DIGITAL TERRAIN MODELING AND DRAINAGE MODELING

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DIGITAL TERRAIN MODELING AND DRAINAGE MODELING

By

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FINAL YEAR RESEARCH PROJECT REPORT

Submitted to the Civil Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Civil Engineering)

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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.

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Mohd Nasir B Nordin

CERTIFICATION OF APPROVAL

DTM AND DRAINAGE MODELING

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A project dissertation submitted to the
Civil Engineering Programme
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Approved:

____

Dr Abdul Nasir Matori
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS

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To all individuals that has helped the author in any way, but whose name is not mentioned here, the author thank you all.

LIST OF FIGURES

LIST OF ABBREVIATIONS

CSV - Comma Separated Values

DTM - Digital Terrain Modeling

DXF - Drawing eXchange Format

DWG - Drawing

CHAPTER 5

TABLE OF CONTENTS

ABSTRACT

Digital Terrain Modeling (DTM) has always been the base for representing terrain. Combine with hydrologic modeling; this can help to provide the necessary information of the hydrologic cycle, inflow and outflow in the catchment area and the change in elevation of that particular area.

All of this can be done using Geographical Information System (GIS). The data that will be obtained such as the contour lines, height elevation and etc. will be put into the system. Using this, it will eventually represent the real hydrologic movement of the author's area of study.

CHAPTER 1

INTRODUCTION

1.1 Background study

This project is anticipated to combine the use of DTM and hydrologic modeling to create a model based on GIS. Many studies have been made in this field of area however seldom combine this two things together. In the early 4000 B.C, the Nile was dammed to improve the agricultural productivity of previously barren lands. Mesopotamian towns were protected from flooding with high earthen walls. Aqueducts were built by the Greeks and Ancient Romans, while the History of China shows they built irrigation and flood control works. The ancient Sinhalese used hydrology to build complex irrigation works in Sri Lanka, also known for invention of the Valve Pit which allowed construction of large reservoirs, anicuts and canals which still function.[(1)]

A digital terrain model is a mathematical (or digital) model of the terrain surface. It employs one or more mathematical functions to represent the surface according to some specific methods based on the set of measured data points. [Zhilin Li, Qing Zhu and Christopher Gold][2] By using the both DTM and hydrologic modeling, this will produce a model that is equipped with not just a terrain but also a hydrologic or water movement in a catchment area. Also, this model will expect to show any loss of water to the ground, evaporated to the air and interception by the vegetation. The water coming from the ground or groundwater is also put into account in this matter.

By implementing all of the data acquired, a more accurate determination of the outflow and the water discharge from the runoff will be produce. This will effectively determine and predict any occurrence of high or low outflow .In future; this will help engineers to design a more suitable drainage to accommodate the water volume later.

1.2 Problem statement

1. The water discharge in an area coming from rainfall or groundwater usually is calculated using gauges such as Tipping Bucket, Weighing Bucket or Natural-Syphon[K Subramanya][2].

2. *These recording gauges will determine the intensity and duration of rainfall for* hydrological analysis of storms.
3. There are few limitations or constraint if the author wants to use the above method to obtain the data of the area. The limitation such as:
   - Cost
   - Labor
   - Time
4. That is why the author opts for using GIS to present the hydrologic modeling where it is more economical and time saving.

1.3 Objective of study

1. To generate Digital Terrain Modeling to show the hydrologic flow of the study area
2. To develop a workable simulation of water drain on the earth surface using Geographical Information System.

1.4 Scope of study

The DTM and hydrologic modeling is to be completed within approximately in one year time frame (two semesters or two phases). The scope for phase 1 of the project is doing research and obtaining the data from the respective company in the selected area of study. Also the goal is to learn the software and try to combine the theoretical knowledge with the software. In the second phase, which is the implementation part, the target is to use all the data obtained and utilize it into the system. In the end, a 3 dimensional terrain equip with the hydrologic modeling that shows its surface runoff and its outlet.

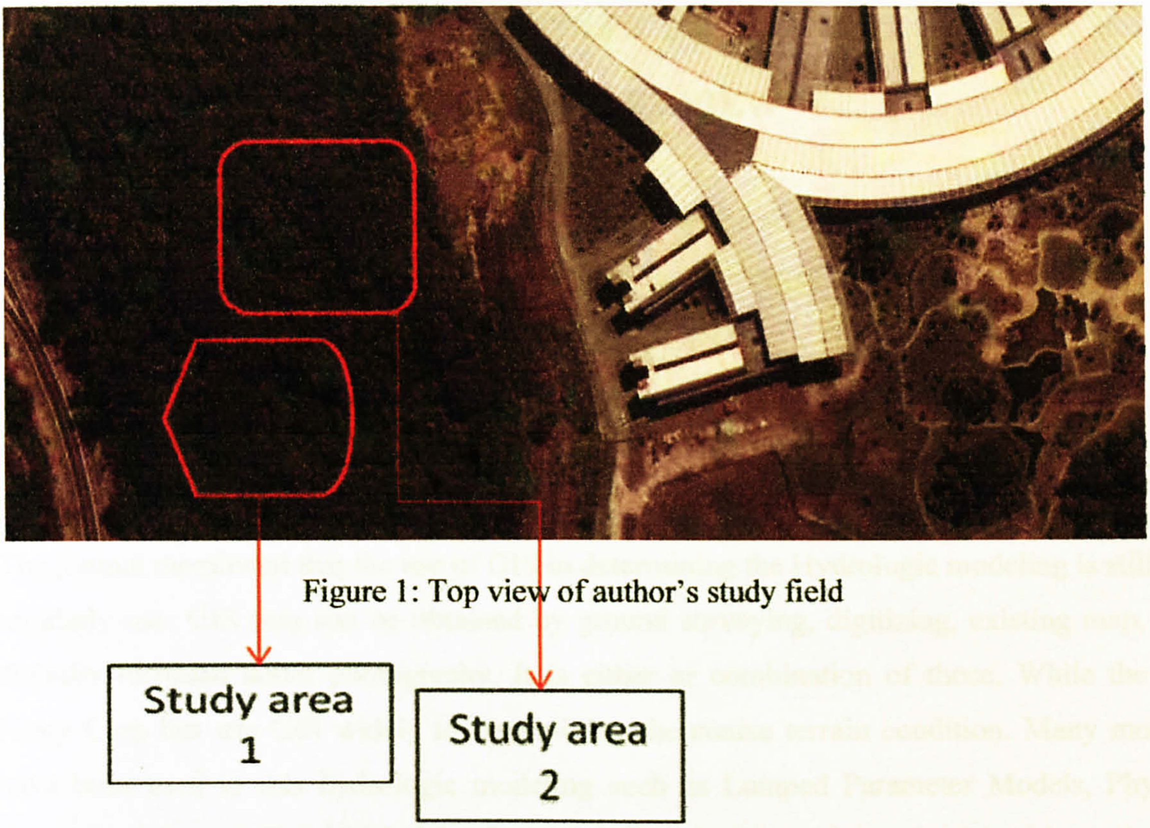


Figure 1: Top view of author's study field

CHAPTER 2

LITERATURE REVIEW

2.1 The study of the project was also abundantly related with a few journals found in the internet. A few of it were highlighting about the DTM and also the use of GIS in hydrologic modeling which interrelated with the title of this project.

2.1.1 GIS application in Hydrologic Modeling [Bruce A. DeVantier, and Arlen D. Feldman][4]

The journal mentioned that the use of GIS in determining the Hydrologic modeling is still not regularly use. GIS data can be obtained by ground surveying, digitizing, existing map, and digitally recorded aerial photography. It is either or combination of those. While the US Army Corp has use GIS widely in determining the coarse terrain condition. Many models have been used in this hydrologic modeling such as Lumped Parameter Models, Physics Based Models, and Hybrid Models. General indices had been determined in this section of study which is imperviousness and natural land cover.

The result of this study is

a. Floodplain Management and Flood Forecasting
b. Erosion Prediction/Control
c. Water Quality Prediction/Control
d. Drainage Utility Implementation

All in all, the application of GIS is still based on work at station. In the future, the author hopes the GIS applications will be brought to desktop. The application of GIS is not also focus on its usage but to integrate it with hydrologic application also.

2.1.2 A GIS interface for hydrologic modeling [William H. Merkel, Ravichandran M. Kaushika, and Eddy Gorman][5]

Before 1960s, slide rule is a common tools used for hydrology projects. In the 1970s, Federal agencies such as the US Army Corps of Engineers (USACE), US Department of Agriculture (USDA)'s Soil Conservation Service (SCS, currently, Natural Resources Conservation Service (NRCS)), and US Geological Survey developed backwater calculation programs to automate hydrologic calculations. These computer-based hydrologic applications were of significant help compared with the slide rule methods (Lovell and Atkinson, 2004). The program is NRCS GeoHydro 9x, which is a new ArcGIS application to complement the WinTR-20 application. The NRCS GeoHydro 9x use GIS tools and techniques to perform hydrologic modeling on a drainage area to compute

a. Catchments
b. Drainage points
c. Time of concentration (T_c)
d. Drainage lines
e. Slope
f. Runoff curve number
g. Longest flow path
h. Cross section details

The software reinforces the idea that GIS tools and techniques enhance productivity by doing preliminary hydrological analysis of the drainage area in an objective and accurate manner within a short duration.

2.1.3 Digital Terrain Modeling of Drainage Channel Erosion [J. Casalm H., A. Laburu, J. J. López, R. Garcia][6]

Channels that were constructed in areas of Southern Navarre during 1988 have undergone severe erosion, including bed and bank degradation. Average soil losses along an eroded reach are $3.62m^3/m$, showing that there should be a necessity of using improved design methods.

Current simulation models which are DTM could aid in determining such design criteria. Sudden changes in bed slope should be avoided and an adequate erosion control techniques within the channel should be considered. Simulation models could play an important role in achieving this goal.

2.1.4 Calibration of a semi-distributed hydrologic model for streamflow estimation along a river system [Newsha K. Ajami, Hoshin Gupta, Thorsten Wagener, Soroosh Sorooshian][7]

An important goal of spatially distributed hydrologic modeling is to provide estimates of streamflow. The questions rises from the study are distributed to four which are:

1. Can a semi-distributed approach improve the streamflow forecasts at the watershed outlet compared to a lumped approach?
2. What is a suitable calibration strategy for a semi-distributed model structure, and how much improvement can be obtained?
3. What is the minimum level of spatial complexity required, above which the improvement in forecast accuracy is marginal?
4. What spatial details must be included to enable flow prediction at any point along the river network?

The calibration results reveal that moving from a lumped model structure, driven by spatially averaged NEXRAD data over the entire basin, to a semi-distributed model structure, with forcing data averaged over each sub-basin while having identical parameters for all the sub-basins, improves the simulation results. However, varying the parameters between sub-basins does not further improve the simulation results, either at the outlet or at an interior testing point.

2.1.5 An assessment of the VIC-3L hydrological model for the Yangtze River basin based on remote sensing: a case study of the Baohe River basin [Suoquan Zhou, Xu Liang, Jing Chen, Peng Gong][8]

In order to simulate the terrestrial hydrological process for the entire Yangtze River basin, a hydrologically based three layer variable infiltration capacity (VIC-3L) land surface model is applied to the Baohe River basin, which has a drainage area of 2500 km^2. This study indicates clearly the important role that remote sensing (e.g. MODIS data) plays in improving model simulations.

The applications of remote sensing in hydrological studies and water resources management can be categorized as follows:

1. Using original remote sensing imagery directly to identify hydrologically important spatial phenomena.
2. Using processed remote sensing data, such as precipitation, as forcings of hydrological models.
3. Using multispectral data, such as vegetation (land covers) types and density, to quantify surface parameters.
4. Direct calculation of evapotranspiration distribution in terms of spectral data of satellite remote sensing based on surface energy balance (e.g. Bastiaanssen et al., 1998)
5. Using remote sensing derived fields, such as soil moisture, to improve model simulations through data assimilations
6. Validating model simulations using remote sensing data.

CHAPTER 3
METHODOLOGY

In order to complete this project, a familiarity to the system which is ArcView is done because most of the work is based on the system. The steps taken in this case study will be drawn out clearly to show the flow of the project from the beginning till the end. Also, to draw out the plan view of the selected terrain, AutoCAD will become a useful tool in completing this project.

3.1 Microsoft Excel (CSV format)

The ".CSV" format is an extension for excel which means comma separated values. is a computer data file used for implementing the tried and true organizational tool, the Comma Separated List. The CSV file is used for the digital storage of data structured in a table of lists form, where each associated item (member) in a group is in association with others also separated by the commas of its set. Each line in the CSV file corresponds to a row in the table. Within a line, fields are separated by commas, each field belonging to one table column. [9]

Figure 2: CSV file format

3.1 AutoCAD

AutoCAD or Automatic Computer Aided Design will be helpful throughout this project. It is a software use by many engineers and architects to draw out a plan or a 3D view of an object. In this project, the AutoCAD will be use to draw out the plan view of the terrain so that a view of the selected terrain could be represented to the audience.

For this project, two set of data is used which the data of contour lines from the As-built are drawing that is in ".DWG" format and also the data from ".CSV" format.

The As-Built drawing is obtained in ".DWG" form, however, ".DWG" which is for plan purposes, that is why the author have to convert it to ".DXF" file. The meaning for those two are:

1. DWG - A standard AutoCAD drawing file format. The thing to remember is that older versions of AutoCAD cannot read files created on newer versions. The newest version can read any of the older files. If exchanging files with other companies, do not assume that they are using the same version you are. Some co-workers will also have older or newer versions than the one on your computer. (10)

2. DXF – This is not really an AutoCAD format but an industry standard, but one that should be aware of. DXF stands for Drawing eXchange Format. This is a very standard format that is used by many different CAD and graphics programs. This allows users to exchange drawings even if they don't have the same program. When you use the DXF format, some objects may change their appearance when re-opened. As with DWG formats, DXF formats vary from different releases. You have the option of saving the files as a DXF or you can use the DXFOUT command, conversely DXF Files can be imported using the DXFIN command.(10)

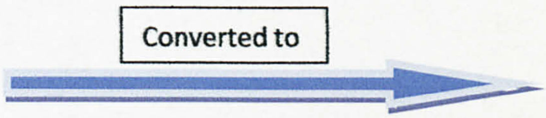


Figure 3: "DWG" format

Figure 4: "DXF" format

After converting the format of the drawing to "DXF", the drawing needs to be exploded by clicking this key "". The purpose of doing this is so that the drawing will be separated and changed from grouped item into its individual item.

This is essential in doing the work because the author needs the contour line of the drawing to be individual form. Only after doing all of the stated above, then the use of ArcView comes in place.

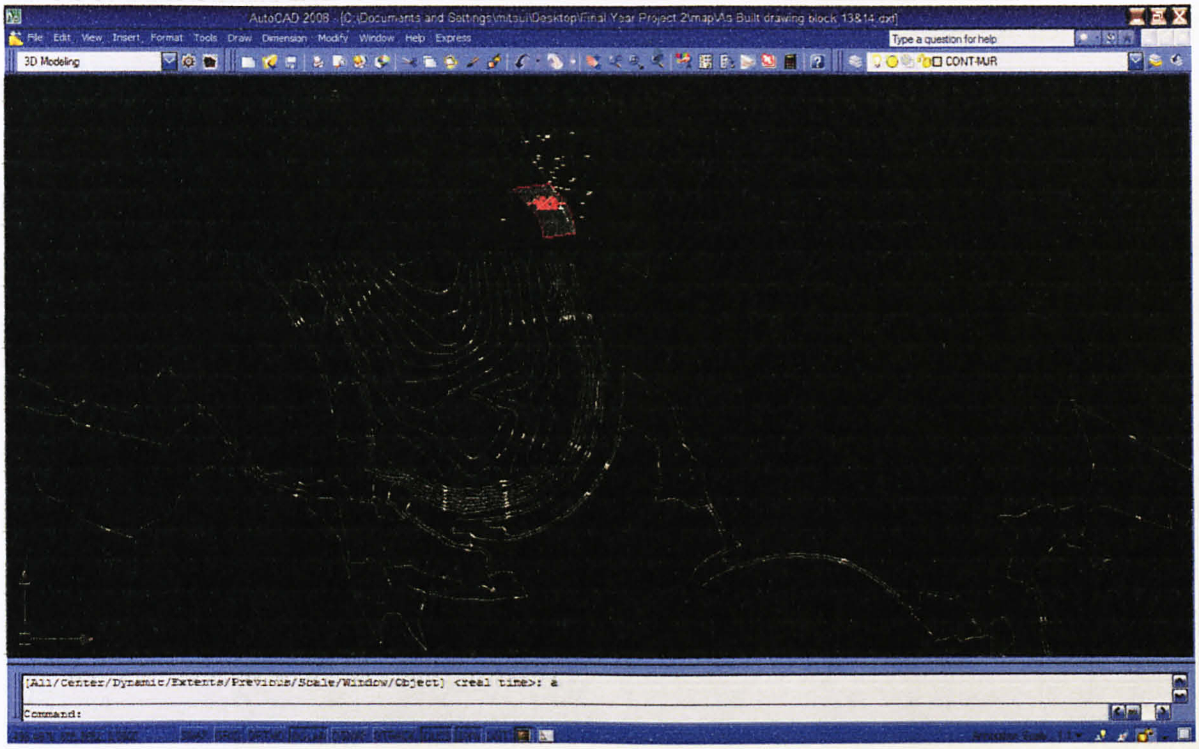


Figure 5: Contour lines in DXF format

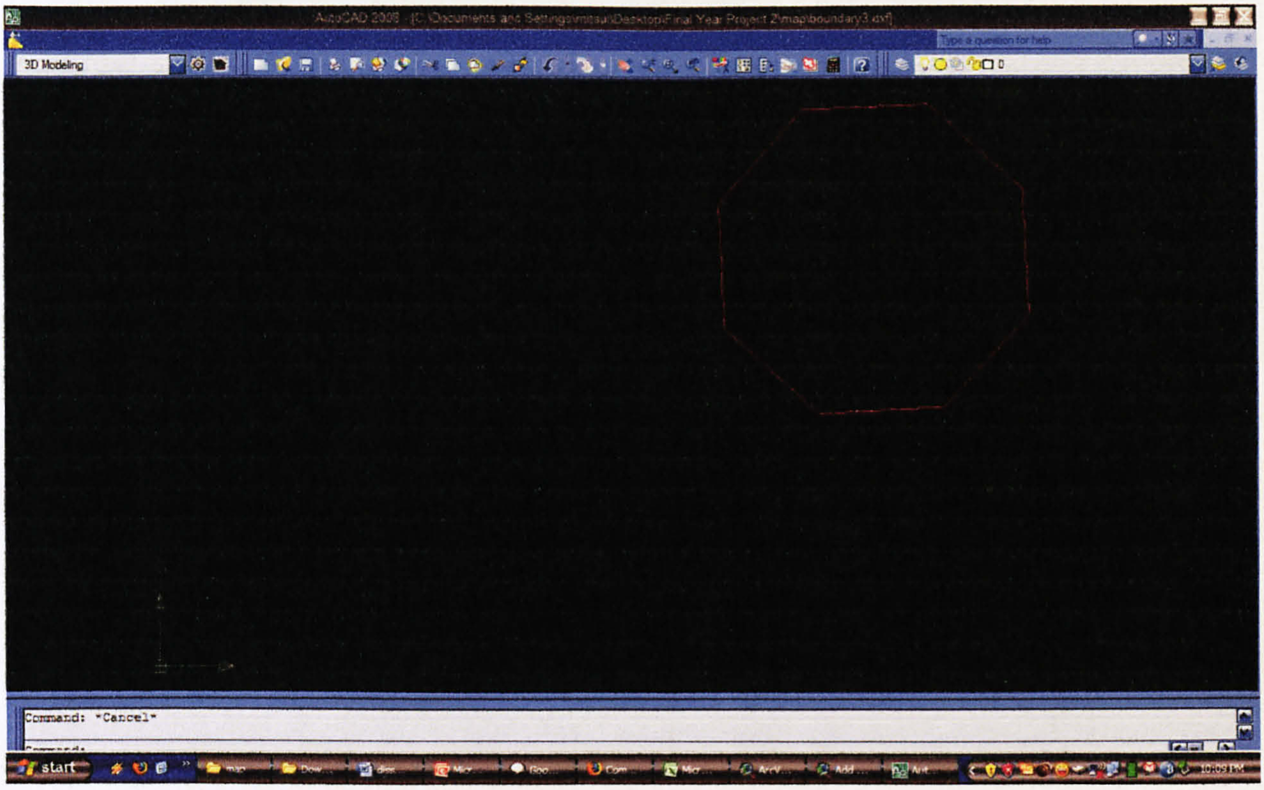


Figure 6: Boundary for study area 1

For a ".CSV" format, AutoCAD Land Development has to be use to import the data, and then the contour lines were created.

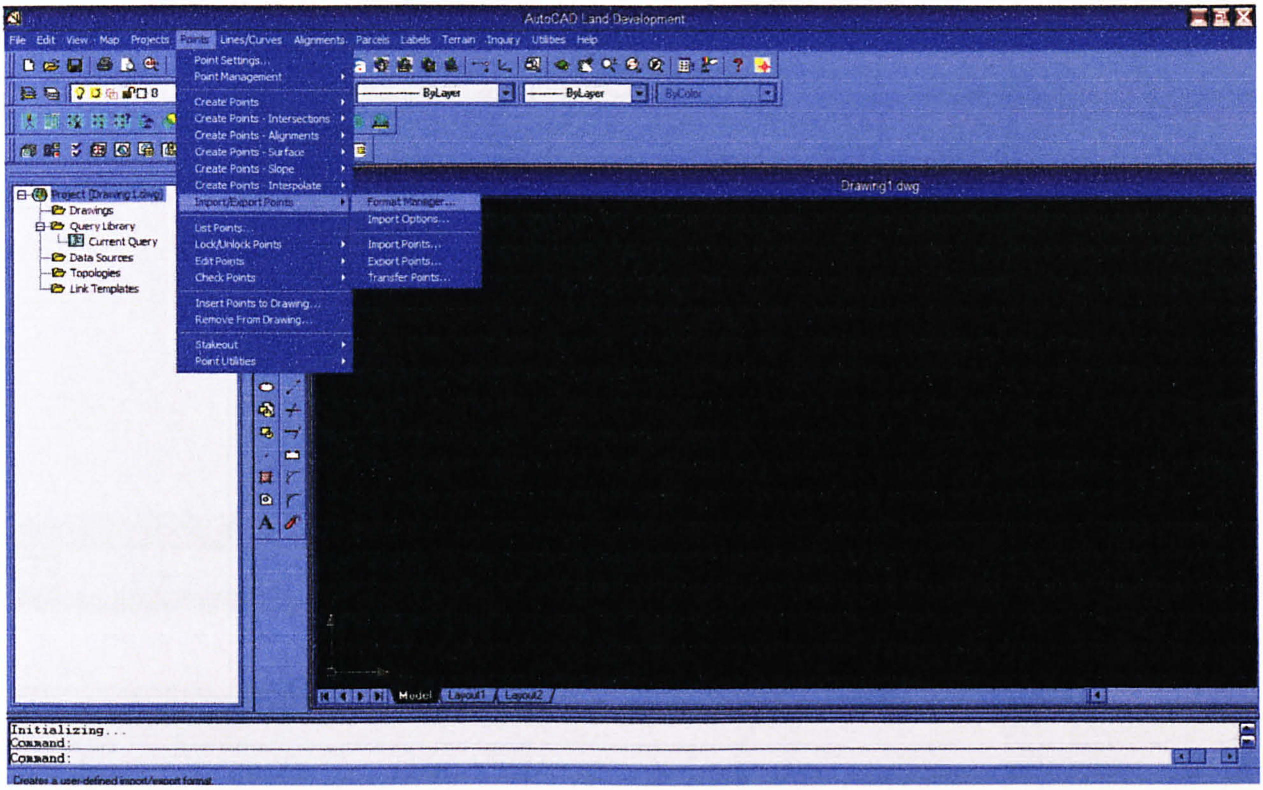


Figure 7: Import CSV data using AutoCAD Land Development

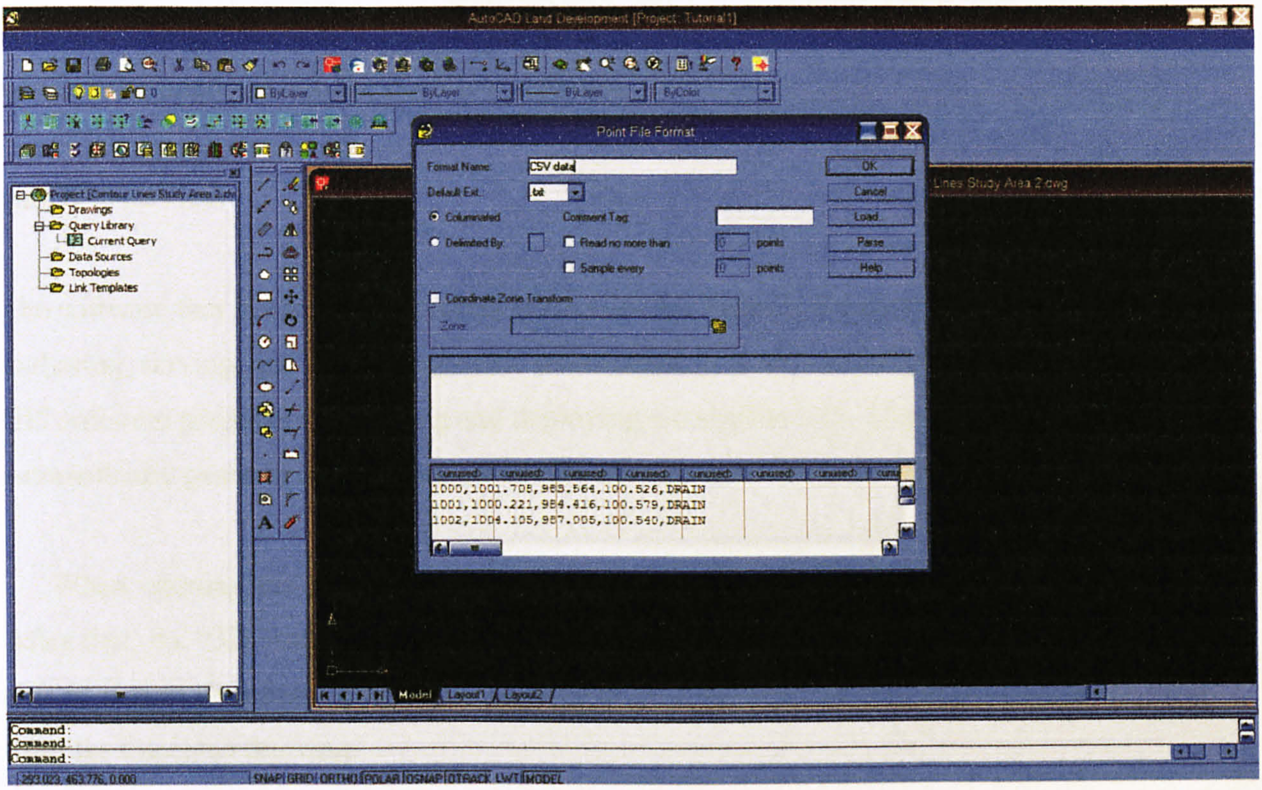


Figure 8: Pointing to the file of selection

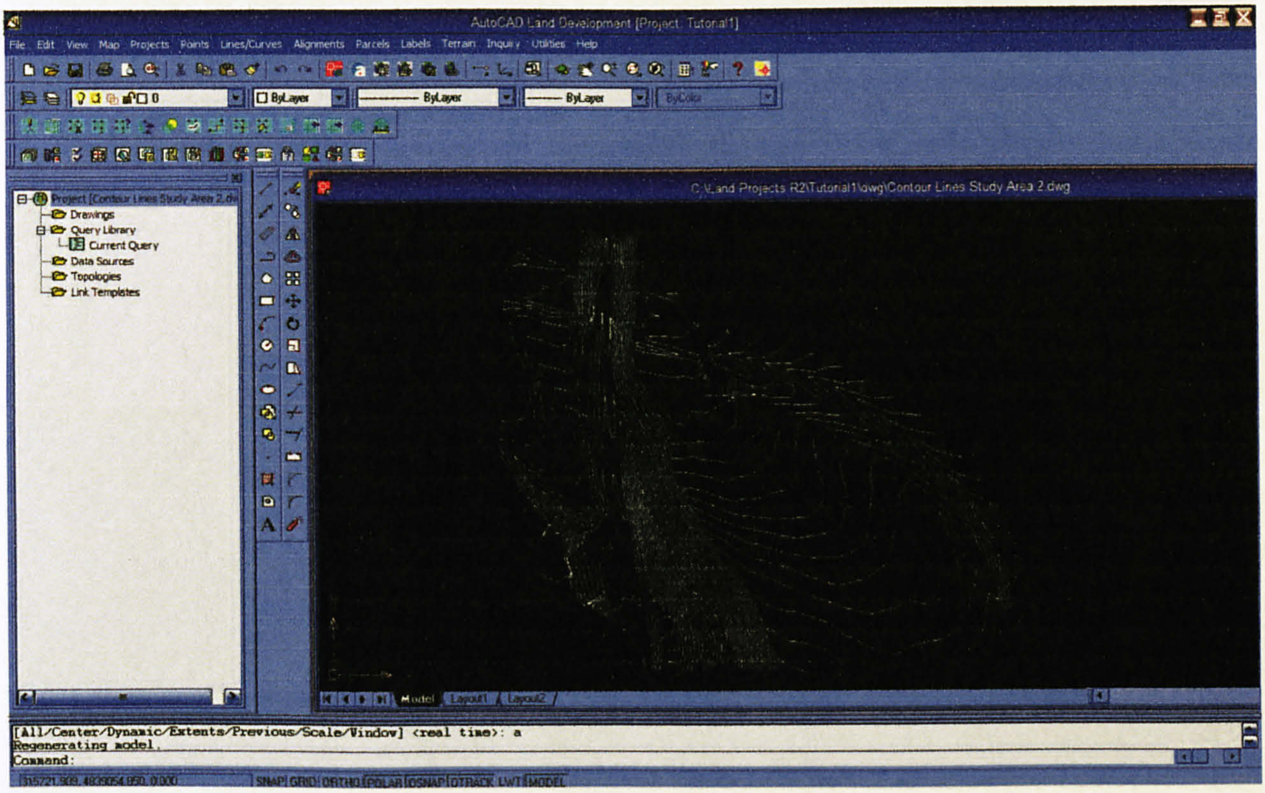


Figure 9: Contour lines for study area 2

After developing the contour lines, it will be saved under DXF format just like study area 1 which to be imported into the ArcView software.

3.2 ArcGIS/ArcView

The software that is use for this project is ArcGIS/ArcView. It is a complete system for authoring, serving, and using geographic information. It is also an integrated collection of GIS software products for building and deploying a complete GIS. The software will automatically generate a digital terrain model after the user key in the data to it. (11)

When opening the software, "Extension" command under the "File" tab was selected. After that, the "3D Analyst" and "CAD Reader" were ticked. This is for the software to be able to import data from AutoCAD which is in DXF format and also to produce a 3D view from the imported drawing.

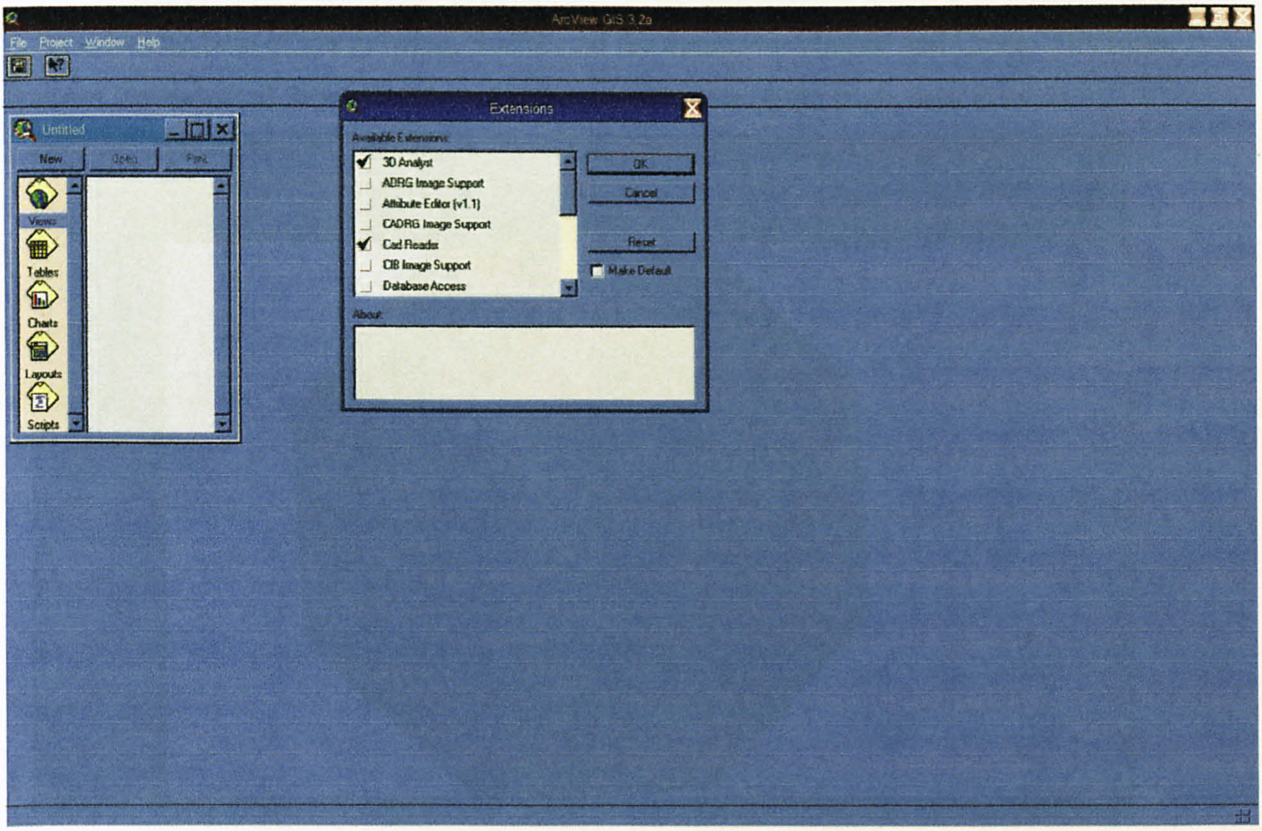


Figure 10: "Ticking 3D Analyst, CAD Reader and Hydrotools 1.0" in ArcView 3.2

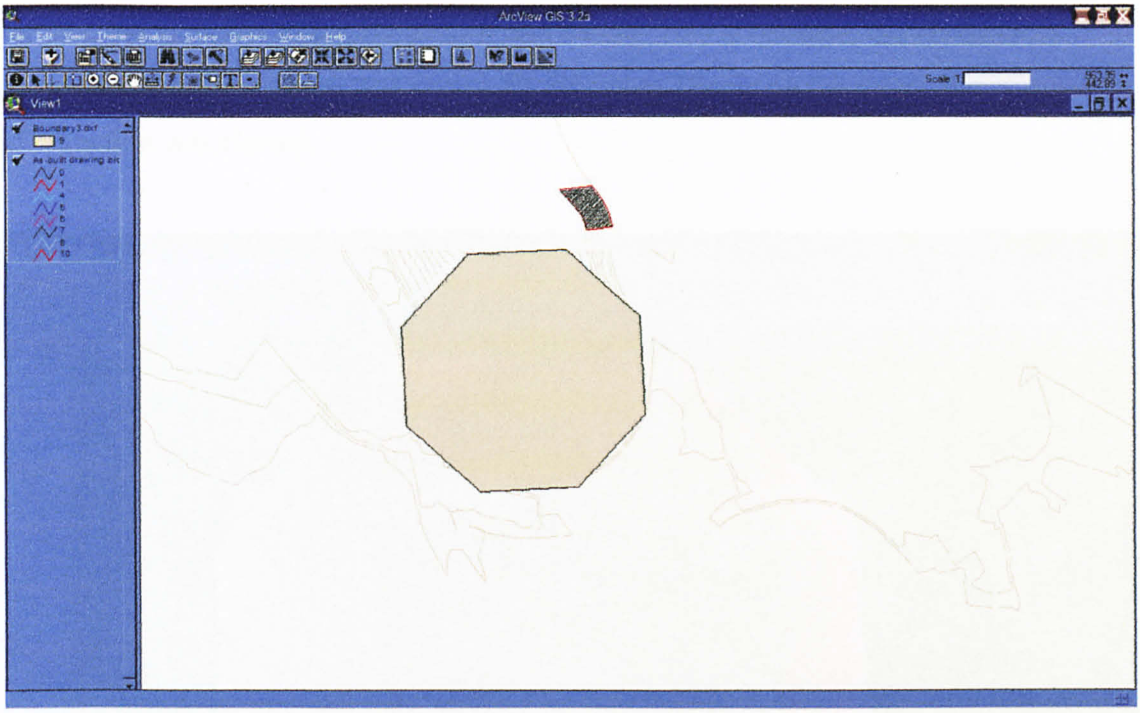


Figure 11: Both of the DXF file were imported and boundary is overlaid to show the study area

After selecting both of the drawing, Surface on the menu was clicked and Create TIN from features was selected. Immediately, a 3 dimensional view of the study area is made.

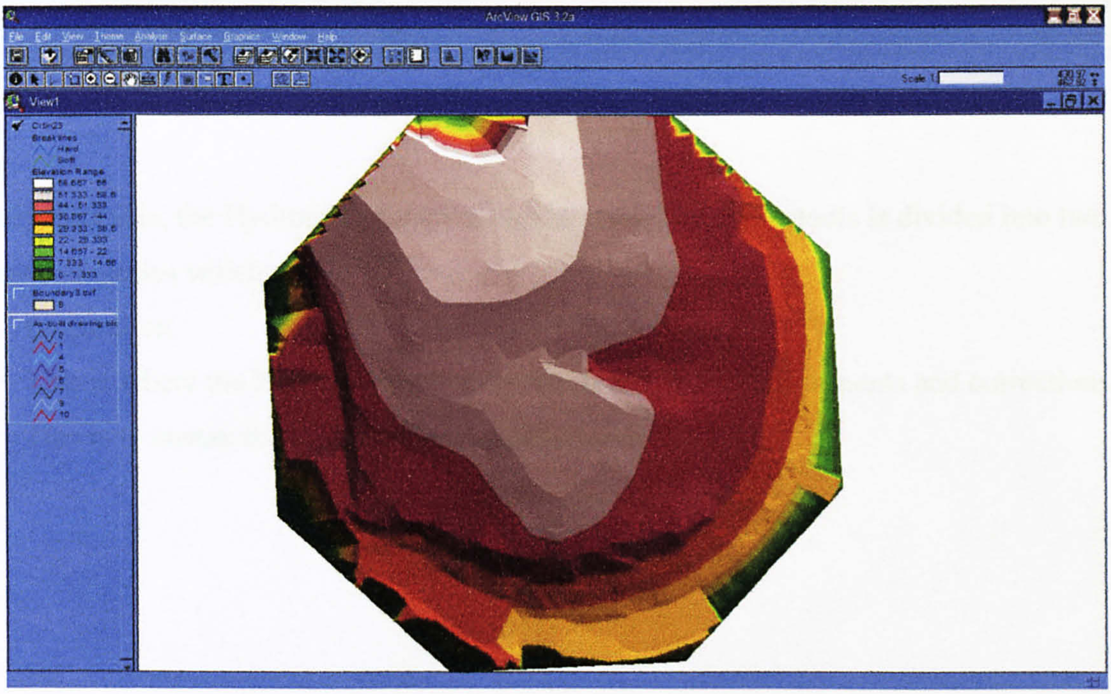


Figure 12: 3D view of the slope for study area 1

After that, the view has to be change to a grid theme. This is because; the Hydrotools application can only work on grid theme. By selecting Theme on the menu, the "Convert to Grid" function was chosen.

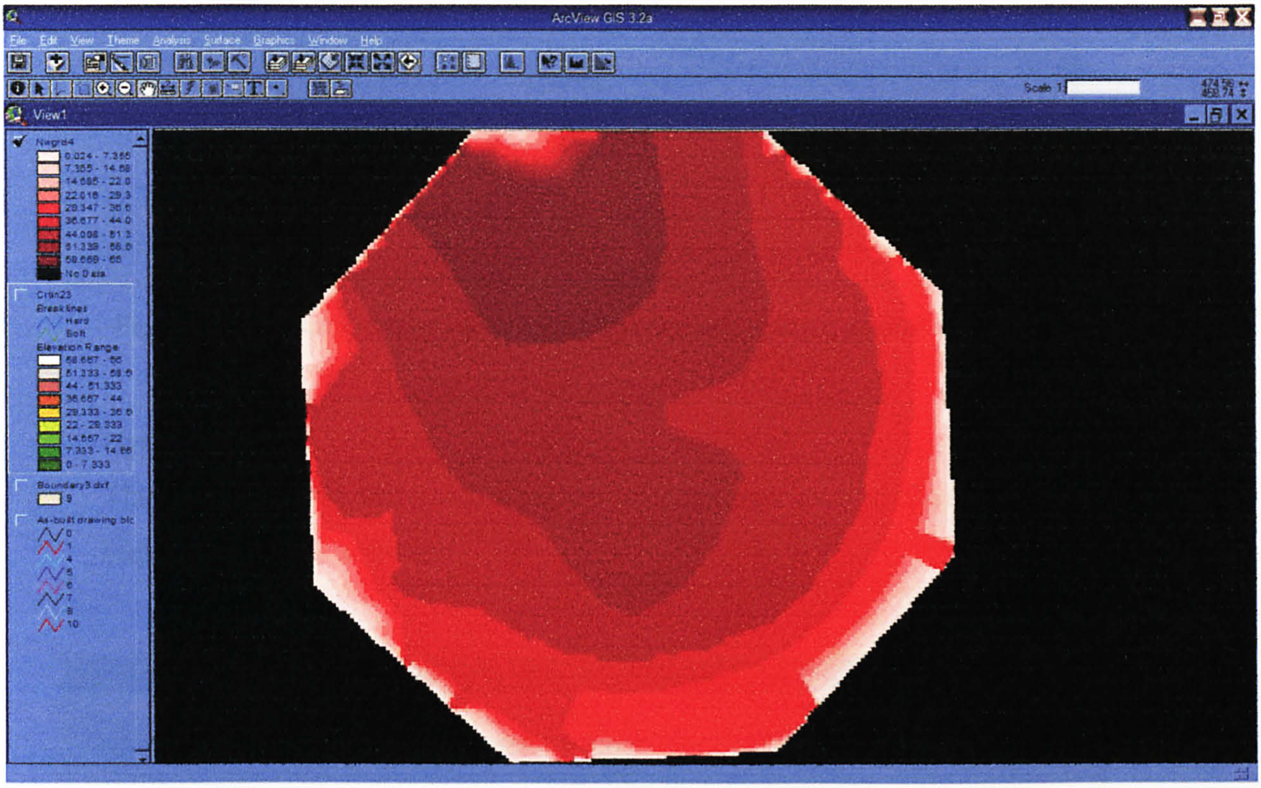


Figure 13: View in Grid theme

Only after this, the Hydrotools function can be used. The Hydrotools is divided into two main categories which are:

1. Preparation

   This is where the land or area of study will undergo few adjustments and corrections. This is to ensure the reliability of the end results.

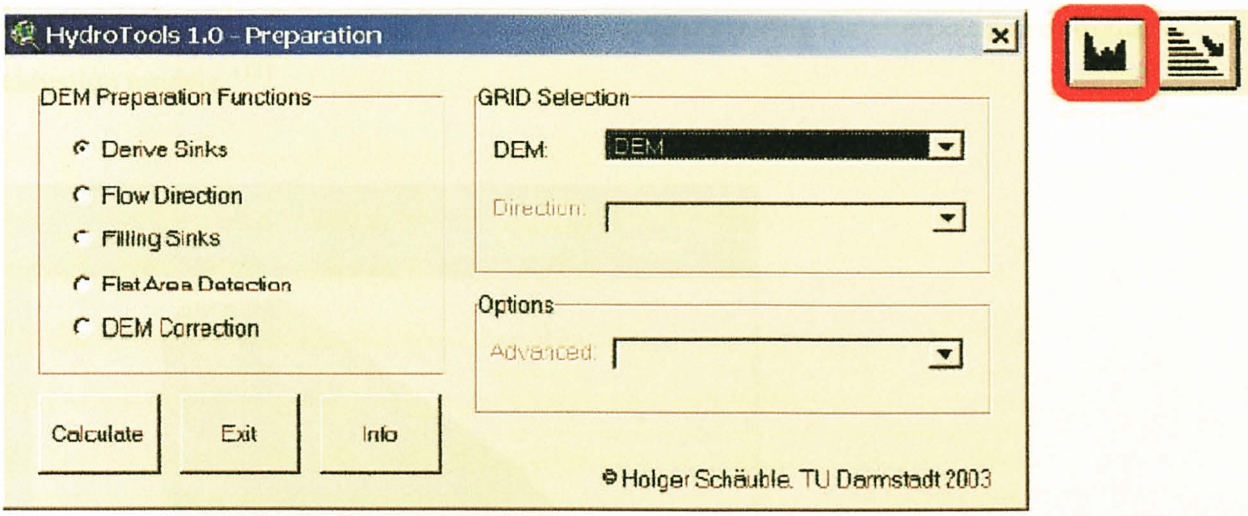


Figure 14: Preparation window with functions to correct digital elevation models [12]

2. Hydrology

The Hydrology functions will illustrate what the user want to obtain from the data that he imported into this software.

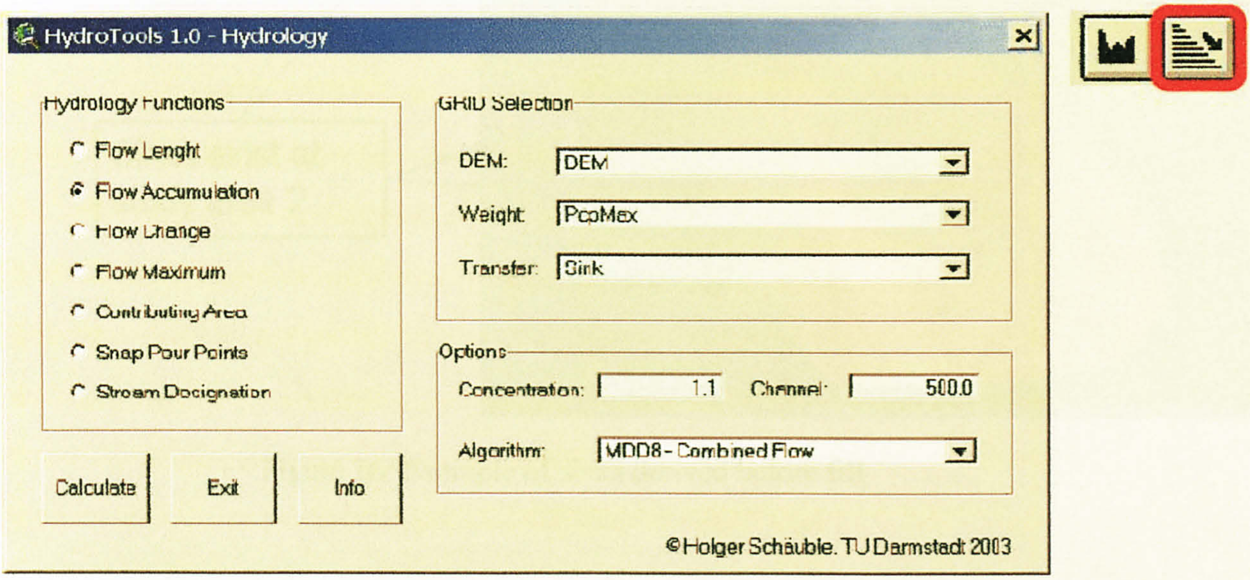


Figure 15: Hydrology window with hydrological functions to analyze digital elevation models and catchments [12]

Starting with the preparation part, the data represented in Grid theme, sinks have to be calculated. This is because sinks will interrupt the flow of water and falsify hydrological calculations, especially when they were born as artifacts during the interpolation of digital elevation models. (12)

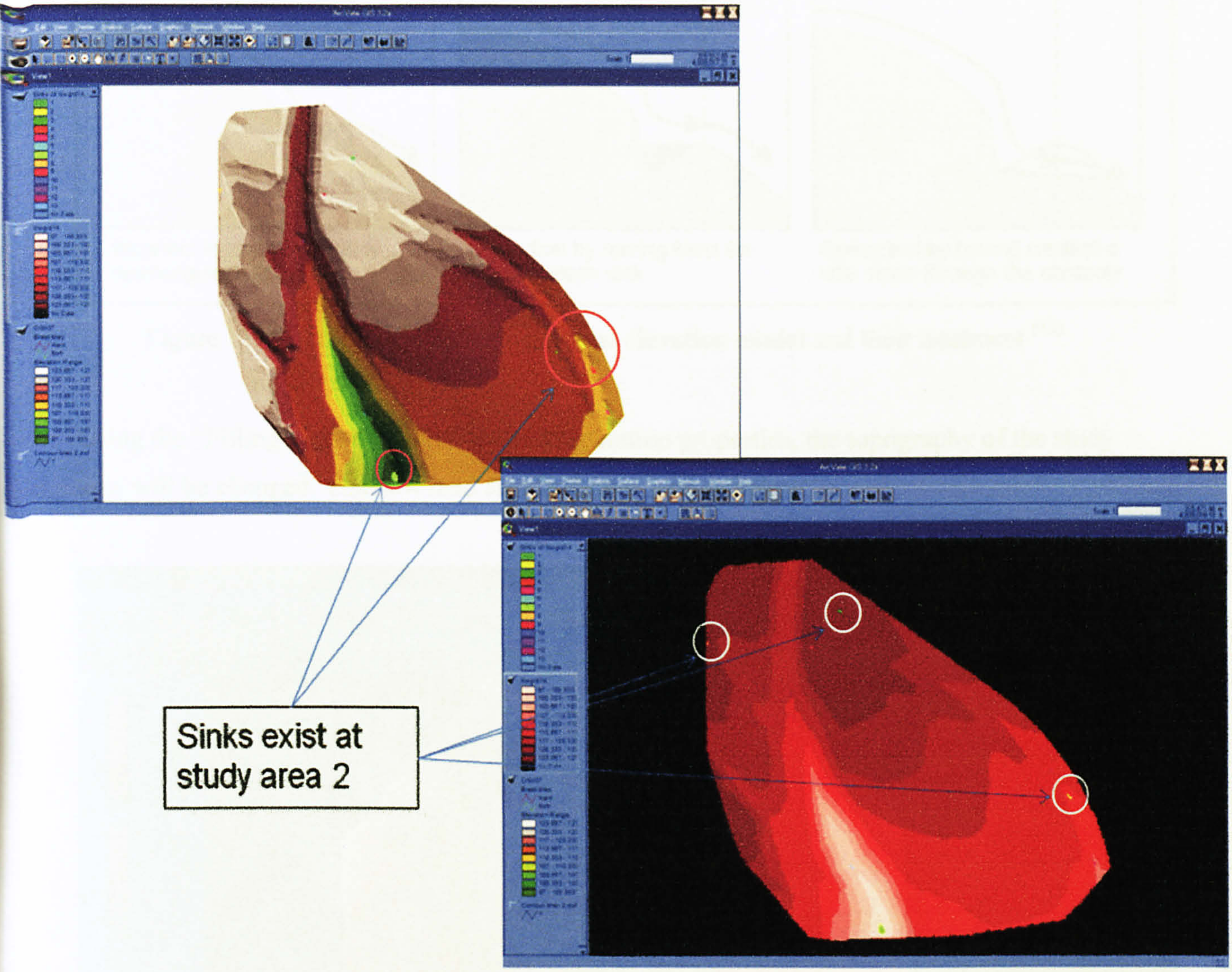


Figure 16: Example of sinks derived before fill

Sinks can be illustrated as below:

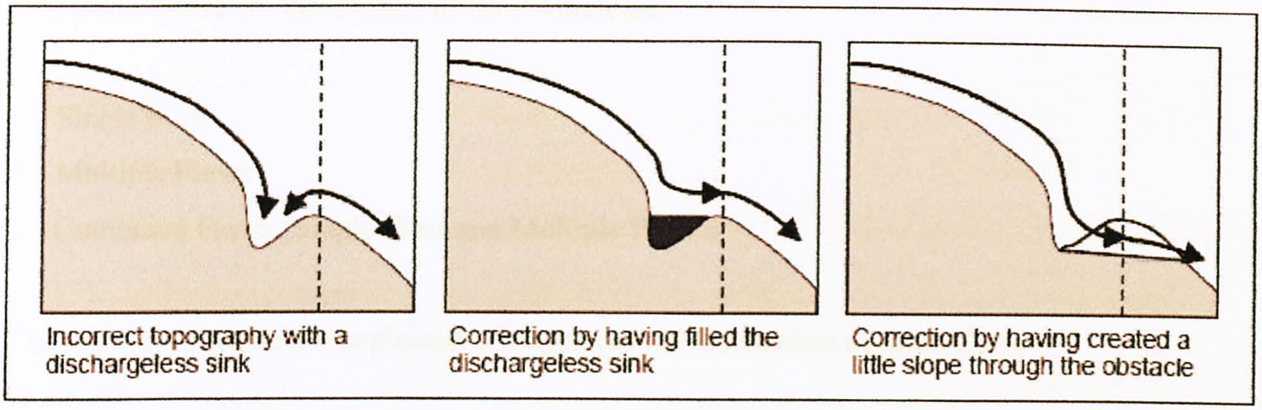


Figure 17: Dischargeless sinks in a digital elevation model and their treatment [12]

Using the "Filling Sinks" function under Preparation properties, the topography of the study area will be changed. The new land area is shown such as below:

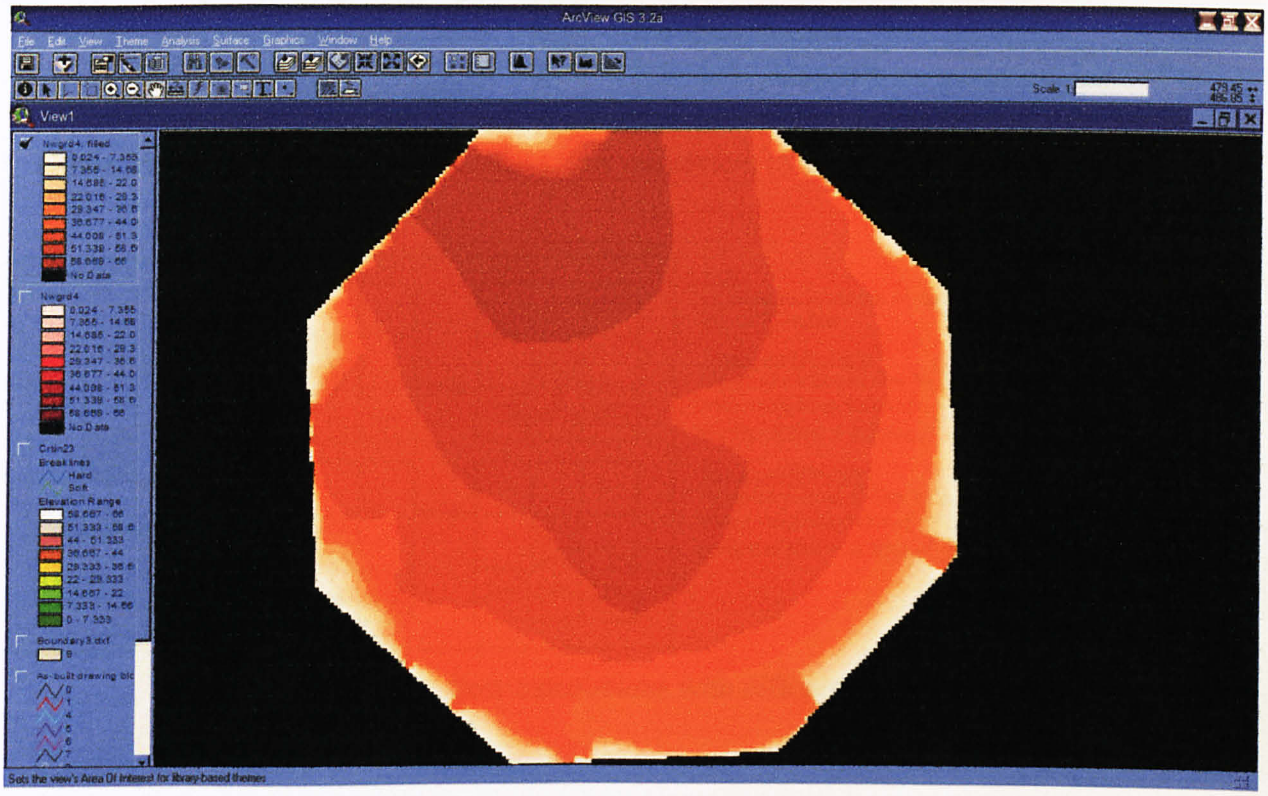
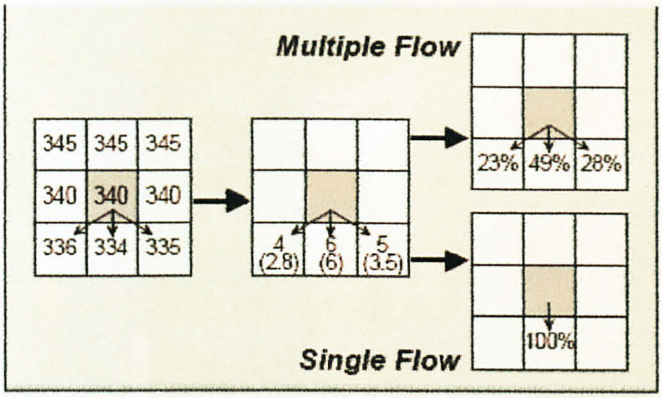


Figure 18: Filled sinks applied to the study area

After the sinks were filled, the author took the next step in determining the hydrological nature of the study area by using the Flow Accumulation function under Hydrology properties. There are three kinds of flow which are:

1. Single Flow
2. Multiple Flows
3. Combined Flows (Single Flow and Multiple Flows)

The picture shown below explained briefly about the mechanism of these flows



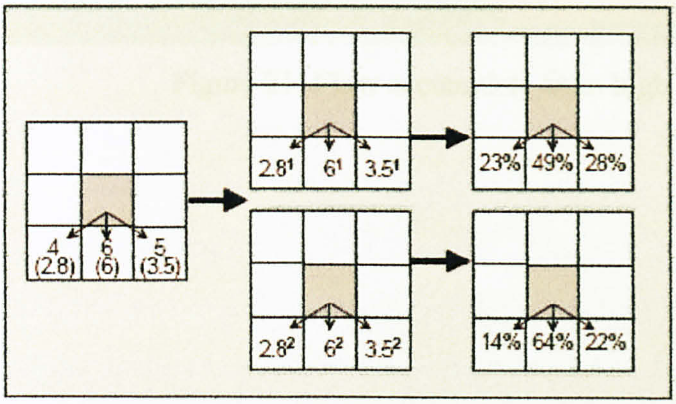
Left:
Part of a digital elevation model with altitudes in m; black arrows show possible flow paths of flow from the central grey pixel

Middle:
Differences in altitude of the flow paths in m; adjusted differences in brackets (because of the longer distance the differences to the corner cells are recalculated by the formula: (height difference / √2)

Right, upper part:
Received portion of flow, calculated with a multiple flow algorithm and the formula: difference / ∑ difference

Right, lower part:
Received portion of flow, calculated with a single flow algorithm and the principle: 100% flow to the cell of the steepest descent

Figure 19: Basic algorithms to calculate flow movement (Single versus multiple flows)[12]



Left:
Differences in altitude of the flow paths in m; same as above in Figure 7, middle

Upper, middle-right:
Received portion of flow by the multiple flow method; calculated with a weighting value of c = 1 and the subsequent formula: portion of flow = $difference^c$ / Sum ($difference^c$)

Lower, middle-right:
Received portion of flow by the multiple flow method, calculated with a weighting value of c = 2 and the subsequent formula. portion of flow = $difference^c$ / Sum ($difference^c$)

Figure 20: Multiple flow calculations with different weighting[12]

For this project, the author chooses "Multiple Flows" to present the water accumulation and its flow. This is because in reality, the chance for multiple flow principle to happen is the highest between all three.

After choosing the "Multiple Flow" function, the result is shown as below

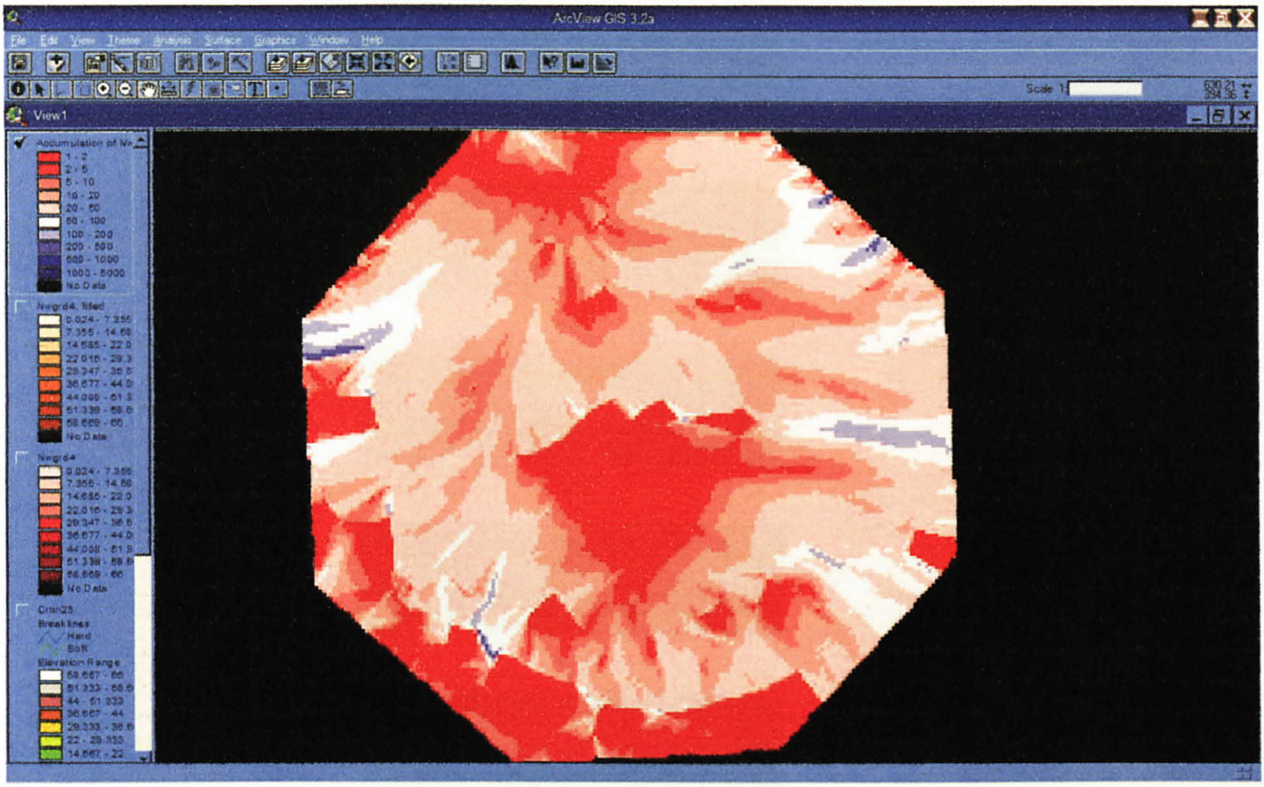


Figure 21: Flow accumulate from high altitude to lower altitude

3.3 Project Flow

The flowchart shows the steps taken in completing the project.

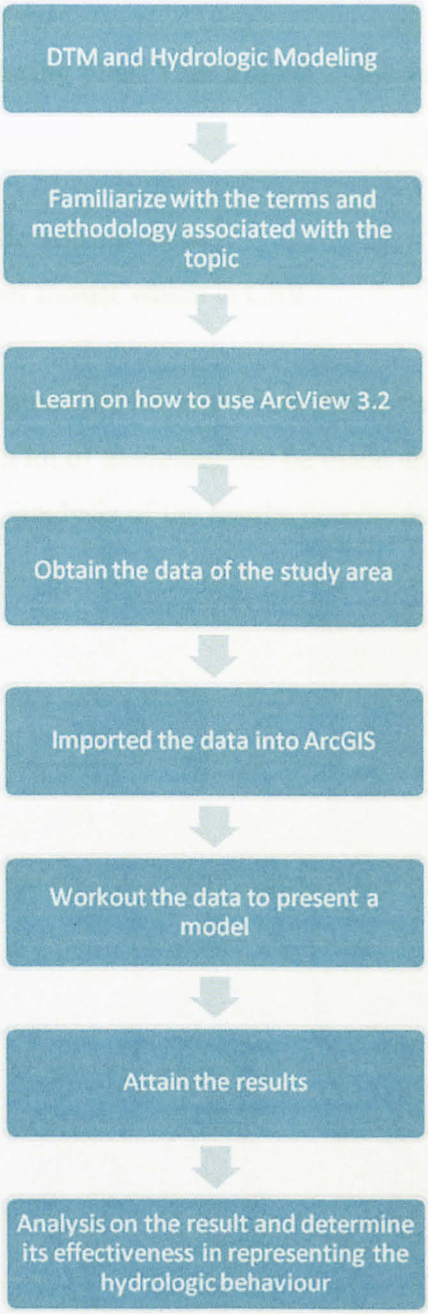


Figure 22: Project flowchart

The first two steps which are familiarize with the term and methodology and learn on how to use ArcView were done at the first phase of the of this final year project mainly during the first semester of the author's final year.

On the second phase which is during Final Year Project 2, the author obtains the data by two means, which are:

1. As-Built drawing from license surveyor
2. In one of Microsoft Excel format which is CSV

By using ArcView, the data obtained are imported into this software and a model is created. Depend on the author's desire, a lot of modeling can be made and use to predict or measure the data. Upon attaining the results, analysis of the results determines the effectiveness of the hydrologic behavior.

CHAPTER 4

RESULTS AND DISCUSSIONS

Single Flow for Study Area 1

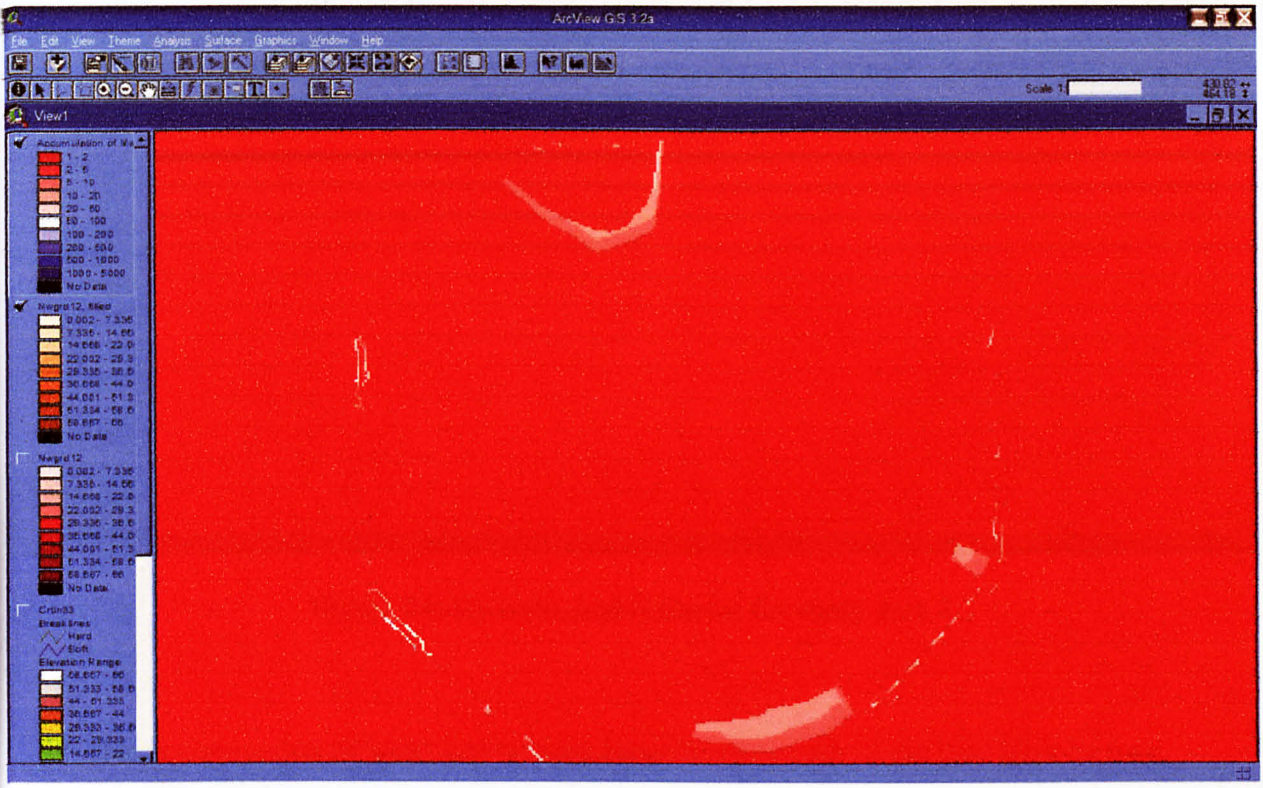


Figure 23: Hydrologic behavior for study area 1

✓ Only a small water accumulation can be seen in the area

Single Flow for Study Area 2

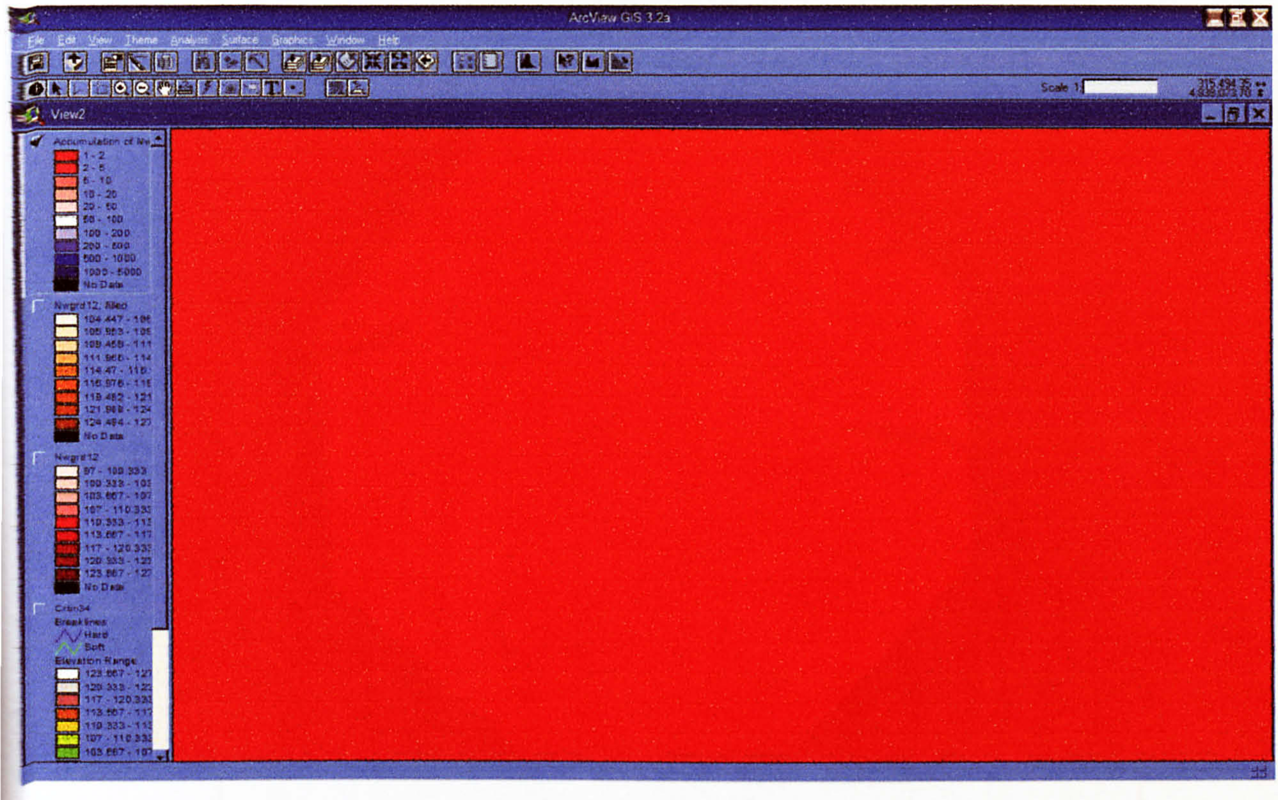


Figure 24: Hydrological behavior for study area 2

- ✓ No accumulation of water can be seen because every path of the land have its own starting point

Multiple Flows for Study Area 1

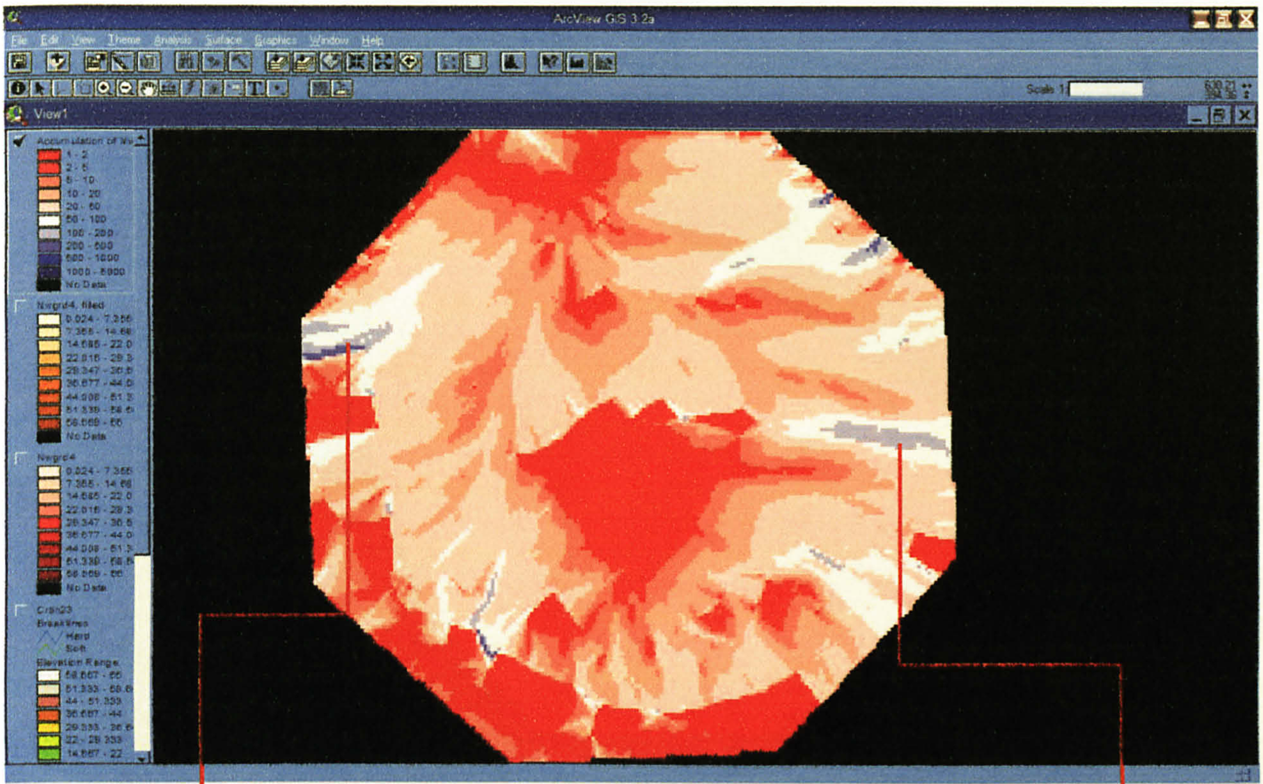


Figure 25: Hydrological behavior for study area 1

A large amount of water flowing through this area

A large amount of water flowing through this area

There are a few obstacles and uncertainties in doing this work. They are the intensity of the rainfall and the land behavior that may change in an event such as erosions and other things.

Multiple Flows for Study Area 2

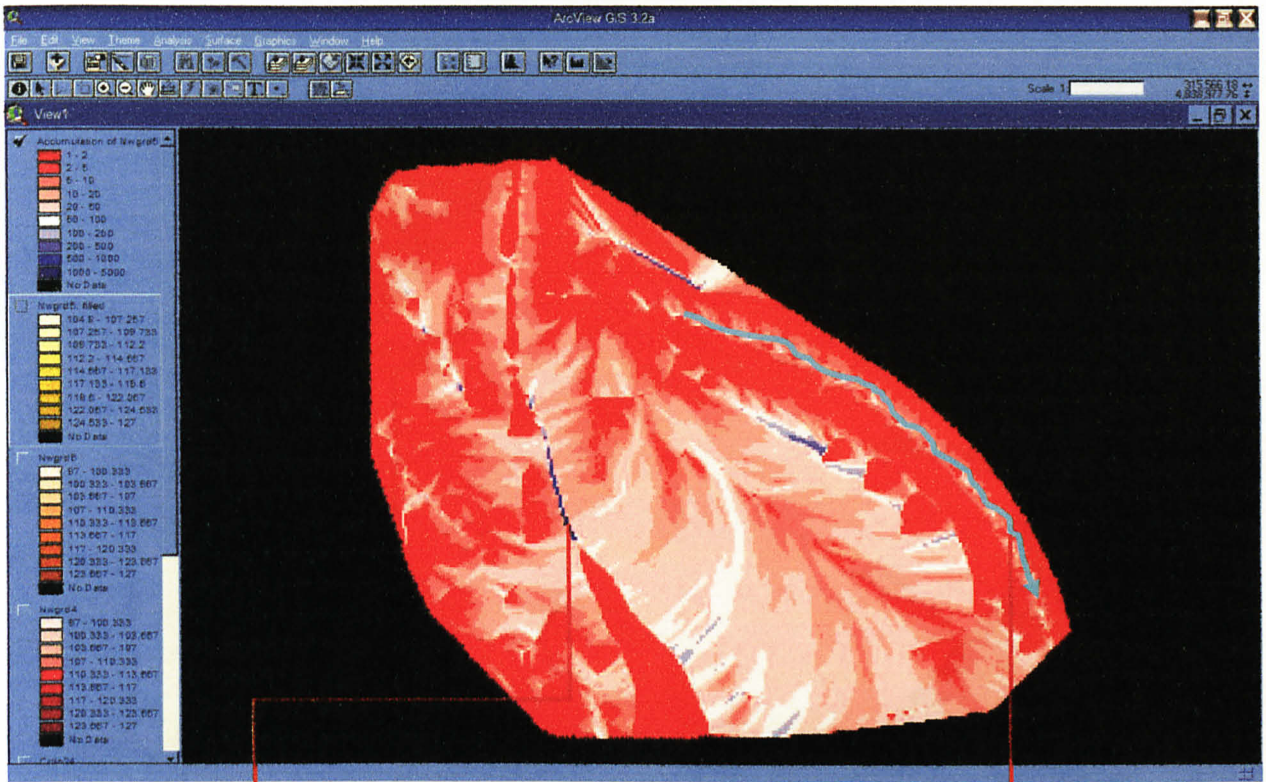


Figure 26: Hydrological behavior for study area 2

The blue line shows that the area has a high intensity of water flowing in a straight direction

The white area clearly shows that a high intensity of water is flowing at one direction

Combine Flow for Study Area 1

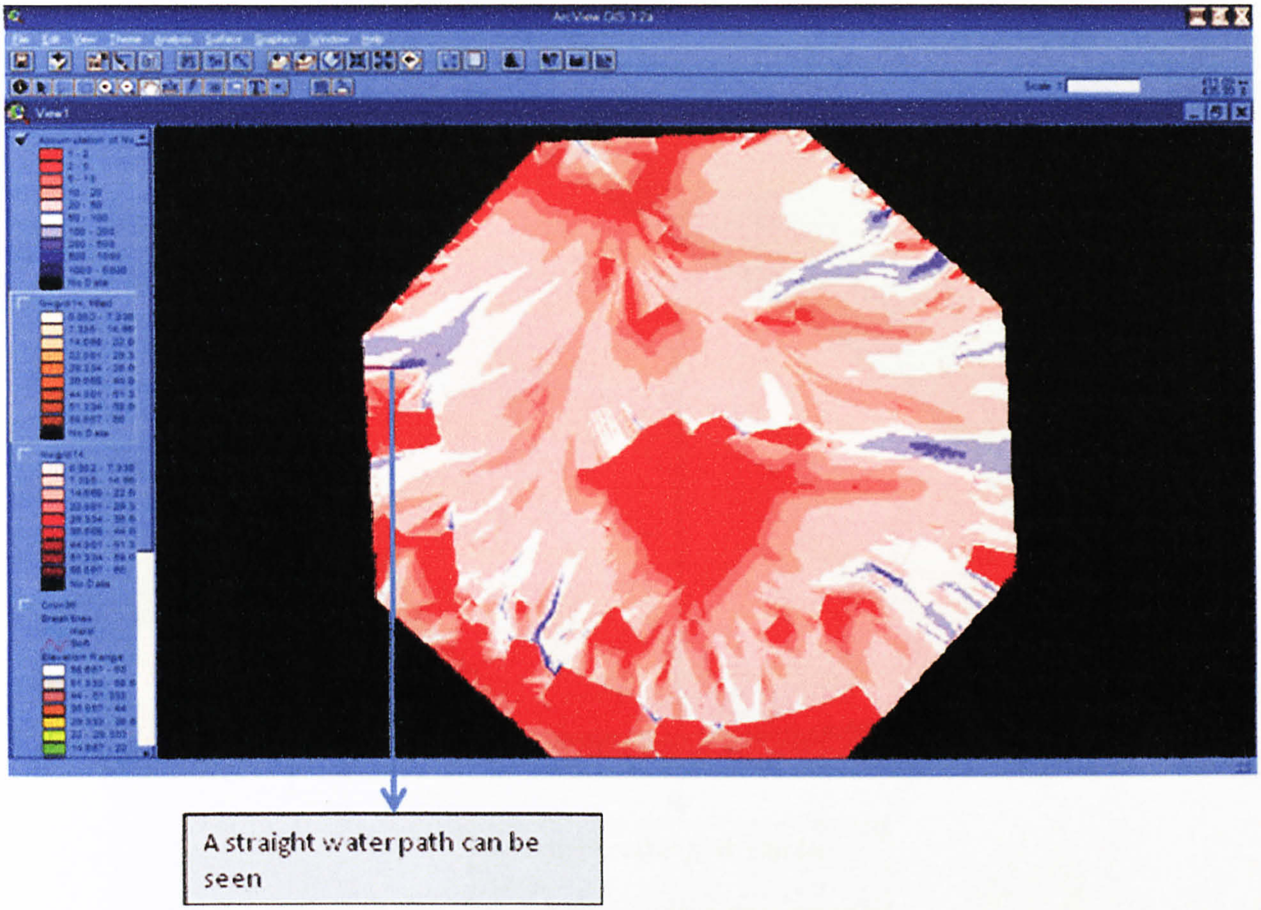


Figure 27: Hydrological behavior for study area 1

Combine Flow for Study Area 2

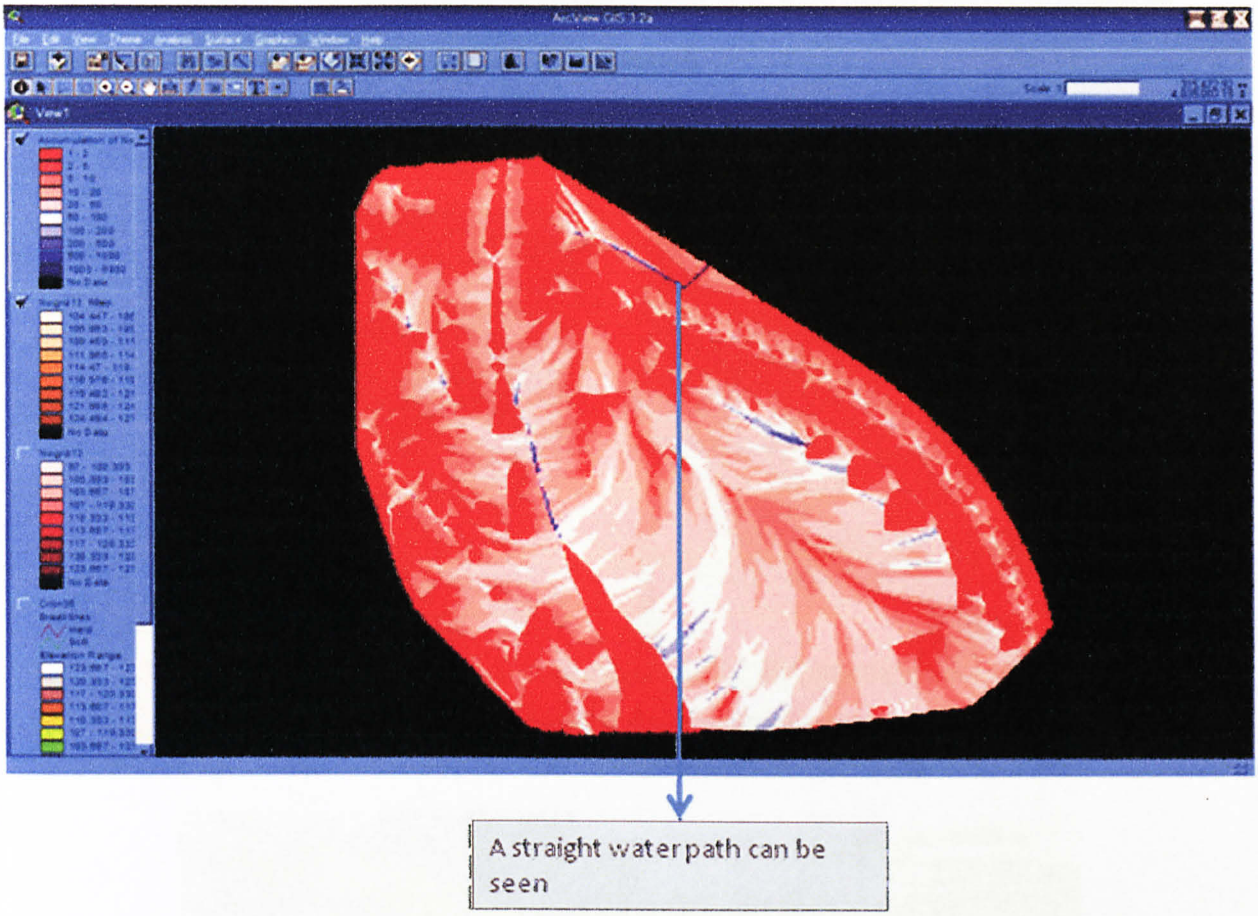


Figure 28: Hydrological behavior for study area 2

From all three method of representing the hydrological flow, the author chooses the Multiple Flow method because it best represents the flow in the real world.

Based on the Multiple Flow method results, it is obvious that the two areas stated above in study area 1 and 2, are having a large amount of water running at that place. Drainages or channel have to be built along those areas because the high intensity of water running through there. If these places do not have any significant drainage to cater for the water, a catastrophic situation may occur such as flood or even land slide because the water penetrate through into the ground in a large amount and weaken the soil strength.

The end result of this project would be determining or predicting the upcoming outflow and inflow of the studied area. This would be essential as it may help future engineers to design channels, drainages or irrigations prior to this research.

Study Area 1 – Ground Picture

Figure 29: Existing drain at study area 1

Figure 30: Existing drain at study area 1

Figure 31: Existing drain at study area 1

Figure 32: Existing drain at study area 2

Study area 2 – Ground Picture

Figure 33: Existing drain at study area 2

Figure 34: Existing drain at study area 2

Figure 35: Existing drain at study area 2

Figure 36: Existing drain at study area 2

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 CONCLUSION

The aims or objectives of this whole project have been met, which are:

1. To generate Digital Terrain Modeling to show the hydrologic flow of the study area

2. To develop a workable simulation of water drain on the earth surface using Geographical Information System.

This project is successful in presenting the hydrologic application. The flows of water accumulated and follow its path thus showing water drainages. By showing where the large volume of water accumulated, the author could predict where drainage or channel should be built to prevent any unwanted condition. This may prevent flood occurrences in the future.

5.2 RECOMMENDATIONS

There are a few recommendations that the author can look into to improve or obtaining a better result.

- Take more study area and find areas that are overlapping each other, this will produce more precise and related set of data
- Implement the use of total station to record the elevation of the terrain
- Study more on the use of land porosity and groundwater

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APPENDIX A

PROJECT GANTT CHART

Final Year Project 1

No.	Work/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Selection of Project Topic	■	■													
2	Seminar 1 (compulsory)		■	■	■											
3	Project Work					■	■	■								
5	Seminar 2 (compulsory)						☆									
6	Submission of Progress Report						☆									
7	Project work continues									■	■	■	■	■	■	
8	Submission of Interim Report Final Draft								■	■	■	■	■	■	■	
9	Oral presentation															☆

Final Year Project 2

No	Work/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Continuing from previous semester	■	■	■	■	■										
2	Submission of Combined Progress Report						■									
3	Seminar 1							■								
4	Field work								■							
5	Project work						■	■	■	■	■	■				
6	Poster Presentation										■					
7	Dissertation Report Submission												■			
8	Preparing for Oral presentation													■	■	
9	Oral presentation															■

APPENDIX B

DATA FROM CSV FILE

1000	1001.708	983.564	100.526	DRAIN
1001	1000.221	984.416	100.579	DRAIN
1002	1004.105	987.005	100.54	DRAIN
1003	1002.733	988.197	100.518	DRAIN
1004	1005.984	989.669	100.543	DRAIN
1005	1004.553	990.685	100.477	DRAIN
1006	1006.92	993.787	100.602	DRAIN
1007	1008.031	995.678	100.593	DRAIN
1008	1009.128	997.313	100.514	DRAIN
1009	1012.016	999.527	100.427	DRAIN
1010	1018.086	1006.479	100.416	DRAIN
1011	1020.492	1008.492	100.472	DRAIN
1012	1022.226	1007.823	100.514	DRAIN
1013	1024.628	1009.814	100.526	DRAIN
1014	1023.458	1011.17	100.438	DRAIN
1015	1029.342	1013.489	100.478	DRAIN
1016	1028.208	1014.999	100.423	DRAIN
1017	1008.423	978.498	104.817	DRAIN
1018	1007.477	979.147	104.789	DRAIN

1019	1009.472	979.971	104.829	DRAIN
1020	1008.637	980.881	104.787	DRAIN
1021	1010.695	982.515	105.184	DRAIN
1022	1009.972	982.987	104.78	DRAIN
1023	1011.013	983.535	105.305	DRAIN
1024	1010.269	984.022	104.715	DRAIN
1025	1026.16	1000.804	105.2	DRAIN
1026	1025.415	1001.766	105.085	DRAIN
1027	1027.815	1002.361	105.172	DRAIN
1028	1027.127	1003.145	105.064	DRAIN
1029	1032.938	1006.197	105.132	DRAIN
1030	1032.496	1007.134	105.005	DRAIN
1031	1016.324	974.644	109.523	DRAIN
1032	1015.2	975.144	109.675	DRAIN
1033	1017.58	976.726	109.509	DRAIN
1034	1016.691	977.477	109.633	DRAIN
1035	1019.145	978.998	109.522	DRAIN
1036	1018.155	979.713	109.663	DRAIN
1037	1028.545	989.633	109.359	DRAIN
1038	1027.567	990.321	109.538	DRAIN
1039	1031.516	992.562	109.385	DRAIN
1040	1030.779	993.479	109.533	DRAIN

1041	**1034.83**	**995.339**	**109.386**	**DRAIN**
1042	**1034.162**	**996.349**	**109.507**	**DRAIN**
1043	**1040.461**	**999.553**	**109.383**	**DRAIN**
1044	**1039.959**	**1000.542**	**109.505**	**DRAIN**
1045	**1024.469**	**968.991**	**114.93**	**DRAIN**
1046	**1023.355**	**969.395**	**115.049**	**DRAIN**
1047	**1026.549**	**973.794**	**114.921**	**DRAIN**
1048	**1025.58**	**974.488**	**114.847**	**DRAIN**
1049	**1028.976**	**977.41**	**114.754**	**DRAIN**
1050	**1028.265**	**978.197**	**114.749**	**DRAIN**
1051	**1033.154**	**981.938**	**114.633**	**DRAIN**
1052	**1032.376**	**982.771**	**114.55**	**DRAIN**
2000	**1008.246**	**989.05**	**101.943**	**SLOPE**
2001	**1008.559**	**987.662**	**102.824**	**SLOPE**
2002	**1009.635**	**985.872**	**103.993**	**SLOPE**
2003	**1010.149**	**984.171**	**104.751**	**SLOPE**
2004	**1013.623**	**985.043**	**105.597**	**SLOPE**
2005	**1015.925**	**984.272**	**106.291**	**SLOPE**
2006	**1017.402**	**983.174**	**107.342**	**SLOPE**
2007	**1018.108**	**981.028**	**108.391**	**SLOPE**
2008	**1018.252**	**980.235**	**109.649**	**SLOPE**
2009	**1019.669**	**980.068**	**109.447**	**SLOPE**

2010	**1020.524**	**980.925**	**109.671**	**SLOPE**
2011	**1022.384**	**982.2**	**108.991**	**SLOPE**
2012	**1024.189**	**983.766**	**108.928**	**SLOPE**
2013	**1025.525**	**985.465**	**109.024**	**SLOPE**
2014	**1026.7**	**986.196**	**110.408**	**SLOPE**
2015	**1028.179**	**987.646**	**110.381**	**SLOPE**
2016	**1028.654**	**989.293**	**109.756**	**SLOPE**
2017	**1028.009**	**991.119**	**109.117**	**SLOPE**
2018	**1030.309**	**993.253**	**109.44**	**SLOPE**
2019	**1028.086**	**993.562**	**108.132**	**SLOPE**
2020	**1030.976**	**994.445**	**109.542**	**SLOPE**
2021	**1028.433**	**995.177**	**107.72**	**SLOPE**
2022	**1031.386**	**995.474**	**109.271**	**SLOPE**
2023	**1025.791**	**995.222**	**106.926**	**SLOPE**
2024	**1026.941**	**998.966**	**105.737**	**SLOPE**
2025	**1026.256**	**1000.497**	**105.461**	**SLOPE**
2026	**1024.933**	**1002.429**	**104.404**	**SLOPE**
2027	**1023.882**	**1003.075**	**103.273**	**SLOPE**
2028	**1022.712**	**1006.141**	**101.44**	**SLOPE**
2029	**1022.379**	**1007.315**	**100.702**	**SLOPE**
2030	**1019.706**	**1006.149**	**100.747**	**SLOPE**
2031	**1017.45**	**1004.68**	**100.92**	**SLOPE**

2032	1014.335	1001.543	100.744	SLOPE
2033	1011.462	998.626	100.844	SLOPE
2034	1009.116	997.681	100.422	SLOPE
2035	1007.823	994.823	101.219	SLOPE
2036	1005.589	992.338	100.413	SLOPE
2037	1007.267	990.428	101.621	SLOPE
2038	1006.84	989.477	101.212	SLOPE
2039	1007.691	989.031	101.675	SLOPE
2040	1006.017	989.79	100.48	SLOPE
3000	1009.052	995.577	101.546	CRS SEC
3001	1010.494	994.102	102.7	CRS SEC
3002	1011.877	993.115	103.509	CRS SEC
3003	1012.858	991.66	104.049	CRS SEC
3004	1013.679	990.996	104.783	CRS SEC
3005	1014.37	990.035	104.981	CRS SEC
3006	1015.015	989.309	105.084	CRS SEC
3007	1015.985	988.516	105.264	CRS SEC
3008	1016.645	987.613	105.487	CRS SEC
3009	1017.892	987.129	105.779	CRS SEC
3010	1018.501	986.566	105.971	CRS SEC
3011	1019.679	985.649	106.252	CRS SEC
3012	1020.478	984.898	106.615	CRS SEC

2032	1014.335	1001.543	100.744	SLOPE
2033	1011.462	998.626	100.844	SLOPE
2034	1009.116	997.681	100.422	SLOPE
2035	1007.823	994.823	101.219	SLOPE
2036	1005.589	992.338	100.413	SLOPE
2037	1007.267	990.428	101.621	SLOPE
2038	1006.84	989.477	101.212	SLOPE
2039	1007.691	989.031	101.675	SLOPE
2040	1006.017	989.79	100.48	SLOPE
3000	1009.052	995.577	101.546	CRS SEC
3001	1010.494	994.102	102.7	CRS SEC
3002	1011.877	993.115	103.509	CRS SEC
3003	1012.858	991.66	104.049	CRS SEC
3004	1013.679	990.996	104.783	CRS SEC
3005	1014.37	990.035	104.981	CRS SEC
3006	1015.015	989.309	105.084	CRS SEC
3007	1015.985	988.516	105.264	CRS SEC
3008	1016.645	987.613	105.487	CRS SEC
3009	1017.892	987.129	105.779	CRS SEC
3010	1018.501	986.566	105.971	CRS SEC
3011	1019.679	985.649	106.252	CRS SEC
3012	1020.478	984.898	106.615	CRS SEC

3013	1021.059	984.208	107.036	CRS SEC
3014	1021.889	983.332	107.853	CRS SEC
3015	1022.173	982.786	108.558	CRS SEC
3016	1022.57	982.616	109.164	CRS SEC
3017	1022.22	982.125	109.689	CRS SEC
3018	1021.681	1007.363	100.466	CRS SEC
3019	1022.39	1006.292	101.062	CRS SEC
3020	1023.081	1005.238	101.716	CRS SEC
3021	1023.17	1004.215	102.623	CRS SEC
3022	1023.806	1002.876	103.376	CRS SEC
3023	1024.453	1001.987	103.952	CRS SEC
3024	1025.447	1000.801	104.567	CRS SEC
3025	1026.307	999.693	105.543	CRS SEC
3026	1026.852	998.661	105.792	CRS SEC
3027	1027.302	996.623	106.92	CRS SEC
3028	1027.5	995.474	107.186	CRS SEC
3029	1027.971	993.521	108.042	CRS SEC
3030	1028.23	992.404	108.352	CRS SEC
3031	1028.282	991.465	108.711	CRS SEC
3032	1028.604	990.52	109.267	CRS SEC
3033	1028.991	989.089	110.006	CRS SEC
4000	1028.175	989.312	109.24	CNTR

4001	1027.449	987.878	109.68	CNTR
4002	1026.501	986.758	109.792	CNTR
4003	1026.027	986.213	109.706	CNTR
4004	1025.168	985.638	108.896	CNTR
4005	1024.395	984.77	108.51	CNTR
4006	1023.386	983.894	108.016	CNTR
4007	1022.298	983.431	107.861	CNTR
4008	1021.676	983.083	107.897	CNTR
4009	1020.789	982.516	108.149	CNTR
4010	1020.215	983.221	107.348	CNTR
4011	1021.237	983.931	107.033	CNTR
4012	1022.902	984.451	107.482	CNTR
4013	1023.347	985.478	107.645	CNTR
4014	1024.524	986.404	108.045	CNTR
4015	1025.104	987.525	108.085	CNTR
4016	1026.199	988.773	108.259	CNTR
4017	1027.346	989.568	108.626	CNTR
4018	1026.132	990.164	107.941	CNTR
4019	1024.872	989.707	107.609	CNTR
4020	1023.917	989.412	107.242	CNTR
4021	1022.742	989.072	106.668	CNTR
4022	1021.196	988.747	106.188	CNTR

4023	1019.782	987.605	106.032	CNTR
4024	1018.639	986.647	106.006	CNTR
4025	1017.473	985.673	106.118	CNTR
4026	1016.372	984.951	106.258	CNTR
4027	1014.793	985.726	105.742	CNTR
4028	1015.435	986.525	105.584	CNTR
4029	1015.945	987.28	105.625	CNTR
4030	1016.327	987.712	105.379	CNTR
4031	1016.969	988.691	105.913	CNTR
4032	1017.821	989.652	105.677	CNTR
4033	1019.247	991.237	106.141	CNTR
4034	1021.196	991.953	106.082	CNTR
4035	1022.475	992.868	106.352	CNTR
4036	1022.77	995.222	106.129	CNTR
4037	1021.61	995.303	105.387	CNTR
4038	1021.796	996.921	104.869	CNTR
4039	1022.693	997.98	104.754	CNTR
4040	1022.844	999.168	104.429	CNTR
4041	1023.018	1000.665	104.136	CNTR
4042	1019.833	999.229	103.537	CNTR
4043	1018.206	998.64	103.357	CNTR
4044	1017.072	998.525	103.017	CNTR