
Temp (°C)	14.2	16	16.4	NO	15.5	14.5
pH	6.7	6.2	6.4	DATA	7	6.9
TDS (mg/L)	120	200	600		1670	1810
Conductivity (µS/cm)	250	450	1270		3240	3695
Salinity (ppt)	0.1	0.4	7.0		1.8	2.2

Gannon Slough	Site 1	Site 2	Site 3	Site 4	Site 5
Time	3:25	3:32	4:51	4:55	4:57
DO (mg/L)	6.43	6.15	6.87	6.99	6.52
Temp (°C)	14.9	14.7	15.1	14.9	14.9
pH	6.4	6.6	6.3	6.7	6.8
TDS (mg/L)	2850	4270	3100	4070	4890
Conductivity (µS/cm)	5690	8590	6410	8030	9630
Salinity (ppt)	3.4	5.1	3.5	4.6	5.1

4/13/2005			
Gannon Slough	Site 3	Site 4	Site 5
Time	4:10	4:15	4:16
DO (mg/L)	8.03	7.33	6.8
Temp (ºC)	12.6	12.6	12.7
pH	5.9	6.1	6.2
TDS (mg/L)	1930	1930	1920
Conductivity (µS/cm)	3900	3910	3910
Salinity (ppt)	2.4	2.6	2.4
Tide Weather Observation	High tide at 5.0 at 5:03 pm Overcast, light rain, south winds		

Discussion

Water quality of Campbell Creek, Beith Creek and Gannon Slough was expected to have heavy amounts of brackish water flowing through them, due to the leaking tide gates. The results that were obtained after five weeks of testing did not support the expected results. From the data that was collected, the water quality of Campbell Creek, Beith Creek and Gannon Slough are as follows:

- **Dissolved Oxygen**

Dissolved oxygen (DO), which is measured in mg/L, is the concentration of oxygen in a water column. DO is dependant on temperature, salinity and biotic effects. DO is inversely proportional to temperature, which means that when temperature increases DO decreases. Salinity affects DO minimally by reducing intermolecular space that could be available to oxygen[2] for binding. The Regional Water Quality Control Board (RWQCB) recommends that DO in streams and creeks is no less the 6 mg/L. Beith Creek is well above the recommended value for DO concentration. Campbell Creek's DO values were slightly above the minimum recommendations given by the RWQCB. On March 9th, two of the values for DO were below RWQCB recommendations. The decrease in DO may be a result of the increase in vegetation at sites 1 and 2 and an increase in temperature in the stagnant water, which would prevent any turbulent mixing. Depth also has an effect on DO, which decreases with depth. These results may also be a result of human error. The DO levels for Gannon Slough were consistent and well above the RWQCB recommended level for DO. The high levels of DO indicate an aerobic environment which is preferred for biological agents to break down pollutants and organic matter. All three creeks are well oxygenated and further studies could determine whether fluctuations would occur as temperatures change with seasonal input as well as increase under vegetative cover.

- **Temperature**

Temperature is a measure of the internal energy that a substance contains and is inversely proportional to DO. Temperature is also highly dependant on the amount of shading vegetation present. Many streams are shaded by trees, which considerably reduce solar heating. Clearance of streamside vegetation increases water temperature and,

[1] Horne, A and Goldman, C.R. Limnology 2nd edition. McGraw Hill Inc. New York.

together with the loss of tree root habitat, can cause dramatic reductions in fish production. Sites 1 and 2 along Beith Creek are the only shaded regions of the stream. Site 1 is located right after the stream resurfaces after passing underground through a culvert. The temperatures at these regions were consistently lower, but there is not a significant temperature change after leaving the shaded regions. The riparian cover aids in regulating stream temperature, keeping it relatively consistent throughout the region. Campbell Creek lacks riparian vegetation and site 1 is located right after the creek resurfaces from under Highway 101. The stream temperature was consistent at site 1, but fluctuated further downstream. Campbell Creek lacks any vegetative cover except for the flora, which includes cattails and marsh grasses, inhabiting the stream. This vegetation helps to regulate temperature, but does not provide adequate coverage to the entire stream. The temperature along Gannon Slough varied more than Beith Creek and Campbell Creek. This could be caused by the influent from the bay, mixing salt water with fresh water. The density difference between freshwater and saltwater can cause temperature gradients to form. Saltwater is denser then freshwater, which would create temperature stratification.

The data for Gannon Slough indicates the occurrence of thermal stratification. Because thermal stratification is depth dependent, temperature changes are proportional to the change in tides and the amount of saltwater flowing back upstream. There is no vegetative cover for Gannon Slough, which prevents any sort of decrease in temperature for that stream. Major fluctuations in temperature were associated with higher flows and high tide.

- **pH**

pH is a term that is universally used to express the intensity of the acid or alkaline condition of a solution. It is a way of expressing the hydrogen-ion concentration, or more precisely, the hydrogen-ion activity. Most lakes range between 6.5 which are slightly acidic to 9 which are basic, with 7 representing a neutral pH. There are several different factors that can affect pH, but most streams have natural buffers that help to prevent any extreme fluctuations in pH. Inorganic and organic chemicals can change the pH significantly as well as anoxic conditions, which are only present when oxygen has been completely removed from the system and anaerobic bacteria are breaking down organic material.

The pH for Beith Creek was below the RWQCB recommended levels for cold water habitats at some of the sites during the monitoring period. The change in pH from site 1 to site 6 did not change drastically. The small fluctuations could be caused by organic decomposition and the introduction of humic acids to the stream, as well as any runoff from the street into Beith Creek. Since there is no buffer zone surrounding Beith Creek the introduction of fecal matter, with the high amounts of nitrogen, could potentially lower the pH of the streams. With time the pH increased to neutral levels, but would slightly increase or decrease due to tributaries merging with Beith Creek.

The pH for Campbell Creek fluctuated between 5 and 6.9 and would fluctuate more with the disturbance of anoxic sediment, which would rise to the surface. This anoxic sediment is high in Hydrogen Sulfide, which would cause the pH to decrease very rapidly to extremely acidic levels. Campbell Creek is deep, with a small amount of vegetation. On consistently windy days, water from the hyplimnion mixes with water from the epilimnion, allowing oxygen to be evenly distributed through the water column, keeping the pH relatively constant. The low pH for Campbell Creek could support salmonids, juveniles, and adult fish, although the fluctuations in pH levels could make spawning unfavorable.

The pH for Gannon Slough was the most inconsistent for the three streams. This could be a result of the numerous tributaries that flow into Gannon Slough. With an increase in sediment, chemical runoff, and animal waste flowing into Gannon Slough, it is assumed that the pH would be lower than the other streams because more variables would be considered. Site 1 of Gannon Slough had a very low pH, 4.3 to 6, which is not consistent with the recommendations for cold water habitats by the RWQCB. In order to identify the cause of pH fluctuations at Gannon Slough, the non-point source that introduces the profusion of hydrogen ions to Campbell Creek and Beith Creek needs to be determined. The pH at Gannon Slough would need to be monitored during high and low tide in winter and summer months in order to determine what effect the large amounts of water that settle in and around the stream sites have on pH. This would be helpful in determining if pH is dependent of stream flow or soil characteristics. The pH of

Beith Creek, Campbell Creek, and Gannon Slough seem to be similar to that of the aquaculture ponds at the wastewater facility. These ponds, a combination of bay water and wastewater, have a pH of 5 to 6, with little fluctuations depending on the tide. Little can be done to change the pH of the streams because soil has naturally low acidity. One option would be to monitor the influents for their contribution to pH values. The pH also can be affected by the amount of total solids present, along with alkalinity and temperature.

- **Total Dissolved Solids**

Total dissolved solids (TDS) are materials in the water that will pass through a 2.0-micron or smaller filter. The amount of dissolved solids present in water determines whether it is suitable for domestic use. In general, water with total-solids content of less than 500 mg/L is most desirable for domestic use. In order to reach this suitable level of total dissolved solids, the water must be treated in some sort of process. Solids can be removed from a water body by the use of settling ponds or increasing the amount of vegetation.

TDS for Beith Creek was consistent, yet dependant on the net flow of the stream. During high precipitation, the TDS increased because the flow rate increased and lifted the sediment from the bottom of the stream. On March 28th, the TDS increased to 190 mg/L, which is approximately double the normal amount. When precipitation increased, the surrounding stream area became weathered and deposited solids into the stream. The influx of sediment increased the TDS, but soon after precipitation occurred the TDS decreased.

The TDS for Campbell Creek was inconsistent. The values ranged from low to high values between sites. The beginning of Campbell Creek has vegetation which helps to remove some solids and acts as a natural settling basin for solids. After the water has passed though this section of stream, those solids that did not settle are transported throughout the rest of the stream. Since Campbell Creek meanders and is very wide and shallowly sloped, sediments can easily deposit into the stream. The TDS at sites 4, 5 and 6 triples the TDS amount found in Beith Creek. This was expected because Beith Creek is long, narrow and straight with steeper slopes. During high precipitation, the stream would increase in volume, in turn increasing the amount of solids in the water system.

This would not necessarily create higher TDS values, although the concentration of solids is higher at the final site.

The TDS values for Gannon Slough changed with the tides and with the amount of water that had settled in the fields. The values for Gannon Slough were expected to be higher than Campbell Creek and Beith Creek since they converge into the slough and the solids from the streams would pass through the first site of the slough. Due to the leaking tidal gates, it was also expected that Gannon Slough would have more solids entering it from the settling basin. The TDS values for Gannon Slough tended to be high because of the leaking tide gate, which allowed freshwater to mix with saltwater. TDS values were greater at high tide than low tide. This shows that high tide is carrying significantly more solids than low tide. Also, since Gannon Slough does not have a buffer around it, the tendency for fecal matter to enter the system is high. This could potentially increase the TDS values. Monitoring needs to be done in order to determine if the tidal gates and the tributaries that flow into Gannon Slough are responsible for the increase in TDS.

- **Conductivity**

The conductivity of a solution is a measure of its ability to carry an electrical current and varies both with the number and type of ions the solution contains. Current is carried by both anions and cations of a salt, but to a different degree. Conductivity can be used to determine the TDS or TDS can be used to determine conductivity.

The conductivity of Beith Creek can be represented by the very small levels of TDS. Beith Creek had consistent values for conductivity, which is expected, due to the consistently low TDS values. The conductivity increased in areas that had metal wires or pipes exposed to water. Metal ions are passed into the water column; increasing conductivity at some stream test sites. Beith Creek had low values for both TDS and conductivity, which is affected by the amount of TDS. The tributaries that flowed into Beith Creek were not monitored. These tributaries could potentially alter the conductivity by adding more dissolved solids or salts from the surrounding soils.

The conductivity of Campbell Creek is twice the amount of TDS that were found in the creek. The data collected shows that the conductivity of Campbell Creek is proportional to TDS values. Campbell Creek has tributaries that were not tested, regardless of the tributaries conductivity; the dissolved solid content remains consistent with the conductivity. The conductivity could be lowered by removing the dissolved solids from the system. The conductivity increase at sites 5 and 6 could be due to the infiltration of salt water from the leaking tidal gate at Gannon Slough.

The conductivity for Gannon Slough is twice the TDS amount. The difference in results between Beith Creek and Campbell Creek and Gannon Slough is that the tidal gate is located directly on the Slough. During high tide, saltwater infiltrates through the leaking tidal gate allowing it to mix with freshwater. Differences in density between the cold seawater and the warmer freshwater, cause chemical stratification to occur in the water column. Depending on the depth placement of the probe in the water and its location, the conductivity could be expected to increase due to the newly added solids. Sites 4, 5 and 6 of Gannon Slough were expected to have very high levels of conductivity, but the values did not change significantly. This could be a result of large amounts of fresh water mixing with the minimal amounts of saltwater. Because the density differences are significant, the depth that the samples were taken at is important. The changes in depth should yield different conductivity values. Depth measurements need to be considered when analyzing the conductivity.

- **Salinity**

Salinity is a measure of the dissolved salts present in 1.0 kg of filtered seawater after oxidation of organics, expressed in parts per thousand (ppt). Salinity is also present in soil. Salts that are abundant in ocean and bay water are Sodium Chloride. Salinity changes with tide and with the seasons. When fresh and salt water meet, the resulting combination is called brackish water, which is defined as having salinity greater than 0.5 ppt.

Beith Creek is considered a freshwater stream because the salinity values do not exceed 0.5 ppt. The leaking tidal gate and the high tide did not have an effect on the salinity of Beith Creek. The only possibility for Beith Creek to change from a freshwater stream to a brackish stream is by anthropogenic influences, which would include road salt.

Campbell Creek would also be considered a freshwater stream because the salinity values do not exceed 0.5 ppt. It was assumed that the salinity of Campbell Creek would be the same as Beith Creek because of the stream length and the residence time of the stream. The leaking tidal gates did not affect the salinity values for Campbell Creek. High tide could affect the amount of saltwater present in the creek, but has not according to the current data. The leaking tidal gates and the amount of water present at the time of high tide could dictate whether or not salt water intrusion occurs at this stream.

Gannon Slough would be considered a brackish stream since the values for salinity range from 0.1 to 5.0 ppt. There are two tidal gates leaking at Gannon Slough, which makes it difficult to prevent saltwater from mixing with freshwater. These gates allow saltwater to flow almost the entire length of Gannon Slough. The increase of salinity was assumed to be most prevelent near the tidal gates as shown by the results. The brackish water stays abundant near sites 4, 5, and 6 and varies at sites 1, 2, and 3. This could be due to the density differences associated with the brackish water. Since brackish water is heavier then freshwater, it takes more energy to travel upstream. If there is a lack of wind and tidal energy, brackish water will not form, but if wind and tidal energy are abundant, mixing of salt and fresh waters to form brackish water is likely.

- **Problems**

There are a number of problems associated with the research and monitoring that was achieved. The calibration of the instruments was completed, but the YSI DO and Temperature Meter have different error correction factors and this was not known until after the research was completed. Certain error corrections were dependant on the concentration of dissolved oxygen in the water column. If the concentration of DO is under 6 mg/L, the meter would read Error 5 and if over 20 mg/L, the meter would read Error 4. These numbers are representative of the correction factor that we would have to multiply by the values attained during sampling.

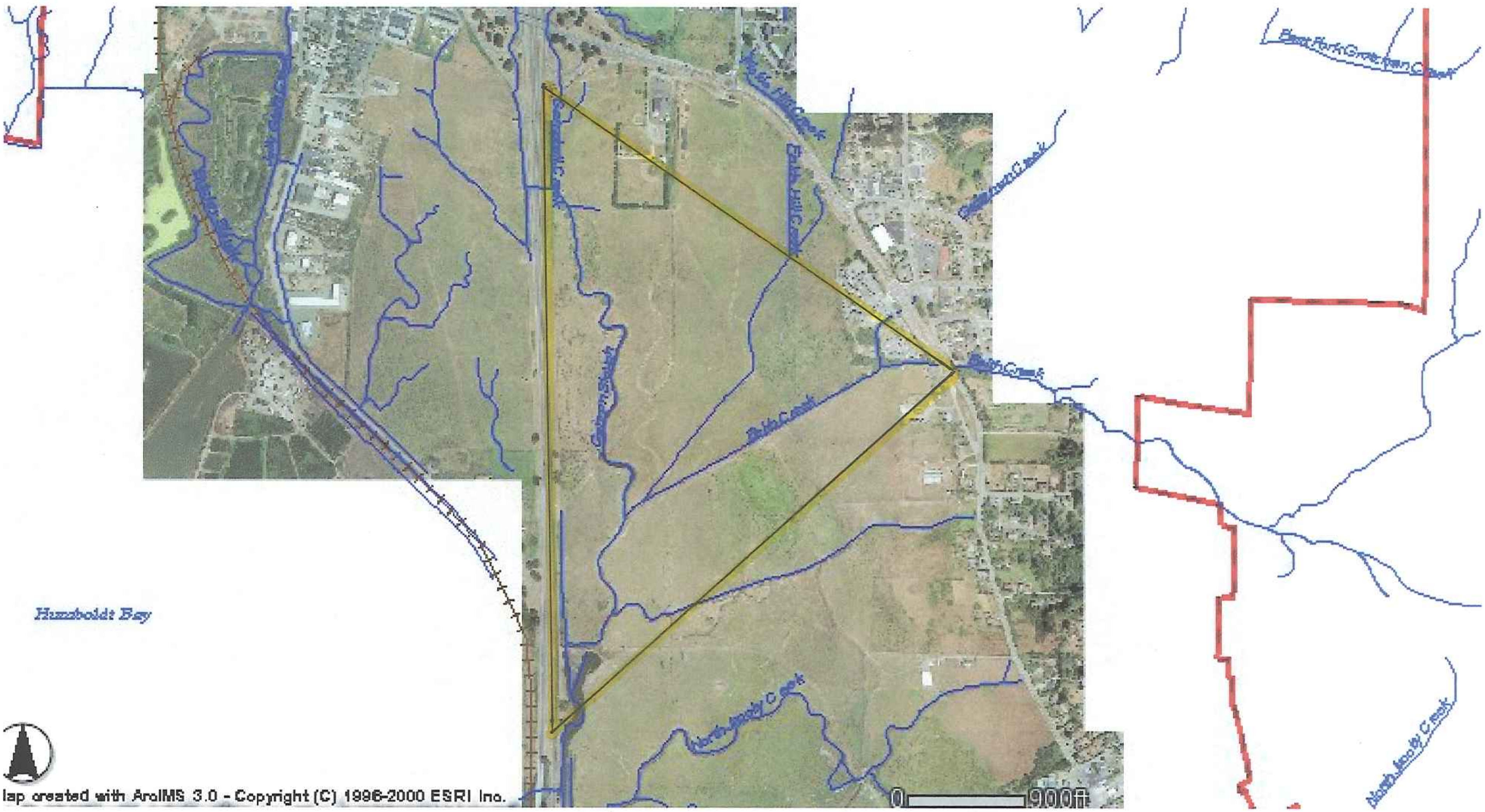
Various other errors occurred during field analysis. The data that was collected may not be accurate because it was obtained in a narrow five week time frame during the rainy season. Testing over an entire year period, taking into account seasonal changes, may yield more accurate results. Due to daily testing time constraints, there was a limited amount of tidal changes observed. Missing data resulted from high water that caused the streams to be impassable. This data, in combination with the data collected, may have resulted in more accurate results. The missing data during these days may have provided more accurate results.

Conclusion and Future Recommendations:

We expected that the leaking tidal gates would contribute an influx of saltwater into Gannon Slough that would in turn affect the salinity of Campbell Creek and Beith Creek. From the results attained, we can conclude that Gannon Slough was the only creek affected by the leaking tidal gates. The conductivity and TDS of Gannon Slough increased well above expected values, due to the positioning of the tidal gates and the tide. During low tide the conductivity, TDS, and salinity were minimal, but during high tide these parameters were well above the expected values. From our results we can conclude that Beith Creek and Campbell Creek were not affected by the leaking tidal gates.

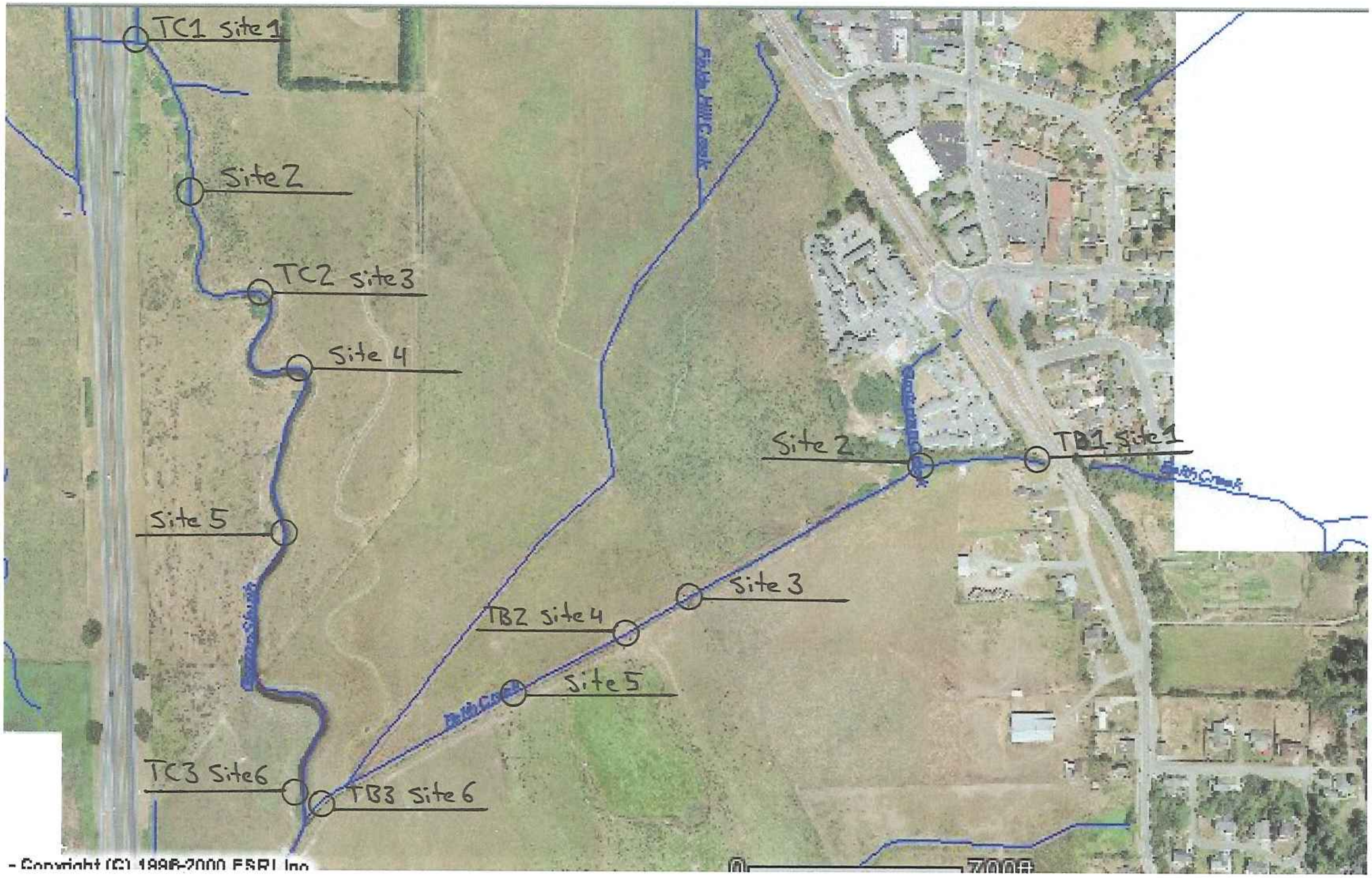
In order to make a more accurate representation of results, more research would need to be conducted during high tide and during different climatic events. Observations done at these times would help to determine the overall influence that the tidal gate is having on salt water intrusion into Gannon Slough.

Appendix A

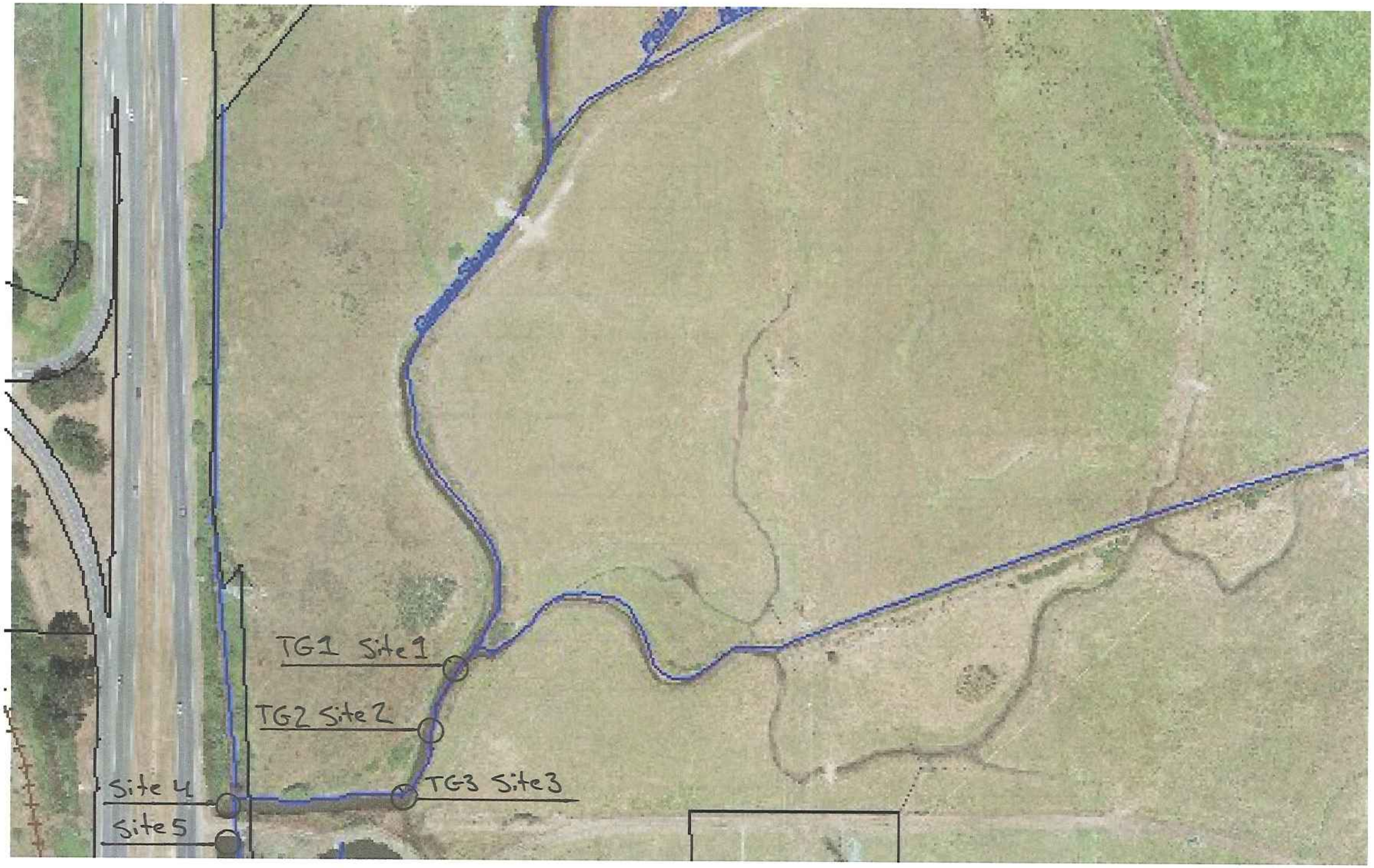


Area of Study

Appendix B

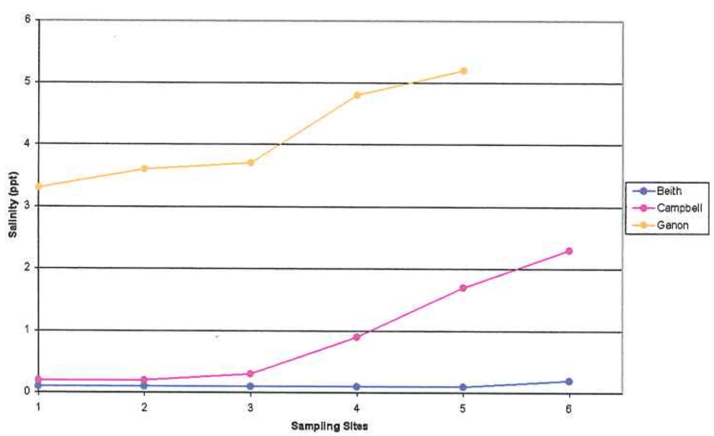

TC1 site 1
Site 2
TC2 site 3
Site 4
Site 5
TC3 Site 6
TB3 Site 6
Site 5
TB2 site 4
Site 3
Site 2
TB1 Site 1

Appendix C

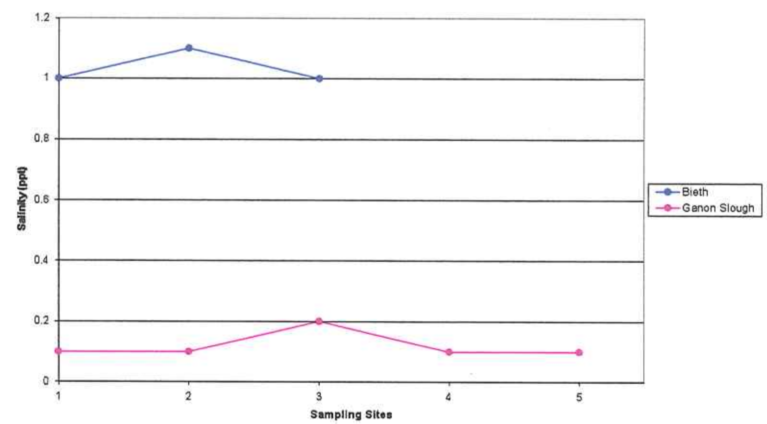


Appendix D

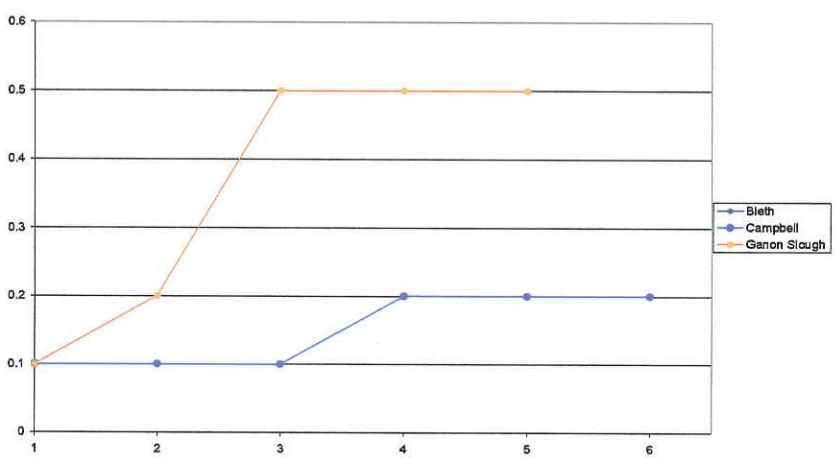
Salinity Analysis of Beith, Campbell, and Ganon Slough 03/09/2005



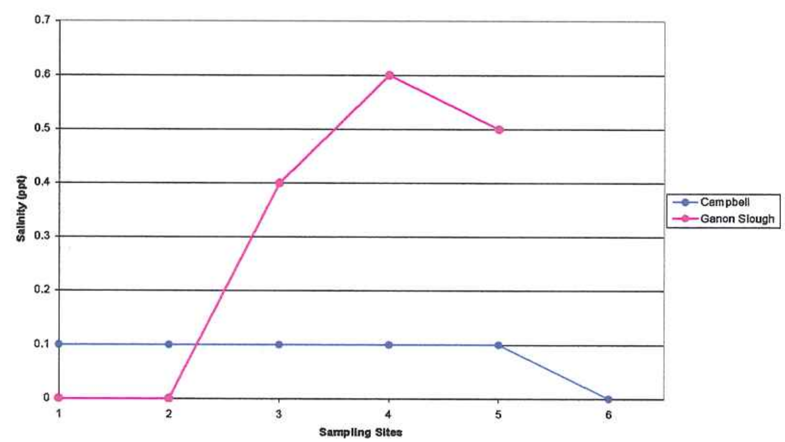
Salinity Analysis for Beith and Ganon Slough 03/21/2005



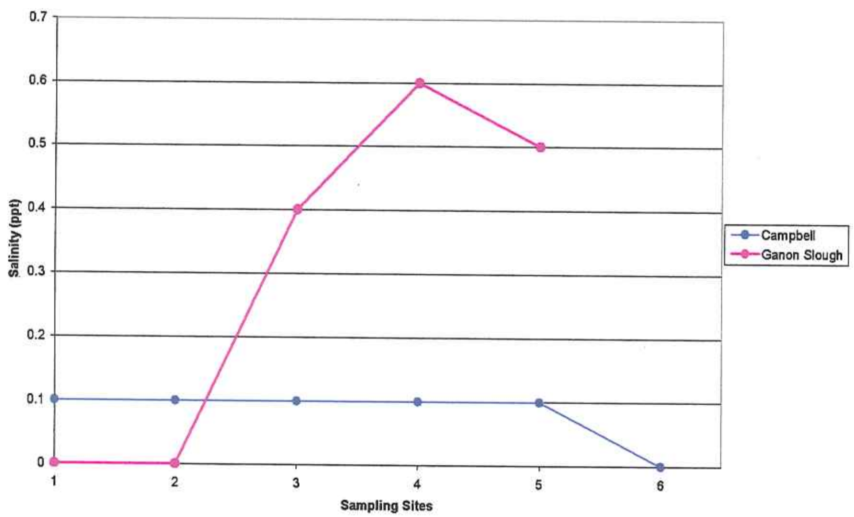
Salinity Analysis for Beith, Campbell, and Ganon Slough 03/23/05



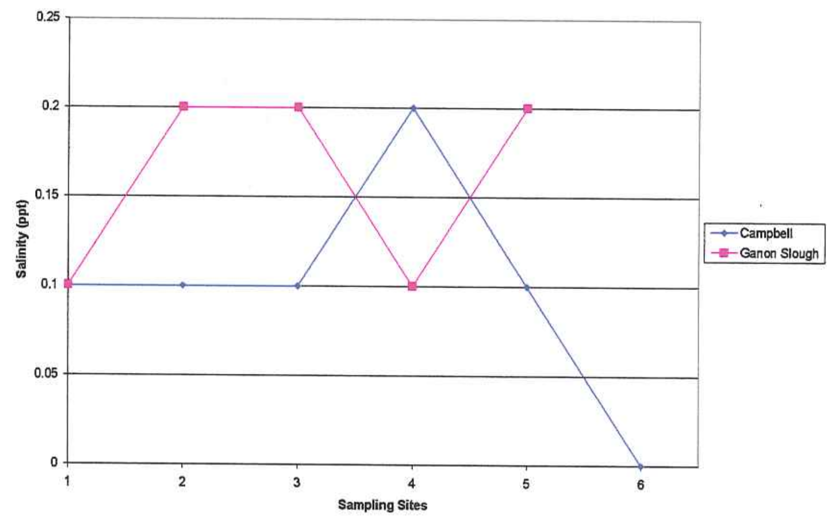
Salinity Analysis for Campbell and Ganon Slough 03/28/05



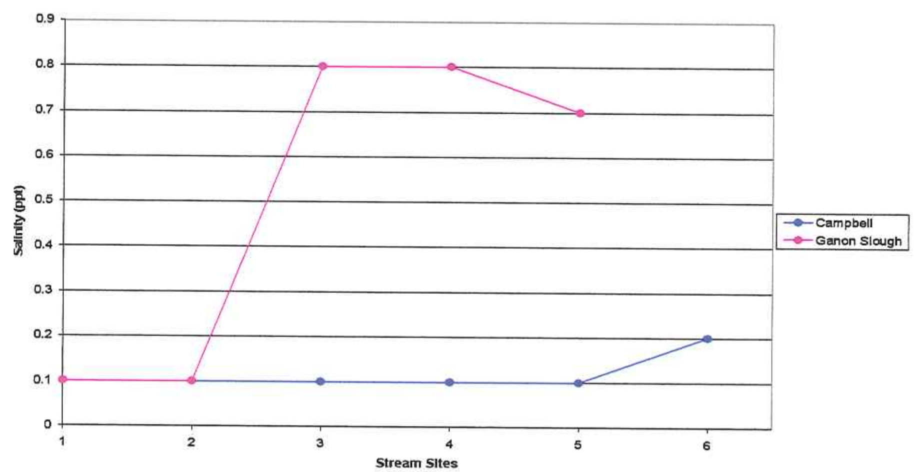
Salinity Analysis for Campbell and Ganon Slough 03/28/05

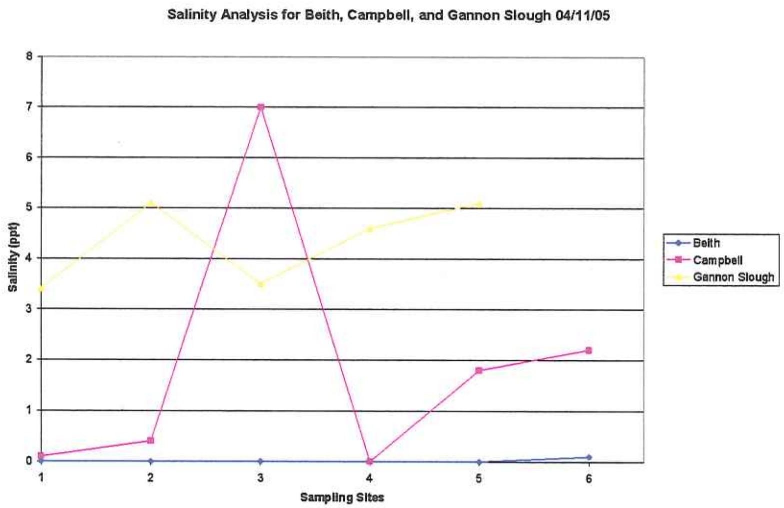


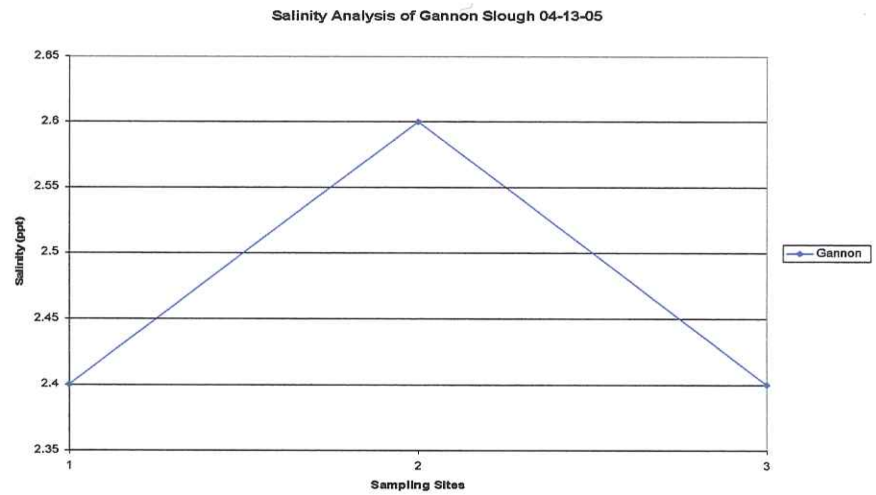
Salinity Analysis for Campbell and Ganon Slough 03/30/05

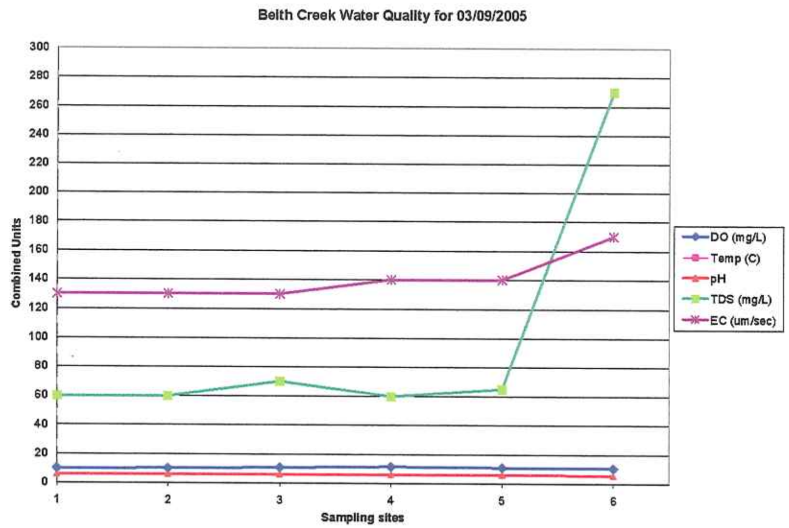


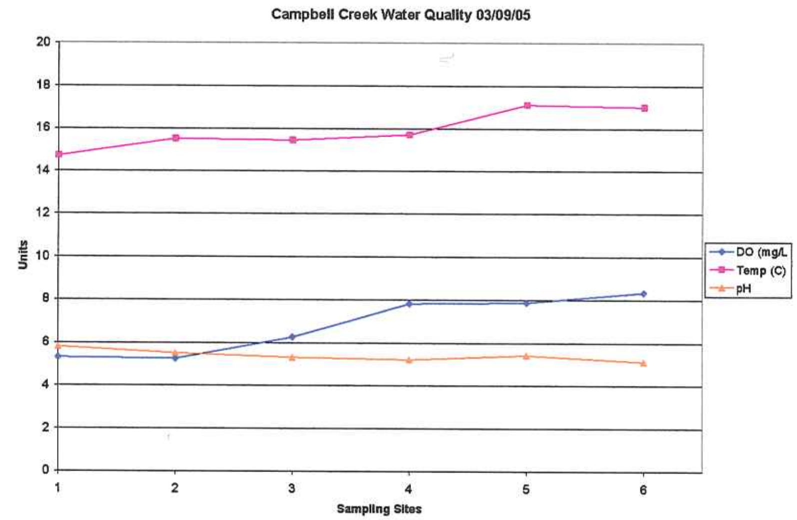
Salinity Analysis for Campbell and Ganon Slough 04/04/05

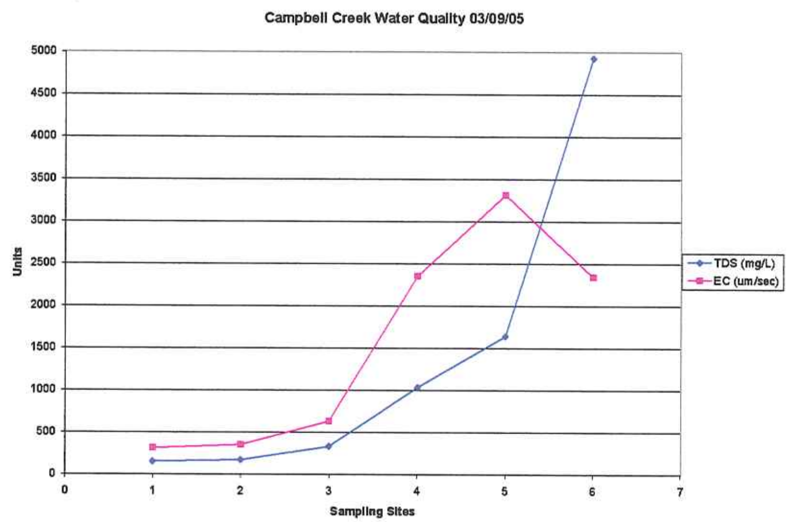


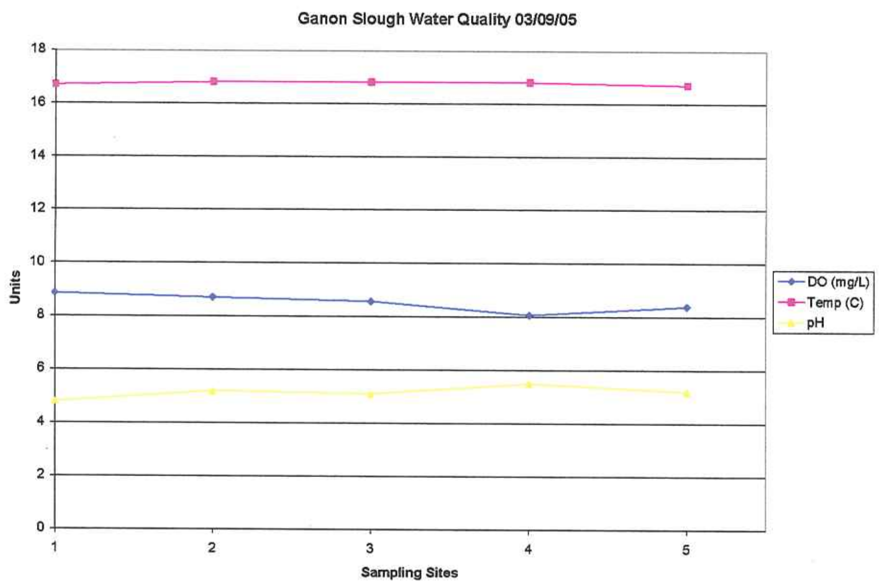

Salinity Analysis for Beith, Campbell, and Gannon Slough 04/11/05
Salinity (ppt)
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Sampling Sites
Beith
Campbell
Gannon Slough

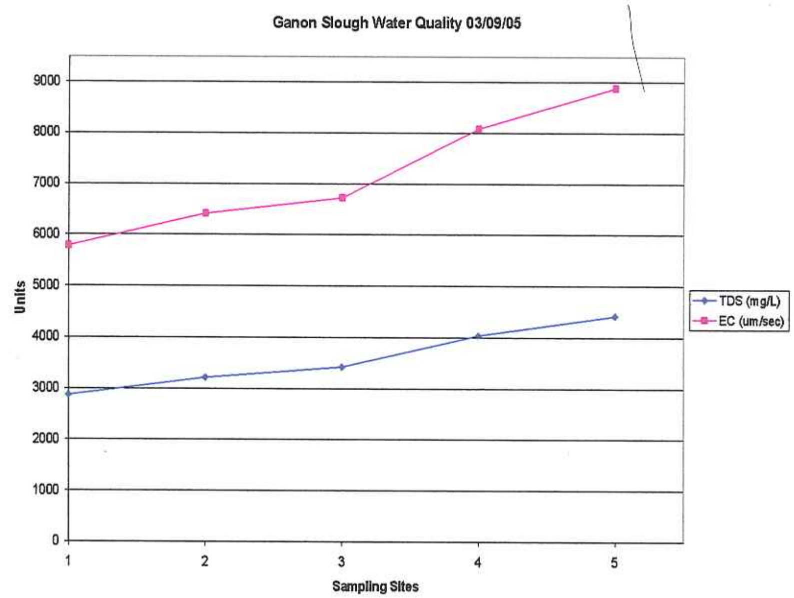

Salinity Analysis of Gannon Slough 04-13-05
Salinity (ppt)
2.65
2.6
2.55
2.5
2.45
2.4
2.35
1
2
3
Sampling Sites
Gannon


Beith Creek Water Quality for 03/09/2005
Combined Units
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
1
2
3
4
5
6
Sampling sites
DO (mg/L)
Temp (C)
pH
TDS (mg/L)
EC (um/sec)

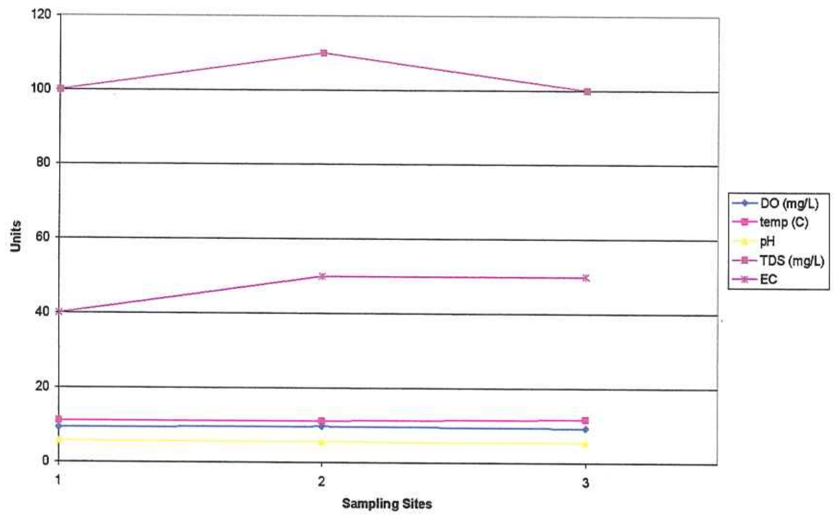

Campbell Creek Water Quality 03/09/05
Units
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
Sampling Sites
DO (mg/L
Temp (C)
pH


Campbell Creek Water Quality 03/09/05
Units
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
1
2
3
4
5
6
7
Sampling Sites
TDS (mg/L)
EC (um/sec)

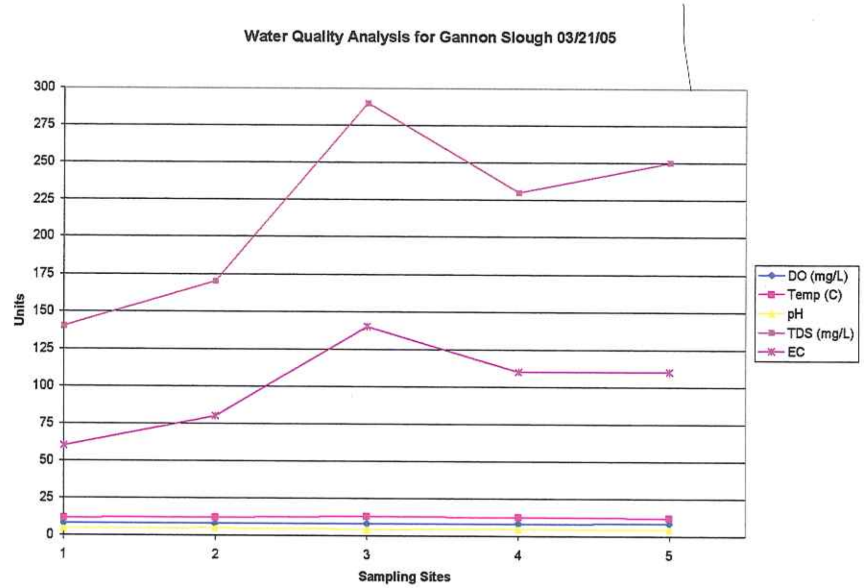

Ganon Slough Water Quality 03/09/05
Units
Sampling Sites
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
DO (mg/L)
Temp (C)
pH


Ganon Slough Water Quality 03/09/05
Units
Sampling Sites
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1
2
3
4
5
TDS (mg/L)
EC (um/sec)

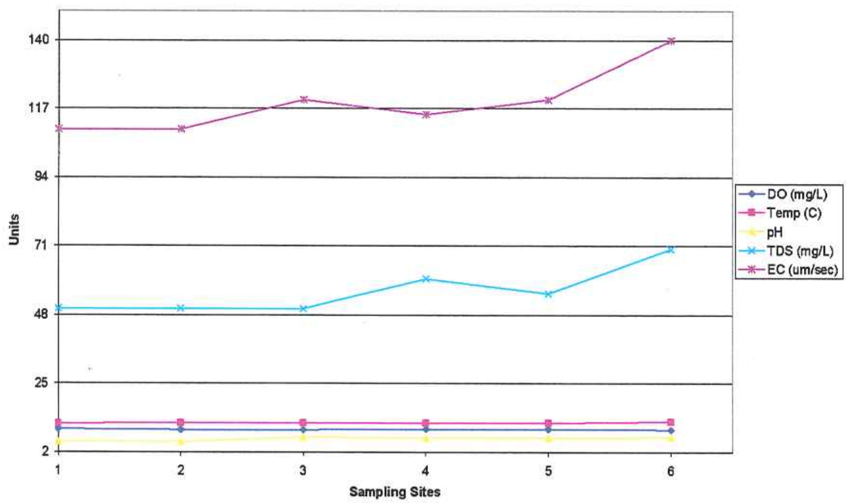
Water Quality Analysis for Bleth Creek 03/21/05



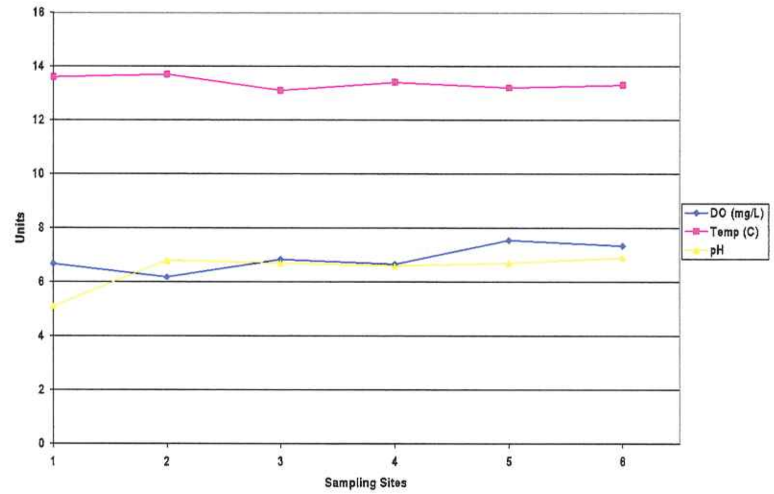
Water Quality Analysis for Gannon Slough 03/21/05



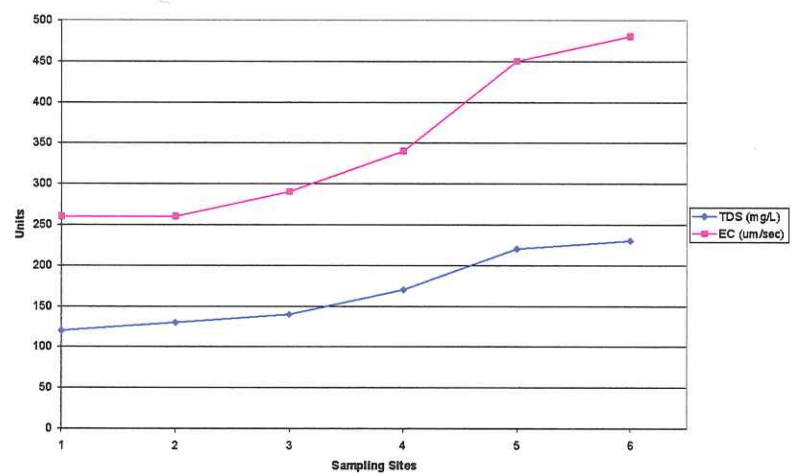
Water Quality Analysis for Beith Creek 03/23/05



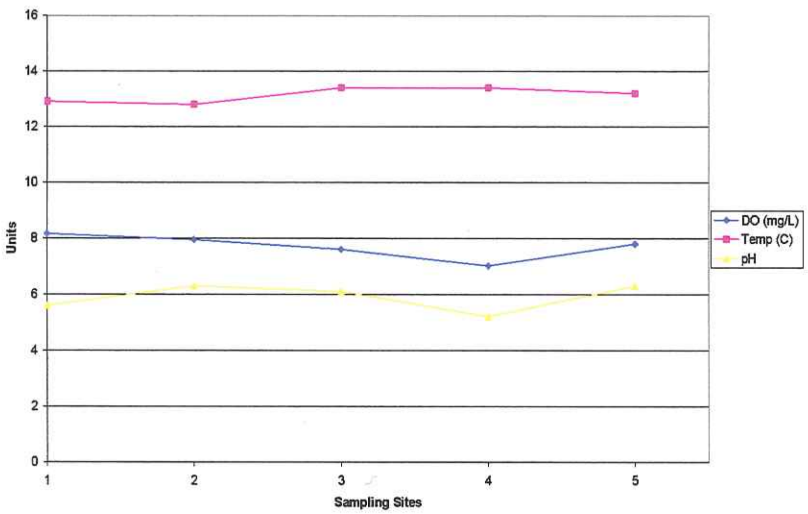
Water Quality for Campbell Creek 03/23/05



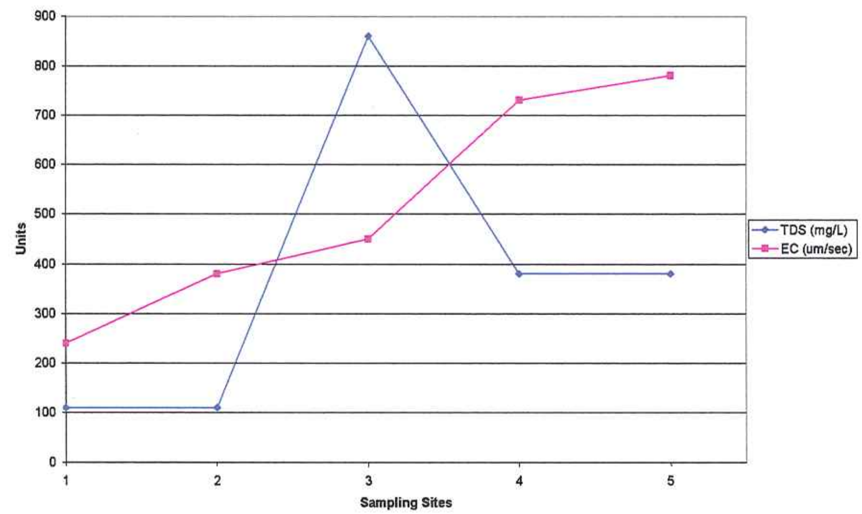
Water Quality for Campbell Creek 03/23/05

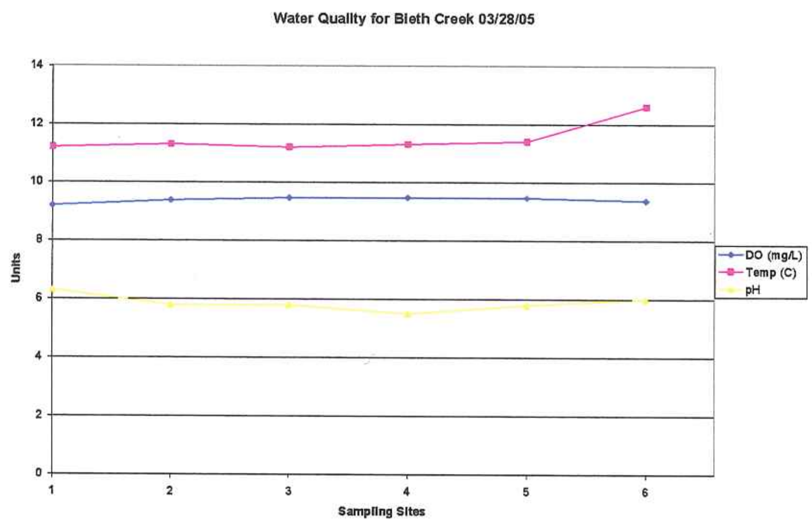


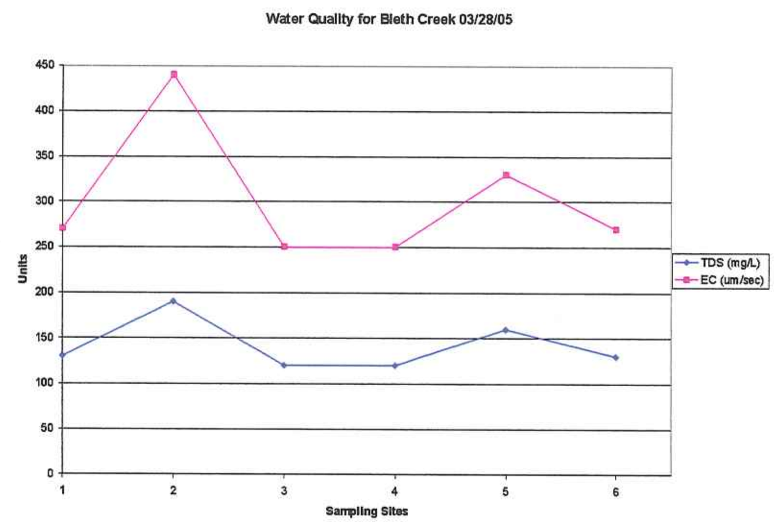
Water Quality for Gannon Slough 03/23/05



Water Quality for Gannon Slough 03/23/05




Water Quality for Bleth Creek 03/28/05
Units
Sampling Sites
DO (mg/L)
Temp (C)
pH
0
2
4
6
8
10
12
14
1
2
3
4
5
6


Water Quality for Bleth Creek 03/28/05
Units
Sampling Sites
TDS (mg/L)
EC (um/sec)
0
50
100
150
200
250
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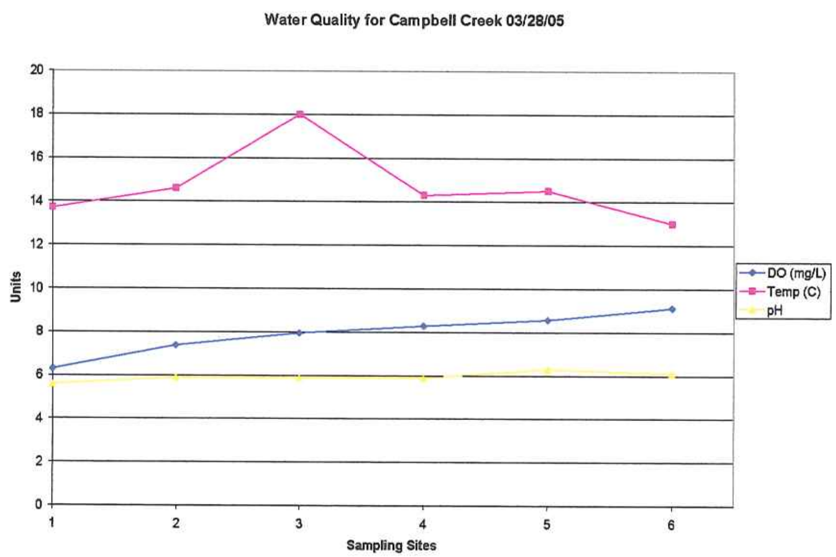
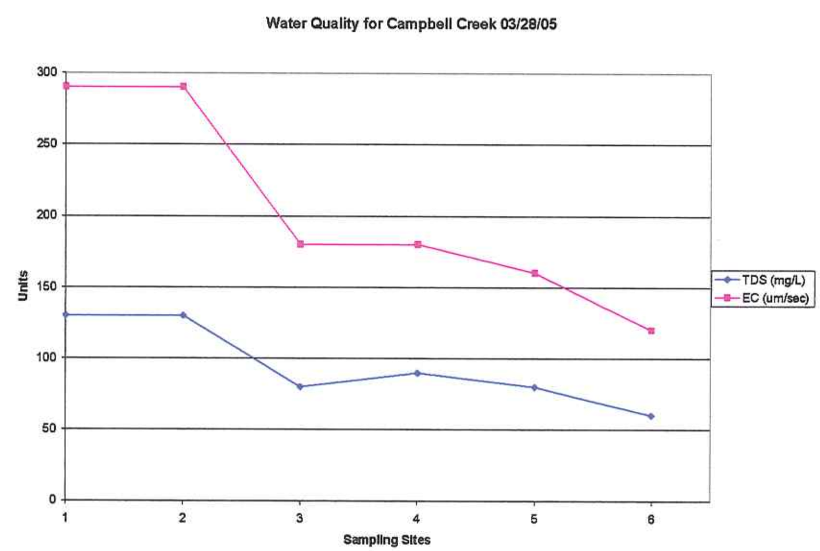
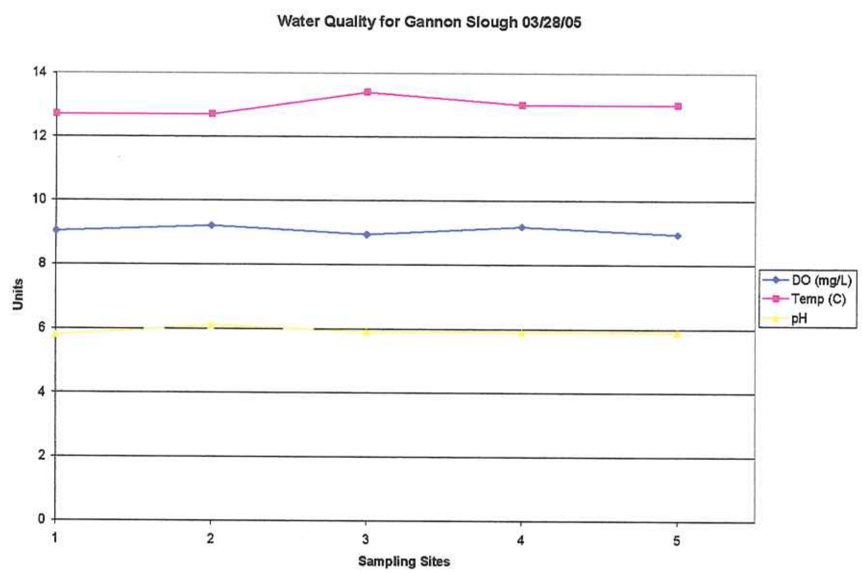
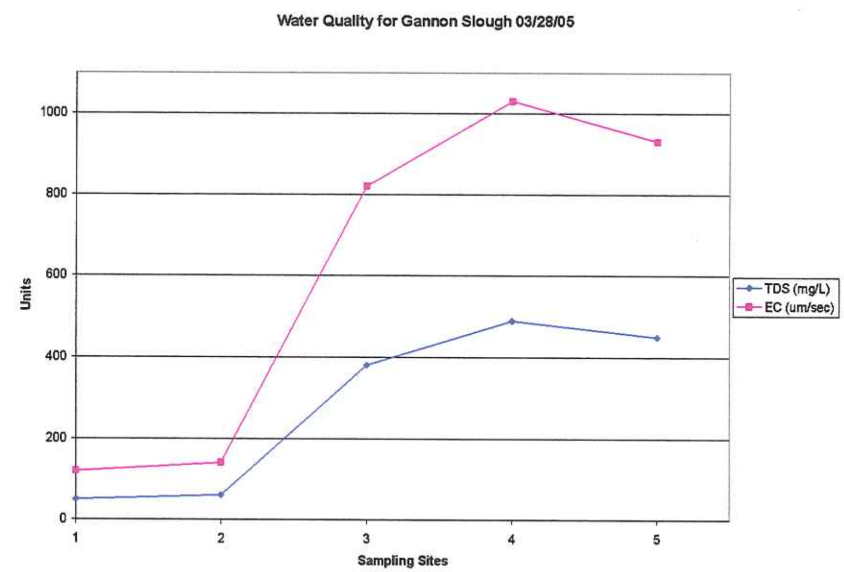
350
400
450
1
2
3
4
5
6

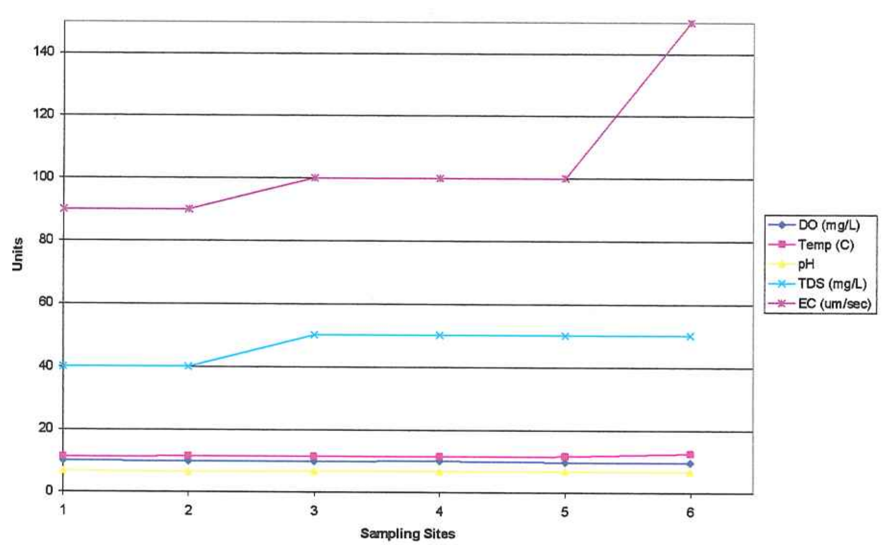

Water Quality for Campbell Creek 03/28/05
Units
Sampling Sites
DO (mg/L)
Temp (C)
pH
0
2
4
6
8
10
12
14
16
18
20
1
2
3
4
5
6


Water Quality for Campbell Creek 03/28/05
Units
Sampling Sites
TDS (mg/L)
EC (um/sec)
0
50
100
150
200
250
300
1
2
3
4
5
6

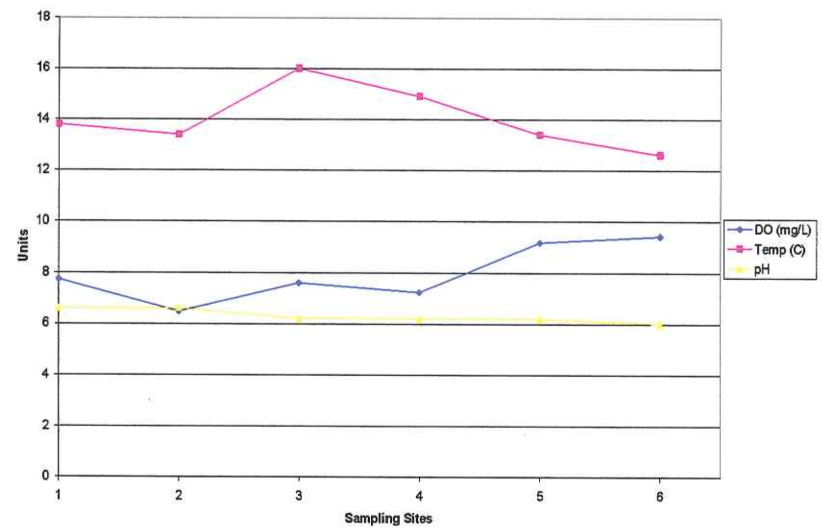

Water Quality for Gannon Slough 03/28/05
Units
14
12
10
8
6
4
2
0
1
2
3
4
5
Sampling Sites
DO (mg/L)
Temp (C)
pH


Water Quality for Gannon Slough 03/28/05
Units
1000
800
600
400
200
0
1
2
3
4
5
Sampling Sites
TDS (mg/L)
EC (um/sec)

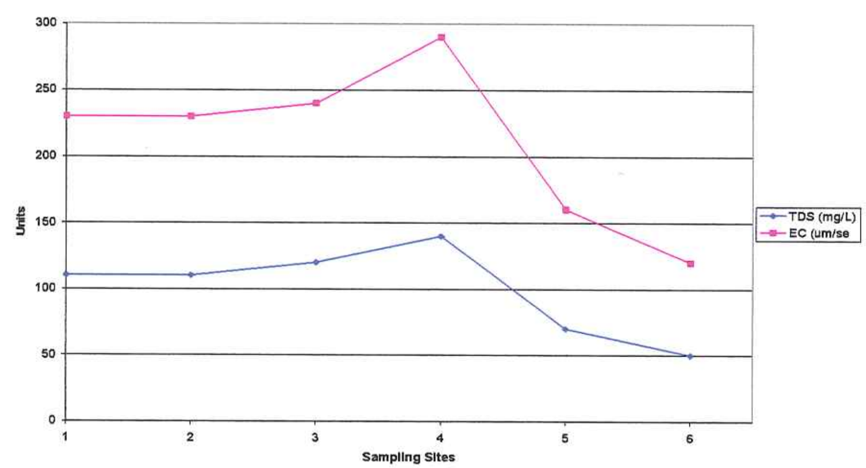
Water Quality for Bieth Creek 03/30/05

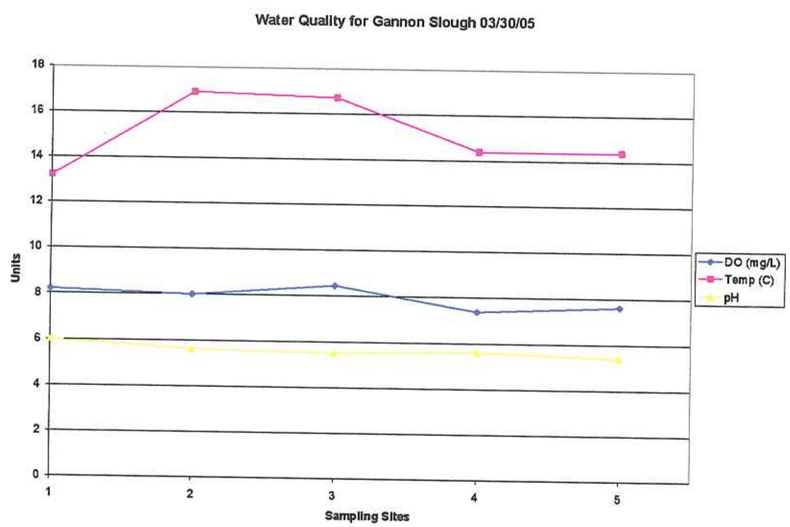


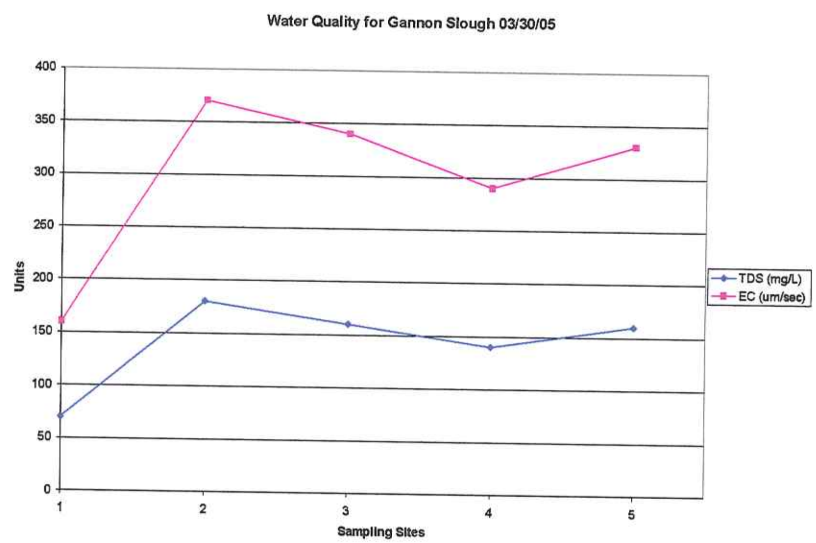
Water Quality for Campbell Creek 03/30/05



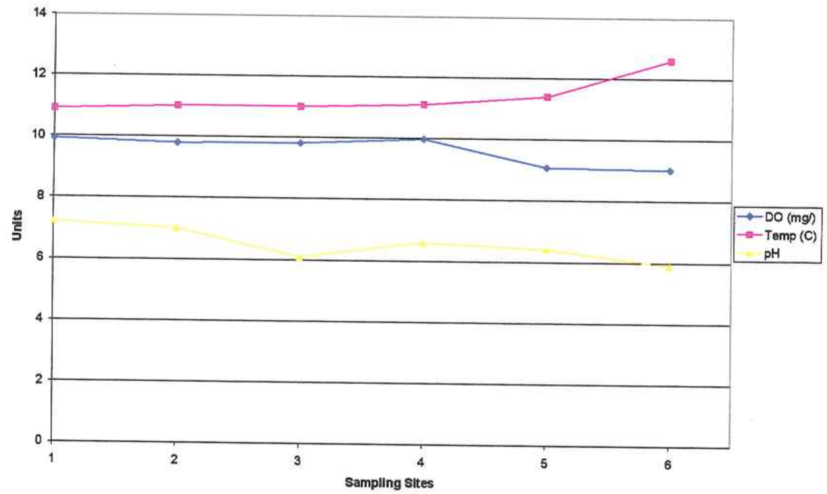
Water Quality for Campbell Creek 03/30/05



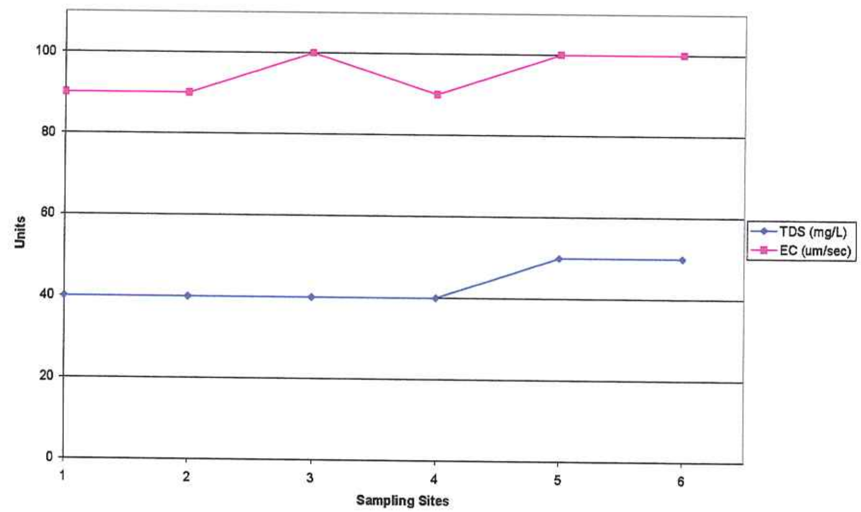

Water Quality for Gannon Slough 03/30/05
Units
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
Sampling Sites
DO (mg/L)
Temp (C)
pH


Water Quality for Gannon Slough 03/30/05
Units
400
350
300
250
200
150
100
50
0
1
2
3
4
5
Sampling Sites
TDS (mg/L)
EC (um/sec)

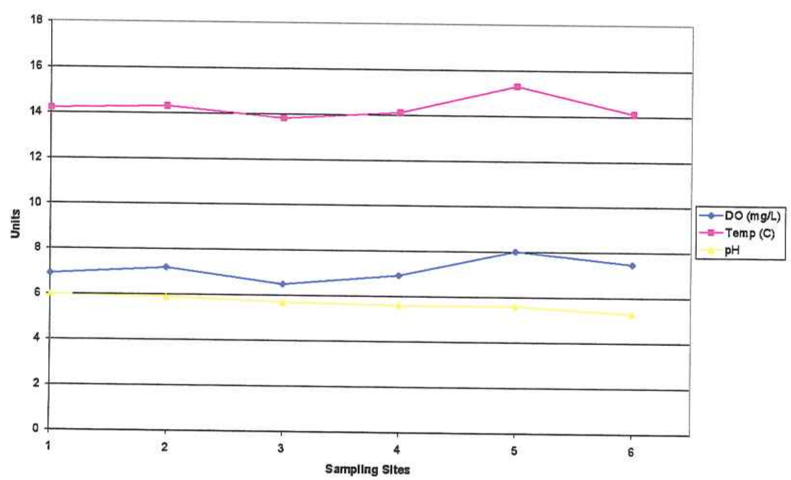
Water Quality for Bieth Creek 04/04/05



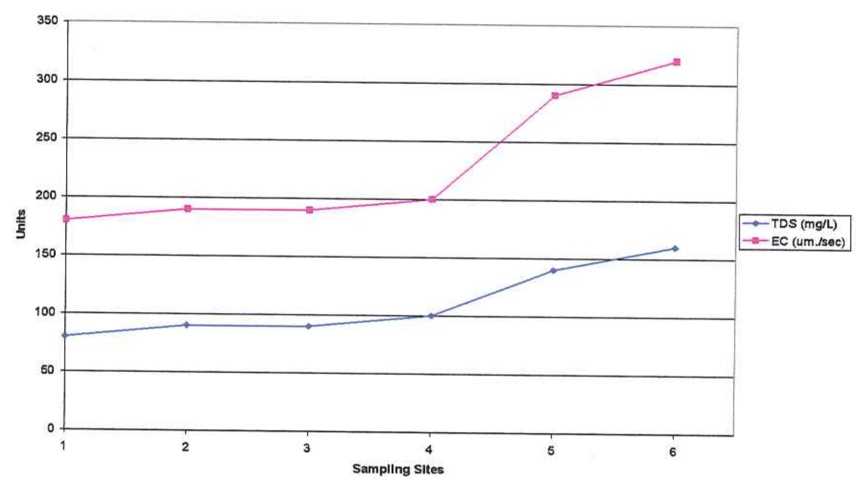
Water Quality Analysis for Bieth Creek 04/04/05

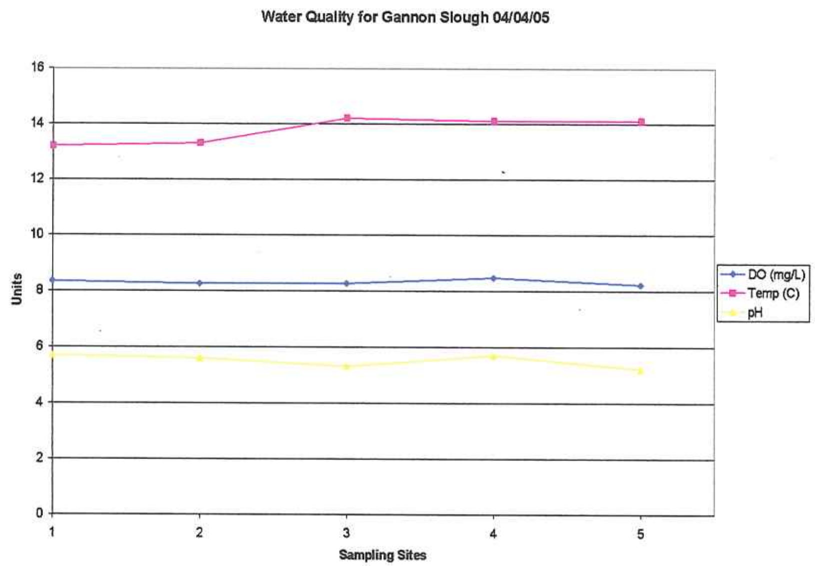


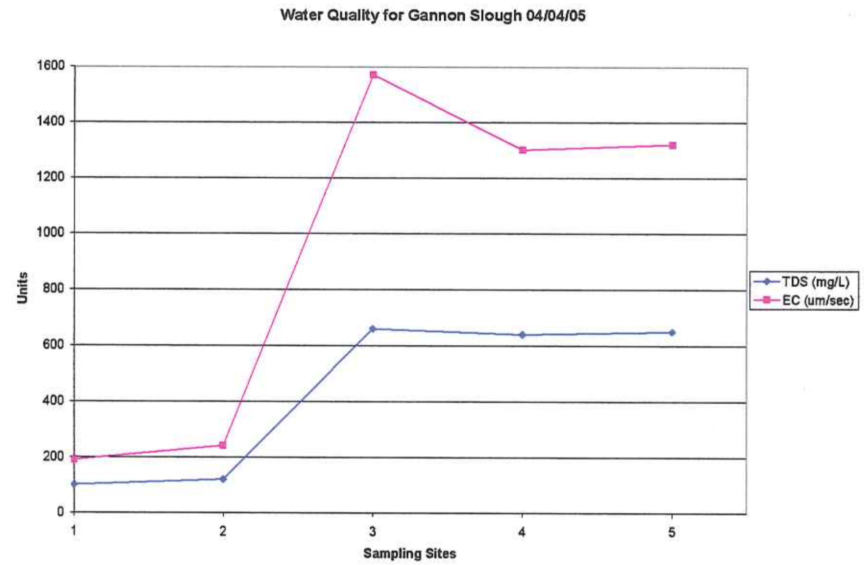
Water Quality Analysis for Campbell Creek 04/04/05



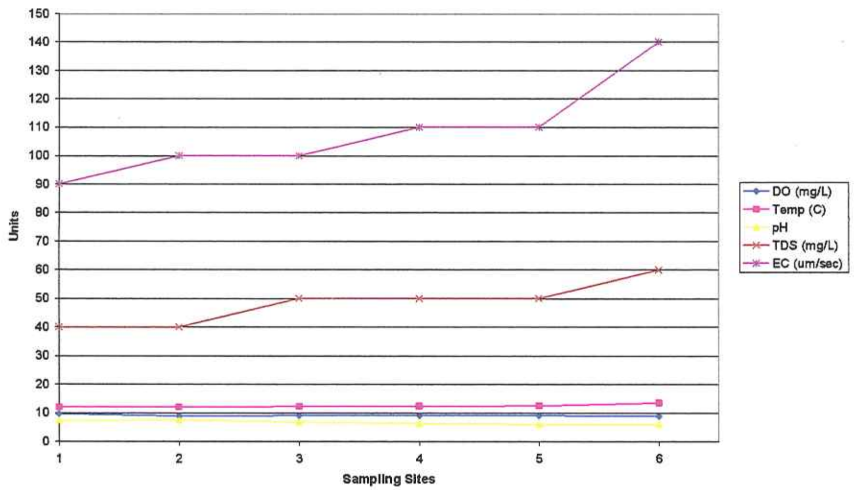
Water Quality Anaylsis for Campbell Creek 04/04/05



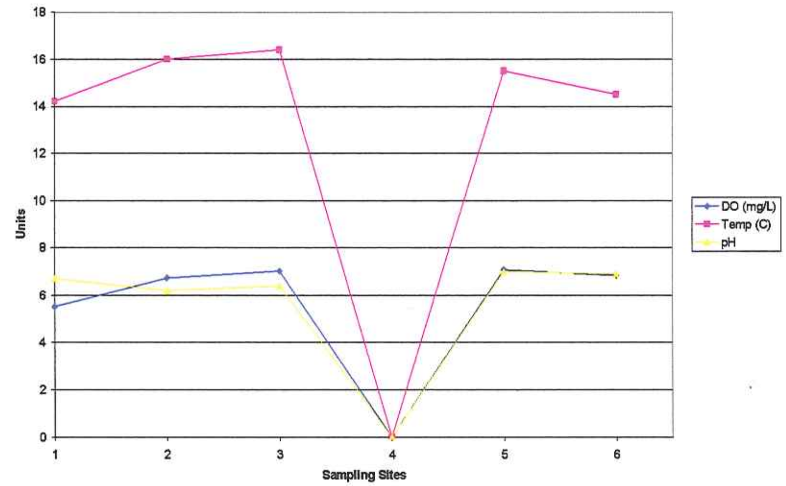

Water Quality for Gannon Slough 04/04/05
Units
16
14
12
10
8
6
4
2
0
1
2
3
4
5
Sampling Sites
DO (mg/L)
Temp (C)
pH


Water Quality for Gannon Slough 04/04/05
Units
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
5
Sampling Sites
TDS (mg/L)
EC (um/sec)

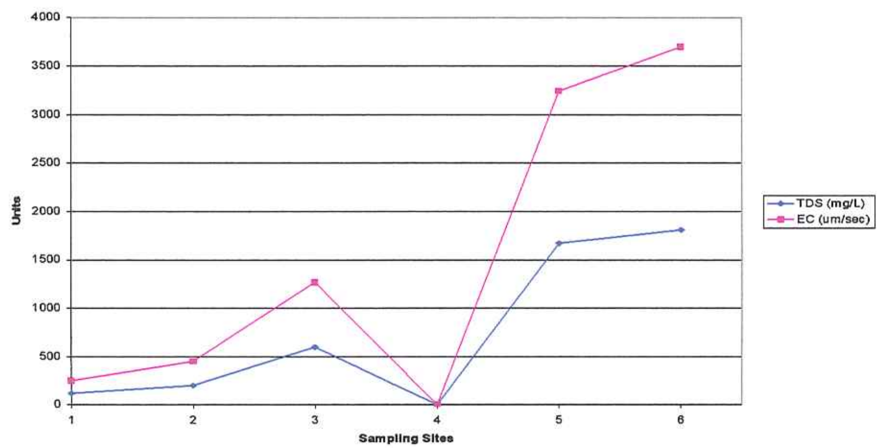
Water Quality Analysis of Beith Creek 04/11/05



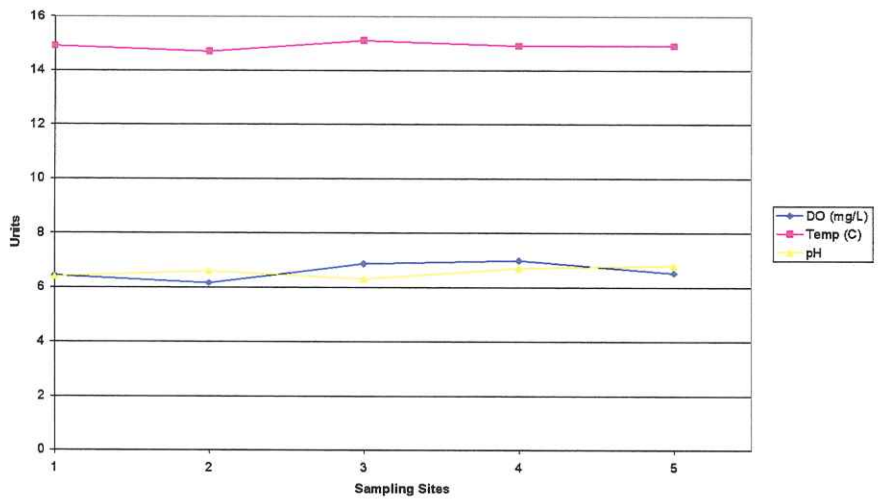
Water Quality Analysis of Campbell Creek 04-11-05



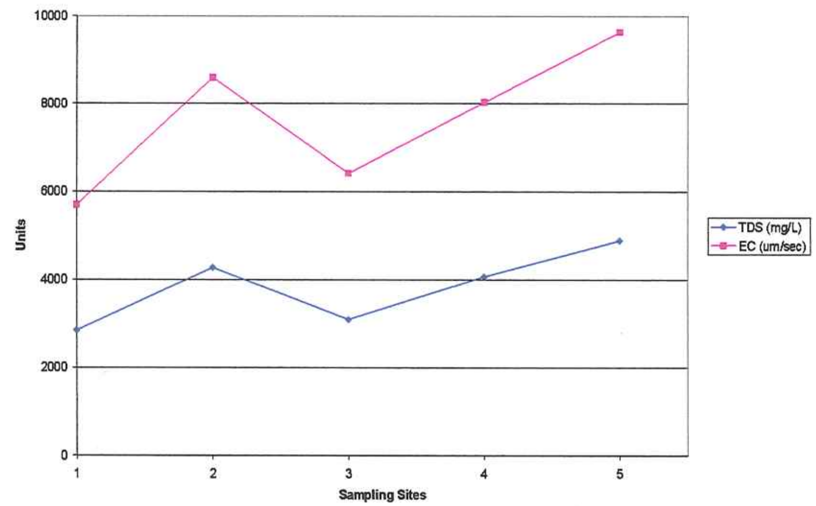
Water Quality Analysis of Campbell Creek 04-11-05



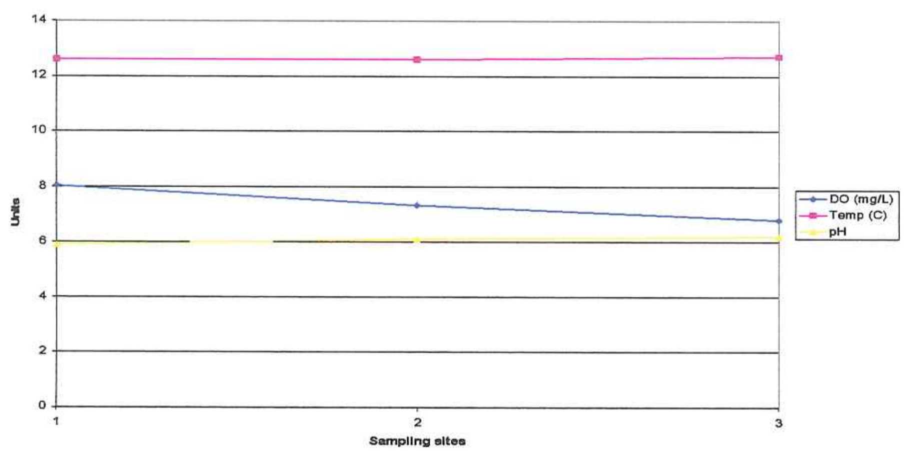
Water Quality Analysis for Gannon Slough 04-11-05



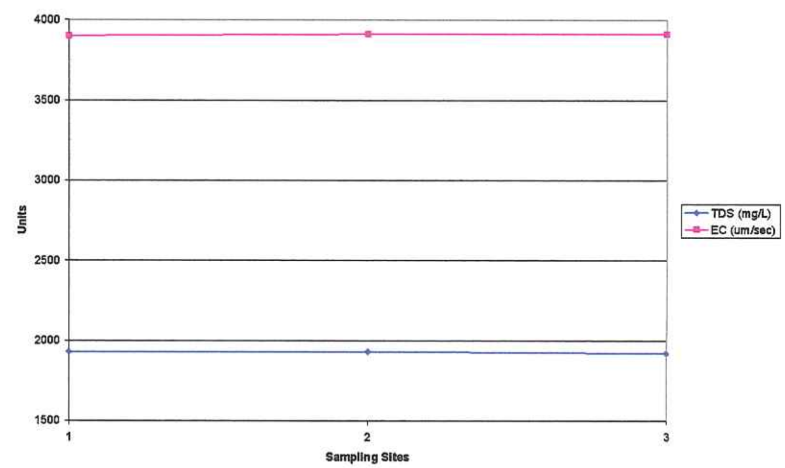
Water Quality for Gannon Slough 04-11-05



Water Quality Analysis for Gannon Slough 04-13-05



Water Quality Analysis for Gannon Slough 04-13-05



1/31/05   2:30 – 3:30 pm   (1 hr)

- We contacted Margret Lang to get background information
- Called Julie Neanders to get the scope of the project
  - Julie was unavailable so we left a message for her.

2/2/05   2:30 – 3:00 pm   (1/2 hr)

- We went to Julie Neanders office and left a message for her to get in contact with us.
- We described our project to the Receptionist at Arcata City Hall.

2/7/05   2:30 – 3:00 pm   (1/2 hr)

- Our group met and responded to an e-mail from Julie Neanders to set up an appointment to meet her.
- We discussed what we wanted to do with the project

City of Arcata Water Quality Project

Steven Smith
Jason Soto
Anne Murry

Gannon Slough Tide Gate Replacement Project

~ 72 hrs

[Key PW2 ES Key #4]

2/24/05 2:00 - 3:00 pm (1 hr)

- Met with Julie to go to sites.
- lower Campbell and Beith creek because upper is already being done
- Drove to sites to get coordinates of where we want to be
- Got PW2 key and lock
- Decided to set up markers at each site
- Julie told us we need to contact the Rancher that leases this land from Arcata before we go on land.
  - Dean Hunt
    - 499 - 2491 cell
  - Call couple days in advance
- Got some crude arial maps of the area from Julie
- Decided to do a walkthrough on Mon.
- Contacted Dean Hunt about walkthrough on Mon.
  - Said He wanted to meet us

2/23/05

on next page

2/9/05 2:00 - 2:30 pm (1/2 hr)

- We met and reviewed a similar project called The Dellavina Nature Area done by students from the same class.
- We decided to take weather observations each day we do sampleing
- Talked about researching other paired watersheds.
- Began formulating goals for project
- Set a meeting time with Julie for the following wed. at 2:00.

2/16/05 2:00 - 3:00 pm (1 hr)

- Met with Julie Neanders at Arcata City Hall
- Discussed possible sample sites and projects
- Decided on performing tests on Cambel creek, Beith Creek, and Gannon Slough for future tide gate replacement
- Set up appointment with Julie to go out to sites (Feb. 25th @ 2:00)
- Getting an access key to the fields next meeting

3/2/05 2:10 - 3:00 pm (50 min)

- Created final field checklist
- Emailed Julie about getting site stakes for permanent placement and private property access.
- Set up proposed sites according to maps
- Set up Tues. Morning and Wed. Afternoon test times in order to accomodate everyon.

3/9/05 2:30 - 5:00 pm (2½ hrs)

- 1st tests
- Performed stream tests on all sites
- Increased the amount of sites on all streams
- Found out we can use equipment on Mon. afternoon and changed our Tues. Morning testing time to Mon. afternoon

Last Pad

Switch date order

2/28/05 2:30 - 4:30 pm (2 hrs)

- Met Dean to show us around
- He gave us gate access code
  - [code 4343]
- Told Dean we would give him a copy of the finished paper and data
- We walked the creeks to see where we would set up sites.
- Decided to make a checklist for each field trip with specifics for tests.

2/23/05 2:00 - 2:30 pm (½ hr)

- Only Jason and Steve present
- Made a Rough draft checklist.
  - Salinity
  - Ph
  - D.O.
  - Conductivity
  - Turbidity
  - ? Stream height (Tides/Precip. Affect)
  - Time date
  - Tide/Moon
  - Weather
  - Precip

3/23/05 2:00 – 5:45pm (3 hr 15 min)

- Only Jason and steve
- We went to Arcata City Hall to pick up site stake markers.
- Performed all tests on all sites and placed stakes.
- Wrote Julie email telling her we needed 7 more stakes and that the PW2 still has not been moved back so we can get field access through the gate.

3/21/05 2:30 – 4:00 pm (1 1/2 hr)

- Only Steve and Anne present.
- Jason provided equipment, but had to leave before going in the field.
- Performed tests
  - Difficulties for the day
  - Access to Campbell was denied do to someone moving our lock off of the gate chain and the field was heavily flooded restricting some access to parts of Bieth Creek.
  - All tests were done on Gannon Slough
  - The 1st two sites and last site were done on Bieth

~~3/21/05~~

4/6 2:15 – 3:00 (45 min)

- We all met and split up work areas for the final Report.

4/8 10:00 – 11:30 AM (Steve only) (1 1/2 hr)

- Installed a 7 day trial of the program Keyhole onto my computer. ~~This was~~ The program gives detailed satelite images of areas around the globe. The only problem is that its detailed photos surround only major metropolitan areas unless I was to buy the entire program for $599. The images obtained were far to bad to use for the project.

3/28/05 2:15 – 5:00 pm (2 hr. 45 min)

- We went to the field and performed all tests on all locations
- This was our first high tide experience which made creek crossings very difficult.

3/30/05 2:00 – 4:30 (2 1/2 hr)

- We went to the field and performed all tests on all locations.
- Before testing Jason calibrated one of the measuring tools to see if it was working correctly. Readings stayed constant.

4/4/05 2:00 – 4:30 (2 1/2 hr)

- We went to the field and performed all tests on all locations.
- We emailed Julie & Neander about receiving more stakes to mark our unmarked sites. Also to get the gate and lock situation fixed so we no longer have to jump the fence.

(45min)

4/17/05 4:00 — 4:45 pm

- We all met at the HSU library to discuss and organize papers
- Divided up work and research aspects of the Report.
- Discussed how to write a proper report for city of Arcata and report for class.
- Set up meeting time with Julie Neander for Wed. at 2:00
- Need to talk to Dick about paper on mon.

(2hr)

4/10 6:30-8:30 PM
Anne entered all data info into Excel spreadsheets

(1/2hr)

4/11 11 - 11 1/2 AM
Anne spoke with Julie on Background info for paper

(1hr)

3/28 10-11 PM
Anne worked on weighing alternatives and those were revised and edited by Steve.

(3hr 20min)

4/11 2:10 — 5:30
- Jason provided us with the sampling tools, but had to leave for an appointment.
- Anne and Steve performed all tests on all sites.

(2hr 45min)

4/13 2:00 — 4:45
- All of the group planned and talked about information we needed to make the final report.
- We went to City Hall to get background information
- We then took samples on only the last three test sites on Gannon Slough due to field flooding and high tide.

4/23/05 8:30 – 9:15 AM (45min)

- Steve went to the City of Arcata Web page and copied and croped arial photos to make maps for the report and locate unmarked testing sites.

4/24/05 5:00 – 8:00PM (3hr)

- We all met at HSU library and worked on various parts of the Report in order to begin putting together a final copy

4/25/05 2:30 – 4:30 (2hr)

- We all met at the Gist computer lab and worked on the final lab report.

4/18/05 2:00 – 4:45 Pm (2hr 45min)

- Steve Anne & Jason discussed project layout with dick.
- Jason got background info from Dr. Brenamin
- Steve and Anne started formatting and putting together final report.

4/18/05 8:30 – 10:30 (2hr)

- Steve looked up information on Creeks
- Steve began typing introduction to Lab write up.
- Jason began typing materials and methods.

(4hr)

5/2/04 4:00 – 8:00pm
Entire group met and finished the lab report document. Worked on our presentation also.

5/3/04 7:00 – 9:00pm (2hr)
Entire group met and finished the power point presentation. We also had all three documents bound to hand out.

03-09 – 04-14
- every monday & wednesday Jason nomar got all the materials needed for the study.

04-18 - start typing out materials and methods. 3:00 – 5:00 p.m (2hrs)

04-20 - Compiling results & data into tables & graphs. worked on formatting results. (3hrs)

(1/2 4hr)

4/27/05 2:30 – 7:00
Steve and Anne worked on compiling, and formatting all data into final report for all parties involved.

4/29 6:30 – 10:00 (3hr)
Anne edited and revised report for City and Dick

4/29 9 – 9:30 (1/2hr)
Anne phoned Dean and Julie for presentation information -

5/1/05 7:00 – 9:00 (2hr)
- Anne and Steve met at HSU library to work on final paper and power point presentation.

04-21 - Meeting w/ Dr. Brenneman @ wastewater treatment plant. Discussed results & data. Re-calibrated machines for future use. 12:00 - 3:00 p.m (3hrs)

04-25 - Worked on final graphs (2 hrs)

04-26 - finalized materials & methods and discussion. 10:00 - 2:00 (4hrs)