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ABSTRACT:

The Lehigh Earth Observatory in partnership with The Nature Conservatory has been involved in an ongoing project to monitor the water quality, climate and water levels in the Mount Bethel Fens Complex. The water levels are monitored on a monthly basis by checking the surface height in each of the eight peizometers or wells. From five out of these eight peizometers, water samples are taken quarterly along with samples from the Jacoby Creek that runs throughout the entire fens complex. These samples are then used for water quality analysis. The Jacoby Creek gauging station, which is located at the northeast-southwest end of the fens complex monitors the discharge of the creek though the fens. To monitor the climate at the Mount Bethel Fens there are two weather stations within the watershed of the Jacoby Creek. This data is also collected on a monthly basis.

Also beginning this year is an invasive plant-monitoring project. Permanent vegetation plots were established in March at four fens: Bartlet, Taylor II, Savadge and Houdaille. *Phragmites* densities were estimated in March at Bartlet and Taylor II, and were compared with June densities for accuracy. In June and July the density and size (diameter or height) of *Phragmites australis* (common reed) and *Lythrum salicaria* (purple loosestrife) were recorded along with percent cover of each native vegetation species. 2002 is the baseline year for a five-year monitoring project. This project is going to help us to see if the efforts by The Nature Conservancy to control these plants are working.

INTRODUCTION:

Marshes, swamps, fens and bogs are all types of wetlands. The main difference between these wetlands is how they get their water. A fen is feed from underground aquifers. The water that forces its way slowly to the surface holds many vital nutrients and minerals, which nourish the diverse and endangered plant and animal life. Another vital component of the fens is peat. Peat is a completely organic material formed from the remains of incompletely decaying plants. This material also supports the wildlife that thrives only in the fen complex. The most common plant genus that grows within the fens are sedges (*Carex*). These tussock plants share the fens with many broad-leaved forbs and ferns, many of which are rare and endangered. There are also invasive plant species now growing in the Mount Bethel Fen Complex, notably *Lythrum salicaria* (a non-native commonly called purple loosestrife) and *Phragmites australis* (a native commonly called common reed). These invasive populations are now being monitored and managed because they are reducing the high plant diversity of the fens (often exceeding 40 species per square meter).

The Mount Bethel Fens Complex is a collection of five fens located in Northampton County, Pennsylvania. These fens, which are within the Jacoby Creek watershed, are being continually monitored by the Lehigh Earth Observatory (LEO) and The Nature Conservancy (TNC). The Jacoby Creek is a tributary of the Delaware River and the major rivulet passing through the complex. This fact makes it important part of our study. Because the Creek runs though the fens, it has a great impact on the quality of the fen water. If the Jacoby Creek is contaminated, these contaminates can be spread throughout the fens. Along with the five fens and the Jacoby Creek, two weather stations were placed within the fens in the spring of 2001. With these weather stations we can keep track of the rainfall, temperature and relative humidity. Also installed in the spring of 2001 was a gauging station at Jacoby Creek. This gauging station is used to determine the flow rate of the creek and the temperature.

The five fens that makeup the Mount Bethel Complex are Savadge Fen, Bartlet Fen, Taylor Shrub Fen, Taylor Seep and Taylor Fen. At all these sites, the well or peizometric heights are monitored on a monthly basis and the quality of the water is analyzed quarterly. The water quality is used to decide the composition of the water at each fen site. Water quality testing consists of measuring pH, temperature, conductivity, as well as the nutrients (NO_x and PO_x) and selected anion and cation concentrations. The IC (Ion Chromatograph) is used to detect the concentrations of anions, SO- and Cl-, while the ICP (Inductively Coupled Plasma) detects the concentration of cations, K, Fe, Al, Mg, Ca and Na. All these concentrations are in parts per million (mg/L). The results of these tests can be compared to demonstrate any natural or unnatural changes in the chemistry of the fen water and also to monitor the nutrient cycle. These changes could greatly affect the ecosystem of the fen complex. Water quality samples are taken from each of the five fens (TF1, TS1, TSF1, BF5 and SF1), Savadge Pit, Bartlet Lake and from two sites along the Jacoby Creek. Savadge Pit is believed to be septic overflow from the Mount Bethel Diner and Bartlet Lake is a small body of water that was created by a beaver dam. It isn't really a lake but that was the name given to it. Savadge Pit and Bartlett Lake are not always sampled but they were in April 2002 and July 2002. Jacoby Creek (JC2 and JC4) is sampled because of its close interaction with the fens. These samples are important because they show how outside influences are affecting the fens. The Jacoby Creek samples are also important because they allow us to see how the water changes from one part of the complex to another.

Besides monitoring the water quality, other environmental factors are monitored. These include rainfall, temperature and relative humidity. Jones weather station is located on a ridge on the outskirts of the fen complex. It is at a higher elevation then the peizometers that we sample. Godshalk weather station is at nearly the same elevation as the fens. This weather station is located outside Taylor Shrub Fen on Hazel's property. The data collected allows for an overall fell for the fen environment and is also helpful in determining connections with differences in the water and varying peizometer height. The heights of eight peizometers are taken each month. These are Taylor Fen (TF1), Taylor Seep (TS1), Taylor Shrub Fen 1 and 2 (TSF1 and TSF2), Bartlett Fen 3, 5, and 8 (BF3, BF5, and BF8), and Savadge Fen (SF1).

The focus of this report is from August 2001 through August 2002 with some data from a few years back to complete certain analyses. Each fen will have its own analyses and will be compared with all the other fens to determine how they, the Jacoby Creek and weather affect each other. This will allow for an enhanced understanding of the fen ecosystem and the surrounding environment to help in the preservation of the delicate wetland and to prevent the extinction of the diverse and endangered plant and animal life that is only present in a fen.

SITE DESCRIPTION:

The Mount Bethel Fen Complex is located in Mount Bethel, Pa Northampton County within the Jacoby Creek watershed. The area is mainly comprised of forests, residential lots, and a small amount of industrial areas. The Mount Bethel Fens Complex is made up of five fens. Eight peizometers are located as follows: Savadge Fen well #1, Taylor Fen well #l, Taylor Seep well #1, Taylor Shrub Fen wells #1 and 2, Bartlett Fen wells #3, 5, and 8. These are all feed from seeps and springs. The water that runs through the fens eventually joins the Jacoby Creek but does surface as steams in some places.

The fens are located in a valley just south of the Kittitany Ridge near a northern sloping hill perpendicular to the regional trend of water flow east to the Delaware River (Snaith et al, 1999). An East/West railroad track marks the southern broader and Route 611 is the northern.

The bedrock geology in the Jacoby Creek watershed is primarily composed of three major formations: the Upper Cambrian to Lower Ordovician Allentown Dolomite, the Middle to Upper Ordovician Martinsburg Formation, and the Upper Ordovician to Middle

Silurian Shawangunk Formation (Fanok, 2000). Today the underlying bedrock in the Jacoby Creek valley and the fen complex is the Allentown Dolomite. The Martinsburg Formation, which is composed of silts, sandstones and fine grained slates, forms the low lying ridges located within the watershed. And finally the Shawangunk Formation is what forms the Kittatinny Ridge which is immediately to the north of the complex.

During the Taconic orogeny, complex folding and faulting created the Ackerman Anticline, the main geologic structure in the Mount Bethel area. This anticline exposes each of the three formations at the surface but also influences the regional groundwater flow and gradients in the area.

Two periods of glaciation affected the Jacoby Creek watershed: the Illinoian glaciation 0.55 to 0.1 Ma, and the Wisconsinan glaciation 20,000 to 14,000 ka. The Wisconsinan deposits have a greater affect on the fen complex even though the Illinoian glaciation left a deeply weathered till in the Jacoby valley. During the Wisconsinan, a major ice lobe occupied the lower Delaware Valley and segments of the Jacoby Creek Valley. This blocked the drainage of Jacoby Creek and formed the glacial Lake Portland. During the retreat of the Wisconsinan glaciers, kames, kame terraces, kame delta and unstratified till was deposited in the Jacoby Creek valley (Fanok, 2000). This "kame-and-kettle topography" is a very irregular landscape filled with till, lacustrian clays and glacial outwash deposited in the glacial lakes and ponds. The Mount Bethel Fen Complex is located in the kettles or depressions in the glacial outwash.

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 which feed the fens. The blue-green lacustrian clay forms an impermeable layer that retards both the upward and the 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 show that all three aquifers are contributing to different fens in the complex.

DATA COLLECTION:

Water levels:

The height of water in eight monitored peizometers is collected on a monthly basis. This data was taken three times at each well to ensure accuracy. Water table elevation is determined by measuring the depth to water, subtracting that from the height of the riser above the ground. The water height is recorded in cm. Water elevations and fluctuations are assessed and compared through time to determine the natural variability associated with seasonal and long term climatic changes.

Water Sampling:

Water sampling occurs on a quarterly basis, one time for each season. A well from each of the fens along with 2 sites on the Jacoby Creek are sampled. In the fens, a sample of water is collected to record pH, temperature, specific conductance, and dissolved oxygen. These parameters are also tested in the surface waters. Then the well is purged to ensure that the field measurement and sample data that are subsequently collected (post-bail samples) reflect the chemistry of water in the aquifer, and not that of the water that has been standing in the peizometer. After the well has been purged, time is allotted for the well to recover, and then a representative water sample is taken and then analyzed. Temperature, pH, specific conductance, and dissolved oxygen are again recorded. In the field, temperature, pH, conductivity and DO were measured using the Quanta G Hydroprobe. Water taken from these sites is then brought back to the lab to be tested. Three analyses are preformed: nutrient, IC, and ICP. Temperature is the key determinant of what species can survive in a particular environment. Temperature preferences vary widely among species and all species are negatively impacted by rapid fluctuations in temperature. Temperature, which is measured out in the field, is recorded in degrees Celsius ("Explanation of Water Quality Parameters"). The pH is based on a scale from 0 to 14. On this scale, 0 is the most acidic value, and 14 is the most alkaline value. Seven would be neutral. The pH levels between 6.5 and 8.2 are optimal for most aquatic organisms. A change of one pH unit represents a 10-fold change in acidity or alkalinity. Type of bedrock and other natural conditions may affect pH readings. Since previous analysis of fen pH showed that fens have a relatively high pH, the Quanta G Hydroprobe was calibrated with pH buffers of 7 and 10 (Snaith et al, 1999). Variations in pH affect chemical and biological processes in water; low pH increases availability of metals and other toxins for intake by aquatic organisms; thus it is critical to maintain a constant pH ("Explanation of Water Quality Parameters"). Conductivity measures the quantity of ions in the water or in other words, the ability for the water to conduct an electric current. The units for conductivity are micro Siemens (uS), with measurements commonly expressed in uS per centimeter at a degree Celsius. Natural waters will have a conductivity of less than 1 uS. Geologic formations have significant impact on the specific conductance of a stream. Streams and groundwater flowing through carbonate bedrocks often yield high conductivity. Conductivity was measured to indicate the ion concentration and hardness of the water. Conductivity increases as the ion concentration increases, and hardness is affected by the ion concentration (Snaith et al, 1998). Measurements outside normal range may indicate the presence of a contaminant ("Explanation of Water Quality Parameters"). Nutrient tests for phosphates and nitrates are conducted in determining water quality. Organic phosphates are associated with living material and are essential for plant and animal growth. Slight increases may cause numerous undesirable effects such as accelerated plant growth and algal blooms, which would result in low dissolved oxygen and death of certain aquatic organisms. Nitrate is the most completely oxidized state of nitrogen commonly found in water, and is the most readily available state utilized for plant growth. High nitrate levels in streams cause excessive plant and algae growth and promote a deteriorating process called eutrophication. Fertilizer runoff resulting from improper application, human and animal wastes from failing septic systems and livestock confinement areas, and decomposing organic matter are all causes for elevated nitrate readings ("Explanation of Water Quality Parameters"). The Ion Chromatograph tests anion concentrations, such as sulfate and chloride. Sulfur is commonly found as a component of sedimentary and igneous rocks in the form of metallic sulfides. Sulfides are oxidized upon contact with aerated water, producing sulfate ion in solution. The combustion of fuel and ore-smelting processes are major anthropogenic causes of sulfate concentrations found in natural waters. Sulfides may also be present in soils that are oxidized through natural processes or organic waste treatment. Excessively high sulfate are often associated with mine drainage. High sulfate as well as chloride concentrations may be found in residual runoff from irrigated areas due to water that was lost through evapotranspiration. Chloride is contained in rock and soil, as well as animal wastes and is released during the decomposition of living organisms. The value of chloride, for the purpose of water quality monitoring, is its role as an indicator of other substances, such as street salting, sewage, failing septic systems, landfills, and various industries ("Explanation of Water Quality Parameters"). The

Inductively Coupled Plasma tests for cation concentrations such as Fe, Al, K, Ca, Na, and Mg. Although iron is the second most abundant metallic element on the earth, concentrations in water are generally small. Iron is an essential element in the metabolism of animals and plants. If present in water in excessive amounts, it forms red oxyhydroxide precipates. Near coalmine drainage water, lower pH and higher iron concentration can occur. Aluminum rarely occurs in solution in natural water in concentrations greater that a few tenths or hundredths of a milligram per liter. The exceptions are mostly waters of very low pH. The dissolved aluminum in waters having low pH has a deleterious effect on aquatic life. Water having a pH below 4.0, like water draining from abandoned mines, may contain several hundred or even several thousand milligrams of aluminum per liter. Elevated aluminum concentrations have also been observed in runoff and lake waters in areas affected by low pH precipitation. Potassium is an essential element in both plants and animals. Maintenance of optimum soil fertility entails providing a supply of available potassium. The element is present in plant material and is lost by crop harvesting and removal as well as by leaching and runoff acting on organic residues. Sodium is analyzed to detect if road salts laid down to melt ice are seeping their way into the fens. Allentown Dolomite, which is predominantly Mg/Ca CO3, is the main bedrock in the Jacoby Creek watershed and a source aquifer for the fens. Therefore calcium and magnesium are monitored. Calcium is the most abundant of the alkaline-earth metals and is a major constituent of many common rock minerals. It is an essential element for plant and animal life and is a major component of the solutes in most natural water. Calcium is generally a predominant cation in river waters. Measured pH in river water is generally not well correlated with calcium concentration. Sodium is also analyzed to detect if road salts laid down to melt ice are seeping their way into the fens. Magnesium is monitored since it is a mineral that comes from the underlying bedrock. The water picks up this mineral as it flows through the rocks. Finally bicarbonate is another intrinsic part of the fens system. The water picks up bicarbonate as it flows through the limestone ("Explanation of Water Quality Parameters").

Weather Data:

Two weather stations are set up within the fen complex, one at Godshalk and one on the Jones' property. Each weather station monitors rainfall on an event basis, dew point, temperature, and relative and absolute humidity on a 15 minute timed interval. This data is downloaded monthly and brought back to the lab via a HOBO shuttle to be put in a spreadsheet. This data is analyzed to see how other environmental factors impact the fens.

Stream Gauging Data:

The gauging station monitors depth of the Jacoby Creek in order to calculate its discharge, especially after a rain event or periods of drought. To see how these conditions may affect water levels in the fens. The data is collected by the station every five minutes and averages every 15 minutes. The data is collected on a monthly basis. The gauging station procedure for this can be found in Appendix B.

Plant Data:

In four fens (Bartlet, Taylor II, Savadge and Houdaille Wildlife Refuge) there are multiple plots set up to monitor populations of *Lythrum salicaria* and *Phragmites australis* as well as the native plants. The vegetation sampling entails recording the number of stems of the invasive species and also the maximum diameter of the *Phragmites* and the maximum height of the *Lythrum salicaria.* The plots themselves are broken up into four quadrants and the maximum height and diameter is taken in each. Percent cover of the native species was recorded, with most plants identified to the species level (including sedges). This data is then put into a formatted spreadsheet and analyzed. This year *Phragmites* density was counted in March 2002 and the again in June 2002. The March and June data were then compared to see if the density of *Phragmites* could be accurately predicted in winter before the bog turtles came out of hibernation. This is the first year this part of the study has taken place and therefore there may be alterations made in the coming year. We also have made an electronic and natural herbarium to use in the identification of the different plant species.

METHODS:

Please see Appendix B for all procedures and equipment used.

RESULTS:

<u>Weather Data:</u>

All of the weather parameters for the fens that we measure are displayed in the Godshalk Monthly Weather Averages chart, and the Jones Monthly Weather Averages chart in Appendix C. Temperature degrees F, Temperature degrees C, High-Res Temperature degrees F, High-Res Temperature degrees C, Dew Point degrees F, Dew Point degrees C, Absolute Humidity, and Relative Humidity percent are all measured and shown in the chart for each site since June 2000, when the stations were installed. Data was unavailable at that time of the production of this paper for the months of August 2000, September 2000, August 2001, September 2001, October 2001, and November 2001 for both Jones, and Godshalk weather stations. May 2001 data is also not available at this time for Godshalk weather station.

A closer analysis of the temperature degrees C, relative humidity percent, and rain total has been done for both weather stations for all the data back till October 2000. This information is shown in the Temperature, Relative Humidity, and Rain Total Data chart, and two visuals are provided displaying this data for the Godshalk and Jones weather stations, in Appendix C page 32.

The August 2001 monthly average temperature for Godshalk was 20.33 degrees Celsius, while Jones was about the same at 20.32 degrees Celsius. Relative Humidity information is not available at this time for both weather stations. The total rainfall for Godshalk was 68 hundredths of an inch of rain, while Jones received 176 hundredths of an inch of rain.

The September 2001 monthly average temperature for Godshalk was 16.10 degrees Celsius, while Jones was slightly colder at 16.03 degrees Celsius. Relative Humidity information is not available at this time for both stations. The total rainfall was zero for both sites.

The October 2001 monthly average temperature for Godshalk was 10.78 degrees Celsius, while Jones was warmer at 11.21 degrees Celsius. Relative Humidity information is not available for both sites at this time. The total rainfall for Godshalk was 67 hundredths of an inch of rain, and the rainfall data for Jones is unavailable.

The November 2001 monthly average temperature for Godshalk is 6.35 degrees Celsius, while Jones was higher at 7.36 degrees Celsius. Relative Humidity information is unavailable at this time for both sites. The total rainfall for Godshalk is 30 hundredths of an inch of rain, while the Jones rainfall data is not available.

The December 2001 monthly average temperature for Godshalk is .91 degrees Celsius, while Jones was lower at .36 degrees Celsius. The Relative Humidity for Godshalk was 38.29%, while Jones had a relative humidity of 71.90%. The total rainfall for Godshalk was 120 hundredths of an inch, while Jones received 110 hundredths of an inch.

The January 2002 monthly average temperature for Godshalk was -0.17 degrees Celsius, while Jones was warmer at 0.51 degrees Celsius. The Relative Humidity for Godshalk was 41.91%, while Jones was higher at 74.04%. The total rainfall for Godshalk was 158 hundredths of an inch, while Jones received less with 127 hundredths of an inch being produced.

The February 2002 monthly average temperature for Godshalk was 1.29 degrees Celsius, while Jones was colder at 1.18 degrees Celsius. The Relative Humidity for Godshalk was 27.94%, while Jones Relative Humidity was higher at 63.92%. The total rainfall for Godshalk was 42 hundredths of an inch, while Jones received 25 hundredths of an inch of the month.

The March 2002 monthly average temperature for Godshalk was 3.62 degrees Celsius, while Jones was lower at 3.51 degrees Celsius. The Relative Humidity for Godshalk was 36.28%, while the Jones Relative Humidity was higher at 69.40%. The total rainfall for Godshalk was 303 hundredths of an inch, while Jones received 338 hundredths of an inch of rainfall.

The April 2002 monthly average temperature for Godshalk was 10.50 degrees Celsius, while Jones was about the same at 10.55 degrees Celsius. The Relative Humidity for Godshalk was 35.46%, while the Jones Relative Humidity was higher at 67.75%. The total rainfall for Godshalk was 368 hundredths of an inch of rain, while Jones received less rainfall at 283 hundredths of an inch.

The May 2002 monthly average temperature for Godshalk was 12.99 degrees Celsius, while Jones was warmer at 14.69 degrees Celsius. The Relative Humidity for Godshalk was 54.39%, while Jones Relative Humidity was higher at 83.88%. The total rainfall for Godshalk was 503 hundredths of an inch, while Jones received less rainfall at 323 hundredths of an inch.

The June 2002 monthly average temperature for Godshalk was 19.38 degrees Celsius, while Jones was about the same at 19.34 degrees Celsius. The Relative Humidity for Godshalk was 57.98%, while Jones Relative Humidity was 80.83%. The total rainfall for Godshalk is not entirely available due to technical difficulties with the rain data logger, but Jones total rainfall was 479 hundredths of an inch of rain.

Rain Data:

The Jones Weather Station is located on a ridge outside of the fens complex. This site was established to give us a different perspective of how rain events can differ from one site compared to another. The Godshalk Weather Station is located in a hollow near Taylor Shrub Fen in the fen complex. Having these two weather stations allows us to view the rainfall differences as well as other weather differences in these two different microclimates.

Jones rainfall can be seen in the Monthly Rainfall Totals chart for this past year, as well as for the previous year, in Appendix C on page 32 of this report. August 2001 had 1.76 in. of rain produced, 0.00 in September 2001, and there is no data available for rain events for the months of October and November 2001 as there were technical difficulties. December 2001 had 1.10 in. of rainfall, rainfall increased to 1.27 in. in January 2002, there was a dramatic decrease in rainfall in February 2002 with only .25 in. being produced, a great increase in rainfall for the month of March 2002 produced 3.38 in., then 2.83 in. in April 2002, 3.23 in.

in May 2002, and the highest monthly average of rainfall for this year at Jones was 4.79 in. of rain in June 2002. July 2002 data is not yet available.

Godshalk rainfall can also be seen in the Monthly Rainfall Totals chart for this past year (2002), as well as for the previous year (2001), in Appendix C on page 32 of this report. August 2001 saw a small amount of rainfall, .68 in. was produced, and September 2001 was dry with 0.00 in. of rain being recorded. October 2001 and November 2001 were both dry months producing .67 in. and .30 in. of precipitation, respectively. December 2001 had 1.2 in. of rainfall, 1.58 in. in January 2002. Then February had .42 in. of rainfall, 3.03 in March 2002, 3.68 in. in April, 5.03 in. in May 2002, and 3.04 in. of rainfall in June 2002. June 2002 data is not yet available.

Water Conductivity, pH, and Temperature:

Our sampling of the wells is done quarterly, and since we chose to show the data for a whole year we will have five dates where data was collected. These months are July 2001, October 2001, January 2002, April 2002, and July 2002. Therefore the individual post bail temperatures, pH values, and conductivities will be given in the order from July 2001 to July 2002 and all the data as well as graphs can be seen in Appendix D on page 33.

Taylor Fen 1 had a temperature of 16.5 degrees Celsius, 17.9 degrees Celsius, 9.7 degrees Celsius, 12.1 degrees Celsius, and 15.8 degrees Celsius throughout the year. pH values were 8.05 in July 2001, 7.88 in October 2001, 7.90 in January 2002, 7.98 in April 2002, and 7.63 in July 2002. The conductivity was 465 micro Siemans/cm. in July 2001, 452 micro Siemans/cm., 501 micro Siemans/cm., 473 micro Siemans/cm., and 463 micro Siemans/cm. in July 2002.

Taylor Seep 1 had a temperature of 26.9 degrees Celsius in July 2001, 22.5 degrees Celsius in October 2001, 3.6 degrees Celsius in January 2002, 12.9 degrees Celsius in April 2002, and 26.7 degrees Celsius in July 2002. pH values were 7.61 in July 2001, 7.61 in October 2001, 7.8 in January 2002, 7.7 in April 2002, and 7.54 in July 2002. The conductivity for Taylor Seep1 was 622 micro Siemans/cm. in July 2001, 621 micro Siemans/cm. in October 2001, 611 micro Siemans/cm. in January 2002, 601 micro Siemans/cm. in April 2002, and 580 micro Siemans/cm. in July 2002.

Taylor Shrub Fen 1 had a temperature of 18.4 degrees Celsius in July 2001, 18.5 degrees Celsius in October 2001, 8.6degrees Celsius in January 2002, 10.1 degrees Celsius in April 2002, and 17.3 degrees Celsius in July 2002. pH values were 7.53 in July 2001, 7.58 in October 2001, 7.67 in January 2002, 7.66 in April 2002, and 7.35 in July 2002. The conductivity for Taylor Shrub Fen 1 was 669 micro Siemans/cm. in July 2001, 777 micro Siemans/cm. in October 2001, 754 micro Siemans/cm. in January 2002, 814 micro Siemans/cm. in April 2002, and 757 micro Siemans/cm. in July 2002.

Bartlett Fen 5 had a temperature of 22.0 degrees Celsius in July 2001, 17.8 degrees Celsius in October 2001, 5.2 degrees Celsius in January 2002, 13.0 degrees Celsius in April 2002, and 20.9 degrees Celsius in July 2002. pH values were 7.64 in July 2001, 7.44 in October 2001, 7.76 in January 2002, 7.92 in April 2002, and 7.28 in July 2002. The conductivity for Bartlett Fen 5 was 731 micro Siemans/cm. in July 2001, 555 micro Siemans/cm. in October 2001, 595 micro Siemans/cm. in January 2002, 401 micro Siemans/cm. in April 2002, and 608 micro Siemans/cm. in July 2002.

Savadge Fen 1 had temperatures of 21.9 degrees Celsius, 17.5 degrees Celsius, 6.1 degrees Celsius, 10.17 degrees Celsius, and 16.4 degrees Celsius throughout the year. The pH was 7.33 in July 2001, 7.48 in October 2001, 7.58 in January 2002, 7.09 in April 2002, and 7.08 in July 2002. The conductivity was 731 micro Siemans/cm., 727 micro

Siemans/cm., 738 micro Siemans/cm., 679 micro Siemans/cm., and 697 micro Siemans/cm. during the time period 2001-2002.

Well Levels:

The Mt. Bethel Fens Well Levels chart in Appendix, displays the mean monthly water levels for Taylor Fen 1(TF1), Taylor Seep 1(TS1), Bartlett Fen 3(BF3), Bartlett Fen 5(BF5), Bartlett Fen 8(BF8), Taylor Shrub Fen 1(TSF1), Taylor Shrub Fen 3(TSF3), and Savadge Fen 1(SF1). There is also a graph displaying these mean monthly well levels, called Mt. Bethel Fens Well Water Levels, in Appendix.

It should be noted that some of the wells have negative well heights, which simply means that the water level within the well sits below the surface. A positive value would mean that the water level is above the surface of the ground, but within the casing.

Taylor Fen 1 showed fluctuating well levels throughout the year, with a maximum well height in May 2002 of 104.02 cm., and a minimum in August 2001 of 74.03 cm. For August the level was 74.03 cm., then the well level increased in September 2001 to 81.57 cm., October 2001 showed a drop to 79.90 cm., then November 2001 had an increase to 81.83 cm., and December 2001 finished the year with an increase to 92.57 cm. For the month of January 2002 the well level was 93.57 cm., then a drop occurred in February 2002 to 88.27 cm., then an increase in March 2002 to 101.50 cm., followed by a drop again in April to 96.60 cm., then an increase in well level occurred in May 2002 to 104.02, followed by a decrease in well level for the months of June 2002 to 94.10 cm. and July to 79.45 cm.

Taylor Seep 1 showed well levels that had some fluctuation throughout the year, with a maximum well level of 34.64 cm. in May 2002, and a minimum of 19.53 cm. in August 2001. From the low in August 2001, the well levels increased for the month September 2001 to a well level of 25.70 cm, October 2001- 23.63 cm., November 2001- 22.00 cm., December 2001- 26.50 cm., January 2002- 31.23 cm., February 2002- 29.27cm, March 2002- 32.57 cm., April 2002- 30.53 cm., March 2002- 34.64, June- 34.63 cm., and a decrease in the month of July 2002 to a well level of 26.75 cm.

Bartlett Fen 3 showed fluctuating well levels throughout the year, with a maximum well level in May 2002 of 14.44 cm., and a minimum well level in February 2002 of -6.00 cm. August 2001 well level data is not available at this time. September 2001 had a well level of 5.97 cm., October 2001- 3.90 cm., November 2001- 6.37 cm., December 2001- 4.30cm, January 2002 showed a sizable decrease to -4.00 cm., and still another decrease was observed in February 2002 to a level of -6.00 cm., March 2002- 1.00 cm., April 2002- 4.43 cm., and an increase in May 2002 to the maximum high well level of 14.44 cm, followed by a decrease for both the months of June 2002 to 2.73 cm, and July to 0.93 cm.

Bartlett Fen 5 showed well level fluctuation, with a maximum well level of -8.78 cm. in the month of May 2002, and a minimum well level of -32.17 cm. for the month of February 2002. August 2001 well level data is not available at this time. September 2001 well level was measured to be -9.83 cm., October 2001- -15.20 cm., November 2001- -23.03cm, and December 2001- -16.50 cm., January 2002- -13.70 cm., February 2002 showed a decrease in well level to the minimum well level of -32.17 cm., a slight gain in well level occurred for the months of March 2002 to -25.50cm, April 2002 to -24.77, and May 2002 to -8.78 cm. June 2002 and July showed decreases in well levels to -14.93 cm. and -19.70 cm respectively.

Bartlett Fen 8 had fluctuations in well level throughout the year, with a maximum well level of 5.60 cm in September 2001, and a minimum well level of –16.73 cm in February 2002. Well level data for the month of August 2001 is not available at this time. September 2001 started the year off at its maximum well level of 5.60 cm. followed by decrease in well level for the months of October 2001 to 0.47 cm, and November 2001 to –9.17 cm. There was then an increase in well height observed for the month of December 2001 to –1.77 cm. Then similar well levels were recorded for January 2002, February 2002, and March 2002 to well levels of –15.47 cm., -16.73 cm., and –16.23 cm. respectively. There was then an increase in well height for April 2002 to –9.97 cm., May 2002 to –8.69 cm and June 2002 to –2.03 cm. July 2002 well level decreased to –6.75 cm.

Taylor Shrub Fen 1 seemed to have a relatively stable well level throughout the year, ignoring the month of April 2002 data. The maximum well level was 34.37 cm. in June 2002, and the minimum was observed to be in April 2002 of –82.00 cm, with the next lowest well level being that of the month of February 2002 of 26.90 cm. August 2001 well level was recorded to be 28.17 cm, September 2001 to 32.97 cm. October 2001 to 32.10 cm, November 2001 to 31.10 cm., December 2001 to 31.50 cm., January 2002 to 29.63 cm, February 2002 to 26.90 cm., March 2002 to 28.93 cm. Then for the month of April 2002 the well level was measured to be –82.00 cm; this data doesn't seem to fit and there must have been an error present when this data was collected or analyzed due to how low the value is. May 2002 and June 2002 showed increases in well levels to 33.27 cm and 34.37 cm respectively. There was then a decrease in well level for July 2002, with a well level of 29.23 cm.

Taylor Shrub Fen 3 had mostly stable well levels with a few exceptions. The maximum well level was 40.00 cm in April 2002, and the minimum well level was 2.20 cm. in January 2002. August 2001 reported a well level of 4.20 cm., September 2001, October 2001, November 2001, and December 2001 all showed increases in their well levels to 6.90 cm., 8.23 cm., 9.07 cm., and 10.23 cm respectively. There was then a decrease in well level for the month of January 2002 to a well level of 2.20, the minimum well level for the year. February 2002 measured to 8.00 cm., March 2002 to 11.03 cm., April 2002 to 40.00 cm., May 2002 to 13.44 cm., June 2002 to be 12.54 cm and July 2002 to 35.60 cm.

Savadge Fen 1 had fluctuations throughout the year, with a maximum well level of -1.90 cm. in December 2001 and a minimum well level of -18.43 cm. in February 2002. August 2001 well level was -3.10 cm, September 200- -8.50 cm., October 2001- -9.33 cm., November 2001- -13.60 cm., December 2001- -1.90 cm., January 2002 to -15.90 cm., and February 2002 to -18.43 cm. March 2002 recorded a well level of 65.30 cm. but this seems out of range for this site though it is possible. April 2002 had a well level of -17.33 cm., May 2002 to -8.20 cm., June 2002 to -6.11 cm and July 2002 to -12.17 cm.

Well Levels vs. Rainfall:

The amounts of rainfall reported at both the Jones weather station, and the Godshalk weather station, are shown in the Rainfall vs. Well Height Data sheet in Appendix C. Jones reported 1.76 in. in August 2001, no rainfall occurred in September 2001, data is unavailable for the months of October 2001 and November 2001, 1.10 in. in December 2001, 1.27 in. in January 2002, .25 inches in February 2002, 3.38 in. in March 2002, 2.83 in. in April 2002, 3.23 in. in May 2002, 4.79 in. in June 2002, and the July 2002 data is unavailable at this time due to the collection of that data in mid August.

The well levels for your reference can be found in a table on the Rainfall vs. Well Height Data page in Appendix E on page 34 of this report, along with the rainfall data for both stations.

The well levels have a correlation with the rainfall data. When there was less rainfall in the months of January and February of 2002, the well levels were also reporting low levels. In times when the rain increased during the months of March, April, May, and June of 2002, the well levels were reported to have an increase in water height. Some of the wells follow the rain totals more accurately than the others.

It should be noted that some of the well levels are reported as negative values, and this means that the water level sits below the surface of the ground. Well levels that are positive mean that the water level sits above ground in the galvanized steel casing

<u>Jacoby Creek Gauging Station:</u>

We found the weekly average from the data collect for the gauging station and used this to find the flow or *Q* of the Creek. The flow data, which can be found in Appendix F, is in cubic feet per second (CFS). With the weekly data we found linear and exponential (curved) flow rates. From the linear and curved data we found the maximum, minimum and average CFS passing by the gauging station. The linear maximum was 21.281 CFS, the minimum was -3.597 CFS, and the average was 6.188 CFS. The curved data was slightly large with a maximum of 27.938 CFS, a minimum of 2.703 CFS and an average of 7.250 CFS. We then found the exceedance values. To find the exceedance, we took the maximum value of each and multiplied by the percent I was trying to find, for example 21.28*0.2 would be 20% linear exceedance. Linear exceedance at 50% was 10.64 CFS and the exponential exceedance at 50% was 13.97. All data and graphs for Jacoby Creek can be found in Appendix F, page 35, of this report.

<u>Water Quality:</u>

Nutrient:

The following nutrient data covers data collected in the summer of 2001 up to and including the spring of 2002. Samples were collected for the summer of 2002 as well, but due to equipment problems and time constraints these results will be following in an addendum. Nutrient data is used to give the concentrations of nitrates and phosphates in the fen water.

Taylor Fen (TF1) had its highest nitrate concentration, 1.4 ppm, in April of 2002. This can not be compared with April of 2001 because this fen was not tested until July of 2001. The lowest nitrate concentration, .3580 ppm, occurred in December of 2001. Again we can not compare this with data from previous years because none exists. It does however seem to be slightly below the average concentration. Looking at phosphate concentrations, we see that the highest (0.5 ppm) and lowest (0 ppm) or B/D (below detection) occurred in July 2001 and December 2001 respectively. Because there is not other data we can only speculate on weather or not these concentrations are normal.

Taylor Seep (TS1) recorded its maximum nitrate concentration at 1.5 ppm in April 2002. This is slightly above normal for this particular fen as seen in previous years. The lowest (0.7072 ppm) was recorded in July of 2001. This again is a lower concentration then normal but not by enough to cause any problems. Phosphate had an unusually high concentration of 0.5461 ppm in July of 2001. This is a huge jump from the previous years and should be watched to see if it occurs again. The lowest was 0 ppm (or B/D) in December 2001 and April 2002 and this concentration is about the average for Taylor Seep.

Taylor Shrub Fen (TSF1) on average has a lower concentration of nitrate but in April 2002 the nitrate level was 1.70 ppm. A level like this was found in November of 2000. The lowest level was found to be 0 ppm (or B/D) in December 2001. Zero isn't extremely low and is within the limits of previous data. Phosphate levels at TSF1 are also usually low and this past year was no exception. The highest level was 0.5 ppm and the lowest was 0 ppm in July 2001 and December 2001 respectively. Although 0.5 ppm is slightly higher then usual it isn't the highest ever found and should not cause alarm.

Savadge Fen (SF1) has been tested from the beginning of this project. Its nitrate levels are on average higher then the rest of the fens. This year was no exception. We found the highest level in April 2002 at 2.60 ppm and the lowest in April 2001 at 1.3033 ppm. Phosphate, on the other hand, is somewhat lower then the nitrate and this pattern continues this year. SF1 had a concentration of 0.8959 ppm in July 2001 making that the highest ever found. Zero (0) ppm (or B/D) were found in December 2001 as well as April 2002 but isn't that much lower then normal.

Savage Pit, which is believed to be overflow from the Mount Bethel Diner's septic tank, was only tested in December of 2001 and July of 2002. Because the analysis of the July 2002 samples could not be completed in time there is nothing to compare the values with. The concentrations found in December 2001 were 0 ppm (or B/D) of nitrate and 0.0059 ppm of phosphate.

Bartlett Fen 5 (BF5) is one of the three well that are monitored in Bartlett Fen itself. It is however the only one we have ever tested for nutrients. In the past year the highest concentration of nitrate occurred in April 2002 at 0.80 ppm. The lowest nitrate concentration occurred in December 2001 at 0.1522 ppm. Both of these concentrations are within the normal range. Phosphate on the other hand had a huge concentration of 11.1366 ppm in April 2001 which is by far the highest ever found in Bartlett Fen. The lowest was 0 ppm (or B/D) which was found in December 2001 and April 2002. These concentrations are about average for BF5.

Jacoby Creek 2 (JC2) usually has very low concentrations of nitrate and phosphate. The highest nitrate concentration was 0.50 ppm in April 2002 and the highest phosphate concentration was 1.6195 ppm in July 2001. The lowest of both nitrate and phosphate was 0 ppm in December 2001.

Jacoby Creek 4 (JC4) also has low levels of both nitrate and phosphate. The highest found in the past year 0.70 ppm of nitrate in April 2002 and 4.1692 ppm of phosphate in July 2001. The high phosphate concentration is the highest to date and will be carefully watched over the following months. The lowest levels again occurred in December 2001 with 0 ppm (or B/D) found for each.

Overall Savadge Fen (SF1) had the highest concentration of nitrate (2.60 ppm) in the past year whereas Bartlett Fen 5 (BF5) had the highest concentration of phosphate (11.1366 ppm) in the past year. The lowest concentrations of nitrate were found in Savadge Pit, JC2 and JC4 with 0 ppm (or B/D) each. TF1, TS1, TSF1, SF1, BF5, JC2 and JC4 all had a concentration of 0 ppm for phosphate making them all have the lowest detectable value. All water quality data can be found in Appendix G, page 36, of this report.

ICP:

The ICP (Inductively Coupled Plasma) is used to test the concentration of K, Na, Mg, Al, Ca, and Fe in the water samples that are taken from the fens. This year we have enough data from previous years to compare the concentrations of these elements. This will allow us to find any trends that may exist and also to track large drops or increases. All this data can be found in Appendix G. Again due to equipment problems and time constraints, the ICP analysis for the July 2002 samples was not done. This will follow in an Addendum. We can however compare the results from the previous 5 years to find any trends.

The first year that we have ICP data for is the fall of 1997. This year only Savadge Fen was sampled and analyzed. The highest concentration was in Calcium (Ca) at 239.00 ppm. The lowest concentration was with Potassium (K) at 0.050 ppm.

Next is the winter of 1998. It may look like a few samples were skipped but this is how the data was recorded. In the winter of 1998, Savadge Fen was again the only fen tested. It also has the highest concentration in Ca at 106.00 ppm and the lowest in K at 0.977 ppm. It seems as if Ca is the dominant element in Savage Fen and K is hardly noticeable. The same is true for the spring of 1998. Again Ca is the highest concentration (102.00 ppm) and K is the lowest (2.360 ppm). We can not get an accurate comparison until the fall of 1999 when more then just Savadge Fen is tested.

The same five sites were tested through out 1999. They were SF1, BF5, TSF1, TS1 and JC2. In all five of the sites tested that fall, Ca was again present in the highest concentrations. The highest actually occurred in SF1 at 66.320 ppm. However K was not the lowest in concentration that fall. It was actually the Aluminum (Al) and Iron (Fe) concentrations. SF1, TSF1 and TS1 all read 0 ppm (or B/D) for both Al and Fe in fall 1999. JC2 had a 0 ppm concentration of Fe. BF5 had 0.058 ppm Al and 0.194 ppm Fe. Now it looks as though Ca will be the most abundant in all the sample sites but perhaps K will not be the least. The winter was not so different. Savadge Fen again had the highest concentration of Ca with 62.990 ppm in the sample. The other four sites were within that range as well. Also like the fall, Al and Fe are not present, meaning that they have concentrations of 0 ppm in all but one site. The only one to differ is JC2 with a 0.001 ppm concentration of Fe. Continuing though 1999 we again see that Ca is the prevalent cation. This quarter (spring) it isn't found in Savadge Fen it is actually found in Jacoby Creek 2 (JC2). The concentration here is 71.178 ppm compared to SF1 66.982 ppm. You can see there is a large difference. Also Fe is present, although in minuscule amounts. Al is again not present in any of the sites. And finally summer. Once again Ca makes up a huge majority of the water with it begin at 152.102 ppm concentration at SF1. But once again there is a change with K again being non existence in any of our samples. This time there is Al and Fe but these are again in very small amounts. A reason for these small amounts could possibly be where we started to have trouble with the ICP machine since the K channel no longer works.

The year of 2000 we added more wells to be sampled. The ones added were BF8, JC1, JC3 and JC4. They did not test for Al, Fe, and K. But following the pattern that we can somewhat see, Ca again holds the spot as having the highest concentration. It was not however at Savadge but in the Jacoby Creek. Jacoby Creek 3 (JC3) had a concentration of 39.827 ppm closely followed by Jacoby Creek 4 (JC4) with 39.8631 ppm. These close values may have happened because JC3 is just upstream of JC4. Given that we did not test three of the six cations, we can only give the lowest out of those three. The lowest concentration occurs at Jacoby Creek 1. It is 1.321 ppm of Magnesium (Mg). This site, which we no longer test, was the head waters of the Jacoby Creek. The fact that it is upstream of everything or that is out side the fens could account for the lower levels of Mg and Sodium (Na). In the spring of 2000 JC4 and BF8 were not tested. As in the fall, JC3 had the highest concentration: Ca at 32.422 ppm. JC1 again had the lowest with 1.31 ppm of Mg recorded.

The next year, 2001, we can again see that Ca is present in large amounts throughout the fen complex and as well as Savadge Pit. SF1 had a concentration of 75.02 ppm of Ca in the fall of this year. The K channel of the ICP was not working and no data was recorded. The lowest concentration was found at JC2. It was recorded as 0.010 ppm Fe. Al also had very low concentrations but none were close to the 0.010 ppm. In the spring of 2001, the Pit was not sampled but all the others were. Once again Ca was present in the highest concentrations throughout the fens but the largest was 72.13 ppm at SF1. TSF1, TS1, TF1, JC4, and BF5 all had the lowest concentrations: 0.010 ppm Fe.

Now we come to the present year, 2002. As previously stated, the samples taken in July 2002 were not completed and that data will follow in an addendum. Before the fall of this year, we could surmise that Ca would always be present in the largest concentration throughout the fen complex. However, in the fall we found that the highest concentration of Ca fell from 75.02 ppm to 5.023 ppm in Savadge Fen. This is a tremendous drop in concentration. This means that another of the cations is now the most ubiquitous. This is in fact the case. In Taylor Shrub Fen (TSF1) the sodium concentration escalated from 24.68 ppm to 54.847 ppm. So in the fall of 2002, the trend we thought we knew changed slightly. The lowest concentration didn't change much. It was still found to be Fe at 0.004 ppm. This is the smallest to date and happened at JC2. In the spring once again Na was the peak concentration. Taylor Fen (TF1) and Taylor Shrub Fen (TSF1) both had Na concentrations of 62.020 ppm. The smallest was once again Fe with 0.605 ppm at TF1.

Potassium (K) is the one thing that we have had the most problems with. In many of the years the channel was not working correctly or at all and therefore there is no data for some of the years. From the data we do have it looks as though the most K ever detected was in the fall of 1999 at TSF1. The concentration recorded there was 3.958 ppm. The smallest detectable concentration was 0.050 ppm the first year it was tested. As we only tested Savadge Fen and no other fens the first two years, it is not clear if this is completely accurate.

The next cation we will consider is Magnesium (Mg). The largest concentration in the past 5 years was 66.640 ppm at Taylor Seep (TS1). This was in the summer of 1999. The smallest was 0.054 ppm at JC4 in the fall of 2002.

Sodium (Na) largest concentration was 62.020 ppm at Taylor Shrub Fen and Taylor Fen. The lowest was 0.060 ppm at Bartlet Lake in the spring of 2002. Bartlet Lake was formed by the pooling of water from a beaver dam; it isn't really a lake and is found near BF3.

Although aluminum was found in very small quantities when compare to the other cations, comparing it over the years allows us to see where the most Al is. In the spring of 2002 we had a concentration of 13.028 ppm at JC2 which is the largest Al concentration ever recorded to date. The lowest ever is 0.010 ppm at TSF1 in the summer of 1999.

As with Al, Fe is also in such small amount is it sometimes undetectable. Over the past 5 years the highest concentration of Fe was 10.400 ppm at Savadge Fen the very first year, 1997. The lowest was 0.001 ppm at JC2, winter 1999.

The last cation is Calcium (Ca). By far throughout the year Ca has been the most abundant. The largest concentration was the very first year we test (fall 1997) with an astonishing 239.00 ppm at SF1. The smallest ever was 1.208 ppm JC2 in fall 2002. All water quality data can be found in Appendix G, page 36, of this report. The ICP data follows the nutrient data.

IC:

The IC (Ion Chromatography) is used to find the concentration of Cl- and SO- in the fen and creek water. Standards are made using NaCl and $NaSO_4$. Each standard and sample is run through the machine, manually, three times. Unfortunately there wasn't time to compile all the IC data like what was done with the ICP and no comparisons can be made based on years. Also, due to technical problems and lack of time, the July 25th, 2002 samples were not analyzed. The results will follow in an addendum.

Over all the sites sampled, Taylor Shrub Fen (TSF1) had the highest concentration of Cl- with 88.9 ppm on November 30, 2001. It also had the highest concentration of SO- with 53.3 ppm on May 1, 2002. The lowest concentrations in all the sites were 0.10 ppm Cl- at Bartlett Fen (BF5) on May 1, 2002 and 3.0 ppm SO- in Taylor Fen on November 30, 2001.

The highest concentration of Cl- for TF1 was 17.3 ppm on November 19, 2001 and the lowest Cl- was 4.6 ppm on February 21, 2002. For SO- the highest concentration in Taylor Fen was 34.6 ppm on February 21, 2002 and the lowest was 3.0 ppm on November 30, 2001.

For Taylor Seep the highest Cl- and SO- were 42.1 ppm November 30, 2001 and 43.3 ppm May 1, 2002 respectively. The lowest of both of theses were 24.1 ppm Cl- May 1, 2002 and 16.8 ppm SO- November 30, 2002.

In TSF1, the highest Cl- was 88.9 ppm November 30, 2001 and the lowest was 55.4 ppm November 19, 2001. For SO- the highest was 53.3 ppm on May 1, 2002 and the lowest was 27.2 ppm November 30, 2001.

The highest concentrations in Savadge Fen were 61.0 ppm Cl- on November 30, 2001 and 44.0 ppm SO- on May 1, 2002. The lowest were November 19, 2001 at 37.7 ppm Cl- and November 30, 2001 at 17.5 ppm SO-.

Savadge Pit was not test on November 19th, November 30th, or February 21st. In May of 2002 it was the concentration were 32.3 ppm Cl- and 24.4 ppm SO-.

In Bartlet Fen Cl- was at its peal concentration on February 21, 2002 at 19.3 ppm. SO- was at its peak on May 1, 2002 at 38.1 ppm. The low points of these anions were both on November 30, 2001 at 1.3 ppm Cl- and 3.1 ppm SO-.

Bartlet Lake was not tested on November 19th, November 30th, or February 21st. The concentrations from May 2002 are 3.4 ppm Cl- and 52.1 ppm SO-.

Jacoby Creek 2, the upstream site, had it highest concentration of Cl- at 2.5 ppm on February 21, 2001 and its lowest, which was below detection, on November 30, 2001. As for SO- the highest was 19.7 ppm on May 1, 2002 and it's lowest was also on November 30, 2001. This too was below detection.

Jacoby Creek 4, the downstream site, had its highest concentration of Cl- on November 30, 2001 at 21.9 ppm. The lowest concentration of Cl- was on May 1, 2002 at 6.6 ppm. The highest SO- concentration was 32.0 ppm on May 1, 2002 and the lowest was 8.1 ppm on November 19, 2001. The SO- looks as though it goes on a steady climb here through the months and peaks in May 2002. However since sampling is only done four times a year, this is only an assumption. All data concerning the IC can be found in Appendix G, page 36, of this report. It follows the ICP data.

Plant Data:

The four fens being monitored are Taylor II, Bartlet, Savadge and Houdaille Wildlife Refuge. The raw plot data for *Phragmites* and *Lythrum* populations are reported in tables in Appendix H, page 37. Percent cover of native species can be found in excel files stored by LEO.

In Taylor II, 12 plots were sampled. Monitoring focused on *Phragmites* so replicate plots were placed in the interior of the *Phragmites* stand (n=3), along the border of the *Phragmites* advancing front (n=3) and in the un-invaded open fen (n=3). Because goat herbivory was to be tested for *Phragmites* control, we also sampled three additional plots in the stand interior, which are to be fenced off and used as control plots. The average *Phragmites* stem density in the control plots was 94 ±11 SD, in the stand plots was 67±6 SD, in the border plots was 24±19 SD, and the open was zero. The average *Phragmites* stem diameter (cm) in the control plots was 0.62 ±0.02 SD, stand interior plots was 0.67±0.04 SD, in the border plots was 0.61±0.10 SD, and in the open fen there were no stems.

In Bartlet fen, 11 plots were sampled in the *Phragmites* stand interior (n=3), at the advancing front (n=3) and in the open fen (n=5). The average *Phragmites* stem density in the stand interior plots was 34±4 SD, in the border plots was 21±20 SD, and in the open fen was 3±7 SD. The average *Phragmites* stem diameter (cm) in the stand interior plots was 0.55±0.06 SD, in the border plots was 0.51±0.07 SD, and in the open fen was 0.12. The average *Lythrum* stem density in the stand interior plots was 47±43 SD, in the border plots was 2±4 SD, and in the open fen was 2±3 SD. The average *Lythrum* stem height (cm) in the stand interior plots was 21.7±4.6 SD, in the border plots was 37, and in the open fen was 21.9±5.5 SD.

In June, Savadge Fen 11 plots were sampled, in the open fen (n=5), in interior of the *Phragmites* patch (n=3) and on the patch border (n=3). Out of these six plots three were in the stand and three were along the border. The average *Phragmites* stem density in the stand interior plots was 38±19 SD, in the border plots was 6±5 SD. The average *Phragmites* stem diameter (cm) in the stand interior plots was 0.43±0.07 SD, in the border plots was 0.25±0.18 SD. There were no stems at all in the five open fens. The average *Lythrum* stem density in the stand interior plots was 4±3 SD, in the border plots was 1±1 SD, and in the open fen was 6±7 SD. The average *Lythrum* stem height (cm) in the stand interior plots was 43.46±10.27 SD, in the border plots was 13.55±13.65 SD, and in the open fen was 13.63±10.85 SD.

Also done only in June was the Houdaille Wildlife Refuge. There are only five plots in this area and are not differentiated by open, control, stand or border. In Houdaille there was no *Phragmites* but there was an enormous amount of *Lythrum*. The average *Lythrum* stem density was 36±17 SD. The average *Lythrum* stem height (cm) in was 79.65±12.44 SD. The Nature Conservancy released beetles here in late summer as a control against the *Lythrum*.

DISCUSSION:

Weather Data:

The relative humidity recorded at Godshalk weather station is different than that recorded at Jones weather station, as can be seen when comparing the Godshalk Weather Station Temperature, Relative Humidity, and Rainfall graph to the Jones Weather Station Temperature, Relative Humidity, and Rainfall graph in Appendix C, page 32. Godshalk from December 2001 to June 2002 has always had a lower relative humidity than Jones weather station. This may be due to the fact that the Jones weather station sits on a ridge, and therefore as air rises up the slope it has more time to condense and produce a more humid environment. An interesting point is that the relative humidity at Godshalk appears to be much lower than the readings that were observed last year at the same time. Comparison of the Jones relative humidity between the years shows it to be about the same, just a little higher this year than the previous. The trend for the colder months to have a higher relative humidity due to cold air being able to hold more moisture is not the case. The early summer months have the highest readings for relative humidity during the year.

In terms of temperature both sites have about the same temperature throughout the year with neither site staying warmer or colder than the other does. There is the usual trend that one would expect to find in this region of the world. We have colder temperatures during the months of November, December, January, February, and March and then warming temperatures till we reach the warmer months of June, July, and August. A comparison of the temperatures from the previous year to this one shows that we had a milder winter this year. This indeed was the case as we can all remember how there was a lack of snow and cold temperatures. The temperature compared against the rainfall data might show a trend, but this will need further investigation. There is missing data for the rainfall amounts for the months of October 2001 and November 2001 at Jones weather station so it's hard to assume anything. However, it appears that when it's cold there is less rain, and when it is warm there is more rain. I know this can't be the case, but for this year that seems to have been the trend. Future years will probably show a trend where the rain fluctuates throughout the year, while temperature will continue with its usual consistent pattern of a general warming and cooling during the year.

The rainfall data for Godshalk shows less rainfall being produced during August 2001 to February 2002. Then in March 2002 the rainfall totals began to become sizable till the month of June, which is where our information ends. Jones rainfall data is missing the rainfall amounts for the months of October 2001 and November 2001. However, it shows a similar pattern being dry in December 2001, January 2001, and February 2001, and then the monthly average rainfall amounts increasing during March, April, May, and June of 2002. There is a difference in the amount of rain received at each site showing that they both exist in separate and different microclimates. The rainfall data has a slight trend to decrease when the temperatures are lower, and increase when the temperatures increase. But we know the rainfall is independent of the temperature. Rainfall does correlate with the well levels though, as can be seen in the Well Levels vs. Rainfall part of this paper, in Appendix E page 34. Most of the wells have rising levels when there are rain events, and tend to have lower levels when there is a lack of precipitation.

Rain Data:

Along with the Monthly Rainfall Totals chart in Appendix C there is also Godshalk vs. Jones Rainfall graph, which gives you a nice picture to compare the differences between the two sites.

Over the past two years there seems to be a correlation between Jones and Godshalk weather stations. When rain events happen, they usually happen to both sites, and they tend to receive a similar amount of rainfall. However there are differences seen between the two sites. For the previous year (2001) the trend was for Jones to receive more rainfall than Godshalk weather station with the bulk of the rainfall in February 2001 till July 2001. This year the trend was different. This year we had a dry winter in comparison to the previous winter and our rainfall didn't really pick up till March 2002, and it only persisted into June 2002. We suspect that July 2002 will be a dry month. Another interesting note is that this year there is no one weather station consistently receiving more rain than the other as can be seen in the Godshalk vs. Jones Rainfall graph in Appendix C, page 32. Godshalk rain data does seem to record more rainfall than Jones for parts of the year, like in December 2001, January 2002, and February 2002. However in March 2002, Jones received more rainfall. Then for the April and May 2002 Godshalk received more rain than Jones weather station.

Data is not available for the months of October 2001 and November 2001 for Jones weather station due to a technical malfunction. Also data is not available for the month of June 2002 for Godshalk weather station due to a battery that lost its power during that time period.

The Godshalk weather station may record higher values because of its location in a hollow, where the humidity levels are greater than on a ridge. There are more chances for water to condense and therefore add to the total amount of precipitation recorded by the rain data logger. Jones weather station may record more rain occasionally because it is on a ridge and therefore when air rises to where Jones sits it cools and loses its ability to hold water and more precipitation may fall. These are just some of the things that must be considered for why there are differences between these two sites. At a quick glance these two sites seem to be similar but there are differences between how and when it rains at these two sites. Both sites are useful for watching rainfall data for the fens complex.

Water Conductivity, pH, and Temperature:

The temperature of Taylor Fen 1 follows the yearly-expected temperature that occurs with the seasons, having high temperatures in the summer months and lower temperatures in the winter months. When comparing all the wells maximum water temperature, Taylor Fen 1 had the lowest temperature reading. The pH was fairly steady throughout the year, staying between 8.05 (the highest pH recorded of all the wells) and 7.88, except for the pH that was observed on July 2002 of 7.63. There is no seasonal trend found in the pH data. The conductivity is fairly consistent staying between 452 micro Siemans/cm. and 501 micro Siemans/cm.

The temperature of Taylor Seep 1 follows the typical seasonal temperatures of the Northeastern United States, being warmest in the summer, and coldest in January. This well appears to have the warmest temperatures recorded of all the wells. The pH appeared very consistent from July 2001 till April 2002 remaining between 7.61 and 7.8. However the last measurement in July 2002 gave us a pH of 7.54, which isn't too far below 7.61, but still with every point being tenfold in intensity large changes should be watched for. The conductivity was also very steady throughout the year remaining between 601 micro Siemans/cm. and 622 micro Siemans/cm., except for the last value obtained in July 2002 of 580 micro Siemans/cm.

The temperature of Taylor Shrub Fen 1 followed the same seasonal variation as the other wells. The pH appeared very consistent for most of the year, remaining between 7.53 and 7.67, except for the July 2002 sampling when a 7.35 was recorded. The conductivity has fluctuated for this well from 669 micro Siemans/cm. to 814 micro Siemans/cm.

The temperature of Bartlett Fen 5 shows a strong seasonal pattern. The pH of this well isn't as consistent as the others, varying from 7.44 to 7.92 without the July 2002 reading of 7.28. This well fluctuates the most with its pH. The conductivity also fluctuates a great deal, varying from 401 micro Siemans/cm. to 731 micro Siemans/cm. Bartlett it is suspected receives some of its water from the nearby quarry, and this may be the reason that there is fluctuation with the pH levels and the conductivity.

The temperature of Savadge Fen 1 follows the same seasonal pattern that the other well exhibited, having a high temperature in the summer and a low temperature in the winter. The pH was consistent around 7.33 to 7.58 during the months of July 2001 till January 2002, but then in April and July 2002, readings of 7.09 and 7.08 were produced. This could be a long-term trend, or maybe just a short fluctuation. The conductivity has remained somewhat consistent remaining between 679 micro Siemans/cm. and 738 micro Siemans/cm. for the year.

Some interesting facts is that all the wells follow a seasonal pattern of their temperature showing that the well water is impacted by the surface temperature, even though the source of their water comes from aquifers below the surface. Another interesting trend that was noticed was that the pH of all wells decreased, becoming more acidic during the July 2002 sampling. We feel that this may be due to the drought that we are currently experiencing, though we would expect the pH to rise since it would have to gets its water from its underground sources which should have a high pH. Rain water tends to be acidic, so with a lack of it we would expect the pH to go up and become more basic. This is just an interesting fact, and we should see what happens.

The table Temperature, pH, and Conductivity of Mt. Bethel Fens Wells and some accompanying graphs are shown in Appendix D on page 33, to show that the values differ for temperature, pH, and conductivity depending on if the well water is bailed or not. Generally after the wells were bailed and allowed to recover, it was found that in some of the wells that the conductivity increased and the pH became lower. This was typically true for Taylor Fen 1, Taylor Seep 1, Bartlett Fen 5, and Savadge Fen 1. Taylor Shrub 1 had a conductivity that followed the other wells, increasing after getting bailed, but the pH values for January and April 2002 are higher after bailing, while for the rest of the year the pH after bailing is lower. The higher conductivity found in the post bail water could possibly mean that the water coming out of the aquifers feeding the fens is naturally more ionized than the water that has been sitting in the well. The pH changes before and after bailing is also interesting to note. Why the water is more acidic in the well pipes is not known for sure, but it is assumed that this may be due to microbes living in the water, or to the reactions of the water with the galvanized steel casing. A good future project would be to see if this is indeed the case, that either microbes in wells fed by ground water, with no sunlight cause the pH to lower, or if reactions of the well water with the galvanized steel cause the pH to lower.

Wells Levels:

The water levels for all of the wells if looked at collectively show much variation and fluctuations on a monthly basis. However if one looks at the well levels on an individual or proximity scale some patterns do emerge and some similarities become apparent. The data discussed here comes from the table of Mt. Bethel Fens Well Levels, and there are also individual graphs displaying the individual well levels in Appendix E, page 34.

When looking at the data for the Taylor Fen 1 and Taylor Seep 1 sites one can see that they both are fairly similar. They both start out in August 2001 with a low well level, and then they both show an increase in well level from November 2001 to January 2002. Then a decrease in well level occurs at both sites in February 2002. Then both sites have high well levels for March 2002 till May 2002, with a decrease in well level in July 2002. The other trend is that they both have positive, that meaning above ground, well levels compared to the other fens.

Bartlett Fen 3, 5, and 8 have a slight correlation with increases and decreases over time. These three sites all have low well levels around the months of January 2002, February 2002, and March 2002. Then they exhibit a general pattern of all having their well levels increase during the months of April 2002, May 2002, and June 2002. The Bartlett fen sites have the trend of being negative, or below ground, when it comes to their well levels.

Savadge Fen 1 shows fluctuations throughout the year, but there is a decrease in well level from August 2001 to November 2001. Then there is a high well level that was recorded in December 2001 of –1.90 cm. Low well levels were then seen from January 2002 to April 2002. The March 2002 well level was 65.30 cm., however this must be wrong because Savadge Fen 1 has well levels that are below ground, and to have a reading of 65 cm would mean that the fen was flooded. Then there was an increase in the well levels for the months of May 2002 and June 2002. Savadge Fen 1 well levels all fall within a negative range, with well levels below ground.

Taylor Shrub Fen 1 and Taylor Shrub Fen 3 seem to have fairly stable well levels, with the exceptions being that of –82.00 cm for the month of April 2002 in Taylor Shrub Fen 1, and 40.00 cm. in April 2002 for Taylor Shrub Fen 3. The well level of –82.00 cm. observed in April 2002 doesn't seem right, and is completely off scale with all the other well data that was collected for this site. Taylor Shrub Fen 3 has two well levels, that in April 2002 of 40.00 cm and that of July 2002 of 35.60 cm that seem a little high. Since there are two of these relatively high well levels for this fen it either means that there was a great increase in well level during these months or that these two well levels were in error. Looking into rain data might explain these two rouge well levels. Rain events might have occurred at this time and may have influenced the well levels significantly. The Taylor Shrub Fens have well levels that were positive, meaning above ground, throughout the year. Taylor Shrub Fen 1 exhibits generally a higher well level than Taylor Shrub Fen 3.

Well Levels vs. Rainfall:

There are graphs of the individual well levels compared to the rainfall from both weather stations in Appendix C.

Taylor Fen 1 is one of the wells that have a strong correlation with the rainfall as is seen in the graph in Appendix C. The well level mimics the rainfall for the months of November

2001 till May 2002. Then in the month of June 2002 the well level decreases as the rainfall totals decreased for the Godshalk station.

Taylor Seep 1 is another one of the wells that has a strong correlation between the well level and rainfall totals. The well levels follow the increases and decreases in rainfall for the months of October 2001 till June 2002. More specifically the well level in the months of May 2002 and June 2002 the well level appears to be influenced by both the Jones Rainfall and the Godshalk rainfall. The well level remains nearly the same as the Godshalk rainfall reaches 5.03in. May 2002, and Jones rainfall reaches 4.79 in. in June 2002.

Bartlett Fen 3 is one of the wells that have some correlation of its well level with rainfall. This correlation occurs from the months of January 2002 till June 2002. Rainfall and well levels decrease from January till February 2002 and then increase through the months of March, April, and May. The well levels seem to follow the Godshalk rain totals for the month of April when there is some divergence between the Jones and Godshalk rain stations. There was a technical difficulty at the Jones rain gauge station for the month of April so the totals are not complete. Then the well level of Bartlett Fen 3 decreases in June 2002 just as the rainfall at Godshalk decreases.

Bartlett Fen 5 has well levels that follow the increases and decreases of rainfall throughout the year. The well levels and rainfall match each other for the months of October 2001 to the month of June 2002. Besides the conclusion that this well is influenced by rainfall another conclusion can be made. The other possibility is that the well levels appear to be dramatically affected by the amount of rainfall, as the well level decreased from -13.70 cm. in January 2002 to -32.17 cm. in February, as the rainfall totals during the same time decreased from 1.27in to .25in. for Jones weather station, and 1.58 in. to .42 in. for Godshalk weather station. Then again in April 2002 to May 2002 the well level increased from -24.77 cm. to -8.78 cm. while the rain increased from 2.83 in. to 3.23 in. for Jones weather station, and increased from 3.68 in. to 5.03 in. for the Godshalk weather station from April to May 2002.

Bartlett Fen 8 seems to have a slight correlation of its well level with the rainfall. There is a low well level reported during the time of January 2002 to March 2002 when the rainfall reached a low in February of .25 in. for Jones rain gauge, and .42 in. for Godshalk rain gauge. There is the trend of the well level to increase as the rain increased throughout the months of March 2002 till June 2002. There is another conclusion that can be made here, and that is that the well level appears to exhibit some lag in responding to the rainfall totals. This hypothesis came about because the rainfall increased from February 2002 to March 2002 from .25 in. and .45 in. to 3.38 in. and 3.03 in. for Jones and Godshalk respectively. However the well level only increased from-16.73 cm. to -16.23 cm. from February to March. Then in the month of April the well level increased from -16.23cm to -9.97 cm, while the rainfall totals remained about the same for the months of March and April. Something else that should be considered for the Bartlett sites is that the mining operations at the neighboring quarry are coming to a close, and this might affect the water supply to these sites. We don’t know yet how this might affect Bartlett Fen.

Taylor Shrub Fen 1 shows a slight correlation of its well level with the rainfall totals. There is a low in the well level that occurred in February 2002 when the rainfall totals were low and the well level appears to increase through the spring months and into early summer. There seems to be an error for the month of April 2002 for the well level of Taylor Shrub Fen 1. This measurement, of -82.00 cm. was excluded from the graph so as to not distort the graph by increasing the scale and decreasing the ability to see the increases and decreases in well level with rainfall. This value is displayed in the Mt. Bethel Fens Well Levels table in

Appendix E. It is highly doubtful that the well level decreased from 28.93 cm. in March 2002 to -82.00 cm in April 2002, and then increased to 33.27 cm. in May 2002.

Taylor Shrub Fen 3 has a slight correlation of its well level with the rainfall totals. Generally the rainfall totals increased from September 2001 to December 2001, and the well level also increased slightly over that same time. There is a period of reported low well levels for the months of January, February, and March 2002, which relates to the decreases in rainfall at that time. However it should be noted that this well seems to be slightly resistant to drought conditions. When the rainfall was .25 in. and .42 in. in February for Jones and Godshalk rain gauge stations, the well level was increasing from its low point in January straight into March 2002. The other wells that are sampled all showed a decrease in well level for the month of February 2002, while Taylor Shrub Fen 3 had an increase from 2.2 cm. in January 2002, to 8.00 cm. in February 2002, to 11.03 cm. in March. There is another interesting note and that is that there appears to be a lag in the response of the well level to the rainfall. There was an increase in rain from February 2002 to March 2002, from .25 in. to 3.38 in. for Jones rain station, and from .42 in. to 3.03 in. for Godshalk rain station. At this time the well level only increased from 8.00 cm. to 11.03 cm. The next month is where we see the well level respond to the increase in rain from the previous month. The well level rose from 11.03 cm. to 40 cm. Now this 40.00 cm. well level does seem out of range compared to the other well levels recorded at this site, but it does fit. There was also a similar high well level that was recorded in July 2002 of 35.6 cm. The casing height of this well is 40 cm., which does allow for these two measurements to be possible.

Savadge Fen 1 has some of its well levels that increase and decrease with the rainfall totals but they don't mesh as well as the other wells. There is a rise in well level in December 2001 from -13.6 cm. in November 2001 to -1.9 cm. in December 2001, as the rainfall had an increase from November 2001 till January 2002. Then the well level appears to have been influenced by the lack of rainfall in February 2002 as its well level decreased from -15.9 cm in January 2002 to -18.43 cm in February 2002. Data was omitted for the month of March due to some bad well level data. There was a reported well height of 65.30 cm in March 2002 which doesn't seem to fit in with the other well levels that have been reported throughout the rest of the year, which all have been below 0.00 cm. It is possible though because the casing height is 68.5 cm. which would allow for this reading to have been taken. There was a lot of rainfall during March 2002 (over 3 inches) which could support this amount of water in the well. In the future it should be noted if the well level ever reaches a similar point so that this point can be considered in the future. After March the well level increases from April 2002 to the month of June, as the rainfall levels remained high at this time.

Jacoby Creek Gauging Station:

The flow rate (Q) curve is based on both exponential and linear models for two reasons. Exponential models are used worldwide as the conventional flow rate curve for streams. But because the bridge where the sensor is placed confines the stream, the linear model is used as well. When the percent exceedeance was calculated, there was no previous formula to follow. This means that our exceedance values could be wrong. The flow of the Creek correlates well with the rain data from Jones and Godshalk. However we are missing some data. We do not know way this is because everything was working properly. Overall the height of the creek increases after rain events and decreases when there is no rain. When compared to the height of the wells, we can see that these do correlate well to the height of the creek. This shows that Jacoby Creek is indeed linked to the height of the peizometers.

<u>Water Quality:</u>

Nutrient:

The nutrient data shows overall that the nitrate levels within the Mount Bethel Fen Complex have increased slightly over the past year. The greatest increase was in Savage Fen this past April, jumping up to 2.60 ppm from 1.58 ppm. This is the highest value of nitrate found at the fens so far. It will continue to be monitored carefully.

The phosphate concentrations were around previous values this year unlike last year's concentrations. There was a large amount of phosphate found in Bartlet Fen 5 last April but it dropped to an average level after that. There seems to be no reason to be concerned with phosphate at this time.

ICP:

The ICP data shows, based on years of data, normal values over the past few years. In most cases K was found to be the cation with the smallest concentration but this could be due to the fact that there were so many problems with the K channel on the ICP machine.

Calcium was overall the most prevalent cation throughout the complex. The only quarter where Ca was not present in the highest concentration was the fall of this year. This shows a common trend in the fens that calcium is a major part of the water composition and is very important. In most cases, we see that Ca, Mg and Na are more abundant then the other three cations. Al, Fe, and K are usually present in only small amounts with K being the hardest to detect.

IC:

The IC data for the past year follows the same pattern as previous years. There were no large increases or decreases to cause any worries or amplified monitoring. The chloride (Cl-) concentrations were consistent with all other years. Taylor Shrub Fen had the largest concentrations, at an average of 75.3 ppm, throughout the year and Jacoby Creek 2 had the lowest with and average of 3.0 ppm.

As for the sulfate (SO-) concentrations, Bartlet Fen 5 had the highest concentrations with an average of 25.2 ppm. There was a very large drop on November 30th but it increase just as much in February 2002. Again Jacoby Creek 2 consistently has the lowest value of SO- , with an average of 12.0 ppm. This could be because the creek flows though the fen complex and loses some of these anions as it does.

<u>Plant Data:</u>

In comparing the March and June data from Taylor II, we can see that we underestimated the number of *Phragmites* that would appear in the summer months. Plot number 10, which is in the control group, had a difference of 55 viable plants. This shows that a count in March is not necessary. The same occurred in Bartlet as in Taylor II. Here however the greatest over estimation was 33 plants.

<u>CONCLUSION:</u>

The data that has been presented in this report covers August 2001 to August 2002. We can see in the peizometers heights as well as the weather station data seasonal data. These both follow similar trends as previous years with lower numbers in the spring and summer 2002 due to and exceptionally dry period.

The water quality data, although incomplete for this year, also shows trends similar to previous years. In most of the wells sampled, the composition of the water changes very little thoughout the year. The July 2002 analyses will follow in an addendum.

The plant data shows that counting plant data in March is unreliable. Due to the fact that the March count didn't help predict the overall number of *Phragmites* and *Lythrum*, this will probably not be done in the next year.

This project is ongoing and will continue in the following years. Hopefully the efforts by The Nature Conservancy and Lehigh Earth Observatory will be fundamental in helping to preserve this wondrous ecosystem and the many rare and endangered species that reside there.

References:

Fanok, Su. A ground water chemistry and flow system assessment for the Mt. Bethel Fens. The Nature Conservancy. March 30, 2000.

Gobeille, Myles. Middleton, James. Randazzo, Tina. Mount Bethel Fens Complex 2001. Lehigh Earth Observatory. August 18, 2001.

Pielou, E.C., Fresh Water. Chicago: The University of Chicago Press. 1998.

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Yasko, George. Kocher, Chris. Wild Lands Conservancy. Explanation of Water Quality Parameters.

Appendix A-Map

Appendix B-Procedures and Equipment

Appendix C-Weather Station Data

Appendix D-Water Conductivity, pH, and Temperature

Appendix E-Water Level Data

Appendix F-JCGS Flow Rate

Appendix G-Water Quality

Appendix H-Plant Data

Monthly Well Monitoring Procedures

Make sure to monitor all wells

a. Savage Fen (1 well)
b. Bartlett Fen (3 wells)
c. Taylor Shrub Fen (2 wells)
d. Taylor Seep (1 well)
e. Taylor Fen (1 well)

Materials:

· Kolorkut
· Rag
· Metric measuring tape
· Field book to record data and to take DETAILED notes
· Squirt bottle of de-ionized water

Procedure for each well:

· Make sure you are monitoring the correct well. Each well is labeled on the top of the pipe, right below the cap. Make sure the well number corresponds with the data sheet to be filled out with data.
· Stand on the uphill side of the well
· Unscrew the cap on the well.
· Put a thin veneer of Kolorkut (water indicator paste) up to a measure line on the metric measuring tape. Put about a 6-cm length of Kolorkut on the measuring tape.
· Place the measuring tape into the well. Be sure not to dip the entire section of Kolorkut into the water. Approximate well heights can be found on the data sheets to prevent this.
· Remove the tape from the well.
· Once the Kolorkut has touched water, it will turn a bright pink/red. Well height is determined by measuring the depth to water, subtracting that from the height of the riser above the ground.
· Record the data.
· Wipe off used color cut from the measuring tape using a rag and rinse with DI
· Take 3 measurements from each well to ensure accuracy. (The three measurements should be within 1 to 3 cm of each other). Then calculate the average for data processing.
· Screw the cap back onto the well.
· Repeat steps 1 through 8 for each well.

Procedure for Taking Water Quality Samples in the Fens

Materials:

· All the materials needed can be found on the "Equipment List for water sampling in the Fens"

Procedure:

· Because of the differences in recovery rates, the fens need to be sampled in a specific order

· *NEED RECOVERY RATES (look in the binder for recovery rates)

· The fens that need to be sampled are: Bartlett #5, Savadge #1, Taylor Shrub #1, Taylor Fen #1, and Taylor Seep #1.

· During the first visit of each well, take the well heights, even take the heights of the wells that you do not take water samples from.

· Take pH and temperature using the Orion probe.

· Bail out each of the 5 wells until it is almost empty. Be sure not to touch the bottom as to disturb sediment.

· After all the wells have been bailed. Wait for their recovery.

· During the second visit, take the well heights again. On the second bail take the bailed water and pour it into a 125-mL bottle.

· Take pH and temperature of the water in the bottle.

· Take the bottle of water back to the lab for analysis.

· With the water from the next bails, fill up a liter bottle to take back to the lab for testing and analysis.

· Put all water samples on ice.

Procedure for Filtering Fen Water

*Do this procedure in Room 110, where you will find all the necessary materials.

Materials:

· 2000-mL flask with a vacuum spout (See Figure 1: E)

· vacuum hose (See Figure 1: G)

· filter spout (See Figure 1: A)

· 300-mL open-ended glass (See Figure 1: B)

· blue clamp (to clamp the filter spout to the open-ended glass) (See Figure: C)

· 47-mm circular filters (See Figure 1: D)

· A squirt bottle of de-ionized (DI) water

· 50 mL sample tube bottles with caps (9 bottles for each fen sample: label all tubes with the appropriate fen name and label 3 bottles "ICP", 3 bottles "IC", and 3 bottles "Nutrient") ex. "Fen Name" ICP #1 "Fen Name" IC #1 "Fen Name" Nutrient #1 "Fen Name" ICP #2 "Fen Name" IC #2 "Fen Name" Nutrient #2 "Fen Name" ICP #3 "Fen Name" IC #3 "Fen Name" Nutrient #3

· Zip lock bags

· Sharpie Permanent Pen (one that does not wash off with water)

· Small funnel

· Tweezers (See Figure 1: F)

Procedure:

· Apply DI to the filter paper to hold it in place after you have placed the filter onto the spout using the tweezers.

· Place the open-ended glass on top of the filter spout and make sure that everything lines up and that the filter is in the center and clamp them together.

· Hook up the 2000 mL flask to a vacuum hose and hook up the hose to the vacuum nozzle (This nozzle has the yellow handle that says vacuum), which is located on the lab counters.

· Turn on the vacuum and begin pouring the fen water into the 300-mL open-ended glass. The water should poor right through and the sediment should get trapped in the filter.

· After all the water has filtered into the flask, shut off the vacuum.

· Disassemble the apparatus.

· Place the dirty filter in a labeled zip lock bag. (Make sure the correct fen name is labeled on the bag).

· Pour the filtered water into the 9 sample tubes, each tube being labeled correctly. Use a funnel to avoid spilling.

· Pour the rest of the water back into the 1000-mL sample bottle and refrigerate it.

· Rinse all of the glassware and the funnel three times with the large supply of DI which is on the very top the of lab counter.

· Repeat the procedure for all of the water samples. (You should do 7 samples in all…5 fen samples….Taylor Seep, Taylor Fen, Taylor Shrub, Savadge Fen, Bartlett Fen…..plus 2 Jacoby Creek samples).

*If you are not analyzing the samples right away, add .33 microliters of nitric acid to each ICP sample to preserve them….DO THIS UNDER THE HOOD WITH GLOVES ON….Nitric acid's fumes are very potent and if it spills on your skin, it will burn and make your skin turn yellow. If it does spill on your skin, wash it off thoroughly.

Figure 1:

Figure 2:

A

B

C

D E

F G

Procedure for Mixing Standards for the ICP

Materials:

- Calibration Standards Worksheet
- 8 Beakers (any size will do)
- micropipette (1000 μl and a 100 μl)
- micropipette tips
- 1000 ppm stock solutions of Al, Ca, Mg, Fe, K, Na
- 5 mL, 10mL, 20mL, and 30mL burettes
- Pipette Helper (pulls the liquid up into the burette)
- Nitric Acid
- 36, 50 mL tubes
- Deionized water
- 2, 100 mL volumetric flasks
- 2, 50 mL volumetric flasks
- Parafilm
- 1 L Bottle

Procedures:

- LABEL ALL OF YOUR BOTTLES, FLASKS, AND BEAKERS BEFORE YOU START SO AS TO AVOID ANY ERROR!
- Pour the stock solutions into 6 beakers. Only pour about 15 mL of the Ca, Mg, and Na, and only pour about 1 mL of Al, Fe, and K. Each stock solution goes into its own separate beaker. You are now done with the stock solutions, do NOT pour any remaining stock solutions back into the bottle or contamination will occur.
- Burette 10 mL of Ca, Mg, and Na each into a 100 mL volumetric flask. Fill the rest of the flask with DI. Make sure the miniscus of the water is at the 100-mL line. Be as accurate as possible.
- Pipette 100 μl of nitric acid into the flask.
- Cover with parafilm and invert three times to mix the liquid.
- Pipette 0.5 mL of Al, Fe, and K into a 100-mL volumetric flask. Fill the rest of the flask with DI. Make sure the miniscus of the water is at the 100-mL line. Be as accurate as possible.
- Pipette 10 μl of nitric acid into the flask.
- Cover with parafilm and invert three times to mix the liquid.
- Fill the 1 L bottle with DI and pipette 100 μl of nitric acid into the bottle. Place the cap back onto the bottle and invert three times to mix the liquid.
- Burette 5 mL of the newly made Ca, Mg, Na standard into a 50 mL flask.
- Fill the rest of the flask with DI.
- Cover the flask with parafilm and invert it three times to mix the liquid.
- Pour the liquid into a 50-mL labeled, bottle.
- Repeat this process for all the standards, but be sure to use the correct amounts for each standard.
- Refrigerate the bottles until you are ready to run the ICP.

Procedure for Collecting Weather Station Data

Materials:

· Hobo Data Shuttle
· Hobo Data Logger cables
· Field Book
· Pen
· Laptop Computer *

Procedures:

In the lab:

It would be easiest to follow these procedures on the computer on Room 205

· Open up the UTC website on the computer by going into the bookmarks option and clicking on “Time”
· Set the computers time to the UTC time (Make sure you are as accurate as possible)
· Open the program “Boxcar”
· Plug in the shuttle. There is an adaptor (COM 1 port) in the back of the computer where the shuttles cable fits.
· In Boxcar, go to “logger” on the tool bar.
· Select launch from the scroll down menu
· The computer will automatically launch the shuttle
· Exit Boxcar and unplug the shuttle

In the Field:

The two weather stations you will be collecting data from are the Jones and Godshalk weather stations. Each weather station has a two data collection ports: one for rainfall and the other for temperature and relative humidity.

· At each weather station open the rainfall collector by taking off the black lid.
· Inside the collector you will find a black shuttle that looks like the Hobo shuttle.
· Open the black shuttle and connect the black shuttle to the Hobo Shuttle using the data logger cable.
· Hit the button on the Hobo shuttle and the Hobo shuttle should offload the information. You can see the status of the shuttle by the blinking lights on the shuttle.
· After the shuttle has finished offloading the light next to testing will start to blink.
· Press the button again
· The next to successful will begin to blink
· Press the button once again. This completes the rainfall data collection.
· Unplug the shuttles and make sure the light is blinking again in the black shuttle. This light indicates that the shuttle is collecting data again.
· Close the black shuttle and place it into the collector and place the lid back onto the collector.
· At the weather collector, unscrew three wing nuts from the bottom of the collector and take off the two lids.
· Unscrew the white dime-size cap from the port.
· Plug in the Hobo shuttle into this port.
· Press the button on the shuttle.
· The shuttle will offload the data and automatically go to successful.
· Press the button again.
· Unplug the shuttle.
· Make sure the red light is blinking on the weather collector by looking up inside the port.
· Screw the white cap back on.
· Screw back on the lid and the wing nuts.

* You will only need the laptop computer if you need to rename the weather stations. Consult George Yasko before doing this.

Procedure for Downloading Weather Station Data

When you return to Lehigh, the data on the shuttle must be downloaded. Follow these instructions for downloading and turning the files into an Excel format.

· Using a serial port or USB port cable, connect the shuttle to the computer.

· Run the BoxCar Pro program, select the "Logger" menu, and select the "HOBO Shuttle Readout" option. The program will now download the files from the shuttle. Save each of them to the Fens folder (you may have to ask George where this is).

· Open each file in BoxCar and pull down the "File" menu. Select "Export" and "Microsoft Excel."

· At the Export Setup window, click on "Multi-file". At the Multi-file Export Setup window hit "OK" and export to the Fens folder.

· Run Microsoft Excel and open the new files in it. At Wizard Step 1select "Delimited" and hit "Next."

· At Step 2, have "Tab" selected under Delimiters, and at Step 3 select "Date" with "MDY" in the box next to it. Hit "Finish."

· In the column for date and time you may have to format the cells. To do this, highlight all the cells in that column, right-click on them, and select "Format Cells."

· In the "Number" tab select "Date" and the "3/4/97 13:30" option.

Procedure for Changing the Compact Flash Card at the Jacoby Creek Gauging Station

The Jacoby Creek Gauging station will take data every five minutes (on the hour, 5, 10, ... 45, 55 after the hour). Check your watch for the correct time (you can do this when you sync the Hobo shuttle). That way you should be close to the station's data times. Although this is not critical, if you change the card between the five-minute data intervals, the station will not miss any data points.

· Check the site:

1. Check the solar panel for cracks.
2. Check the sensor. Make sure it is pointing straight down at the water and that there are no obstructions between it and the water surface. Any adjustments to the sensor or removal of the obstructions should be noted and one more data point should be taken noting the time.
3. Check the conduit, and that the enclosures are secure.

· Open the top enclosure

1. With the mirror found in the enclosure, look at the status LEDs located under the flash card. If the bottom LED is flashing green it is safe to turn off the gauging station power (see LED status definitions).
2. If there is any other LED activity, wait until it has completed and the lower LED is flashing green.

· Turn off the gauging station power by moving the toggle switch to the opposite position.

· Remove the flash card by pulling it to the right.

· Remove the replacement card from the storage case and slide it into the connector. While applying even pressure push the card firmly into place.

· Place the flash card that has the current data on it in the storage case and place it in the toolbox or another safe place for transport. Make a note in the field log as to which card and the date of retrieval.

· Power the station on by moving the toggle switch to its original position.

· Check the bottom LED and make sure it is flashing green.

· Wait for the next data event to verify the stations operation.

· Place the mirror in the enclosure.

· Close and lock the enclosure.

Procedure for working with gauge station data

· Put the data from the chip in the gage station into Excel.

· Using the 15 minute averages, use Excel to calculate a Daily Mean Flow value. This will just be the average of all the heights measured for each day. The number will be in meters.

· Create these columns: “Date”, “Height measured in meters”, “Height converted to feet”, “Correction for the sensor height”, “Q linear”, and “Q curved”.

· Input the date, and the Daily Mean Flow in the “Height measured in meters’ column.

· Convert the Height in meters to Height in feet. (The rating curve is in cubic feet per second (cfs) so our measurements need to be in feet!) Put this in the “Height converted to feet” column.

· Add 1.673 feet to correct for the distance from the bottom of the bridge (what the rating curve was based upon) to the tip of the sensor. Put this in the “Correction for the sensor height” column.

· Using the equations from Ryan Linthicum’s Rating Curve, calculate the discharge (Q) that corresponds to each height that we measured (now in the “Correction for the sensor height” column). The exponential curve is similar to most other rating curves, and represents an “ideal” situation. Its equation is Stage = $6.28\ Q^{-0.0375}$ where stage is the measurement taken (depth to water surface), and Q is discharge.

· The linear rating curve was added because the gage station is directly under a bridge. When the flow is increasing, the bridge acts as a “bottleneck” for the stream; that is, as Q is increasing, the height under the bridge will increase abnormally fast, when compared to a “natural” channel. Because the Rating Curve is not well constrained yet, both the linear and exponential rating curves should be considered. The linear rating curve’s equation is: Stage = -0.0204Q + 5.9787.

· Now you have daily average discharges, based upon two different rating curve interpretations. From these you can calculate the Mean, Maximum, and Minimum for the time of record. This should be done on the daily averages, but it can also be done on weekly averages.

· Exceedance values also need to be calculated for 20%, 50% and 80% exceedance. 20% exceedance should be reported as a single discharge measure (in cfs). This means that 20% of the weekly average discharges are above the discharge that you report.

<u>Note:</u> The formula entered into excel for the linear data is Q=(stage-5.9787)/-0.0204. The formula for the exponential curve is (LN(stage/6.282)/-0.0375. Now you need to take the answer and put it to the base of e. In Excel, type EXP(the number), and it will give you the discharge. On the TI-85 calculators, it’s 2nd LN the number.

Equipment List for Monitoring Well Heights

- The yellow Mt. Bethel Fens Toolbox (Including the Hobo data logger cables, Hobo data shuttle, Data card for the gauging station, screwdrivers, field notebook, pen)
- Sync the shuttle to UTC time before leaving Lehigh
- Lumbar pack with tools
- The Mount Bethel Fens Binder, Fens maps
- LEO magnetic car signs
- A First Aid kit
- Cellular phone, leave the phone number with Margie
- Safety Glasses
- Cotton work gloves
- Tecnu
- Bug repellant and sunscreen
- Rubber boots, and a garbage bag to put them inside the car
- Digital Camera
- The bailer, and a bag to keep the rope inside
- Carboy filled with deionized water
- Squeeze bottles to rinse the bailer
- Well height indicator, or metric measuring tape, Kolorkut and a rag
- Data sheets
- Sample bags
- Rubber gloves
- Garbage bag to dispose of contaminated gloves
- Cooler with ice

Equipment List for Water Sampling in the Fens

- The yellow Mt. Bethel Fens Toolbox (Including the Hobo data logger cables, Hobo data shuttle, Data card for the gauging station, screwdrivers, field notebook, pen)
- Sync the shuttle to UTC time before leaving Lehigh
- Lumbar pack with tools
- The Mount Bethel Fens Binder, Fens maps
- LEO magnetic car signs
- A First Aid kit
- Cellular phone, leave the phone number with Margie
- Safety Glasses
- Cotton work gloves
- Tecnu
- Bug repellant and sunscreen
- Rubber boots, and a garbage bag to put them inside the car
- Digital Camera
- The bailer, and a bag to keep the rope inside
- Carboy filled with deionized water
- Squeeze bottles to rinse the bailer
- Well height indicator, or metric measuring tape, Kolorkut and a rag
- Data sheets
- Sample bags
- Rubber gloves
- Garbage bag to dispose of contaminated gloves
- Cooler with ice
- Quanta G Hydroprobe (calibrate before leaving Lehigh)
- Six 1 liter bottles filled with deionized water (bottles must have been acid washed)
- Seven 1 liter bottles to take samples of water back to the lab, plus a few more bottle just in case of error.

Fens: 1. Savadge Fen #1
2. Savadge Pit
3. Bartlett Fen
4. Taylor Shrub Fen
5. Taylor Seep
6. Taylor Fen