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Historic Bethlehem Spring, LEO Internship

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Historic Bethlehem Spring

The Historic Bethlehem Spring project is an internship sponsored by a partnership between the Lehigh Earth Observatory (LEO), Historic Bethlehem Partnership, and the Moravian Archives that focuses on the occupation of the Moravian people, who settled the Bethlehem, PA, area in the 1750's. The spring that supplied the Moravians with drinking water up until 1912 influenced the history of the Moravian settlement in Bethlehem in several ways. The original location of the spring was a primary geographical factor for establishing the first buildings in Bethlehem. The quantity of water flowing out of the spring could supply only a limited number of inhabitants in the city, and the quality of the water probably had an impact on public health in Bethlehem. The aim of the historic Bethlehem Spring research initiative is to locate the spring through historical and field research; the latter includes GPR (ground-penetrating radar) and GPS (global positioning system) surveys, as well as the construction of a GIS (geographical information system) coverage of the area. If the exact location of the spring is found, the next step will be to analyze the current condition of the spring, conducting tests to determine such qualities as water chemistry and flow rate. In addition, another project goal is to identify whether or not the spring is causing flooding in nearby buildings in the Bethlehem Industrial Corridor.

The interns rely on both gathered historical information and measurements taken firsthand in the field. Historical research is focused on locating the general area of the spring, identifying key structural characteristics of the spring and water supply system, and answering why the spring was ultimately abandoned and how it was sealed. The archaeological studies can either bolster past theories or presumed facts, or can yield completely different results. With the help of the Moravian Archives and Historic Bethlehem Partnership, access was provided to the original ledgers, maps, and journals that documented everyday Moravian life during the 1700-1800's. The meticulous record-keeping on the part of the Moravians has made these very valuable sources of information.

The methodology for this research will involve various primary sources, mainly through the use of documents provided by our research partners. These documents will help to locate the site of the original spring in respect to other buildings still standing in the area. Also, the records, which were often recorded daily, should reveal how access to this water source affected Moravian society and why the well was capped. Furthermore, an archaeological dig was performed in the area during the 1960's; the results of the dig will be evaluated and will hopefully aid in the location of the spring. The project members will implement ground-penetrating radar (GPR) as the definitive method of locating the spring. As a final option, if the site is not located with previously-mentioned methods, several test pits can be dug to see if they provide the evidence to answer any of our questions.

Difficulties will undoubtedly arise with the proposed plans. One such problem is the frequently encountered bias in historical records and the rare comprehensiveness in accounts of events. Dates are often inaccurate. Small inaccuracies in documentation can result in major misinterpretations when these records are later examined. For example, one account may show the construction of an element of the water system to be the first of its kind, while another historical document may list it as a second attempt.

Specific evidential constraints are like those found at any archaeological site. Errors will be introduced with measurements and cross-referencing. Other problems may come up because of poor preservation of the site as a result of weathering and erosion by precipitation and high variation in seasonal temperatures. The results of this research will be presented as a limited interpretation of the raw data.

The Historic Bethlehem Spring project may either verify or refute the Moravians' claim that they established the first waterworks system in the New World. Instead of relying on wells like those commonly used by their colonial counterparts, the Moravians exploited the presence of a natural spring, and, using technology already practiced in Europe, developed a waterworks system lauded to be the first in the Eastern hemisphere. If the spring is located, artifacts and structures around the spring may in turn be excavated and dated accordingly. At a later point in Moravian Bethlehem history, the spring was capped for a reason and in a way that this team has yet to discover. Hopefully, the information as to how and why this was done lies somewhere in the records of early Bethlehem occupation. Once the spring is located, the researchers will be able to determine if it is still active.

Research Initiatives

George Yasko, the Historic Bethlehem Spring Project Coordinator, laid out the goals for the internships in a document that was distributed to the interns at the beginning of the spring semester 2003. The document outlined the tentative plans for the internship as the following: visit and shoot some pictures of the Historic Moravian Industrial Site (the general location of the spring), collect old drawings or photos of the original structures, locate topographical maps and aerial photos of the area, conduct historical research concerning the original spring, complete GPR and GPS surveys of the site, and create a GIS coverage of the area.

To initiate research, Yasko set up an appointment for his interns to meet with Peter Wolle, the historian at the Moravian Archives. Peter Wolle formally introduced the interns to the different types of historical material available at the archives. He provided each of the interns with a folder of documents representing each category of historical material, including diaries, minutes, journals, inventories, civic treasury records, maps, and photographs. Diaries, minutes, and journals were often hand-written in German script, and so only the small translated portion of the information they contain was accessible to the interns. Nevertheless, the archive contains exclusive resources that the interns intended to utilize in order to locate the general area of the Bethlehem spring before they set up the GPR survey to be conducted later in the semester.

In the week following the meeting at the Moravian Archives, the interns met to discuss how they would divide up research responsibilities. In order to avoid redundancy in their research efforts, the group decided to delegate tasks by the following locations of resources: historic research at the Kemmerer Museum, Historic Bethlehem Partnership, Lehigh University Special Collections and Fairchild-Martindale Library, Bethlehem Public Library, and Moravian Archives and studies done in the field. They then split up to follow through on their respective assignments.

The interns came together approximately two weeks later to compare the historical notes and field data acquired during independent research. They had collected a variety of materials referring to the spring, such as old newspaper articles and books, archaeological reports, utility maps, and GPS data. The next week, Yasko introduced the ArcGIS software to the interns. Kelly accepted the responsibility of

working with GIS for the duration of the project while the other interns, Theo and Andres, decided to continue their independent historical research to find more information regarding the location of the spring.

Historical Research Methods

The first line of historical research completed involved a trip to the Kemmerer museum. The purpose of this visit was to document any information the museum had that could be relevant to locating the spring. The Kemmerer museum contained such useful material as photographs, archaeological reports, and several old maps of the Industrial Quarters. These materials have yet to be carefully analyzed, but will be important contributors to future conclusions drawn from historical research concerning the location of the spring and its effect on the Bethlehem community. Additionally, historical research conducted at the Bethlehem Public Library and Lehigh University Special Collections (see civil engineering theses from the late 19th century) unearthed more information regarding the location of the spring and the reason the spring was capped and the method with which this was done.

The next step was a visit to an office of the Historic Bethlehem Partnership located in the grist mill in the Industrial Corridor. Interns looked into the available records concerning the history of the water works. Direct references to the spring were identified, as well as indirect references that refer to people, events, or documents that can provide information about the spring's location. Unfortunately, aside from a few documents that verified that the spring was at the foot of the hill below the modern Hotel Bethlehem, most of the information the researchers found at the mill consisted of indirect references. Events relevant to the spring were recorded in the research notebooks. (See Theo Thwing's notebook pp. 5-7 to view additional indirect references that were cited at the tannery.) For example, the original water works shot a stream of spring water above the level of houses on top of the hill east of the springhouse on June 21, 1754, an important date in the history of the water works that could be recorded in private journals, memoirs, newspapers, and other documents. February 8, 1819 is another relevant date because on that day Brother C.D. Bischoff was given the task of making improvements to the spring, specifically to install approximately 200 linear feet of new piping. The year 1888, when the spring was deepened by blasting so that it could produce more water for the town, is a significant event in the history of the spring, as well. Documents about events like these may expose additional information about the location of the spring. ,

After completing their work at the mill, the researchers concluded, however, that the mill does not hold much useful information about the location of the spring.

Historical Research Findings and Discussions

Below are some important historical references to the location and characteristics of the spring, categorized by date, that were cited within historic literature of Moravian Bethlehem. The significance of each reference is discussed. These discussions helped the LEO interns to define the area to be surveyed using GPR and will also aid in the interpretations of the GPR survey results.

1743

For the Moravians, Henry Antes selected "an advantageous site for the mill, a few rods north of the big spring, and near the creek" (http://bdhp.moravian.edu/art/architecture/oldmill.html)

*A rod is an old English measure of distance equal to 16.5 feet (5 m). That length is sometimes also called a perch. Thus, the interns concluded that the spring was probably located around 30 to 35 ft south of the location of the old mill.

1799

"The spring…is at the foot of this hill, and enclosed with a small stone vault or cellar" (Ogden 22)

*There is plenty of historical evidence that indicates the spring is at the bottom of the hill rather than on the slope. In this context, it can be assumed that there is probably rubble left over from the vault or cellar structure that enclosed the spring. This type of structure could be identified by GPR.

"The main tube, which conveys the water, is of lead, and of the diameter of 4 inches. It is so cold that the hand cannot rest upon it, but a few seconds" (Ogden 22)

*If identified by GPR, remnants of the lead pipe are an excellent landmark that would lead us to the location of the spring.

“Near the spring is a milk house, or a room for preserving butter and fresh meats, through which issues the surplus of the spring” (Ogeden 22)

*The runoff from the spring which did not flow into the water works may travel toward this milk house. Old maps that label the milk house would give a better idea of where the spring may be.

1873

The spring "is a very small affair, not more than three feet square, and two feet deep, situated near the ‘oil mill,’" on Water Street, opposite the "Old tannery" (Martin, John Hill 29).

*It is important to identify the size of the spring; otherwise, it would be difficult to locate it using the GPR data. Of course, it is important to recognize that the well was deepened (and probably widened) by dynamite blasting in 1888.

“A large frame building is erected over the spring” (Martin 29)

*Like the vault or cellar that once contained the spring, it is useful to know that the remains of such a structure may still be present at the site of the spring.

“The water of the spring is very cool and clear, and slightly impregnated with lime” (Martin 29)

*Testing the temperature of the water that is flooding the tannery may indicate whether or not the water originates from the spring. Water analysis will help to identify whether traces of lime exist in the water flooding the tannery. This test may be inconclusive in linking the tannery water to the spring, as much of the Lehigh Valley is covered by soils formed by the dissolution of limestone rocks in the area.

1912

“A three-hundred-foot well was then drilled between the spring and the creek, but it was so badly contaminated by sewage that it could not be used” (Rau 421)

*This text indicates that the spring had to have been a reasonable distance from the bank of the creek so that this well could be drilled. The word “between” may imply that the spring and well are located on a line perpendicular to the edge of the creek (Appendix 1).

Fieldwork

After enough historical data was gathered to estimate the approximate location of the spring, the team took to the field to try to more accurately locate the targeted spring using available technology. The two primary goals of the field studies are the precise location of the Moravian spring and the detailed mapping of the Industrial Corridor area. Data was gathered through GPR and GPS surveys, and the information was then organized in a GIS coverage. Initially, none of the interns were acquainted with the procedures involved in using these tools, but at the end of the semester, all have at least a basic knowledge of their methods of operation.

Precise measurements of location on the Earth's surface were first taken with GPS units (Trimble) for chosen landmarks, buildings, roads, and waterways in the area of interest. When the GPR survey was later conducted, location measurements were taken for points used to set up the GPR grid. The GPS units calculate their current positions by timing signals of known velocity from several (at least 4) different satellites, which are always orbiting the Earth. These measurements are accurate to within a few meters, but can be made enough more accurate with differential correction, which accounts for any delays and errors that the signals may encounter in space. File names for all measurements were recorded in George's and Kelly's field books. The data was differentially corrected and re-projected in the lab.

Next, a GPR survey was performed by all interns in an attempt to produce concrete evidence of water system remains buried in the Industrial Corridor; evidence of the spring foundation, sealing material, or pipes leading to the spring are anticipated if the spring is to be located. The GPR uses electromagnetic wave propagation and scattering to identify changes in electrical and magnetic properties between different subsurface stratigraphic layers. Cables and pipes show up on the GPR readings as inverted hyperbolas because of the wave diffraction around them. This tool has the highest resolution of any geophysical method for subsurface imaging, with a scale on the order of 1 cm sometimes possible. A GPR system can be deployed from the surface, in or between boreholes, and from aircraft or satellites; the particular device used by this team was pulled along the surface on a sled. Before taking any readings, a grid was set up along the ground as a guideline for the path to be taken by the team pulling the sled. Construction lines (marked "A," "B," and "C" in Kelly's field book) were set up between distinct, permanent landmarks on the site. The southeast corner of the grist mill porch is an example of such a landmark. These are the

points whose locations were later determined with GPS measurements. Notes were taken in Kelly's field book so that the grid can be reproduced at a later time to locate any point on it that warrants further attention by the GPR readings. A digital diagram of the GPR grid was also created in AutoCAD. Actual GPR readings were taken every ten feet along six lines, of approximately 100 feet each, all from north to south. Due to poor weather conditions and scheduling difficulties, the GPR survey was not conducted until nearly the end of the semester. For this reason, the data has not yet been analyzed to locate any subsurface remains of the spring.

The interns then began to assemble all data collected from measurements taken in the field and from historical research into a GIS coverage. This program combines information in layers (which can be turned on and off) to organize a large number of facts from different types of media on one map. An aerial map of the area was acquired from LEO and several photographs were taken for points of interest. These objects and the corrected, re-projected GPS points for the landmarks, etc. and grid points were combined into one coverage. The current coverage will be refined, and more data, the AutoCAD grid, and any other useful information will be added to the coverage.

Measurements were then made in regard to the water flooding the tannery building. The water collects in a wooden box in the center of the floor in the main tanning room, at a level approximately six feet below the level of the floor. Two pumps also occupy the box, and at least one is always operating in cycles to flush the water out of the building and into the Monocacy Creek. While it was observed, water entered the box from three of its four sides. Water samples were taken from each of these three sources. The team then measured the amount of time it took for the water to completely fill the box (to the level of the highest row of holes through which the water entered) and activate the pump and then the time needed for the pump to drain the box to some constant, nonzero minimum water height. Calculations will be performed to determine the flow rate of water into the box to compare that, as well as the water analysis results, to known and, hopefully, discovered properties of the spring. Historical records estimate the output of the spring during the time of its use to be about 1 million gallons per day. Water samples will be taken from the spring if it is uncovered and results from their analyses will be compared with those from the tannery water to determine whether or not the spring is causing the tannery to flood.

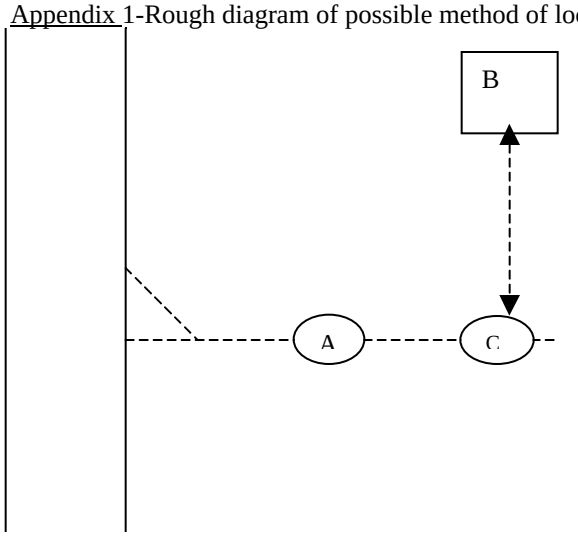
The final data collected for the semester were water samples taken from an outlet into the raceway that was only uncovered on April 12, 2003. This outlet had gone unnoticed in the recent past. It was observed that no pipe exists here to channel the water into the raceway, just a small (5 in. diameter) tunnel coming up out of the ground. Furthermore, the other end of the outlet could be felt and was noticed to be no more than about two feet below the surface. The researchers noted that very cold water bubbles up out of the ground at this point. Studies of this outlet may be pursued in the future.

In summary, many measurements and data were gathered in the field, but a lack of time prevented the analysis and organization of this information. These tasks will be carried out by interns in the future of this ongoing project.

The research into the Historic Bethlehem spring in the spring semester of 2003 resulted in a few conclusions. Efforts to find the spring were inconclusive because of time restraints; consequently, related questions could not be answered involving the spring itself. Fortunately, various findings were obtained through historical research. It was determined that the spring was capped in 1912 because of contaminants (thought to be coming from the hotel on top of the hill overlooking the industrial corridor) found to be in the water. The historical research also yielded some surprising inaccuracies in different accounts of the spring. A completely failed attempt at constructing the waterworks was absent in one account. (Huetter 1972; Martin 1872) In beginning the research, it was thought that by evaluating various media, the location of the spring could be established. While these methods were helpful, they only aided in establishing some general points of reference as to where the spring may be.

The future of this project will rely on the continued devotion to research by LEO interns. After analyzing the GPR data that was omitted from this report due to time constraints, the location of the spring will hopefully be discovered. Once located, various other questions may be answered. Among those, the most important is whether or not the historical records match the actual findings. The current condition of the spring will also be evaluated. Upon the anticipated discovery of the spring and given enough time to interpret the findings, the questions posed at the initiation of the project should be answered.

Appendix 1-Rough diagram of possible method of locating the spring.



A is the 300 ft. well. **B** is the old tannery, and **C** is the spring.

Appendix 2-Civil Engineering Theses from Lehigh U. Special Collections

All are located in the Bayer Reading Room in Linderman Library.

THESIS 1909 P123s, Padgett, "A Study of Illick's Mill Water Supply for Bethlehem."

THESIS 1898 D418w, de Obaldia, "Water Power and How Used in the Bethlehems." (See Part III, p. 56.)

*THESIS 1898 A213w, Adams, "Investigation of the Water Supply System of Bethlehem."

THESIS 1898 G149p, Gallardo, "The Power and Efficiency of the Pumping Machinery of the Waterworks at Bethlehem."

*THESIS 1894 W886n, Wooden, "A New Water Supply for Bethlehem."

THESIS 1894 B858r, "Review of the South Mountain Waterworks."

**SC Trx 1016B, "Historical Sketch of the Bethlehem Waterworks."

* Of the sources examined, these sources were found to be more relevant to the project.
** This source is not a thesis, but can be found in the same location.

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