

UTILITY MAPPING OF UNIVERSITY OF BENIN UGBOWO CAMPUS



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CERTIFICATION

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DEDICATION

I dedicate this project to Almighty God who has been there for me from the beginning to this very point. I also dedicate this project to my ever supportive Family, for their relentless support and compassion towards my pursuit for a B.Sc Degree in Geomatics, in University of Benin.

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ABSTRACT

This project was undertaken for the purpose of creating a Utility map of the University of Benin. The goals were to locate subsurface utilities using the Global Navigation Satellite System and to provide information from the data in form of maps. This details the procedures that are taken to collect, process, and manipulate data from secondary sources as well as data collected on the field in order to accomplish the project's objective. The fieldwork took place in July/August 2023. The TERSUS GNSS rover used during this fieldwork was connected to Geosystem CORS, which was used to obtain the X, Y, and Z coordinates for all the utilities inside the research area, and the antenna of the rover was placed at 200 cm was used to obtain the height. Data from the field was downloaded from the data logger, transferred to a notepad, and then opened in a Microsoft Excel environment. With ArcMap's display X, Y data tool, the excel file was opened and then converted to shapefile format. It was added as a layer using the shapefile. The layer was placed on top of a Google Earth image of the study area, however there was a slight displacement that was fixed with ArcGIS's spatial adjustment tool.

An extensive and precise database of subsurface utilities has been produced as a result of the underground mapping project at the University of Benin utilizing GNSS technology. The location, depth, type, and condition of the several utility networks on campus have all been usefully revealed by this mapping project. The university has considerably enhanced its infrastructure management, safety procedures, and maintenance processes by utilizing GNSS technology. The mapping data acts as a fundamental resource for upcoming development initiatives, ensuring effective resource allocation, reducing disruptions, and improving the overall sustainability of the campus infrastructure.

CHAPTER ONE

1.0 Introduction

1.1 Background of study

Utility mapping involves mapping all utilities in the region, including those above and below buildings.

The term "utility" refers to built-in public services like organized, large-scale public utilities like water, oil, and gas, telephone lines, electrical supplies, sewage systems, etc. Governments own and maintain a large portion of the nation's physical infrastructure. To set priorities and create a budget for the future, effective utility management is essential.

Utility mapping entails the physical network of distribution lines, their description, and the facilities they are connected to, as well as the delivery of geographically referenced data for use in managing these extremely complex networks. In order to keep up with the rapidly expanding economy's increasing demand, utilities must be urgently expanded for effective management and upkeep. As a multifunctional database of fundamental data on topography, construction, size and shape of landed properties, soil classification, land use, degree and efficiency of land usage, and age, kind, and state of maintenance of structures on land, the cadastre, through the use of digital mapping technology. Therefore, GIS technology must be used to create accurate and current distribution network maps in order to administer utility services successfully. The majority of infrastructure distribution maps in Nigeria nowadays are analog (paper maps) and have set scales. When GIS is used to manage utility services, data processing and communication will be made easier because updating maps in digital form is typically simple and gives current information for efficient administration of the utility services.

1.2 Statement of Problem

The lack of accurate and up-to-date data on infrastructure and utility facilities is a significant problem in many countries, including Nigeria. However, deploying modern technologies and establishing a centralized data collection system are effective solutions that can help to address this problem and enhance the efficiency of utility mapping. Additionally, improving coordination among different utility agencies and promoting inter-agency collaborations and partnerships can also help to streamline the data collection process and ensure that data is accurate and up-to-date.

1.3 Aim and objectives

Aim

The aim of this project is to produce a layered map of utilities within University of Benin (UNIBEN) Ugbowo campus, Benin, Edo state.

Objectives

The objectives of this project are;

- 1 To determine the location of underground utilities in University of Benin (UNIBEN).
2. To acquire spatial data of those utilities.
3. To produce maps of the utilities in UNIBEN.

1.4 Scope of study

The following are encompassed in the scope, but they are not exclusive:

- a. To update current maps and plans.

- b. To develop a useful database with a connection between the spatial geometry data and the attributive data.
- c. Developing appropriate layers for the data sets and superimposing them for spatial analysis.
- d. To create a final report in the form of a digital map that layers together all the information about the infrastructure (both above- and below-ground).

1.5 Justification of the Study

This project is justified because, the students of the Department of Geomatics are trained to not only be knowledgeable in theory but also versatile in practice and their applications in solving practical problems. This project will also be used as a resource for a future student who might be interested in implementing the suggestions from it.

CHAPTER TWO

2.0 Literature review

Utilities such as water, electricity, gas, and sewage systems are the basic services that are essential for the sustainability and progress of human lives. The provision of these utilities must be ensured by government and private sector agencies, and it is important to properly manage their locations and infrastructure.

Infrastructure is the permanent foundation or the fundamental components of a system, plan, operation, etc. The immovable, physical, man-made components of our environment known as "infrastructure" include things like roads, bridges, buildings, and other networks for communication and transit. The term "utilities" is typically limited to the terms "water," "power," "telephone," and "sewer," but by utilizing the term "infrastructure," other man-made characteristics, including transportation networks, may also be included. The focus of the infrastructure information system is divided into two areas: the first is at the broad regional level, where information is required for operations and planning, and the second is at the urban level, where it is required for a wide range of purposes.

. It cannot be overstated how important it is to have a comprehensive, accurate, and up-to-date information system on the current infrastructure. Ayeni (2007) states that. He discusses infrastructure information systems in his paper.

The city of Lake Wood's infrastructure map was created by Mercurio (2000). The map showed that some infrastructure layers had been developed, and lines, manholes, and curbs had been digitized using a range of sources, including as-built and substructure maps. Individual feature layers, such as fire hydrants and water valves, had been recorded in the field by water department staff using GPS equipment. Four inch color aerials and parcel data were used to digitize building footprints, transmission towers, and transmission lines. Using address point and street center-line layers, annotation layers with details like addresses and street names were produced,

Satellite images are registered in the necessary projection system and digitalized in various layers based on the variety of features present on the ground. To enable linking between the actual attribute data of the relevant feature on the ground and the numerous digitized features, topologies of the digitized features are developed. In order to collect the actual names of the buildings, roads, and other features that are not apparent on a satellite picture (such as transformers, manholes, electrical poles, telephone poles, etc.), ground surveys are done. Associated feature's attribute table and ground survey data are combined. A precise subsurface utility map that prevents utility breaks, safety risks or claims, and public outrage can be created.

An article on how BEREAS GIS Mapping (2006) scanned, matched, and entered the existing paper country tax maps into the computer system in order to solve a local sewage authority's problem in South Carolina (USA) was published in an infrastructure, environment, and facilities management magazine. This was done because surveying the entire system would be expensive. The parcel base map that was used had a direct impact on the sewage system's positional accuracy. The positional accuracy of layers like road centerlines, pavement edges, and parcels has improved as a result of a complete update of the GIS data that is currently available. The database was modelled and final editing was performed using ARCGIS 10.1.

On a regular basis, new base map data (property lines, ownerships, road, etc.) are received from the nation and updated in Berea's Arc reader map document. Since the inception of the country wide sewage geo-database modeling standards were established by ARCADIS on average, an updated sewage map is delivered monthly. As new sewage lines were constructed, the digital CAD files were sent to the GIS technician to include the new data in their sewage network.

By taking the initiative to execute an internal translation of all utility infrastructures from Mylar drawings to digital 16 Jatial data in a fully working Geographic information system (G.I.S.), Ken, (2007) generated the utility infrastructure map of the city of Coconut Creek, Florida. procedure involves the initial stage of meticulously inventorying and documenting all archived record drawings, followed by document scanning. Then, using a georeferencing process, each digital image was rotated, scaled, transformed, and clipped using ESRI's Arc info (versions 8.0 and 8.1). Following completion of this task, the city of Coconut Creek completed the tailored internal application development necessary to make the newly created G.I.S. data easily accessible to network users. This software product was then used to map all pertinent line and point information into a personal geo-database in the state-plane coordinate system. The Avenue programming language was initially used to create and implement this graphical user interface (GUI) in Arc View 3.1. The ESRI version of Visual Basic (ArcInfo-based Visual Basic for Applications) was then used to recreate this GUI application in ArcInfo8.0/8.1.

In order to collect data directly from the field for this project, a Sokkia 520k Total station was used. A few of the procedures that were previously examined were then applied to the archiving, processing, and production of this project. Using satellite photos to contribute information to the infrastructure map is one example. All of the field data was georeferenced and plotted on an AutoCAD 2007 map. Each data set's layer was created using imagery from Google and the area's distribution map, creating an infrastructure map of the study area.

2.0.1 History of Utility mapping in Nigeria

The history of utility mapping in Nigeria dates back to the colonial era when the British initiated the process of mapping infrastructure across the country. The need to map infrastructural facilities was driven by the need to provide reliable and effective delivery of utilities such as electricity, water, sewerage, and telecommunications services to the growing population of Nigeria.

The first utility mapping project in Nigeria was initiated in 1920 by the Public Works Department (PWD), which was responsible for the planning and construction of infrastructure across the country. The PWD used traditional surveying techniques to map infrastructure such as roads, bridges, and public buildings, as well as the location of utilities such as water pipes, sewer lines, and telecommunication cables.

After Nigeria gained independence in 1960, the government launched a series of initiatives aimed at expanding the provision of basic utilities such as electricity, water, and telecommunications services across the country. This led to an increase in the demand for utility mapping services, and private companies were contracted to carry out mapping projects in different parts of the country.

In the early 1980s, the Nigerian government established the National Electric Power Authority (NEPA) to manage the country's electricity grid. NEPA embarked on a massive mapping project to document the location of transmission and distribution lines, substations, and distribution transformers across the country. The project was aimed at improving the efficiency of the electricity distribution system and reducing losses due to faulty equipment and theft.

In the 1990s, the Nigerian government introduced policies aimed at liberalizing the telecommunications sector. This led to the emergence of private companies offering

communication services such as voice and data transmission, internet services, and cable television. The government, in collaboration with these companies, initiated mapping projects aimed at documenting the location of telecommunication cables and facilities across the country.

In recent years, the Nigerian government has invested heavily in infrastructure development, including the expansion of utilities such as electricity, water, and telecommunications services. The need to accurately map these facilities has become even more critical, and the government has deployed Geographic Information System (GIS) technology to capture and store location-based data on infrastructure and utilities across the country.

GIS technology has made it possible to collect, manage, and analyze data related to utilities and infrastructure, enabling decision-makers to make informed decisions on the planning, construction, and maintenance of these facilities. GIS has also made it easier to share information between different agencies and stakeholders involved in the delivery of utilities, improving coordination, and collaboration and reducing duplication of efforts.

The history of utility mapping in Nigeria shows that the provision of basic utilities such as electricity, water, and telecommunications services has been a priority for successive governments. The advent of GIS technology has improved the accuracy of utility mapping and made it easier to manage and analyze data related to infrastructure and utilities. As the country continues to grow and develop, the need for accurate utility mapping will continue to be a critical component of infrastructure development in Nigeria.

2.1 Utility Agencies in Nigeria

Utility agencies in Nigeria are organizations established to provide essential services such as electricity, water and telecommunications to the public. These agencies are responsible for planning, constructing, managing, and maintaining critical infrastructure required for the delivery of these services across the country. In this article, we will discuss some of the most important utility agencies in Nigeria and the role they play in providing services to the public.

Electricity Distribution Companies (DISCOs)

There are eleven electricity distribution companies in Nigeria, responsible for the distribution of electricity to the various parts of the country. Nigerian Electricity Regulatory Commission (NERC) regulates the activities of these companies, and they are required to comply with certain standards regarding customer service, tariff rates, and service quality.

The DISCOs are responsible for the installation, operation, and maintenance of distribution networks within their jurisdictions and are expected to collaborate with various stakeholders to ensure that electricity is available to consumers at all times.

Nigerian National Petroleum Corporation (NNPC)

The Nigerian National Petroleum Corporation (NNPC) is the national oil company responsible for exploring, producing, and refining oil and gas in Nigeria. NNPC plays a critical role in the economy of Nigeria because oil and gas is the primary source of foreign exchange earnings for the country.

In terms of utility, NNPC produces and supplies petroleum products such as gasoline, diesel, and kerosene, which are used to power generators, automobiles, and other

machinery and equipment. NNPC is responsible for ensuring that adequate supplies of petroleum products are available to consumers at all times.

Nigerian Communications Commission (NCC)

The Nigerian Communications Commission (NCC) is Nigeria's telecommunications regulatory agency responsible for regulating the telecommunications industry in Nigeria. The NCC is responsible for setting standards regarding quality of service, tariffs, and licensing procedures.

The NCC ensures that telecommunications companies operating in Nigeria comply with these standards, and consumers receive quality services. The NCC is responsible for issuing licenses to telecommunications companies that comply with regulatory standards, and for ensuring that consumers are not exploited by unscrupulous operators.

Water Corporations

There are numerous water corporations in Nigeria, responsible for providing potable water to consumers. These corporations collect, transport, and purify water from different sources, such as rivers and boreholes, and supply it to consumers through a network of pipes and collection points.

The water corporations are responsible for the maintenance of this infrastructure and ensuring that consumers have access to clean and potable water at all times.

Utility agencies play a critical role in the provision of essential services to the public in Nigeria. These agencies are responsible for planning, constructing, managing, and

maintaining critical infrastructure, and ensuring that these services are available to consumers at all times.

Some of the most important utility agencies in Nigeria include the electricity distribution companies, the Nigerian National Petroleum Corporation, the Nigerian Communications Commission and the numerous water corporations. These agencies work together to ensure that the basic needs of the Nigerian population are met, promoting the economic growth and development of the country.

2.2 Importance of Utilities

Utilities are essential for a functioning community. Access to water and electricity is necessary for people to maintain a decent standard of living. It is the responsibility of the government and private sector organizations to provide and maintain these services. Efficient and effective management of utilities infrastructure is important as it ensures that the services required by the community are available when needed.

2.3 Importance of Utility mapping

Utility mapping is essential for safety and cost-effectiveness in construction and excavation projects. Accurate and reliable information about underground utilities reduces the risk of damage to infrastructure and improves productivity by allowing workers to plan and execute projects more efficiently.

Utility mapping is also crucial in disaster management. By knowing the location of utilities, emergency management teams can quickly assess damages and prioritize

repairs. A study by Swarupa and Jain (2013) found that utility mapping can significantly improve emergency response times during natural disasters.

Another important application of utility mapping is in urban planning. By accurately mapping utilities, city planners can identify areas where new infrastructure is needed and anticipate potential problems. A study by Ozturk et al (2019) found that utility mapping can help planners make more informed decisions and better allocate resources for infrastructure development.

There are also benefits to utility mapping for utilities companies themselves. By having accurate maps of their infrastructure, companies can identify areas that need maintenance or repairs and reduce downtime for customers. A study by Surasani et al. (2016) found that utility mapping can improve customer satisfaction by reducing outages and improving maintenance times.

2.4 Challenges of Utility Mapping

Utility mapping is an essential part of infrastructure planning and management. However, there are many challenges that come with this task. The most significant challenge is the lack of accurate and up-to-date information on the location of underground utilities. This arises because the utilities may have been installed many years ago, and the maps or plans may no longer be reliable. Also, most utilities are not visible, so the only way to locate them is by using specialized equipment or conducting intrusive on-site investigations. Furthermore, utility mapping can be challenging because utilities infrastructure is a complex network of pipes and wires

that are often intertwined, making it difficult to distinguish between them. These challenges can make it difficult to accurately and efficiently map utilities.

2.5 Techniques used in Utility Mapping

Several techniques are used in utility mapping, each with its own advantages and disadvantages. The most common techniques are electromagnetic induction (EMI), ground penetrating radar (GPR), Global Positioning System (GPS), and Global Navigation Satellite System (GNSS).

Electromagnetic Induction (EMI)

EMI is a commonly used technique that involves the use of an electromagnetic field to detect metallic objects buried underground. A transmitter generates the EMF, which penetrates the ground and induces current in any metallic object. A receiver detects the current and records the location and depth of the metallic object. EMI is a non-destructive and non-intrusive technique, making it an ideal choice for locating utilities.

Principle of Electromagnetic Induction (EMI)

Electromagnetic Induction (EMI) is a non-destructive and non-intrusive geophysical survey technique that is widely used in utility mapping. The principle of EMI is based on Faraday's law of electromagnetic induction, which states that when a magnetic field passes through a conductor, an electric current is generated in the conductor. In EMI, a transmitter coil generates a magnetic field that penetrates the ground. This magnetic field energizes any metallic object in the ground, causing eddy currents to

flow around it. These eddy currents, in turn, create their magnetic fields, which are detected by a receiver coil placed above the ground surface.

By measuring the strength and frequency of the detected magnetic fields, EMI can identify the presence and location of metallic objects, including utilities such as pipes and cables.

The utility of EMI as a mapping technique lies in its speed, relatively low cost, and ability to cover a large area in a short period. It is also a non-destructive technique, making it suitable for use in urban areas where underground utilities are densely packed, and their locations are not well known.

The effectiveness of EMI in utility mapping depends on several factors, including the type of transmitter coil used, the frequency of the magnetic field, and the depth and size of the target object. Metal pipes and cables are particularly easy to detect with EMI, while non-metallic materials such as plastic and fiberglass may not be detected.

One limitation of EMI as a utility mapping technique is its susceptibility to interference from other metal objects in the vicinity. For instance, nearby buildings, vehicles, or metallic fences can cause significant interference, leading to false readings or masking the presence of the target underground utilities.

In summary, EMI is a useful non-destructive and non-intrusive method for detecting metallic pipes and cables, making it a valuable tool for utility mapping. Its speed, relatively low cost, and wide coverage make it an attractive option for large-scale utility mapping projects. Despite its limitations, EMI continues to be an essential technique in utility mapping, and constant technological advancements are being made to improve its accuracy and reduce interference.

Advantages of Electromagnetic Induction (EMI)

1. Non-destructive: EMI is a non-invasive and non-destructive technique that does not require excavation or disturbing the ground surface.
2. Rapid survey: EMI can quickly cover large areas in a short time, making it a suitable technique for large-scale projects.
3. Suitable for a variety of soils: EMI can be used in a range of soil types, including clay, sand, and rock. Because it does not rely on electrical conductivity, it is not affected by soil type or moisture content.
4. High accuracy for metallic objects: EMI is particularly effective at detecting metallic objects, such as pipes and cables.
5. Relative low cost: EMI can be relatively inexpensive compared to other geophysical survey techniques.

Disadvantages of Electromagnetic Induction (EMI)

1. Not effective for non-metallic materials: EMI only detects metallic objects such as pipes and cables. Non-metallic materials like plastic, fiberglass, and concrete cannot be detected by EMI.
2. Interference from other metallic objects: EMI signals can be disrupted by other metallic objects in the vicinity, such as fences or buildings. This can lead to false-positive readings or mask the presence of underground utilities.
3. Limited depth range: EMI is typically effective at depths of up to 10-15 feet, making it less suitable for detecting deeper utilities.

4. Requires a clear line of sight: EMI requires a clear line of sight between the transmitter and receiver coils. This can be challenging in areas with dense vegetation, buildings, or other obstructions.

5. Unreliable results in areas of high-conductivity: EMI results can be unreliable in areas of high-conductivity, such as saltwater, which can interfere with the signal.

Ground Penetrating Radar (GPR)

GPR is another commonly used technique that involves the use of high-frequency radar waves to penetrate the ground and locate underground utilities. A transmitter emits radar signals, which reflect off any objects buried underground and bounce back to a receiver. The receiver measures the time taken for the signal to bounce back, allowing it to determine the depth and location of the object. GPR can detect both metallic and non-metallic objects, making it a versatile technique.

Principle of Ground Penetrating Radar (GPR)

Ground Penetrating Radar (GPR) is a geophysical survey technique commonly used in utility mapping to detect and locate underground utilities. The principle of GPR is based on the transmission and reception of high-frequency electromagnetic signals. In GPR, a transmitter sends short pulses of high-frequency (usually 100 MHz to 1 GHz) electromagnetic waves into the ground. The signal penetrates the soil and interacts with changes in the electrical properties of subsurface materials. The nature of the reflection depends on the dielectric properties of the medium the signal passes through. The contrast between the dielectric properties of different subsurface materials creates a reflected signal that is captured by a receiver located on the surface of the ground.

The radar signal is reflected by geological layers and variations in structure or composition beneath the surface. When the signal encounters an object or material with a different dielectric coefficient, such as a utility cable, it reflects back to the surface from where it is detected by the receiver. The time delay between the transmitted signal and the reflected signal can be used to determine the depth and location of underground utilities.

By analyzing the strength and timing of the reflected signal, GPR can provide detailed information about the depth, location, and size of buried utilities. With the help of a computer, the data collected by the GPR equipment can be processed and visualized in 3D images or maps.

The effectiveness of GPR as a technique in utility mapping depends on several factors, including the frequency of the radar signal, the nature of the subsurface materials, and the size and orientation of the target object. Higher frequency signals can provide higher resolution and detail, but they have a shorter depth range. Lower frequency signals have a longer depth range but lower resolution.

In summary, GPR is a powerful geophysical survey technique that has many applications in utility mapping. The principle of GPR is based on the transmission and reception of high-frequency electromagnetic waves, which are reflected by subsurface materials with varying dielectric properties, including underground utilities.

Advantages of Ground Penetrating Radar (GPR)

1. Non-destructive and non-invasive: Unlike traditional utility mapping methods, GPR is a non-invasive and non-destructive technique that does not require excavation or disruption of the surface.

2. High-resolution imaging: GPR provides high-resolution subsurface images that allow for accurate mapping and the identification of abnormalities.
3. Wide coverage area: GPR can cover a larger area quickly, providing more efficient mapping and reducing survey time and costs.
4. Versatile: GPR can be used to map a wide range of subsurface utilities, including pipes, cables, and even archaeological features.
6. Reduced risk of damage: Using GPR helps reduce the risk of damage to buried utilities, such as gas pipelines, telecommunication cables, and electric power lines, since excavators can avoid digging in areas with GPR anomalies.

Disadvantages of Ground Penetrating Radar (GPR)

1. Limited penetration depth: The effectiveness of GPR in identifying buried utilities may decrease as the depth increases. Moreover, some objects or materials, such as certain types of rocks, soils, or debris can reduce the penetration depth of the EM wave and create false-negative readings.
2. Inaccuracy: Due to the complexity of the subsurface structure and the presence of noise, various factors, such as signal attenuation, scattering, and diffraction, can affect the accuracy of the GPR readings.
3. Interpreting data can be challenging: The interpretation of the GPR data by the trained professionals can be difficult and subjective. Incorrect interpretation by the operator may impact the accuracy of the results.
4. Geology and saturation may affect the results: The GPR technique's effectiveness is highly dependent on the terrain and soil conditions. Signal loss can occur in areas with high moisture, electrical conductivity, or salinity.

5. High-cost: GPR is a high-end technology, typically more expensive than conventional utility mapping methods, which may make it difficult for small projects or budgets.

GLOBAL POSITIONING SYSTEM (GPS)

GPS, or Global Positioning System, is a satellite-based navigation system that can be used as a technique in utility mapping. GPS technology allows mapping professionals to precisely locate and map the exact position and elevation of underground utilities. To use GPS for utility mapping, GPS data is collected first using GPS receivers and antennas. These devices receive signals from the GPS satellites and use the data to calculate the precise location of the receiver on the surface of the earth, as well as its elevation.

The GPS data is then used, along with other data such as as-built plans and survey data, to create digital maps of underground utilities. The GPS data is often combined with other techniques such as ground-penetrating radar (GPR) or electromagnetic locators to allow mapping professionals to accurately locate the exact position and elevation of underground utilities.

Principle of Global Positioning System (GPS)

Global Positioning System technology is a satellite-based navigational and geolocation system used in utility mapping to determine the precise location of underground utilities. The principle of GPS is based on the emission of radio signals from a network of GPS satellites orbiting the earth.

In GPS technology, a GPS receiver is used to receive signals transmitted from the GPS satellites. The receiver then analyzes the signals to determine the latitude, longitude, and altitude of the receiver's current position. This position information is then recorded and can be used to create a map or to locate underground utilities.

In utility mapping, a GPS receiver is integrated with a Geographical Information System (GIS) to produce an accurate utility map. The map is created by collecting GPS coordinates at various points along the utility lines and then connecting the dots to create the map. This allows for the precise location of underground utilities to be recorded for future reference.

GPS technology uses multiple satellites to triangulate the receiver's position. The GPS receiver receives signals from at least four GPS satellites, and the time delay of the signals is used to calculate the distance between the receiver and the satellite. Once the distance for each of the satellites has been calculated, the position of the receiver on the earth's surface can be determined.

The accuracy of GPS depends on various factors, including the number of satellites the receiver can receive signals from and the strength of the signal received. In ideal conditions, GPS can provide a location accuracy of less than one-meter and altitude accuracy of less than 10 meters.

To summarize, GPS technology is based on the reception of radio signals from GPS satellites to determine the precise location of underground utilities. The technology is integrated with GIS to create utility maps that accurately locate the underground utility lines. GPS technology is a powerful technique that can determine the location of underground utilities with high accuracy and help prevent unintentional damage to these assets during excavation work.

Advantages of Global Positioning System (GPS)

1. High-precision: GPS technology provides high-precision location data, which helps in accurately mapping the location of underground utilities.
2. Time Efficient: The GPS technology is very fast, and the fieldwork to map the utilities can be completed quicker than the traditional methods.
3. Cost-Effective: GPS technology reduces the expense associated with traditional mapping techniques that require manual field measurement tools such as tapes or string.
4. Accurate Map Creation: GPS technology is used in conjunction with Geographical Information Systems (GIS) to create accurate maps of underground utilities that can be accessed by anyone on the team, from the field or office.
5. Improved Safety: The use of GPS technology in utility mapping improves safety because the exact location of underground utilities is identified. This helps to prevent accidents, and reduce the risk of unintended damage to underground utilities.

Disadvantages of Global Positioning System (GPS)

1. Limited vertical accuracy: GPS technology uses horizontal location information, but it is not always effective for precise vertical location, especially in areas of rugged terrain or soil or where GPS signals are blocked.
2. Signal interference: GPS signals can be affected by interference or obstructions from tall buildings or bad weather. In extreme cases, this can cause errors in GPS readings or disrupt communication between the GPS satellites and the GPS receiver.

3. Dependence on satellite technology: The accuracy of GPS technology is dependent on satellite availability and is less effective in areas with low satellite coverage, such as in rural areas or heavily wooded areas.
4. Power Requirements: GPS receivers require battery power to function, which could cause a challenge in remote areas where power supply is limited.
5. Limited precision in some areas: In areas with high structures, including urban areas, GPS signals can experience multipath errors, which can result in inaccurate measurements.

Global Navigation Satellite System (GNSS)

GNSS, or Global Navigation Satellite System, is a technology that uses a network of satellites to determine the precise location of a receiver on Earth's surface. GNSS is a very effective technique used in utility mapping, as it provides accurate and reliable data on the underground utilities.

Principle of Global Navigation Satellite System (GNSS)

The principle of GNSS is based on triangulation, which involves using signals from multiple satellites to calculate the precise location of an object on Earth's surface. The GNSS receiver receives signals from at least four satellites, and the distance between the receiver and each satellite can be calculated using the time it takes for the signal to travel from the satellite to the receiver. By combining the distance between the receiver and each satellite, the receiver can determine its precise location on the Earth's surface.

This principle of GNSS is useful in utility mapping, as it can be used to accurately locate buried utilities. A GNSS receiver can be placed on the surface above the

utilities, and the receiver can collect data on the locations of each utility. This data can then be used to create accurate maps of the utilities' locations.

GNSS technology can also provide real-time data on underground utilities, which is especially useful during construction projects. By using GNSS, site surveyors can quickly and accurately determine the location of underground utilities and share this information with construction crews. This helps to prevent damage to utilities during excavations and can save time and money by reducing the need for rework.

In conclusion, the principle of GNSS is based on triangulation, which is useful in utility mapping as it can provide accurate and real-time location data on buried utilities. GNSS technology is essential in the field of utility mapping, and it greatly helps in identifying and mapping underground utilities without causing damage to them.

Advantages of Global Navigation Satellite System (GNSS)

1. High Accuracy: GNSS provides survey-grade accuracy, making it an ideal technology for mapping utility networks.
2. Global Coverage: GNSS systems work globally and are therefore useful for utility mapping in any location.
3. Efficiency: GNSS allows for rapid data collection and can cover large areas quickly, making it an efficient method for mapping utility networks.
4. Cost-effective: GNSS systems have advanced over the years, and the costs associated with equipment and maintenance have decreased, making it a cost-effective option for utility mapping.

Disadvantages of Global Navigation Satellite System (GNSS)

1. Environmental factors: GNSS signals can be affected by environmental factors, such as obstructions like buildings and trees that can result in signal blockages, reduce accuracy and affect data only if the receiver has no clear view of the open sky.
2. Accuracy limitations: GNSS has limitations with accuracy when measuring the depth of utilities, such as underground pipelines and cables.
3. Availability of signal: In certain locations or where there are signal interference GNSS signals may not be available. For instance in dense forest areas, and in urban cities covered by tall buildings obstructing satellite signals.
4. Human error: GNSS relies heavily on data collection techniques, which can be subjective to human error. The interpretation of the collected data can, therefore, be incorrect if not carried out properly.

In conclusion, Utilities are essential for the sustainability and progress of human life, and their efficient management is crucial. Utility mapping is a vital part of infrastructure planning and management, but it comes with many challenges due to the complexity of underground utilities. Techniques such as EMI, GPR, GPS and GNSS are commonly used to map underground utilities. Although each technique has its own advantages and disadvantages, they are all vital for ensuring that essential utilities are properly managed and maintained.

CHAPTER THREE

3.0 METHODOLOGY

This details the procedures that are taken to collect, process, and manipulate data from secondary sources as well as data collected in the field in order to accomplish the project's objective. The fieldwork took place in July 2023. The TERSUS DAVID

GNSS rover was connected to Geosystem CORS, which was used to obtain the X, Y, and Z coordinates for all the utilities inside the research area, and the antenna of the rover was placed at 200 cm was used to obtain the height. The field data was downloaded from the data logger, copied to a notepad, and then opened in the Microsoft Excel environment.

3.1 STUDY AREA

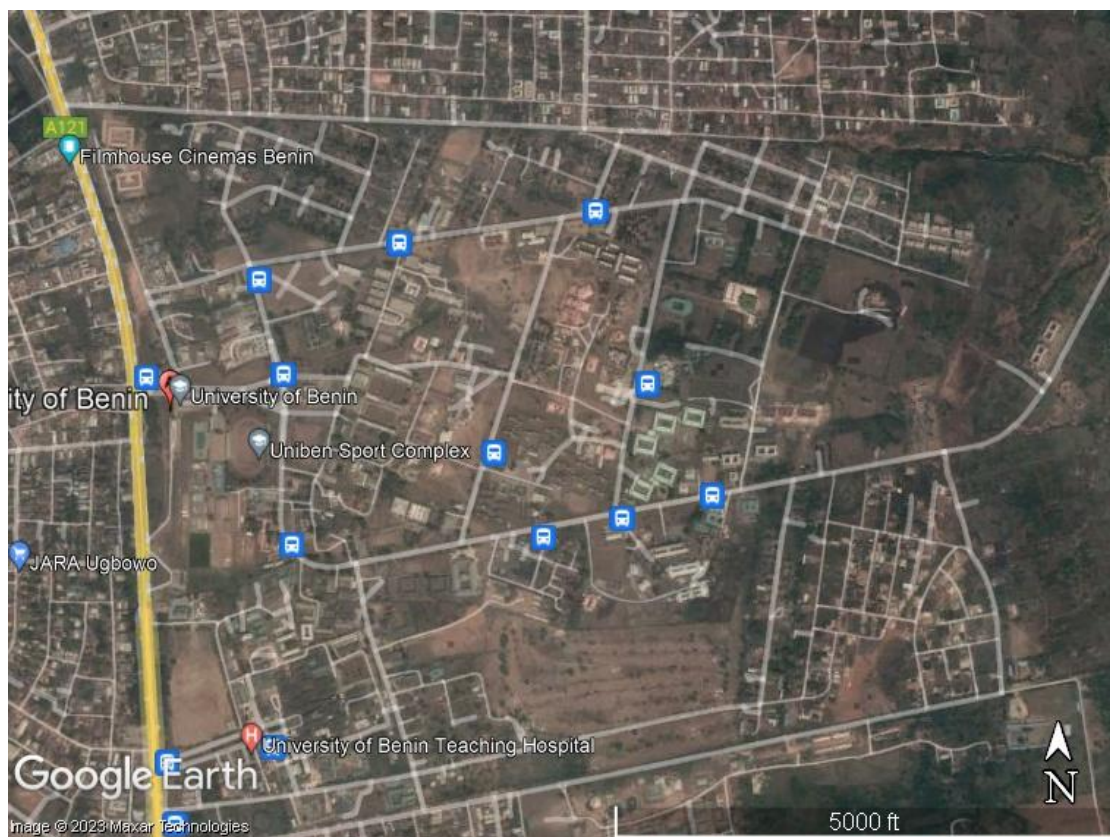


Figure 3.1: Google Earth map showing the study location

The University of Benin, also known as UNIBEN, is a federal government-owned university located in the city of Benin, Edo State, Nigeria. Established in 1970, the institution offers undergraduate and postgraduate programs in various fields and is one of the top-ranked universities in Nigeria.

The University of Benin's Ugbowo Campus is the subject of this study. Its position lies on the border of Edo State's Ovia North-East LGA and Egor LGA. The campus is located at latitude 6.3500° N and longitude 5.6000°E, and its coordinates are 6°21'00.0"N, 5°36'00.0.

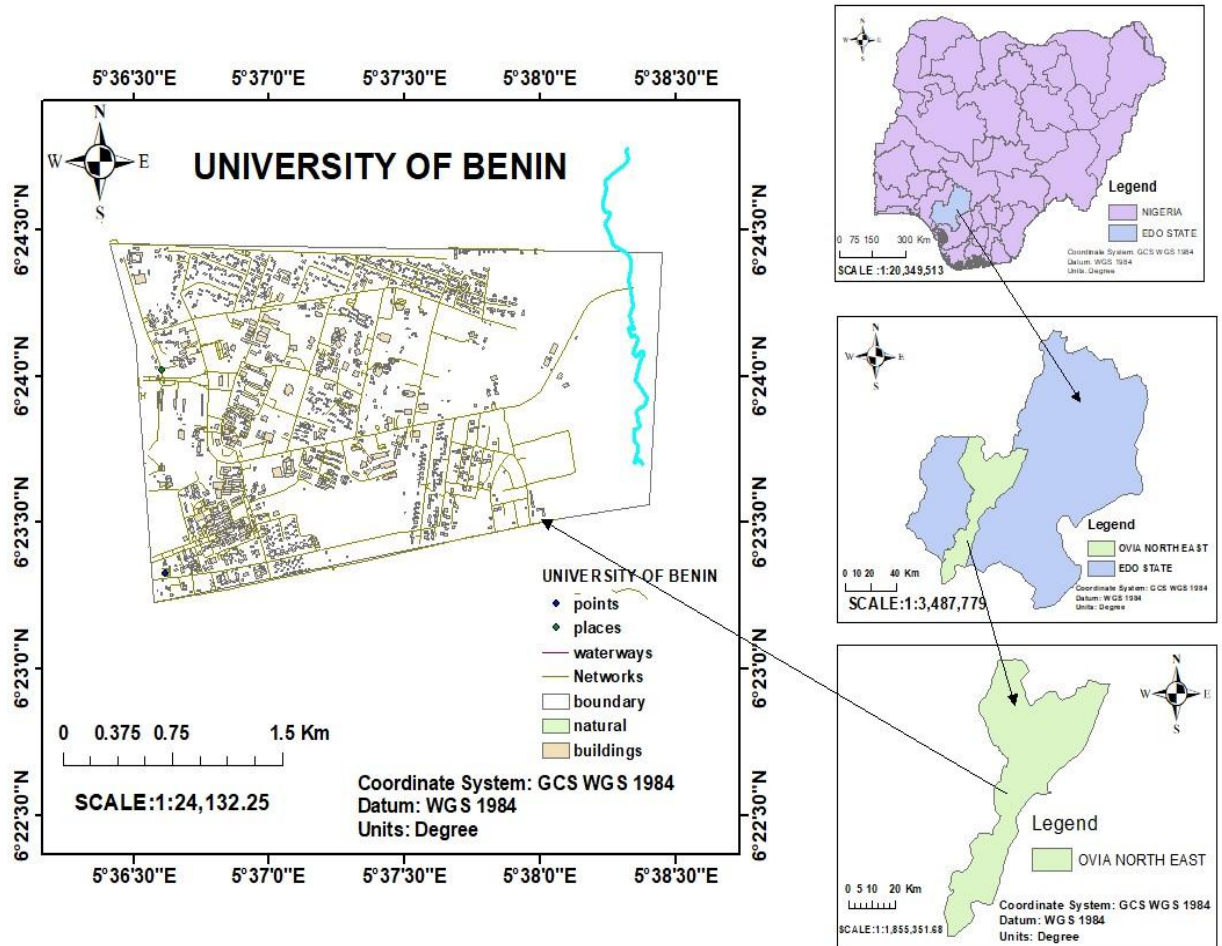


Figure 3.2: Map of the Study Area

3.2 RECONNAISSANCE

To properly plan the project, tools, methodology, staff, and skill needs, the initial stage of any survey operation involves visiting the site to verify that the utilities are indeed underground. Every group member took part in the planning phase of

completing this project job. The two stages of reconnaissance are office reconnaissance and field reconnaissance.

3.2.1 FIELD RECONNAISSANCE

This operation entails going out into the field, making the initial trip to the project study area to help with planning, choosing inter-visible station locations, evaluating project execution costs, and noting all aspects. The project region was thoroughly examined to identify which of the many potential pathways could merit a detailed survey given the number of utilities (electric cables, pipelines) to map out. A diagram was created during the reconnaissance to serve as a base map that would complement the other base maps.

3.2.2 OFFICE RECONNAISSANCE

This is a procedure done at the office to gather necessary information and data required for the project's accuracy and completion. These data were collected from the Department of Geomatics, and the instruments were also examined to determine whether they were functioning properly. The GNSS TERSUS DAVID RTK was coupled with the GEOSYSYTEM CORS. The antenna was tested on GPS100 and GPS101 at a setting of 200 cm. The information and control attributes that were obtained are displayed below.

GPS100: 354262.896E, 265821.355N, 127.663(Height)

GPS101: 354077.424E, 265813.106N, 128.324(Height)

INSTRUMENTS AND MATERIALS

The following instruments were used during the execution of this project.

Hardware Equipments

Tersus David GNSS Rover

Computer system (HP Laptop).

A Toyota Camry (Four Wheel Drive) Vehicle.

Software Packages

AutoCAD 2016

ArcGIS 10.7

Google Earth Pro

Data logger

Notepad

3.3 DATA ACQUISITION

Source of Data

In this project, two primary sources of data acquisition were used, namely:

- i **Primary Source:** This is the site's direct data collection. A ground survey method utilizing GNSS was used to gather the data for the various utilities.
- ii **Secondary Source:** It is the distinctive information regarding the attribute data, which was acquired from the University of Benin Water Board and Powerhouse. The data gathered include:
 - (a) Size of pipes
 - (b) Size of cables
 - (c) Types of transformers
 - (d) Location of underground cables and pipes

3.3.1 DATA PROCESSING

GNSS data processing

To get the X, Y coordinates of the pipes, cables, and borehole locations, the coordinates were determined using GNSS and downloaded into the computer system. The coordinates were derived by connecting GNSS RTK to CORS, which is located in zone 31 of the WGS 84 coordinate system. The data was subsequently imported from Microsoft Excel to ArcGIS 10.3 so that the map could be updated.

3.3.2 METHOD OF DATA ACQUISITION

Geometric data (X Y Z) of feature positions on the project site were obtained using the land surveying method. Attribute data were obtained through oral interviews. Among the attribute data are:

- i Identifying names and the functions of various pipes and cables
- ii Identifying the different types of transformers, (Ring Main Unit) RMU, and boreholes
- iii Identifying the different sizes of pipes and cables

3.3.3 FIELD WORK

The fieldwork started with setting up our GNSS instrument, making a project file, connecting the rover to GEOSYSTEM CORS, and then we started with mapping underground cables within the University of Benin. We started from UNIBEN POWERHOUSE, where we were shown how the cables were buried underground, the sizes of the different cables, and the routes of the different cables within the campus. We then mapped the underground cables as shown by the staff members working in the power plant. After conducting a border survey of the UNIBEN water board, we moved on to the project's second phase, which involved pipe mapping.

3.4 GEO-REFERENCING

Geo-referencing is the process of choosing a prominent point or location on a satellite image and aligning it with ground coordinates. Using the add control on the Geo-referencing toolbar, the identified locations on the coordinates of the image should be added one after the other. By using georeferencing, it is ensured that the picture's pixels' coordinates correspond to the actual coordinates of the location on the ground they depict. The following procedures were followed when georeferencing:

- i Prepare the software.
- ii Selecting: will make the entire geo-referencing toolbar visible, if it isn't already.
- iii Access to georeferencing is available via the View > Toolbar menu.
- iv Activate each spatial layer that will be applied to the image during georeferencing.
- v Zoom in on the area of the image that roughly corresponds to the area to which these layers will be applied.
- vi Points should have their color and shape adjusted so that they are visible when the image is displayed.

3.4.1 CONTROL POINTS

Matching the picture layer points to the corresponding form layer points is the procedure of including control points. From the Geo referencing toolbar, choose the Add Control Points icon. You can geotag an image using this tool:

Start by using the left-click function on your mouse to choose a recognized area of the image. As a result, a cross will be placed there.

Then, on a different layer, left-click on the corresponding control point. This will move the image and enhance control alignment.

For each control point, repeat this process. Instead of using the method outlined above, you can enter x and y coordinates by placing a cross in the appropriate location, right-clicking, and then entering the information.

3.4.2 MODIFYING THE FINISHED RESULT

The residual error gauges how well the output control points' converted and real positions fit together. By highlighting the problematic link's location in the link table and selecting the delete icon, you might want to remove it. You can use the Geo-referencing table to do a 1st, 2nd, or 3rd order transformation depending on the number of control points.

The transformations produce two least-square-fit equations that change the image coordinates into map coordinates by comparing the picture source coordinates to the control locations. A first order transformation rotates the entire image, moves it in any direction, or extends or contracts it. Non-uniform point shifting is possible thanks to the second and third-order transformations' ability to fit higher-order polynomial equations to the data. Usually, a first or second order is sufficient. Choose the one that works best for you after trying all three. Layout physically Physical design is the process of showing the relational structure (table structure) in accordance with the data types that the implementation software has designated. Integer, string, Boolean, and date are the four forms of data that are available.

The software developed a data type that was mapped to the columns of the table from the logical design step. In this case, an effort was made to ensure that the foreign key and the primary keys produced in the software environment are of the same kind.

3.4.3 DATA IMPORTATION

Input data must be finished before conducting analysis in a geographic information system. The information consists of characteristics data, which are used to define the

spatial data, location data expressed in terms of x, y, and z coordinates, and spatial data, which includes geographic features (points, lines, and regions).

Because the quality of the input data and the method have a significant impact on how the analysis turns out, data entry in a geographic information system should be done with the utmost care. You can enter data into geographic information systems in the following ways.

- A) Digitization, which involves using analog maps;
- B) Keyboard entry, which involves entering attribute data
- C) Scanning, which involves using aerial photos and satellite information
- D) Analyzing data from CD-ROMs, flash drives, and diskettes.
- E) The information used for this project was entered into the computer via the keyboard. create a database.

Following the completion of the database design, the appropriate data collection technique that was found to be the best during the user demand survey is used to gather the geographic data and associated attributes. The information is then formatted, modified, and recorded in the database in preparation for use in spatial analysis.

The set of instruments used to arrange data in a database is known as database management. Data input routing, validation, storage, and retrieval are frequently included.

The ARCVIEW GIS 3.2 tool was used to handle the project's database. The updated AutoCAD map was saved in the dxf format, the ARCVIEW environment was launched, and each layer imported was converted to a shape file. The attribute of each theme was linked by selecting the layer and clicking on the theme table icon on the tools bar. More fields were added, field names were changed, and the table can now

be filled out by choosing edit start editing from the drop-down menu. The application provides user interface features that allow me to create databases, files, add data to tables, edit tables, and get data from them whenever it is needed.

Following the completion of the tables, the hard copy was printed once the proper formatting and editing were completed on the computer's visual display unit (VDU).

A DBMS's main goal is to provide users with straightforward access to the database, even if such users are not conversant with its complexities. The complexity of the entire database should be hidden from the user by a good DBMS.

The spatial database needs to be well-maintained in order to accomplish the stated objective. Duplicate items must be removed, and the database must be updated as needed, as part of database maintenance.

An integral part of a geographic information system (GIS) is data quality. The quality of the data is essential in establishing which applications are authorized because it affects the types of decisions that are made. The database was built with current, trustworthy data of high quality. The attribute data used was current, the coordinates were plotted and verified using an existing topographical map, and the data was also examined against a background. The following challenges were resolved:

- (a) Updated data currency
- (b) Data update procedures and methods
- (c) Data updates and consistency propagation
- (d) Archiving of data

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Presentation of Result

This chapter presents the raw data obtained from the field using GNSS RTK Receiver instrument. The data are presented in the following categories under listed. This chapter also presents the various maps produced in the task to produce digital utility map of Electric cables and Pipes within University of benin.

This project was carried out to map the route of underground cables and pipes and also to know the size of different cables and pipes as a case study.

Table 4.1 Breakdown of the different types of pipes and size

DIFFERENT TYPES OF PIPES AND SIZES	
PIPE TYPE	PIPE SIZE
PVC PIPES	8inches
PEX PIPES	6inches
COPPER PIPES	4inches
CAST IRON	8inches
GALVANIZED STEEL PIPES	8inches
CPVC PIPING	6inches

4.2 WATER DISTRIBUTION NETWORK

The GNSS data was imported into ArcGIS, where each point was shown with a distinct function before digitization started. Digital maps and attribute tables were used to illustrate the database query results. The findings of several example database searches are described. According to the analysis, the research region consists of 50 transformers, 30 RMU, 3 campus sub-stations, and 3 reservoirs. The result is displayed in Figure 4.1.

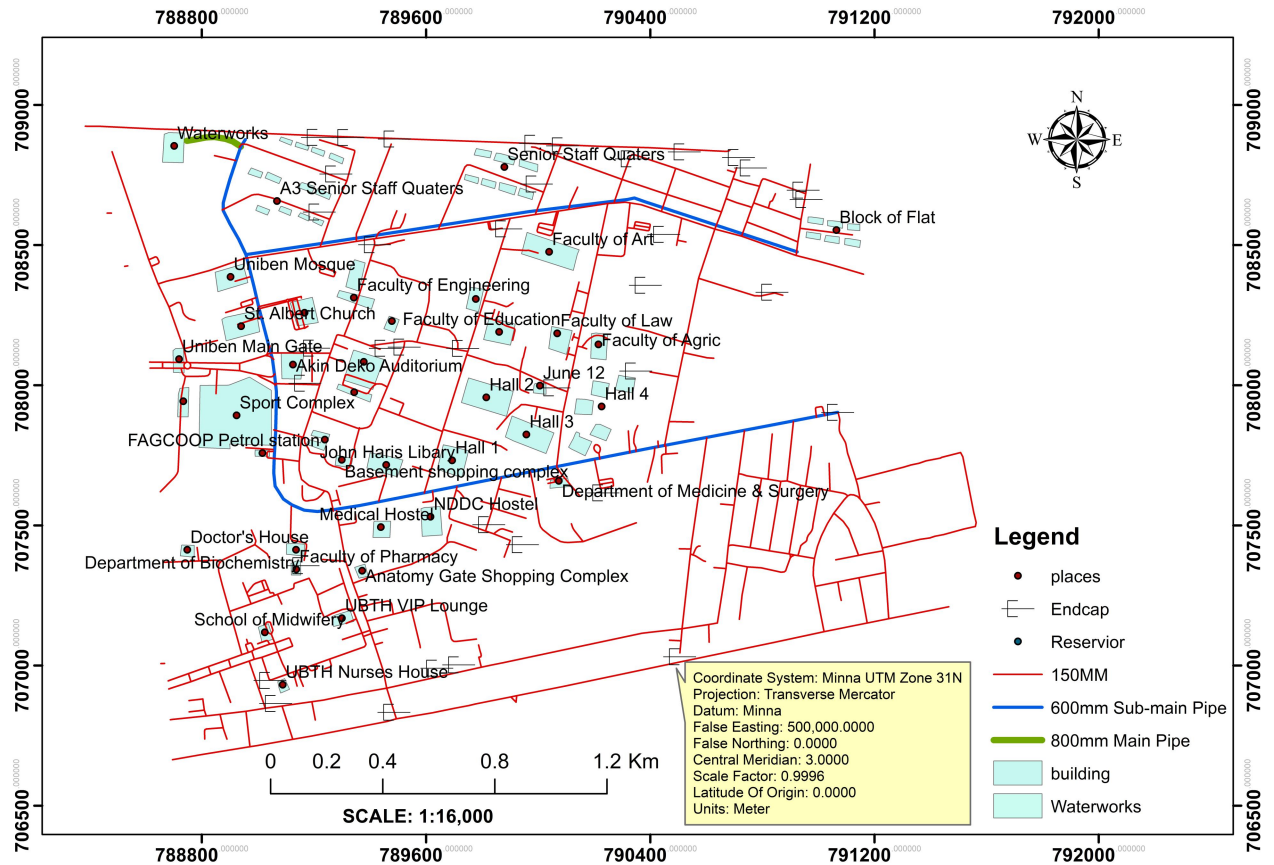


Figure 4.1: Water Distribution Map

4.3 UNDERGROUND ELECTRIC CABLES WITHIN UNIBEN

The GRID IRON SYSTEM is the water distribution system in use at the University of Benin. The main pipe providing water from the storage tank is a 9-inch pipe, while the smaller pipes used for distributions around campus are 4-inch and 6-inch pipes. In the University of Benin, electricity was delivered from the transmission system to the sub-station, from the sub-station to the various transformers on campus, which were then distributed to the various RMU on

campus.

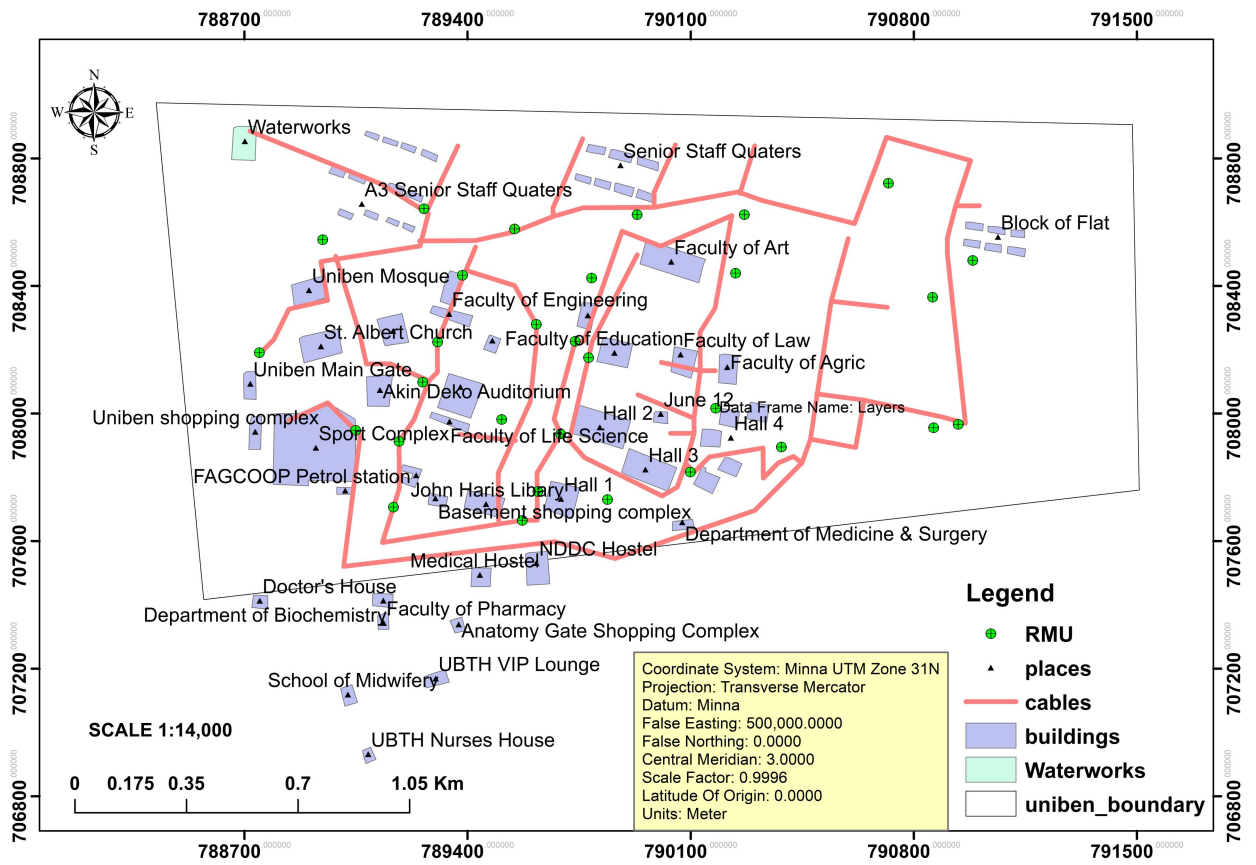


Figure 4.3: Underground Electric Cables Within UNIBEN

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The discussion so far on the mapping of underground cables and pipes within the university of benin has come with a lot of findings. Considering the benefits of the developed system, university of benin would be able to know the route of the different pipes and cables in order to avoiding building on the route of the cables and pipes.

In conclusion, the various stages of carrying out this project in the University of Benin, Benin city, Edo state have been discussed in the proceeding chapters.

Hence the essence or importance of carrying out utility of an area cannot be over-emphasized as it serves as a tool for proper planning of various projects and engineering construction designs as well as a fundamental base for map update and user information.

It would also be deemed appropriate to simply say that the project exercise was carried out successfully and the main aims and objectives was realized; though without such as rainfall, limited man power, distraction from class work, etc .

The project provides an outlook for land use planners and policy makers to appreciate the emerging challenges of land encumbrances by these facilities. It becomes imperative for land managers to have an institutional framework that will aid in providing a geographical basis for sitting these facilities.

5.2 RECOMMENDATIONS

It is recommended that the utility map produced should be used as a current base of reference for subsequent updating of the University of Benin, Ugbowo Campus since it is also in digital format.

Moreso, it is recommended that more digital equipment be provided as well as repairs and adequate maintenance be meted out to the ones at the store in order to keep up their functionality and also avoid wreckage.

Furthermore, increased practical tasks should be inculcated into the school's curriculum in order to enhance the student's operational knowledge of various digital survey instruments that evolve with the day to day technological advancement.

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APPENDIX I
ACQUIRED DATA USING GNSS RTK ROVER FOR UTILITY MAPPING OF
UNIVERSITY OF BENIN,UGBOWO CAMPUS.

POINT	EASTING	NORTHING
1	790108.0918	707812.943
2	790098.4871	707816.668
3	790075.6221	707827.133
4	790091.1834	707935.025
5	790096.7976	707985.470
6	790131.1921	708118.635
7	790170.2475	708118.861
8	790170.9877	708322.821
9	790133.6621	708247.209
10	790249.2861	708692.907
11	790307.2594	708657.724
12	790300.969	708567.726
13	790675.9779	708781.6296
14	790714.21	708857.9351
15	790924.492	708647.940
16	791008.611	708640.962
17	790909.657	708550.012
18	790461.227	707906.690
19	790959.611	707961.488
20	790941.293	707958.092
21	790939.4291	707966.3048
22	790958.231	707969.9569
23	790942.032	707967.226
24	790938.400	707960.828
25	790932.912	707950.439
26	790840.384	707941.082
27	790846.844	707988.969

28	790885.997	707983.684
29	790862.334	707955.694
30	790862.802	707960.608
31	790879.388	707947.584
32	790627.915	708034.565
33	790617.074	707890.785
35	790443.462	707831.952
36	790409.521	707882.420
37	790373.906	707844.081
38	790311.203	707882.420
39	790326.159	707783.620
40	790304.101	707679.890
41	789992.726	707747.915
42	789994.355	707748.151
43	790057.652	707762.006
44	789620.577	707755.869
45	789625.202	707766.060
46	789605.8869	707723.063
47	789496.345	707803.305
48	789604.917	707670.948
49	789574.049	707656.020
50	789855.625	707542.860
51	789125.811	707580.285
52	789123.949	707578.616
53	789062.211	707938.162
55	789065.216	707935.620
56	789063.415	707940.387
57	789067.748	708135.340
58	789038.761	708240.261
59	789153.903	708152.500
60	788746.842	708190.968
61	788794.179	708232.647

62	788728.216	708188.849
63	788843.328	708328.046
64	788825.087	707968.562
65	789175.809	707747.228
66	789167.7836	707749.382
67	789172.260	707865.643
68	789180.276	707906.826
69	789305.996	708224.538
70	789302.945	708215.002
71	789306.977	708212.618
72	789281.952	708129.376
73	789272.631	708103.660
74	789270.465	708096.894
75	789259.1674	708098.428
76	789262.425	708107.617
77	789261.190	708066.007
78	789257.991	708066.001
79	789223.511	707972.320
80	789227.1281	707980.733
81	789363.557	707923.267
82	789364.706	708431.200
83	789382.605	708431.200
84	789385.218	708431.200
85	789383.967	708433.849
86	789398.032	707980.744
87	789400.4185	708455.3987
88	789544.705	708396.930
89	789545.453	708396.366
90	789239.569	708550.782
91	789259.549	708639.170
92	789263.172	708642.544
93	789110.035	708722.104

94	788701.854	08901.608
95	789535.663	708583.646
96	789547.454	708578.992
97	789542.559	708567.834
98	789532.384	708575.926
99	789533.554	708573.432
100	789471.783	708531.771
101	789659.098	708641.414
102	789644.505	708613.320
103	789764.697	708628.088
104	789983.204	708693.510
105	789878.366	708569.673
106	790010.499	708519.466
107	789938.147	708497.815
108	789766.375	708217.157
109	789777.932	708221.052
110	789745.027	708221.737
111	789736.934	708199.029
112	789619.308	708216.352
113	789617.494	708259.377
114	789676.7415	707938.0543
115	789679.2323	707941.1462
116	789665.6095	707977.3251
117	789758.7835	707850.8987