The Drainage Exchange of Stormwater Potential in Flat Area Problems

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The Drainage Exchange of Stormwater Potential in Flat Area Problems

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Abstract: Groundwater as an alternative source still does not contribute to the water supply in area of Parit Raja because of the limitation of water availability in the ground. This lacking of groundwater could be caused by the circumstance that the top layer of soil is dominated by compacted clay around 2 meters in which its permeability is small, so the water is difficult to infiltrate the ground. The recharge well technique was designed based on the flat area problems, layer of real condition, flow water table and low infiltration rate. Resistivity soundings were made at existing wells to assess the subsurface layers. Beside that, the past records on floods event, sub surface and surface studies were collected around study area as a preliminary studies. It was presented that the study area promised good prospects to increase the capability of groundwater and contribute to the drainage system by reducing the volume of rainfall runoff using the recharge well technique.

Key words: Groundwater, recharge well, water supply, drainage system.

1. Introduction

As we know that south Malaysia of Peninsular has been nature filled by peat soil and deep of clay layers. Low flows are often important ecologically. Some time, low flow movement to the rivers uncontrolled when the wet season out come. Then, flooding always occurred during rainy season caused by flat area and lacking of proper drainage system.

Recently, the development of Districts of Batu Pahat has caused the increasing number of inhabitant. More even in area of Parit Raja, the growing of population more than other areas since UTHM (Universiti Tun Hussein Onn Malaysia) is developed, which has been established as a big university. With the increase of buildings and pavement, the green area smaller causes too much stress on the remaining drainage area, which can cause several flooding in rural or urban especially Parit Raja area [1]. Besides, the drainage system in UTHM also had faced some terrible condition where in the end of year 2006, the flood happened and it caused partially sunk of UTHM old campus. This condition happened because of the poor drainage system around the campus. Thus, this research is then carried out to find out the best way to overcome that poor drainage system where the drilled well that is used to generate the source of water can be a part of drainage system during wet season to mitigate the flood.

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This study examines the potential of artificial recharge, the water supplied to a surface infiltration or injection well recharge system. It is evaluated that the quantity of municipal storm-water runoff by the supporting drainage system may be suitable for ground water recharge, its potential use would be extremely site specific and a general evaluation is not useful. The well recharging process will be helpful in improving the groundwater quality because the groundwater that is observed contains a lot of iron [2]. The quality of groundwater can be diluted by the rainwater that can be recharged into the well. Thus, the rainwater itself is beneficial for the groundwater improvement. Wherefore, the potential source waters of impaired quality for artificial recharge consider treated storm-water runoff and potable water return flows.

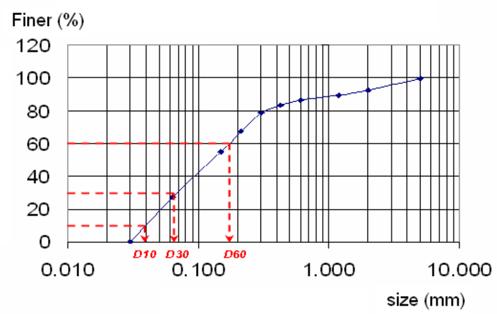


Fig. 1 Grain size distribution on related location.

Fig. 2 Flood problems in Batu Pahat district.

2. Preliminary Studies

2.1 Top Soil Surface

A study on infiltration and particle size distribution has been done in the most area of UTHM campus. It was found that the rate of infiltration is in the range of 0.004-0.007 mm/s and the soil classification based on particle size is between silt to fine sand (Fig. 1). That mean, the top soil surface had low infiltration rate and high moisture content caused by the types of soil.

At the land occupied by clay soil at the top layers commonly has confined aquifer layer that can be used as groundwater recharge well. And hence, by providing a recharge well it is possible that the surface water runoff can be released by directing into the ground (confined aquifer) through recharge well.

2.2 Floods

Report from Department of Irrigation and Drainage, Malaysia was presented [3], at December 19, 2006 and January 12, 2007, Batu Pahat District was hit by a huge flood (Fig 2). More than 70% of the areas were flooded and it causes damage to property, business, or road. The flood caused by: (1) The rainfall intensity was too high, where 170 and 247 mm/day we recorded at Bekok Dam and 181 and 229 mm/day recorded at Sembrong Dam; (2) The capacity of the available reservoirs is insufficient to store rain runoff, where the occurred water levels were above the critical levels, 20.31 m over 17.5 m in Bekok Dam and 13.66 m over 12.0 m in Sembrong Dam; (3) The cross section of river is insufficient to flow the peak flow rate; (4) Most of areas of Batu Pahat are low infiltration rate and flat area (around 0.5 to 2 m above mean sea level) that causes the river is not capable to discharge storm water direct to the sea.

Hence, it is required to study on groundwater as an alternative source for water supply and to enhance the drainage system of flat area by using sub surface land as water storage [4]. This method will be designed based on the flat area problems such as soil type, layer of bedrock, flow water table in flat area, and low infiltration rate.

2.3 Subsurface Conditions

The research area in Fig. 3 selected by flooding problems and existing wells was shown by resistivity survey nearby RECESS (Research Centre of Soft Soil Malaysia), UTHM. The pseudo section of line survey was illustrated in Fig. 4 through the wells exist.

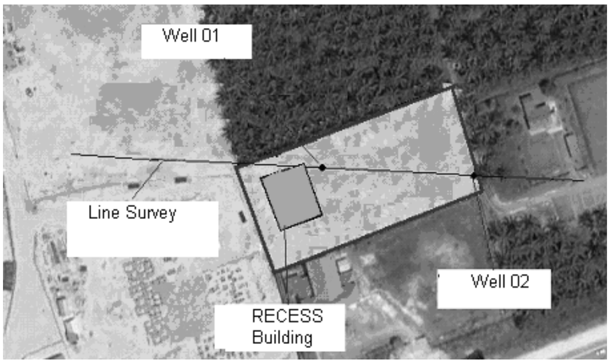


Fig. 3 The existing wells in RECESS area.

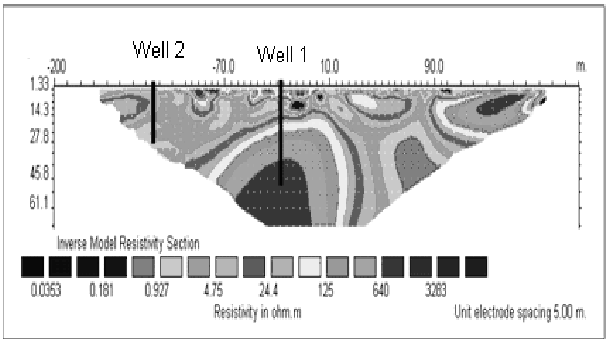
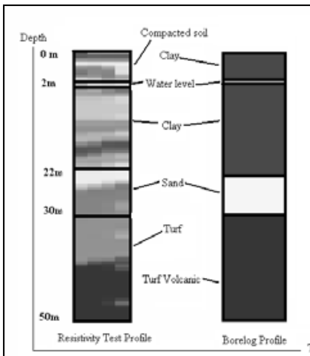


Fig. 4 Sub surface image through the wells.



Depth (m)	Borelog	Electrical resistivity survey
0-2	clay	Compacted soil
2-4	Clay + groundwater	Clay + groundwater
4-6	clay	clay
6-8	clay	clay
8-10	clay	clay
10-12	clay	clay
12-14	clay	clay
14-16	clay	clay
16-18	clay	clay
18-20	clay	clay
20-22	clay	Sand
22-24	Sand	Sand
24-26	Sand	Sand
26-28	Sand	Sand
28-30	Sand	Sand
30-32	Turf Volcanic	Bedrock (turf)
32-34	Turf Volcanic	Bedrock (turf)
34-50	Turf Volcanic	Bedrock (turf)

Fig. 5 Comparison of subsurface profile between borelog and resistivity result on Well 1.

The interpreted geological section on the basis of geo electrical resistivity survey is shown in Fig. 5 with two existing wells. This survey was tested at RECESS by using *Wenner_L* and *Wenner_S* Protocols. It was interpreted to 61.1 m deep with maximum length of survey tools. This method was conducted [5] and used in the resistivity soundings made at existing boreholes, both high and low yielding, to calibrate responses with geology. Application method had good records, it was concluded that this approach of looking for horizontal features was correct, because such features associated with good borehole yields existed in the area.

The reliable and usable method was compared [6, 7] between borelog and resistivity image approximately. The Well 1 profile in Fig. 5 was being consistency almost 95% of strata profiles. The interpretation clearly shows that area contains the thickness of clay, sand and turf whichever water level around 2 m above mean sea level. Based on borelog profile, the top layer which contains clay and silty clay soil wherefore resistivity records is considered as a compacted soil cause the image of this layer mixed colours with others. The ground water saturated with maximum level around 2 m and had a little bit of salt water instrusion existed caused by the location of Pantai Rengit only 20 km nearly. Considering the yellow to brown colours as a sandy layer, a thickness of aquifer [6] approximately 10 m depth on that area was proved. The potential at another point to survey around it commonly does not dismay to carry out some of planning ground project effectively. This result is believable to find the reliable layer at real site condition without traditional and coastly methods used.

It was assessed that top layer of clay was present, which veried in thickness from 1 m to 30 m, approximately. The layer of Tuff covered up to 30 m of the sub surface to hardrock of the layers. At all other locations, medium sand to course sand was present beneath the fine sand layer, which promised good prospects for the groundwater recharge [8]. Although, the deeper possible profile can be acceived by this method because the maximun lenght of cables was used until 400 m. The limitation of this survey should be provided another method by drilling as possible deep to find out the real profile and solve any water problems.

Based on Well 1 (Fig. 6), the drilling works by Maju Teknik Kota indicates (Well 1) at 1st crack zone in Tuff occur at the depth of 44 m to 46 m deep, spit well water approximately 0.91 m^3/hr (200 gallons/hr). Similar recovery investigation work and test well records [9] at RISDA nursery, Kampung Panchor (MR

Fig. 6 Single well.

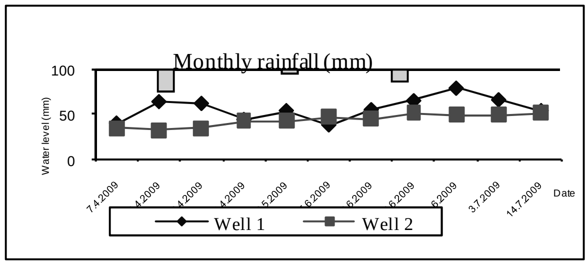


Fig. 7 Water level records.

123/WL 568045) with diameter 203 mm and well depth 20 m found that the granite was friable and broken into fragments, the interstices between which could store groundwater. Other potential were considered in this area also in fractured rocks, which is water only moves through the fractures, even if the fractured matrix blocks are porous. It mean that the effective porosity of the rock mass is linked to the volume of these fractures.

According to records which were presented in Ref. [4], the real condition of deep soil is karsts, which is more potential as groundwater resources than granite and seal rocks in which the hydraulic conductivity is about 1×10^{-1}-1×10^{-5} m/s. The presence of Karstification is important in areas of regionally important aquifers. It can indicate short groundwater travel time (high velocities), variability in well yields and vulnerability to pollution. For confined bedrock (usually sandstone) aquifers, the depth at which the top of aquifer is 150 m b.g.l, if possible, as this is the general practical limit for groundwater development [10]. Studies in Ref. [11] was found that capability of storativity of aquifer increase parellel to depth of well. Almost of the wells was drilled 100 m and above had a good capacity. Normally, drilling work should be deeper which is possible to get more capacity of the storativity of layers.

2.4 Water Level

A prior record for on existing well and borehole indicates that the water level available around 1-2 meters under mean sea level. It means that the layer under the ground had high water table. Based on the observation on water level (Fig. 7), the fluctuation on well 1 showed that the precipitation affects the water level in the well. But, the record from well 2 does not show a similar response in well 1. This situation indicates that relationship between these 2 well in the sub surface condition is not same in continuously layer. The different layer also affects the storage and capacity of the well. The weaknesses well in RECESS area are located in unsuitable point to find the good capacity storage. That mean is, the suitable point to identify the best mechanisms interaction of surface water and ground water was determined correctly.

2.5 Test Well

Before testing the wells for yield, the static water level was determined (Fig. 7). After initial water level of the wells had been determined, the wells were tested for yield by pumping at the maximum rate until the water level in the well stabilized. The depth of the water level was then noted. The difference is that the depth is the drawdown, and the discharge drawdown is an estimate of the specific capacity of the well [12]. The discharge of the well when the water level of water had been stabilized was measured. The yield capacity (m^3/day) of the well was determined by measuring the volume of water collected by the calibrated bucket per unit time. The equation is:

$$Yield\ capacity = \frac{Discharge\ x\ 1000}{60\ x\ 60\ x\ 24} \qquad (1)$$

Identification of aquifer parameters plays an important role in assessing and managing the groundwater resources. The constant flux pumping test is commonly applied to identify the aquifer parameters from the measured drawdown data [13]. Analyses of the drawdown and recovery data Well 1 in Figs. 8 and 9 respectively indicated that water bearing layer has yield of 144.029 m^3/day with coefficient of trasmissivity and storativity is 1.076 m^2/day and 0.189 respectively. These records commonly tested to identify by estimating possible recharge and analyzing the real condition response to pumping. According this well test, half of pumping yield was loss by recovery in range 25-26 m in 50 minutes. This constructed well is not proper in determining the porous layer and have

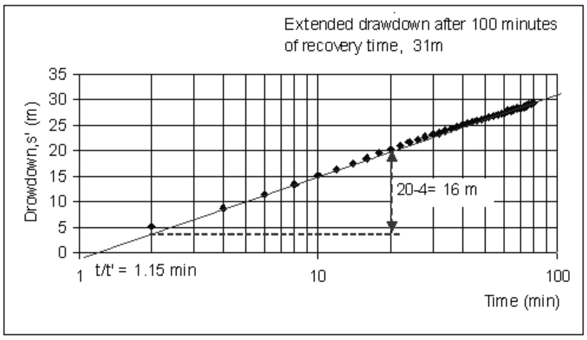


Fig. 8 Drawdown of pumping test.

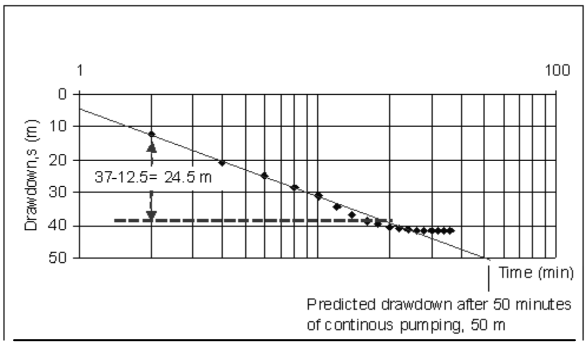


Fig. 9 Recovery test on single well.

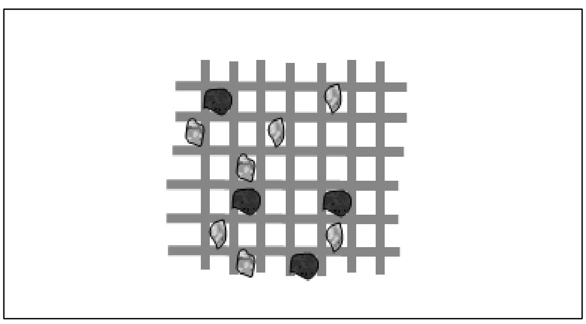


Fig. 10 Sand grains make opening screen blocked during pumping and recovery time.

small yield capacity and low static water levels. This may be due to the fact that the study area is occupied by varying clayey and sandy contents. It also depends on limitation and capability of water movements in the ground to recharge and discharge parts. Therefore, the ability to store the water at this point still lack and needs future studies on other points and area.

Some time, the shape of the louver openings is such that the shutter screen cannot be performed successfully used for naturally wells. The opening becomes blocked during the running procedure where the aquifer material contains any appreciable proportion of sand and fractures rock as shown in Fig. 10.

2.6 Sri Gading Records

An appraisal of geological logs from the exploratory drilling indicates that the subsurface is predominantly clayey in nature. The occurrences of sandy layers which are water bearing are rather limited both vertically and laterally. Some of the boreholes drilled penetrated an entirely clayey sequence [9]. This present investigation is aimed at studying the sub surface lithological and hydrogeological conditions in the area and to determine whether any useful amount of groundwater can be obtained for domestic and/or industrial/agriculture usage.

Generally, there is a top layer of brown, peaty clay which covers most of the area. Below the top covering is a layer of grey clay, which is frequently mottled and locally contains a lateritic hard pan. Greenish, shell bearing clay, probably of marine origin, is also extensive, particularly near the coast. The clay layers just above the bedrock are usually sandy in nature. Sand is limited in extent both vertically and laterally and often admixed with a little clay. In Sembrong area, sand occurs probably as a isolated lenses within the extensive clay layers and is there of limited capacity as aquifers. Also, elsewhere in the investigation area had sand layers only a few meters thick which do not appear to have extensive lateral continuity. This condition effects to this research needs to continue with the proper investigation and perhaps that it can be refreshing some of suitable solution on these area problems.

Report on Soil Investigation for New Campus at UTHM-Phase I (January 2003) presented in Ref. [14] also found the same result with average 20 m depth of clay and silt. Only 2 point of bore hole shows a little bit of sandy layer at BH3 and BH10 (Table 1). The totals of 48 undisturbed soil samples were obtained from very soft clayey layer in BH-1, BH-3, BH-4, BH-5, BH-7, BH-8 and BH-9. Nevertheless, this study will be produced deeper recharge well more than 100 m deep and target to be found a good solution in this problems.

Therefore, meorological and geo-hydrological/ geophysical information about the recharge area, existing water table and its fluctuations, water demands, availability of run off water and socio economic condition are fundamental inputs for undertaking recharge projects [15]. This identification of recharge and discharge area is important for land use plaaning purposes.

Table 1 Types of soil for boreholes in new campus.

BH	BH depth	Clay	Silt	Sand
1	36.3	0-27	27-36.30	-
2	31.93	0-23	23-31.93	-
3	39.15	1.10-25	0-1.10, 28.2-39.15	25-28.2
4	34.8	0-23.6	23.6-34.8	-
5	34.62	0-22	22-34.62	-
6	34.62	0.8-24.8	0-0.8, 24.8-34.62	-
7	31.87	0-24.4	24.3 - 31.87	-
8	28.65	0-21.8	21.8- 28.65	-
9	37.77	0-23.2	23.2-37.7	-
10	45.3	0.8-11.2, 13-19	0-0.8 , 19-45.3	11.2 - 13

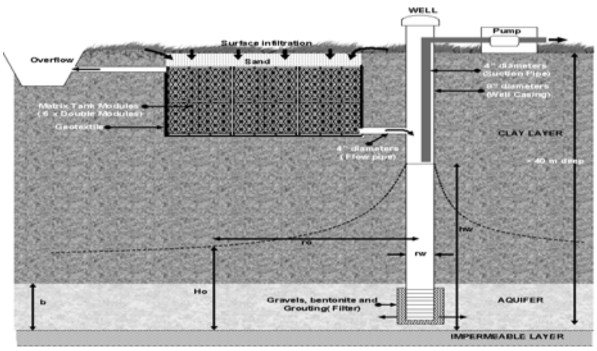


Fig. 11 Illustration of physical model.

3. Design of Concepts

The artificial recharge to groundwater aims at augmentation of its capacity by modifying the natural movement of surface water utilizing appropriate engineering structures. Artificial recharge techniques normally address to the following issues [15]: (a) Enhance the sustainable yield in areas where over development has depleted the aquifer. (b) Conservation and storage of excess surface water for future requirements, since these requirements often change within a season or a period and (c) Improve the quality of existing groundwater through dilution.

Artificial recharge well is a simple concept in which water is stored in subsurface permeable aquifers when water is plentiful and extracted during times of peak (Fig. 11). The recovery of confined aquifer is useful to us to modify the hydrology cycle in term as drain system solution. The basic equation for recharge well is:

$$Q = \frac{Kb\left(h_w - H_0\right)}{0.366\log\left(r_0/r_w\right)} \qquad (2)$$

Where,

Q = rate of injection (m^3/day);

K = hydraulic conductivity (m/day);

b = aquifer thickness (m);

h_w = head above the bottom of aquifer while recharging (m);

H_0 = ead above the bottom of aquifer;

when no pumping is taking place (m);

r_0 = radius of influence (m);

r_w = radius of injection well (m).

4. Discussion

Artificial groundwater recharge is possible in the depleting water table areas of Parit Raja plains using recharge tube wells. Estimation of availability of rechargeable water is very important before planning any groundwater recharge project [8]. The geo-electrical resistivity survey may be effectively used to search suitable sites for recharge.

However, resistivity tests were conducted at some locations in the study area using ABEM SAS 4000. One of the resistivity test which was done through the existing wells showed that the almost 95% of comparison result with borelogs interpretation was accurate and usable [6]. The borelog records show that the layer of aquifer found at 30-40 m depth and some layer at 44- 46 m depth at the bedrock as fracture rock. Therefore, one area was decided as a potential area to build the recharge well model whether it aquifer or fracture rock thickness. The development of considerable amounts of groundwater through high capacity wells is possible.

Provision of silt basin and suitable filter can ensure long life for recharge tube well [8]. This study applied the bio ecology concept (MASMA-Urban Stormwater Management Manual for Malaysia) [16] as a surface infiltration filter by controlling the quality and quantity of recharge water. It also can be protected any debris from breaking a quiet of recharge system. The filter designed based on the area of catchments, level, amount and flow of runoff and ground water table records. With the capsule concept, the water will be collected through the capsule before passing away to the well. All water quantity and quality should be considered in evaluating the filter assessment.

The drainage system is affected by several small south flowing rivers. Due to the generally flat terrain, the flow in the rivers is usually sluggish, and even during rainy season is often inundated. Hence, it is required to enhance the availability of groundwater by recharging waste water into the ground using recharge well, especially in the area of UTHM with hope the result is significant. It can be implemented in the similar areas around Batu Pahat district. And, it is also expected that by using artificial recharge, the volume of water in the pond is reduced, so the pond is able to anticipate the storm water. This groundwater studies as an alternative source for water supply and to enhance the drainage system of flat area by using sub surface land as water storage.

5. Conclusion

According to the overview studies respectively, the potential area as adequate aquifer storage should be found by drilling as deep as possible in layers. Standard exploration techniques can be used to identify channel aquifers and resistivity methods proved useful to locate successful sites. By discharging filtered surface water into the ground could increase the potential of groundwater and also would reduce the volume of water in the channel and pond, then the groundwater will be able to contribute the water supply and the drainage system will be able to anticipate stormwater. At the vertical drainage in REWES applications able balancing the hydrologic cycle and control the environmental aspects via recharging and discharging useful water by rotating in the ground naturally.

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