Hydrology, Geochemistry, Sedimentology and Geophysics of the Baker Woodlands Environmental Research Site.

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INTRODUCTION

This interdisciplinary project examined the environmental conditions at a post industrial/landfill site in Lancaster, PA. The site has been used to a variety of industrial activities including mining, brick manufacture and landfilling. The Baker Woodlands Environmental Research site is owned by Franklin and Marshall College and is used by faculty and students from the Geosciences, Biology, and Environmental Studies Programs. Data collection has been active since 1966, accelerating greatly since 1990 (de Wet et al., 1998). A Geographic Information Systems (GIS) database that includes ten aerial photographs taken between 1947 and the present, topography, hydrology, geophysical data, ecological data and utilities has been developed for the site (de Wet et al., 1999).

SITE DESCRIPTION

The research site is located on the northwest edge of Lancaster City within a suburban/industrial/commercial development zone that has rapidly expanded out from the densely populated city center. The 26.3 hectare site overlies early Paleozoic Conestoga limestone and includes most of a small watershed which flows into the Little Conestoga Creek. Ecosystems on the site include woodlands, wetlands, and meadows. These areas are essentially unmaintained today, except for access trails through the woodlands, a paved road to the site of a former brickworks, and an unpaved accessway to a complex of 4 radio towers, the environs of which are maintained in meadow by mowing. Sports fields and the College's astronomical observatory occupy a 12 hectare site on the eastern edge of the woodlands. Residential and commercial developments occur to the south, east, and west, and regenerated woodlands and agricultural fields lie across a railway line to the north (Figure 1).

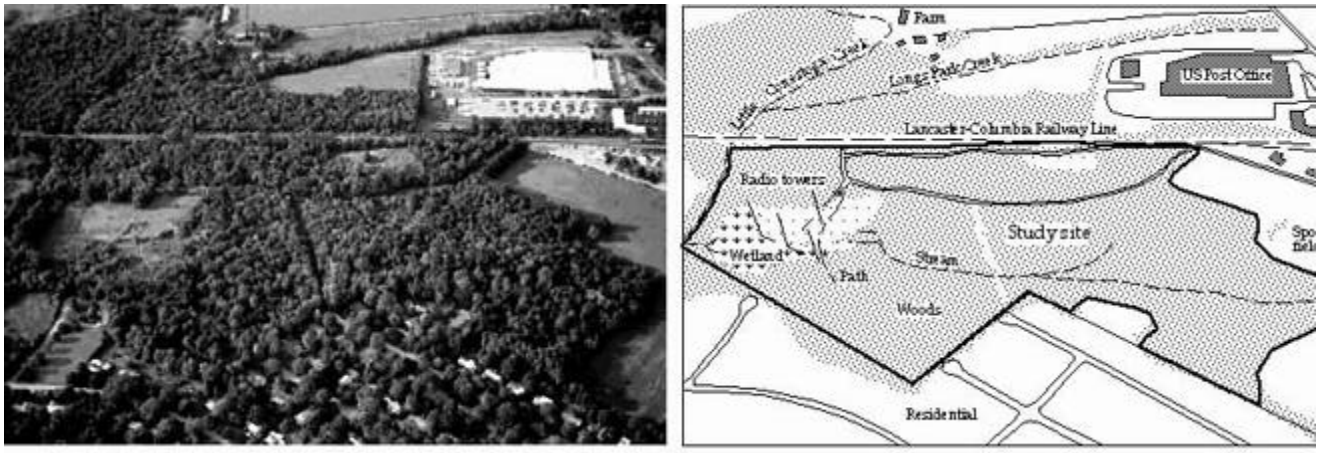

Figure 1: Oblique aerial photograph and matching oblique map of the site showing the site boundary (looking approximately north). Notice the residential development to the south, the sports fields to the east, the railway along the northern boundary of the site and the agricultural and

commercial development to the north. Wetlands and an early successional forest now cover the area. Photo by Rick Anderer (1997).

Much of the site's present topography is the result of human activity. Until the 1700s the site was completely forested. It was cleared for farming in the early 1700s, and was used probably solely for agriculture until 1920, when a brick company purchased the area and used it for a brickworks plant from 1920 to 1980. The north-central sector, formerly the site of the brickworks, is now flat with a steep embankment down to the radio tower access road. Parts of the site were excavated for the clay required to manufacture bricks. The southwestern sector is hummocky due to past clay mining operations. A narrow limestone ridge near the eastern border of the site separates a bowl-shaped southeastern valley, where clay was excavated in the mid-twentieth century, from a landfill in the central sector. Streams draining the watershed converge in the southwest in a palustrine wetland that discharges into the Little Conestoga Creek. This creek forms the western boundary of the watershed. All buildings at the site were demolished in 1980 when Franklin and Marshall College bought the property, and the site has been left as an open space since then (Figure 2).

The Baker Woodlands research site is an ideal location to study interacting earth systems as it includes a rich diversity of systems in a small area. In addition, the impact of human activities on natural systems is well represented at the site. For example, landfilling has clearly impacted ecological succession, stream hydrology and wetland sedimentation.

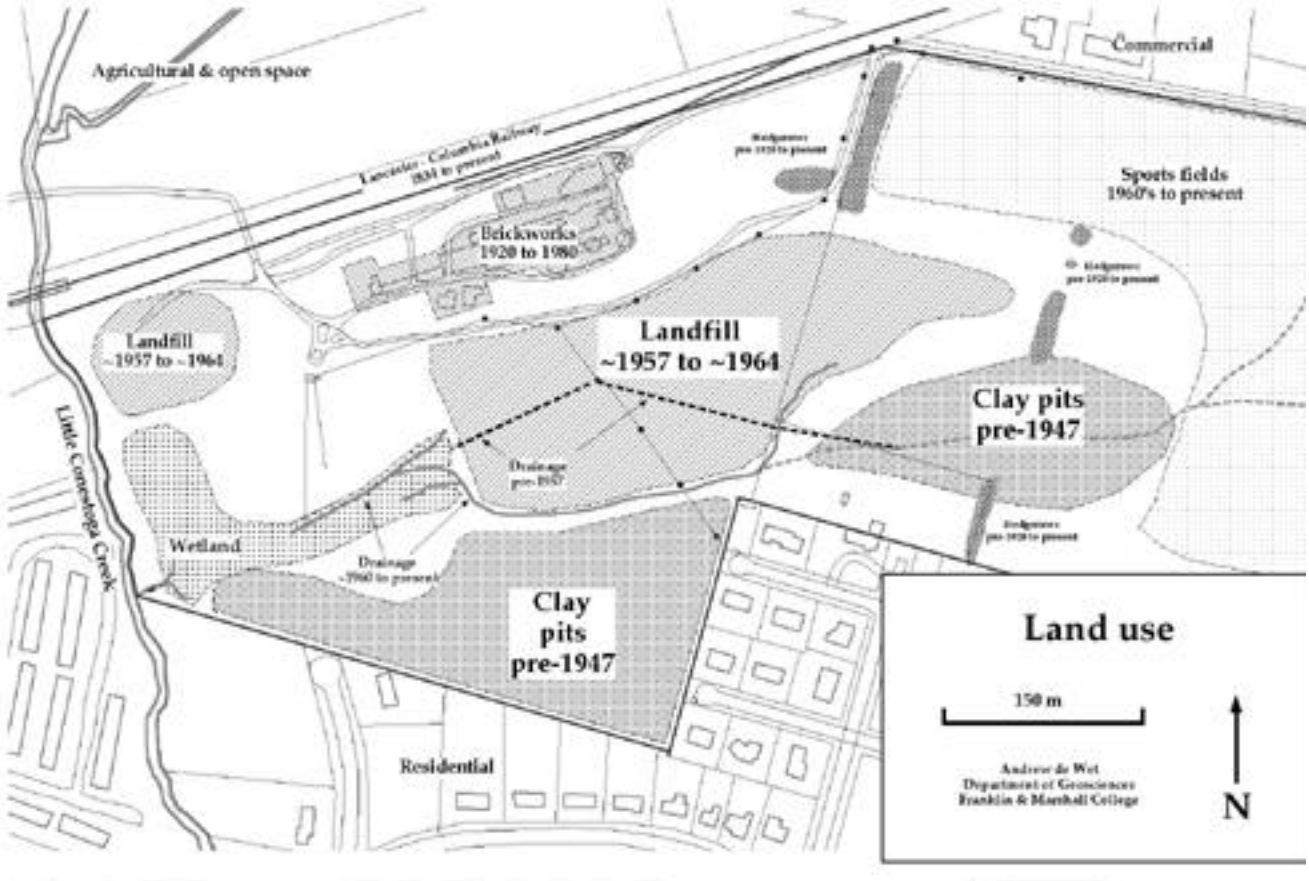

Figure 2: Land-use/land-cover map of Baker Woodlands. Two landfills cover the central and north-western parts of the site. Runoff from most of the site accumulates in the large wetland in the south-western corner of the site before discharging into the Little Conestoga Creek.

PROJECT PARTICIPANTS

Faculty participants in the project were: Andrew de Wet, Franklin & Marshall College, Steve Weaver, Colorado College and Steve Acheampong, Summit Envirosolutions.

Student participants were: Jennifer Cabrera, College of William and Mary; Saskia Campbell, College of William and Mary; Erin Carlson, Franklin and Marshall College; Mary Chen, Amherst College; Seth G. Cowdery, Colorado College ; Anne G. Hereford, Williams College; Sean Williams, Pomona College; Anne Sawyer, Carleton College; Stephanie Miller, Washington and Lee University; Read D. Porter, Amherst College; Kevin Takeguchi, College of William and Mary; and Alexander Williams, University of Minnesota, Morris.

Heather MacDonald visited from the College of William and Mary. In addition, we were very fortunate to obtain input and help from a wide range of experts from F&M and beyond. Joe Richardson (Biology, F&M) gave a lecture on the ecology of the site and led a field trip to the site to examine the land-use impacts on the ecology of the site. Dorothy Merritts (Geosciences, F&M) assisted the students working on the hydrology of the site. She helped with the software for the dataloggers and the design and construction of gauging stations. Steve Sylvester (Geosciences, F&M) helped with the analytical equipment and Rick Schaeffer (Chemistry, F&M) assisted the water chemistry group with their analyses. Steve Spadafore (Electronics Engineer, Physics & Astronomy, F&M) helped with demonstrating the use of a remotely operated vehicle (ROV) constructed by Spadafore and Andrew de Wet from an internal F&M grant. The vehicle was used to explore a series of tunnels below the brickworks buildings. Cathy Davis (Dept of Geology, University of Delaware and SEM technician at F&M) demonstrated the capabilities of the SEM and trained Jennifer Cabrera in the use of the SEM as part of the 'metals in sediment cores from the wetland' project. Sharon Moran (Environmental Studies, F&M) presented a history and present status of the Superfund legislation. This provided the students with a policy framework for the scientific work they were doing at Baker Campus. Rob Sternberg (Geosciences, F&M) assisted with the use of the geophysical equipment. Duro Rajkovic (Enviroscan - a geophysical consulting company - and a former F&M geoscience major) completed a demonstration gravity survey over part of the site. Two F&M geoscience majors, Emily Himmelstoss and Mat Mittenthal helped with logistics and equipment use.

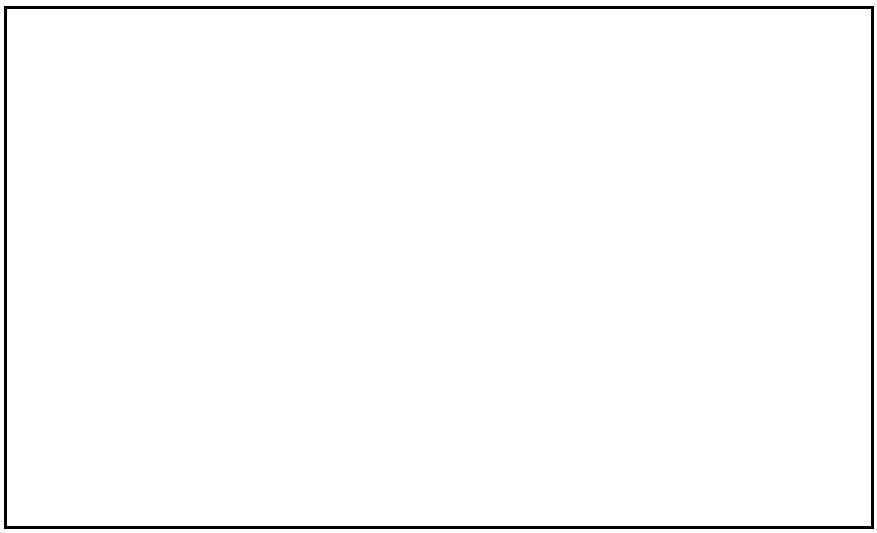

Figure 3: The project participants gather after the partially successful ROV demonstration at the location of the tunnels under the brick kilns. Back from left to right: Sean Williams, Saskia Campbell, Jennifer Cabrera, Erin Carlson, Kevin Takeguchi, Read Porter, Seth Cowdery, Alex Williams and Steve Acheampong. Front left to right: Andy de Wet, Anne Hereford, Mary Chen, Anne Sawyer, Steve Spadafore (with the ROV) and Steve Weaver.

STUDENT PROJECTS

Four major projects were developed by the students. They examined different aspects of the highly impacted field site.

1) Geophysical Investigation of a former landfill and brickworks area, Baker Woodlands Research Site Lancaster, Pa. - Saskia Campbell, Erin Carlson and Alexander Williams. This project used near-surface geophysics to examine the structure and composition of the main landfill on the site as well as some of the building foundations of the former brickworks. Parameters measured included total field magnetic intensity (G858 magnetometer), ground conductivity (EM31 conductivity meter), and magnetic susceptibility (Bartington susceptibility meter). A gravity survey of the foundations of one of the brick kilns was carried out by a local consulting company. We were attempting to delineate the positions of the known tunnels under the brickworks. Unfortunately the results of this survey were inconclusive. Several pits were excavated in the landfill and samples of slag material from the brickworks and the landfill were analysed. The results from the landfill indicate that the landfill is heterogeneous and includes slag and demolision debris brought in from outside the site. The results from the brickworks area better delineated the positions of the former brickworks buildings and helped in reconstructing the details of the land-use history of the site.

2) Geochemical Evidence of Landfill Seepage in a Wetland at Baker Woodlands, Lancaster, Pa. - Jennifer Cabrera, Stephanie Miller and Kevin Takeguchi. This project examined the vertical (temporal?) distribution of metals in sediment cores from the wetlands at the site. Leachate emanating from numerous seeps around the landfills is accumulating over time in the sediments in the wetlands. The metals tested for in projects 2) and 3) were Ba, Cd, Co, Cr, Fe, Mg, Mn, Pb, V, and Zn. This project addresses the following issues: which metals are accumulating in the wetland sediments?, is the concentration of the metals changing with time?, and, what is the relationship between the metals and sediments? The cores taken from next to the main seep from the landfill showed high levels of metal and the metal concentration decreased as the distance from the main seep increased, suggesting that the metals originated from the landfill. This type of spatial distribution suggests that the wetland is absorbing metals that are draining out of the main seep. As the core depth increased, the concentration of metals generally decreased. However, temporal and spatial distribution can be complicated by a number of factors, including grain size, pH of groundwater, the presence of organic matter, and other factors. Some sediment particles from the cores were examined under the SEM.

3) Geochemistry of surface sediments, Baker Woodlands, Lancaster, Pa. - Anne G. Hereford and Read D. Porter. This project complimented the sediment core project and focused on the spatial distribution of metals surface sediments at the site. Samples were collected from sediments in the streams and wetlands. The main issues included which metals had the highest concentration?, where were they distributed? and what was their source? Elevated levels (but not dangerous) of all metals were found in the sediments downstream of the leachate sites. Fe and Mn had the highest levels. Metal concentrations declined rapidly from the seeps (generally within 10 to 30 m) and reached background levels at the fartherest parts of the wetland indicating that the wetland sediments effectively absorbed most of the metals originating from the landfills.

4) Hydrology and aqueous geochemistry of Baker Woodlands, Lancaster, Pa. - Sean Williams, Anne Sawyer, Seth G. Cowdery and Mary Chen. This project examined the water budget and water chemistry of the site. Weirs, wells and gaging stations were installed on the site and will be used to document the water budget at the site (unfortunately because of the drought conditions in SE PA only a small amount of water flow data was collected). The surface water and groundwater at the site were analyzed for for temperature, pH, total dissolved solids, major cations, nutrients, and alkalinity in order to correlate these values with local geology and land use. Nine surface water samples and twelve groundwater samples were analysed. The water chemistry seems to confirm the influence of the landfill on the geochemistry of the local water and sediment.

OTHER ACTIVITIES

As part of the project we took the students on several field trips including one to the anthracite coal mining area in Eastern PA. Here acid mine drainage (similar to the leachate from the landfills at the study site) was examined. Other trips were taken to local areas of geologic interest to give the students an appreciation of the regional geologic and environmental conditions. For the 4th of July we went on a trip to Washington D.C. to see the Natural History Museum geology displays and to enjoy the spectacular fireworks show.

SUMMARY

All the projects were intergrated and the data was input into a GIS database. The results have provided a better understanding of the impact of past landuses on the environment at the site. One of the major successes of the project was the exposure the students received to a wide range of techniques and approaches to understanding and solving environmental problems. The students were exposed to and used the following instruments/techniques: magnetometer, susceptibility meter, resistivity, ground conductivity meter, ICP, XRF, XRD, SEM, GPS and GIS. This provided the students with a unique opportunity to observe and use a wide range of equipment. The proximity of the field site with the labs in the Geosciences Department at F&M meant that the students all had the opportunity to work in the field, collect samples etc and then to analyse the samples using the variety of equipment mentioned above and ultimately to integrate all the field and lab results into a GIS database. This provided them with a unique opportunity to gain a rounded experience of geologic research.

No major problems were encountered however the severe drought in eastern Pennsylvania prevented the project involving the the determination of the water budget in the Baker Campus area from collected much stream flow and groundwater data. It is hoped that data will be collected over the next several months once water levels return to normal. Unfortunately the recent flooding caused by Hurricane Floyd may have damaged some of the equipment. We are working on this problem now and hope to be able to salvage the data from the datalogger.

ACKNOWLEDGEMENTS

We thank the Keck Foundation, the Keck Geology Consortium and NSF for supporting this project. The Franklin & Marshall College Hackman Fellowship program provided funding for our student helpers Emily Himmelstoss and Matt Mittenthal. Thanks to Janie Wissing and Marty McGrath for making our stay at F&M comfortable and productive.

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