

Mt. Bethel Fens Fall 2001

**Prepared for:
The Nature Conservancy and
The Lehigh Earth Observatory (LEO)**

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Introduction:

A fen is a type of wetland, in which the hydrology is primarily driven by groundwater. This mineral-rich groundwater flowing through the fens, along with the constantly moist environment, is necessary for the development and maintenance of the

rare vegetative and animal species found in such areas. This project in particular focuses on the Mount Bethel Fens Complex, a collection of five fens located near the town of Mount Bethel, PA in Northampton County. Lehigh Earth Observatory (LEO) in conjunction with The Nature Conservancy (TNC) is monitoring these fens on a monthly basis along with two sites on the Jacoby Creek, which runs through the complex. Hydrologic interaction between the fens and Jacoby Creek plays an integral role in defining the overall water composition of the system. A stream gauging station, which monitors discharge, is located on Jacoby Creek within the fens complex. In addition to studying the fens and Jacoby Creek, LEO and TNC have included two weather stations to monitor weather aspects such as rainfall and temperature. The overall goal of this long term project is to continuously monitor the flow and quality of the water in the fens in order to observe if the surrounding industries and residential areas are polluting the fens or lowering the water table, which will ultimately impact the rare and endangered species. This report in particular focuses on the data collected on the months of September, October, and November of 2001.

Site Description:

The Mount Bethel Fen Complex is located in Mount Bethel, PA within the Jacoby Creek watershed of Northampton County. This area is mainly comprised of forests, residential lots, and a few industrial areas. The Mount Bethel Fens Complex encompasses five fens which are monitored by a total of eight piezometers: Savadge Fen #1, Bartlette Fen #3, 5, and 8, Taylor Shrub Fen #1, 3, Taylor Seep #1, and Taylor Fen #1. These fens are fed by springs and seeps. The water runs through the fens emerging in some places as streams but ultimately joining with the Jacoby Creek.

Three major aquifers feed the fen complex: the surficial glacial aquifer, the limestone Allentown Formation aquifer, and the Martinsburg Formation slate aquifer. The irregularity of the glacial deposits and its proximity to the ground surface creates many seeps and springs that feed the fens. The blue-green lacustrine clay forms an impermeable layer that retards both the upward and downward flow of water, in some areas decreasing the input to the fens from the underlying bedrock aquifers. However, the geochemical signatures of the water in the fens shows that all three aquifers are contributing to different fens in the complex

Methods:

The Mount Bethel Fen Complex encompasses Savadge Fen, Bartlette Fen, Taylor Shrub Fen, Taylor Fen, and Taylor Seep. Piezometric water heights are monitored monthly, while water quality is analyzed quarterly. Water quality data is used to ascertain the water type of each of the fens and seeps. Water quality tests consist of analyzing samples of water taken from one well in each of the fens and running a series of tests including pH, temperature, conductivity, nutrients (NO_x, PO_x), Ion Chromatograph (IC), and Inductively Coupled Plasma (ICP). IC detects concentration of anions such as SO_x and Cl, while ICP detects the concentration of cations such as Na, Al, Mg, Ca, K, and Fe. The water chemistry is compared through time to determine the natural variability associated with nutrient cycling, budgets in the complex, and any changes in chemistry. Since the fens and the Jacoby Creek are closely intertwined, two sites along Jacoby are studied, one site upstream and one downstream from the fens. Quarterly water samples taken at these sites are analyzed in the same manner as the fen samples in terms of water quality. This analysis is performed to monitor any changes in

the Jacoby Creek watershed, as well as changes in the water quality as Jacoby Creek runs through the fens, possibly changing the water composition and water quality of the fens. The stream gauging station, which is located on the Jacoby Creek at a site within the fens complex, collects stream stage data with 15-minute frequency in order to calculate discharge. This information will provide a better understanding of the watershed in which the fens are located.

Along with monitoring water quality, other factors of the environment such as rainfall, temperature, and relative humidity are also analyzed. This data is collected from weather stations located on two sites in the same area as the fens. One weather station is located in the middle of the fens complex and the other on a nearby ridge, within the Jacoby Creek watershed. These aspects are monitored to more completely assess the fen environment and possibly explain any influences on the fens, such as varying piezometric water height and composition of the water.

All of the specific methodology for sampling and analyzing the water quantity and quality can be found on the Lehigh Earth Observatory website (www.leo.lehigh.edu) under the Mount Bethel Fens project.

Results:

Weather Data: The Mount Bethel Fens Complex weather data consists of information from August 8, 2001 to November 18, 2001. Air temperature and rainfall depths were collected from two sites; Jones and Godshalk.

Jones Weather Station:

The Jones Weather Station is located on a ridge outside of the fens complex. Due to a technical malfunction with the precipitation gauge, Jones rainfall for the month of

October is not available at this time. After repairs, it is likely that the data will be recovered. Analysis of the previous months data, however, reveals a lack of precipitation for the month of September and an average of 0.416 inches per day throughout August with major events occurring on August 18, 2001 with 0.7 inches of rain.

Temperature data for Jones indicates an average of 20.43 degrees Celsius for August and an average of 14.93 degrees Celsius for September. October yielded an average of 11.05 degrees Celsius and November, 7.5 degrees Celsius. Drastic changes in temperature were reported as followed: September 13, 2001, drop of 5.8147 degrees from the previous day, and an increase of 5.8147 degrees for September 14, 2001, October 7 and 26, 2001 both dropped over 6 degrees in temperature from the previous day while October 30, 2001 had a rise of 6.31 degrees from the previous day.

Specific graphs for rainfall and temperature for Jones Weather Station can be located in Appendix B.

Godshalk Weather Station:

The Godshalk Weather Station is located within the fens complex, near Taylor Shrub fen. Rainfall data in Godshalk also reveals a dry period during the month of September. October's average rainfall was 0.136 inches and November yielded an average of 0.15 inches. Peaks for October and November were reported as October 15, 2001 at 0.45 inches of rain and November 3, 2001 at 0.15 inches of rain. August was reported as having an average of 0.145 inches the peak of which was August 10, 2001 with 0.29 inches of rain.

Temperature data for Godshalk indicates an average of 20.46 degrees Celsius for August and an average of 15.79 for September. October yielded an average of 10.63

degrees Celsius and November, 6.5 degrees Celsius. Drastic changes in temperature were reported as followed: August 31, 2001 was 4.32 degrees warmer than the previous day while September 26, 2001 yielded a drop of over 6 degrees, October 30, 2001 had a rise of over 5 degrees from the previous day while November 17, 2001 cooled 8.62 degrees from the day before.

Specific graphs for rainfall and temperature Godshalk Weather Station can be located in Appendix B.

Water Height:

Water elevations were measured each month from September to November. Water elevations were calculated by subtracting the depth to the water from the height of the riser. Graphs of water elevations for Fall 2001 can be found in Appendix B. Of all the fens, Taylor Fen 1 produced the highest water elevations averaging to be 81.3 cm, and Bartlett Fen 5 produced the lowest water elevations, averaging to be -15.4 cm. Only three of the fens, Savadge Fen 1, Bartlett Fen 5, and Bartlett Fen 8, displayed negative water elevations below ground level. Water elevation levels for Taylor Shrub 1, Savadge Fen 1, Taylor Shrub Fen 1, Taylor Shrub Fen 3, Bartlett Fen 3, and Bartlett Fen 8 averaged to be 23.8, -10.5, 32.1, 8.5, 5.4, and -1.0 cm respectively.

Temperature, pH, and Conductivity:

Temperature, pH, and conductivity data for Fall 2001 are located in Appendix B. The data obtained from the water quality samples shows no direct relationship between temperature, pH, and conductivity for any of the fens. Temperature ranged from 14.8 to 19.6 degrees Celsius, Taylor Shrub Fen 3 being the coolest and Bartlett Fen 5 the warmest. The only fen that did not have a basic pH level was Taylor Shrub Fen 3, which

was 6.82. All other pH levels ranged from 7.58 to 8.24, the most alkaline being Taylor Fen 1. Conductivity, measured in micro-Siemans, varied for each fen from 308 μS at Bartlett Fen 3 to 663 μS at Savadge Fen 1. Overall, there does not seem to be any existing trends between these three variables.

Nutrient data:

Water quality samples were taken in the month of October. Figure 21 displays the nitrate levels for the fens, the Jacoby Creek sites, and the pit. The Jacoby Creek sites and the pit display negligible amount of nitrates in the water. Taylor Fen, Taylor Shrub, Taylor Seep, and Bartlett all show a relatively moderate amount of nitrates; all below a concentrate of 0.7 ppb. Savadge fen, however, displays a relatively high amount of nitrates with 1.58 ppm.

Figure 22 displays the phosphate levels for all the fens sites, the two Jacoby Creek sites and the pit. All of the sites with the exception of the pit display negligible amounts of phosphates. The pit, on the other hand, has extremely high phosphate levels, with 5.88 $\mu\text{v-s}$.

ICP & IC:

Inductively Coupled Plasma (ICP) test results revealed the presence of various metal cations in fens groundwater. Samples were analyzed for calcium, magnesium, aluminum, sodium, and iron. Samples were also tested for potassium ions, but test results were faulty and were thus discarded.

In each of the sites tested (Bartlette, Jacoby Creek 1, Jacoby Creek 2, Savadge, Taylor Fen, Taylor Seep, Taylor Shrub, and the Pit), calcium is the dominant cation, with concentrations reaching as high as 75 ppm in Savadge. The second most prevalent cation

is magnesium, followed by sodium, aluminum, and finally iron. This trend holds true at each site tested for both the summer and fall 2001 sampling rounds. Iron is the least plentiful ion, its concentrations often times falling below method detection limits. Between the summer and fall sampling events, a general decrease is observed in most ion concentrations.

Ion Chromatograph (IC) test results indicated the presence of chloride and sulfate anions dissolved in fens groundwater. In summer tests, sulfate was more plentiful than chloride, while in fall testing results chloride was generally the more plentiful anion. Overall, fall concentrations tend to be lower than summer concentrations, as was the case for cations in the ICP test results. It is unclear, however, whether this represents a viable trend or whether it is the result of erroneous data. Although the summer testing results appear reasonably accurate, fall tests—especially replicate I—exhibited erratic calibration curves with data points straying far from mixed standard concentrations. To dampen this effect, data points were often thrown out when generating the calibration curves. Such changes are noted beneath corresponding data tables.

Discussion:

Weather:

Comparative analysis of the various data regarding water levels in correlation with temperature or rainfall does not yield any substantial conclusions.

Rainfall appears to have little or no direct correlation with well heights of the targeted locations in the fens. As rain over time increased, well heights in Savadge, Taylor Shrub, Taylor Seep, and Bartlett 5 & 8 all decreased. This may indicate a lowering of the water table and water being lost from the surface to the groundwater

table. A slight increase in well height resulted in Taylor Shrub 3 and Taylor after an increase in rain over time. The only fen that was seemingly affected by rainfall was Bartlett 3.

Temperature seemed to have more of a direct relationship with the well heights located in the fens. As the onset of colder weather approaches, the well heights, regardless of rainfall patterns, seem to drop with the temperature. Taylor Seep, Taylor Shrub, Savadge, Bartlett 5 & 8 and Taylor Fen all seem to have direct correlations between well height and temperature. Bartlett 3 and Taylor Shrub 3, however, do not appear to be related to temperature.

Graphs of the relationships between well heights, temperature and rainfall can be located in Appendix B.

Water Height:

Water elevations for all wells except Taylor Fen 1, Taylor Shrub Fen 3, and Bartlett Fen 3, dropped continuously from September to November. Since there was no recorded rainfall in September, it would seem that September water elevations would be the lowest for all the wells. However, this never occurred in any of the wells. Taylor Fen 1 and Bartlett Fen 3 showed similar trends, in that their lowest water elevations occurred in the month of October. Water elevations for Taylor Shrub Fen 3 remained steady from September to October, and then rose in November.

Temperature, pH, and Conductivity:

The cooler temperatures of the fens can be attributed to cooler fall temperatures. As the temperature begins to drop outside due to change in season, the temperature of the water is going to follow a similar pattern. The pH levels are a bit high for most of the

fens when compared to pure water, which has a neutral pH level of 7.00. Basic pH levels obtained for all but one fen can be explained, as the fens are fed from a limestone aquifer, which increases the alkalinity of the water. The conductivity for each fen varied with each fens concentration of ions, conductivity having a directly proportional relationship with ion concentration. High conductivity levels imply high ion concentrations, which may be indicative of water contamination. It is suspected that Savadge Fen 1, which is located below the Mt. Bethel Diner, may include contaminants from sewage originating from the diner. This would explain this fen's high conductivity level.

Nutrient:

In terms of nutrient levels, the fens displayed relatively low to moderate amounts of nitrates and phosphates. The upstream and downstream Jacoby Creek sites show negligible amounts of nutrients, which means that no nutrients are flowing into the fens and no nutrients are flowing out of the fens. Therefore, the fens are getting their nutrients from other sources and retaining these nutrients. Looking at the amount of nitrates in the fens, the fens are not considered polluted, with the exception on Savadge fen. This fen has relatively high nitrate levels, which may indicate that sewage (most likely from the Mount Bethel Diner) is flowing into this fen. Phosphate levels for all of the sites except the pit are negligible. Low phosphate levels are expected for this time of year since this is not the growing season and therefore the fens should not be receiving runoff from fertilizers. The pit site, however, had extremely high phosphate levels, which may indicate polluted water. This pollution is most likely coming from the Mount Bethel Diner. The strange thing about the pit is that it should have high nitrate levels as well as

high phosphate levels if it was receiving sewage from the diner. Therefore, it is possible that another factor might be influencing the pit.

ICP & IC:

The most obvious trend exhibited between summer and fall testing events is the general decrease in dissolved ion concentrations. Several explanations can be offered as to the cause of this phenomenon:

One potential cause of this decrease is the change in climate between summer and fall. Decreased autumn temperatures cause the groundwater to cool slightly, resulting in a decrease in its ability to keep these salts dissolved. It is also possible that drier summer conditions meant that less groundwater was present beneath the Fens. When rain increased during the fall months, the groundwater was effectively diluted and ion concentrations decreased.

Decreased ion concentrations could also be a result of reduced anthropogenic effects on the Fens. If the Nature Conservancy's campaign to protect the fens has been effective, people living nearby may have become more sensitive to the harmful effects their actions have on groundwater quality and made an effort to curb these effects.

Finally, the trend could represent neither of the above suggestions. It could be a completely random natural fluctuation in salt concentrations, or it could have been falsely created through experimental error and not truly exist at all.

