

Teck Duck Pond Operations Real-Time Water Quality Monitoring Network Annual Report 2011

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Government of Newfoundland & Labrador
Department of Environment and
Conservation
Water Resources Management Division

Acknowledgements	2
Section 1.0 Introduction.....	3
Section 2.0 Maintenance and Calibration.....	6
Section 3.0 Discharge from Polishing Pond.....	7
Section 4.0 Data Interpretation.....	9
4.1 Tributary to Gills Pond Brook Station (NF02YO0190).....	9
4.2 East Pond Brook Station (NF02YO0192).....	16
4.3 Well after Tailings Dam Station (NF02YO0193).....	22
Section 5.0 Quality Assurance / Quality Control (QA/QC) Measures	26
Section 6.0 Conclusions.....	30
Section 7.0 Path Forward.....	31
Section 8.0 References.....	33

Acknowledgements

The Real-Time Water Quality Monitoring Network at Teck Duck Pond Operations is successful in tracking emerging water quality issues due to the hard work and diligence of individuals from three different organizations. The management and staff of Teck Duck Pond Operations work in cooperation with the management and staff of the Department of Environment and Conservation (ENVC) as well as Environment Canada (EC) to ensure the protection of ambient water resources in the vicinity of the mine and mill.

At Teck Duck Pond Operations several staff members including General Manager Bob Kelly have assisted in ensuring that the real-time system is operating such that data are reliable and accurate. Boyd Gulliford, Jill Kelly, Carol-Ann Hayden, and Robert Vaters have provided valuable assistance with the stations and feedback from time to time.

Various individuals from the Department of Environment and Conservation under the direction of Haseen Khan have been integral in ensuring the smooth operation of such a technologically advanced network. Robert Picco, Renée Paterson and Robert Wight played the lead roles in coordinating and liaising between the major agencies involved, thus, ensuring open lines of communication at all times. Robert Wight was responsible for the data management/reporting, troubleshooting, along with ensuring the quality assurance/quality control measures are satisfactory. Throughout the year, Robert travelled to Teck Duck Pond Operations sometimes twice monthly to maintain and service the equipment and troubleshoot any technical problems as they arose. Paul Neary and Leona Hyde have worked on the communication aspects of the network ensuring the data is being provided to the general public on a near real-time basis through the departmental web page.

Staff of Environment Canada (Water Survey Canada) under the management of Howie Wills play an essential role in the data logging/communication aspect of the network. Brent Ruth, Roger Ellsworth, Perry Pretty, Dwayne Ackerman, and Mike Ludwicki visit the site several times throughout the year to ensure the data logging equipment is operating properly and transmitting the data efficiently. They play the lead role in dealing with hydrological quantity and flow issues.

All individuals from each agency are fully committed to maintaining and improving this network and ensuring it provides meaningful and accurate water quality/quantity data that can be used in the decision-making process. This network is only successful due to the open communication and high level of cooperation of all three agencies involved.

Section 1.0 Introduction

The Real-Time Water Quality Monitoring Network at Teck Duck Pond Operations began in 2006 when the property was being developed by Aur Resources Inc. This network forms part of a larger network of government run and government-industry partnership run real-time water quality stations throughout the Province. **Figure 1** depicts the Real-Time Water Quality Monitoring Network at Teck Duck Pond Operations in relation to the others on the island portion of the Province.

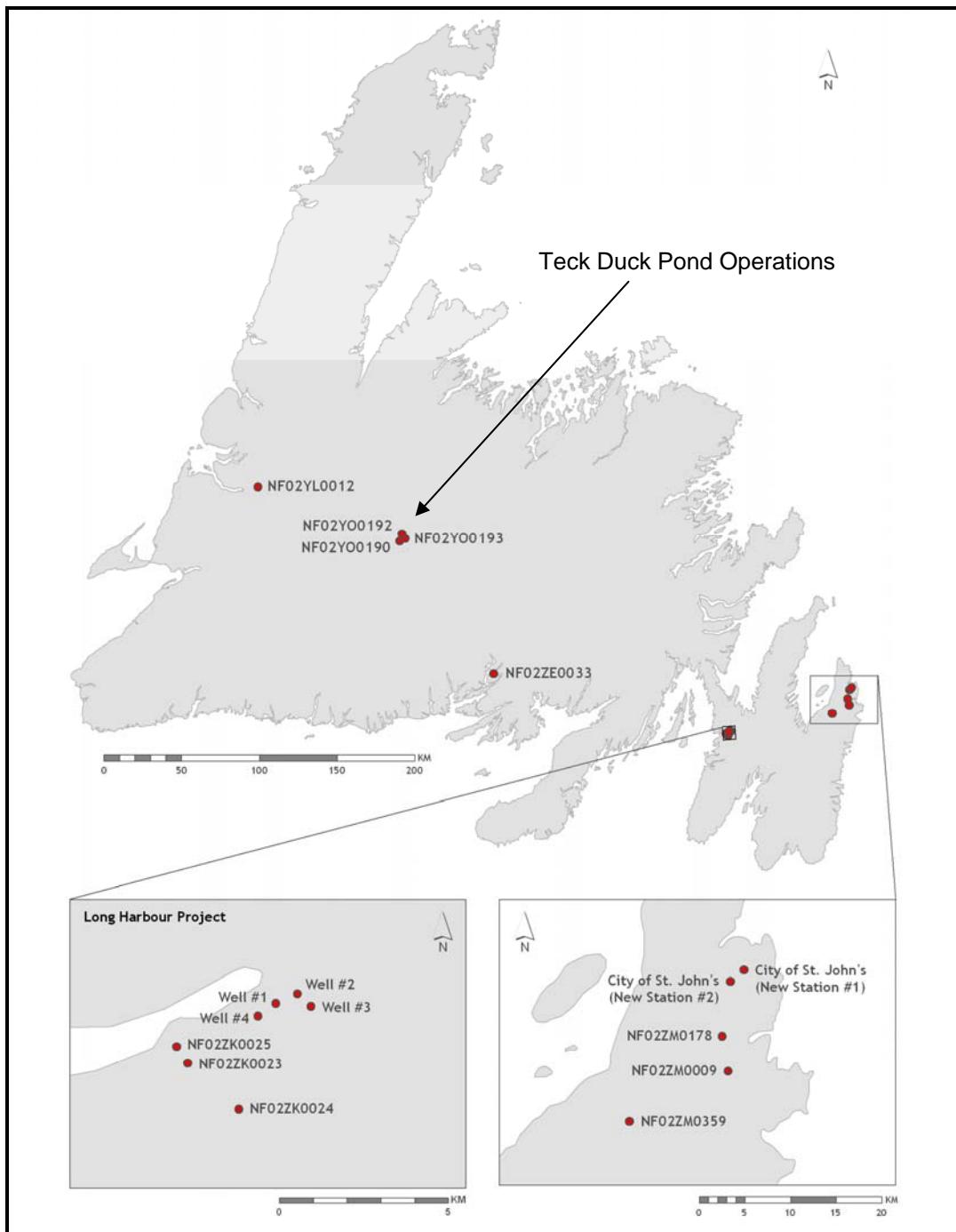
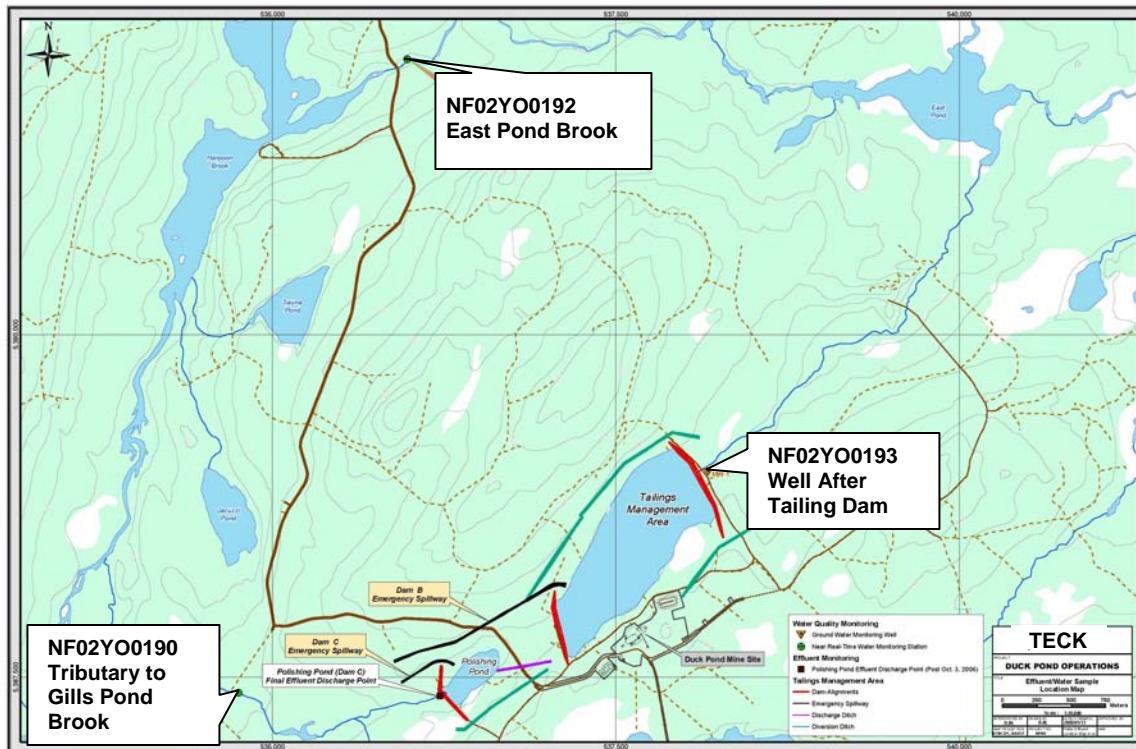


Figure 1: Real-Time Water Quality Monitoring Stations, Newfoundland

Three permanent stations (**Figure 2**) are established at Teck Duck Pond Operations; two in surface water streams and one in a ground water monitoring well:

- **Tributary to Gills Pond Brook Station (NF02YO0190)** is located 1700 m downstream of the final release point for the site's Tailings Management Area / Polishing Pond. This station is located such that any impacts from normal mine/mill discharge on receiving waters can be measured. This station has been fully operational since May 10, 2006 during the mine/mill construction phase.
- **East Pond Brook Station (NF02YO0192)** is located several kilometers downstream of the Tailings Management Area. This station is located such that any surface water impacts from the Tailing Management Area via seepage through Dam A may be measured. This station has been fully operational since September 7, 2006, during the mine/mill construction phase.
- **Monitoring Well After Tailings Dam Station (NF02YO0193)** is located approximately 100 meters below Tailings Dam A. This station is located such that any ground water impacts from the Tailing Management Area via seepage through Dam A may be measured. This station has also been fully operational since September 7, 2006.



**Figure 2: Real-Time Water Quality Monitoring Stations
Teck Duck Pond Operations**

The two surface water stations (Tributary to Gills Pond Brook Station (NF02YO0190) and East Pond Brook Station (NF02YO0192)) are operated under a renewable cost-share agreement with Teck Duck Pond Operations. The operation of the ground water station (Monitoring Well After Tailings Dam Station (NF02YO0193)) is funded solely under the Canada-Newfoundland and Labrador Water Quality Agreement.

The objective of operating these stations is to provide an early warning of any potential or emerging water quality issues such that mitigative measures can be employed to ensure that discharge from Teck Duck Pond Operations meets all regulatory requirements and has minimal impact on the receiving waters and other water in proximity to the site.

It was initially intended to remove the instruments from the three stations during the winter months, as the instruments are prone to be damaged by freezing. Furthermore, initially, there was no discharge planned for the winter months. However, as the mine and mill have become operational, discharge from the site has been required outside the planned time frame of July through November. Accordingly, the instruments have been deployed continuously whenever possible throughout the year.

The instruments at Tributary to Gills Pond Brook Station (NF02YO0190) and East Pond Brook Station (NF02YO0192) were deployed nearly continuously throughout the year. During the winter months, they remained deployed for longer periods to minimize the risk of damage from freezing during deployment and removal. Up to this point in time no significant negative impacts on the instruments have been observed. During the remaining months, these instruments were removed approximately monthly for short periods, generally two days, to facilitate regular maintenance and calibration.

As Monitoring Well After Tailings Dam Station (NF02YO0193) freezes at surface, the instrument was deployed continuously over the winter months. Following regular servicing and calibration it was placed in the well on October 21, 2010, and remained deployed until May 3, 2011. However, due to a failed seal in the instrument, the instrument did not provide accurate data for part of this period. Inaccurate data have been removed from the data set. While the regular instrument was also out of service, a replacement instrument having the same technical specifications was deployed from May 12, 2011 to July 12, 2011. Following its return from the factory and after regular cleaning and calibration, the regular instrument was deployed on September 7, 2011 and will remain deployed until the spring of 2012. Although the regular instrument was deployed on September 7, 2011, there were no data transmissions until September 9, 2011 due to minor communications error. Past experience has indicated that this probe is very stable over the long term, thus deployments up to six months have been recommended by the vendor.

Presently, all instruments are **Hydrolab®** brand **DataSonde®** probes in the surface water stations and a **Quanta G®** probe in the ground water station. Normally, the same probe is deployed consistently at a given station. However, from time to time, an alternate probe, having the same technical specifications, may temporarily be substituted. Portable **Hydrolab®** brand **MiniSonde®** probes are used for QA/QC purposes.

From time to time there are transmission errors resulting in a loss of data through our satellite-based communications system. For the surface water-based instruments (**DataSondes®**) we have the ability to log the water quality data internally, and augment any missing data, particularly for periods of more than a few hours. This feature is not available on the ground water-based **Quanta G®** instrument. Any significant periods of missing satellite-based data which are augmented with internally logged data are noted in specific Deployment Period reports.

Section 2.0 Maintenance and Calibration

All staff involved in the installation, deployment, maintenance and calibration of these probes have undergone training and certification by **Hydrolab®**. Maintenance and calibration of these probes are undertaken in controlled conditions at the laboratory of the Department of Environment and Conservation in Grand Falls – Windsor. Maintenance and calibration procedures, specified by the equipment manufacturer are followed precisely, and all calibration values logged into a database. All replacement parts, reagents and calibration solutions used meet the manufacturer's specifications.

It is recommended that regular maintenance and calibration of the **DataSonde®** instruments take place on a monthly basis in order to ensure the accuracy of the data. Particularly during the warmer months, the sensors are prone to fouling from the accumulation of biofilm and other organic matter in the streams. **Quanta G®** instruments are intended for longer term deployments, with less frequent maintenance and calibration, as they may not be as subject to fouling in the well where temperatures are colder and water chemistry more stable. **Table 1** details the dates the instruments were installed and removed for maintenance and calibration in 2011. It is important to note that during the winter months instruments remained deployed for periods longer than a month to minimize the risk of damage from freezing during installation and removal. It has also been demonstrated that during the winter months, due to the colder temperatures, there is less fouling of the sensors, thus allowing them to remain accurate for longer periods of time.

Tributary to Gills Pond Brook Station (NF02YO0190)			
Deployment Period			
Installation Date (yyyy-mm-dd)	Removal Date (yyyy-mm-dd)	Days Deployed	Remarks
2010-11-30	2011-05-03	153	Winter deployment
2011-05-05	2011-07-12	67	
2011-07-14	2011-08-08	24	
2011-08-10	2011-09-16	36	
2011-09-20	2011-11-01	41	
2011-11-03			Ongoing winter deployment
East Pond Brook Station (NF02YO0192)			
Deployment Period			
Installation Date (yyyy-mm-dd)	Removal Date (yyyy-mm-dd)	Days Deployed	Remarks
2010-12-03	2011-05-03	151	Winter deployment
2011-05-05	2011-07-12	67	
2011-07-14	2011-08-08	24	
2011-08-10	2011-09-16	36	
2011-09-20	2011-11-01	41	
2011-11-03			Ongoing winter deployment
Monitoring Well After Tailings Dam Station (NF02YO0193)			
Deployment Period			
Installation Date (yyyy-mm-dd)	Removal Date (yyyy-mm-dd)	Days Deployed	Remarks
2010-10-21	2011-05-03	192	Winter deployment
2011-05-12	2011-07-14	63	
2011-09-07			Ongoing winter deployment

Table 1: Maintenance and Calibration Schedule

Section 3.0 Discharge from Polishing Pond

Under Provincial and Federal regulatory measurers, effluent from the mine's Tailings Management Area may be discharged (controlled release) through the Polishing Pond to receiving waters (Tributary to Gills Pond Brook) provided it meets stringent criteria. During 2011, there were 13 separate Discharge Periods. The number of days discharging each month and the Average Daily Discharge are summarized in **Table 2**.

Month 2011	# of Days Discharging	Average Daily Discharge (m ³ /day)
January	10	12108
February	0	0
March	0	0
April	5	14123
May	12	15376
June	28	10847
July	22	18797
August	11	16725
September	24	14237
October	27	15637
November	29	14742
December	25	15470

Table 2

Figure 3 illustrates the Total Daily Discharge from Polishing Pond in relation to the Stage or Water Level in the receiving waters, Tributary to Gills Pond Brook. Increases in Stage above normal baseline levels are quite evident during discharge periods. Other peaks are the result of significant precipitation/runoff events.

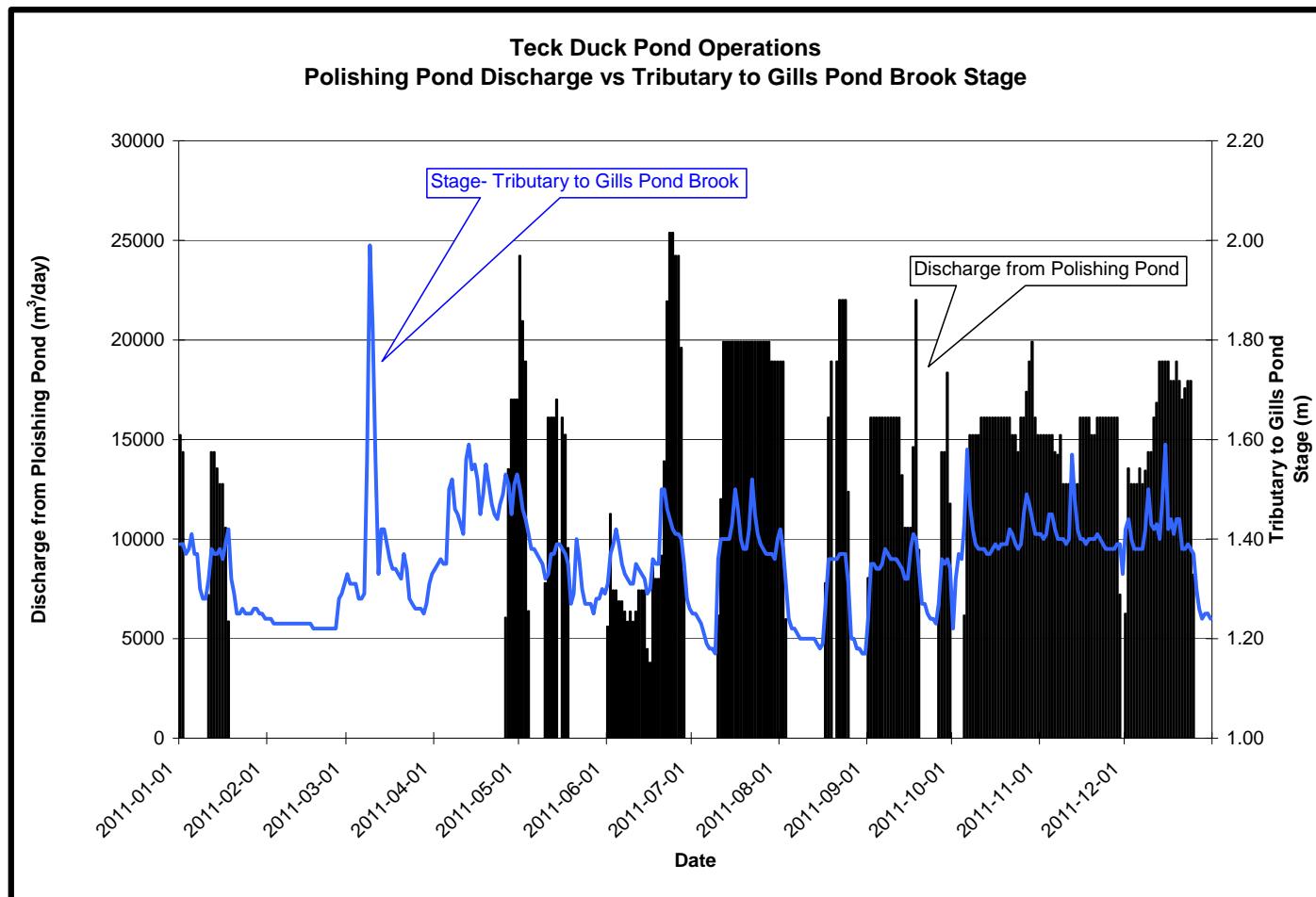


Figure 3

It is important to note, that while meeting the discharge criteria, the physical and chemical characteristics of the discharge water will be different than the receiving water. This will be evident in some of the parameters reviewed in Section 4.1.

Section 4.0 Data Interpretation

Section 4.1 Tributary to Gills Pond Brook Station (NF02YO0190)

Tributary to Gills Pond Brook Station is located 1700 m downstream of the final discharge point for the mine's Tailings Management Area - Polishing Pond. This station is located such that any impacts from the mine discharge on receiving waters can be measured.

The water temperature (**Figure 4**) ranged from a minimum of -0.44 °C to a maximum of 25.22 °C. In the winter months, under the cover of ice in the stream, temperatures were generally at or slightly below the freezing point. The highest temperatures were measured in July. The temperature profile for this stream is very similar to that of East Pond Brook (**Figure 10**). There are no obvious changes in temperature during discharge periods (**Figure 3**). Accordingly discharge from the Polishing Pond does not appear to have any significant impact on the water temperature at this station.

There is no recommended limit or range for water temperature.

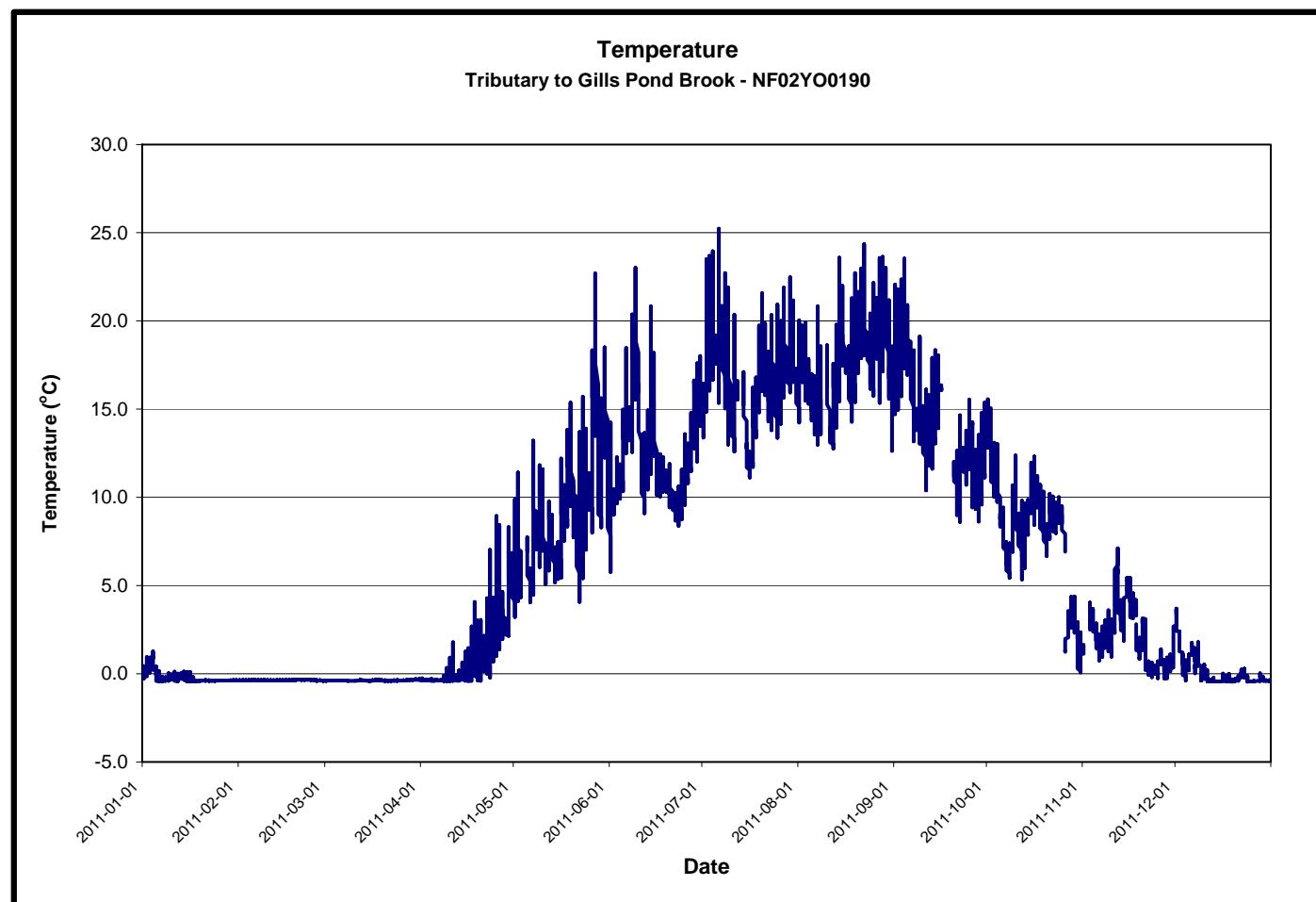


Figure 4

The pH (**Figure 5**) ranged from a minimum of 5.87 to a maximum of 7.49. The pH of this stream is naturally quite low, often being documented to be near or below the lower limit of the recommended range (6.5 – 9.0 – see colored lines on **Figure 5**) for the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*⁽¹⁾. It should be noted however, that discharge from Polishing Pond often has a pH higher than the natural background pH of the receiving waters. Thus, when there is discharge from Polishing Pond (**Figure 3**), there is generally an increased pH in the stream at this station, which often brings the water within the pH range recommended by CCME. The pH profile throughout the year is similar to East Pond Brook (**Figure 11**), except for the influences of the discharge periods.

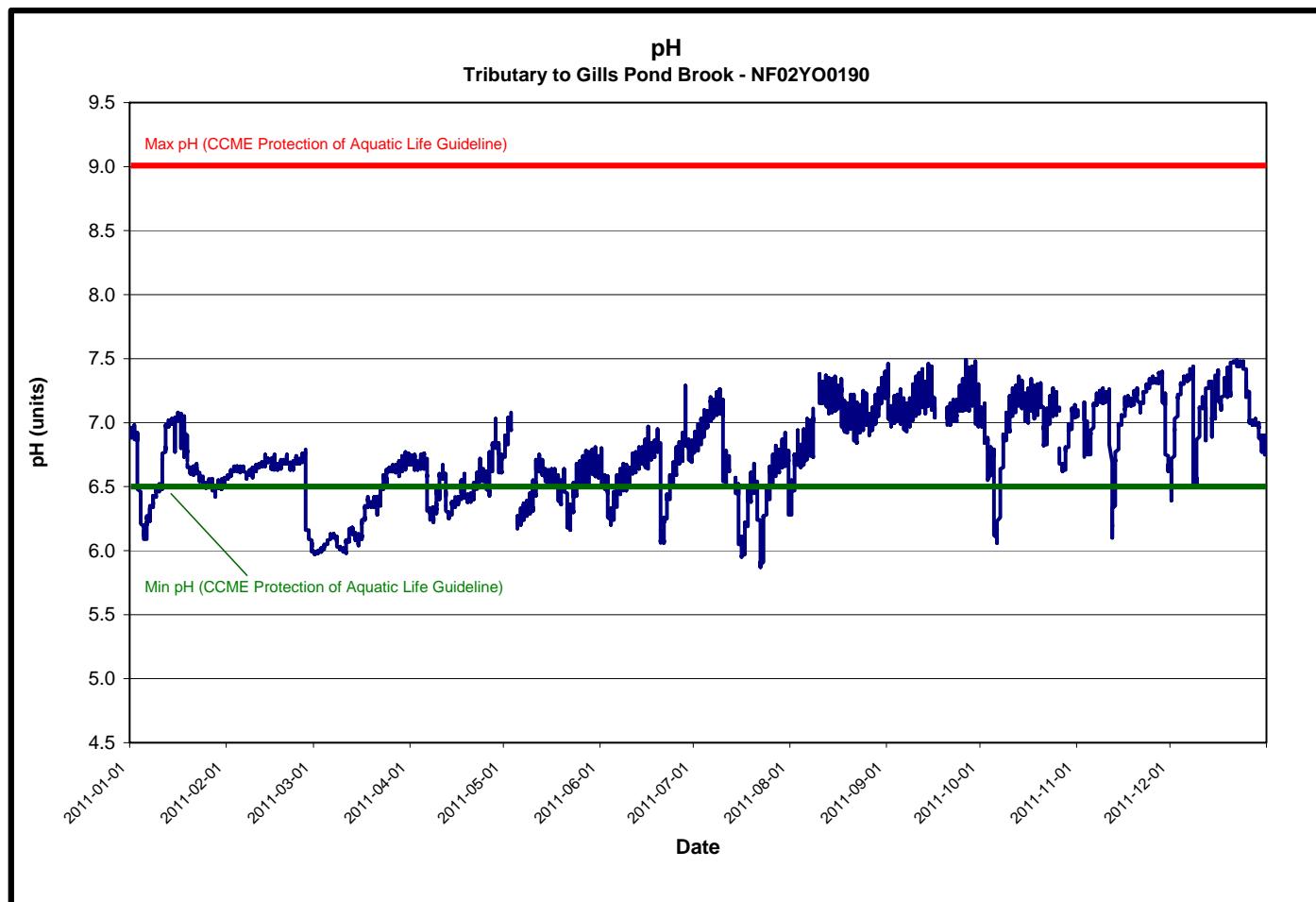


Figure 5

The specific conductivity (**Figure 6**) is affected by the amount of dissolved metals and salts in the water. Pristine waters in this part of the island generally have a specific conductance of less than 50 $\mu\text{S}/\text{cm}$. Outside the periods when there is discharge from Polishing Pond (**Table 2**), the specific conductivity in this stream would generally be quite low. During the past year, the minimum specific conductivity was measured to be 17.3 $\mu\text{S}/\text{cm}$. When there is discharge from the Polishing Pond, conductivity increases significantly, the highest value being measured to be 1193.0 $\mu\text{S}/\text{cm}$. The significant increases and decreases in specific conductivity correspond closely with the beginning and end of the discharge periods from polishing pond (**Figure 3**).

It is interesting to note, that specific conductivity dips, sometimes significantly, following periods of snowmelt or rainfall. Snowmelt and rainfall contributions to the stream's discharge would generally have an extremely low (approaching zero) background specific conductivity and would effectively 'dilute' water in stream. This is particularly more evident when there is discharge from the Polishing Pond.

There is no recommended limit or range for specific conductance, although it is a key indicator to the potential effects of the discharge from Polishing Pond.

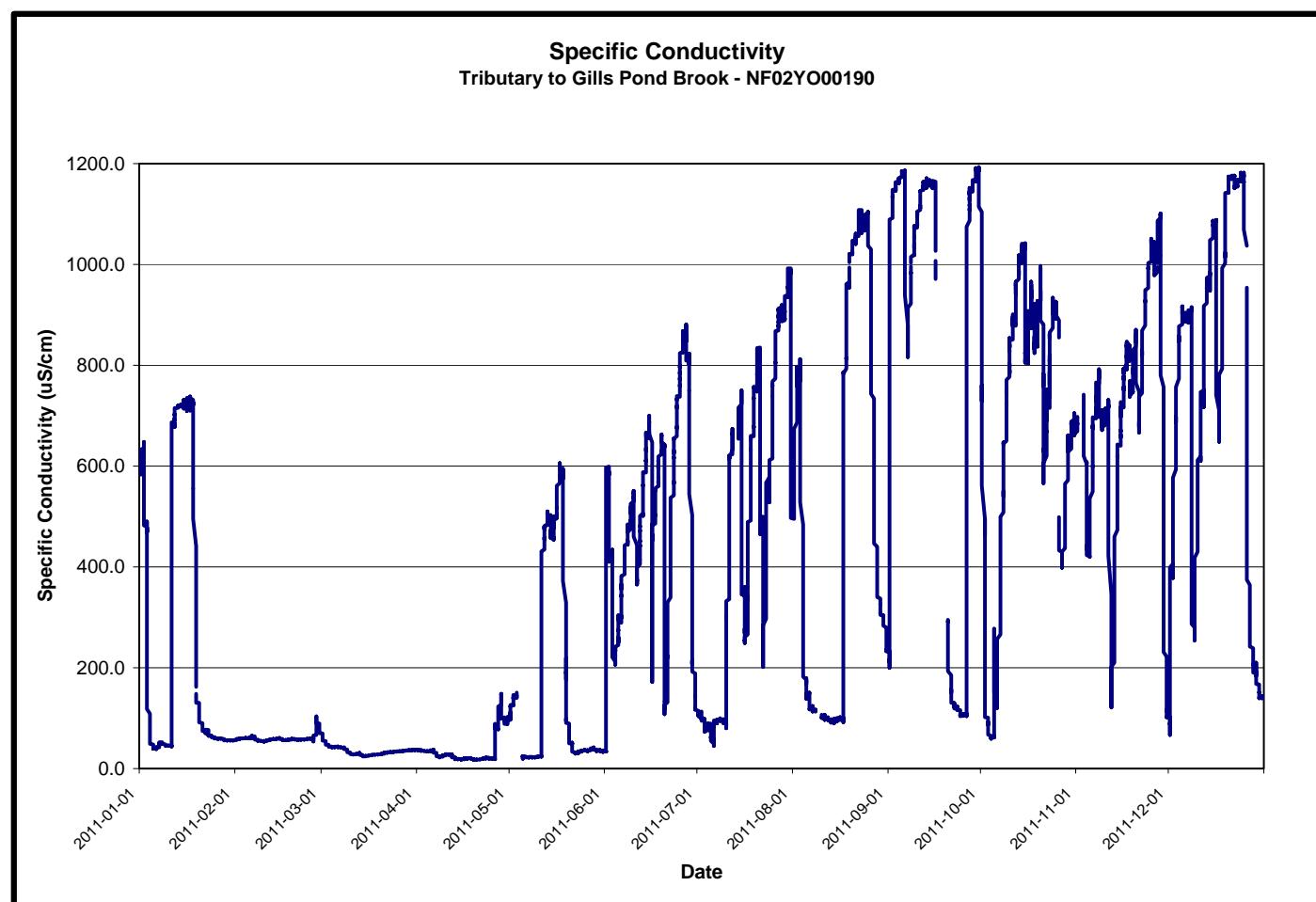


Figure 6

Dissolved oxygen (**Figure 7**) ranged from a minimum of 7.57 mg/L to a maximum of 14.38 mg/L. Generally, dissolved oxygen is inversely proportional to water temperature; this being evident in comparison to **Figure 4**.

There was a rapid and uncharacteristic drop in Dissolved Oxygen starting on March 1, 2011 (see red ellipse in the graph below). As a similar response is evident for East Pond Brook (**Figure 13**), it is assumed that this is related to some weather event, although none of the other parameters measured are as obviously affected. It is important to note that there was no discharge from the Polishing Pond into Tributary to Gills Pond brook at that time.

The CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*⁽¹⁾ for dissolved oxygen establish two separate lower limits for cold water biota: other life stages – above 6.5 mg/L; and early life stages – above 9.5 mg/L. While dissolved oxygen consistently remained above 6.5 mg/L, in the warmer months, it did not remain above 9.5 mg/L, the recommended lower limit for early life stage cold water biota. This is a function of the inverse relationship to the warmer water temperatures. During the period when dissolved oxygen was below 9.5 mg/L, the percent saturation (DO % Sat) remained in the normal range between 80 % and 100 %, indicating that the water was fully saturated with oxygen. In fact, the dissolved oxygen in waters in East Pond Brook (**Figure 13**) has a very similar profile. There does not appear to be any appreciable change in dissolved oxygen resultant from discharge from Polishing Pond.

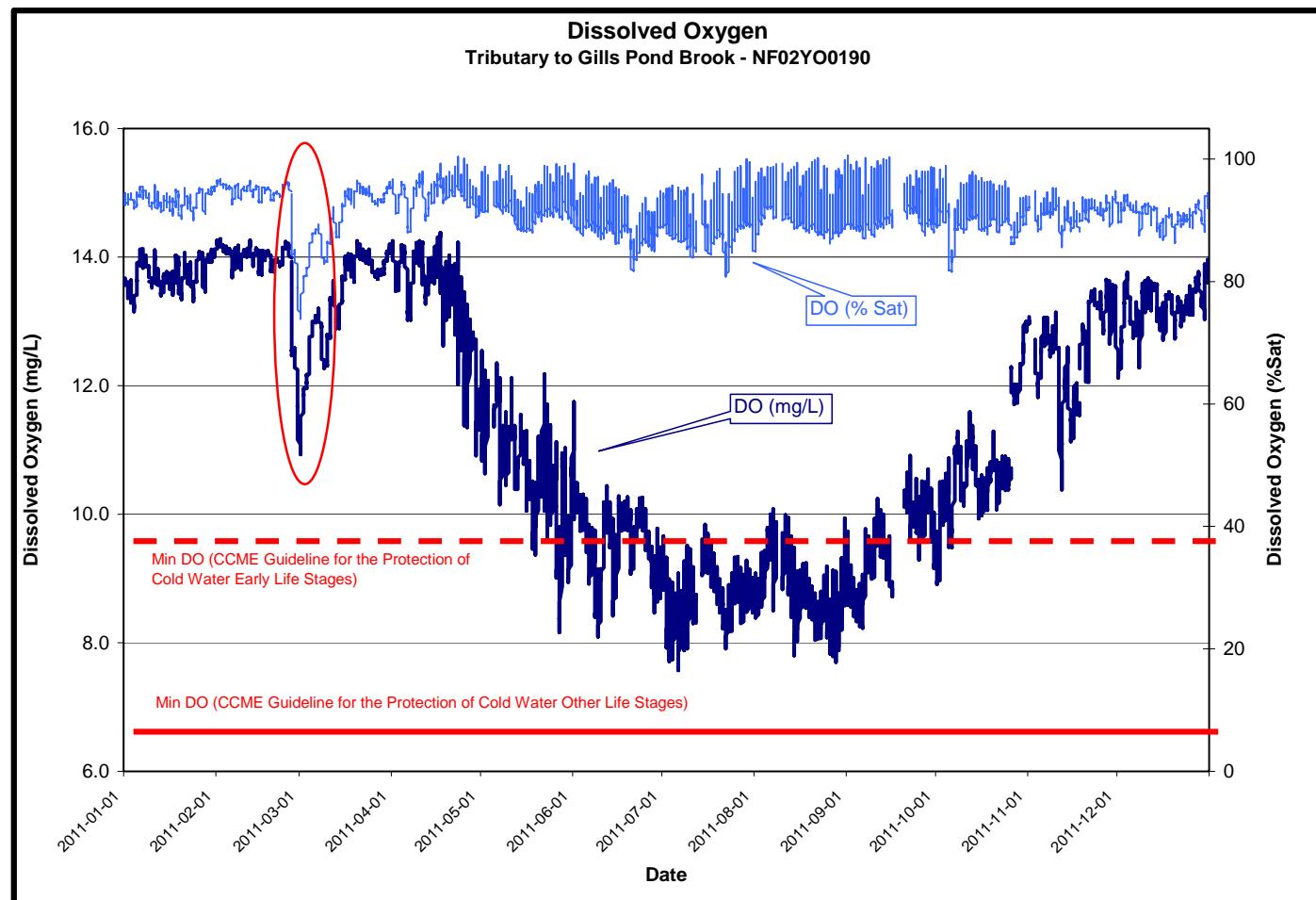


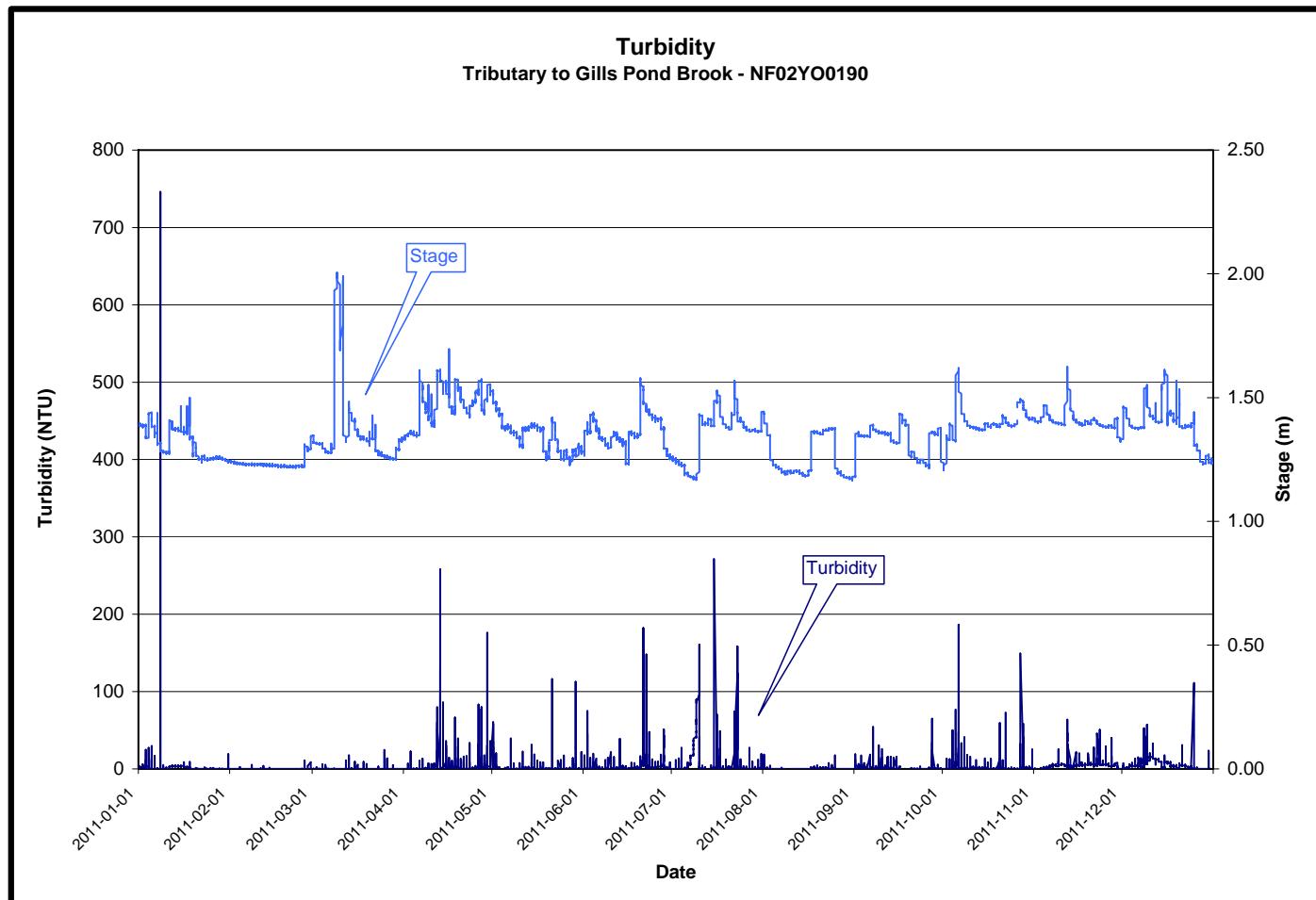
Figure 7

Turbidity (**Figure 8**) ranged from a minimum of 0.0 NTU to a maximum of 746.0 NTU. Minor and unsustained spikes are usually the result of natural debris passing over the sensor. On occasion on-line transmitted turbidity values were reported to be 3000 NTU. This number represents a system error in data transmission. Accordingly, these values have been removed and internally (**DataSonde®**) logged turbidity values substituted. During periods when there was no discharge from Polishing Pond, turbidity values were generally at or close to zero. The frequency and intensity of turbidity spikes was generally greater during discharge periods (**Figure 3**).

It has also been documented in the *Real Time Water Quality Report Duck Pond Operations (Teck Cominco Limited) Deployment Period 2008-10-16 to 2008-11-12*⁽²⁾ that at this location, air entrainment due to higher water velocities, and turbulent flow at higher stream discharges sometimes results in false-positive turbidity values. Accordingly, the on-line real time turbidity graph is annotated with the following comment: ‘Turbidity values may be exaggerated due to air entrainment (turbulent flow)’.

In 2011 the sensor was placed as far downstream of the plunge pool as possible to avoid the influences of turbulent water, and the introduction of air bubbles (air entrainment), which sometimes cause the false-positive readings. In fact, it has been demonstrated in *Real Time Water Quality Report, Duck Pond Operations (Teck Duck Pond Operations), Deployment Period 2011-08-10 to 2011-09-16*⁽³⁾, that during periods of no discharge, the turbidity is seldom measured above zero. However, given the limitations of the site (i.e. a small pool in a small tributary, which is subject to high flows, introduced from the discharge from Polishing Pond) there is little else that can be done physically. We will continue to monitor the situation, and test and employ any further mitigative measures which may be beneficial.

Throughout the year, particularly in the last quarter there were sustained periods where higher-than-normal turbidity was measured and visible in the stream. This has been documented with *in situ* measurements and water sample results collected by both staff of the Department of Environment and Conservation and Teck Duck Pond Operations. Accordingly, the higher-than-normal turbidity values (frequency and intensity) during the periods of discharge from Polishing Pond can not all be attributed to air entrainment due to high flows, but are influenced by the quality of water discharged from the Polishing Pond, and/or natural debris passing over the sensor. Any unusual turbidity measurements will continue to be investigated by staff of the Department of Environment and Conservation and/or Teck Duck Pond Operations.



The stage or water level (**Figure 9**) was recorded to be between 1.17 m and 2.01 m. The flow or discharge ranged from a minimum of 0.01 m³/s to a maximum of 2.48 m³/s. At this location, stage is referenced to an arbitrary bench mark. The highest stage was recorded in March, presumably due to the backwater effect from ice formation.

For the remainder of the year, however, stage and flow were within normal ranges, with the higher levels corresponding to periods of controlled release from Polishing Pond (**Figure 3**) and following snow melt and rainfall events.

The flow or discharge is calculated based upon a stage-discharge curve which is developed over time. There are periods during the year, when extreme high and low flows could not be calculated as they were outside the range of the existing curve.

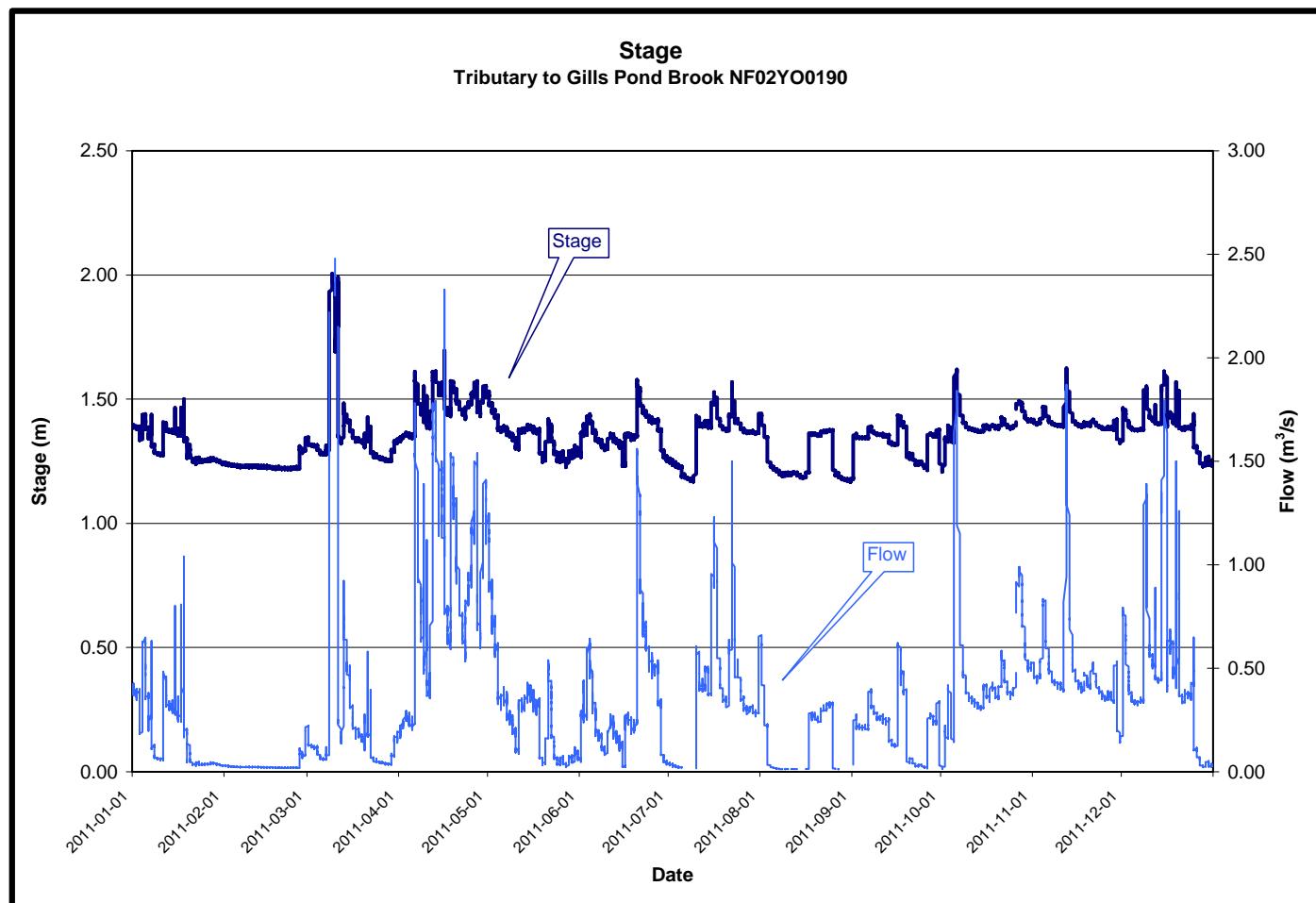


Figure 9

Section 4.2 East Pond Brook Station (NF02YO0192)

East Pond Brook Station is located several kilometres downstream of the Tailings Management Area. This station is located such that any surface water impacts from the Tailing Management Area via seepage through Dam A may be measured.

The water temperature (**Figure 10**) ranged from a minimum of -0.07 °C to a maximum of 25.54 °C. In the winter months, under the cover of ice in the stream, temperatures were generally at or slightly below the freezing point. The highest temperatures were measured in July through September. The temperature profile for this stream is very similar to that of Tributary to Gills Pond Brook (**Figure 4**).

There is no recommended limit or range for water temperature.

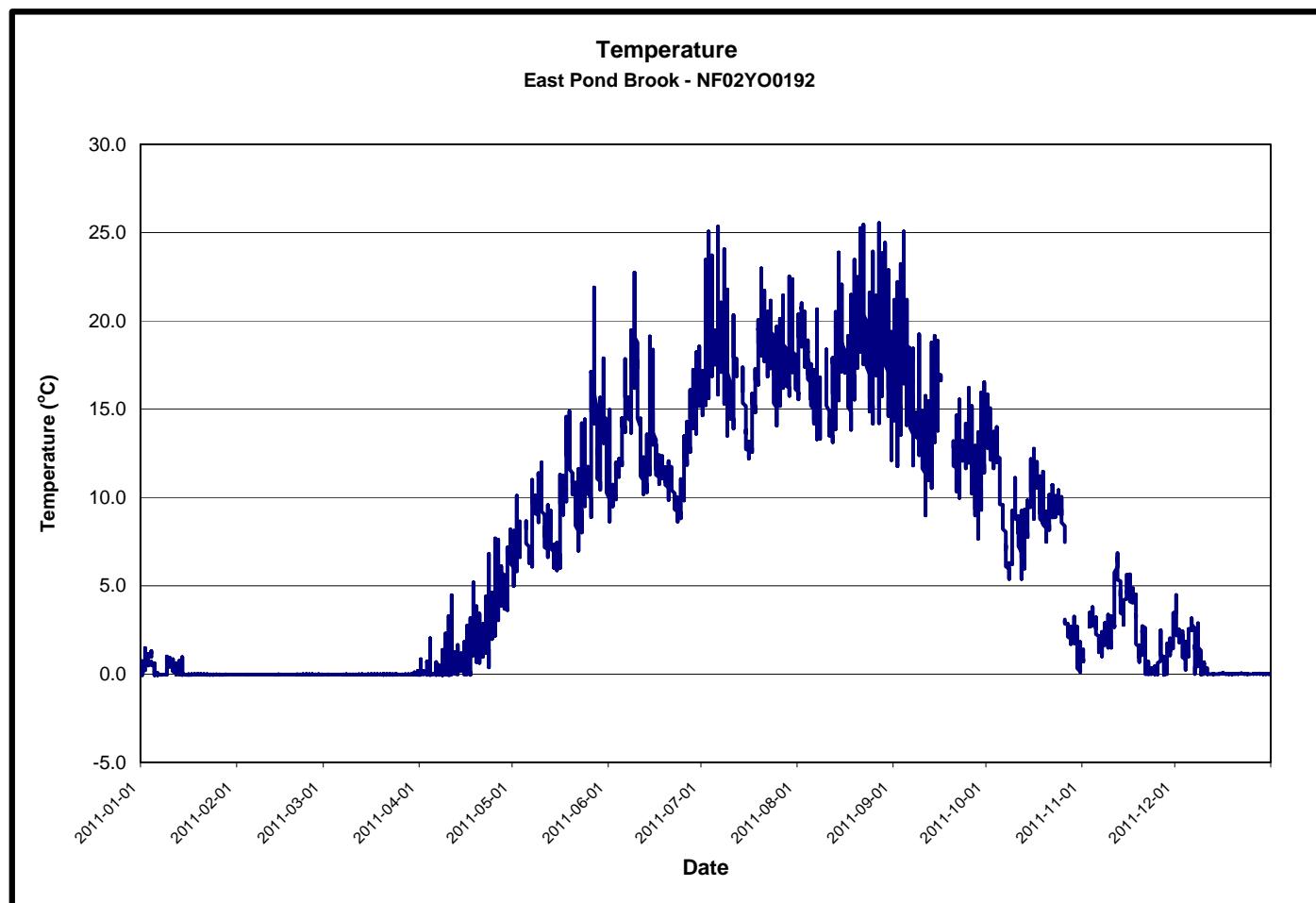


Figure 10

The pH (**Figure 11**) ranged from a minimum of 5.51 to a maximum of 7.06. The pH of this stream is naturally quite low, often being documented to be near or below the lower limit of the recommended range (6.5 – 9.0 – see colored lines on **Figure 11**) for the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*⁽¹⁾.

Variation in pH is influenced by a number of factors. For example, there is an inverse relationship with stage (**Figure 15**) which is influenced by snowmelt and precipitation, and a positive relationship with specific conductivity (**Figure 12**). All variations in pH appear to be due to natural influences.

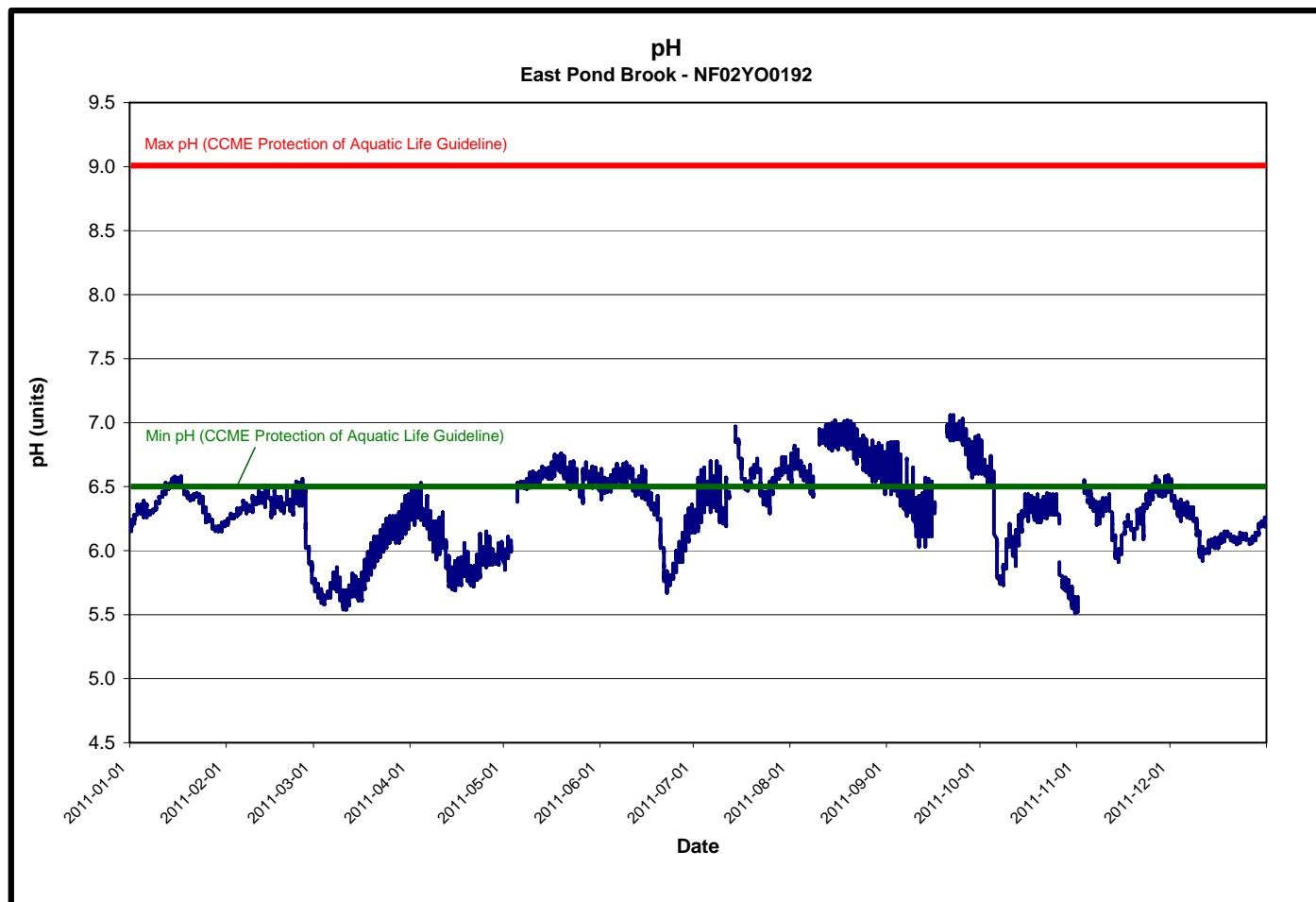


Figure 11

The specific conductivity (**Figure 12**) is affected by the amount of dissolved metals and salts in the water. Pristine waters in this part of the island generally have a specific conductance of less than 50 $\mu\text{S}/\text{cm}$.

During the past year, the specific conductivity ranged between 6.3 $\mu\text{S}/\text{cm}$ and 47.6 $\mu\text{S}/\text{cm}$. Specific conductivity shows a similar profile to pH (**Figure 11**) and an inverse relation to stage (**Figure 15**).

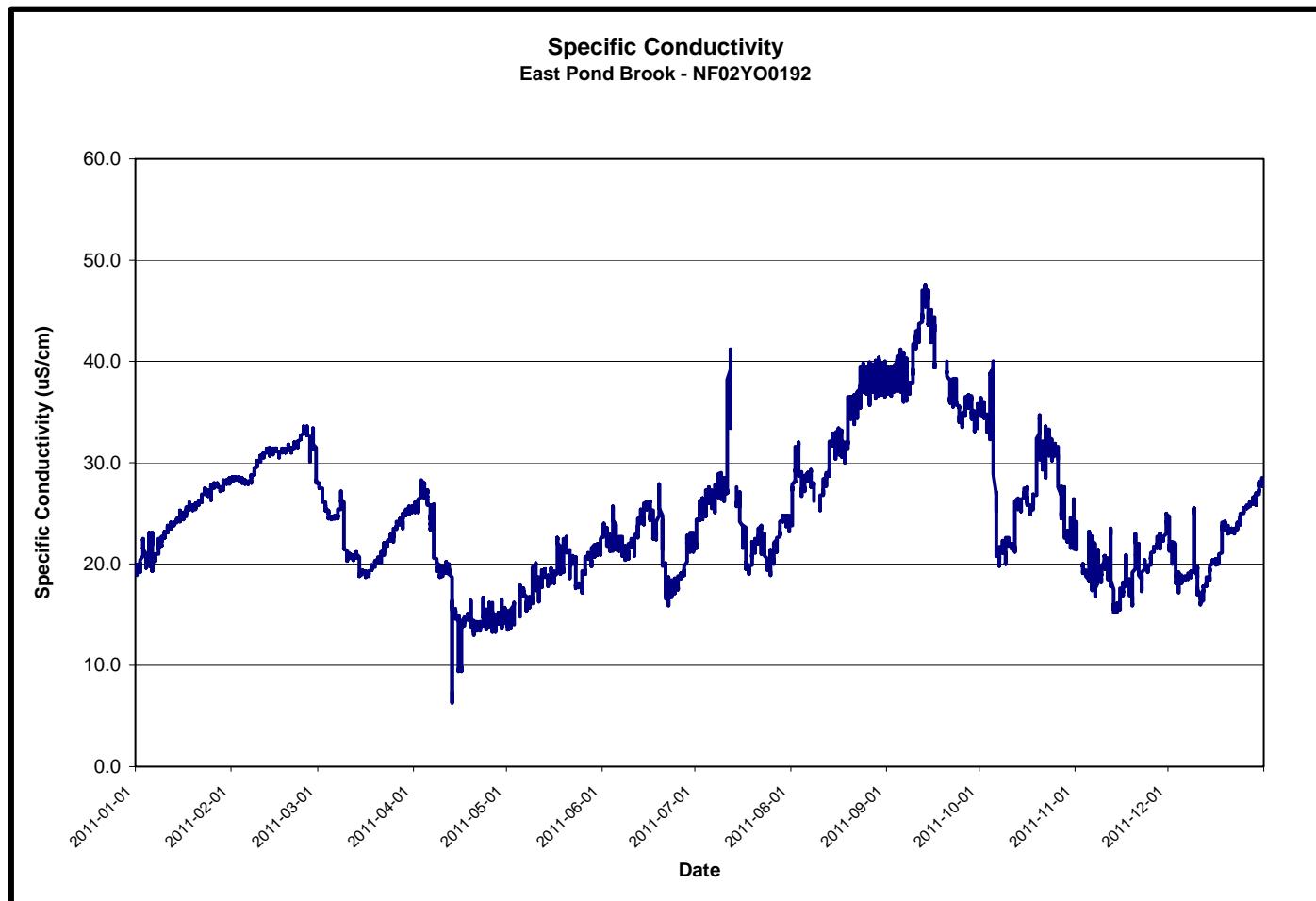


Figure 12

Dissolved oxygen (**Figure 13**) ranged from a minimum of 7.63 mg/L to a maximum of 14.06 mg/L. Generally, dissolved oxygen is inversely proportional to water temperature; this being evident in comparison to **Figure 10**.

There was a rapid and uncharacteristic drop in Dissolved Oxygen starting on March 1, 2011 (see red ellipse in the graph below). As a similar response is evident for Tributary to Gills Pond Brook (**Figure 7**), it is assumed that this is related to some weather event, although none of the other parameters measured are as obviously affected.

The CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*⁽¹⁾ for dissolved oxygen establish two separate lower limits for cold water biota: other life stages – above 6.5 mg/L; and early life stages – above 9.5 mg/L. While dissolved oxygen consistently remained above 6.5 mg/L, in the warmer months, it did not remain above 9.5 mg/L, the recommended lower limit for early life stage cold water biota. This is a natural function of the inverse relationship to the warmer water temperatures. During the period when dissolved oxygen was below 9.5 mg/L, the percent saturation (DO % Sat) remained in the normal range between 80 % and 100 %, indicating that the water was fully saturated with oxygen.

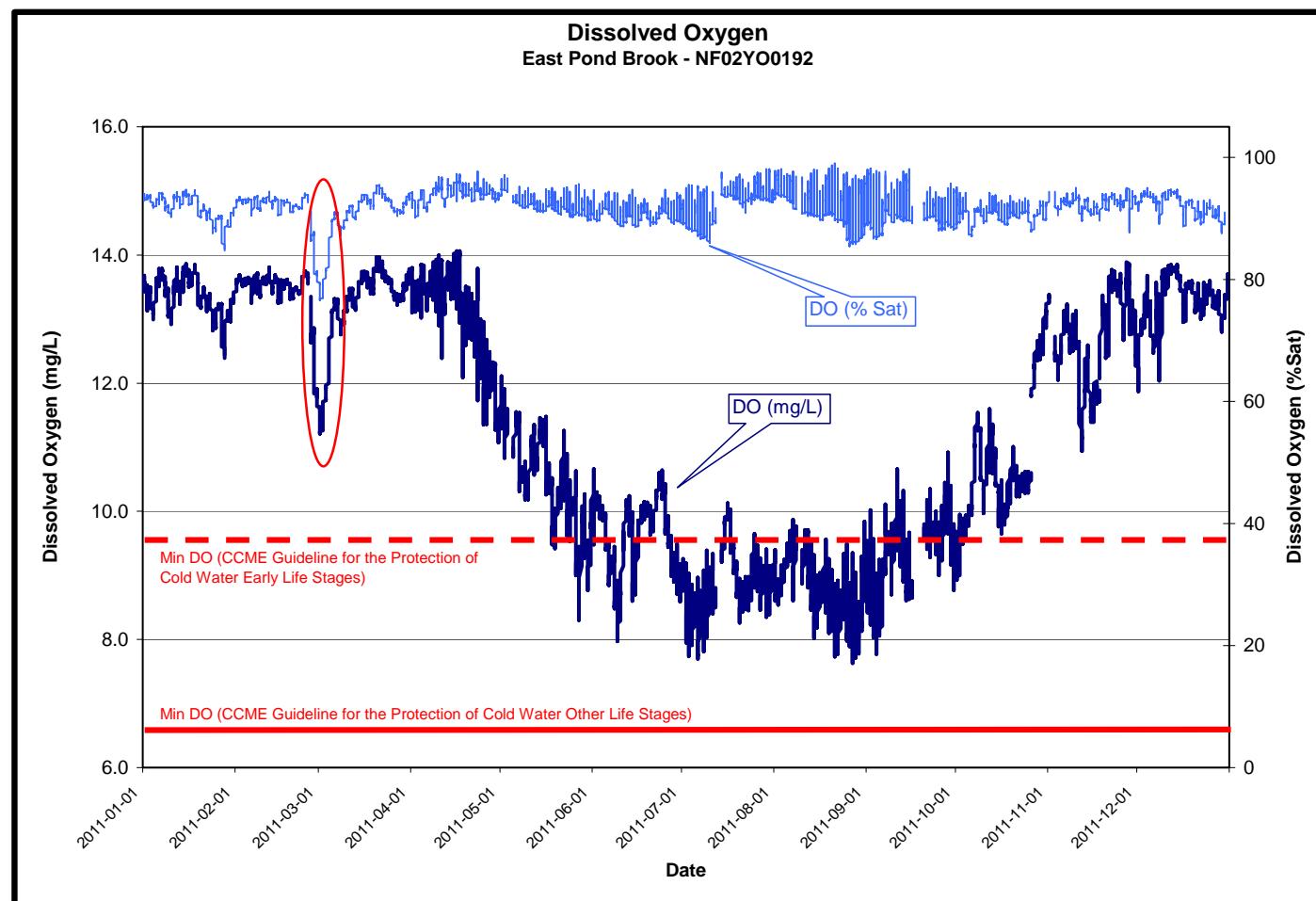


Figure 13

Turbidity (**Figure 14**) ranged from a minimum of 0.0 NTU to a maximum of 204.1 NTU. Generally, turbidity values in this stream are at or close to zero. Minor and un-sustained spikes are the result of natural debris and or air bubbles passing over the sensor. The cause of the turbidity peak in early July (up to 204.1 NTU) is unknown, but is suspected to have been leafy debris which cleared itself prior to the end of the deployment period.

On occasion on-line transmitted turbidity values were reported to be 3000 NTU. This number represents a system error in data transmission. Accordingly, these values have been removed and internally (**DataSonde®**) logged turbidity values were substituted. There were also a couple of occasions when leafy debris was noted to have been caught in the sensor, resulting in false-positive data. Data for these periods have been removed from the data set.

Throughout the year, high turbidity was not visible in the stream nor documented in any water sample results.

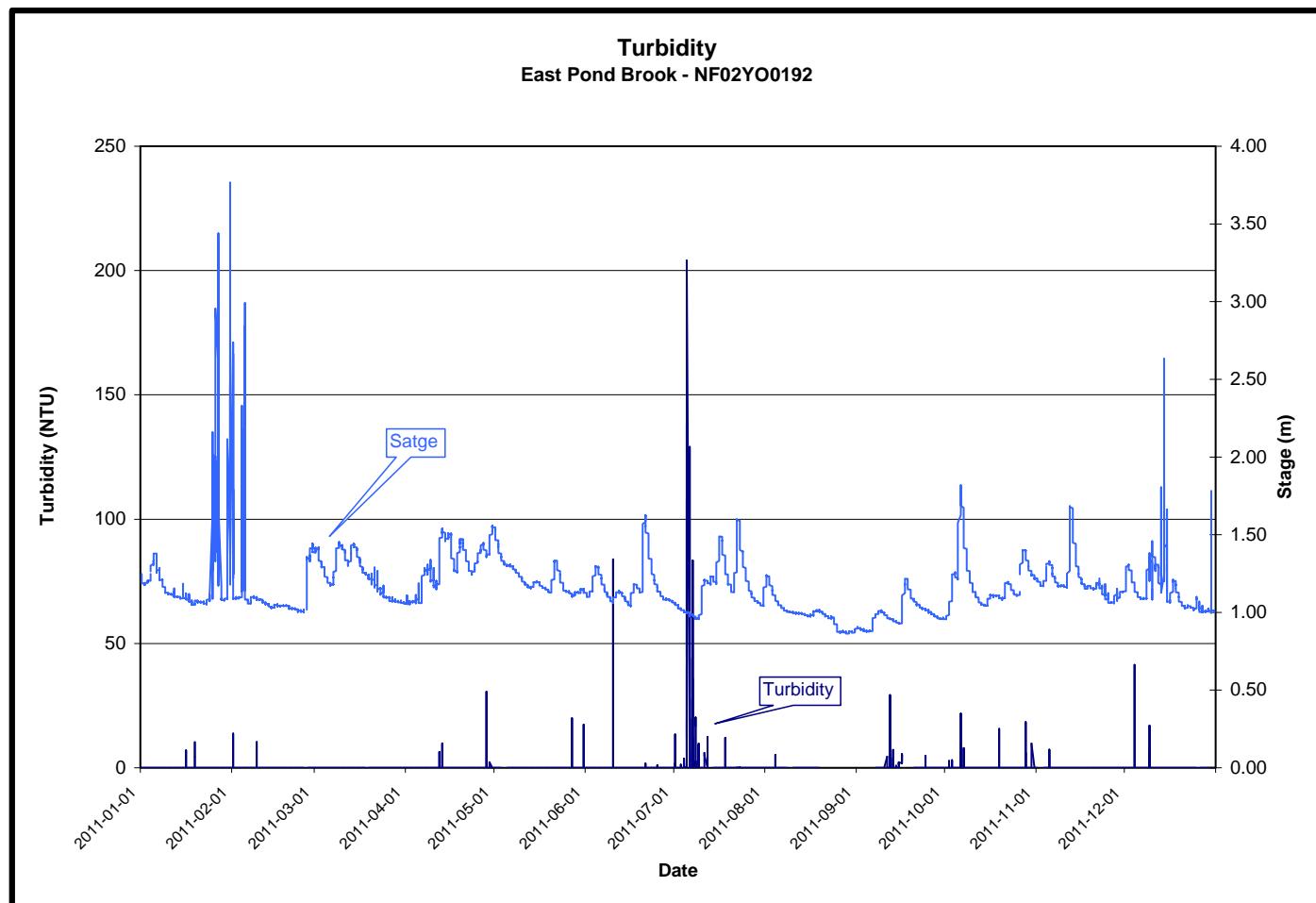


Figure 14

The stage or water level (**Figure 15**) was recorded to be between 0.86 m and 3.77 m. The flow or discharge ranged from a minimum of 0.12 m³/s to a maximum of 13.00 m³/s. At this location, stage is referenced to an arbitrary bench mark. The highest stage was recorded in January, presumably due to the backwater effect from ice formation.

For the remainder of the year, however, stage and flow were within normal ranges, with the higher levels following snow melt and rainfall events.

The flow or discharge is calculated based upon a stage-discharge curve which is developed over time. There are periods during the year, when extreme high and low flows could not be calculated as they were outside the range of the existing curve.

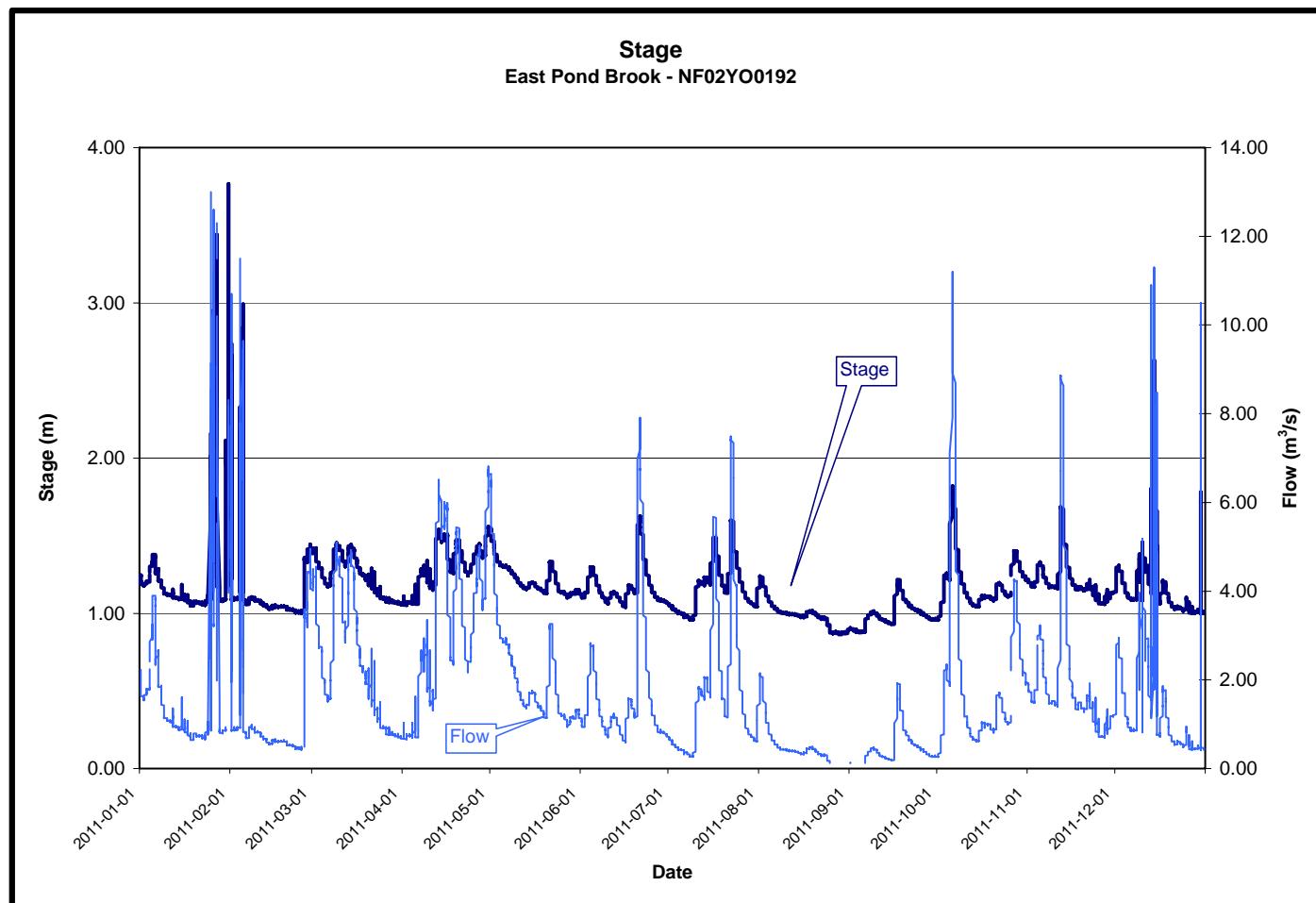


Figure 15

Section 4.3 Monitoring Well After Tailings Dam Station (NF02YO0193)

Monitoring Well After Tailings Dam Station is located near Tailings Dam A. This station is located such that any ground water impacts from the Tailing Management Area via seepage through Dam A may be measured.

Water temperature (**Figure 16**) ranged from a minimum of 5.03 °C to a maximum of 5.80 °C. Lower temperatures were recorded in the summer months, while the higher temperatures were recorded in late December. The temperature profile is very similar to previous years.

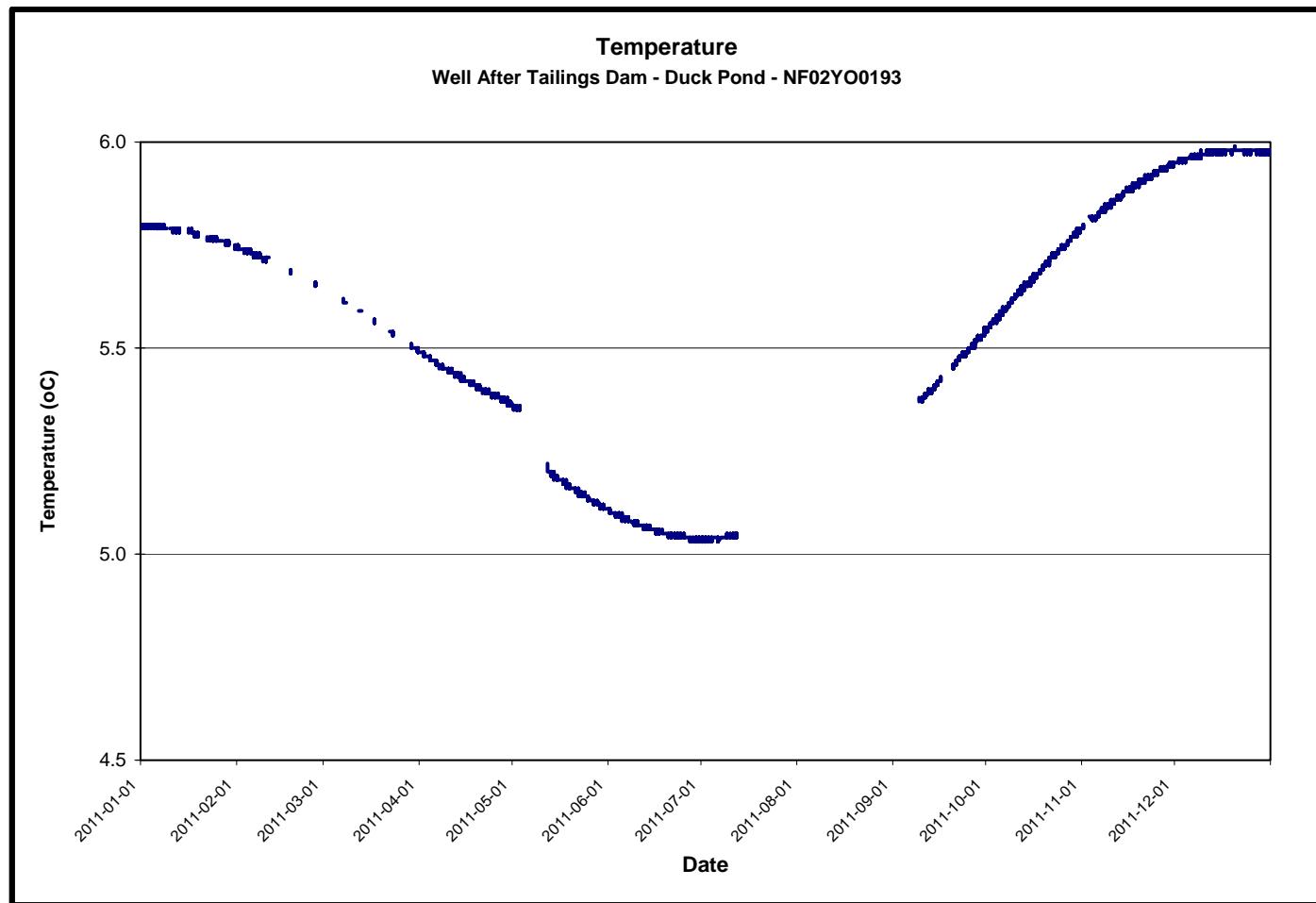


Figure 16

The pH measurements for this well are depicted in **Figure 17**. Values ranged from a minimum of 6.69 to maximum of 8.99.

At the beginning of each deployment period, there is a significant increase in pH which essentially ‘levels off’ for the remainder of that period. This response in pH is typical of previous deployments. Prior to an investigation of this feature in May of this year, it was believed that this is a function of the well being purged. However, it has been determined that the rapid change in pH at the beginning of each deployment is simply a function of the water in the small diameter well being displaced, as the instrument is deployed in the well⁽⁴⁾, thus temporarily disturbing the relatively ‘static’ nature of the well. Accordingly, it has been decided to minimize the number of deployments of the instrument in this well, and maximize the length of the deployment periods (approximately 6 months). Furthermore, it has also been demonstrated that even by purging the well of five casing-volumes, as was done on May 18, 2011 there is no long term (i.e. less than 60 minutes) effect on the water quality, including pH, in the well⁽⁴⁾. The effects of purging the well at the beginning of deployment, and during deployment continue to be monitored, as it is necessary to sample this well from time to time while the instrument is deployed. A draft Standardized Purging and Sampling Protocol⁽⁵⁾ has been developed for this particular well.

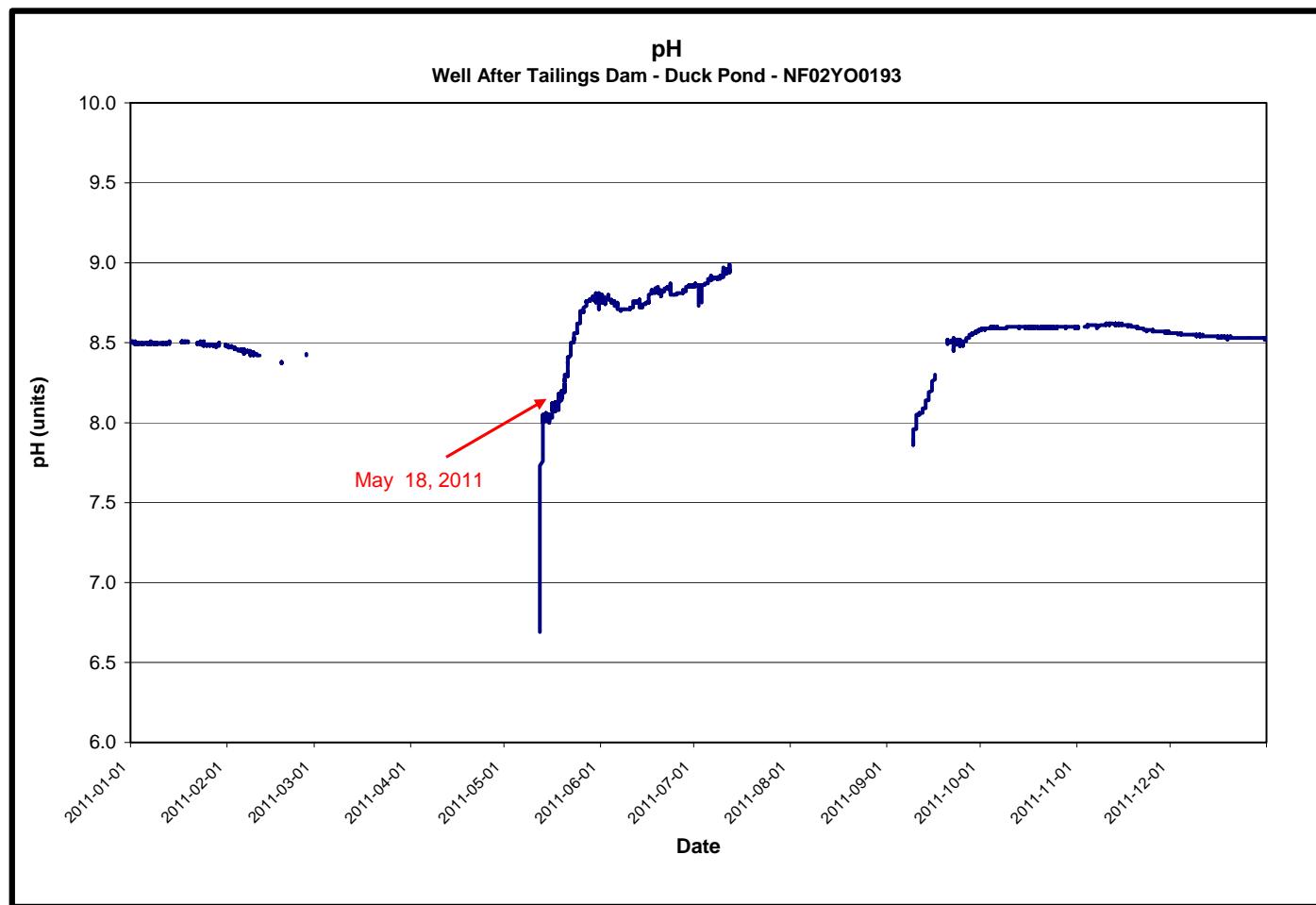


Figure 17

Specific conductance in this well (Figure 18) ranged from a minimum of 0.526 mS/cm to a maximum of 0.662 mS/cm. The range is higher than measured in previous years. Specific conductivity in this well is higher than surrounding surface waters due to the highly mineralized nature of the material through which it is drilled. The well is also located such that it can be used to measure changes in ground water resultant from seepage from Tailing Dam A.

Specific conductivity is increasing significantly over this year, confirming a trend that has been apparent in previous years. This has been investigated⁽⁴⁾⁽⁶⁾ by staff of both Water Resources Management Division and Pollution Prevention Division of ENVC. It has been determined, that while changes do exist, and they are statistically significant, they are not immediately indicative of a serious problem nor do they represent any potential violation of discharge criteria. The situation will continue to be monitored and reviewed from time to time.

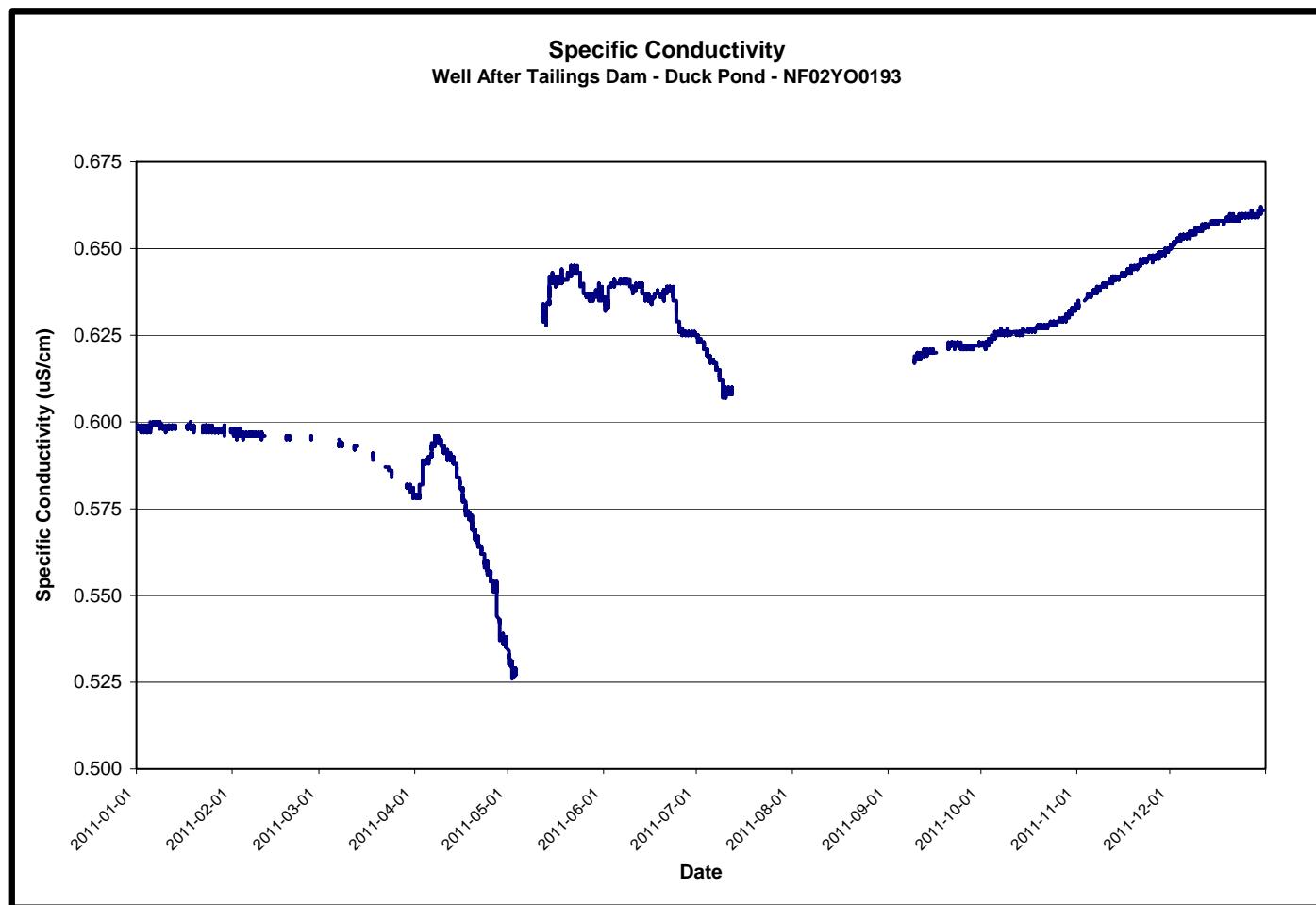


Figure 18

The water elevation (**Figure 19**) ranged between a minimum of 270.80 m and maximum of 271.14 m. This shallow well is located in a glacial till, less than 50 meters from a small stream (Trout Brook). The water elevation in this well is influenced by periods of snow melt and precipitation, showing elevation peaks which correspond closely with monitored streams in the area (Tributary to Gills Pond Brook and East Pond Brook). This is not surprising given its proximity to the stream.

A significant drop in water elevation is noted on May 18, 2011 (see red ellipse in the graph below). This variation corresponds to a pump test which was being carried out on this well during that particular day. The well recovered to its normal static water level within the hour.

There is excellent agreement between recorded and measured water elevations throughout the year, with the maximum differential being measured to be 0.005 m. This indicates that the water elevation being logged is extremely accurate.

There appears to be a slight decrease in water elevation throughout the year.

The long term variation in water elevation in this well will continue to be investigated further to determine if changes are correlated with changes in the water elevation in the Tailings Management Area, or simply a seasonal fluctuation. This may be the subject of a separate report.

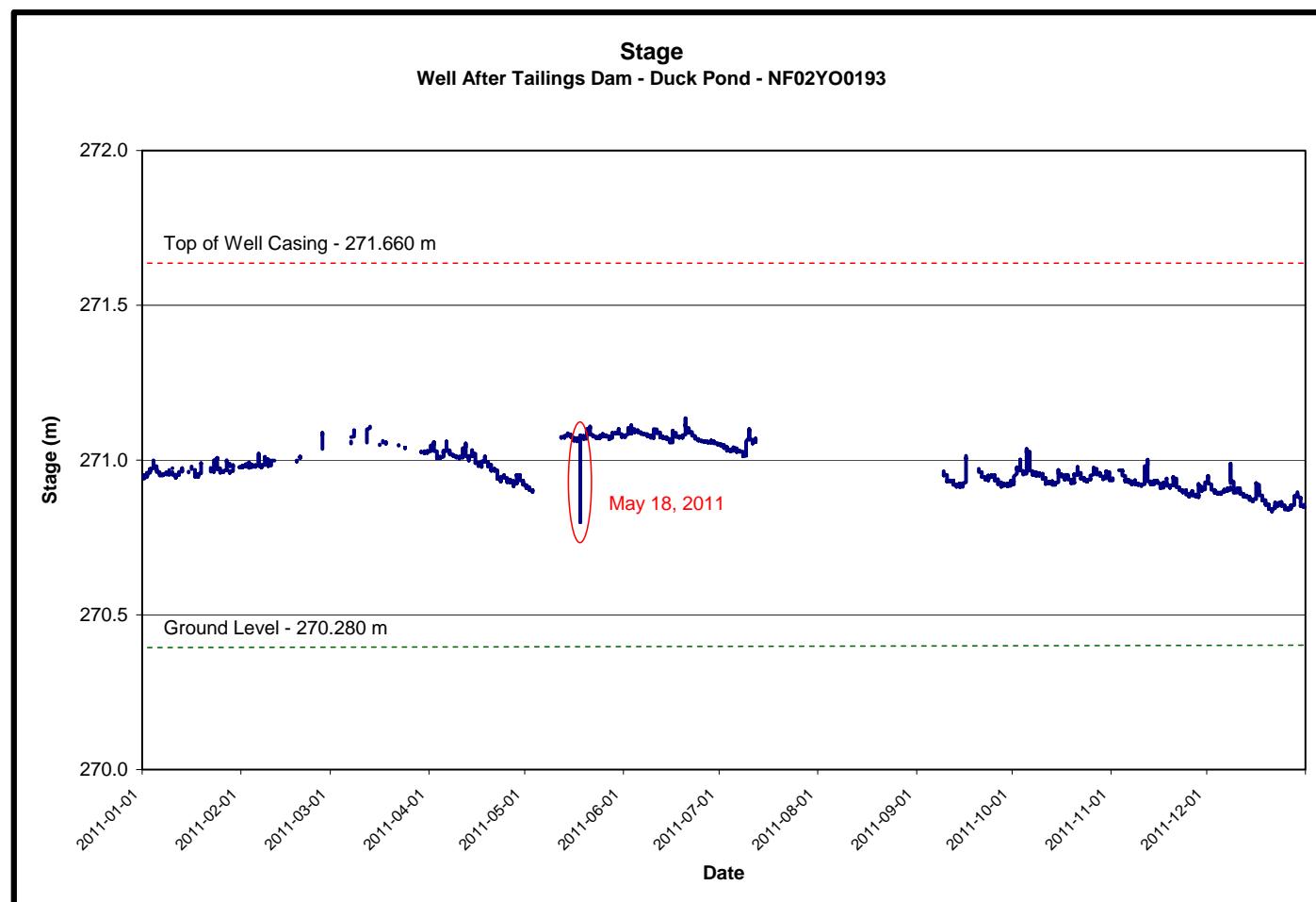


Figure 19

Section 5 Quality Assurance / Quality Control (QA/QC) Measures

- Quality Assurance/Quality Control (QA/QC) measures are a very important aspect of the Real-Time Water Quality Monitoring Network at Teck Duck Pond Operations. These measures are put in place to ensure that the instruments are reading data accurately, and the numbers that are reported are representative of the actual environmental conditions.
- As part of the QA/QC protocol, an assessment of the reliability of data recorded by an instrument is made at the beginning and end of the deployment period. The ranking system is based upon methodology developed by the U.S. Geological Survey ⁽⁷⁾, and uses the formulae in **Table 3** to qualify or rank the accuracy of the instruments.

Parameter	Rank				
	Excellent	Good	Fair	Marginal	Poor
Temperature (oC)	<=+-0.2	>+-0.2 to 0.5	>+-0.5 to 0.8	>+-0.8 to 1	<+-1
pH (unit)	<=+-0.2	>+-0.2 to 0.5	>+-0.5 to 0.8	>+-0.8 to 1	>+-1
Sp. Conductance (μ S/cm)	<=+-3	>+-3 to 10	>+-10 to 15	>+-15 to 20	>+-20
Sp. Conductance > 35 μ S/cm (%)	<=+-3	>+-3 to 10	>+-10 to 15	>+-15 to 20	>+-20
Dissolved Oxygen (mg/L) (% Sat)	<=+-0.3	>+-0.3 to 0.5	>+-0.5 to 0.8	>+-0.8 to 1	>+-1
Turbidity <40 NTU (NTU)	<=+-2	>+-2 to 5	>+-5 to 8	>+-8 to 10	>+-10
Turbidity > 40 NTU (%)	<=+-5	>+-5 to 10	>+-10 to 15	>+-15 to 20	>+-20

Table 3

- For the Surface Water Stations, upon deployment and removal, a QA/QC **MiniSonde**[®] is temporarily deployed along side the Field **DataSonde**[®]. Values for each recorded parameter are compared between the two instruments. Based upon the difference between the parameters recorded by the Field **DataSonde**[®] and QA/QC **MiniSonde**[®] a qualitative statement (Ranking) is usually made on the data.
- The ranking at the beginning of the deployment period is shown in **Table 4** for Tributary to Gill's Pond Brook and **Table 5** for East Pond Brook.
- Because the deployment set-up for Well After Tailings Dam (MW1) is different, comparison with another instrument is not possible. In this case, a grab sample is usually collected at the beginning and end of the deployment period, and the ranking is calculated for pH and Specific Conductance based upon live data and laboratory data. However, during this reporting period, there are a few examples when a grab sample could not be collected and thus no comparisons or rankings are possible. See **Table 6**.
- With the exception of water quantity data (Stage), all data used in the preparation of the graphs above and subsequent discussion below adhere to this stringent Quality Assurance and Quality Control (QA/QC) protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

Tributary to Gills Pond Brook Station (NF02YO0190)				
Parameter	Installation Date (yyyy-mm-dd)	Ranking	Removal Date (yyyy-mm-dd)	Ranking
Temp (°C)	2010-11-30	Good	2011-05-03	Good
pH (units)		Good		Fair
Sp. Conductivity (uS/cm)		Good		Excellent
Dissolved Oxygen (mg/L)		Good		Good
Turbidity (NTU)		Excellent		Excellent
Temp (°C)	2011-05-05	Good	2011-07-12	Good
pH (units)		Excellent		Good
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Excellent
Turbidity (NTU)		Excellent		Excellent
Temp (°C)	2011-07-14	Good	2011-08-08	Fair
pH (units)		Excellent		Excellent
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Excellent
Turbidity (NTU)		Excellent		Excellent
Temp (°C)	2011-08-10	Good	2011-09-16	Good
pH (units)		Excellent		Excellent
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Excellent
Turbidity (NTU)		Excellent		Excellent
Temp (°C)	2011-09-20	Excellent	2011-11-01	Good
pH (units)		Excellent		Excellent
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Excellent
Turbidity (NTU)		Excellent		Excellent
Temp (°C)	2011-11-03	Good	Ongoing	n/a
pH (units)		Good		n/a
Sp. Conductivity (uS/cm)		Excellent		n/a
Dissolved Oxygen (mg/L)		Excellent		n/a
Turbidity (NTU)		Excellent		n/a

Table 4

East Pond Brook Station (NF02YO0192)				
Parameter	Installation Date (yyyy-mm-dd)	Ranking	Removal Date (yyyy-mm-dd)	Ranking
Temp (°C)	2010-12-02	Excellent	2011-05-03	Excellent
pH (units)		Excellent		Good
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Excellent
Turbidity (NTU)		Excellent		Excellent
Temp (°C)	2011-05-05	Excellent	2011-07-12	Excellent
pH (units)		Good		Good
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Good
Turbidity (NTU)		Excellent		Excellent
Temp (°C)	2011-07-14	Excellent	2011-08-08	Excellent
pH (units)		Excellent		Excellent
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Excellent
Turbidity (NTU)		Excellent		Excellent
Temp (°C)	2011-08-10	Excellent	2011-09-16	Excellent
pH (units)		Good		Excellent
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Excellent
Turbidity (NTU)		Excellent		Fair
Temp (°C)	2011-09-20	Excellent	2011-11-01	Excellent
pH (units)		Excellent		Excellent
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Good
Turbidity (NTU)		Excellent		Excellent
Temp (°C)	2011-11-03	Excellent	Ongoing	n/a
pH (units)		Excellent		n/a
Sp. Conductivity (uS/cm)		Excellent		n/a
Dissolved Oxygen (mg/L)		Excellent		n/a
Turbidity (NTU)		Excellent		n/a

Table 5

Well After Tailings Dam (MW1) Station (NF02YO0193)				
Parameter	Installation Date (yyyy-mm-dd)	Ranking	Removal Date (yyyy-mm-dd)	Ranking
pH (units)	2010-10-21	Marginal	2011-05-03	n/a
Sp. Conductivity (uS/cm)		Excellent		n/a
pH (units)	2011-05-12	n/a	2011-07-14	Good
Sp. Conductivity (uS/cm)		n/a		Excellent
pH (units)	2011-09-07	Good	Ongoing	n/a
Sp. Conductivity (uS/cm)		Excellent		n/a

Table 6

For Tributary to Gills Pond Brook Station (NF02YO0190) the monitoring instrument performed very well. The *in situ* **DataSonde®** ranked ‘Excellent’ or ‘Good’ compared to a portable **MiniSonde®** results in 53 of 55 measurements.

For East Pond Brook Station (NF02YO0192) the monitoring instrument performed very well. The *in situ* **DataSonde®** ranked ‘Excellent’ or ‘Good’ compared to a portable **MiniSonde®** results in 54 of 55 measurements.

For the two surface water stations, the occasional ranking below good could not be attributed to any one particular event or parameter. They are considered to be random errors within the tolerances and limitations of the equipment and procedures.

For Well After Tailings Dam (MW1) Station (NF02YO0193), the monitoring instrument performed very well. The *in situ* **Quanta G®** ranked ‘Excellent’ or ‘Good’ compared to laboratory results in 5 of 6 measurements. A ‘Marginal’ ranking for pH is the subject of further investigation, related to the depressed pH values at the beginning of each deployment period.

This confirms that the measurements recorded by each of these instruments and transmitted to our web site in real-time are very accurate. However, it is understood drift may increase over time, particularly in the warmer months when bio-fouling is more likely to occur. Accordingly, when conditions and accessibility permit, the instruments will continue to be maintained and calibrated at the intervals recommended by the manufacturer.

Maintenance and calibration are always undertaken by trained staff in accordance with protocols prescribed by the manufacturer. All replaceable parts, reagents and calibration solutions used meet the specifications of the manufacturer. All work is undertaken in a controlled laboratory environment.

In order to ensure long term accuracy for the instruments, they are returned to the vendor and/or our in-house factory-trained staff periodically (approximately every two years, or when problems or issues are observed) for Performance and Evaluation Testing (PET). At this time, sensors are replaced if required, and the instruments are maintained and calibration to factory specifications.

Section 6.0 Conclusions

The Real-Time Water Quality Monitoring Network at Teck Duck Pond Operations has again this year proven to be quite useful. The data derived from this network has been used by Teck management and staff to monitor their performance. Government has reviewed the data daily to ensure that equipment is functioning properly, and that discharge from the site remains within the regulated discharge criteria. The public, who have access to this data through the web, have undoubtedly been diligent in monitoring the water quality data as well.

In the two surface water stations (Tributary to Gills Pond Brook and East Pond Brook), while changes to water quality have been observed throughout the year, no serious incidents has been identified which have raised any cause for concern. No mitigative measures have needed to be employed to address any problems or issues resultant from this monitoring.

Some progress has been made at minimizing the false-positive turbidity measurements at Tributary to Gills Pond Brook due to air entrainment. However, given the continued elevation in turbidity at Tributary to Gill's Pond Brook in the last quarter of 2011, diligence must be exercised to ensure that continued elevation in turbidity does not become, or become indicative of, a serious problem.

In Monitoring Well After Tailings Dam (MW1), some long term changes in specific conductance have been documented. It has been determined, that while changes do exist, they are not immediately indicative of any serious problem, nor do they represent any potential violation of discharge criteria. The situation will continue to be monitored and reviewed from time to time.

Continued operation of the Real-Time Water Quality Monitoring Network at Teck Duck Pond Operations is planned for the life of the operation.

Section 7.0 Path Forward

In order for this program to remain successful, it is essential to continually evaluate, improve and move forward. The following is a list of initiatives and activities to be carried out in the upcoming year:

- 1) The **DataSonde®** instruments owned by Teck Duck Pond Operations will be monitored closely to ensure their accuracy and reliability. Should any issues be identified, they will be returned to the vendor and/or Department of Environment and Conservation for factory servicing and calibration.
- 2) The two **DataSonde®** instruments owned by Teck Duck Pond Operations are nearing their projected lifecycle of 5 to 10 years. In anticipation of their need for replacement, Teck has purchased two new instruments. These will be deployed intermittently, as the original instruments are removed for Performance and Evaluation Testing and long term maintenance issues. Eventually, the new instruments will replace the original ones, and the original ones will be used as back-ups if they are still functional.
- 3) Work will continue to overcome the challenges with false-positive turbidity measurements at Tributary to Gills Pond Brook Station (NF02YO0190). We will continue to monitor the situation, and test and employ any further mitigative measures which may be beneficial.
- 4) Work will continue to monitor and evaluate water elevation changes at Monitoring Well After Tailings Dam Station (NF02YO0193) and the possible relationship with water elevations in Tailings Management Area.
- 5) Evaluation of the Standardized Well Purging and Sampling Protocol for Monitoring Well After Tailings Dam will continue by ENVC and Teck staff.
- 6) Work will continue to obtain weather data from on-site weather station operated by Teck Duck Pond Operations, and possibly incorporate it into the real-time reporting systems. Weather data can be used to more precisely assess the changes in water quality/quantity, as presently there is no automatic weather station nearby.
- 7) The pathways leading to the Real-Time Water Quality Monitoring stations were upgraded significantly in 2011. Some minor maintenance work may be needed in 2012 and subsequent years.
- 8) With the planned development of the Boundary Deposit, consideration is being given to installing a new ground water monitoring well with real-time data collection, in the vicinity of the open pit operation. Ideally, installation must take place in ample time to allow for 12 months baseline monitoring before this aspect of the project starts. Teck staff have been provided with specifications and budget estimate in order to facilitate the purchasing of all equipment needed to set up another real-time water quality monitoring station. It is anticipated that the existing monitoring wells at Boundary Deposit are inadequate, thus we have engaged the Ground Water Section of ENVC to specify the monitoring well's design criteria.

- 9) Work will continue to optimize sensor performance, data transmission, and information transfer. Any emerging issues will be addressed in a timely manner.
- 10) Work will continue to enhance and automate the data handling and reporting processes. ENVC is working on extrapolation of other water quality parameters using regression analysis.

Section 8.0 References

1. *Canadian Water Quality Guidelines for the Protection of Aquatic Life*, Canadian Council of Environment Ministers, 1999, Update 7.1, December 2007.
2. *Real Time Water Quality Report, Duck Pond Operations (Teck Cominco Limited), Deployment Period 2008-10-16 to 2008-11-12*, Department of Environment and Conservation, 2009. <http://www.env.gov.nl.ca/env/waterres/rti/rtwq/csdr/index.html#11>
3. *Real Time Water Quality Report, Duck Pond Operations (Teck Duck Pond Operations), Deployment Period 2011-08-10 to 2011-09-16*, Department of Environment and Conservation, 2011. <http://www.env.gov.nl.ca/env/waterres/rti/rtwq/csdr/index.html#11>
4. *Accuracy and Precision in Real-Time Water Quality Monitoring - How good is my data?* , Proceedings of Real Time Water Quality Workshop, Department of Environment and Conservation, June 7, 2011. <http://www.env.gov.nl.ca/env/waterres/rti/rtwq/workshops.html#2011>
5. *Draft Standardized Purging and Sampling Protocol for MW1@ Teck Duck Pond Operations*, Department of Environment and Conservation, June 15, 2011.
6. *Review of Teck Duck Pond Operations Monitoring Data (MW1, Sump A and TP2)* Pollution Prevention Division, Department of Environment and Conservation, April 4, 2011.
7. *Guidelines and standard procedures for continuous water-quality monitors – Station operation, record computation and data reporting: U.S. Geological Survey Techniques and Methods 1-D3*, U.S Geological Survey, 2006.