Mapping and Monitoring Universiti Teknologi Petronas (UTP) Drainage system using Geographic Information System (GIS)

By

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CERTIFICATION OF APPROVAL

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Approved by,

(A.P. Dr. Abd. Nasir Matori)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

July 2007

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MUHAMMAD FIRDAUS BIN YAHAYA

ABSTRACT

This project is about mapping and monitoring Universiti Teknologi Petronas (UTP) Drainage system using Geographic Information System (GIS). The purposes of this project are to develop appropriate database of spatial and attribute data that contribute to drainage system in UTP and also to perform spatial analysis in order to establish monitoring system to drainage system in UTP. The report includes the theory, software and hardware used in order to execute the project. This project use GIS software which is MapInfo Professional 7.0. Basic of MapInfo software is consist of three components; mapping, creation of database and analysis. For the drainage system database, it will display information of spatial and attribute data such as names, types, dimension and pictures. The analysis section consists of drainage flood analysis that shows the affected area cause by overflow of water during precipitation.

ACKNOWLEDGMENT

Above all, the utmost gratitude goes to the Most Gracious and Most Merciful God for giving the guidance and blessings throughout my project.

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ABBREVIATIONS AND NOMENCLATURES

UTP	Universiti Teknologi PETRONAS
GIS	Geographic Information System
FYP	Final Year Project
DEM	Digital Elevation Model
TIN	Triangulated Irregular Network
PVC	Polyvinyl chloride
OLE	Object Linking and Embedding

CHAPTER 1
INTRODUCTION

3.1 Background of Study

Geographic Information System (GIS) is a collection of computer hardware, software, and geographic data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. With this system, information or attributes can be linked to location data, such as people to addresses, buildings to parcels, or streets within a network. It gives a better understanding of information before any analysis is done. GIS also allow us to see relationships, patterns, or trends intuitively that are not possible to see with traditional charts, graphs, and spreadsheets. In recent research, GIS has made the geographical mapping and consolidation of information more easily and efficient. Besides, it has the ability to analyze complex data and do fast recall of data when needed.

Drainage is a natural or artificial removal of surface and sub-surface water from a given area. Many municipal areas have drainage to improve production and manage inflow and outflow of water. A drainage system is an integrated system of tributaries and a trunk stream, which collect runoff and surface water from the land and funnel to the larger stream, sea, lake, or some other body of water. They are governed by the topography of the land, whether a particular region is dominated by hard or soft rocks, and the gradient of the land. Drainage systems fall into one of several categories, depending on the topography and geology of the land such as dendritic drainage system, parallel drainage system, trellis or rectangular drainage system, radial drainage system and deranged drainage system.

The purposes of this project are to develop appropriate database of spatial and attribute data that contribute to drainage system in UTP and also to perform spatial analysis in order to establish monitoring system to drainage system in UTP.

3.2 Problem Statement

It was not until the GIS maps and databases were completed that the UTP Maintenance Department had a clear idea of drainage situation in the study area. The authors believe that without the GIS capability, the situation may have never been properly understood.

The GIS allowed us to consolidate information and to clearly understand possible destinations of drainage water. In addition, it provided a means of organizing the tremendous amount of information regarding drainage water qualities and quantities which have been obtained by various agencies. The various pieces of the drainage puzzle which had been analyzed by maintenance department could now be properly placed into the big picture.

The GIS also has capabilities of modeling interactions with drainage flow rates and qualities. It's required such an analysis to gather information and utilized it on the mapping system of the GIS. The GIS can also allow us to understand and analyze the various Drainage Operation Plans which the maintenance individual districts have adopted in concept.

3.3 Objective and Scope of Study

3.3.1 Objective

- To develop appropriate database of spatial and attribute data that contribute to drainage system in UTP.
- To perform spatial analysis in order to establish monitoring system to drainage system in UTP.

3.3.2 Scope of Study

The study on drainage mapping and monitoring system is to be completed within the time frame given which is approximately 13 weeks. In order to achieve that goal, the author has to do some research, work planning, and interview. Resources regarding the drawings, maps and drainage system are available at Property Management and Maintenance Department at Universiti Teknologi Petronas, Perak.

The GIS software that was used in this study is MapInfo Professional. It was used to configure the mapping process of UTP drainage system. The program will provide efficient tools to do mapping, compilation of data and display of information of the research.

CHAPTER 2
LITERATURE REVIEW

2.1 Geographical Information System (GIS)

Geographic Information System (GIS) is a collection of computer hardware, software, and geographic data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. With this system, information or attributes can be linked to location data, such as people to addresses, buildings to parcels, or streets within a network. It gives a better understanding of information before any analysis is done. GIS also allow us to see relationships, patterns, or trends intuitively that are not possible to see with traditional charts, graphs, and spreadsheets. In recent research, GIS has made the geographical mapping and consolidation of information more easily and efficient. Besides, it has the ability to analyze complex data and do fast recall of data when needed.

Most computer technology is designed to increase a decision-maker's access to relevant data. GIS goes beyond mining data to give us the tools to interpret that data, allows to see relationships, patterns, or trends intuitively that are not possible to see with traditional charts, graphs, and spreadsheets.

More than that, a GIS lets us model scenarios to test various hypotheses and see outcomes visually to find the outcome that meets the needs of all the stakeholders. For example, a retail manager looking to build a new store can analyze consumer demographics and the locations of competitors in relation to potential locations in a spreadsheet view. GIS lets that manager visualize potential locations on a map along with drive-time analysis, environmental concerns such as wetlands or protected species that might hamper construction, or any number of siting criteria that would be too cumbersome to comprehend otherwise.

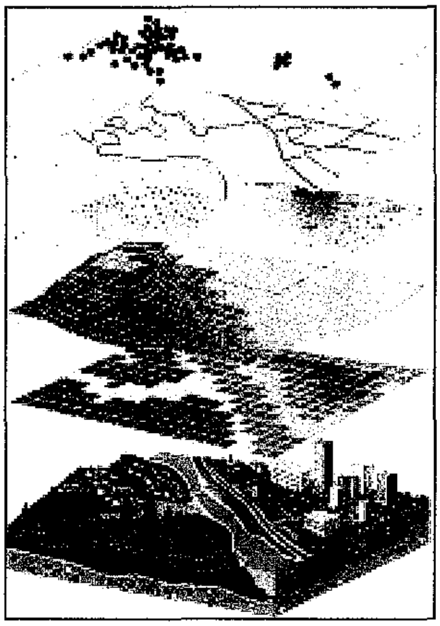


Figure 1: Layers of digitized maps using GIS software

The application if GIS is unlimited. It has been used to solve problems as diverse as where to place self-service coin counting machines, how to improve the yield of crops in a traditional Tuscan vineyard, or how to manage an entire city enterprise. GIS can provide us with powerful information - not just how things are, but how they will be in the future based on the applied changes. GIS is, therefore, about modeling and mapping the world for better decision making. GIS tools range from simple contact mapping tools to consumer analysis to complex enterprise systems that are part of an organization's overall enterprise resource planning infrastructure. If used wisely, it can be a transformational tool for any organization.

2.2 Drainage System

There are three main sources of water that go through in the drainage path: rain falling directly onto and running down the path surface, surface water from surrounding land flowing directly into the channel and underground water running into the channel surface, in the form of springs or seepage.

The main purposes of the drainage system included:

- For artificially removing excess water from the surface or the subsurface of the soil.
- Collect runoff and surface water from the land and funnel to the larger stream, sea, lake, or some other body of water
- Reducing the length of time soils remain waterlogged by the installation of appropriate drainage systems.
- Prevent flooding to the area that has high possibility of heavy rain for long time.
- For agriculture, farm drainage is also an important way of improving the working conditions on the land for the farmer and his employees by removing the unpleasantness of muddy, wet condition. Improving drainage reduces the risk in many enterprises.
- To dissipate the high energy of the flow of rain water and also reducing the damage to structure around the drains.

Drainage problems can arise when both surface water and foul sewage are allowed to share the same sewer. This situation can cause flooding during periods of high rainfall. Increased surface water run-off also can leads to flooding problems. Problem also arises when there are no nearby public sewers and alternative arrangements to be made for disposal of foul and surface water sewage. No maintenance arrangements for the drainage system before the development and usage of water channel is occupied are also sources of the problem.

When constructing the map for drainage system, first thing to know is the types and methods of drainage in UTP. All information about the drainage type will be put in the data acquisition part in the GIS map.

Drainage is carried out either on the surface or underground depending on the diagnosis of the problem. Diagnosing the drainage problem is the key to achieving success with any drainage solution. Correct diagnosis will provide information on the source of water and where it is moving. This will ensure correct selection of drain type that was installed and the appropriate depth of drains.

The drainage can be dividing to two categories, surface drainage and underground drainage. Surface drainage can take the form of open arterial drains, grassed waterways, reverse bank interceptor drains and hump and hollow drainage. Underground drainage can take the form of pipe drains, mole drains and deep ripping or subsoiling.

Open arterial drains are the first component of drainage system to be installed. This is because they are the means by which water is removed from paddocks whether the ditch is collecting water from a pipe drainage system, acting directly as a land drain to lower the water table, or intercepting surface or groundwater flow. Grassed waterways promote surface water removal along natural drainage lines and should be used as drainage lines which link up hollows and depressions, particularly on undulating paddocks of duplex soils in the Midlands. Grassed waterways are usually 2.5m wide, of minimum depth (100-200mm) and should run along the natural water pathway.

If they are on a side slope, they will need to be deeper and more carefully constructed. Ensure that the base is level and that spoil does not create a levee along the sides of the waterway which should be spread out across the paddock.

Reverse bank interceptor drains intercepts surface run-off as well as subsurface seepage. The spoil from the drain is taken upslope to collect surface run-off in a contour style bank which is surveyed at 0.6 to 1.0 per cent to lead water off to a safely grassed waterway. By intercepting surface flow, upslope batter erosion and channel silting are prevented which can be critical for drain stability in unstable or dispersive soils such as many of the duplex soils of the Midlands.

Hump and hollow drainage is where major land surface reshaping creates parallel ridges with even side slope to shallow drains. This form of surface drainage is appropriate when water either perches on the soil surface or winter water tables are at or near the surface and subsoil drainage is limited by restricted outfall. There is a need to either shed water off the surface by creating a slope on the ground, or elevating the soil above the water table. Hump and hollow drainage is most appropriate in swamp areas with large flat areas having a regionally high water table. It is also used on sandy soils with surface water perching. Sandy soils cannot normally be subsurface drained because the pipes become blocked with inflowing sand.

Pipe drains are the underground pipe drains can be installed to intercept groundwater flow or to lower the watertable over a wider area. Drains can be laid using clay pipes or PVC plastic pipe and French drains. The different pipe types have advantages and disadvantages for ease of handling, performance and cost.

Mole drains are unlined cylindrical channels which function like clay or plastic pipes and are formed using an implement called a mole plough. The mole plough consists of a cylindrical foot attached to a narrow leg. Connected to the back of the foot is a slightly larger diameter cylindrical expander. The foot and expander form the drainage channel as the implement is drawn through the soil and the leg leaves a slot and associated fissures.

The fissures extend from the surface and laterally out into the soil. Any surplus water above moling depth can therefore move rapidly through these fissures into the mole channel.

Deep ripping generally will improve drainage only if the operation allows water to move down through a compacted layer into a soil zone of relatively high conductivity or for disturbed soil so that water can move laterally more rapidly towards an existing underground pipe system. A deep ripper should be designed to lift and shatter the soil as it passes. For optimum results the tine is fitted with wings set at an angle to the horizontal so that a wide band of soil is lifted. A narrow tine will only form a narrow groove with minimal lateral effect.

The properties of open channel in UTP drainage system can be divided into two parts which are artificial channels and natural channels. Artificial channels are channels made by man. They include irrigation canals, navigation canals, spillways, sewers, culverts and drainage ditches. They are usually constructed in a regular cross-section shape throughout and are thus prismatic channels which not widen or get narrower along the channel. In the field they are commonly constructed of concrete, steel or earth and have the surface roughness reasonably well defined, although this may change with age; particularly grass lined channels. Analysis of flow in such well defined channels will give reasonably accurate results.

Natural channels can be very different. They are neither regular nor prismatic and their materials of construction can vary widely although they are mainly of earth this can possess many different properties. The surface roughness will often change with time distance and even elevation. Consequently it becomes more difficult to accurately analyze and obtain satisfactory results for natural channels than is does for man made ones. The situation may be further complicated if the boundary is not fixed such as erosion and deposition of sediments.

The water properties also need to be review and the information regarding on it can be present in the map. Water plays important roles in drainage system. Water is continually on the move, some fast, some slowly, and this movement is mostly cyclic. Water moves rapidly as precipitation in the atmosphere such as rain, hail and snow or as flowing streams across the ground surface. It moves more slowly beneath the ground surface as ground water gradually flowing to streams and oceans or percolating through permeable soils towards the underlying water table. The fate of precipitation falling on the land surface is varied. Some will be evaporated while falling and some will be intercepted by vegetation or buildings and evaporated back into the atmosphere.

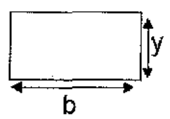
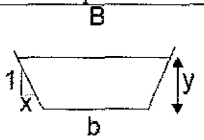
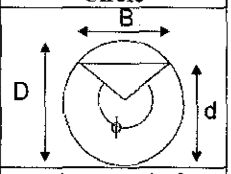
Precipitation which reaches the ground may follow through out the four courses which are pooling on the surface, surface run-off, evaporation and infiltration. It may remain on the surface as pools, puddles or surface soil moisture which is directly evaporated. It may flow over the land surface into depressions and channels to become surface runoff in the form of streams which either recharge ground water via seepage or flow to lakes and the ocean. It may infiltrate through the ground surface to join existing free soil water.

If the soil water is below the root zone it will not cause drainage problems. If however, it rises into the root zone then it can cause water logging. If it cannot infiltrate and remains on the soil surface or becomes perched above a shallow impermeable layer, water logging may also occur. Soil water may move upwards to the atmosphere by evaporation or via plants as transpiration. It may percolate downwards to the underlying ground water where it may be held for weeks, months or even longer.

Ground water can supply water to overlying soils and vegetation by capillary rise or it can flow into streams and the ocean by seepage. Three out of the four courses of water movement (pooling on the surface, surface run-off, and infiltration) can result in a problem to agriculture which requires a land drainage solution. However, it must be remembered that solving one problem on a particular site may only relocate the problem, or when dealing with water, concentrate it so that different problems of greater magnitude can arise in other locations.

The geometric properties of the channel in UTP should be known. In analysis section, various geometric properties of the channel cross section are required such as depth, area of the cross sectional flow, wetted perimeter, surface width, hydraulic mean depth and hydraulic radius.

Table 1: Table of equations for rectangle, trapezoid and circle channels

	Rectangle	Trapezoid	Circle
			
Area, A	by	$(b+xy)y$	$\frac{1}{8}(\phi-\sin\phi)D^2$
Wetted perimeter P	$b+2y$	$b+2y\sqrt{1+x^2}$	$\frac{1}{2}\phi D$
Top width B	b	$b+2xy$	$(\sin\phi/2)D$
Hydraulic radius R	$by/(b+2y)$	$\frac{(b+xy)y}{b+2y\sqrt{1+x^2}}$	$\frac{1}{4}\left(1-\frac{\sin\phi}{\phi}\right)D$
Hydraulic mean depth D_m	y	$\frac{(b+xy)y}{b+2xy}$	$\frac{1}{8}\left(\frac{\phi-\sin\phi}{\sin(1/2\phi)}\right)D$

2.3 GIS Application in Drainage System

2.3.1 GIS in Flood Hazard Mapping

The available geographic information system (GIS) data can be used to construct a set of GIS data, a flood hazard map, and land development priority map to help the responsible authorities develop, design, and operate flood control infrastructure and prepared aid and relief operations for high-risk areas during future floods. The GIS plays a major role in flood control technique, and the integration of this data in a spatial database is crucial, especially for a development country.

The role of GIS as a tool to enable the visualization and analysis for flood hazard assessment, and the development of a map for land development on priority basis, is obviously important. Consequently, a unique use of GIS to delineate flood prone areas, and shows how to determine the relative sensitivity of the individual pixel of flood prone areas within a place. This enhances the capability to utilize GIS for water resources planning and management, and may help implement or act as the basis for a hydrological decision support system to ascertain critical locations. This technique can be used from a local or regional scale to a global scale.

2.3.2 Determine of drainage flow direction using digital elevation models

Automated delineation of drainage areas is carried out using a model of the land-surface terrain. This application model can be a raster digital elevation model (DEM) or a triangulated irregular network (TIN).

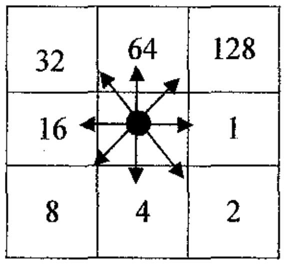


Figure 2: Flow directions in eight-direction pour point model

In a DEM grid structure, there exist at most eight cells adjacent to each individual grid cell. Accordingly, water in a given cell can flow to one or more of its eight adjacent cells according to the slopes of the drainage paths. This concept is called the eight-direction pour point model.

2.3.3 GIS in drainage hydrologic modeling

GIS can be used in various ways to support hydraulic modeling. GIS can:

i) Manage data – GIS performs basic geospatial data-management tasks (data storage, manipulation, preparation, and extraction) and spatial data processing (overlays and buffering).

ii) Extract parameters – GIS provides characteristic properties of watersheds and channel reaches for hydrologic modeling.

iii) Provide visualization – GIS displays data, either before the hydrologic analysis is performed to verify the basic information, or after the analysis to evaluate the results. For example, floodplain mapping in GIS shows the extent of areas damaged by floods.

iv) Model surfaces – GIS delineates and represents channel shapes based on digital terrain or elevation models.

v) Develop interfaces – Map-based interfaces to hydrologic models can be developed using GIS tools.

2.3.4 GIS as Information Sources

The GIS provides a simple, compact data structure for storing the most important geospatial data describing a drainage system. The information organized in several levels:

i) Geodatabase – if a personal geodatabase is being used.
ii) Feature data set – classes within geodatabase which are map projection, coordinate system, and spatial extent.
iii) Geometric network – information where topologically connects hydro edges and hydro junctions is stored.
iv) Feature class – this is where information on individual geographic features is stored, such as watershed or channel segment information.
v) Relationship – this is where features from one class are related to those in another such as watershed, water body, and monitoring point is related to a hydro junction on the network.

GIS has become one of the important tools to control and manage problems associated with drainage system. The system can provide a great deal of problem-solving capabilities such as linking spatial data with the ordinary mapping tools etc. It enables researchers to locate system at risk, identify area in need of resources and make decisions on resource allocation. Correlation between drainage system problem in UTP and its causes can be linked and investigated by the use of GIS. The trend of drainage problem then can be recognized and prevented if possible.

CHAPTER 3
METHODOLOGY

There are some procedures that were develop in order to carry out this project. This is to ensure that the project flow is smooth and accomplish in the given period. The procedures that need to be done were data gathering, research and develop GIS application.

3.1 Data

All the geospatial data and attribute data to have been gathered to develop the database. This information is retrieve from the related party. The data include the types of the drainage, channel depth, area, stage, level, length, size of drains, wetted perimeter, surface width and hydraulics radius. The requirement of an understanding of the occurrence and processes of water movement in the environment is also needed.

The research involve in this study scope are the research on procedure for the drainage, water flow, length and slope. Risks of avoiding maintenance of the drains also need to be find such as clogging and flooding. The author also introduces some improved methods of surface water design to give a reduced environmental impact from surface water drainage.

3.2 Tools

3.2.1 Hardware

Minimum specifications of computer facilities need to be prepared by author in order to run the software, preparing reports and accessing data

3.2.2 Relevant Software

MapInfo Professional 7.0

- **MapInfo** has the capability to turn data from word processors and spreadsheets into 'mini-MapInfo' program. A map can be created and edited for presentation or reporting purposes.

- **Object Linking and Embedding (OLE)** is a process of server application (such as MapInfo) provides information that is stored in a client application that can accept OLE information (such as a word processor). Any kind of map can be embedded in any application that accepts OLE objects.

- **MapInfo Map** provides a variety of map display, viewing and editing capabilities. More of its capabilities including;
  a) opening multiple tables at once
  b) controlling individual layer properties like display and labeling
  c) creating and modifying thematic maps
  d) manipulating the Map window view
  e) finding information associated with a map layer

3.3 Database Development

3.3.1 Spatial Data

For starting, the creation of drainage map using MapInfo software has been done. The first step is registration of raster image. This raster image registration is involving the scanned map of UTP from the plan view. Using this original map image, all layers of drainage system including road, building and other parameters can be digitizing.

All layers of road, building, watersheds, contours, landuse and drainage system that have been digitized are bind together into one layer. This is to visualize the drainage path more clearly and analysis can be done with referring to the map.

Besides, the legend has been added to the map to show the denotation of every layer. All colors of the denotations are the same with the digitized map to make observation more delectable.

Below are the steps of creating the raster image registration, map layers and legend for all layers:

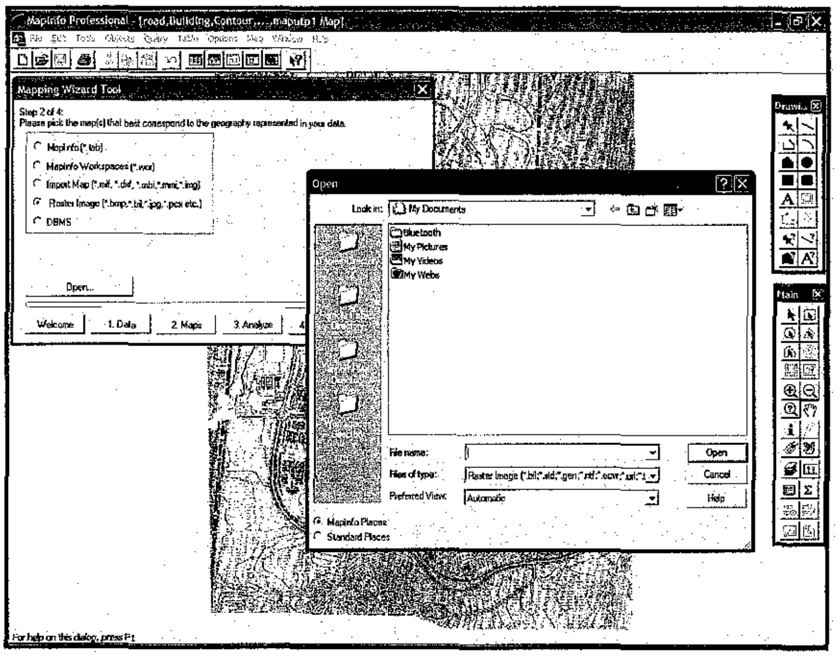


Figure 3: Raster image registration

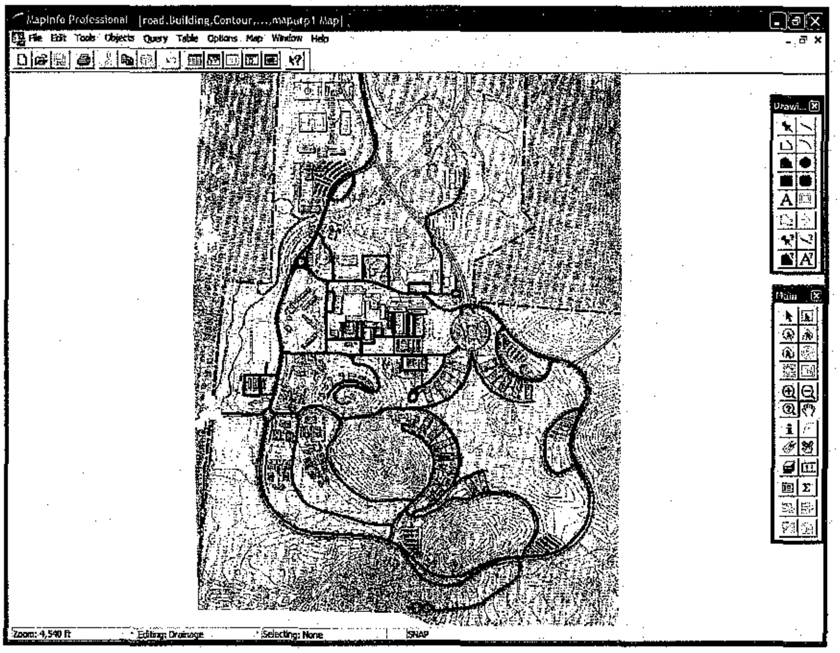


Figure 4: Digitizing the map and adding layer for road

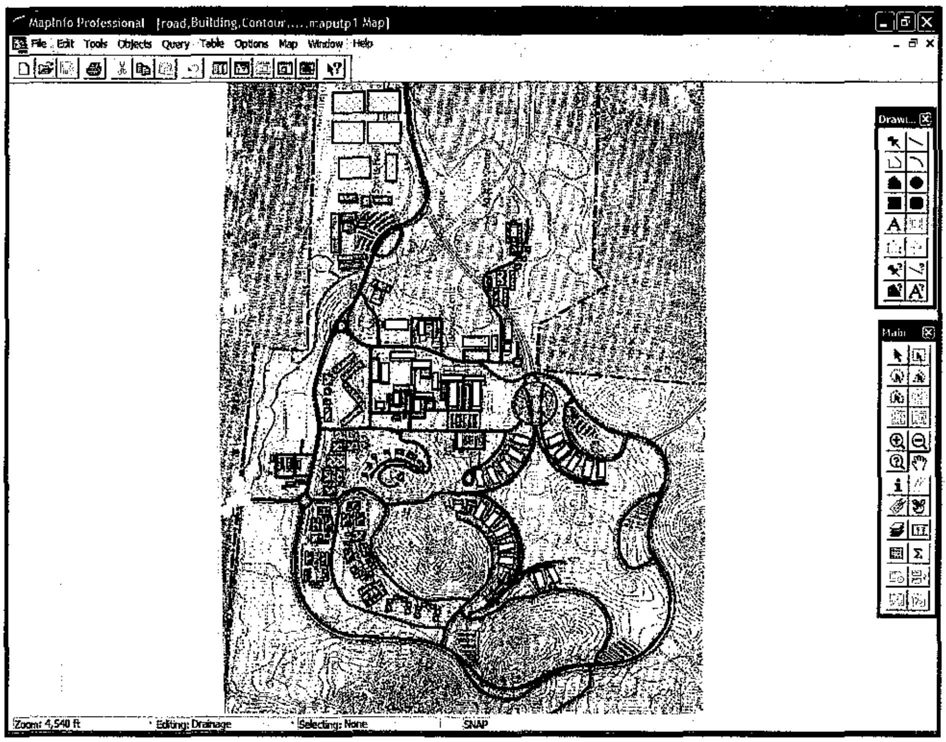


Figure 5: Layer for building

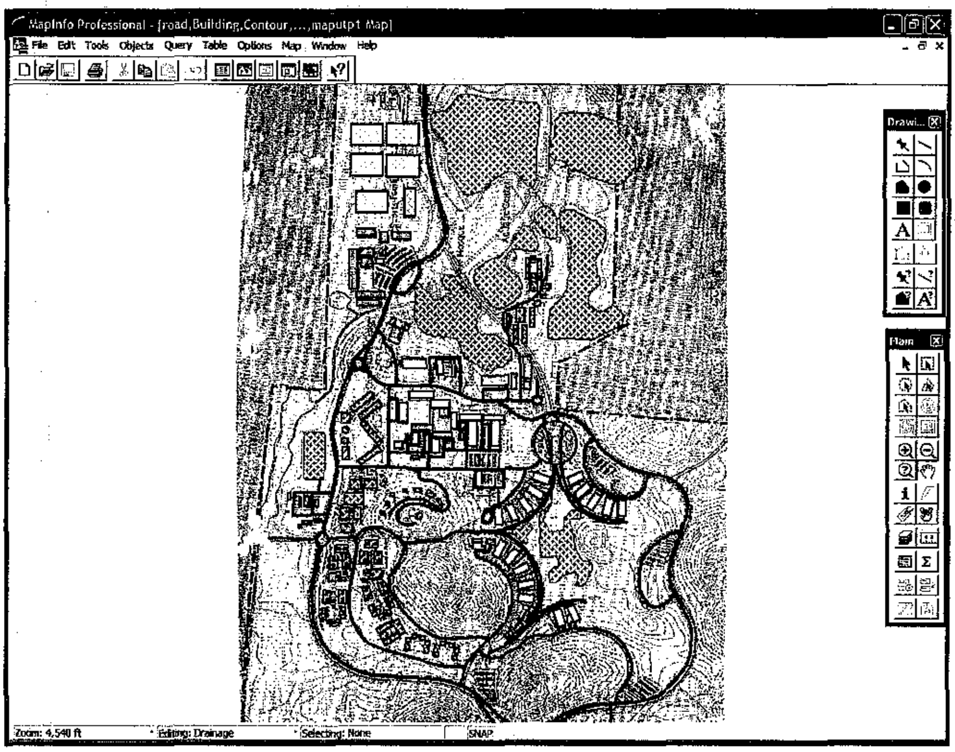


Figure 6: Layer for water shade

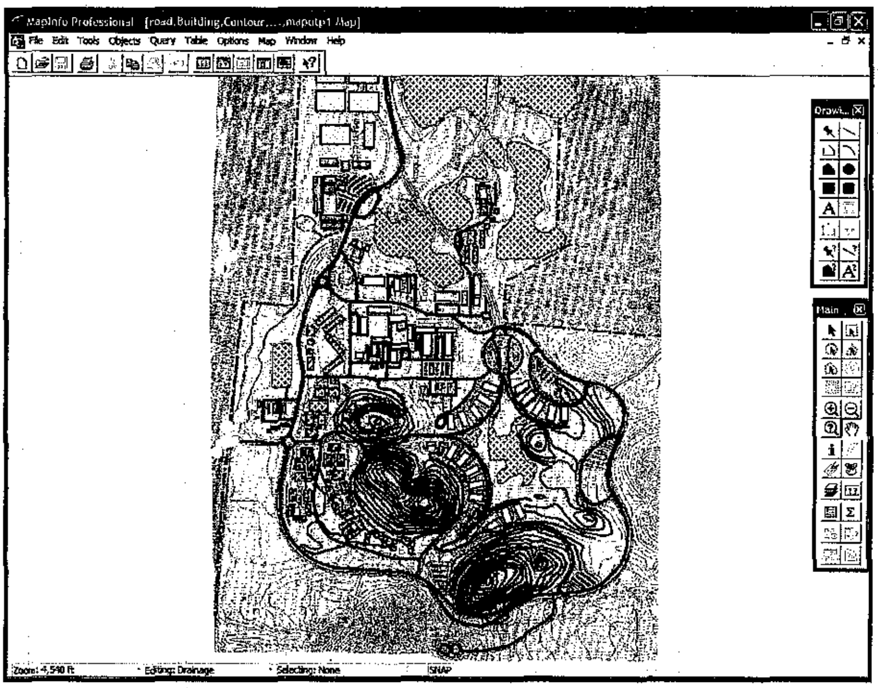


Figure 7: Layer for contour

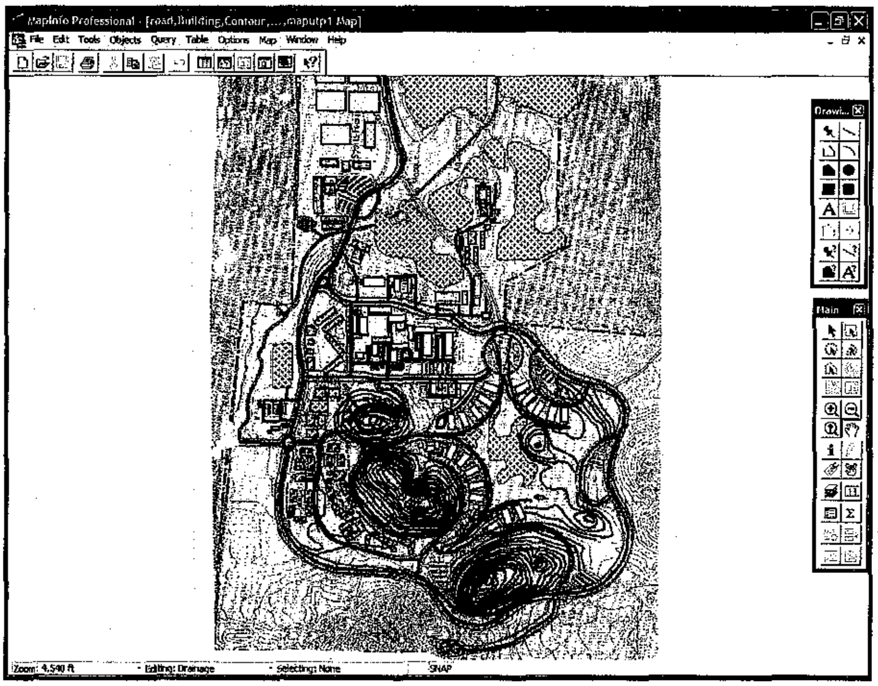


Figure 8: Layer for drainage system

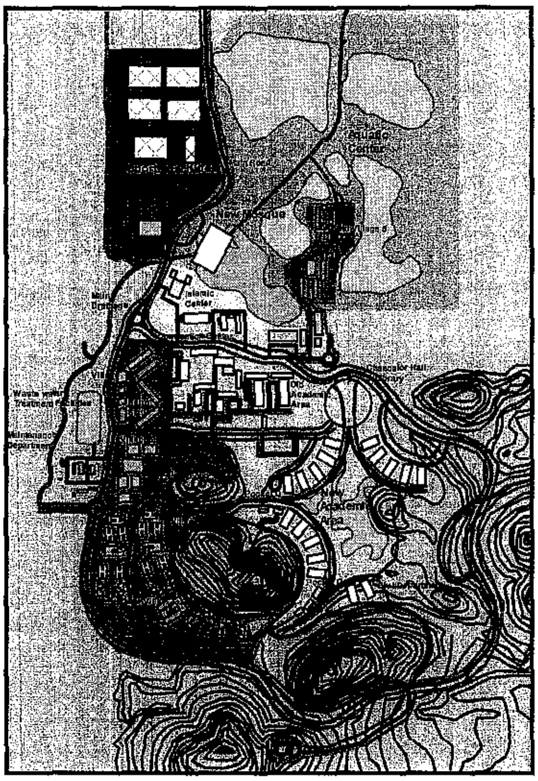


Figure 9: Layer of landuse with different colors

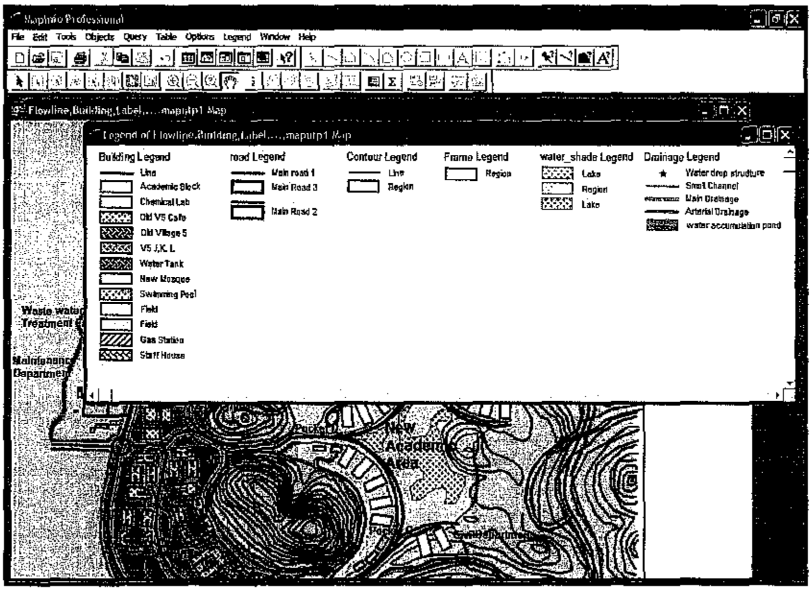


Figure 10: All layers loaded with legend

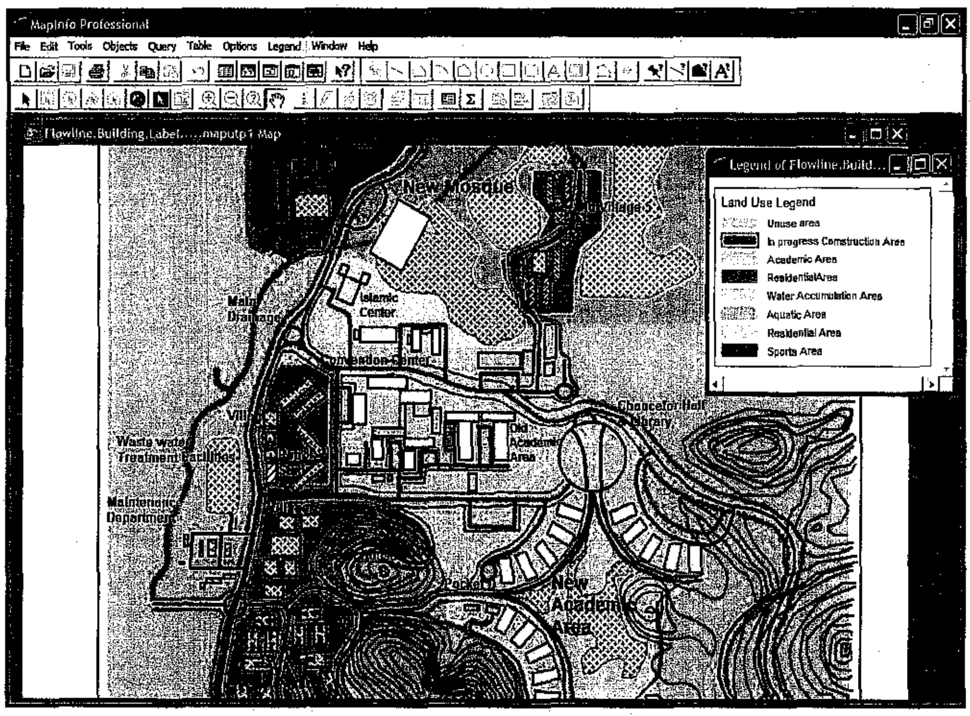


Figure 11: All layers loaded with landuse legend

Pictures of the building and drainage structure can be acquired by clicking the hotlink cursor to any icon, area and line on the map. This function can be done by modify the table structure and add new field of picture.

At the new picture field, the URL of picture sources must be added. When the hotlink cursor has been select to the any building and drainage icon, the window of pictures will be displayed to the screen.

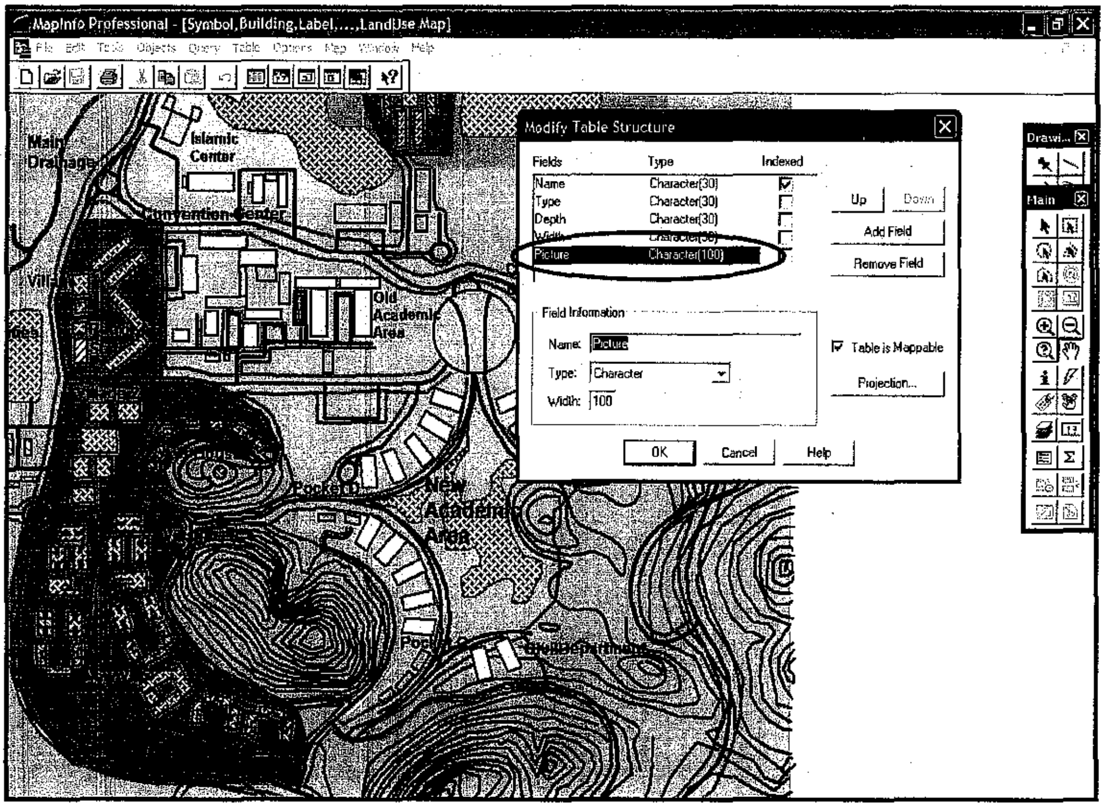


Figure 12: Process of adding new field for picture acquisition

3.3.2 Attribute Data

The construction of data base for the drainage map using MapInfo software was started by modifying the table structure (See Figure 5).

All the data gathered was arranged properly and transformed into the layer of GIS software. The data was arranged layer by layer for easy access and make analysis. All data and information to the layers of road, building, watersheds, contours, and drainage system can be included by using the info tool. This is to make data acquisition and analysis easier just by clicking to the specific structure on the map.

In the new table, the criteria of the drainage information must be created such as name, type, depth, length and width of the channel structure (Figure 6 & 7).

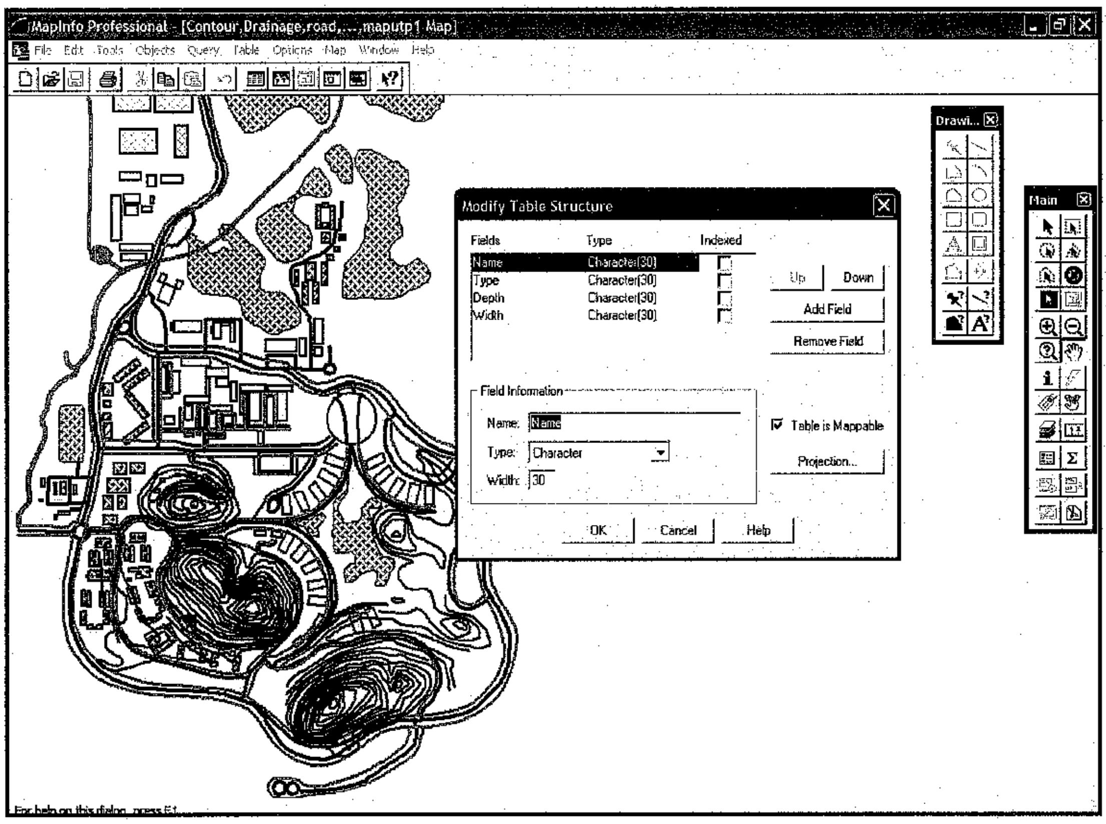


Figure 13: Modify table structure for creating data

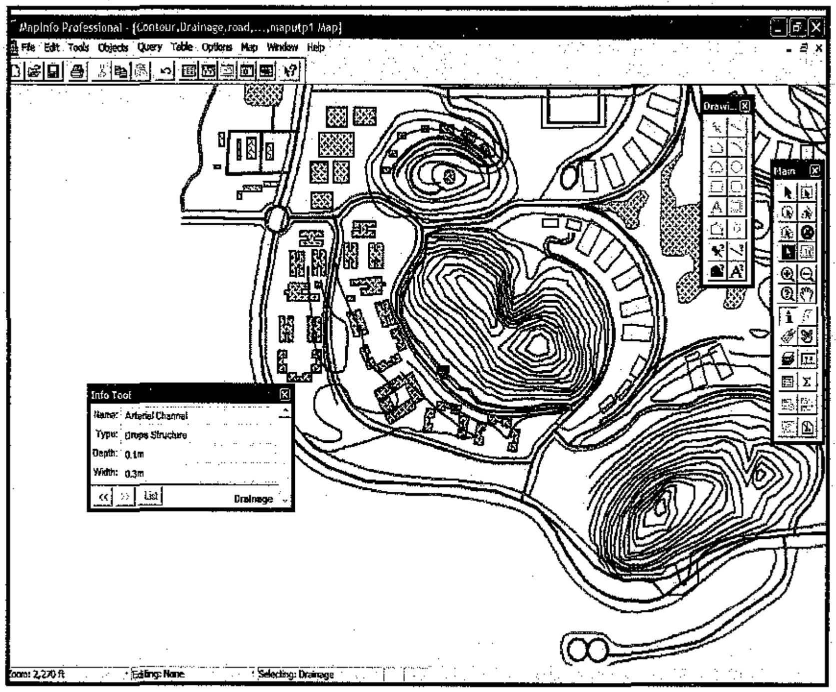


Figure 14: Process of data input to the drops structure for open channel

CHAPTER 4

RESULTS

4.1 Drainage Information System

This is the result of mapping the UTP drainage system using MapInfo software. The map includes several features such as roads, buildings, contour, watershed, label, and legend.

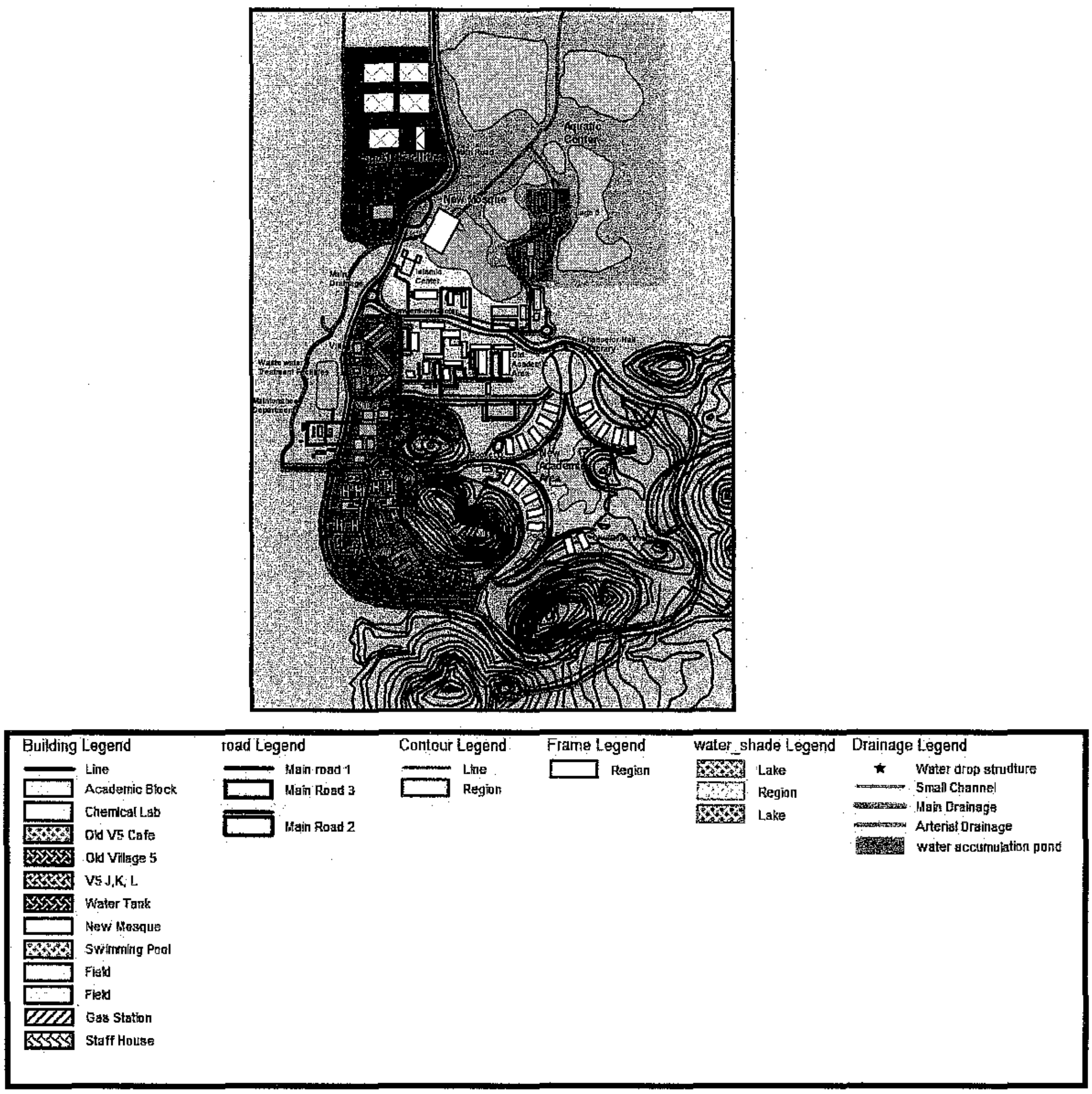


Figure 15: Digitized map of drainage system in UTP and legend

All data about the drainage structure such as type, width, depth and length can be acquired by clicking the info cursor to any drainage icon, area and line on the map. This function was done by modifying the table structure and add new field of categories.

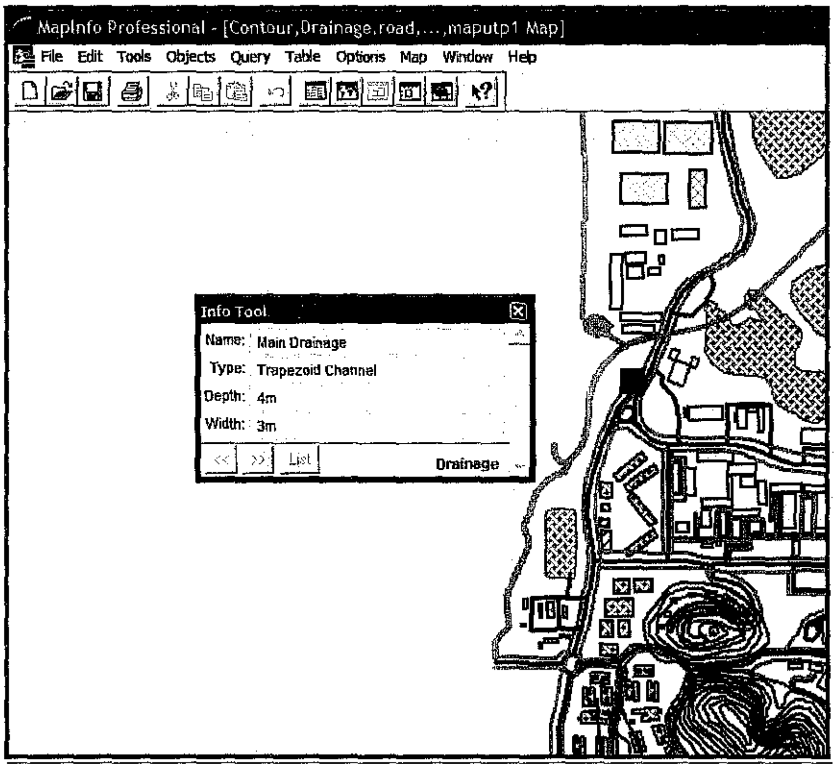


Figure 16: Data acquisition of trapezoidal channel in main drainage

Pictures of the building and drainage structure can be acquired by clicking the hotlink cursor to any icon, area and line on the map. This function was done by modify the table structure and add new field of picture.

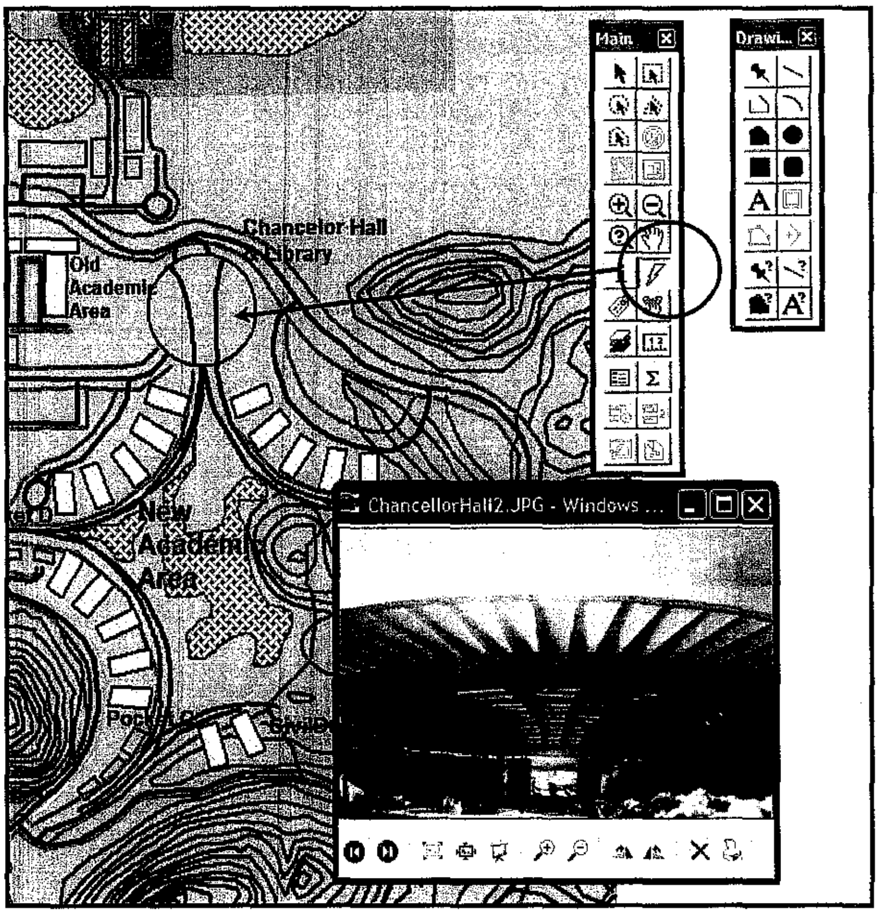


Figure 17: Picture window displayed when Hotlink cursor applied

These are the pictures of different channels and their location regarding on the UTP drainage system. There are several types of channels that were built in UTP. The types of channels are rectangle, trapezoid and circle channels. The depth and width of these channels are differ from each other depend on the types and location.

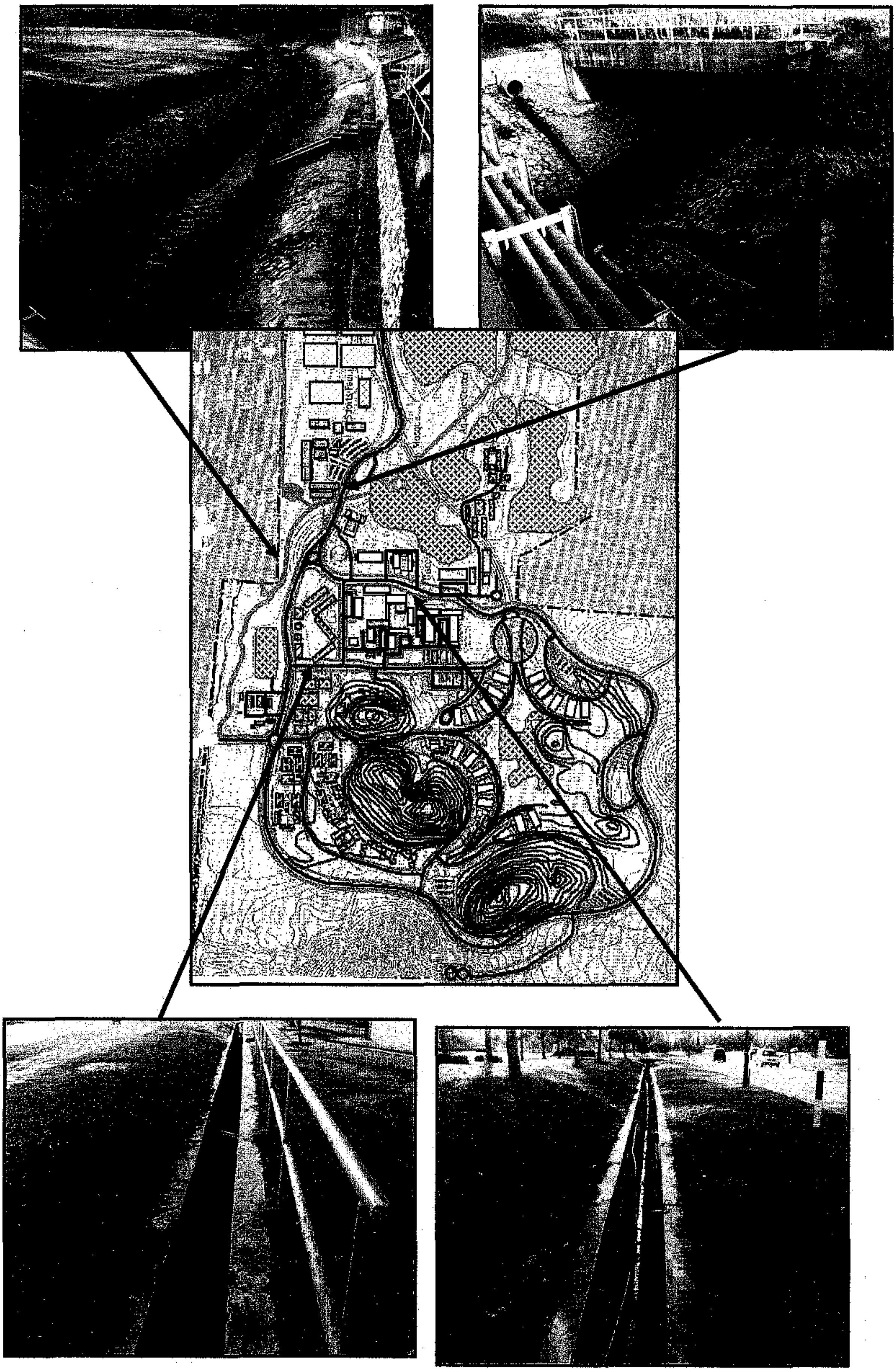


Figure 18: Picture windows display for drainage structures

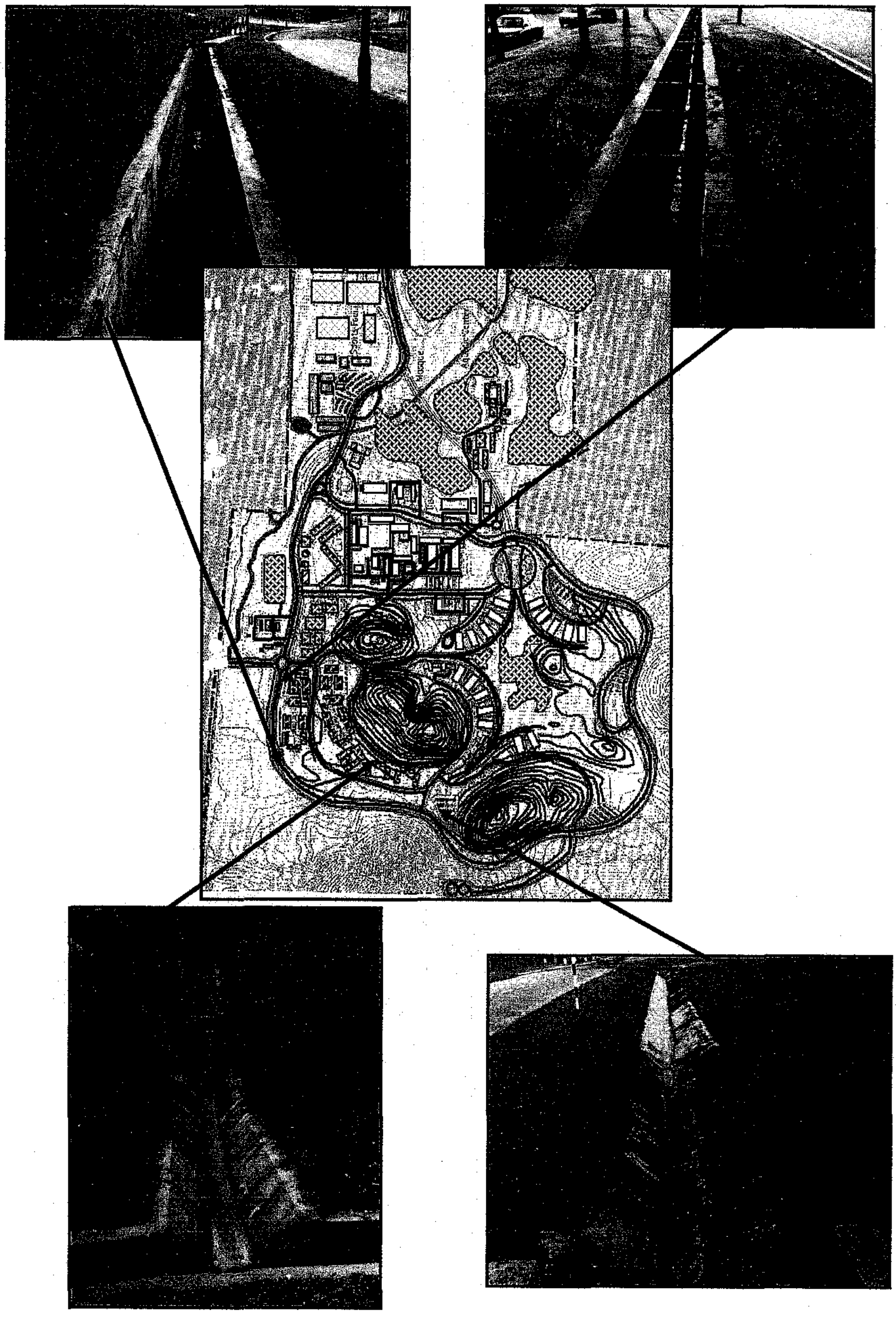


Figure 19: Picture windows display for drainage structures

Referring to the pictures, the channels were built at the appropriate location to smooth out the flow of water. The main channel (Figure 1) which located near the sport complex and mosque was built to collect all water that flows from the small branch channel all over UTP area. The depth is almost 4 meters. The width at the top of the channel is about 5 meters and the width at the bottom is 2 meters. Figure 2 shows the inlet point to the main channel from the small branches of channels all over UTP.

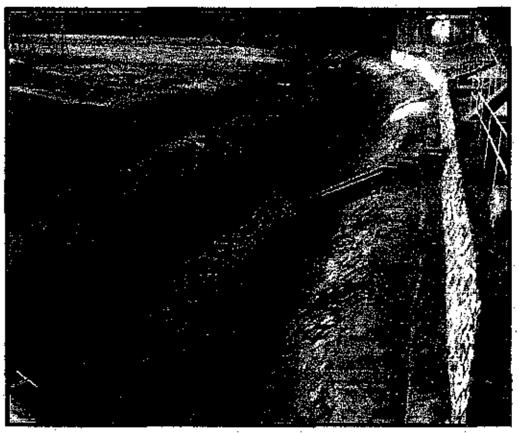


Figure 20: Main Channel

Figure 21: Inlet to the main channel

Drops structures for open channels structure (Figure 3) as shown below used when the channel would otherwise be too steep for design conditions. This type of channel structure built at the hilly area in UTP where the high level of contour shown in the map provided. All drops should be designed to protect the upstream and downstream channel from erosion. Drop structure analysis may be required to determine the length of hydraulic jump and adequate erosion control measures.

Sloped drops should be constructed of concrete, gabions, or rip-rap. Rip-rap drops should have a minimum of 6 inches thick gravel base and may require grouting. Engineering fabric under riprap may be required depending on soil conditions. At drop structures, both the channel bottom and banks should be protected from erosion.

Figure 22: Drops Structures for open channel at the high level of contour in UTP

From the pictures below (Figure 4), these showed the drainage system for the road artery in UTP. The inlet structures were built at the curb of the road within range of 3 meters for each inlet.

These inlets were connected to the channels near the road through the clay pipes. This is to make sure all the water on the road can be channeled properly into the drainage system.

The channels are always built parallel to the road. These channels were built along all the road system to avoid flood and water pond on the road. This system need to be monitored and maintained every schedule period to avoid any clogging in the inlet and clay pipe.

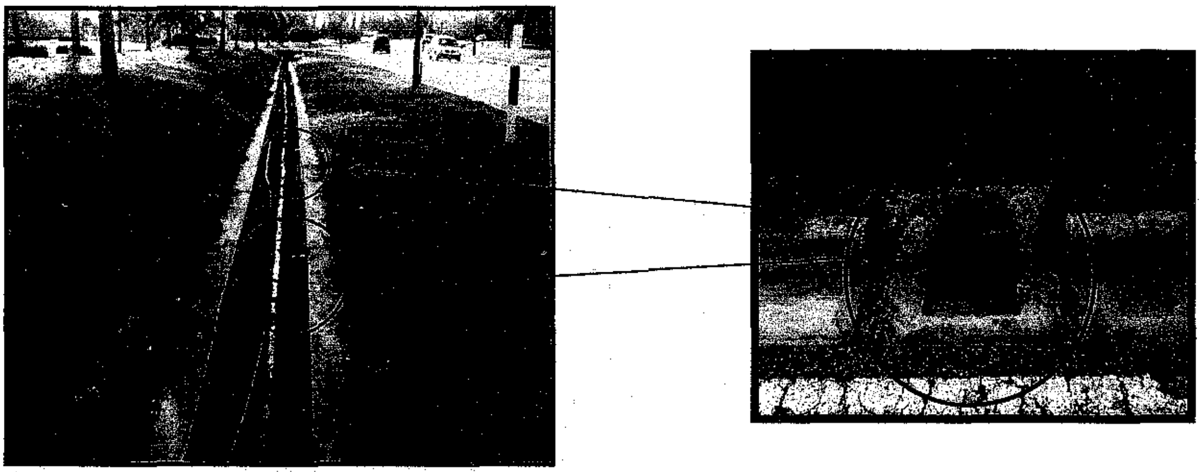


Figure 23: Water inlets system from the road to the channel

4.2 Drainage Flood Analysis

For analysis part, water storm analysis has been chose as main interest in this discussion part. Firstly, the geometric properties of the channel in UTP should be known. In analysis section, various geometric properties of the channel cross section are required such as depth, area of the cross sectional flow, wetted perimeter, surface width, hydraulic mean depth and hydraulic radius.

Perak state experience 3,218mm of precipitation per year which equivalent to average 8.8mm per day. UTP which is located at Perak Tengah area has experienced 2000mm of precipitation per year which is equivalent to average 5.47mm per day. The evaporation rate of Perak Tengah area is 5.9 to 6 inch per month and the average temperature is 81 Fahrenheit.

The water catchments area for precipitation in UTP covered for 400 hectare which is equivalent to 1000 acre.

From the calculation that involved formulae, data collection of water catchments and various geometric properties of the channel cross section, the output flow and volume of the storm water in UTP can be determined.

After the calculation completed, the excessive output flow and discharged volume of storm water in channel can be known. This phenomenon will result to overflow of the water in the channel. Analysis in MapInfo software can determine the overflow location of excessive water on the ground in UTP area during precipitation. The analysis will depend on the level or height of the land around the drainage system.

The precipitation that occurred continuously for along time will cause overflow of the water from the channel. This overflow will cause flood. MapInfo will show the area affected by flood.

If the average rate of precipitation didn't exceed 0.23mm per hour for 24 hours continuously, the overflow will not occur. The buffer solution in MapInfo software will show the affected flood area cause by the overflow of storm water.

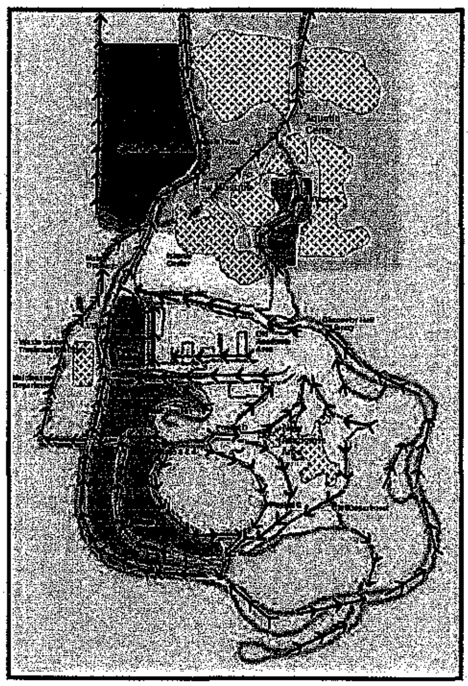


Figure 24: Flow direction of drainage water using digital elevation model (DEM)

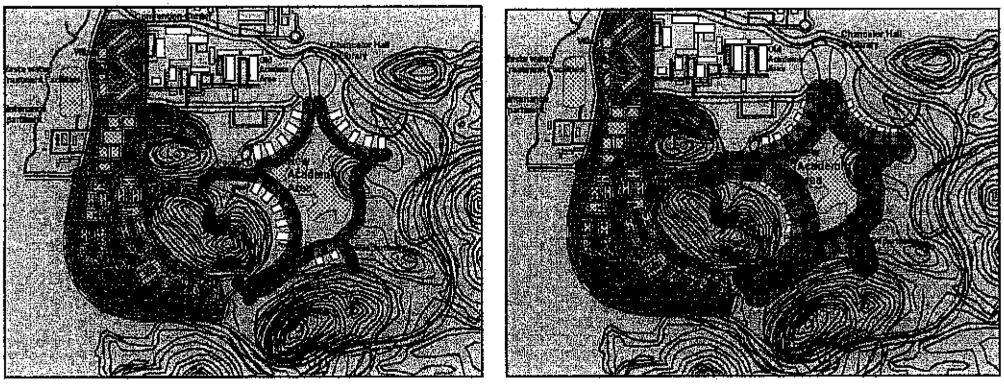


Figure 25: Overflow during precipitation of 0.5mm/hr and 1.0mm/hr for 24 hour

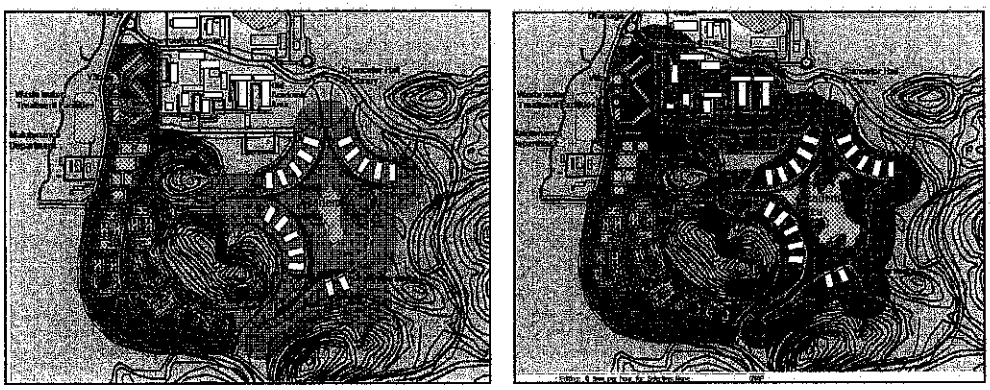


Figure 26: Overflow during precipitation of 1.5 mm/hr and 2.0mm/hr for 24 hour

CHAPTER 5
DISCUSSION

Throughout the project, it was found that some channels are not properly placed according to the hydraulics principal. Several channels also had improper level which contributed to the unsmooth flow of water. Locating the possible alternative location for channels is the most crucial aspect in this project because the probability for successive of drainage system management system starts from eliminating the broken and disfunction of channels.

The contour also plays important roles in maintaining the drainage system because it shows the level of the drainage from a place to another place. This level contributes the flow characteristics in the channels. Unsuitable leveling of the channel will contribute to unsmooth flow of waters in the drainage system.

The hydraulics theory stated that the channel should be properly built and installed to avoid any problem such as flooding, water clogging, and damage to near structure. The information on drainage solutions for drainage problems was discussed by many constitutions. There are many drainage systems were design to improved methods of surface water design and enhance the efficiency of the channels. Some were used until today and some were not relevant to the situation depending on the place and weather.

Some sorts of management controls and services can be introduced to the UTP drainage system to improve its quality and as preventions of any incoming problems. Sludge Management and Disposal Services can be introduced to the original UTP's management of drainage system. This service include preparation of sludge management master plans, sludge thickening, dewatering, thermal drying, stabilization, mineralization, hygienization, composting, anaerobic digestion, biogas utilization, sanitary landfill, incineration, land application, environmental risk assessment, and management of toxic organics, heavy metals, and agricultural slurries.

The other service that also can be implemented in UTP's drainage system is Stormwater Management. This service take account of storm runoff hydrographs computation, storm sewer analysis and design, detention pond design, and flow routing through a network of ditches, channels, gutters, pipes, culverts, flow structures, detention ponds, and reservoirs.

Wastewater Collection and Treatment service include wastewater collection, treatment, analysis and discharge, sludge disposal, planning wastewater treatment facilities, biosolids management and disposal, chemical storage, and hazardous materials management.

GIS is a powerful tool used in this research. It provides a better management of resources and data about the drainage system in UTP. The author took one step into GIS by learning MapInfo Professional software. He learned how to create some database of the study area. For future analysis, the author will try to explore more on the advance function of MapInfo in order to generate output and analysis from this project.

Using Geographical Information System (GIS) we can do spatial data collection, storage, and analysis for planning water distribution systems, infrastructure management, sewer system rehabilitation, sludge management and disposal, and wastewater collection and treatment.

From the study and analysis, UTP drainage system itself cannot adequate the amount of water for continuous and long precipitation. Some area always got same problems which are flood, overflow and damage of channels structure. Now is the time for UTP to apply GIS system and analysis to maintain and monitor the drainage system. Besides, cost of building and repair channels can be reduced if the GIS system is applied to the drainage in UTP.

CHAPTER 6
CONCLUSION

From the types, purposes, data, and design of the drainage system, it is very essential to come up with mapping system to increase its efficiency. The successful completion of the GIS database with the user interface of this application will provide an easy access for mapping, monitoring and maintenance of Universiti Teknologi Petronas drainage system. The GIS technique offers an effective tool to manage the location and area affected by the improper installed channel or poor maintenance of drainage system. GIS will provide a better picture of spatial data regarding drainage system and the existing drainage management system can be improved by using GIS.

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