CHAPTER V

AQUIFER PARAMETERS
Pumping test is carried out primarily to determine the aquifer parameters like Transmissibility \( T \) and Coefficient of storage \( S \). Aquifer parameters may be used for solving a general problem of assessment of groundwater potential of certain regions.

5.1 PUMPING TESTS

Pumping tests are of great importance, if they are carried out in a proper way. Carefully conducted tests reveal important facts about the groundwater reservoir itself—facts which cannot be determined reliably by any other means. Several methods are available to know the aquifer performance. Pumping tests are designed to obtain information of the yield and drawdown of wells, for proper selection and installation of pumps. A "Well test" is a specific type of pumping test, designed primarily to evaluate well characteristics. An "aquifer test" is a controlled field experiment to determine hydraulic properties of aquifers and associated rocks by observing groundwater, flow in response to pumping, changes of head along streams, changes in the rate of recharge, etc.

Pumping test mainly consists of measuring the depth to water level at different stages of pumping (i.e., before, during and after pumping). Drawdown measurements are taken at short intervals of time during early stages of pumping and later
increased gradually. The discharge measurement is checked at every change of time for drawdown and accordingly recorded. To avoid complication in computation, the discharge rate is normally maintained constant throughout the pumping. However, constant discharge is not a prerequisite for pumping test analysis. The recovery measurements are made until there is considerable decline in rise of water level.

5.2 ESTIMATION OF AQUIFER CHARACTERISTICS

Most of the wells in the study area receive water from weathered and fractured rocks. Wells are mostly dug cum bore wells, receiving water not only under unconfined condition, but also from water bearing fractures within hard rocks. A number of methods are available for the analysis of pumping tests data (Jacob, 1944; Theis, 1963; Prickett, 1965; Papadopulos, 1967; Papadopulos and Cooper, 1967; Walton, 1970; Zdankus, 1974; Schafer, 1978). As the wells in the study area are large diameter wells, any method used should take into account the large storage of water in the well. Sammel (1974) defined a large diameter well as a well in which storage is large enough to provide significant errors when aquifer tests are analysed by methods which neglect well storage. Ever since Slichter (1906) introduced specific capacity as a measure of productivity of wells to apply for large diameter wells also, Sammel (1974) reviewed
different methods of aquifer tests for large diameter wells and considered the method of Papadopulos and Cooper (1967) to be the best. Although this method was used for confined aquifers, Sammel (1974) considered this method to be applicable even water table aquifers provided pumping tests were kept small enough to have low drawdown relative to the aquifer thickness. According to Sinha et. al., (1986) large diameter dug wells in India are mostly partially penetrating wells showing layering due to changes in the degree of weathering and fracturing in a vertical direction, leading to apparent confined condition and the method of Papadopulous and Cooper (1967) could be applied with reasonable success. A number of scientists including Narasimhan (1968), Singhal (1977), Obul Reddy (1981), Krishna Reddy (1982), Sivamurthy Reddy (1986) and Janardhana Raju (1991) have applied these methods for large diameter wells in parts of India.

Evaluation of the performance of formations as aquifers has been carried out through pump tests on large diameter wells situated within granitic gneisses and alluvium. The time drawdown and time recovery data obtained from each well have been analysed using the methods of Papadopulos and Cooper (1967) method to estimate transmissivity ($T$) and storativity ($S$). Specific capacity ($C$) has been calculated with the help of Slichter's method.
Pumping has been carried out for about 12 hours in each well during which period the measurement of the drawdown of the water table at regular intervals has been obtained. Immediately after the stopping of the pumping, the recovery measurements were also made with time. The time drawdown data has been used in the analysis by the Papadopoulos - Cooper (1967) method while the time recovery data has been utilised in the estimation of Specific capacity.

5.3 PAPADOPULOS - COOPER METHOD

In this method, the discharge drawdown relation is given as

\[
S = \frac{Q}{4T} F(\frac{U_b}{a}, \rho) \quad \text{Ex... (1)}
\]

Where

\[
U = \frac{r^2}{2 \pi} \left( S/4T \right)^{1/2} \quad \text{Ex... (2)}
\]

\[
a = \frac{r_w^2}{2} \left( S/r^2c \right) \quad \text{Ex... (3)}
\]

\[
\rho = \frac{r}{r_w} \quad \text{Ex... (4)}
\]

\begin{align*}
Q &= \text{Discharge (m}^3/\text{d)} \\
S &= \text{Drawdown (m)} \\
T &= \text{Transmissibility (m}^2/\text{d)} \\
r &= \text{Distance from the centre of the well (m)} \\
S &= \text{Storage Coefficient (dimensions)} \\
r_w &= \text{Effective radius of the well (m)} \\
r_c &= \text{Radius of the well casing in the interval over which the water level declines (m)} \\
t &= \text{Time since pumping started (min.)}
\end{align*}

In the present case, since \( r = r_w \) and \( \rho = 1 \), the expression can be written as

\[
S_w = \frac{Q}{4T} F(\frac{U_w}{a}) \quad \text{Ex... (5)}
\]
where \( F(u_w, \alpha) \) is a function and is computed by numerical integration.

A family of type curves, \( F(U_w, \alpha) \) versus \( 1/u_w \) for different values, plotted on double logarithmic paper are utilised for the determination of the transmissibility and storage coefficient. The almost straight portion of the type curves corresponds to the period when water discharged is from the stored water in the well. The data curves so obtained were superimposed on the type curves of Papadopulos and Cooper on a double logarithmic paper of the same module to get match points.

The values of \( F(U_w, \alpha) \) and \( 1/U_w \) from the type curve and \( S_w \) (drawdown) and \( t \) (time) from field curve are noted from the match point. Then by substituting the values of \( F(U_w, \alpha) \), \( 1/U_w \) and \( S_w \) in the expression

\[
S_w = \frac{Q}{4T} F(U_w, \alpha),
\]

\( T' \) is calculated, 'S' is computed by introducing the values of \( r_w \), \( 1/U_w \), \( t \) and \( T \) (computed from expression \(-1\)) in the expression

\[
U_w = \frac{r_w^2 S}{4Tt}
\]
5.4 SLICHTER'S FORMULA

Specific capacity of wells is calculated using theslickter's formula (1906)

\[ C = 2.303 \frac{A}{t} \log_{10} \frac{S_1}{S_2} \]

where 
- \( C \) = Specific capacity in m\(^3\)/min/metre drawdown,
- \( A \) = Cross sectional area of the well in m\(^2\),
- \( t \) = time lapse in minutes after the stoppage of pumping
- \( S_1 \) = drawdown in metres at time pumping stops,
- \( S_2 \) = drawdown in metres after 't' minutes.

Slichter (1906) pointed out that the recovery in a given well will have different rates depending on whether the well was pumped for a longer time at a lower rate or a shorter time at a higher rate, even though maximum drawdown may be the same in both cases. Nevertheless, Slichter's formula provides a useful basis for comparison of wells of similar geological environments, which are subjected to more or less the same pumping rates for the same time.


5.5 ANALYSIS AND RESULTS

Pumping tests have been conducted in 2 dug wells in alluvium, 9 dug wells in granitic gneisses aquifer. According to Trainer (1975) 'S' is less than 0.001 (0.1%) in
artesian aquifers, between 0.001 and 0.01 (0.1% and 1.0%) in leaky aquifers and more than 0.01 (1.0%) in water table aquifers. This classification finds support in the results obtained from the pumping test data for the study area. Well nos. 7 and 11 depict artesian aquifers, 3 and 9 are leaky aquifers and remaining are water table aquifers.

5.6 SUMMARY OF AQUIFER CHARACTERISTICS

Table 5.1 provides the values of Transmissibility 'T', Coefficient of storage 'S' and Specific Capacity 'C' obtained by pumping tests. The transmissibility ranges from 25.1 $\times 10^4$ Lpd/Min to 44.8 $\times 10^4$ while Coefficient of storage from 0.02% to 6.6% and Specific capacity from 59 to 310 L/min./m.

<table>
<thead>
<tr>
<th>Type of aquifer</th>
<th>Location</th>
<th>Transmissibility 'T' in LPd/m</th>
<th>Storage Coefficient 'S' in %</th>
<th>Specific Capacity 1/mi/n.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alluvium</td>
<td>laxmireddipalle</td>
<td>30.2 $\times 10^4$</td>
<td>5.7</td>
<td>249</td>
</tr>
<tr>
<td>Granite</td>
<td>Chittoor</td>
<td>25.1 $\times 10^4$</td>
<td>2.4</td>
<td>220</td>
</tr>
<tr>
<td>Granite</td>
<td>Tellagundlapalle</td>
<td>37 $\times 10^4$</td>
<td>0.21</td>
<td>59</td>
</tr>
<tr>
<td>Granite</td>
<td>Greampset</td>
<td>29.2 $\times 10^4$</td>
<td>6.6</td>
<td>217</td>
</tr>
<tr>
<td>Granite</td>
<td>Jankaripalle</td>
<td>41 $\times 10^4$</td>
<td>1.6</td>
<td>187</td>
</tr>
<tr>
<td>Granite</td>
<td>Kukkalipalle</td>
<td>40.7 $\times 10^4$</td>
<td>5.5</td>
<td>310</td>
</tr>
<tr>
<td>Granite</td>
<td>Iruvaram</td>
<td>25.2 $\times 10^4$</td>
<td>0.02</td>
<td>68</td>
</tr>
<tr>
<td>Granite</td>
<td>Kothapalle</td>
<td>39.5 $\times 10^4$</td>
<td>5.9</td>
<td>306</td>
</tr>
<tr>
<td>Granite</td>
<td>Periyambadi</td>
<td>29.3 $\times 10^4$</td>
<td>0.5</td>
<td>193</td>
</tr>
<tr>
<td>Granite</td>
<td>Yadamari</td>
<td>44.8 $\times 10^4$</td>
<td>2.0</td>
<td>166</td>
</tr>
<tr>
<td>Alluvium</td>
<td>Bumireddipalle</td>
<td>27.6 $\times 10^4$</td>
<td>0.08</td>
<td>267</td>
</tr>
</tbody>
</table>
The transmissibility in granitic aquifers ranges from $25.1 \times 10^4$ to $44.8 \times 10^4$ Lpd/m. with an average of $34.6 \times 10^4$ Lpd/m. whereas in alluvial aquifers it ranges from $27.6 \times 10^4$ to $30.2 \times 10^4$ Lpd/m. with an average of $28.9 \times 10^4$ Lpd/m. The Coefficient of storage computed from the pumping test data shows variation from 0.02 % to 6.6 % with an average of 2.75 % in granitic aquifers and from 0.08 % to 5.7 % with an average of 2.89 % in alluvium aquifers. The specific capacity values vary from 59 L/min/m to 310 L/min/m with an average of 192 L/min/m in granitic aquifers, and from 249 to 267 L/min/m in alluvium aquifer with an average of 258 L/min/m. These values depend partly on the design of the pumping wells and partly on the hydraulic characteristics of the aquifer or aquifers in which they were constructed.