
Mount Bethel Fens Complex

Mount Bethel, Pennsylvania

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Introduction

The Lehigh Earth Observatory (LEO), in conjunction with the Nature Conservancy, is currently studying a delicate system of fresh water wetlands in northern Pennsylvania. These wetlands, called fens, are fed mainly by groundwater as opposed to surface water. Vast amounts of carbonaceous subsurface rock formations, peat layers, and groundwater interaction within this area give rise to a unique habitat containing rare plants and animals.

Site Description

The Mount Bethel Fens complex is located within the Jacoby Creek watershed of Upper Mount Bethel Township, Northampton County, PA. The Jacoby Creek watershed is bound by Laurel Hill to the north, Mount Airy to the south, a series of peaks to the west of Echo Lake and the Delaware River to the east (See Figure 1). The watershed is comprised mainly of residential lots and forests with some scattered commercial and industrial areas. Elevations of the watershed range from 832 feet at the top of the watershed to 360 feet at the bottom where Jacoby Creek empties into the Delaware River.

The fen complex consists of six individual fen sites, all located within the Jacoby Creek watershed. For study purposes, the fen complex may be best represented by four main fen locations (See Figure 2). Approximate elevations of the fens range from 490 feet at TS-1 to 425 feet at TSF-1(See Figure 2).

Data Collection

Specific Conductivity, pH, and Temperature - Data collection was performed monthly throughout the Spring of 2000 and weekly throughout the Summer of 2000. Specific conductivity and temperature readings were taken using Orion meters.

Water Levels – Water levels of monitoring wells located within each fen were monitored on a monthly basis throughout the Spring of 2000 and a weekly basis throughout the Summer of 2000. Levels were taken using a 25 foot tape measure and “kolor-kut” water marking paste. Levels were recorded as “depth in inches to water” from the top of the well and then converted to centimeters back at the lab.

Water Sampling – Water sampling is currently scheduled on a quarterly basis. Samples are scheduled for spring, summer, fall, and winter. Sampling was performed at seven locations for the spring and nine locations for the summer (See Table Below).

Spring	
<i>Designation</i>	<i>Source</i>
TS-1	Taylor Seep
BF-5	Bartlett Fen
TSF-1	Taylor Shrub Fen
SF-1	Savage Fen
JC-1	Jacoby Creek
JC-2	Jacoby Creek
JC-3	Jacoby Creek

Summer	
<i>Designation</i>	<i>Source</i>
TS-1	Taylor Seep
BF-5	Bartlett Fen
BF-8	Bartlett Fen
TSF-1	Taylor Shrub Fen
SF-1	Savage Fen
JC-1	Jacoby Creek
JC-2	Jacoby Creek
JC-3	Jacoby Creek
JC-4	Jacoby Creek

Weather Data – Two weather stations were installed the second week of June 2000. Each weather station is equipped with a rain gage, climate sensor, and a solar radiation shield (See Figure 5). Data is downloaded weekly in the field and brought back to the lab by means of a HOBO shuttle.

The Rain gage (Model Number RG1 produced by Onset Computer Corporation), has a six inch opening and a built in HOBO event data logger. The HOBO event logger is capable of recording 8000 events with a 1% accuracy at 1"/hr or less.

The climate sensor (HOBO H8 Pro Series Logger) continuously measures ambient air temperature and relative humidity. The sensor measures temperature with an accuracy of 0.40 to 1.00 degree Fahrenheit, and relative humidity within 3% (from –40 degrees F and 212 degrees F).

The solar radiation shield housing the HOBO H8 Pro Series Logger, protects it from damaging radiation and excessive heat.

The Hobo shuttle is a small (3" by 4") data retrieval device. The shuttle is brought into the field and connected to each data logger via a 1/8" wire. The shuttle downloads data and resets the loggers for future use.

Stream Gauging Data - Stream gauging is performed on a weekly basis. Efforts have been made to perform stream gauging on Jacoby Creek after large rain events or during dry periods. A Marsh- McBirney velocity meter was used to measure velocity. The flow rate is calculated using the velocity area method. The velocity area method involves dividing a river cross section into a series of vertical sections. To assure that no one cross section contains more than 10 percent of the flow, a minimum of 20 vertical sections will be made per station. A Marsh-McBirney electromagnetic velocity meter will be used to measure velocities at each cross section. The average velocity will be determined in accordance with the USGS guidelines for low flow (see Figure 10). When flow depths

are less than 2.5 feet in depth, a single velocity measurement at six tenths of the flow depth will be made. The discharge per vertical cross section is then determined by taking the product of the area of the vertical section and its corresponding average velocity. Lastly, the total discharge flowing through the Jacoby Creek cross section is the sum of the incremental discharges.

RESULTS:

Water Quality Data

Water Quality Data for the Mount Bethel Fens Complex and Jacoby Creek have been collected since March 29, 1999. An ICP machine was used to test the field samples for sodium, magnesium, and calcium cations. An IP machine was used to test for chloride and sulfate anions. Both of these machines were calibrated using a variety of standards. The sample data was corrected in accordance with known standard values. These calculations can be found in Appendix A.

Jacoby Creek

A large increase in the amount of ions can be seen through the creek. At JC 1 the total amount of ions is 27 ppm. This amount of ions continues to increase as Jacoby Creek flows downstream with the highest amount of ions culminating at JC 4, 92.3 ppm. The creek starts out in an area of low flow where sulfate is the dominant ion. As the creek travels through the fens complex large amounts of calcium are collected due to groundwater interaction. Limestone is present in subsurface formations throughout the fens complex. Calcium carbonate, the main component of limestone, interacts with the groundwater. The calcium carbonate dissociates in the presence of water releasing calcium ions into the ground water supply. Since Jacoby Creek is a gaining stream its base flow is constantly being replenished by the calcium rich groundwater. At JC 1 there are only 7.05 ppm, while at JC 3 and JC 4 there are over 39 ppm present. This is an increase of over 550%. See Appendix A for data.

Mount Bethel Fens Complex

A slightly different ion composition is found within the wells throughout the fens complex. Sulfate is the major component in Bartlett and Taylor Seep, while chloride is the dominant ion in Taylor Shrub and Savage fens, although there is still a significant source of sulfate. Traces of sodium and magnesium were found in all the wells, but neither of the two composed more than 7% of the overall total. Both Bartlett fen wells, BF 8 and BF 5, have a considerably smaller amount of dissolved ions. BF 8 only has 70.86 ppm while BF 5 has 77.67 ppm. Taylor Shrub fen has the highest amount of ions with 137.78 ppm, but Taylor Seep and Savage fen also have over 100 ppm. Many bacteria are able to use hydrogen sulfide for oxidation in order to obtain energy. This reaction releases $2\text{H}_2\text{SO}_4$, which breaks down and releases the SO_4 . The presence of this hydrogen-sulfur compound gives soil in the area a black coloring, found in most wetland areas. See Appendix A for a more detailed analysis of the data.

Water Level Data

Water level monitoring in the Mount Bethel Fens Complex has been ongoing since October 3, 1996. Four wells, Taylor Seep (TS 1), Bartlett Fen (BF 5), Savage Fen (SF 1), and Taylor Shrub Fen (TSF 1), have been continuously monitored and an additional well in the Bartlett Fen (BF 8) has just been included in the monitoring. Taylor Seep fen has the highest groundwater elevation. The elevations in this area range from 8546.51 to 8585.88 cm above Sea level. The lowest groundwater table in the area was measured in Taylor Shrub Fen. Here the height above sea level ranges from 6511.85 to 6534.93 cm. The graph *Water Levels in Survey Wells 1996-2000* found in Appendix B shows the groundwater elevation at each of the four wells. The direction of flow in the watershed can be found by using the previously mentioned graph and the site map. The water in the Mount Bethel Fens complex flows from TS 1 and BF 5 towards SF 1 and TSF 1. A crude gradient for the groundwater table within this area is 0.01. Increases in the water levels can be seen in the spring months due to an increase in rainfall in the area and excess

runoff from the thawing ground. Small decreases in the summer months can be seen due to an increase in evapotranspiration. A noticeable dip occurs during the summer of 1999, when the area was suffering from a drought.

Nutrient Analysis Data

Water samples taken quarterly from four locations along Jacoby Creek and the aforementioned four fen locations are analyzed for levels of nitrogen and phosphorous. These elements are vital in the wetland plant life cycle.

Jacoby Creek

Water samples taken June 28, 2000 from four locations along Jacoby Creek were analyzed for phosphorous and nitrogen levels. JC-1, located at the furthest point upstream, contained the highest levels of both phosphorous and nitrogen, 141.2 ppb and 0.660 ppm respectively (see Appendix C). A general decline in these levels was seen throughout the course of Jacoby Creek with JC-3 containing the lowest levels of phosphorous and nitrogen, 7.89 ppb and 0.200 ppm respectively (See Appendix C).

Phosphorous and nitrogen levels of Jacoby Creek have been monitored since March 29, 1999. Compiled data from March 1999 through June 2000 yield no particular trend of phosphorous or nitrogen levels throughout Jacoby Creek.

Mount Bethel Fens Complex

Phosphorous and nitrogen levels throughout the fen complex are generally higher than Jacoby Creek. Samples taken from the complex on the same date as Jacoby Creek indicate the highest level of phosphorous occurs at the Bartlett Fen BF5 (21.05 ppb) and the lowest levels occur at Taylor Seep TS1, Taylor Shrub TSF1, and Bartlett BF8 fen. These levels were undetectable by the testing equipment and were assigned a default value of 0.1961 ppb. Nitrogen levels ranged from 1.42 ppm to 0.28 ppm with the highest

concentration occurring at the Savage fen SF-1 and the lowest at Taylor Shrub Fen TSF-1.

PH, Temperature, and Specific Conductivity Data

Jacoby Creek

The pH of Jacoby Creek is monitored at two different locations (JC1, JC4), at the top and bottom of the watershed. JC1 is located upstream of the Mount Bethel Fens Complex and JC4 is located downstream (see Figure 2). The pH values range from 6.61 to 7.37 upstream and 8.03 to 8.25 downstream. This increase in pH is a direct result of Jacoby Creek's flow path through the calcareous Mount Bethel Fen Complex.

A large increase in specific conductivity can also be seen in Jacoby Creek. The upstream values range from 72 to 126 (uS/cm), while the downstream values range from 297 to 378 (uS/cm). This occurs because the creek picks up a large amount of ions as it passes through the fens.

Temperature readings of Jacoby Creek were recorded on a weekly basis throughout the summer. Temperatures ranged from 15.8 to 20.2 °C upstream and 15.7 to 21.1° C downstream. Overall, downstream temperatures were higher than the upstream temperature readings (See Appendix D)

Mount Bethel Fens Complex

The pH of the Mount Bethel Fens Complex is monitored in five wells at four different fen locations (Taylor Seep Fen, Taylor Shrub Fen, Savage Fen, and Bartlett Fen). The pH values for the fen complex ranged from 7.4 to 7.93 over the course of the summer, with the high being in Taylor Seep Fen and the low being in Savage Fen.

A direct relationship can be seen in the data between temperature and specific conductivity. When temperature increases so does specific conductivity. This occurs because the amount of dissolved ions that can be held by the water is directly related to the temperature and saturation pressure of the water.

Alkalinity

Titration were ran on each water sample taken from both the fen complex and Jacoby Creek to determine their alkalinity. Results indicate that Savage fen has the highest normality and Taylor Seep, the lowest. (See Appendix E)

Stream Gauging Data

Stream gauging on Jacoby Creek is currently being conducted on a weekly basis. The testing is done on a portion of Jacoby Creek located at the bottom of the watershed. The gauging is done under Bridge #37 at the intersection of Jacoby Creek Road (AKA TR 701) and Middle Village Road (AKA TR 736). A rating curve is being developed to determine how much surface water exits the watershed via Jacoby Creek. In order to accurately create this curve, gauging must be done on the creek at varying stages. Efforts are made to gauge the stream after large rainfall events or during extremely dry periods in order to obtain a large span of values. The depths to water ranged from 5.94 feet to 5.63 feet corresponding flow values ranged from 5.96 cfs to 13.6 cfs (see Appendix F). The Stream gauging on Jacoby Creek will continue through the fall and winter months in order to create a more accurate rating curve.

Weather Data

Weather data for the Mount Bethel Fens Complex has been compiled for the dates of June 12, 2000 through July 21, 2000. Data consisting of ambient air temperature, relative humidity levels, and rainfall depth, were collected from two different sites (see Figure 4) within the Jacoby Creek watershed. These locations were chosen to investigate any spatial variance which might occur over the watershed area.

Jones Weather Station:

The “Jones” weather station, located toward the top of the watershed (Approximate Elevation = 730.00 feet), did not experience problems during the above 6 week period. Analysis of the data indicated four major rainfall events. These events occurring on 6/13, 6/22, 6/27, and 7/15 totaled 6.08 inches of rain. A dry period occurred between June 30th and July 15th where only 0.05 inches of rain was observed. Low well levels were observed toward the end of this period on July 12th illustrating the direct impact of groundwater recharge to the fens complex (See Appendix B).

Temperature, humidity, and rainfall graphs for this area can be found in Appendix G and are summarized below:

Jones Weather Station Summary

Parameter	Maximum	Minimum	Average
Temperature (Celsius)	30.03	10.99	18.59
Relative Humidity (%)	100	34.6	86.53
Rainfall (Inches)	1.72” per 1 event	0.00	4.05 inches / month

Godshalk Weather Station:

The “Godshalk” weather station, located toward the bottom of the watershed (Approximate Elevation = 425.00 feet), experienced some technical problems over the course of the study period. The data collected from the Godshalk station during the first week of operation appeared accurate because the patterns in rainfall were similar to the Jones’ weather station. However, an inch less of rain was received. Furthermore, no rain data was recorded the following week even though a fairly large rain event had occurred within the area. The rain gauge was removed from the weather station on June 28, 2000 and brought back to the lab for testing and calibration. The gauge was reattached to the weather station two days later on June 30, 2000. No further problems have been incurred and the gauge is currently recording all information accurately.

Only two major rain events occurred at the Godshalk weather station during the six-week period from June 12 until July 21, 2000 due to the technical difficulties. This weather station collected 2.4 inches of rain, and the same dry period was seen at this location lasting from June 30th to July 15th.

Temperature, humidity, and rainfall graphs for this area can be found in Appendix G and are summarized below:

Godshalk Weather Station Summary

Parameter	Maximum	Minimum	Average
Temperature (Celsius)	31.12	9.82	19.48
Relative Humidity (%)	100	30.4	85.55
Rainfall (Inches)	0.8” per 1 event	0.00	1.6 inches / month

Conclusion

The Mount Bethel Fen Complex possesses a large array of delicate plant species and elaborate groundwater patterns. The information and data contained within the complex presents numerous opportunities for present and future studies.

Currently, ongoing studies as reported herein, have been focused on contributions of the fen complex to the water quality of Jacoby Creek. Recent and past records yield common results in the water quality analysis throughout the watershed. However, in order to develop a more appreciable trend, the continuation of data collection and water quality analyses are essential.

Future studies, such as a groundwater model and a detailed water budget analysis, coupled with the present work will help to create a better understanding of the importance that the Mount Bethel Fen Complex has on its surroundings.