DEVELOPMENT OF FIRE ENGINE NAVIGATION SYSTEM AND FIRE HYDRANT WATER FLOW RATE

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CERTIFICATION OF APPROVAL

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Approve by,

(AP.DR.HANITA BINTI DAUD)

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BANDAR SERI ISKANDAR, PERAK

JANUARY 2017

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 acknowledgment, and that the original work contained here in have not been undertaken or done by unspecified sources or persons.

(MOHD SHAFARIZ AKMAL BIN AHMAD)

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ABSTRACT

This project title Development of Engine Navigation System and Fire Hydrants locator is about mapping fire hydrants location, calculate distance between fire hydrants then display in Hydrant tracker. This project will add pressure sensor to calculate water flow in pipeline that connected with fire hydrants. The author adds water level measurement sensor on top of public water tank, because there are correlation water level measurements with water flow rate. Mapping fire hydrants critical task because the author needs to know the exact GPS coordinates. Fire fighters need quick action hence by using virtual mapping system will help fire fighters.

Table of Contents

List of Tables

List of Figures

CHAPTER 1: INTRODUCTION

This chapter will provide some background information about this project, problem statement, and objective to be achieved in this project.

1.1 Background of study.

This project is about mapping fire hydrants; calculate distance between fire hydrants and measure water pressure. Before this, fire fighters using conventional map to identify the nearest fire hydrants in the fire incident. Unfortunately, that method (referring conventional map) taking too much time. Solution for this problem, the author creates virtual mapping fire hydrants that show coordinate fire hydrant (latitude and longitude), distance each fire hydrant in that location or area. For this project, the author has limited the area. Selected area for this prototype only covers in Universiti Teknologi PETRONAS.

Water flow rate and water level measurement is critical analyses part in this project. Water level measurement is must because by measuring the level of water in tank, we can relate the strength of pressure for the water. Huger the differences for the height, more increase the pressure. Water flow rate is measurement for how many water in liter that can flow in pipeline per hour.

1.2 Problem statement of study.

The problem statements for this study are visibility of fire hydrants in fire incident, location and distance each fire hydrant in that fire incident location, water level inside the tank and water flow rate.

1.2.1 Visibility of fire hydrants in fire incident.

Fire incident can be happening anytime and anywhere. Fire fighters need to execute fast respond to extinguish fire. How fire fighters extinguish fire if they cannot spot fire hydrants location and only depends on conventional map. By using traditional method which is just depend on conventional map, time taken for fire fighters to locate the exact location fire hydrants is about five minutes. In five minutes, a small fire can

be huge fire which can destroyed everything in that time. Hence, virtual mapping will reduce time for searching fire hydrants.

1.2.2 Location and distance for each fire hydrant.

Virtual mapping requires GPS coordinates for each fire hydrants located in UTP. Before create virtual mapping the author must locate each fire hydrants latitude and longitude using GPS receiver. After knowing the GPS coordinate for each fire hydrants, author using Google maps to trace back the latitude and longitude for each hydrant and saved and tags each fire hydrants with respected to it area.

1.2.3 Water level inside the tank and water flow rate.

Water level measurement vital in this project, because water level as the main key in determining the strength of water pressure. Author using ultrasonic sensor module HC-SR04 for reading water level measurement. Knowing the exact height of water level, then from that author can calculate what should be the flow rate from outlet tank.

1.3 Objective of study.

The objective for this project as per below:

I. To create virtual mapping fire hydrants in UTP area, retrieve GPS fire hydrants and determine distance between each fire hydrant in that area.

II. To study about water level measurement with water flow rate for fire hydrants water flow rate.

1.4 Scope of study.

The scope study for this project as per below:

I. Understand how fire fighters do their daily rescue tasks and relate with this project objective.

Before this fire fighters using conventional mapping to search fire hydrants location, that method (referring to conventional method) take long time (5 minutes) to located fire hydrants. Hence, by using virtual mapping fire hydrant will help fire fighters in their daily tasks.

II. Understand how accurate GPS coordinates for each fire hydrant and distance measured for each fire hydrant.

Each GPS receiver types work by provided GPS coordinate. GPS coordinate maybe retrieve in latitude and longitude or maybe in degree, minute, second. Each representation show the same thing but author choose latitude and longitude because easy to write in Google maps.

III. Understand the concept for water level measurement relate with water flow rate by assuming none of fire hydrant pipeline connected to any resistance.

Water level measurement will provide an idea to determine the pressure (water) for the fire hydrant but author does not consider any other factor that will impact the ultrasonic sensor and water flow sensor [5].

CHAPTER 2: LITERATURE REVIEW

This chapter will provide some theory regarding this project as guideline to achieve the objectives for this project.

2.1 Introduction.

In literature review the author will explain about fire incident happen in Malaysia, explain about fire hydrant, types of method that can be used for water level measurement and water flow rate measurement.

2.2 Fire Incident.

December 2014, the Fire and Rescue Department Malaysia (FRDM) has attended 99,830 numbers of emergency cases [1]. Based on table 1, Selangor has recorded the highest number of calls (15,528) then by Johor (12,319) and Perak (10,573) [1]. Then followed by Kedah (8,523) , Kelantan (8,493), P.Pinang (6,523), Sarawak (5,705), Terengganu (5,701), Sabah (5,627), Melaka (5,234), Pahang (5,163), N.Sembilan (4,212), W.P.K Lumpur (3,730), Perlis (1,271), W.Putrajaya (620) and W.P.Labuan (608).

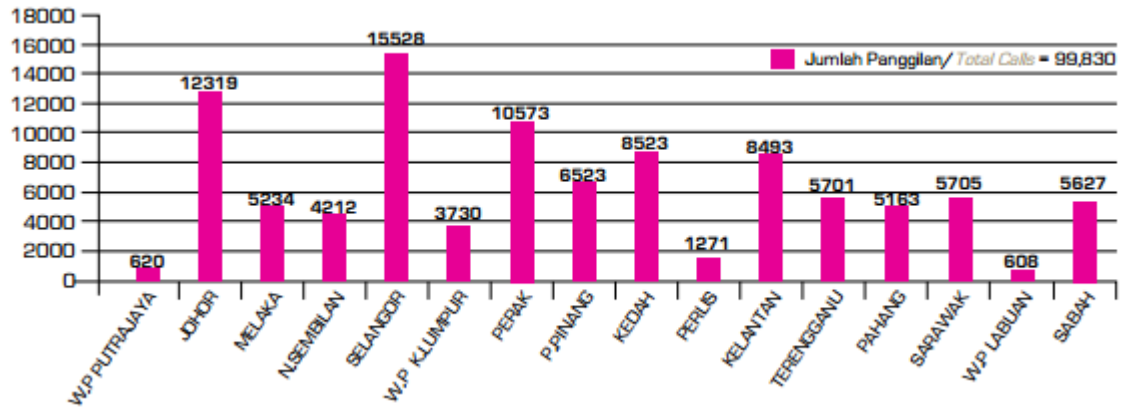


Table 1: Emergency calls by states [1]

From the overall total (99,830) calls, FRDM has received 54,540 calls involving fire cases, 42,712 calls involving rescue and humanitarian services, 1,574 calls involving special tasks, 1,004 calls involving prank calls from January to December 2014.

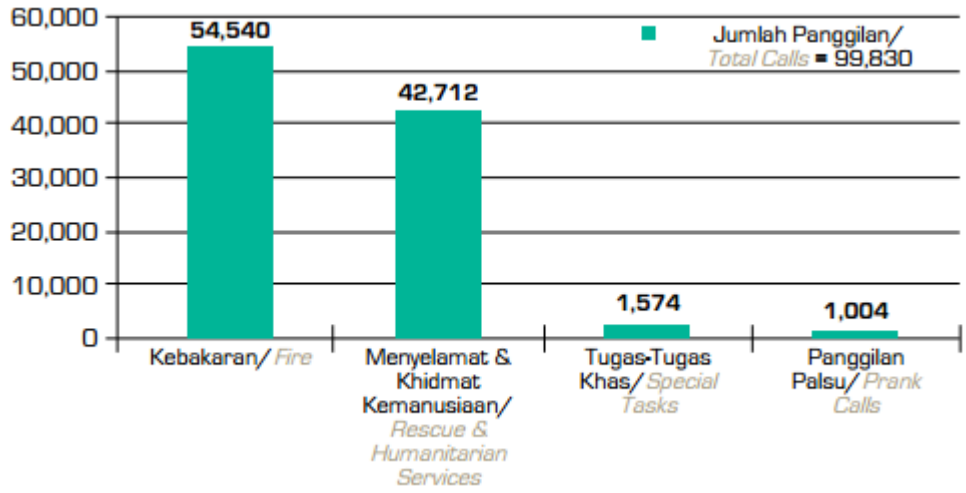


Table 2: Types of calls [1]

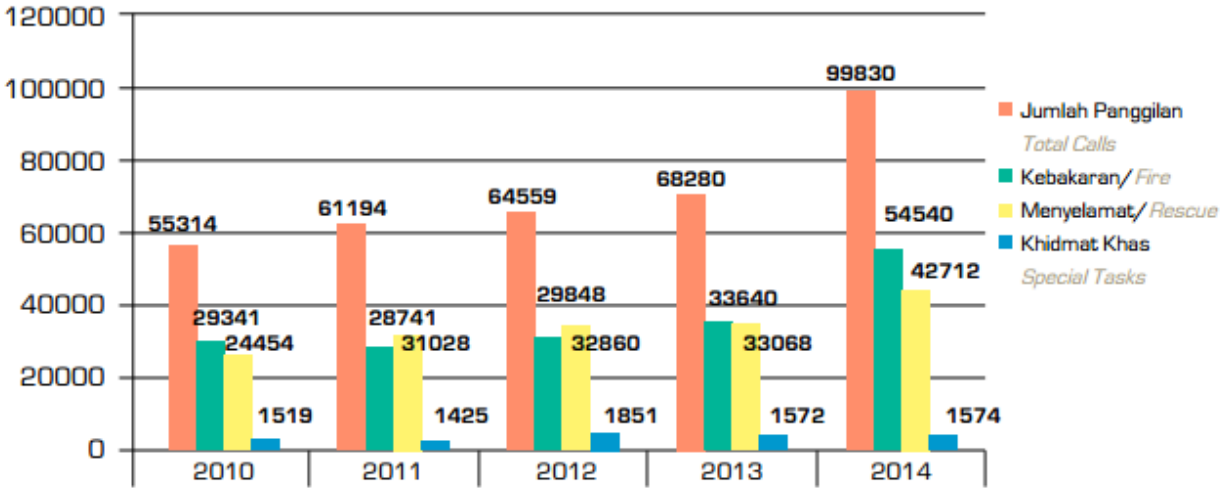


Table 3: Statistical number of calls [1]

The graph (above) shown a statistical comparison on the number of calls for fires, rescue and special functions attended by FRDM for a period 5 years [1]. From table 3, total calls kept on increasing from 55,314 total calls (2010) up until 99,830 total calls in 2014.

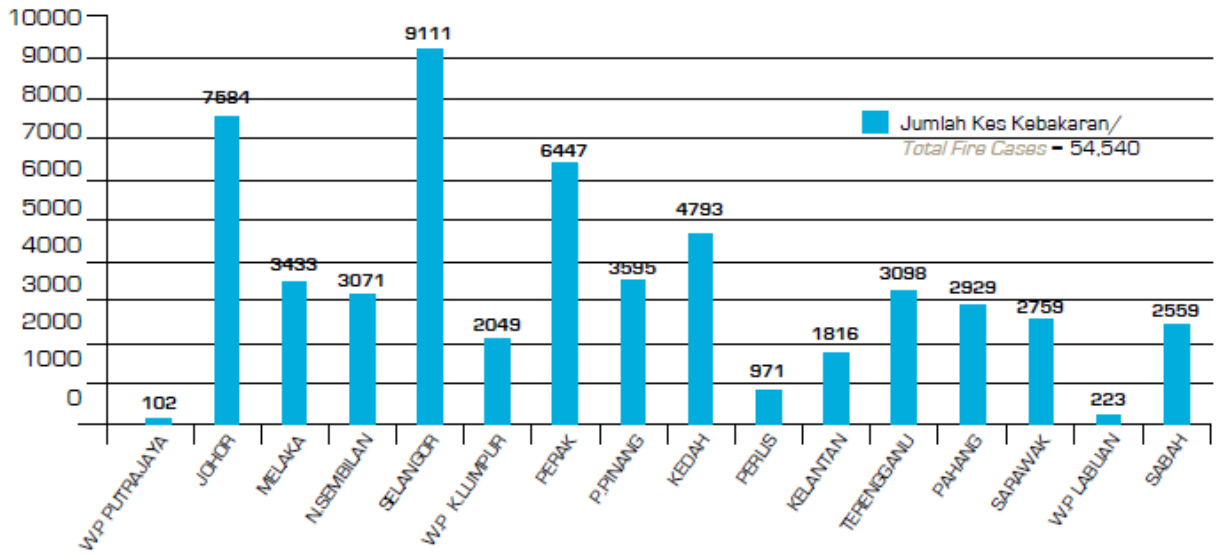


Table 4: Fire cases based on state [1]

Referring table 4 (above), state Selangor recorded highest total fire cases (9,111) followed by Johor (7,584) and Perak (6,447). Then followed by P.Pinang (3,595), Melaka (3,433), N. Sembilan (3,271), Terengganu (3,098), Pahang (2,929), Sarawak (2,759), Sabah (2,559), W.P.K.Lumpur (2049), Kelantan (1,816), Perlis (971), W.P.Labuan (223), W.P.Putrajaya (102). By statistical analysis of the number of calls received by each state found that the type of fire that contributes to a large number is open fire, buildings, vehicles, other types of fires [1].

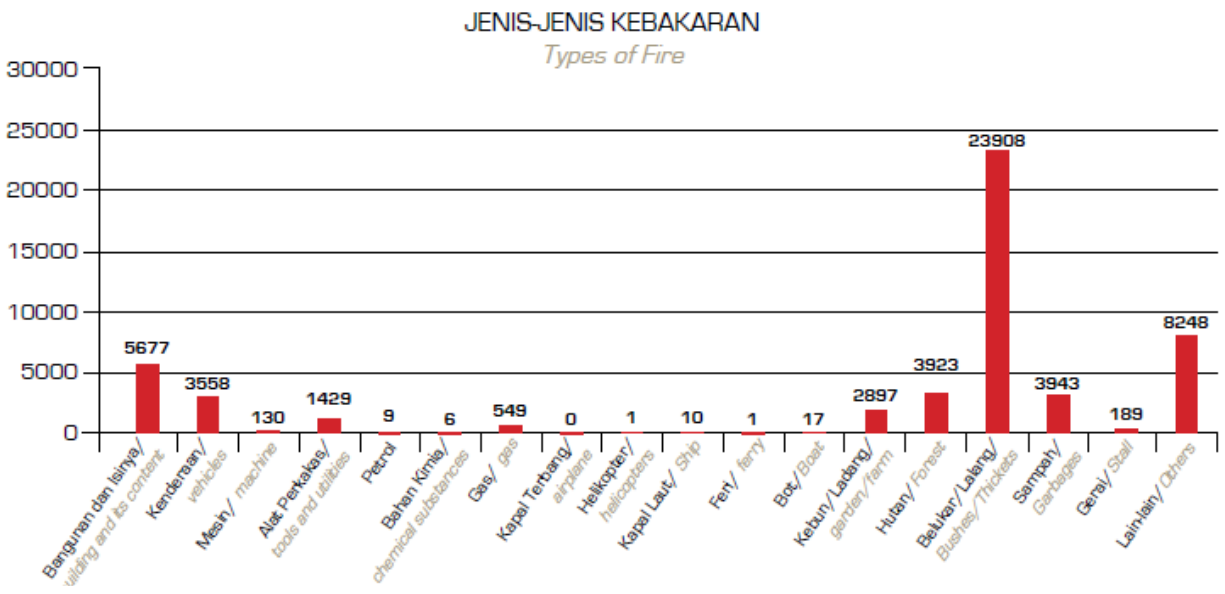


Table 5: Types of fire [1]

Based on table 5 (above), the highest types of fire are bushes with recorded value 23,908, followed by other (8,248) and building (5,677) [1]. The second highest fire was a fire involving the other categories. Examples of fire are: fire on abandoned guard posts, fire on power cable, fuse box, trash, fire on tree, phone booth, pile of wood [1].

2.3 Fire Hydrant.

Fire hydrant is water source for fire fighters to extinguish fire. Each fire hydrant is label with different color. Each color represents how much water that fire hydrant can supply which measure in gallon per minute (GPM). According National Fire Protection Agency (NFPA) 291, which is mention about fire hydrants that using public water supply system must be painted chrome yellow. For the examples GPM less 500 the color is red, 500 until 999 GPM the color is orange, 1000 until 1499 GPM the color is green, 1500 and above the color is blue [3].

2.4 Water level measurement.

Water level measurement is important because many industry using water level measurement sensors to read their products. Mainly, industrial those using level measurements (water) are related with liquid products. Type of measurement (methods) for liquid are float, pressure gauge, ultrasonic, radar, capacitance-type, resistance. Each of method has its own good and bad. Level measurement can be divided into two types: contact and non-contact. Contact level (water) measurement is using pressure gauge and for non-contact level measurement is using capacitance-type, ultrasonic, radar. Non-contact level (water) measurement also known wireless sensor also non-contact level measurement have reduce the complicated wiring [2], moreover ultrasonic sensor is cheap, easy setup, commonly used in distance measurement [4].

2.4.1 Capacitance-type water level measurement.

There are criteria that need to follow before buy level measurement sensor. The criteria are physical phase (solid or liquid), temperature, pressure, density, tank shape. For low profile sensor, such as capacitance-type, ultrasonic sensor, and resistance is simple and cheap. Capacitance level sensor always known as radio frequency (RF). This type sensor (capacitance) can detect material as 1.1 (coke) to as 88 (water). Below (figure 1) is an example capacitance-type sensor.

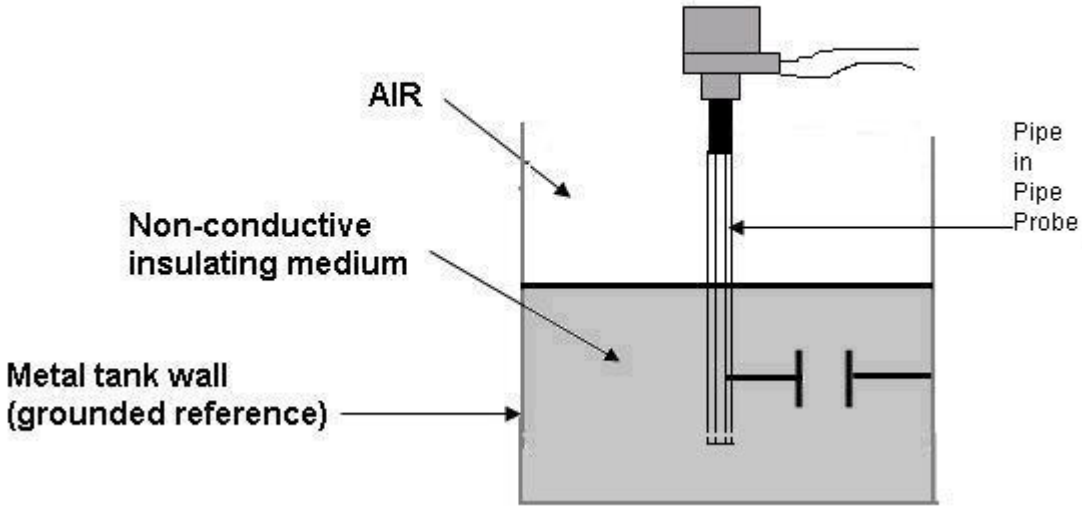


Figure 1: Capacitance-type level (water) measurement

Based on figure 1, tank wall represents plate A and an insulated electrode represent plate B. Capacitor is two metal electrodes that can generate capacitance. Working principle for capacitance-type level sensor, based on rate of change for the capacitance. In this case, tank wall act as electrode and pipe in pipe probe act as another electrode. Liquid level depends on capacitance. Example if empty tank result will be low capacitance and if a filled tank result will be high capacitance, refer below for the capacitance equation.

C = E (K A/d)

C = capacitance (pF)

E = permittivity of free air

K = dielectric constant

A = effective area for metal

d = distance between two plates

Advantages	Disadvantages
Cheap	If light density less 20 lb/ft3
Reliable	If particles larger than ½ in.
Need less preventive maintenance	
No mechanical parts	
Fast installation	
Robust	

Table 6: Advantages and disadvantages for capacitance-type sensor level measurement

2.4.2 Ultrasonic level sensor.

Ultrasonic sensor is one of device that can be used for water level measurement instead of commonly used for object detection distance. For example, ultrasonic ranging finder already is used in sector such as industry, agriculture [4]. Benefit for this method is contactless, which is no issue like corrosion for the electrodes and extra special about ultrasonic sensor is good direction and anti-interference [4]. For the working principle (ultrasonic sensor) can propagate in gas, liquid and solid [4] and ultrasonic sensor low – profile plus accurate if comparing with UWB [5] UWB stand for Ultra-Wide-Band, also known as time of flight concept (speed of light). Ultrasonic sensor divided into two parts transmitter and receiver. The transmitter will send high-frequency (HF) which is 20 kHz until 200 kHz range to the objects and then wait for pulses to echo back. The pulses will reflect back because of the differences density between airs and water (more density compare to air) and that pulses will be captures by the receiver (at ultrasonic sensor). The overall distance is calculated by time taken for the pulses to reach surface material divided by two. The reason why time taken divided by two is because distance from transmitter to surface material and distance from material to receiver is equal. Refer figure below for visualization ultrasonic sensor working principle.

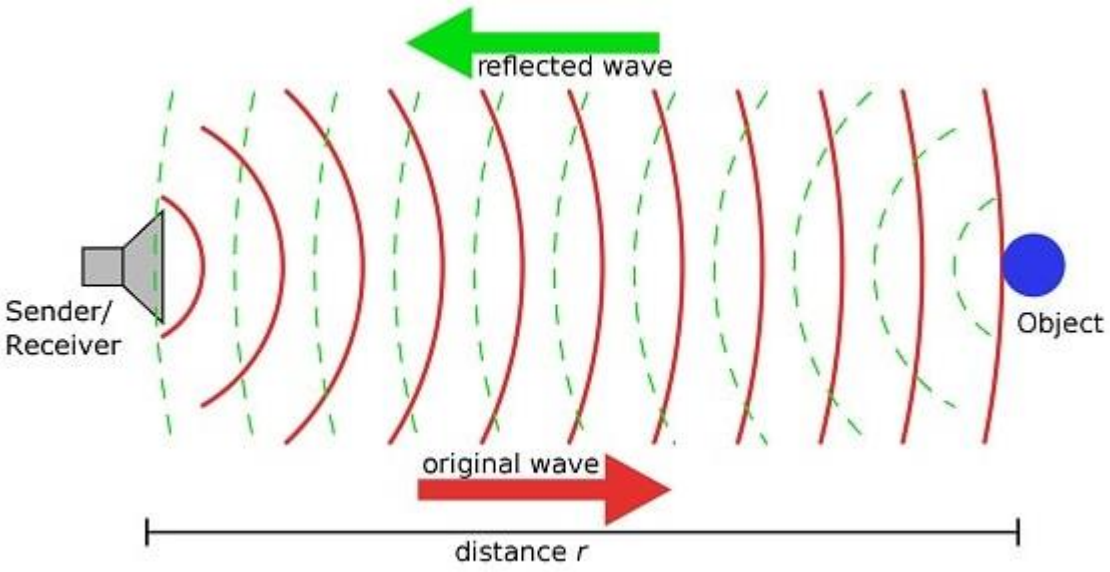


Figure 2: Ultrasonic sensor working principle for object detection

2.5 Water flow rate measurement.

Volume flow rate or volumetric flow rate or volume velocity is equal to flow rate measurement. The symbol for volume flow rate representation is Q. volumetric flow rate standard unit measurement can be gallon per minute (GPM) or liter per minute (LPM) or cubic meter per second (m^3/s). Measurement volume flow rate for piping is different, which mean one part piping measurement volume flow rate is not equal for overall volume flow rate. Reasons for volume flow rate vary for each part pipes are because of different fixture different flow, water flow on pump and in tank different.

Velocities of liquid (water) that flow in pipes are different because varying diameter pipes. For example, velocity (flow fastest) increasing in middle part of pipe but (flow slows) decrease at edges of pipe. Friction and coupling can lead to pressure loss. Each friction loss is different and depends on material (pipe).

Volumetric flow rate calculation:

$Q = A \times V$

Where Q = flow rate in m^3/s

A = cross-section area flow in m^2 ; $(pi \times D^2) / 4$; pi = 3.1416

V = velocity for the liquid in ft/sec

Pressure loss is directly proportional velocity. Based on Darcy-Weisbach Equation, the target head or pressure loss because of friction in pipe and average velocity, refer figure below for relationship between pressure and flow rate for a pipeline.

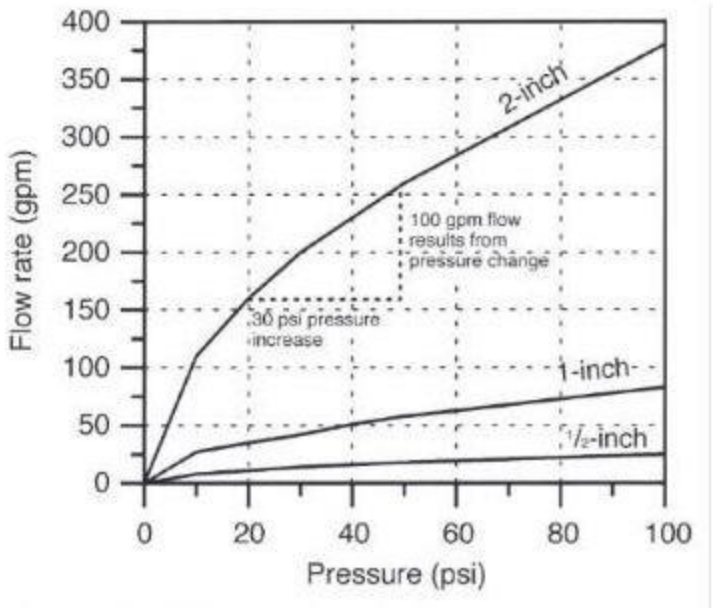


Figure 3: Relationship between flow rate and pressure

Darcy-Weisbach Equation: pressure-loss-formula;

$$\frac{\Delta p}{L} = f_{\mathrm{D}} \cdot \frac{\rho}{2} \cdot \frac{V^2}{D},$$

$\frac{\Delta p}{L}$ = changes for the pressure loss in Pa per meter

ρ = density for the liquid (water) in kg per m^3

V = average velocity for the liquid in meter per second

f_{D} = Darcy friction factor which is 64 / Re

$$f_{\mathrm{D}} = \frac{64}{\mathrm{Re}}, \quad \rightarrow \quad \mathrm{Re} = \frac{\rho}{\mu} VD = \frac{VD}{\nu}, \quad \rightarrow \quad \nu = \frac{\mu}{\rho}$$

μ = 8.90×10^{-4} Pa

2.5.1 Bernoulli principle

Bernoulli principle is about conservation of energy. The energy that meaning in here are pressure energy (P) , kinetic energy (½ pv) and potential energy (pgh). Combine these energy bring to Bernoulli equation. In this principle, ideally if there is less pressure ($P_1 < P_2$) hence there will be high velocity at area P_1 . Bernoulli equation:

Energy per unit volume before = Energy per unit volume after

$$P_1 + \tfrac{1}{2} pv^2_1 + pgh_1 = P_2 + \tfrac{1}{2} pv^2_2 + pgh_2$$

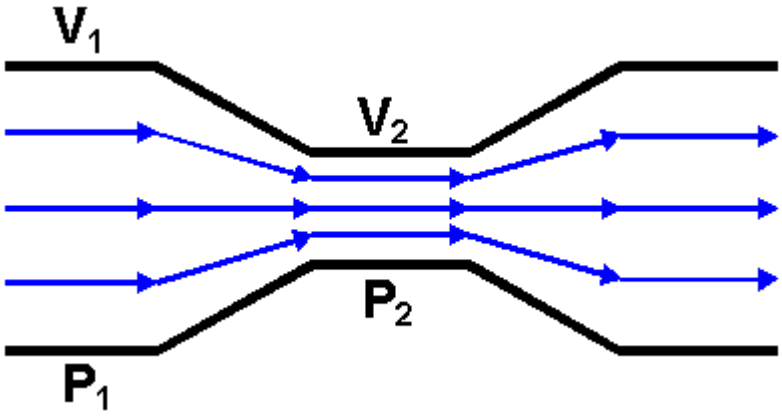


Figure 4: Example of laminar flow

Referring figure 4, this figure explains about what will happen when the pipeline is different in term of area. By Bernoulli principle: if the area (region 2) is smaller compared to other area (region 1), hence velocity at that area (region 2) is higher than velocity at region 1. If that happen, then pressure at region 2 is smaller than pressure at region 1.

Area region 2 < Area region 1

Hence

Velocity region 2 > Velocity region 1

Then

Pressure region 2 < Pressure region 1

2.6 Global positioning system

Global positioning system or GPS is a global navigation system that provide location and time on Earth to a GPS receiver which can be receive only when there are four or more GPS satellites. GPS is important because it is providing positioning in military, civil and other. The fundamental for GPS are, first there must be at least four GPS satellites that needed to compute four unknown quantities which are latitude, longitude, altitude, and time. GPS satellites continually propagate the signals which are: pseudo random code and time of transmission.

GPS receiver measure time of arrive (TOA) from four GPS satellites, by using TOA and TOT, GPS receiver initialize four time of flight (TOF). GPS contain three segment which are space segment (SS), control segment, and user segment. Space segment is orbit GPS satellites or known as space vehicle. There are 24 space vehicles which eight of satellites in three circular orbit but already modified to six orbit with four satellites each.

Control segment contain of a master control station, an alternate master control station, four ground antennas and six monitor station. User segment contain of antenna, tuned frequencies, receiver processor and crystal oscillator (CLK). Application for GPS are robotics (self-navigation), navigation, GPS aircraft tracking and other.

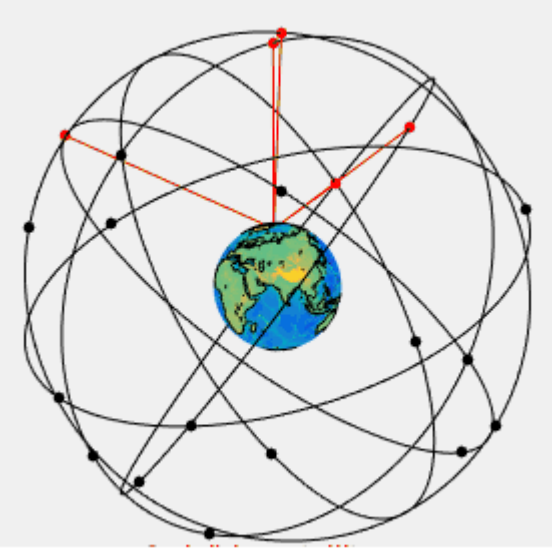


Figure 5: GPS satellites in six orbit plane

CHAPTER 3: METHODOLOGY

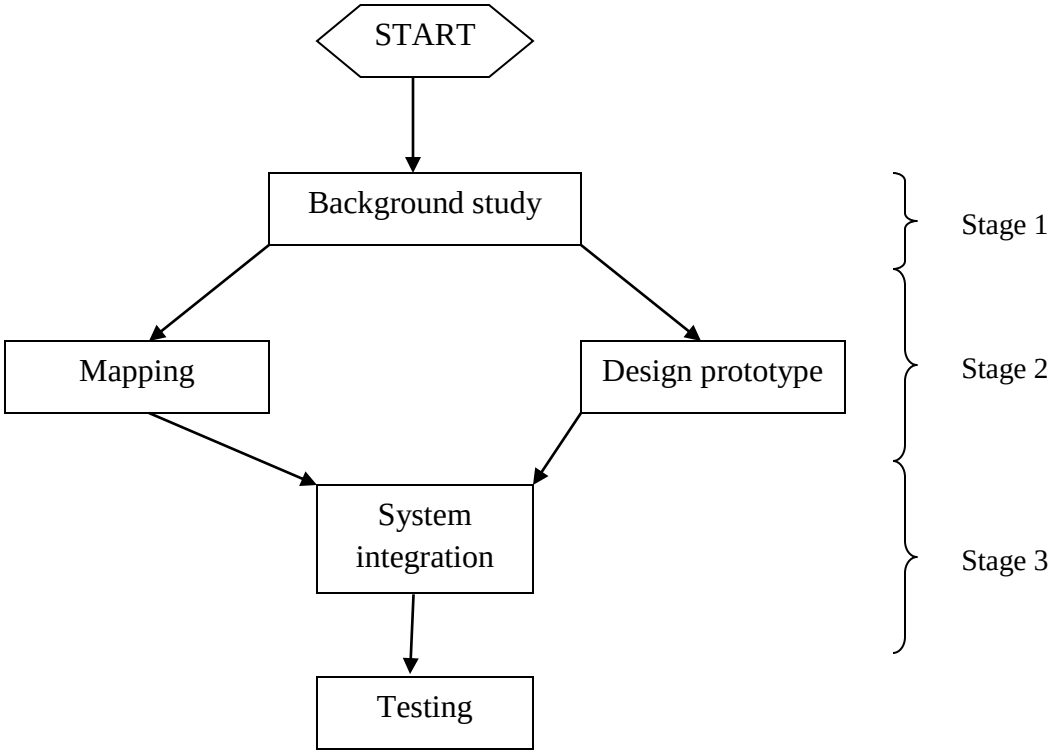
This chapter will provide methodology for this project and explain about Gantt Chart and key milestones.

3.1 Research methodology

Methodology involve in this project are as per below.

3.1.1 General flow chart for methodology

In this part, stages for achieving this project objectives will be briefly explaining here.



3.1.1.1 Background study (stage 1)

Stage 1, author did background study about fire incident in Malaysia, fire hydrant, water level measurement, water flow rate, and Bluetooth applications.

In stage 1, author collects important data from research papers, conference papers and journals.

3.1.1.2 Mapping & Design prototype (stage 2)

Stage 2, author initiates project. Author used global positioning system (GPS) receiver to collect GPS coordinate for each fire hydrant in UTP. Mapping, author divides into 16 areas. Each of fire hydrant GPS coordinate will be used in virtual mapping.

Design prototype, author design a mini water tank to show how water level can impact water flow rate for fire hydrant. This water tank will be assuming close tank.

3.1.1.3 System Integration (stage 3)

Stage 3 about system integration, author combine water level measurement prototype (ultrasonic) with water flow rate (flow rate sensor) then relate with author's calculation for the pressure.

3.2 Project work

The key milestone to be achieve in this project illustrate as per below figure.

No	Detail/Week	01	02	03	04	05	06	07	08	09	10	11	12	13	14
FYP 1															
1	Extended proposal														
2	Verify components														
3	Proposal defense														
4	20% prototype														
5	Interim report														
FYP 2															
1	50% prototype														
2	Progress report														
3	100% prototype														
4	Pre-SEDEX														
5	Final report														
6	Dissertation (SC)														
7	Viva														
8	Dissertation (HC)														

Figure 6: Project key milestone

No	Detail/Week	01	02	03	04	05	06	07	08	09	10	11	12	13	14
FYP 1															
1	Selection of project title														
2	Background research study														
3	Setup extended proposal														
4	Extended proposal														
5	Setup proposal defense														
6	Proposal defense														
7	Development prototype														
8	Setup interim report														
9	Draft interim report														
10	Interim report														
FYP 2															
1	Development prototype														
2	Progress report														
3	Prototype testing														
4	Pre-SEDEX														
5	Setup final report														
6	Final report														
7	Setup dissertation														
8	Dissertation (SC)														
9	Technical report														
10	Viva														
11	Dissertation (HC)														

Figure 7: Project Gantt-chart

3.3 Mapping

Mapping is one of objective for this project. To do mapping, author must have at least knowledge how to read GPS coordinate. In UTP area there are 81 fire hydrants. Author using portable GPS car navigator model (A903i) to read GPS coordinate for each fire hydrants. Time taken to gather all GPS coordinates for fire hydrants was three days, because the area is huge. Refer figure below for GPS receiver.

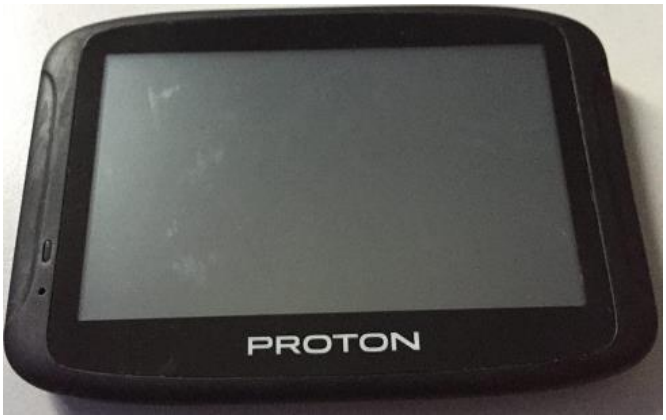


Figure 8: GPS receiver model A903(i)

Figure 9: GPS indicate zone A (A1) location

After gather all GPS coordinates then author splits the fire hydrants based on zone. Each zone is representing from their building intensity and fire hydrants coverage area. Author using google map to trace back the exact location that has been read from GPS receiver, check whether the GPS coordinates are correct. Then from google map also, author has tag each fire hydrants in that map to get the general mapping area and more clear. By using google map, author can calculate the distance from each fire hydrant. For this case, author assuming each zone must has

a reference point which is will be first tag fire hydrant in that zone, so each zone has only one reference point. The reference point (fire hydrants) is one that start with number one tagged, example is zone A, reference point is A1; zone B, reference point is B1 and so on until zone R. The reason author assuming a reference point is because for easiness to calculate each fire hydrant distance, example for zone B, distance B2 from B1 is 14.48 meter and distance B3 from B1 is 88.99 meter, if let say there is fire incident at B3; then fire fighters will know the distance from reference point (B1 for zone B) is just 88.99 meter only and they (fire fighters) also knowing that there is one more fire hydrants (B2) available just only 86.87 meter from fire hydrant B3.

3.4 Design Prototype

Meaning for designing prototype is to create a small tank such as normal public tank, the reason for this because author wants to measure what is the water flow rate at that current time and relate with water level inside that tank. The idea is build a small tank connect the outlet tank with flow rate sensor and on top of tank, attach an ultrasonic sensor then observe the water flow rate. To build this prototype, author needs a flow rate sensor, an ultrasonic sensor, Bluetooth module and Arduino board for main board. Refer as per below the items need for designing this prototype.

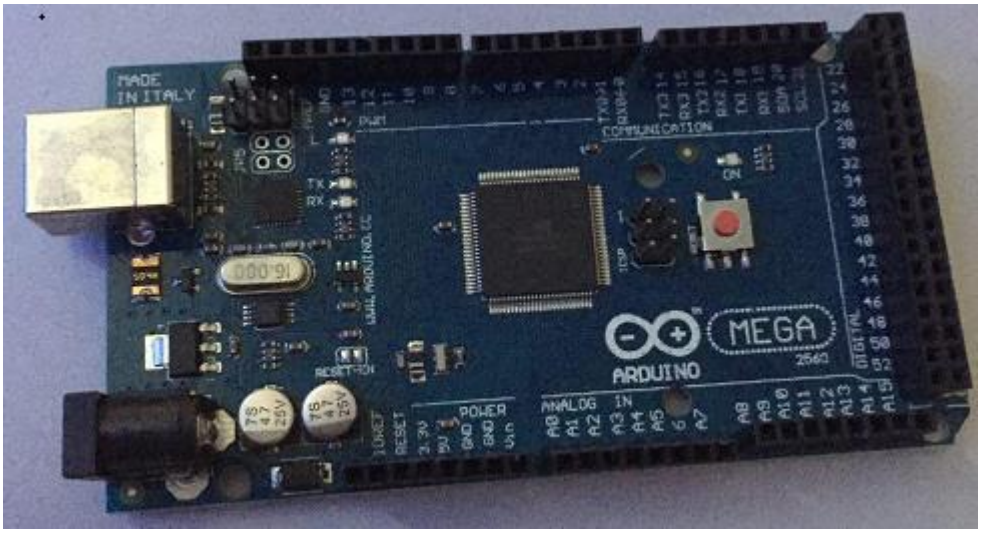


Figure 10: Arduino Mega 2560 for coding water flow rate, water level and Bluetooth

Figure 11: water flow rate sensor will be attach at the outlet tank

Figure 12: Bluetooth module for communication with fire fighters

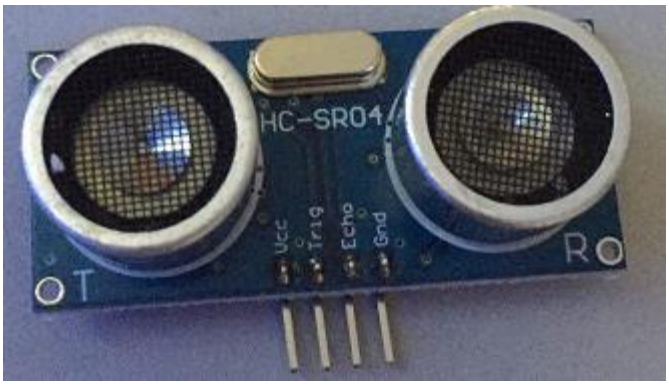


Figure 13: low profile ultrasonic sensor for verify water level

3.4.1 Explanation about designing prototype

The idea for designing prototype is as per below. The shape for tank is commonly been used. Below is the calculation for pressure and velocity:

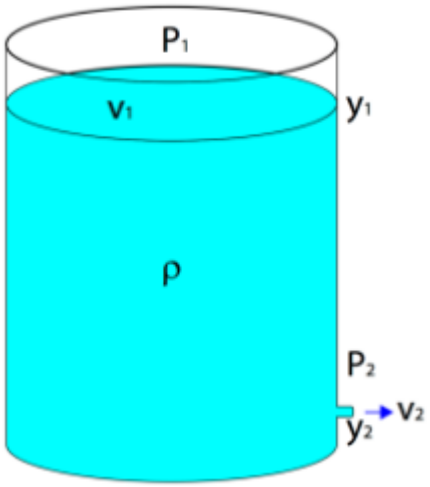


Figure 14: Example of prototype

Since this tank contain water as fluid, so density for both region is same. Referring to Bernoulli principle:

Energy per unit volume before must be equal to energy per unit volume after.

$$P_1 + \tfrac{1}{2} p v_1^2 + p g h_1 = P_2 + \tfrac{1}{2} p v_2^2 + p g h_2$$

Because of P_1 and P_2 is P_{atm}, hence we can simplify the equation. Area at region 1 is bigger comparing area at region 2, then velocity at region 1 can be assume nearly equal to zero. Based on concept continuity equation which is area multiple velocity at region 1 equal to area multiple velocity at region 2.

$$A_1V_1 = A_2V_2$$

After simplified Bernoulli equation:

$pgy_1 = ½\ pv_2^2 + pgy_2$ (because density (p) is same)

$g\ (y_1 - y_2) = ½\ v_2^2$ (g is gravitational speed)

$v_2 = square\ root\ (2g\ (y_1 - y_2))$ (Torricelli's theorem)

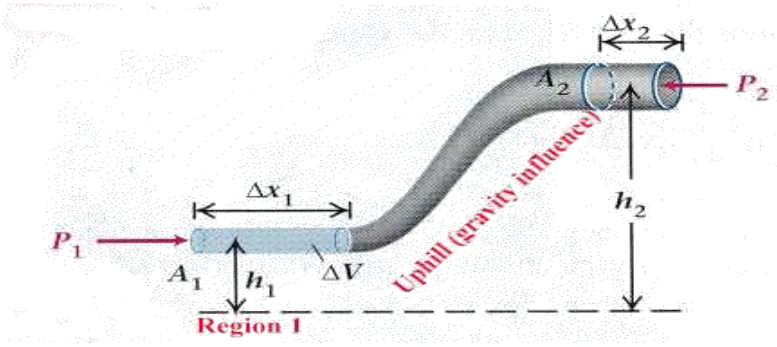


Figure 15: The vary for pipeline height

From figure 15, we can see that the differences of height for pipeline. The calculation for pressure respect to region 1 and region 2 is per below:

By Bernoulli principle:

$$P_1 + ½\ pv^2_1 + pgh_1 = P_2 + ½\ pv^2_2 + pgh_2$$

** assuming diameter for pipe is same, if diameter does not change then velocity region 1 and velocity region 2 same.

$$P_1 + pgh_1 = P_2 + pgh_2$$

** $P_{atm} = 1.013\ x\ 10^2\ N/m^2$, $p = 1000\ kg/m^3$ (density for fluid)

$$P_1 - P_2 = pgh_2 - pgh_1$$

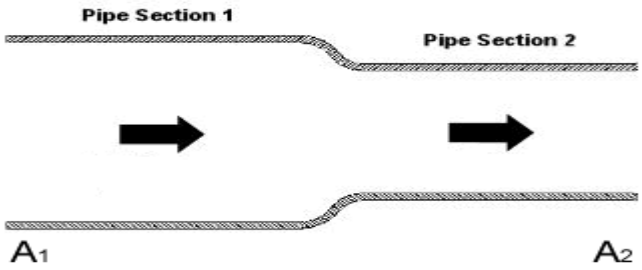


Figure 16: Vary of diameter for pipeline

Based on continuity equation (Av = constant) which mean, if area is change and velocity also change. By Bernoulli principle:

$$P_1 + \tfrac{1}{2} pv^2_1 + pgh_1 = P_2 + \tfrac{1}{2} pv^2_2 + pgh_2$$

** height is same for both region, then can simplify

$$P_1 + \tfrac{1}{2} pv_1^2 = P_2 + \tfrac{1}{2} pv_2^2$$

** Continuity equation

$$A_1V_1 = A_2V_2$$

$$V_2 = (A_1V_1)/ A_2$$

Chapter 4: Results and Discussion

In this chapter, author explains about the result he got from testing the virtual mapping and designed prototype.

4.1 Fire hydrant locations detail

The coverage area for this project only focusing in Universiti Teknologi PETRONAS (UTP) only because of limited time. To prove this project, author has divided into 16 area based on building intensity and fire hydrant coverage area. Each of the area is naming by alphabet A until R. Zone A contain two fire hydrants, zone B contain nine fire hydrants, zone C contain five fire hydrants, zone D contain four fire hydrants, zone E contain five fire hydrants, zone F contain five fire hydrants, zone G contain 11 fire hydrants, zone H contain six fire hydrants, zone J contain five fire hydrants, zone K contain two fire hydrants, zone L contain three fire hydrants, zone M contain two fire hydrants, zone N contain four fire hydrants, zone P contain two fire hydrants, zone Q contain six fire hydrants, and zone R contain 10 fire hydrants. All the details (GPS coordinate) for the fire hydrants mention in table below.

Figure 17: UTP fire hydrants

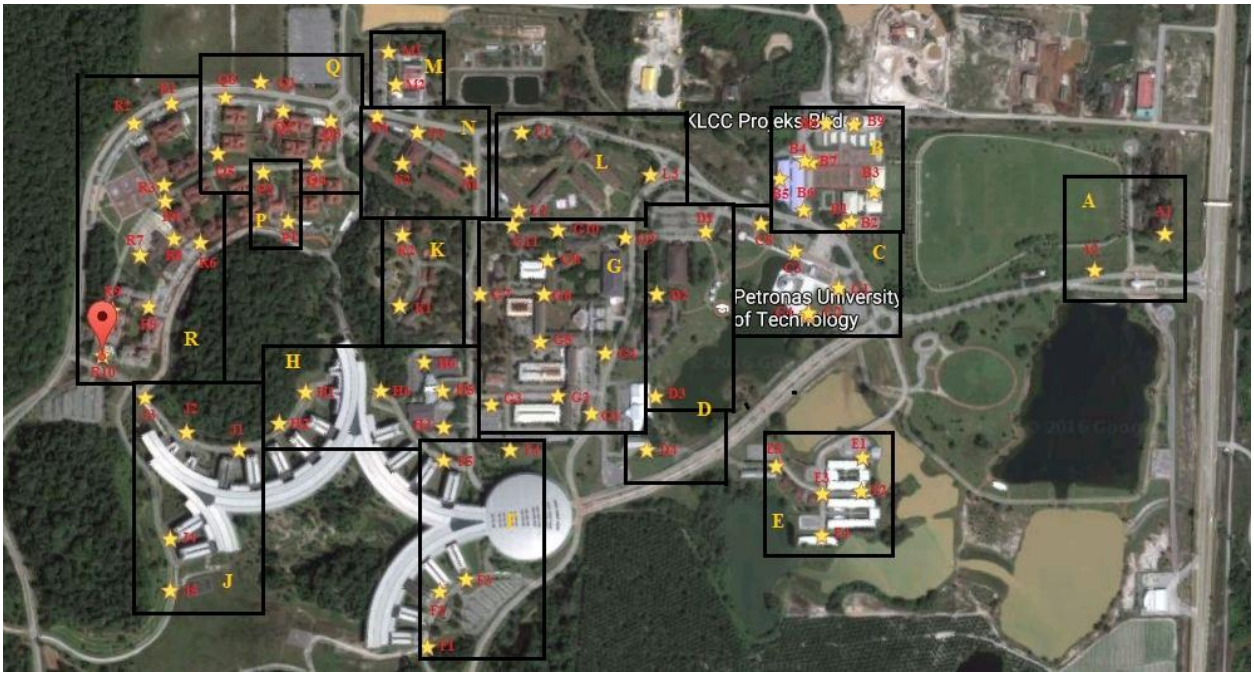


Figure 18: Fire hydrants in UTP in their zone

From figure 7 (above), indicate fire hydrants in their zone. Each zone represents their building intensity and fire hydrant coverage area. For example, zone G (research center), in that zone there are 11 fire hydrants that cover all the buildings in that zone. Refer figures below for zoom in zones.

Figure 19: zone A (main entrance)

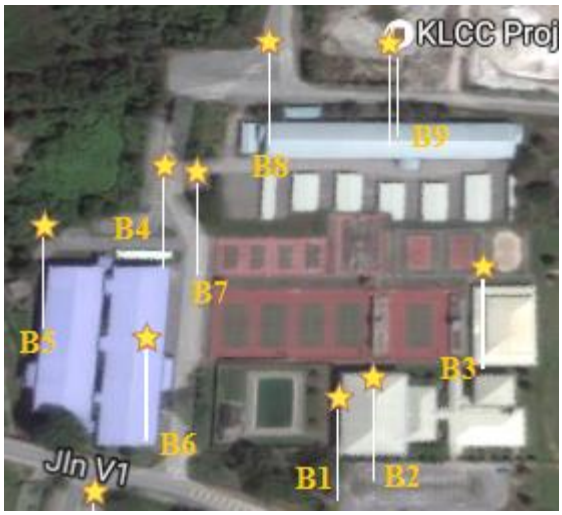


Figure 20: zone B (sport complex)

Figure 21: zone C (mosque)

Figure 22: zone D (hall)

Figure 23: zone E (village 6)

Figure 24: zone F (chancellor complex)

Figure 25: zone G (research center)

Figure 26: zone H (pocket D)

Figure 27: zone J (pocket C)

Figure 28: zone K (guest house)

Figure 29: zone L (village 1)

Figure 30: zone M (maintenance office)

Figure 31: zone N (village 2)

Figure 32: zone P (village 3)

Figure 33: zone Q (village 4)

Figure 34: zone R (village 5)

Table 7: Details for all fire hydrant in UTP

Hydrant tag	Remarks	Latitude	Longitude
Main entrance/Main gate UTP (zone A)			
A1	Main gate (near fence)	04.3864500°	100.9797667°
A2	Main road	04.3858833°	100.9786500°
Sport/Playground complex (zone B)			
B1	Parking area (near a tree)	04.3865667°	100.9746333°
B2	Security parking area	04.3866500°	100.9747500°
B3	Tennis court	04.3871333°	100.9751167°
B4	Block B car park	04.3876167°	100.9740000°
B5	Block B, (near electrical sub)	04.3873333°	100.9736000°
B6	Block B (in front)	04.3868333°	100.9739833°
B7	Tennis court (left side)	04.3875833°	100.9741167°
B8	Block C (in front)	04.3882167°	100.9743500°
B9	Block C (in front/main entrance)	04.3882000°	100.9747833°
Mosque/ Masjid An-Nur (zone C)			
C1	Car park (garden)	04.3856000°	100.9745500°
C2	Mosque (in front/ near the garden)	04.3851500°	100.9740500°
C3	Mosque (in front/ pond)	04.3861833°	100.9738500°
C4	Old mosque (in front/under a tree)	04.3852000°	100.9740667°
C5	Block D (main road)	04.3866167°	100.9733167°
Main hall/ Dewan Besar (zone D)			
D1	Main hall (in front)	04.3865000°	100.9724333°

D2	Registrar office (in front/under tree)	04.3855000°	100.9716500°
D3	Behind MPH	04.3838667°	100.9716167°
D4	Petrobot lab	04.3830167°	100.9714833°
Village 6 (zone E)			
E1	Tembungo (A); (behind/near fence)	04.3829000°	100.9749333°
E2	Ruby (B);(behind/ near fence)	04.3823500°	100.9749167°
E3	Etana (C) (in front)	04.3823167°	100.9743000°
E4	Propana (E) (in front)	04.3816667°	100.9742833°
E5	Duyung (F);(in front/ near fence)	04.3827500°	100.9735500°
Chancellor complex/Near IRC (zone F)			
F1	Block 5 (behind)	04.3798833°	100.9679833°
F2	Block 3 (behind)	04.3807667°	100.9681833°
F3	Block 1 (behind)	04.3809667°	100.9686000°
F4	Chancellor Hall (Behind)	04.3830167°	100.9693000°
F5	Block 23 (behind)	04.3828500°	100.9682333°
Research Centre/ In front of pocket D (zone G)			
G1	Block I (in front)	04.3836000°	100.9706000°
G2	Block I (behind)	04.3838833°	100.9700667°
G3	Open space parking area	04.3837333°	100.9690000°
G4	Lecture hall	04.3845500°	100.9708167°
G5	Old lab building	04.3847333°	100.9697833°
G6	Block N	04.3855000°	100.9698500°
G7	Guest house (junction)	04.3854833°	100.9688167°
G8	Near the staircase towards cafeteria	04.3860333°	100.9699000°

G9	Car park at CIMB atm machine	04.3864000°	100.9711333°
G10	Behind cafeteria	04.3865167°	100.9700667°
G11	Block O (in front)	04.3865833°	100.9693333°
Pocket D (Zone H)			
H1	Pocket D (behind)	04.3839333°	100.9660500°
H2	Block 17 & 18 (middle block)	04.3834333°	100.9656333°
H3	Block 20 (behind)	04.3833833°	100.9682333°
H4	Pocket D (in front)	04.3839500°	100.9672333°
H5	Nano Research Centre (in front)	04.3839500°	100.9682167°
H6	Nano Research Centre (behind)	04.3844167°	100.9679333°
Pocket C (Zone J)			
J1	Block 15 & 16 (middle block)	04.3830333°	100.9649833°
J2	Clinic (behind)	04.3833000°	100.9641500°
J3	V5J & Pocket C (junction)	04.3838500°	100.9635000°
J4	Block 14 (behind)	04.3816167°	100.9638833°
J5	Open space parking area	04.3808000°	100.9639000°
Guest House (Zone K)			
K1	In front of Block D1-1	04.3853167°	100.9675500°
K2	In front of bungalow	04.3864333°	100.9675833°
Village 1 (Zone L)			
L1	Old petrol station (near V1C)	04.3880667°	100.9694833°
L2	Near V1-C & fellow house	04.3868167°	100.9694500°
L3	Roundabout	04.3873833°	100.9715500°
Maintenance Office (Zone M)			

M1	Workshop (behind)	04.3893500°	100.9673667°
M2	Bus parking area	04.3888167°	100.9674833°
Village 2 (Zone N)			
N1	V2-A	04.3874667°	100.9686667°
N2	Cafeteria (behind)	04.3875667°	100.9675833°
N3	Entrance cafeteria (entrance)	04.3880667°	100.9678167°
N4	V2-C (fence)	04.3883167°	100.9671833°
Village 3 (Zone P)			
P1	Cafeteria (in front)	04.3866500°	100.9657667°
P2	Surau V3	04.3874333°	100.9653667°
Village 4 (Zone Q)			
Q1	Electrical substations	04.3888667°	100.9653167°
Q2	Cafeteria	04.3884167°	100.9656833°
Q3	V4C motorcycle parking	04.3882500°	100.9664500°
Q4	V4C at the pedestrian walkways	04.3875833°	100.9662167°
Q5	V4E (behind)	04.3877333°	100.9646500°
Q6	V4A (in front)	04.3886167°	100.9647667°
Village 5 (Zone R)			
R1	V5A car park	04.3885167°	100.9639167°
R2	V5B car park	04.3882000°	100.9633167°
R3	V5C	04.3872167°	100.9637833°
R4	V5E	04.3869667°	100.9638167°
R5	Beside garbage disposal	04.3863667°	100.9639500°
R6	V5F	04.3863167°	100.9643667°

R7	Behind cafeteria	04.3861167°	100.9634167°
R8	Beside garbage disposal	04.3853000°	100.9635500°
R9	V5K	04.3852333°	100.9629833°
R10	V5K motorcycle parking area	04.3845167°	100.9628167°

Each of fire hydrant be naming with respects to their coverage area. By doing this, there will no redundant naming for fire hydrants. As for example, zone P for Village 3; then each fire hydrant in that area will be tagged P1 and P2; if zone Q then fire hydrant will be tag with Q1, Q2, Q3,Q4,Q5,and Q6.

Table 8: fire hydrants distance with respect their reference fire hydrant

Zone	Remarks	Distance (m)
A	A1 to A2	146.94
B	B1 to B2	14.48
	B1 to B3	88.99
	B1 to B4	148.87
	B1 to B5	143
	B1 to B6	81.83
	B1 to B7	127.15
	B1 to B8	204.44
	B1 to B9	197.31
C	C1 to C2	73.98
	C1 to C3	108.05
	C1 to C4	86.24
	C1 to C5	181.81
D	D1 to D2	147.39
	D1 to D3	319.6
	D1 to D4	412.96
E	E1 to E2	64.59
	E1 to E3	100.97
	E1 to E4	163.06
	E1 to E5	151.6
F	F1 to F2	101.48
	F1 to F3	142.96
	F1 to F4	400.54
	F1 to F5	343.6

G	G1 to G2	74.4
	G1 to G3	186.83
	G1 to G4	114
	G1 to G5	155.3
	G1 to G6	235.8
	G1 to G7	304.57
	G1 to G8	301.14
	G1 to G9	339.43
	G1 to G10	348.78
	G1 to G11	372.87
H	H1 to H2	78.4
	H1 to H3	260.55
	H1 to H4	128.47
	H1 to H5	236.45
	H1 to H6	217.4
J	J1 to J2	102.32
	J1 to J3	199
	J1 to J4	200.27
	J1 to J5	277.58
K	K1 to K2	143.42
L	L1 to L2	158.069
	L1 to L3	250.37
M	M1 to M2	61.59
N	N1 to N2	118.54
	N1 to N3	127.38
	N1 to N4	196.9
P	P1 to P2	98.5
Q	Q1 to Q2	66.39
	Q1 to Q3	148.88
	Q1 to Q4	177.43
	Q1 to Q5	150.02
	Q1 to Q6	71.97
R	R1 to R2	71.19
	R1 to R3	158.49
	R1 to R4	191.88
	R1 to R5	258.33
	R1 to R6	251.1
	R1 to R7	293.92
	R1 to R8	376.16
	R1 to R9	415.51
	R1 to R10	504.36

Based on table 8 (above) the calculated distance is based on one reference point (fire hydrant). The reference point is first fire hydrant in each zone. Fire hydrants that be used as reference point are A1, B1, C1, D1, E1, F1, G1, H1, J1, K1, L1, M1, N1, P1, Q1 and R1.

4.2 Integrate Ultrasonic sensor with LCD 16 x 2

In this part, author have combine ultrasonic sensor (HC-SR04) with liquid crystal display (LCD). The main reason for using ultrasonic sensor in this project is to get water level reading in designed tank. By using concept of sonar wave (reflected signal) from ultrasonic sensor to the bottom designed tank, author can know what is current water level in that tank. Speed of sound equal to 340 m/s or equally 29 ms/cm if change to cm measurement. The duration of time taken for the sonar waves to reflected to echo (receiver for HC-SR04) is:

Water level (cm) = duration for HC-SR04 back and forth x 1/29 x ½

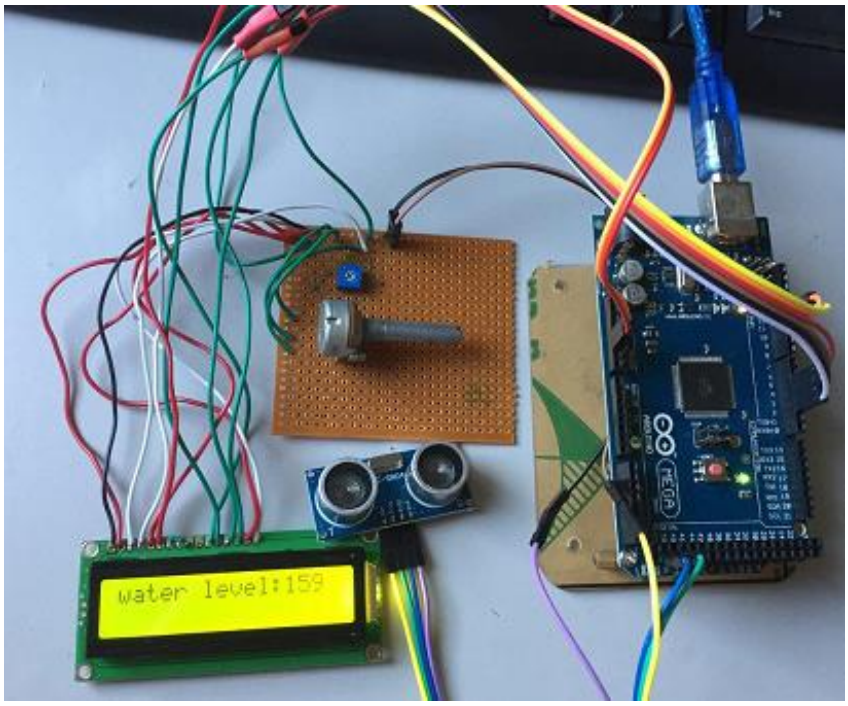


Figure 35: Testing HC-SR04 reading and displays at LCD screen

Initially, the reading from ultrasonic sensor will be transmitting via Bluetooth module to android phone; because of Bluetooth module has random noise such as difficult to connect and require some time to troubleshoot the error/s. The solution for this problem just use LCD. The reading from serial communication and reading displayed at the LCD screen is same.

Figure 36: Ultrasonic sensor reading displayed at LCD 16x2

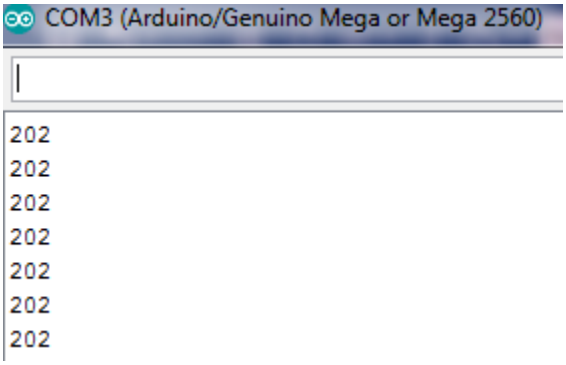
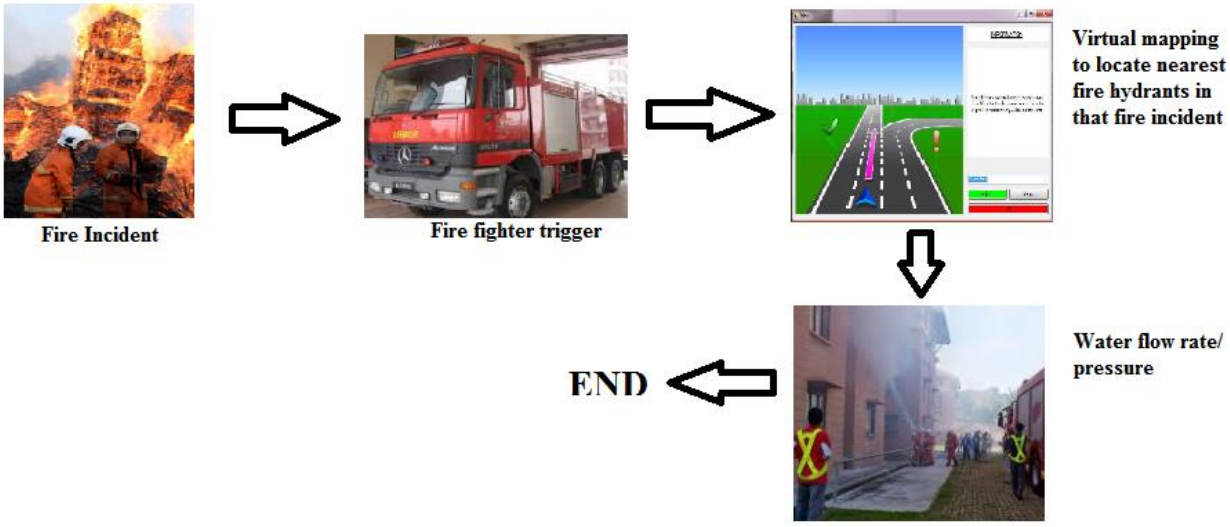


Figure 37: Ultrasonic sensor reading displayed at serial comm. Arduino

4.3 Virtual Mapping

Overall actions that should be act when fire incident happen as per below:



Steps to activated virtual mapping and water flow sensor rate as per following; first when there is fire incident initiate then citizen call the fire fighter for rescue. Fire fighter trigger and searching fire incident area. Fire fighter using virtual mapping to search the fire hydrants which one is nearest with fire incident. By using virtual mapping, fire fighter can access fire hydrants GPS coordinates and distance from reference point (first fire hydrant in that location). After that, fire fighter can view water flow rate or pressure for that particular hydrant.

4.4 Testing Prototype

Data measured from prototype respected to heights of water level, data measured from prototype and taking average for Q and data calculated based on heights of water level inside tank (prototype) .

Table 9: Measurements and Calculated data for water flow rate (outlet tank)

Measure				Calculate	
3 Freq.	Result	Ave	Result	1 Freq.	Result
h(cm)	Q(L/min)	h(cm)	Q(L/min)	h(cm)	Outlet velocity (m/s)
20	10.14 10.13 9.81	20	10.02	20	18.26
19	9.9 9.83 9.68	19	9.8	19	17.71
18	9.52 9.51 9.51	18	9.51	18	17.16
17	9.36 9.3 9.21	17	9.26	17	16.57
16	8.58 8.43 8.2	16	8.4	16	15.97
15	8.27	15	8.21	15	15.34

	8.25 8.11				
14	7.9 7.8 7.64	14	7.78	14	14.69
13	7.17 7.15 6.89	13	7.07	13	14
12	6.09 6.08 6.05	12	6.07	12	13.29
11	5.65 5.6 5.45	11	5.59	11	12.53
10	5.15 5.1 4.99	10	5.08	10	11.72
9	4.99 4.83 4.8	9	4.87	9	10.84
8	4.37 4.21 4.18	8	4.25	8	9.9

7	4.05 3.9 3.85	7	3.93	7	8.86
6	3.43 3.27 3.25	6	3.32	6	7.67
5	2.81 2.6 2.5	5	2.63	5	6.26
4	2.03 3.03 4.03	4	2.03	4	4.43

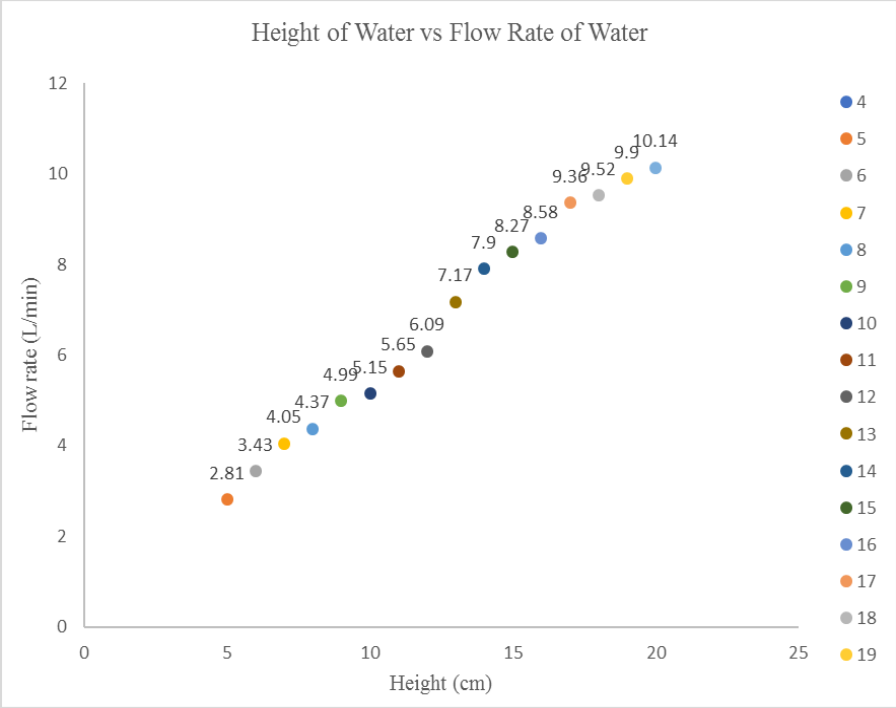


Figure 38 : Graph for height of water versus flow rate water (measure)

As per graph above (figure 38) in that graph are measured points based on 3 Freq. water height in tank and the result is water flow rate (Q). The reason why should repeat the same height of water because author want to know precise water flow rate can be if within that height. The unit for measure height is in centimeter and unit for water (fluid) flow rate is in liter/minute. The tank (prototype's height only 20cm and measurable height only can support from 4cm up to 20cm.For heights 3cm,2cm and 1cm the water flow rate is steady or author can say that the reading Q is known as one resolution.One resolution equal to 1.5+/-0.1 L/min. Logically, if the height of water become higher then the water flow rate will be stronger (high Q reading). Then in figure 38, that graph shows that the higher the height of water then Q become stronger. Hence, this will be advantage for fire fighter in fire rescue.

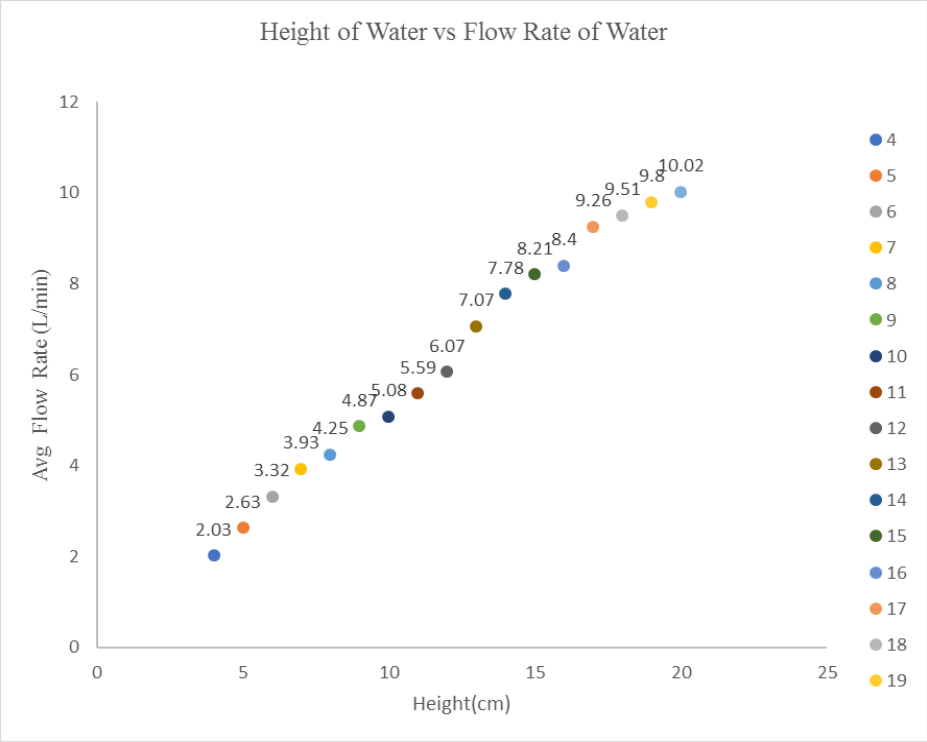


Figure 39 : Graph for average reading flow rate water (measure)

Figure 39 shows the same measure data points as in figure 38, the only different is figure 39 in term of average value for water flow rate, Q. Easier to analyses the pattern behavior. Figure 39 shows an up-trend momentum which prove the design of experiment (DOE) author.

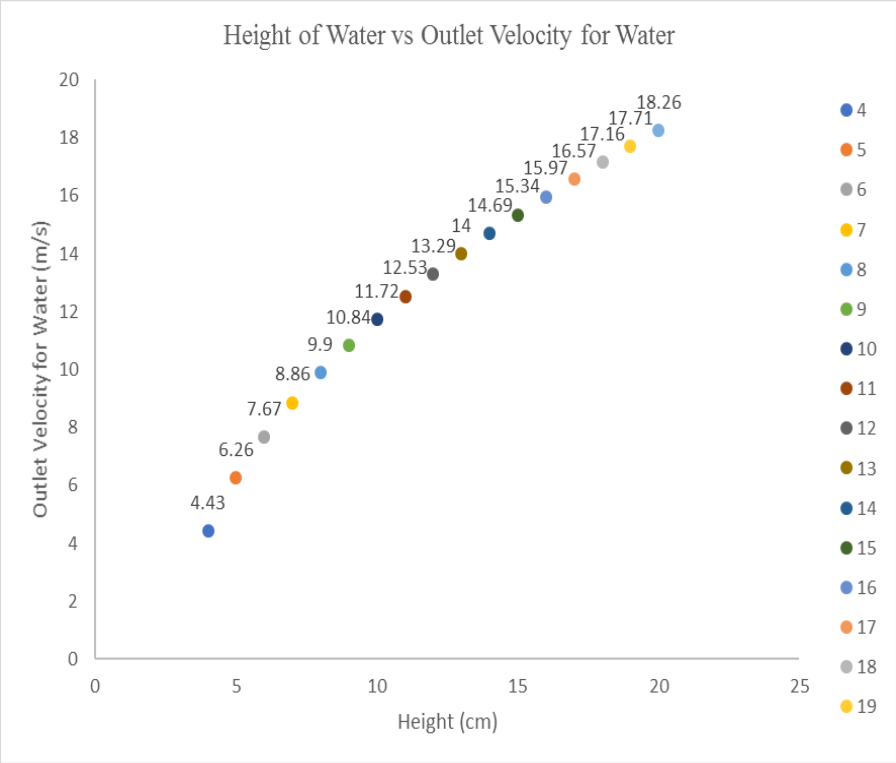


Figure 40: Graph for height of water versus velocity water (calculate)

Figure 40, shows what is author calculated based on Torricelli's theorem;

$$velocity\ at\ outlet\ tank = square\ root\ (2g(h_1-h_2))$$

result from outlet tank. As illustrate the pattern showing up-trend pattern which is same with measured data. By meaning, DOE author is proven by using water flow rate sensor at outlet tank, water flow rate can be measure and its behavior is same with calculated data.

CHAPTER 5: CONCLUSION

As summary for this project, author have proven that by using virtual mapping for looking fire hydrants in a particular area is important because it is reducing time. If compare with conventional method which is using physical map, time for searching a fire hydrant is at least five minutes. In real situation anything can be destroyed in that five minutes delay. That why important to have a system that can helps fire fighter searching fire hydrants.

Other than that, this project also study how to know what are current pressure for water in that fire hydrant to extinguish fire. Fire hydrant have it own rating, the rating be rate based on residual pressure must be 20 psi with all fire hydrant should be more than 40 psi static pressure when delivered water flow [6]. Formula to convert psi to GPM can be:

$$(g * h) + (P/rho) + (V^2/2) = constant$$

$$V = sqrt\ (2((-g*h\ )-(P/rho))$$

$$Q = V * A$$

g = graviti; P = pressure; h = elevation of water from reference point;

rho = density of fluid; A = area of pipeline

Author focus how manipulate dynamic variable which is elevation of water from reference point and output respond is flow rate in liter per minute. Based on DOE author, water flow rate sensor can be used in measure water flow rate at outlet tank or at pipeline fire hydrants. By this way, fire fighter know what are current residual pressure for that fire hydrant; fire fighter can prepare to use water pump to increase water pressure.

REFERENCE

[1]. [Online]. Available: http://www.bomba.gov.my/resources/index/user_1/UploadFile/Penerbitan/LAPORAN_TAHUN_2014.pdf. Accessed: Aug. 17, 2016.

[2] A. A. Kshirsagar and S. Hippargi, "Design and implementation of wireless sensor node for noncontact measurement of liquid," 2014 Annual IEEE India Conference (INDICON), pp. 1–5, Dec. 2014.

[3] "History and usage of fire Hydrants,". [Online]. Available: http://www.usd116.org/ums/apple/service/department/history/hydrant.html. Accessed: Jun. 21, 2016.

[4] Z. Liling, A. Jiaju, Y. Jianxiong, and W. Zhangqiang, "Application of ultrasonic and CCD dual sensor technology in the underwater welding seam tracking," 2016 IEEE Information Technology, Networking, Electronic and Automation Control Conference, pp. 901, 902, 903, 904, May 2016.

[5] M. Mousa, X. Zhang, and C. Claudel, "Flash flood detection in urban cities using ultrasonic and infrared sensors," IEEE Sensors Journal, vol. 16, no. 19, pp. 7204–7216, Oct. 2016.

[6] NATIONAL FIRE PROTECTION ASSOCIATION REPORT
National Fire Protection Association Report 2-3, National Fire Protection Association Report. 2013. Web. 12 Mar. 2017.