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Determination of Optimal Discharge at SB-2 Production Well at PT Calbee Wings Food in Walahar Village, Klari District, Karawang Regency, West Java Province

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Abstract. PT Calbee Wings Food is a company engaged in the food industry, especially snacks, located on Jl. Raya Curug-Kosambi, Walahar Village, Klari District, Karawang Regency, West Java Province. The company utilises groundwater for production purposes, and to support the provision of clean water, a pumping test was carried out on the existing borehole (SB-2). Pumping aims to determine the optimal well capacity in groundwater utilisation using boreholes. The method used in this observation is a vertical downhole and the Hantush-Bierschenk method is used to analyse the step drawdown test data. The values of the Aquifer Loss Coefficient (B) and Well Loss Coefficient (C) are 0.0926 and 0.0002, respectively. Assuming that the efficiency of the well of 75% is an efficient condition, the optimum pumping discharge value is 1.85 liter/second. The decrease in groundwater level occurs due to pumping which can be classified in a safe zone condition which is <40% or 34.82% in the situation of maximum pumping discharge (2.38 liter/second).

Keywords: *drawdown; optimum discharge; aquifer loss coefficient; well loss coefficient.*

1 Background

The development of industry, settlements, services and manufacturing has led to an increase in water demand. Until now, these water needs have not been met by surface water sources, and still rely heavily on groundwater sources. Although groundwater is a renewable natural resource, it is not unlimited. The expansion of industrial, trade and residential areas has reduced infiltration areas, which has led to reduced water infiltration. Therefore, groundwater utilisation must also pay attention to conservation efforts that have been established by regulations, both at the central and regional levels.

PT Calbee Wings Food needs a clean water source to produce snacks and sufficient operational activities. One of the most possible water sources is groundwater, this is obtained by making groundwater boreholes. This happens because the surface water sources in the PT Calbee Wings Food factory area are not suitable for use as supporting materials for snack production and the supply from PDAM does not yet exist. Thus, the use of groundwater is the most logical and capable of supporting snack food production activities in the PT Calbee Wings Food factory area. This technical study intends to conduct a pumping test on the SB-2 well at PT Calbee Wings Food, this is to determine the ability of groundwater production that can be produced by the SB-2 well in supporting snack food production activities.

2 Reseach Method

The research site is located on the Curug-Kosambi Highway, which is administratively included in the area of Walahar Village, Klari Sub-district, Karawang Regency, West Java Province. The geology of the study area belongs to the Flood Plain Deposits or Qaf Formation (Achdan and D. Sudana, 1992) [1]. The hydrogeology of the study area is an aquifer with flow through intergranular spaces with low productivity (Soekardi Poespowardoyo, 1986) [2]. The geological and hydrogeological maps of the study area can be seen in Figures 1a and 1b.

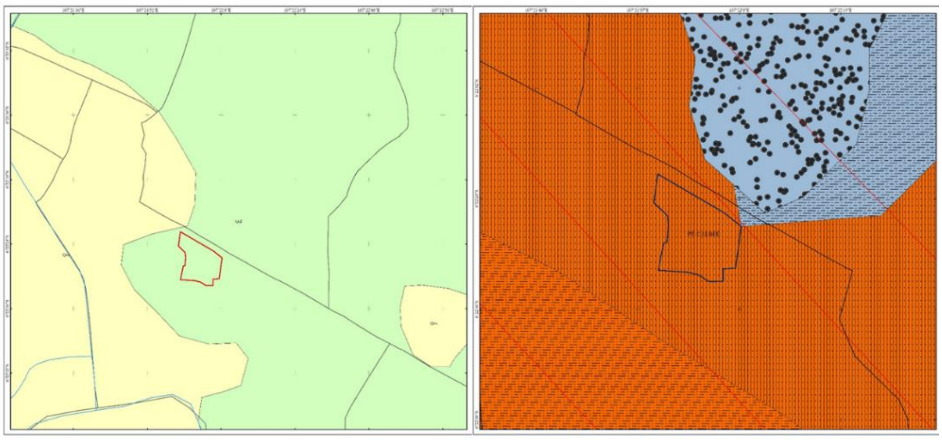

Figure 1 (a) Regional geological map (Achdan and D. Sudana, 1992), (b) regionalhydrogeology (Soekardi Poespowardoyo, 1986).

The research stages consisted of primary data collection in the form of pumping test data and secondary data in the form of drilling reports, analysis of optimum pumping discharge and aquifer parameter, pumping simulation, and determination of safe discharge and its relationship with groundwater zoning. Drilling was conducted using the vertical down hole method or vertical well observation [3]. The results of the borehole camera inspection showed that the SB-2 well has a depth of 80.66 meter. The SB-2 well pumping test at PT Calbee Wings Food was carried out on 5 March 2022, where the well test used the step drawdown test method or a graduated discharge pumping test.

The method used in analyzing the step drawdown test data is Hantush-Bierschenk, the steps for doing this are:

1. From the step drawdown test data, a curve is drawn between sw (drawdown) and t (pumping time in minutes). The curve was drawn on a semi-logarithmic scale graph, where the x-axis is t (pumping time) on a logarithmic scale and the y-axis is sw (drawdown) on a normal scale;
2. From the graph of the relationship between sw and t above, determine the value of Δs (additional groundwater level fall) at each step;
3. After knowing the Δs value of each step, cumulatively add the previous Δs values to find out the sw (n¬) value of each step (Δs (1) + Δs (2) +...+ Δs (n));
4. Conversion of each step's pumping discharge unit to m3/day;
5. Divide the sw(n¬) value by the discharge of each step to find out the sw(n)/Q(n) value;
6. Graph on a normal scale, where the x-axis is the discharge of each step and the y-axis is the sw (n)/Q(n) value;
7. Determine the value of B (Aquifer Loss Coefficient) obtained from the intersection of the regression line with the y-axis (intercept);
8. Determine the value of C (Well Loss Coefficient) obtained from the slope of the regression line;
9. Calculate the Aquifer Loss value by multiplying the well loss coefficient (B) by the discharge (Q);
10. Calculate the Well Loss value with the formula:

$$\text{Well Loss} = C \times Q^2 \tag{1}$$

11. Well efficiency can be determined by:

$$Ew = \frac{BQ}{(BQ+CQ^2)} \times 100\% \tag{2}$$

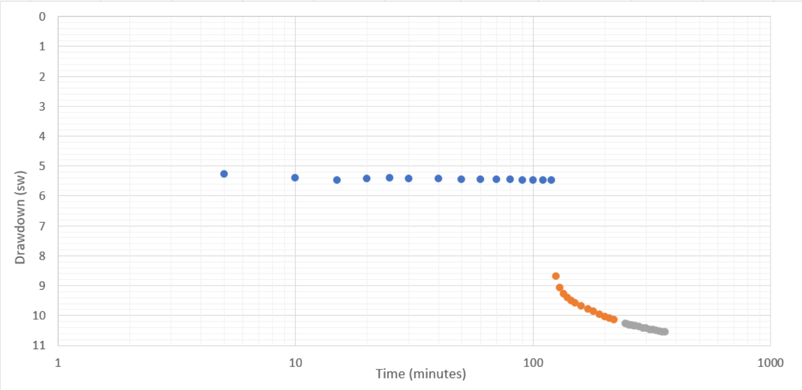

Figure 2 Graph of Cascading Discharge Pumping Test

Table 1 Drawdown characteristics using the Hantush-Bierschenk method

Step	Δs (m)	Sw(n) (m)	Qn (m3/day)	Sw(n)/Qn (m3/day)
1	5.48	5.48	71.712	0.076417
2	4.74	10.22	140.832	0.072569
3	0.35	10.57	205.632	0.051403

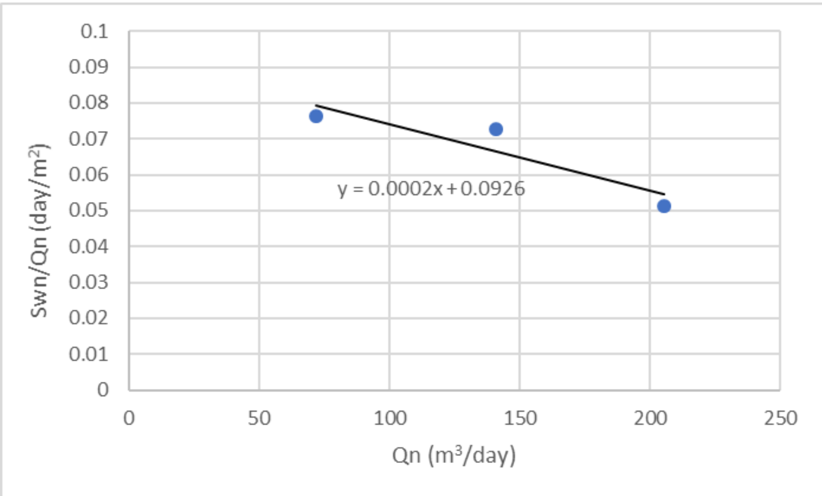

Figure 3 Graph of Determination of Aquifer Loss Coefficient and Well Loss Coefficient

The results of the step drawdown test obtained data in the form of pumping discharge (Q) and also the decline in groundwater level due to pumping (sw). This is the basis for calculating several parameters that can be obtained from step drawdown test activities. Processing the data of the Hantush-Bierschenk method, the value of the Aquifer Loss Coefficient is 0.0926 which is the intercept of the linear line on the y-axis and the Well Loss Coefficient itself is 0.0002 which is the slope of the linear line. This value is relatively very small (close to 0), so it can be concluded that the construction conditions of the well or pump used are very good so that the turbulent flow in the groundwater level drop due to pumping is minimal.

3 Result and Discussion

3.1 Pumping Test

From the results of the multilevel discharge pumping test it is known the following matters:

a) Step 1 starts at 0 – 120 minutes, with a pumping rate of 0.83 liter/second and the resulting drawdown is as deep as 5.48 meter;
b) Step 2 starts at 120 – 240 minutes, with a pumping rate of 1.63 liter/second and the resulting drawdown is as deep as 10.21 meter;
c) Step 3 starts at 240 – 360 minutes, with a pumping rate of 2.38 liter/second and the resulting drawdown is as deep as 10.56 meter;

Table 2. Time intervals for groundwater subsidence measurements

Pumping Time	Observation Time Intervals
0 - 30 minute	5 minute
30 minute – end of every step	10 minute

Source: Kruseman and de Ridder, 1991[4]

3.2 Analysis of Pumping Test Data

From the step drawdown test activity, data is obtained in the form of pumping discharge (Q) and also the decrease in the groundwater level due to pumping (sw). This data will become the basis for calculating several parameters that can be obtained from the step drawdown test. The results of the data processing of the Hantush-Bierschenk method, yielded an Aquifer Loss Coefficient value of 0.0926 which is the intercept of the linear line on the y axis. As for the Well Loss Coefficient itself, a result of 0.0002 is obtained, which is the slope of the linear line. This value can be said to be relatively very small (close to 0) so that it can be concluded that the construction conditions of the wells and the pumps used are very good so that turbulent flow during lowering of the groundwater level due to pumping is minimal.

3.3 Optimum Pumping Discharge

The well efficiency value is needed to obtain the Aquifer Loss (BQ) and Well Loss (CQ2) values and this value is used to determine the optimum pumping rate **Table 3**

Table 2 Well Efficiency Value at Various Pumping Discharge

Pump Rate (m3/day)	Aquifer Loss (BQ)	Well Loss (CQ2)	Well Eff (%)	Description
20.00	1.853	0.074	96.152	
40.00	3.705	0.297	92.590	
60.00	5.558	0.667	89.282	
71.71	6.643	0.953	87.452	Debit at Step 1
80.00	7.410	1.186	86.202	
100.00	9.263	1.853	83.328	
120.00	11.116	2.669	80.639	
140.00	12.968	3.632	78.118	
140.83	13.045	3.676	78.017	Debit at Step 2
160.00	14.821	4.744	75.751	Optimum Debit
180.00	16.673	6.005	73.522	
200.00	18.526	7.413	71.421	
205.63	19.048	7.837	70.851	Debit at Step 3

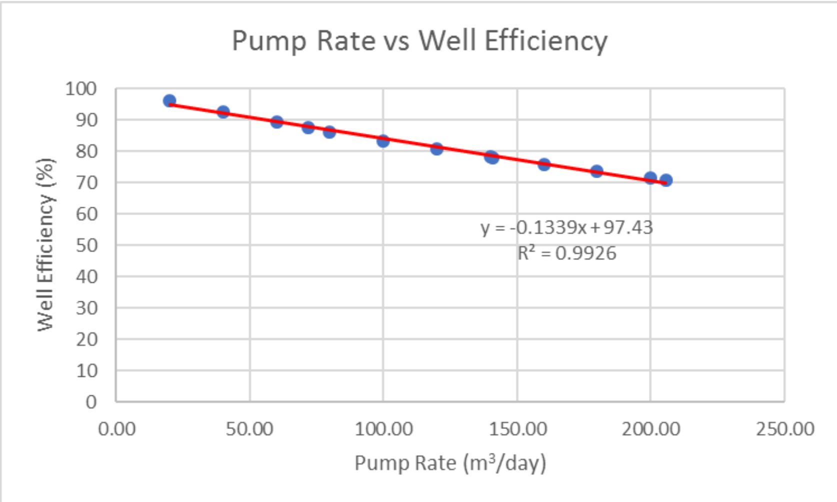

Figure 4 Graph of Relationship between Pumping Discharge and Well Efficiency

Determining the optimum pumping discharge, which is the pumping discharge at the time of operation, an assumed value of the well efficiency limit that can be said to be still efficient can be used. This test uses an assumed well efficiency value of 75%, where this value is still categorised as efficient and when the well efficiency value is less than 75% it is categorised as inefficient.

Based on assumptions and the results of well efficiency calculations, a well efficiency value of 75 % or more precisely 75.751 % has a pumping discharge of 160 m^3 / day or 1.85 liter/second. This means that the optimum pumping discharge recommended during well operation is equal to the well efficiency value. If the pumping simulation in one day the pumping time is limited to 10 hours, the SB-2 well at PT Calbee Wings Food can produce groundwater of 66.6 m^3 / day and is included in the category of efficient well conditions (75.751%).

The analysis of groundwater subsidence criteria due to pumping in the West Java Province area is regulated in a regulation in the form of a Regional Regulation. Based on the Regional Regulation of West Java Province Number 1 of 2017 concerning Groundwater Management Article 13 paragraph (1) letter a, the groundwater utilisation zone with safe criteria is a decrease in groundwater level of less than 40% [5].

Determination of groundwater level decline is done by knowing the value of the thick water column which is the value of the topmost filter position minus the static groundwater level (SWL). In the SB-2 PT Calbee Wings Food well, the top filter is at 31.55 meter and the static groundwater level (SWL) is at 1.22 meter, so the thickness of the water column in the SB-2 PT Calbee Wings Food well is 30.33 meter. Furthermore, the thickness of the water column is multiplied by 40% as a parameter for lowering the water level of safe criteria and produces a value of 12.132 meter. This result shows that 12.132 meter is the max drawdown (Δs) value, so it can be categorised as a safe water level decline. And when the pumping results obtained a drawdown value (Δs) of more than 12.132 meter, this condition can be categorised as a vulnerable zone to a damaged zone. And based on West Java Province Regional Regulation Number 1 of 2017 concerning Groundwater Management Article 13, if the decline of groundwater level is 40%-60%, it is included in the vulnerable zone criteria, a decrease in groundwater level of 60%-80% is included in the critical zone criteria, and a decrease in groundwater level of more than 80% is included in the damaged zone criteria.

The safe drawdown value (Δs) of 12.132 meter can then be plotted or integrated into the graph of the step drawdown test results. This aims to compare the value of the decline in groundwater level due to pumping with various variations in pumping discharge. The following is the result of plotting the safe criteria groundwater level drop value on the graph of the pumping test results. The drawdown (Δs) value of 12.132 meter can then be plotted or integrated in the graph of the results of the step drawdown test. It aims to compare the value of the groundwater level decrease due to pumping with various variations of pumping discharge. The following Figure 5 is the result of plotting the groundwater level subsidence value of safe criteria on the pumping test result graph.

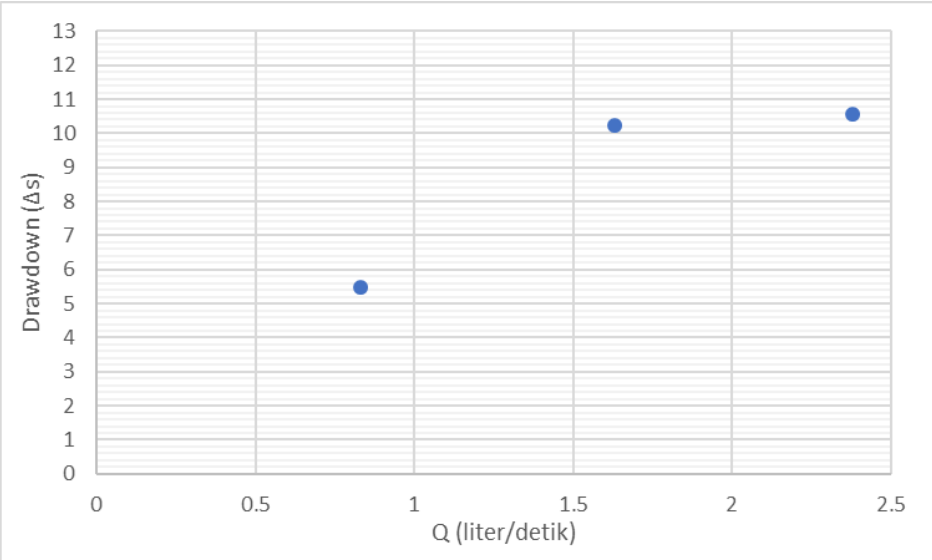

Figure 5 Integration Chart of Groundwater Level Decrease against Pumping Test

The results of the integration of the safe criteria groundwater level decline graph and the pumping test, it is known that the safe criteria groundwater level decline is 12.132 meter. The results of the step drawdown test pumping test show that the discharge used in testing all steps shows a decrease in groundwater level of less than 12.132 meter, where the maximum decline is in the 3rd step with a discharge of 2.38 liter/second and a decrease in groundwater level of 10.56 meter, which means that this decrease in groundwater level is still in the safe zone criteria or a decrease in groundwater level of 34.82 %. And the optimum pumping discharge obtained is 1.85 liter/second, where there will be no decrease in groundwater level due to pumping of more than 12.132 meter because the discharge is still lower than the maximum discharge, which in this case is in the 3rd step condition.

4 Conclusions

Based on the results of the pumping test (step drawdown test) and data analysis using the Hantush-Bierschenk method in the SB-2 well at PT Calbee Wings Food, it can be concluded as follows:

1. The results of the multistage discharge pumping test carried out in three stages resulted in a decrease in groundwater level as follows:

- Step 1 with a discharge of 0.83 liter/second resulted in a decrease in groundwater level of 5.48 meter;
- Step 2 with a discharge of 1.63 liter/second resulted in a groundwater level drop of 10.21 meter;
- Step 3 with a discharge of 2.38 liter/second resulted in a decrease in groundwater level of 10.56 meter.
- The total decrease in groundwater level was 10.56 meter during the test.

2. The values of Aquifer Loss Coefficient (B) and Well Loss Coefficient (C) are 0.0926 and 0.0002 respectively;
3. The assumption of 75 % well efficiency is an efficient condition, so that the optimum pumping discharge value of 1.85 liter/second, Aquifer Loss (BQ) of 14.821 and Well Loss of 4.744 are obtained.
4. The decline in groundwater level due to pumping is categorised in the safe zone of < 40 % by 34.82 % and the maximum pumping discharge is 2.38 liter/second.

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