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HYDROGRAPHIC SURVEY USING REAL TIME KINEMATIC METHOD FOR RIVER DEEPENING

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ABSTRACT

There is many surveys's method in hydrographic surveying due to development of technologies. The latest development in technologies for example Global Positioning System (GPS) gives new challenges in surveying field. Surveyors use GPS technology for simple tasks or complex tasks. In hydrographic survey, the important data required are position, tidal reading and depth value. Normally, tidal reading is obtained at tidal station established near to survey area by using instrument like automatic or self-recording tide gauge. Depth of seabed is measured by using single beam or multi beam echo sounder without add up tidal value at the same time. The latest technique of getting position and depth simultaneously is by using RTK method.

Key words: Real-Time Kinematic GPS, Hydrographic surveys.

1.0 INTRODUCTION

Hydrographic is the science of marine surveying that determines the position of points and objects on the globe's surface and also depths of the sea. In the 1920s the technology of hydrographic changed when they found possible way to measure depths. There are many instruments have been designed to achieve better standard of surveying. With that advanced instruments, surveyor able to perform better and simple data acquisition of observation in surveying and at the same time achieve better accuracy in their observations.

According to Lister (2010), hydrographic survey involves the gathering of data about a particular area of water. This will usually be carried out to confirm that it is safe for boats to navigate and to identify any potential dangers. Some of the measurements which will be taken in a hydrographic survey are tides, currents and waves. Other than that, typical hydrographic surveys are carried out for the purpose of navigation and other surveys differ from it in terms of techniques used and the final desired output. For instance, bathymetric surveys are aimed at collecting depth data.

These new depth-measuring systems collect vast amounts of data, and processing it has become a major challenge. All survey ships now carry computer systems that process it online, and in some cases produce digital plots on board. Data visualization has become an important task both for the purpose of refining survey work while still in the field, and as a final product in forms such as the electronic chart for navigators and other users. Different equipment being

used will need different method to conduct the hydrographic survey either using the conventional method or GPS based method.

For this research, the GPS based method will be used. The use of GPS will allow the position of points to be obtained directly and this is good especially when real-time method of positioning is involved. In this study, method of RTK-GPS will be applied. Using RTK technique, final depth measurement can be calculated directly. This is because the tidal value already adds up in depth taken from echo sounder to seabed and height of GPS when using software such as HYDROpro.

1.1 Tidal

According to Cawood (2004), tide refers to the elevation of the surface of the water disregarding waves and swells. Tide values vary greatly with geographical location and are affected by up to thirty-seven different forces, including the gravitational forces of the sun and the moon, winds, currents, and the topography and bathymetry of the area.

The earth and the moon are attracted to each other by gravitational attraction as shown in **Figure 1**. The moon tries to pull at anything on the earth to bring it closer but the earth is able to hold onto everything except the water. Since the water is always moving, the earth cannot hold onto it, and the moon is able to pull at it.

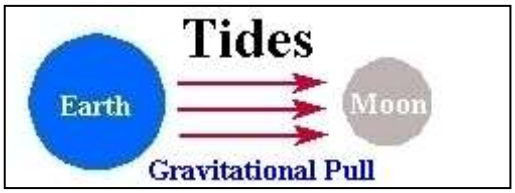

Figure 1: gravitational attraction of the moon
(Source http://home.hiwaay.net/~krcool/Astro/moon/moontides/)

According to Cooley (2002), the earth and the moon are two great masses that have a significant gravitational pull on each other. This is what keeps the moon in orbit around the earth, and it is also what causes tides to occur in the ocean. As the moon travels around the earth and they travel around the sun, the combined gravitational forces cause the world's oceans to rise and fall.

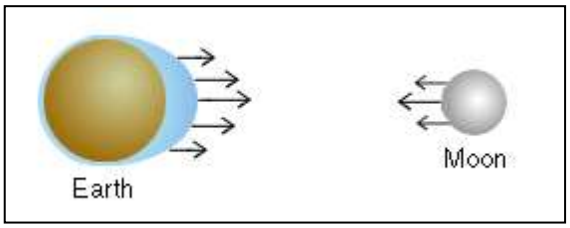

Figure 2: The cause of tides to occur in the ocean.
(Source: http://www.oceanlink.info/oinfo/tides/tides.html)

The moon's gravity pulls on the earth, and pulls the water towards it as shown in **Figure 2**. The water moves up into a slight bulge on the side of the earth that faces the moon. At the same time, there is a force pulling water out in the opposite direction of the moon. The earth turns upon its own axis in about 24 hours, a point on the earth moves through areas with these different forces acting on it.

According to Kay (2010) a diurnal tide has one of high water and one of low water each day. These tides usually occur in locations when the moon is farthest from the equator. A semi-diurnal tide has two of equal high water and two of low equal water each day. The second high tide rises to the same level it did in the first high tide and the second low tide falls to the same level it did in the first low tide.

Semi-diurnal tides tend to occur when the moon is directly over the equator. Mixed tides, like the semi-diurnal tide, can have two of high water and two of low water per day. However, unlike a semi-diurnal tide, mixed tides are unequal, meaning they do not rise and fall to the same levels. Mixed tides can either include both sets of unequal high and low waters, or only one set of unequal high or low waters. Mixed tides will happen when the moon is extremely far north or extremely far south of the equator.

1.2 Equipment for Tidal Observation

Normally, tidal reading is obtained at tidal station established near to survey area by using instrument like automatic or self-recording tide gauge. Equipment for self-recording tide gauge is by using tide staff. One person need to record the tidal reading manually within time range needed by the project.

Another equipment can be used for self-recording tide gauge is Valeport Tide Gauges for example. Using this equipment, the tidal reading will be recorded automatically. Tidal reading will be recorded in the setting of this equipment. In this study, tidal reading will be using RTK technique. It means that tidal reading automatically adds-up to the depth in order to get the final reading.

1.3 Global Positioning System

Static GPS where the receiver is stationary is the original GPS method. It is still the preferred approach to establishing the most accurate positions for the control. Static GPS control methods are useful in GPS methods where the receiver is on a moving platform. These methods include real-time kinematic, RTK, and Differential GPS, DGPS work.

Modern Surveying is unimaginable without the use of electronic equipment and information technology. Surveying with conventional systems has been completely replaced with advanced automated systems stated by Satheesh (2010).GPS encompasses three segments as shown in Figure 3.

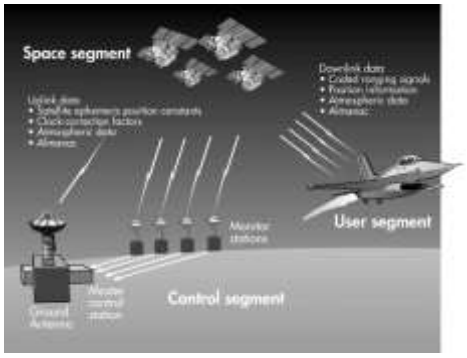

Figure 3: Segment in GPS System.
(Source: http://infohost.nmt.edu/~mreece/gps/whatisgps.html)

According to Andrews (2001), the segments are space, control, and user. The space segment includes the 24 operational Navigation Signal Timing and Ranging Global Positioning System, NAVSTAR satellites that orbit the earth every 12 hours at an altitude of approximately 20,200 kilometres. The control segment is a group of ground stations that monitor and operate the GPS satellites. The user requires a GPS receiver in order to receive the transmissions from the satellites. The GPS receiver calculates the location based on signals from the satellites.

1.4 The Structure of Differential Global Positioning System

According to Jack (2000), DGPS uses two or more GPS receiver-antenna units to position an unknown point or set of points relative to a known point or set of points. Morag (2011) mentioned that the underlying premise of differential GPS, DGPS is that any two receivers that are relatively close together will experience similar atmospheric errors. Meter-level DGPS surveys utilize GPS code phase measurements and are primarily based on the C/A code modulated on frequency L1 stated by Jack (2000).

The corrected information can be applied to data from the roving receiver in real time in the field using radio signals or through post processing after data capture using special processing software. The problems of obtaining high accuracy real time positions in the field have led the surveying community to develop a DGPS-like real time method called Real Time Kinematic GPS, RTK GPS.

1.5 Real Time Kinematic, RTK

Centimetre-level accuracy positioning in real-time based on GPS measurements referred to RTK, real-time kinematic positioning mentioned by Lambert (2004). The principle of RTK GPS is similar to that of DGPS, except that the RTK method uses and processes carrier phase observations for positioning.

Real-time DGPS occurs when the base station calculates and broadcasts corrections for each satellite as it receives the data stated by Morag (2011). The correction is received by the roving receiver via a radio signal if the source is land based or via a satellite signal if it is satellite based and applied to the position it is calculating. As a result, the position displayed and logged to the data file of the roving GPS receiver is a differentially corrected position.

The reason that RTK GPS can produce accuracies on the order of cm is that it uses phase observations mentioned by Cetin (2009).Since carrier phase observations produce more precise

positions than code measurements, spatial positions obtained from RTK GPS are of better quality, with a precision in order of cm stated by Cetin (2009).

As shown in **Figure 4** in RTK GPS mode, one GPS receiver placed on a station is kept static (reference station) during the whole observation session, while the other receiver moves among points (rover stations) whose spatial positions are to be determined.

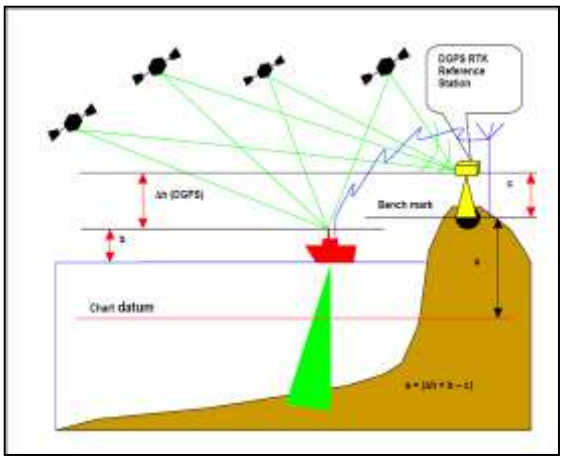

Figure 4: Principle of Real Time Kinematic DGPS elevation determination
(Source: http://www.fig.net/commission4/iho/M-13_Chapter_7.pdf)

In addition, both reference and rover stations are equipped with dual frequency receivers. Reference receiver has a radio transmitter aimed to send phase observation corrections to rover receiver which is also equipped with radio modem to establish a link with the reference station. The radio modem used in this system has to update the correction data sent to a rover in 0.5-2s.

According to Jack (2000), the kinematic GPS solution can be determined either in real-time or after post processing. Real time in the term real-time kinematic, RTK GPS simply refers to the fact that the carrier phase corrections are transmitted in real time via some (wireless) data link. Post-processed kinematic GPS methods might not exist were it not for the complexity associated with real-time data links and the resolution of the carrier phase ambiguity in real time.

When RTK-GPS technology first arrived on the scene years ago, hydrographers knew it would have a tremendous application in hydrographic surveying by providing an accurate z-positioning component of the sonar transducer at an exact place and time mentioned by Tim (2004). According to Sunil (2010), the development over the past decade of commercial, carrier phase, differential, kinematic GPS, specifically Real-Time Kinematic, RTK GPS has meant that an RTK-equipped buoy can potentially be used to accurately measure water level height above the WGS84 ellipsoid.

1.6 Depth Determination

According to Nathaniel (1995), open waters are best surveyed using an array of transducers spread out athwart ships across the hull of the survey vessel. In shallow water, track lines must be much closer together than in deep water also mentioned by Nathaniel Bowditch, 1995. This is fine with hydrographers because shallow waters need more closely spaced data to provide an accurate portrayal of the bottom on charts.

Arzu (2004) mentioned that any type of positioning method or system may be used to locate the depth measurement device. RTK GPS receivers can measure the latitude, longitude and height above the WGS-84 reference ellipsoid to within a few centimetres. Using this vertical accuracy, water level corrections (tide corrections) can determine. This eliminates the need to use conventional tide gauges or to assign personnel to monitor tide staffs. So, must establish their own RTK base station to supply differential corrections to the boat-GPS. In addition, users must pre-determine the separation between the WGS-84 reference ellipsoid and the appropriate chart datum in their survey area.

From **Figure 5** and **6**, how the tidal reading will be collected using RTK technique. This survey was conduct using Mean Sea Level as a datum. Base station located at the land while rover station at the boat.

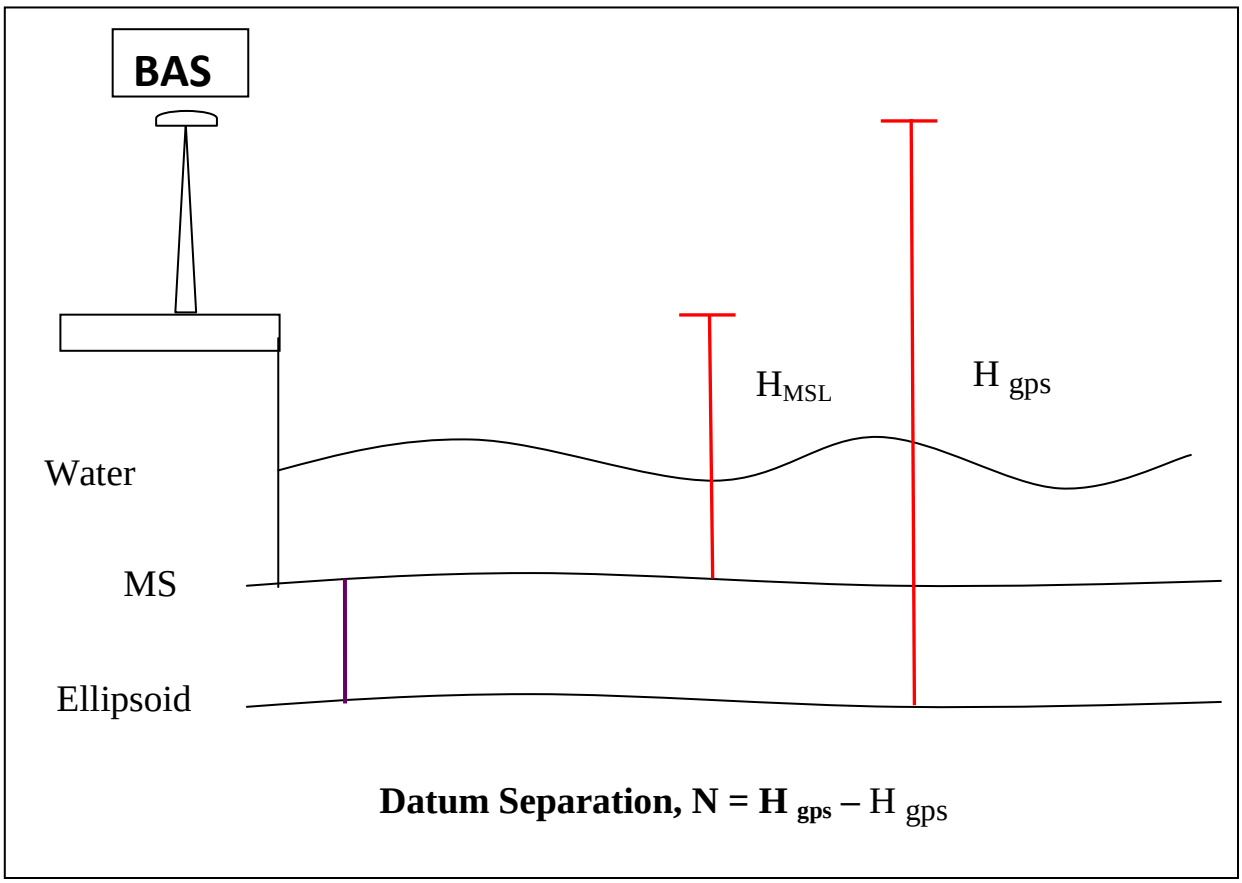

Figure 5: Base Station

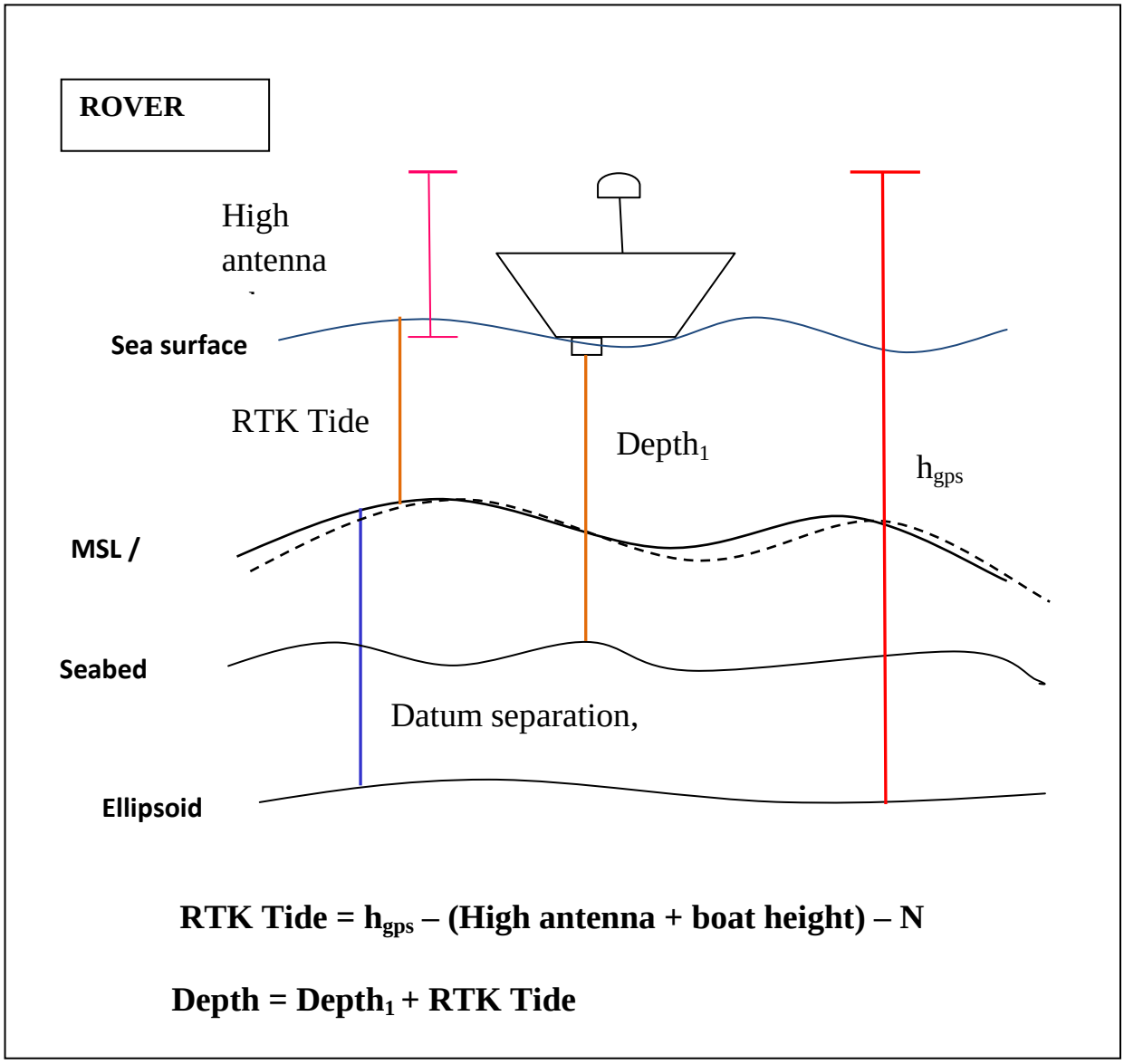

Figure 6: Rover Station

1.7 Software

Hydrographic navigation software is an essential tool for any operation, especially one that requires the interfacing of multiple sensors and storage of the data. The software is used in the positioning of exploitation rigs, control of seismic surveys, dredging operations and oceanographic data collection.

The software available today varies enormously in term of its complexity. At the top end of the scale, it will be used in 3D seismic operations where it will position multiple streamers, multiple vessels, using complex Network adjustments. The software is also playing an ever-increasing

role in the Quality Assurance process, providing statistics and simple checks to ensure that the probability of blunders is reduced.

2.0 METHOD

In RTK-GPS method, GPS receiver at reference station or base is required beside a rover or mobile unit. A radio link is needed to communicate between the two. The rover will get correction from base using the radio link. The signal from base to rover can be transmitted not exceed 10 to 20 km. All these data are important in order to produce a chart or plan of sounding.

Besides that, the suitability of software has chosen also the important part in this study. The software will be used during field work and also for the plan production. The software such as Terramodel, CDS, HYDROpro and AutoCAD will be used in this study. HYDROpro software will be used during data collection. CDS, Terramodel and AutoCAD software will be used in order to produce bathymetric and cross-section plan.

2.1 Research Methodology

Research methodology will discuss about the procedure to conduct survey using RTK- GPS method. The equipments and software being used will be listed in this study. The processing steps using certain software begin after complete data acquisition task. In this study, the research methodology can be summarized into four phases. Phase I will be the planning stage in this stage will give guidance in order to smoothing this study. Phase II is data acquisition and phase III will be the processing stage and phase IV is final stage will determine the objective achieve successful.

The first phase for this study is writing the literature review. From literature reviews, it provides a guide to a particular topic and also can be a simple summary of the related topic. The information can be found from journal, article, books and also internet. After that, the understanding of the concept and plan the for work flow are needed. Next, the work planning can be proposed. Planning of a survey is important in order to have a better preparation before data acquisition and processing phase begin.

At second phase the equipments that will be used for this study are selected. The equipments will be used during the field work are GPS Topcon Hyper GA with radio link, echosounder Sonar Mita. The location of data acquisition is at Sungai Simpang Kiri, Johor. Systematic planning is made to prevent problems and difficulties during observation activities occur.

For phase three is phase for plan production. The software selections are Terramodel, CDS, AutoCAD and HYDROpro. Plan bathymetric and cross-section will be produced as the result of this study. The bathymetric plan will produced using HYDROpro, Terramodel and AutoCAD software while the cross section plan will using CDS and AutoCAD software. Based on these plans, the analysis will be analysed in order to ensure that the objective successfully be achieved. At the final phase, conclusion will be the end for this study. Other than that, the recommendations for improve this research in the future will be suggested.

2.2 Scope of Work

The area for this project is located at Sungai Simpang Kiri, Batu Pahat. The data acquisition will be collected during field work. The equipments that will be used are GPS TOPCON HYPER GA for base and rover, radio link, echo sounder Sonar Mita and also HYDROpro software. There are software that will be used such as HYDROpro, Terramodel,CDS and AutoCAD for complete this study. HYDROpro is using during collected data while Terramodel, CDS and AutoCAD software for plan production.

Figure 7: Hydrographic Survey Techniques
(Source: http://maps.google.com.my/maps?hl=en&tab=wl)

2.2 Equipment and Software

Equipments that were used during survey work are GPS Topcon Hyper GA for rover and base station and radio link for receiving the correction data from base station. Echosounder Sonar Mita was used for depth measurement. The data was logged to the laptop. The laptop had been installed with HYDROpro software.

After data collection has been completed, the software used for analyzing the data is HYDROpro, Terramodel, CDS and AutoCAD. These four of software will be used to produce bathymetric plan and to calculate the volume for pre and post survey in term of cross-section plan.

2.3 Procedure Survey

Before Survey

i. The levelling was done from the nearest BM to get the TBM value near the survey area.
ii. After get the TBM value, the survey can start.
iii. Using GPS Controller, FC200 to start the work. This equipment can help to connect between rover and base. Base located at the land while base at the boat.

During Survey

The procedures of this measurement were as:

i. A base station must be established first in order to get known coordinates at that point. This observation was done for 1 hour.
ii. The instruments were then set up on board such as GPS with radio link as a rover, echo sounder, laptop that already installed with HYDROpro software. After that, the measurement can be made.
iii. The helmsman will manoeuvre the boat. The speed of the boat was 4 knot.
iv. The interval between sounding line was 20m.The data will be collected every 1s in each sounding line. So, every 1s the depth and position will be collected in this measurement. These procedures are for pre survey.
v. After the dredging work has been completed, the procedures were repeated for a second survey.
vi. Finally, data for pre and post survey was then processed and used to produce plan and to calculate volume.

3.0 RESULTS

In this study, two plan produced are bathymetric and cross-section. In bathymetric plan the user can view the depth value and also contour line for each sounding line as shown in **Figure 8**. Each 1m different depth for contour line will have different colour.

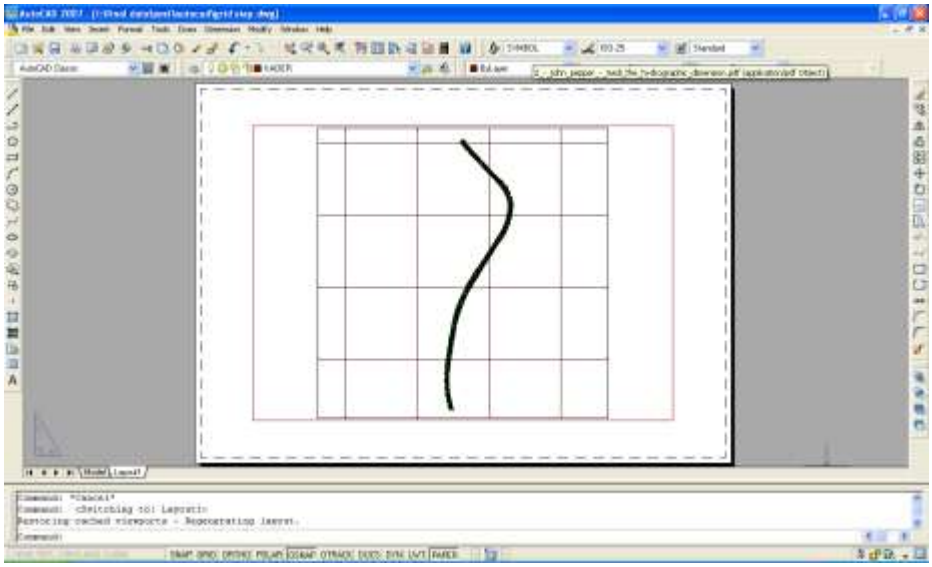

Figure 8: Bathymetric Plan

Each cross-section consists of two cross-section points and one in each side of the river. From cross-section plan user can compare the volume in dredging work. Layer for pre and post is in different colour as shown in **Figure 9**. From this study cross section plan was made in range 200m. It means the user can view the different directly through the plan.

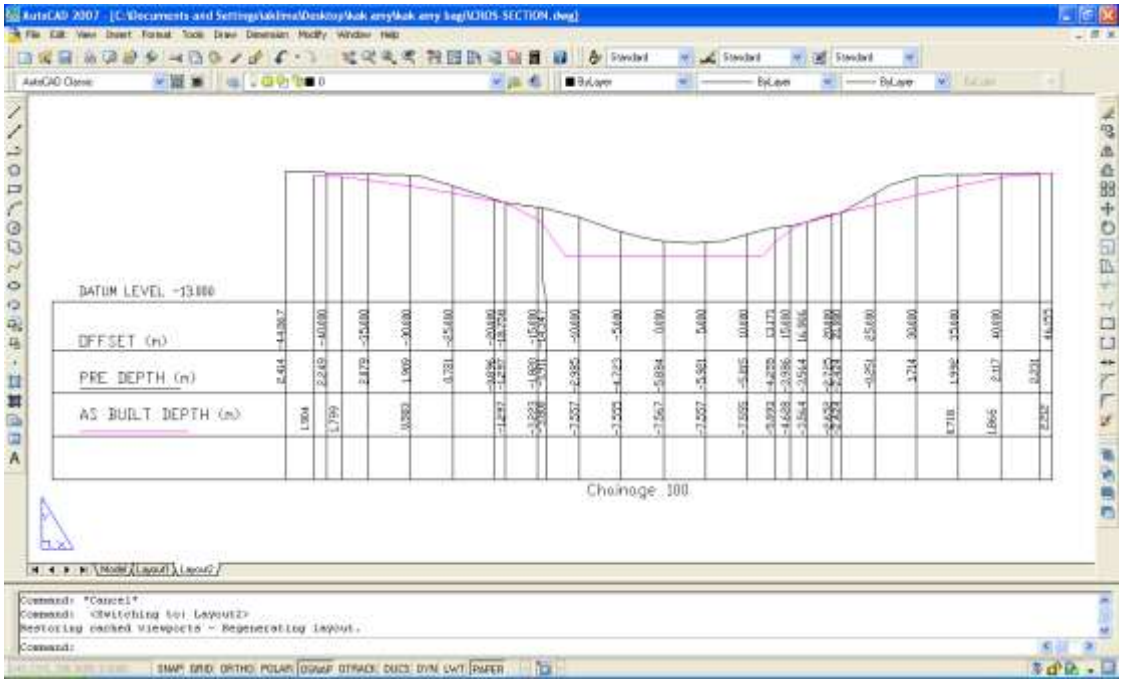

Figure 9: Cross- Section Plan

3.1 RTK Technique

In this study, RTK technique will be used during data acquisition. For this technique, tidal reading will be collected simultaneously with depth. It seems a latest technique in hydrographic survey. In this country, this technique is not being exposed for hydrographer. RTK requires the use of a reliable link between the base station and survey vessel. A radio link typically is used for marine applications as it provides a robust link with low latency of correctors. Cellular links have not proven to be as reliable and typically have too much correction latency for a tightly coupled inertial solution.

There are many advantages using this RTK-GPS technique. GPS is more cost-effective in long-term planning. Even though the GPS receiver quite expensive compare other survey equipments but in long-term costing it is worthwhile because can be used either for land or hydrographic survey. In addition, RTK-GPS technique faster in order to complete the survey works than conventional method. This is because the tidal reading will add up simultaneously in depth reading in the HYDROpro software.

Moreover using GPS, the survey work do not need addition equipments. For instance using total station additional equipment needed is prism in order to make measurement. Besides that, using this technique the hydrographic survey does not need more people to complete the task. It will reduce number of labour needed. Other than that, using this RTK-GPS method is more accurate compare conventional method. Using conventional method hydrographer needs to read tidal value manually in specific time range. It is obviously will give some error because tide pole being used and also can contribute human error. RTK-GPS technique provides real-time water levels that can be used for colour swath coverage relative to datum.

Furthermore, field operations to perform a GPS static control survey are relatively efficient and can generally be performed by one person per receiver. GPS is particularly effective for establishing primary control networks as compared with conventional surveys because inter visibility is not required between adjacent stations. This technique using carrier phase accuracy while DGPS using code phase. RTK procedures allow for the movement of a GPS receiver after the initial integer ambiguity (i.e., whole number of wavelengths) between satellites and receiver has been resolved.

There are also some disadvantages involved using this technique. For example, the communications link for a RTK positioning system differs from the code phase tracking DGPS system in the amount of data that has to be transmitted. The RTK positioning system may require a minimum data rate of 4800 baud, as compared to a baud rate of 300 for the code phase tracking DGPS system. This high data rate eliminates many of the low-frequency broadcast systems and limits the coverage area for high-frequency broadcast systems.

This technique is limited in range from a land-based RTK base station. Two GPS receivers (base and rover) are needed for positioning. RTK technology should normally not be used for surveys in excess of 20 km from the base station. Other than that, this technique need radio link in order to transmitted correction from base to rover station. If radio link loss the signal it mean the rover will affected to loss the correction value. In order to avoid this happen, the GPS receiver must locate at wide area.

4.0 CONCLUSIONS

This study has achieved the objectives for this research. Implementation process involved in this study give an exposure and opportunity to gain and practice knowledge and information about utilizing radio link technologies and real time technique in hydrographic survey. The effectiveness of sending real time tidal data has been discovering the quality of the final result. It can minimize the duration of hydrographic survey progress. Consequently, the tidal observation technique has been changed from manual to automated technologies.

4.1 Recommendations

Recommendations are proposed in this study to make improvement in the future research:

i. Study the use of navigation software HYDROpro with more advanced positioning system that is multi-beam echo sounder.
ii. Using other carrier phase-based GPS technique such as post-processed kinematic (PPK) for hydrographic survey.
iii. Produce cross-section plan for hydrographic survey using Terramodel Software.

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