Chapter 1

Introduction

The Potchefstroom Campus of the North West University (NWU) is one of the oldest university campuses in South Africa. Like many educational institutions, the University includes a large amount of physical infrastructure and utilities associated with services such as water, electricity and communication.

Each year a growing number of students enrol at the university, increasing the pressure on the infrastructure of the campus. Space decreases and the need for expansion increases. With the increased demand on facilities and building structures such as classrooms and offices, utilities inside and outside the buildings need to be modified and improved. These modifications need to be well planned based on previous plans that are not always readily available. This might become a problem, which is enhanced by the fact that many plans for the new developments are not updated on a regular basis. Good management and well informed planning are subjected to adequate and up-to-date building plans.

For years information regarding buildings and facilities inside the buildings was stored in several formats, varying from hard copy data and mental notes, to computer supporting formats such as electronic CAD data. Computer Aided Drafting (CAD) is a medium that is used for building plans, facility drawings, and various kinds of construction plans. Over the years, a considerable amount of CAD data has been accumulated. However, with the constant evolution in technology and software systems, improved mediums and processes for data management occurred. Technology and the advanced abilities it provides for data management and efficiency of use opened the doors to a whole new perspective and opportunities for facility management.

As mentioned by Christodoulou et al. (2009), many communities do have a problem in managing, replacing, monitoring and modelling aging infrastructure. In return operational and management costs would be likely to increase whenever a decrease of management in a system occurs. A common problem according to Harp & Writer (2009) is that many utility records of areas are stored as CAD data, but are rarely updated. The most common phenomena is the fact that information gets undocumented and valuable information are only stored in the minds of contractors, which means that decisions are based on personal knowledge rather than concrete factual sources (Hill & Willet, 2007). It sometimes happen that paper maps are placed in different localities and could not be updated on a regular basis. For this reason a central database with all the information located and readily available is required (Reynaert, 2009). Whenever all this is in place and the data is kept up to date, efficient planning could be done. This will ensure that necessary precautions could be taken concerning the underground utilities whenever a new development is planned or proposed in a certain area (Peachavanish et al., 2006). In times of development planning, large amounts of time could be saved whenever a database is applied in order to locate certain information instead of scanning through a large amount of paper maps (Kumar & Chesser, 2007).

Geographical Information Systems (GIS) is the ideal tool to solve problems as present at the Potchefstroom Campus of the North West University and different communities. GIS serves as a tool consisting of a database that is designed to work with map data. It also provides a set of tools that could be used to work with data tied to a particular location on the earth (Price, 2010). According to Morey et al. (2001), "Computerized representations of water network models are used in various guises throughout the water industry". GIS could be applied to enhance the structure and understanding of these systems. Poor structured information such as circuit maps, records, road maps, water utility maps associated attributes, construction maps and spatial information could be integrated with the use of GIS.

A GIS geodatabase can be used as a medium to store data and attributes of data regarding the water network on the campus in a structured way. GIS may also serve as a tool to overlay different map representations of the water network in order to provide a complete exemplification of the whole water network system. It could be used as an analysis tool to speed up the planning process, ensuring quick data retrieval, data accuracy and consistency as stated by Cheng & Chang (2001). It could also assist in the physical display of data and editing of data (Heywood, Cornelius & Carver, 2006). GIS contributes well in cases where the most efficient pipeline routes need to be located, dealing with large amount of pipeline data that need to be managed and maintained (Luettinger & Clark, 2005). Water supply and management on the campus could be enhanced with the creation of an ArcGIS water data model as explained by Frelka (2008). To support the aim of this study, a seamless geodatabase have to be developed in order to store the water network data and expert knowledge of the campus in a central place of storage as mentioned by Christodoulou et al. (2009).

1.1. Problem statement

The Potchefstroom Campus of the North West University recently went through many physical changes with regard to infrastructural development and expansion. Additional provision of parking facilities, the upgrade of cafeterias and hostels and the expansion of classrooms are among the changes that took place. The campus is also in a phase where most of the metal water pipes are replaced with plastic PVC pipes. For this reason information regarding underground utilities is very important in order to prevent damage to the existing facilities. However, updating the information of newly developed sections are lacking and have been the trend in many situations during the past. Updated information has been stored in the minds of contractors, plumbers or technicians working on the pipelines, with the risk that the information could easily be replaced or forgotten.

Data limitation problems are common phenomena that promoted the increased complexity of the study. Schutte (2010) confirmed that records regarding current water pipelines are incomplete. Many of the existing plans do not take natural features such as trees or rocky sections in consideration, which contributes to the inaccuracy of the information on the available maps. Electronic CAD data in general are not georeferenced, but is rather drawn with arbitrary Cartesian co-ordinates relative to the buildings (Morgan, 2009). Inaccurate indication of water pipelines cause plumbers or construction workers to search for the lines. This procedure demands valuable time and operating costs which affects the level of productivity for the work executed. This is also the case whenever maintenance or inspection activities are executed (Trosello, 2010). Unfortunately the information cannot be retrieved by anyone other than the person that performed the work. The problem escalates when that particular plumber or technician is replaced.

The need for a central place of data storage is required. It is also necessary to have easy access to the data and a simplified process of updating new data on a regular basis. Information with regard to the water network should be available at all times and need to function within a system that could store the information together with attribute data. The system should also have the capability to execute specified analyses on the water network that could contribute to the management process thereof.

1.2. Aim and objectives

The aim of this study was to create a seamless geodatabase as a pilot project for the potable water infrastructure of the North West University's Potchefstroom Campus. The focus of the study would revolve around buildings E4 and E6 that would serve as the key infrastructural reference points for the study. Primarily the focus will first be placed on the main waterlines from where the smaller micro-scale type water systems such as indoor waterlines on different floor levels will follow. The final product would be applied to process, query and model various solutions regarding the water network. Data editing and accessibility would also be simplified with the use of GIS. The research objectives are as follows:

- to conceptualize the design of the geodatabase for the water network on the campus;
- to create a suitable geodatabase for the study;
- to examine how CAD and GIS could be integrated;
- to examine whether or not GIS is suited to serve as a central medium for storing spatial data; and
- to indicate the advantages of the geodatabase within the context of the study and its suitability to solve the problem.

Special notice should be taken of the fact that this study only resembles a prototype model for future applications. It was important to test the concept on a small scale in order to test the ability of the system and also to identify the possibility for future use. It is also important to mention that the focus was placed on the water provision system of the study area that supplies potable water and exclude sewerage and storm water facilities.

1.3. Study area

The Potchefstroom Campus of the North West University is situated in the North West Province, about a two hour drive South West from Pretoria, on the South Eastern border of the North West Province. The Potchefstroom Campus is one of three satellite campuses, with the Mafikeng Campus also situated in the North West Province and the Vaal Triangle Campus which is located in Gauteng. The Potchefstroom Campus of the North West University accommodates a vibrant student life with 16 661 fulltime students enrolled (Tlokwe Municipality, 2009). The origin of the Campus dates back 141 years ago and currently maintains a compact campus infrastructure with 32 departments divided in seven faculties and more than 113 buildings of which 21 are hostels (NWU, 2011). The Mafikeng Campus is the second largest of the three University Campuses and contains more than 8 000 students and five faculties. The Vaal Triangle Campus is the smallest of the three Campuses, situated next to the Vaal River in the town Vanderbijlpark with two faculties and more than 3700 students. Referring to the aforementioned, the Potchefstroom Campus is clearly the largest and contains the most infrastructural elements.

With reference to Figure 1.1 an indication of the study area is presented in the wider context of the University of Potchefstroom. The QuickBird image (2008) serves as a backdrop reference for the study area. The focus of the study area is placed on buildings E4 and E6 (in yellow) of which building E4 is composed of the “De Klerkshuis” and the “Lettie du Plessis” buildings. Building E6 is known as the “J. S. van der Merwe” building. The Lettie du Plessis building consists of one floor level and houses the Geography and Environmental Management subject group. The “De Klerkshuis” building consists of two floor levels, housing the subject groups Geology and Town and Regional Planning. The “J. S. van der Merwe” building is composed of four levels that include a sub-floor level and houses the Zoology, Botany and Microbiology subject groups.

These buildings were chosen due to the fact that they comprise of four different floor levels which contributes to the viability of the study. The availability of data for these buildings proved to be efficient enough for the study, however, a shortage of the data were encountered at a later stage. The familiarity of the different sections that these buildings offer also contributed to the selection thereof.

Figure 1.1. The study area (QuickBird image, 2008)

1.4. Software overview

ArcGIS 10 provides various software extensions for data management and data analysis. Following a definite literature overview and based on practical knowledge of the abilities that ArcGIS offers, the selection thereof in the context of this study were promoted. ArcGIS will serve as the primary software application and will be used in conjunction with CAD data format files. ArcGIS has the advantage that the CAD files could be viewed within ArcCatalog or ArcMap. CAD software was therefore not used in this study. Within ArcGIS, data analysis environments such as ArcEditor, Network Analyst, 3D Analyst and Spatial Analyst are provided. These extensions enable ArcGIS to perform different analyses on data types, as well as to organize and represent the data in different views. ArcCatalog are used to create and organize the geodatabase with the different files and formats added to the system. ArcMap represents the data in a 2D view and contains the ability for data to be edited and analyzed in 2D. ArcScene represents the data in a 3D view and enables the user to have a more realistic view of the data. It also enables the user to retrieve and analyze data more easily.

1.5. Dissertation outline

Chapter 2 provides a holistic and focused overview of GIS, the system and the structure. This also entails the elements that the geodatabase are composed of and other additional concepts that contribute to the study. Chapter 3 provides a discussion on the different types of database concepts and steps that could be followed to create a database and how these concepts links up with the design of a geodatabase. Chapter 3 also contains a discussion on the logical and the conceptual design stages of the geodatabase. It also provides an indication of how the geodatabase differs from an original corporate database design. Chapter 4 contains the last three methodological steps towards creating a geodatabase and physically implementing the concepts discussed in Chapter 3. The results from Chapter 5 presents a discussion on the application of the system and are concluded in Chapter 6 by reflecting on the initial objectives stated for the study.