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# Development of a GIS-Based Underground Utility Mapping System for Facilities Management at UTHM Pagoh Campus

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**Abstract**

Underground utilities such as water, electricity, drainage, and telecom cables are critical infrastructure for a campus. The current utility maps are outdated and scattered are found in many sources. The data on the UTHM Pagoh campus's infrastructure had been stored in CAD software and scanned images, which was a slow process. This study aimed to create a GIS-based underground utility map and database for UTHM Pagoh Campus and to demonstrate the application of the GIS-based system in supporting maintenance decision-making. This study focus on create a GIS mapping system for water pipelines, sewerage networks, and drainage to improve the management of utility information. The process of digitizing and georeferencing of the data on the existing underground utilities on campus was done using QGIS software. The results showed that the GIS successfully integrated multiple data on the utility on a single geographical platform. The study results confirm the usability of the GIS system as a decision-support tool for the detection of utilities prior to maintenance activities. The underground utility mapping GIS system has increased the level of facilities management efficiency at UTHM Pagoh campus.

## 1. Introduction

Underground utilities such as water pipes, power cables, and drainage systems are vital for modern infrastructure. However, managing these utilities is challenging because they are buried underground and often lack accurate location records. This issue is particularly evident at UTHM Pagoh, where information about the underground utilities is outdated and scattered across multiple departments [1]. Geographic Information System (GIS) technology offers a powerful solution to these challenges. GIS allows spatial data to be stored, visualized, and analyzed on maps, enable better planning and decision-making. In Malaysia, agencies such as the JUPEM and JKR have promoted the use of GIS for underground infrastructure [2][3].

Currently, UTHM uses a CMMS to handle maintenance requests and work orders. While this system supports maintenance operations, it does not include mapping or georeferencing features, limiting its effectiveness for managing underground utilities [1]. Additionally, utility records are often kept separately in different formats such as printed blueprints or AutoCAD files, which can cause confusion and inefficiency during construction or maintenance activities [4].

In UTHM Campus Pagoh, the current records of the underground utilities, including water, sewerage, and drainage, are stored in the form of PDF drawings, scanned documents, and CAD systems. These documents are spread throughout various departments, with the data not integrated onto a single platform that can provide easy access. The absence of reliable underground utility maps poses significant risks, as damaging utilities during construction can lead to safety hazards, service disruptions, and costly repairs.

Geographic Information System (GIS) technology provides a robust platform for storing, visualizing, and analysing spatial data, and has been widely adopted for infrastructure and asset management. In Malaysia, agencies such as the Department of Survey and Mapping Malaysia (JUPEM) and the Public Works Department (JKR) have promoted GIS-based approaches for underground utility management. However, at UTHM Pagoh Campus, the existing Computerized Maintenance Management System (CMMS) focuses primarily on work orders and asset records, without spatial mapping or georeferencing capabilities.

Therefore, this study aims to integrate existing underground utility data into a GIS-based system using QGIS software. The specific objectives are: (i) To propose a GIS-based underground utility mapping system for UTHM Pagoh Campus based on existing utility records, focusing on water pipelines, sewerage networks, and drainage systems; and (ii) to evaluate the efficiency of the proposed GIS-based system in supporting maintenance decision making.

## 2. Methodology

### 2.1 Flow Chart

The methodology was carried out in several stages, beginning with data collection, followed by data processing, GIS database development, analysis and system evaluation. The overall workflow of the study is presented in the form of a flow chart to illustrate the sequence of activities involved in developing the GIS-based underground utility mapping system.

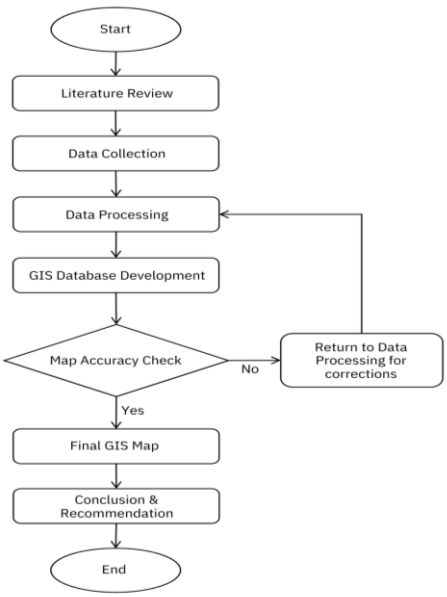


**Fig.1** *Flow Chart*

### 2.2 Data Collection

This study adopts a case study design focused on UTHM Pagoh Campus. The study uses qualitative and spatial data analysis approaches through GIS tools. The project is based on secondary data obtained from the university's facilities department, including PDF utility layout plan. Additionally, a short Google Form was distributed to technical staff to support the identification of data-related issues and gaps in current mapping practices. This helped validate the relevance of this study and supported the framing of the problem statement.

### 2.3 Data Processing

The digitization and georeferencing of the existing underground utility information on campus were carried out using QGIS software. The existing utility information on campus was transformed into spatial information to enable analysis. The procedure above ensured that the underground utility information on campus could be represented in an orderly manner as opposed to when it is represented in documents.

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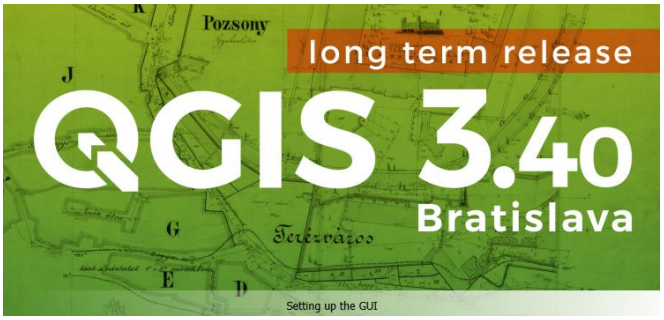


**Fig.2** *Software QGIS 3.40 Bratislava*

## 2.4 GIS Data Development

The GIS data development process included conceptual design and development of the QGIS database. The conceptual design of the GIS database was created by utilizing an Entity Relationship (ER) Diagram to show how the underground utility data and associated fields relate. The ER Diagram shows how various utility tables relate to each other in respect to water pipelines, sewerage systems, and drainage networks.

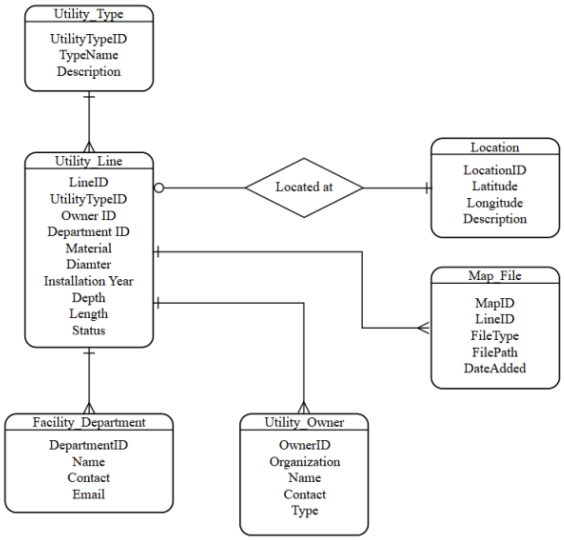


**Fig.3** *ER Diagram for utility GIS system*

QGIS database implementation happened after the data processing step. QGIS solution was used to create a database from the digitized, geographical data of the underground utility. Every type of underground utility was dealt with in a separate layer in the database for easier display, storage, and manipulation of data. Thus, the database enables the data of the underground utility to be easily represented, viewed, and handled from one geographic location.

## 3. Result and Discussion

### 3.1 Development of GIS-Based Underground Utility Database

The outcome of the project indicated the capability of the GIS platform to merge data of the underground utilities. The data for the underground utilities, which were previously stored using a CAD system and scanned documents, were integrated into a GIS system, which had attribute data. The attribute data increased the ability to manage data for the Underground utilities at UTHM Pagoh Campus compared to using a document system.

### 3.2 GIS Mapping Outputs

The GIS system developed maps for the underground utility for water pipelines, sewerage, and drainage networks. It was very convenient to identify where various underground utility networks are located on the campus using this system. The final integrated underground utility map was clear to view, with various underground utility networks depicted on the same map.

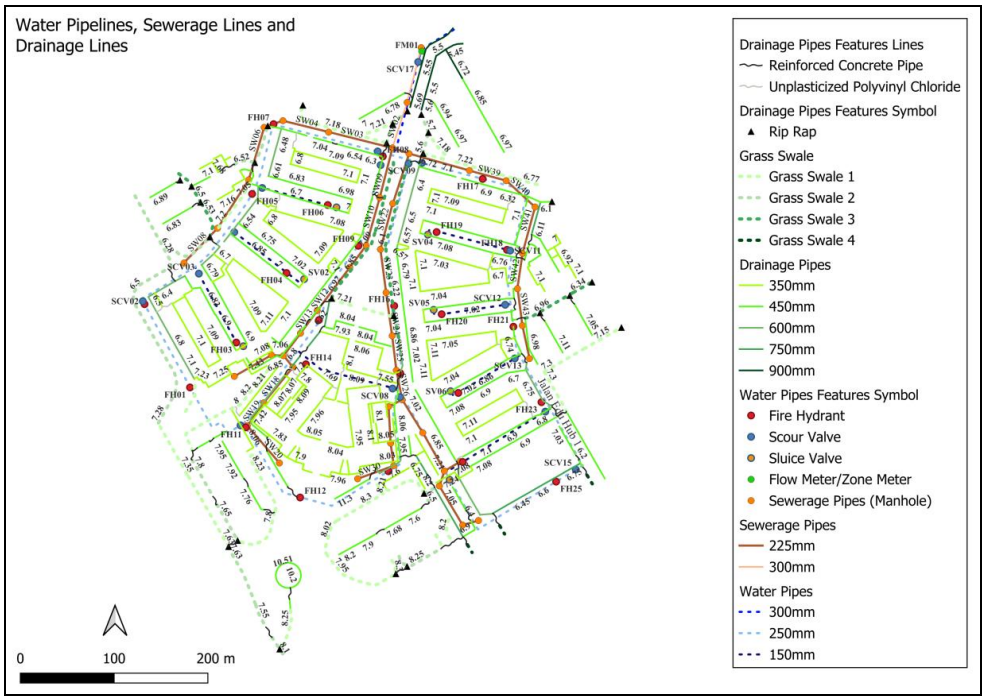


**Fig.4** *Final combined underground utility map*

## 3.3 GIS-Based System Analysis and Enquiry Functions

The GIS system developed facilitated the analysis of data structure and data enquiry. The system enabled the users to display and investigate the underground utility details interactively. The system provided functionality for the identification of underground utilities and promoted the efficiency of accessing information for the purposes of maintenance.

## 3.4 Spatial and Attribute Query Analysis

Informed by GIS technology, the GIS system facilitated spatial and attribute querying to enable the retrieval of information related to underground utilities. This application was fundamental for the prevention of damage to the underground utilities during excavation and construction activities. With spatial and attribute querying, users were able to determine the location, size, and intersection points of the underground utilities.

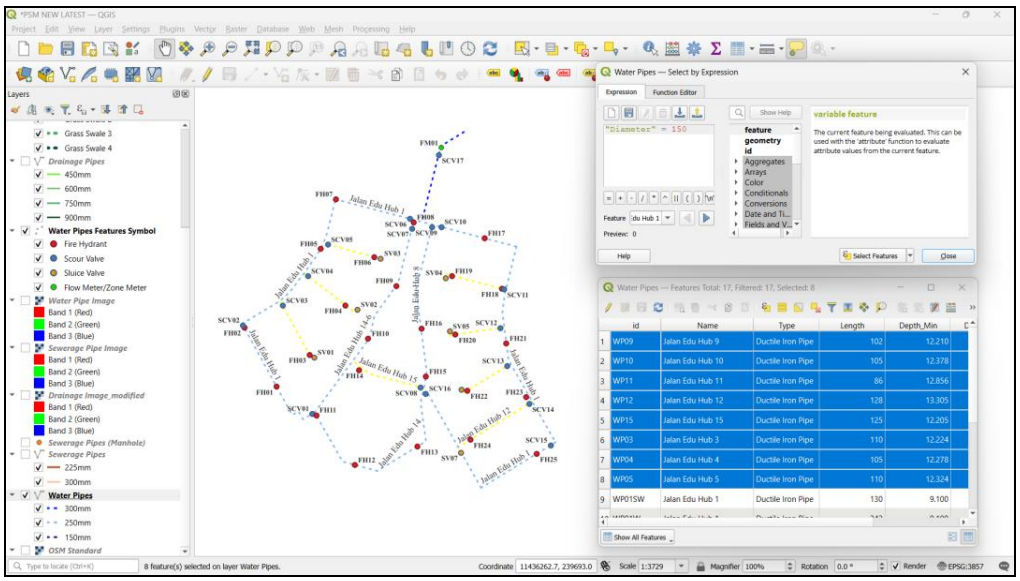

**Fig.5** *Attribute query result showing selected 150 mm water pipelines.*

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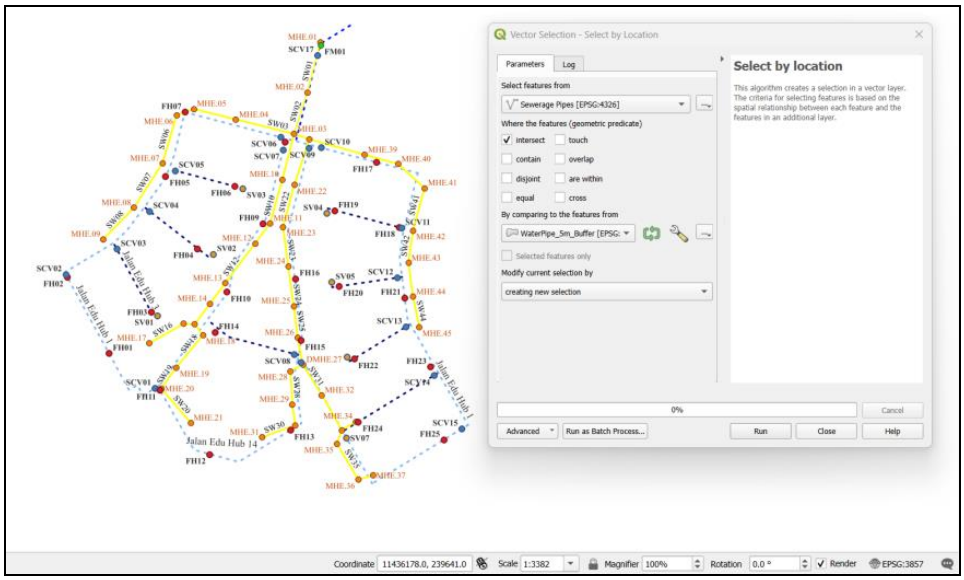


**Fig.6** *Spatial query result showing sewer lines intersecting the 5-meter buffer zone of water pipelines.*

## 3.5 Contribution of GIS System to Facilities Management

The underground utility mapping using a GIS-based system could help improve the level of efficiency of the facilities management at UTHM Pagoh Campus by representing information in a more visually appealing and accessible way than the document-based method. The system allowed maintenance planning and coordination and decreased damage to the underground utility during maintenance and excavation activities.

## 3.6 User Feedback and System Usefulness

In general, the respondents felt that the GIS system facilitated access and clarity of the information about underground utilities compared to the document-based method. The study findings validate the usability of the GIS system in support of decision making for the detection of underground utilities in advance of maintenance activities. In addition, it was found more useful and efficient than the current document-based method.

## 3.7 Discussion on System Usability

Overall, the GIS system is very useful as an aid to decision-making. All respondents indicated that colour-coding, symbols, and organizational structure of the layers made the map easy to read. Additionally, all respondents strongly agreed that the Identify Tool and querying functionality enabled them quickly to view information on utilities.

## 3.8 Limitation

In this study, there are some shortcomings, which include depending on secondary data that has not been validated through an advanced detection methods such as GPR. This was supported by the response that GPR should be use in future study to increase the accuracy of the data. In the GIS system, only water, sewerage, and drainage facilities are considered, and not any other, such as electrical and telecommunication cables.

## 3.9 Recommendation

Even though the GIS system developed within the parameters of this project has proven to be efficient and useful for maintenance planning, further improvements can still be made to enhance the overall usability and functionality of the system. According to feedback and observation of the project, several recommendations are proposed.

It is also recommended that future studies implement the use of GPR scanning. Because this project relies on pre-existing drawings, using GPR would be more effective at the detection of underground utilities and allow for better verification of utility locations.

Secondly, more underground utility categories should be included, such as electrical cables, telecommunication lines, and other service utilities. Inclusion of more utility types would give a more complete underground utility database and maintenance personnel might rely on one platform while planning various site works.

Finally, a three-dimensional underground utility visualization system is strongly recommended. The utilization of 3D GIS would allow users to perceive utility depth and vertical relationships more clearly compared with a two-dimensional map. This approach will improve comprehension and facilitate the making of more appropriate decisions in excavation and maintenance operations involving intricate arrangements of underground utilities.

## 4. Conclusion

A GIS-based underground utility map and database has been successfully created for UTHM Pagoh Campus based on the available data. The GIS system is capable of merging the data of the underground utilities, which are now in CAD files and scanned documents, and bringing it together in a geographical platform. The data of the underground utilities is now more accessible and clearer compared to the previous method of documents.

The GIS system proved its usefulness in terms of its use in making decisions regarding maintenance functions via visualization and attribute queries. Its capability in determining the location, length, and interaction of underground utility helped in avoiding damage to the structure while performing excavations. Moreover, the system was found more useful and efficient compared with the current document system in use, hence improving efficiency in facilities management in UTHM Pagoh Campus. Regular updating of the system as well as improvement in the coverage of the underground utilities are also suggested. An extension covering other types of utilities is also suggested.

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## Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

## Author Contribution

This journal requires that all authors take public responsibility for the content of the work submitted for review. The contributions of all authors must be described in the following manner:

*The authors confirm contribution to the paper as follows:* ***study conception and design:*** *Mazarina Sabirah Mohd Shukri, Abd Sukor Sarif;* ***data collection:*** *Mazarina Sabirah Mohd Shukri;* ***analysis and interpretation of results:*** *Mazarina Sabirah Mohd Shukri, Abd Sukor Sarif;* ***draft manuscript preparation:*** *Mazarina Sabirah Mohd Shukri, Abd Sukor Sarif. All authors reviewed the results and approved the final version of the manuscript.*

An author name can appear multiple times, and each author name must appear at least once. For single authors, use the following wording:

*The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.*

## References

[1] UTHM Pagoh. (2020). Computerized Maintenance Management System UTHM PAGOH - User Manual. [Online] Available: https://aduan.uthm.edu.my/UTHMPagoh2020.pdf

[2] Public Works Department Malaysia. (2018). Utility Mapping Guidelines for Infrastructure Projects. Jabatan Kerja Raya Malaysia

[3] JUPEM. (2021). Geospatial Services Overview. Department of Survey and Mapping Malaysia. Retrieved from https://www.jupem.gov.my

[4] Sime Darby Property South. (2019). The Efficiency Implementation of Computerized Maintenance Management System (CMMS) at UTHM Pagoh. In Book Chapter FM 2019, 1st Edition