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Assessment of Aquifer Parameters under Pravara Canal Precinct Using Pumping and Recovery Test Data

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Abstract:
Aquifer characteristics influence the movement of groundwater and contaminants along with it. Formations comprising of top overburden soil crest, gravel, and weathered rock leading to fissured rock, functioning as flow media are found in the study region. Seepage from agricultural lands and Pravara canal is the chief source of recharge to groundwater and movement of contaminants. The capacity to hold, transmit, water and dissolved solution is measured in terms of Transmissivity, Storativity, and permeability of the formation. Pumping& Recovery tests are carried out on four open shallow wells in the study region. In the absence of data on long duration pumping test with regulated discharge, recovery test data is used to arrive at the aquifer parameters; Transmissivity, Storativity, permeability, radius of influence using modified formula. The average value of Transmissivity, Permeability for well 1&2represent medium to good inflow with radius of influence of 114m&121.75m respectively, while that for well 3 indicate medium to low inflow with radius of influence of 60.52m.The average value for well 4 indicate low inflow with radius of influence of 63.92m.

Keywords: Geological formation, aquifer, weathered, fissured rock, tube well. Pumping test

1.0 Introduction:
Movement of groundwater in hard rock terrain pose a different pattern compared to alluvial terrain. The movement of groundwater in hard rock terrains is due to presence of porous media comprising of fissured rocks, which are present in between impervious hard rock and thus movement of groundwater and contaminants in such terrain depends on the characteristics of geological formations forming the aquifers (VenkataRao, *et.al.,* 2015). The location of water table and depth of aquifer in alluvial terrain can be estimated from surface investigation, which is not possible in hard rock terrain as flow lines may be interrupted by intermittent solid formation resulting in groundwater storage and movement considerably discontinuous and restricted (Adyalkar, *et.al.*, 1981 and Maréchal, *et.al.,*2003).Hard rock by themselves are not porous and therefore are incapable of holding or transmitting water in their primary state, while secondary processes like weathering results in joints, fissure and cleavage make groundwater movement possible(Jeyavel, *et.al.*,2014). Horizontal jointing common in hard rock region, form interconnection, making hard rock function like homogenous formation. Graphical Methods developed by (Cooper and Jacob ,1946) and (Theis ,1935) for aquifer parameter evaluation consists of using the drawdown and recovery test data generated by conducting the pumping-recovery tests on open wells or bore wells. However the results so obtained are suited for alluvial terrains since various assumption made in these methods cannot be applied directly to hard rock terrains as they are inherently anisotropic, heterogeneous and are relatively less permeable as compared to alluvial terrain (Kruseman and Ridder, 2000). Under certain limitation the expressions for alluvial terrain are modified for application in hard rock terrain. The results from pumping test for large diameter open wells are usually influenced by large storage and do not reflect the actual inflow and hence results are usually vague(Singh.2000).

The objective of current study is to evaluate the aquifer parameters like Transmissivity, Storativity, Permeability, Radius of influence, for the region so as to understand the capability of the given aquifer to permit groundwater movement, which will help in studies concerning water resources and groundwater quality studies (Varade,*et.al.*, 2014). The study region falls in basaltic terrain. General geological stratification shows black cotton soil upto 0.5m to 1m depth, followed by highly weathered basalt upto2.5m to 3m,followed by Amygdaloidal basalt to a depth of 5m to 6m,which is followed by fresh Amygdaloidal basalt for the remaining depth (Deolankar,1981). The aquifer parameters are assessed by conducting field pump test in 4 open wells (table 1) falling in the Pravara left bank canal command by pumping the well at variable discharges for certain time and observing the recovery. The aquifer parameters are worked out using the modified formula (Kumarswamy, 1973).

1.1 Description of Study Region:

The study region falls in Ahmednagar district, which is situated in the central part of Western Maharashtra and spreads between north latitudes 18°19’ and 19°59’ and east longitudes 73°37’ and 75°3.Ahmednagar district is surrounded by Nashik district to north, Aurangabad and Beed districts to east, Osmanabad and Solapur districts to south, Pune and Thane districts to west.(CGWB Report, 2014).Pravara river is the tributary of Godavari. Pravara left bank canal takes off from Ozar pickup weir, 85 kms downstream of Bhandaradara dam, with coordinates of $19^0$37’N&$74^0$59’E and ends in Newasa taluka. It has a total length of 77km, and its command extends to six taluka of the district, irrigating 14577ha. Akole taluka has highest average rainfall of 806.04 mm and Newesa has a minimum497.87mm average rainfall. The major portion of the command falls in semi-arid region.

2.0 Material and Method:

The geological characteristics of the formation necessary for any aquifer to be a potential source of groundwater movement depends largely on its inherent characteristics namely, its ability to store water, ‘Storativity’ or "storability" and capacity to transmit it, ‘Transmissivity’(Handbook of Ground Water Development (1990).Four open shallow wells, one each located in the village of Loni (Bk), Loni (Kd) Nimgaonjalli, Rahata,fig. 1, lying in study area is selected for conducting the tests to evaluate the aquifer parameter. These parameters can be evaluated by

1) Pump test and, 2) Recovery test.

The aquifer parameter, i.e., Transmissivity, Storativity, Permeability and Radius of influence is worked out by using the modified formula. Under certain limitations the expression developed for Transmissivity, Storativity, Permeability and Radius of influence for alluvial terrain are modified for the application in the hard rock aquifers for laminar inflow theory for hard rock(Kumarswamy.1973).

(a) ***Rate of Infiltration, Specific Capacity, Coefficientof Permeability:***

$$Q = K(D^2 - d^2) \quad \ldots\ldots\ldots\ldots \quad (1)$$

Where Q = the rate of infiltration in m^3 / day and,
K = the hard rock permeability in m/ day
D = initial depth of water in m (saturated thickness)
d = Depth of water left in the well in m after pumping.

Specific capacity (C) is the ratio of the rate of infiltration Q to its draw down.

Specific capacity $C = \frac{Q}{S}$ m^3/day/m (2)
of drawdown, where S = drawdown

Permeability,

$$K = \frac{Q}{D^2 - d^2} \quad \ldots\ldots\ldots\ldots \quad (3)$$

Substituting, Q = CS & d = D – S

$$K = \frac{C}{(2D - S)} \quad \ldots\ldots\ldots\ldots \quad (4)$$

(b)***Transmissivity T:***

The Transmissivity of the aquifer is a fraction of the permeability and the saturated thickness and decreases when water is withdrawn. This causes decrease in the Transmissivity value as the aquifer is dewatered. Adjustment for the effect of dewatering is made by a factor, $S - S^2/2D$ (Jacob 1963).
Thus, the Transmissivity can be expressed as

$$T = KD' \quad \ldots\ldots\ldots\ldots \quad (5)$$

Where, D' = corrected initial depth of water,

$$D' = D - \frac{(S - S^2)}{2D}$$

The equation T = KD' reduces to

$$T = K\left[D - \frac{(S - S^2)}{2D}\right] \quad \dots\dots\dots\dots \quad (6)$$

Substituting equation (4) in equation (6),

$$T = \frac{C}{(2D - S)} \times \left[D - \left(S - \frac{S^2}{2D}\right)\right] \quad \dots\dots. \quad (7)$$

$$T = C\alpha \quad \dots\dots.. \quad (8)$$

Where $\alpha = \frac{1}{(2D-S)} \times [D - (S - S^2/2D)]$

α is constant arrived at by expressing drawdown in terms of initial depth of water. The drawdown is calculated as a percentage of the total initial depth of water.

If S/D = 0.50 or the drawdown is 50% of the initial depth of water i.e. D = 2S,then,

$T = C \times \frac{5}{12}$ or

$$T = 0.416\,C \quad \dots\dots\dots \quad (9)$$

Thus, at a drawdown of 50% of initial depth of water, the value of K is 0.416

(C)Storativity (Specific Yield):

Specific yield is the fall in volume of water for a drop in unit head. Some computation methods are time-drawdown from pumping test, water balance studies, laboratory methods, numerical methods (Neuman, 1988). The specific yield of the aquifer formation is calculated by employing the (**William C.** Walton, 1978) formula

$$S = \frac{0.0028 \times K \times C \times t}{\frac{rw^2 \times \text{antilog}(1440+65.5)}{264}} \quad \dots.. \quad (10)$$

Where, S = specific yield in fraction.

C = specific capacity in m^3/day/meter

rw = radius of the well in meter

t = time of pumping in minutes

If the well is pumped at a drawdown of 50% of the initial depth of water, then,

$$S = \frac{0.0028 \times 0.416 \times C \times t}{\frac{rw^2 \times \text{antilog}(1440 \times 0.416+65.5)}{264}} \dots \quad (11)$$

$$S = \frac{3.5 \times 10^{-6} \times C \times t}{rw^2} \quad \dots\dots.. \quad (12)$$

(d) *Radius of influence*:

The radius of influence can be calculated by using (Ramasaheya and Lang, 1978)

$$S = \frac{4T\,t}{R^2} \quad \dots.. \quad (13)$$

Where, S = specific yield in fraction,

T = Transmissivity in m^2/d, t = time of pumping in days, R = radius of influence in meters

3.1 ***Pumping and Recovery Test***(Varade *et.al.*, 2014):

The pumping test consists of pumping the well at a constant or a variable rate for 3-5 hours, and by noting the effect of this pumping on the water level in the pumped wells which is used for finding aquifer parameter. In the Recovery test, the well is pumped to a certain depth and the rate of recovery of the water level is noted. Fall and rise in water levels in wells during pumping and recovery are noted by water level indicator at different time intervals. The pump is shut down and the recovery begins. The rate of recovery at certain time interval is noted. Aquifer parameters are then calculated using above relations. Data collected relates to two aspects of study.

1) Collected data i.e. Drawdown and recovery data.

2)Computing aquifer parameter namely Transmissivity, Storativity, specific yield, etc. using recovery data

Table 1: Details of field pump test wells in the study region

Well details			
Nimgaonjalli	Depth of well 4.6m,	Saturated depth 2.85m	Diameter of well=6.70m
Rahata	Depth of well12.10m,	Saturated depth=5.56m	Diameter of well=6.10m
Loni(Bk)	Depth of well=9.10m,	Saturated depth=3.5m	Diameter of well=6.20
Loni(Kd)	Depth of well=6.86m	Saturated depth=5.10m	Diameter of well=5.90ml

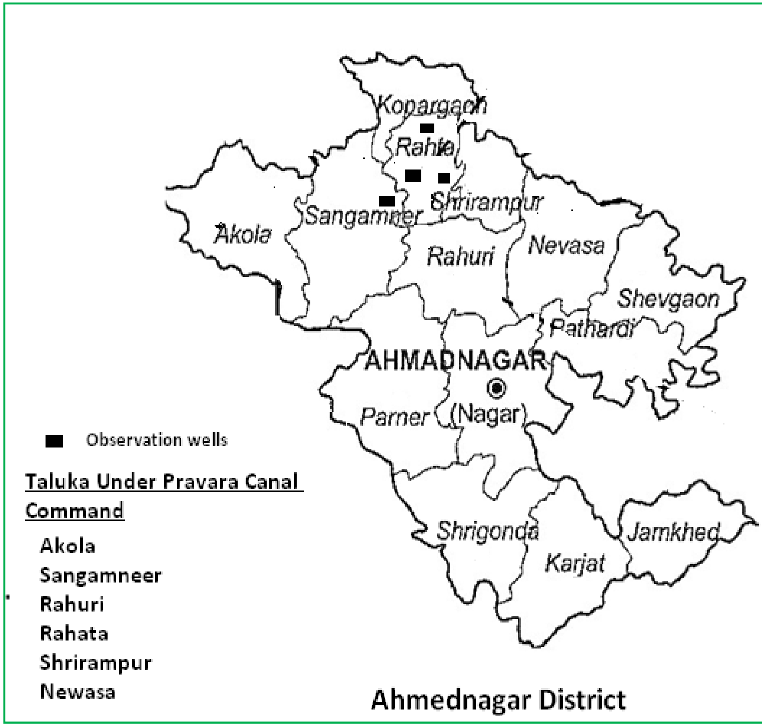

Fig.1: Location of Test Wells

3.0 Result and Discussion:

The behavior of wells is determined in terms of Transmissivity, Storativity, Permeability, and Radius of influence. These are worked as computed data and presented through table No3, 5, 7&9. Recovery data is used for working out the aquifer parameters (Dubey Poonam *et al*,2014)). The values are worked out using the formula as deduced above (Kumaraswamy, 1973)). The recovery rate is more at beginning immediately after the pump is shut. It then declines with time due to reduction in hydrostatic pressure causing reduced inflow. The values of specific capacity C, Transmissivity T, Storativity S, and K in general are found to decrease with time for all the wells with intermittent increase. The rate of infiltration Q is found to decrease with time in all the wells.

3.1. Well 1: The hydrostatic pressure variation results in the fluctuation of C, T, K, &S value, which shows a delayed increase in the values after initial fall in the values. A gradual increase in the values with increase in time is seen due to increased hydrostatic pressure. Maximum values observed are 469.44 m^2/d, 196.22m^2/d, 104.28m/d, 0.00969 respectively (Table 3& fig 2). The radius of influence remains fairly constant with an average value of 114.05m.The average value of Transmissivity of 132.79 m^2/d, Permeability of 70.49 m/d, Storativity of 0.00637 indicate medium storage and medium to high inflow (Deolankar.1981).

3.2. Well 2*:* Gradually decreasing hydrostatic pressure results in the value of C, T, S&K value to decrease with time from a initial high values of 445.17m^2/d, 206.55 m^2/d, 42.27m/d, 0.0055, to a minimum value of 152.64 m^2/d, 74.03 m^2/d,14.18m/d, 0.0018 respectively (Table 5& fig 3).However these value increase with increase of time towards the end. The average radius of influence of 121.75m is more compared to well No1 indicating increased hydrostatic pressure to draw water. The average value of Transmissivity of 120.82 m^2/d, permeability of 23.47m/d and Storativity of 0.0030 indicate medium to high inflow (Deolankar,1981). Due to low storage the radius of influence has increased.

3.3. Well.3*:* The C, T, K, &S value decreases with passage of time from a maximum value of 232.3m^2/d,106.39m^2/d,35.34m/d,0.0152 respectively (Table 7& fig 4) with intermittent increase. However low values of C, T, K&S may be due to change in the geological characteristics of formation. The radius of influence shows sudden fluctuation between 180mint to285 mint and has an average value of 60.52m.The average values of T&K represents medium to low inflow. The average Storativity has a value 0.0164 represent good storage and hence water is drawn from shorter radius of influence.

3.4. Well 4: The C, T, K, &S is seen to decrease from a maximum value of 174.55 $m^{2/}$/d,73.136 $m^{2/}$/d,18.51m/d,0.0179 respectively (Table 9 & fig 5).However intermittent increase in theses value is observed after 135 minutes of beginning of recovery, which decreases continuously. The radius of influence varies constantly and has average value of 63.92m. The average value of Transmissivity of 36.88 m^2/d, Permeability of 8.16 m/d indicate low inflow and average Storativity of 0.00843 represent low to medium storage.

Reduction in permeability resulted in increase in radius of influence, but this did not increase the yield into the well, showing poor storage. Intermittent rise in the value of C, T & S, was observed which fell immediately without affecting the flow into well. The radius of influence varied, for well 1, is found to increase continuously with increase in the value of C T S &K, for well 2, the radius of influence is seen to have varied values indicating varying geological characteristics of formation. Well3&4, the decrease in the value of parameter C, T, K&S with time was associated with decrease in radius of influence. The value obtained is applicable to basaltic terrain prevalent in hard rock area. In general the average value of C T &K fall within the ranges as assessed and reported by CGWB for Ahmednagar district,2004, Deolankar,1981).

Table 2: Original Data of Pump & Recovery Test (Nimgaonjali-Sangamner)

PUMPING /DRAWDOWN DATA						RECOVERY DATA								
Time (hr)	Time (min)	Draw down (m)	Draw down (cm)	Cumulative Drawdown (m)	RL Water Surface (m)	Time (hr)	Time (min)	Water Surface (m)	Recovery (cm)	Cumulative Recovery (cm)	Time since Pump stopped	RL Water Surface (m)	Residual Draw down S' (m)	t/t'
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
08.10 am	0				723.705	11.55am	0				225	722.335	1.37	
08.25am	15	0.14	14	14	723.705	12.10pm	15	0.07	7	7	240	722.405	1.30	16
08.40am	30	0.21	7	21	723.565	12.25pm	30	0.09	2	9	255	722.425	1.28	8.5
08.55am	45	0.30	9	30	723.405	12.40pm	45	0.11	2	11	270	722.445	1.26	6.0
09.10am	60	0.40	10	40	723.305	12.55pm	60	0.15	4	15	285	722.495	1.22	7.75
09.25am	75	0.52	12	52	723.185	1.10pm	75	0.19	4	19	300	722.525	1.18	4.0
09.40am	90	0.61	9	61	723.095	1.25pm	90	0.22	3	22	315	722.555	1.15	3.50
09.55am	105	0.72	11	72	722.985	1.40pm	105	0.25	3	25	330	722.585	1.12	3.14
10.10am	120	0.78	6	78	722.925	1.55pm	120	0.30	5	30	345	722.635	1.07	2.87
10.25am	135	0.86	8	86	722.845	2.10pm	135	0.32	2	32	360	722.655	1.05	2.66
10.40am	150	0.96	10	96	722.745	2.25pm	150	0.37	5	37	375	722.705	1.00	2.50
10.55am	165	1.03	7	103	722.675	2.40pm	165	0.38	1	38	390	722.715	0.99	2.36
11.10am	180	1.13	10	113	722.575	2.55pm	180	0.41	3	41	405	722.745	0.96	2.25
11.25am	195	1.20	7	120	722.505	3.10pm	195	0.44	3	44	420	722.775	0.93	2.15
11.40am	210	1.30	10	130	722.405	3.25pm	210	0.47	3	47	435	722.805	0.90	2.07
11.55am	225	1.37	7	137	722.375	3.40pm	225	0.50	3	50	450	722.835	0.87	2.00

Table3: Computed Data of Pump & Recovery Test

Time Min	S m	S' m	S'/D %	V m^3	Q m^3/min	C= Q/ S' m^3/min/m	C= Q/S' m^2/d	α	T= cα m^2/d	K m/d	S fraction	R M
1	2	3	4	5	6	7	8	9	10	11	12	13
0	-	-	-	-	-	-	-	-	-	-	-	-
15	0.07	1.30	0.451	6.38	0.425	0.326	469.44	0.418	196.22	104.28	0.00969	112.49
30	0.09	1.28	0.444	8.20	0.273	0.213	306.72	0.419	128.51	68.46	0.00633	112.64
45	0.11	1.26	0.437	10.03	0.222	0.176	253.44	0.420	106.44	56.32	0.00523	112.78
60	0.15	1.22	0.423	13.68	0.228	0.186	267.84	0.421	112.76	58.99	0.00553	113.19
75	0.19	1.18	0.409	17.32	0.230	0.194	279.36	0.423	118.16	60.99	0.00576	113.23
90	0.22	1.15	0.399	20.06	0.222	0.193	277.92	0.424	117.83	60.28	0.00573	113.36
105	0.25	1.12	0.388	22.80	0.217	0.193	277.92	0.425	118.11	59.89	0.00573	113.50
120	0.30	1.07	0.371	27.36	0.228	0.213	306.72	0.426	130.66	65.38	0.00633	113.58
135	0.32	1.05	0.364	29.18	0.216	0.205	295.20	0.429	126.64	62.67	0.00609	114.00
150	0.37	1.03	0.357	33.74	0.224	0.217	312.48	0.430	134.36	66.03	0.00645	114.10
165	0.38	0.99	0.343	34.65	0.210	0.212	305.28	0.431	131.57	64.00	0.00630	114.24
180	0.41	0.96	0.333	37.39	0.207	0.215	309.60	0.433	134.05	64.30	0.00639	114.50
195	0.44	0.93	0.322	40.12	0.205	0.220	316.80	0.434	137.49	65.30	0.00652	114.80
210	0.47	0.90	0.312	42.86	0.204	0.226	325.44	0.450	146.44	66.96	0.00671	116.79
225	0.50	0.87	0.302	45.60	0.202	0.232	334.08	0.457	152.67	68.31	0.00689	117.68

Table 4: Original Data of Pump & Recovery Test (Rahata)

PUMPING /DRAWDOWN DATA						RECOVERY DATA								
Time (min)	Time (min)	Draw-down (m)	Draw down (cm)	Cumulative Drawdown (m)	RL Water Surface (m)	Time (hr)	Time (min)	Water Surface (m)	Recovery (cm)	Cumulative Recovery (cm)	Time since Pump stopped	RL Water Surface (m)	Residual Draw down S' (m)	t/t'
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
9.00m	0	0.87	0	0	726.35	11.15am	0	1.49	-	-	135	725.765	0.62	-
9.15 am	15	0.96	9	9	726.25	1130am	15	1.46	3	3	150	725.795	0.59	10
9.30 am	30	1.03	7	16	726.25	11.44am	30	1.44	2	5	165	725.815	0.57	5.50
9.45 am	45	1.10	7	23	726.115	12.00pm	45	1.42	2	7	180	725.835	0.55	4.00
10.00am	60	1.16	6	29	726.095	12.15pm	60	1.41	1	8	195	725.845	0.54	3.25
10.15am	75	1.24	8	37	726.015	12.30pm	75	1.40	1	9	210	725.855	0.53	2.80
10.30am	90	1.30	6	43	725.955	12.45pm	90	1.39	1	10	225	725.865	0.52	2.50
10.45am	105	1.36	6	49	725.895	1.00pm	105	1.38	1	11	240	725.875	0.51	2.28
11.00am	120	1.43	7	56	725.825	1.15pm	120	1.37	1	12	255	725.885	0.50	2.12
11.15am	135	1.49	6	62	725.765	1.30pm	135	1.36	1	13	270	725.895	0.49	2.00
						2.00pm	165	1.35	1	14	300	725.905	0.48	1.81
						2.30pm	195	1.34	1	15	37030	725.915	0.47	1.69
						3.00pm	225	1.32	2	17	360	725.935	0.45	1.60
						3.30pm	255	1.30	2	19	390	725.955	0.43	1.52
						4.00pm	285	1.29	1	20	420	725.965	0.42	1.47
						4.30pm	315	1.28	1	21	450	725.975	0.41	1.42
						5.30pm	375	1.27	1	22	510	725.985	0.40	1.36
						6.30pm	435	1.26	1	23	570	725.995	0.39	1.31
						7.30pm	495	1.25	1	24	630	725.005	0.38	1.27
						8.30pm	555	1.24	1	25	690	726.015	0.37	1.24
						9.30 pm	615	1.23	1	26	750	726.025	0.36	1.21
						7.00 am	1185	1.07	16	42	1320	726.185	0.20	1.11
						8.00 am	1245	1.06	1	43	1380	726.195	0.19	1.10
						9.00 am	1305	1.05	1	44	1440	726.205	0.18	1.10

Table 5: Computed Data of Pump & Recovery Test

Time Min	S m	S' M	S'/D %	V m^3	Q m^3/min	C= Q/s' m^3/min/m	C= Q/s' m^2/d	α	T= cα $m^{2/}$d	K m/d	S fraction	R M
1	2	3	4	5	6	7	8	9	10	11	12	13
0	-	-	-	-	-	-	-	-	-	-	-	-
15	0.03	0.59	0.106	2.73	0.182	0.309	445.17	0.464	206.55	42.27	0.0055	118.67
30	0.05	0.57	0.102	4.56	0.152	0.266	383.04	0.475	181.94	36.30	0.0047	120.48
45	0.07	0.55	0.098	6.38	0.141	0.256	368.64	0.477	175.84	34.87	0.0045	121.05
60	0.08	0.54	0.097	7.29	0.121	0.224	322.56	0.477	153.86	30.48	0.0039	121.63
75	0.09	0.53	0.095	8.20	0.109	0.205	295.20	0.477	140.81	27.87	0.0036	121.11
90	0.10	0.52	0.093	9.12	0.101	0.194	279.36	0.478	133.53	26.35	0.0034	121.35
105	0.11	0.51	0.091	10.03	0.095	0.187	269.78	0.478	128.71	25.37	0.0033	120.93
120	0.12	0.50	0.089	10.94	0.091	0.182	262.08	0.479	125.53	24.67	0.0032	121.28
135	0.13	0.49	0.088	11.85	0.087	0.177	254.88	0.479	122.08	23.97	0.0031	121.52
165	0.14	0.48	0.086	12.76	0.077	0.160	230.40	0.479	122.08	21.65	0.0028	121.57
195	0.15	0.47	0.084	13.68	0.070	0.149	214.56	0.480	102.98	20.13	0.0026	121.85
225	0.17	0.45	0.080	15.50	0.068	0.151	217.44	0.480	104.37	20.47	0.00269	120.62
255	0.19	043	0.077	17.32	0.067	0.155	223.20	0.482	107.58	20.87	0.0027	122.23
285	0.20	0.42	0.075	18.24	0.064	0.152	218.88	0.483	105.71	20.45	0.00271	120.94
315	0.21	0.41	0.073	19.15	0.060	0.146	210.24	0.483	101.54	19.63	0.0026	121.01
375	0.22	0.40	0.071	20.06	0.053	0.133	191.52	0.484	92.69	17.86	0.0023	122.93
435	0.23	0.39	0.070	20.97	0.048	0.123	177.12	0.484	85.72	16.50	0.0021	123.72
495	0.24	0.38	0.068	21.88	0.044	0.115	165.60	0.484	80.15	15.41	0.0020	122.58
555	0.25	0.37	0.066	22.80	0.041	0.110	158.40	0.484	76.66	14.73	0.0019	123.00
615	0.26	0.36	0.064	23.71	0.038	0.106	152.64	0.485	74.03	14.18	0.0018	124.18
1185	0.42	0.20	0.035	38.30	0.032	0.160	230.40	0.491	113.12	21.53	0.0028	123.02
1245	0.43	0.19	0.034	39.21	0.031	0.163	234.72	0.491	115.24	21.95	0.0029	121.09
1305	0.44	0.18	0.032	40.12	0.030	0.166	239.04	0.495	118.32	22.38	0.0029	123.69

Table 6: Original Data of Pump & Recovery Test (Loni (Bk)

PUMP TEST DATA					RECOVERY DATA							
Time (hr)	Time (min)	Draw down (m)	Draw down (cm)	Cumulative Drawdown (m)	RLWater Surface(m)	Time (hr)	Time (min)	Water Surface (m)	Recovery (cm)	Cumulative Recovery (cm)	Time since Pump stopped	RLWater Surface (m)
1	2	3	4	5	6	7	8	9	10	11	12	13
7.45am	0	1.90	-	-	12.00pm	0	6.40	-	-	255	-	-
8.00am	15	2.33	43	43	12.15pm	15	6.19	21	21	270	4.29	18
8.15 am	30	2.80	47	90	12.30pm	30	6.10	9	30	285	4.20	9.5
8.30 am	45	3.15	35	125	12.45pm	45	6.01	9	39	300	4.11	6.67
8.45 am	60	3.55	40	165	1.00 pm	60	5.90	11	50	315	4.00	5.25
9.00 am	75	3.80	25	190	1.15 pm	75	5.80	10	60	330	3.90	4.40
9.15 am	90	4.10	34	224	1.45 pm	105	5.60	20	80	360	3.70	3.43
9.30 am	105	4.42	28	252	2.15 pm	135	5.37	23	103	390	3.47	2.89
9.45 am	120	4.67	25	277	2.45 pm	165	5.20	17	120	420	3.30	2.55
10.00 am	135	4.92	25	302	3.15 pm	195	5.10	10	130	450	3.20	2.31
10.15 am	150	5.16	24	326	4.00 pm	240	4.94	16	146	495	3.04	2.06
10.30 am	165	5.40	24	350	4.45 pm	285	4.8	14	160	540	2.90	1.89
10.45 am	180	5.60	20	370	5.45 pm	345	4.63	17	177	600	2.73	1.74
11.00 am	195	5.80	20	390	6.45 pm	405	4.48	15	192	660	2.56	1.63
11.15 am	210	5.96	16	406	7.00 pm	420	4.44	4	196	675	2.54	1.61
11.30 am	225	6.12	16	422								
11.45 am	240	6.25	13	435								
12.00 am	255	6.40	15	450								

Table 7: Computed data of pump & Recovery test

Time Min	S M	S' M	S'/D %	V m^3	Q m^3/min	C= Q/s' m^2/d	α	T= cα $m^{2/}$d	K m/d	S fraction	R M
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
0	-	-	-	-	-	-	-	-	-	-	-
15	0.17	2.12	0.186	5.13	0.342	232.3	0.458	106.39	35.34	0.0152	59.16
30	0.18	1.94	0.170	5.43	0.362	268.70	0.461	123.87	42.53	0.0176	59.32
45	0.15	1.79	0.157	4.53	0.302	242.95	0.464	112.73	43.25	0.0159	59.54
60	0.155	1.635	0.143	4.68	0.312	274.79	0.467	128.32	38.26	0.0180	59.70
75	0.12	1.515	0.133	3.62	0.242	230.02	0.469	107.88	35.23	0.0151	59.77
90	0.135	1.380	0.121	4.075	0.271	282.78	0.472	133.47	32.35	0.0185	60.06
105	0.11	1.270	0.111	3.32	0.220	249.45	0.474	118.24	30.26	0.0164	60.08
120	0.09	1.180	0.104	2.717	0.181	220.88	0.4776	105.14	26.38	0.0145	60.212
150	0.12	1.060	0.093	3.62	0.121	164.38	0.478	78.57	43.87	0.0107	60.59
180	0.10	0960	0.084	3.019	0.101	152.50	0.480	72.72	28.36	0.0099	60.60
210	0.08	0.880	0.077	2.415	0.081	132.55	0.481	63.76	16.28	0.087	60.53
240	0.095	0.785	0.069	2.868	0.095	174.27	0.483	84.17	32.29	0.00114	60.76
285	0.125	0.660	0.058	3.774	0.083	181.10	0.486	88.01	12.57	0.01187	60.88
330	0.070	0.590	0.052	2.11	0.047	114.71	0.487	55.86	10.321	0.0075	61.02
390	0.095	0.495	0.043	2868.	0.047	136.73	0.489	66.861	8.236	0.0089	61.30
450	0.095	0.400	0.035	2.868	0.047	169.20	0.491	83.08	7.69	0.0111	62.18
470	0.002	0.380	0.033	0.060	0.003	11.368	0.492	5.59	6.79	0.0007	63.18

Table 8: Original Data of Pump & Recovery Test (Name of Village-LoniKd)

PUMP TEST DATA					RECOVERY DATA							
Time (hrs)	Time (min)	Drawdown (m)	Drawdown (cm)	Cumulative Drawdown (cm)	Time (hrs)	Time (min)	Water surface level (m)	Recovery (cm)	Cumulative Recovery (cm)	Time Since Pump Started (min)	Residual drawdown T'	T/T'
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
7.10	0	2.30			10.10	0	4.59	-		180		
7.25	15	2.51	21	21	10.25	15	4.42	17.00	17.00	195	2.12	13.00
7.40	30	2.725	215.	42.5	10.40	30	4.24	18.00	35.00	210	1.94	7.00
7.55	45	2.93	20.5	63.0	10.55	45	4.09	15.00	50.00	225	1.79	5.00
8.10	60	3.12	19.0	82.0	11.10	60	3.935	15.5	65.50	240	1.635	4.00
8.25	75	3.35	23.0	105.0	11.25	75	3.815	12.0	77.50	255	1.515	3.40
8.40	90	3.52	17.0	122.0	11.40	90	3.680	13.50	91.00	270	1.380	3.00
8.55	105	3.705	18.5	140.5	11.55	105	3.570	11.00	102.00	285	1.270	2.71
9.10	120	3.895	19.0	159.50	12.10	120	3.480	9.00	11.00	300	1.180	2.50
9.25	135	3.995	10.0	169.50	12.40	150	3.360	12.00	123.00	330	1.060	2.20
9.40	150	4.220	22.5	192.00	1.10	180	3.260	10.00	133.00	360	0.960	2.00
9.55	165	4.420	20.0	212.00	1.40	210	3.180	8.00	141.00	390	0.88	1.86
10.10	180	4.59	17.0	229.00	2.10	240	3.085	9.50	150.50	420	0.785	1.75
					2.55	285	2.96	12.50	163.00	465	0.660	1.63
					3.40	330	2.89	7.00	170.00	510	0.590	1.54
					4.40	390	2.795	9.50	179.50	570	0.495	1.46
					5.40	450	2.70	9.50	189.00	630	0.400	1.40
					6.00	470	2.68	2.00	191.00	650	0.380	1.38

Table 9:Computed Data Of Pump & Recovery Test

Time Min	S M	S' m	S'/D %	V m^3	Q m^3/min	C= Q/s' m^2/d	α	T= cα $m^{2/}$d	K m/d	S fraction	R M
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
0	-	-	-	-	-	-	-	-	-	-	-
15	0.21	4.29	0.625	7.76	0.520	174.55	0.419	73.136	18.51	0.0179	63.92
30	0.09	4.20	0.611	3.33	0.222	76.11	0.414	31.51	7.99	0.0078	53.50
45	0.09	4.11	0.600	3.33	0.222	77.78	0.414	32.20	8.09	0.0079	53.73
60	0.11	4.00	0.583	4.07	0.271	97.56	0.414	70.39	10.04	0.0100	53.49
75	0.10	3.90	0.568	3.70	0.246	90.83	0.414	37.60	9.25	0.0093	53.52
105	0.20	3.70	0.539	7.39	0.246	95.75	0.415	39.74	9.06	0.0098	53.60
135	0.23	3.47	0.506	8.50	0.283	117.44	0.416	48.86	11.46	0.0120	53.70
165	0.17	3.30	0.481	6.28	0.210	91.64	0.417	38.21	8.79	0.0094	53.66
195	0.10	3.20	0.466	3.70	0.123	55.35	0.418	23.14	5.31	0.0057	53.62
240	0.16	3.04	0.413	5.91	0.131	62.53	0.420	26.26	5.86	0.0064	53.91
285	0.14	2.90	0.423	5.17	0.115	57.10	0.422	24.09	5.28	0.0059	53.78
345	0.17	2.73	0.398	6.28	0.105	55.38	0.425	23.54	5.04	0.0057	54.08
405	0.15	2.58	0.376	5.54	0.092	51.35	0.427	23.93	4.61	0.0053	54.14
420	0.04	2.54	0.378	1.48	0.098	55.56	0.428	23.78	4.97	0.0057	54.36

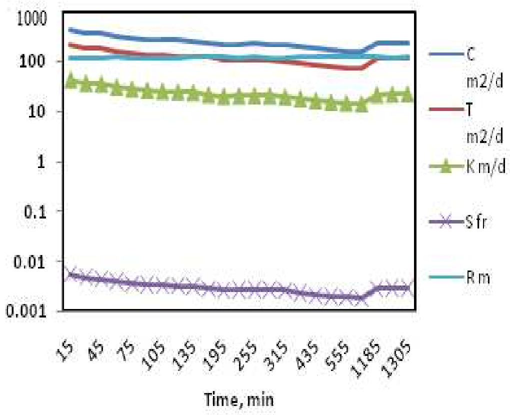

Fig. 2:Semi-Log plot of C, T, K, S&R (Table 3)

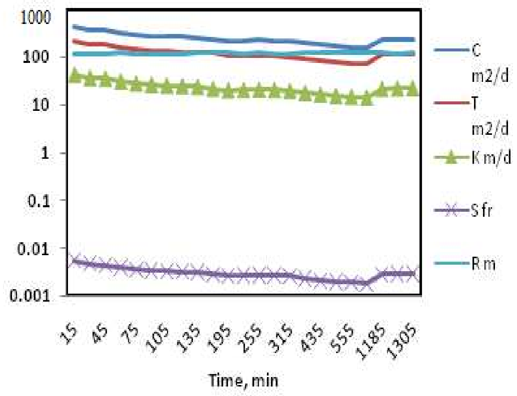

Fig 3:Semi-Log plot of C, T, K, S&R (Table 5)

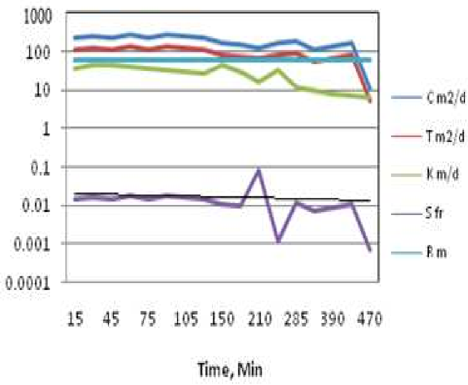

Fig. 4: Semi-Log plot of C, T,K,S&R(Table 7)

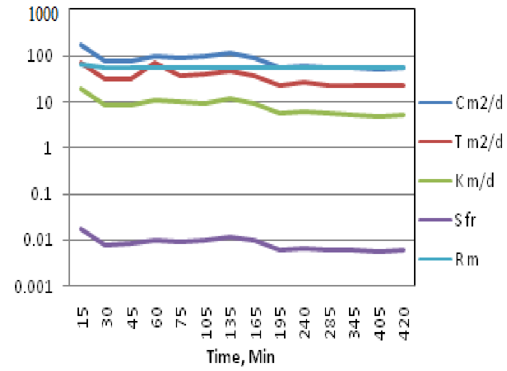

Fig.5:Semi-Log plot of C, T, K, S&R (Table 9)

4.0 Conclusion:

The studies on aquifer parameters reveal that well1 & 2 have medium to high Transmissivity, permeability, well 3 have medium Transmissivity, permeability and well 4 have low Transmissivity and permeability. The reduction in values of Transmissivity and permeability has resulted in shorter radius of influence. The storage in the aquifer has varied with Transmissivity and permeability. These conditions support the fairly constant Radius of influence in each case. Wells in the region being shallow, yield into the well is mainly due to seepage and infiltration. The general equilibrium pump tests are not applicable for large open wells due to presence of high storage volume and as such instantaneous inflow and outflow do not take place in the pumped well. In such cases recharge test data can be used in such cases to find out the aquifer parameter with the help of deduced expression. The groundwater studies of the region conducted on several observation wells during different seasons in the area on the basis of pumping and recovery tests round the year and the developed values can be extended to other area with similar geology. The developed values of aquifer parameter will aid in groundwater development of the region and also aid in contamination transport studies.

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