

The Potential of Recharge Well System in Flat Area with Low Infiltration Rate

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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 clay in which its permeability is small, so the water is difficult to infiltrate the ground. The recharge well technique will be designed based on the flat area problems, layer of bedrock, flow water table and low infiltration rate. According to the assessment of subsurface layer, presented that the study area promised good prospects for the ground water recharge system to increase the capability of groundwater. The recharge system also will contribute to the drainage system by reducing the volume of rainfall runoff using the recharge well technique.

Keywords: groundwater; recharge well, water supply; drainage system.

1. Introduction

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 is developed, which has been established as a big university. One of the consequences of its population increasing is highly water demand. Unfortunately, according to the quantity and quality, the municipal water is not able to fulfill all requirements. Beside it, flooding is always occurred during rainy season due to most areas are flat and lacking of proper drainage system.

This study, which examines the potential of artificial recharge, uses the term "source water" to mean the recharge source - the water supplied to a surface infiltration or injection well recharge system. Potential source waters of impaired quality for artificial recharge include treated municipal wastewater, storm-water runoff, and irrigation return flows. 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.

2. Preliminary studies

2.1. Floods

Report from (JPS, 2007), at December 19, 2006 and January 12, 2007, Batu Pahat District was

hit by a huge flood on Figure 1. 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 [1]. 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.



Figure 1: Flood problems in Batu Pahat district

2.2. Subsurface Studies

The research area in Figure 2 are selected by flooding problems and existing wells was shown by resistivity survey nearby RECESS (Research Centre of Soft Soil Malaysia), Universiti Tun Hussein Onn Malaysia (UTHM). The pseudo section of line survey was illustrated in Figure 3.

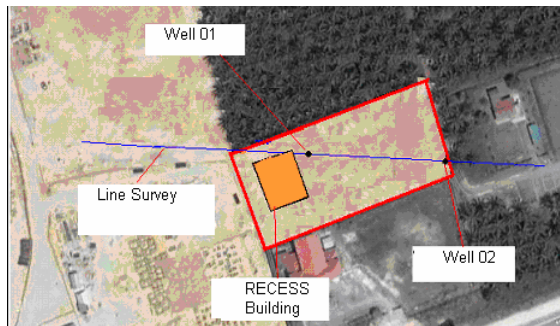


Figure 2: The existing wells in UTHM area

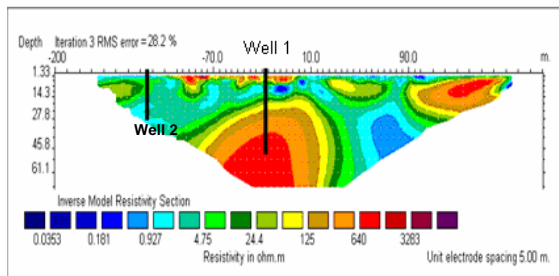


Figure 3: Sub surface image at RECESS site

The interpreted geological section on the basis of geo electrical resistivity survey is shown in Figure 3 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.

It was assessed that top layer of clay was present, which varied in thickness from 1m to 30m, approximately. The layer of Tuff covered up to 30m 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 [2].

Although, the deeper possible profile can be achieved by this method because the maximum length of cables was used until 400m. 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.



Figure 4 : Well 1 in RECESS area

Based on Well 1 (Figure 4), the drilling works [3] indicates (Well 1) at 1st crack zone in Tuff occur at the depth of 44m to 46m deep, spit well water approximately $0.91 \text{ m}^3/\text{hr}$ (200 gallons/ hr). M. Fawzi et. al (2007) was found that capability of storativity of aquifer increase parallel 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.

Nevertheless, this study will be produced deeper recharge well more than 100m deep and target to be found a good solution in this problems. Therefore, meteorological 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 [4].

According to Mohd. Faizal (2003), 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 $1 \times 10^{-1} - 1 \times 10^{-5} \text{ m/s}$. The presence of Karstification is an 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 [5].

2.3. 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 $0.004 - 0.007 \text{ mm/s}$ and the soil classification based on particle size is between silt

to fine sand (Figure 5) [6]. That mean, the top soil surface had low infiltration rate and high of moisture content caused by the types of soil.

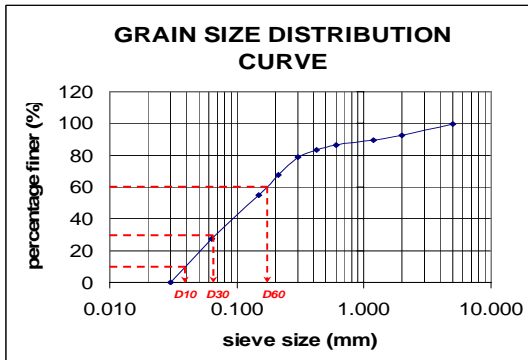


Figure 5 : Type of top soil classification

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.

3. Design of concepts

3.1. Recharge well system

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 [4]:

- Enhance the sustainable yield in areas where over development has depleted the aquifer.
- Conservation and storage of excess surface water for future requirements, since these requirements often change within a season or a period.
- 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 (Figure 6). 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:

$$Q = \frac{Kb(h_w - H_0)}{0.366 \log(r_0/r_w)} \quad (1-1)$$

where:

- Q = rate of injection, in m³/day
- K = hydraulic conductivity, in m/day
- b = aquifer thickness, in m
- h_w = head above the bottom of aquifer while recharging, in m
- H₀ = head above the bottom of aquifer when no pumping is taking place, in m
- r₀ = radius of influence, in m
- r_w = radius of injection well, in m

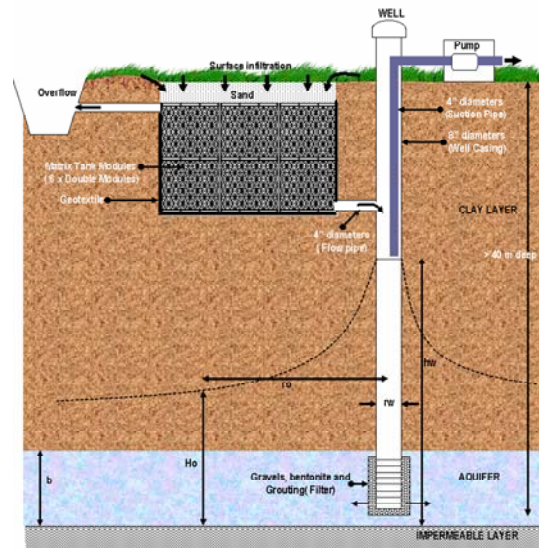


Figure 6: Illustration of physical model

4. Discussion

4.1. Physical Model

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 [7]. 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. Therefore, one area was decided as a potential area to build the recharge well model.

Provision of silt basin and suitable filter can ensure long life for recharge tube well [7]. This study will be applied the bio ecology concept (MASMA - Manual Saliran Mesra Alam Malaysia) as a surface infiltration filter by control the quality and quantity of recharge water. It is also can be protected any debris from break a quiet of recharge system.

The drainage system is affected by several small south-easterly 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 [1]. 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 the overview studies respectively, the potential area as adequate aquifer storage should be found by drilling as deep as possible in layers. By discharging waste 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 storm water.

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