Working Paper No. 21

TUBEWELLS IN PAKISTAN DISTRIBUTARY CANAL COMMANDS: LAGAR DISTRIBUTARY, LOWER CHENAB CANAL SYSTEM, PUNJAB

by

Edward J. Vander Velde

and

Robert L. Johnson

INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE

Vander Velde, E.J. and R.L. Johnson. 1992. Tubewells in Pakistan distributary canal commands: Lagar Distributary, Lower Chenab Canal System, Punjab. Colombo, Sri Lanka: International Irrigation Management Institute. vii+44 pp. (IIMI Working Paper No. 21).

/ irrigation canals / tubewell irrigation / surface water / groundwater / Pakistan / Punjab /

DDC 631.7
ISBN 92-9090-161-6

IIMI's Working Paper series is intended to stimulate discussion among people interested in aspects of irrigation management. These papers make available the results of recent or ongoing research, and the informed opinions of IIMI staff members and collaborators, as early as possible. The views expressed are therefore those of the authors, and do not (at this stage) necessarily represent the consensus of IIMI or its partners. IIMI will welcome comments on this paper, which should be sent either to IIMI or to the coauthors at the following address:

Information Office
International Irrigation Management Institute
P.O. Box 2075
Colombo
Sri Lanka

Contents

Figures and Tables

Acknowledgements

We wish to acknowledge the effective collaboration of the Punjab Irrigation Department's Irrigation Research Institute (IRI) and the Directorate of Land Reclamation (DLR) in the collection of the primary tubewell calibration and water quality data in this joint research activity. Sh. Mohammad Sadiq, Research Officer (Tubewells), IRI, both managed the field collection of those data over a period of several months and contributed very helpful advice at the design stage of this research based upon his extensive research experience with public and private tubewells in Punjab. Field data collection by IIMI Pakistan field staff was ably supervised by Mr. Waheed-uz-Zaman, Field Research Engineer, and Mr. M. Saleem Malik, Field Research Social Scientist.

We accept full responsibility for the contents of this paper.

Edward J. Vander Velde
Irrigation Specialist
IIMI Pakistan

Robert L. Johnson
Irrigation Engineer and Groundwater Specialist
Environmental Assessment and Information Service Division
Argonne National Laboratory
Argonne
Illinois

Introduction

THIS IS ONE of several IIMI working papers intended to make available to interested parties and other users in Pakistan and elsewhere, primary data directly related to both private and public tubewell irrigation systems in different parts of Punjab Province. These primary data have been collected through IIMI Pakistan's collaboration with the Punjab Irrigation Department (PID), in research focused on identifying opportunities for effective conjunctive management of surface and groundwater irrigation systems in Punjab. Working paper readers will find that the analysis and discussion of data presented herein are limited, because the primary intention of this paper is to illustrate the potential provided by these data, and not exhaust them.

As part of its initial research program on irrigation operations in Punjab, Pakistan, IIMI began systematic surface water measurement and monitoring of Lagar Distributary and related crop survey and other watercourse-level investigations in selected parts of its command area in July 1987. The important role played by groundwater irrigation systems in this canal command was soon obvious. As research in Lagar command was slowly expanded to cover the wider range of irrigation management issues and problems associated with irrigation system performance and the sustainability of irrigated agriculture, a significant component of the overall research effort was focused upon the activities of private and public groundwater systems.

Although less readily visible and less frequently acknowledged than the huge network of Indus Basin canals, groundwater irrigation systems have become a very important component in that contiguous irrigation environment. Over very large areas, the surface irrigation system is substantially supplemented by extensive public and private sector groundwater development. It is commonly estimated that 40 percent of the total irrigation supplies at farm gate in Pakistan is now derived from groundwater. Nowhere in Pakistan is this more apparent than in Punjab Province, where groundwater development has played a crucial role in the continued growth of agricultural production.

However, the Government of Pakistan is also at the threshold of a new era in the management of groundwater for irrigation. Direct public agency control over tubewell facilities in "fresh" groundwater areas is to be terminated before the end of the present decade, and groundwater use and further development for irrigation will be left to private initiative.

Guiding both environmentally sustainable groundwater development and the fair distribution of this valuable resource to farmers through the private sector is certain to be a formidable challenge.

Previous Research on Tubewells and Limitations

A large number of useful studies on various aspects of public and private tubewells in Pakistan have been completed since Ghulam Mohammad's pioneering work in the mid-1960s. Collectively, the research constitutes a valuable source of information and insight into many aspects of past public and private groundwater development and tubewell irrigation activities in the country. The more important conclusions on studies of private tubewells have already been summarized elsewhere (Johnson 1989). The Water and Power Development Authority (WAPDA) has also published numerous reports on public tubewells in Pakistan. More significant at this juncture perhaps, are the limitations of this work and the knowledge gaps that remain to be filled.

Those previous studies have, almost without exception, been derived from one-time cross-sectional interview or survey data of samples based upon official records of public tubewells, and estimates of private tubewells drawn from civil administration or political units (e.g., districts, union council areas). Consequently, their focus has been largely upon the issues that can be readily addressed by such cross-sectional data, such as the physical conditions of wells, owner characteristics, the number of wells and technology types, cost of installation and operation, and/or their impact on agricultural production (e.g., cropping patterns and intensities, or crop yields). Thus, while some aspects of tubewell development have been well-established and can be accepted with reasonable confidence, there are other dimensions of groundwater development, especially in the private sector, that remain poorly understood.

Unfortunately, to date, little reliable insight has been gained into such complex and subtle issues as the linkages between the public surface irrigation system and its private groundwater-based counterpart, the distribution of the benefits of private groundwater development among different farmer groups, or the long-term sustainability of groundwater development. The absence of private tubewell data organized around hydrological spatial units (e.g., canal commands), accurate time-series data on private and public tubewell operations, and hydrologic data on aquifer conditions and quality, especially for private tubewells, has greatly restricted efforts to address these and other important related questions.

Present Tubewell Research Objectives

IIMI's research on groundwater irrigation systems in Pakistan is focused upon evaluating opportunities and determining the options for effective conjunctive management of surface and groundwater irrigation systems in Punjab, in ways that will enhance the productivity of irrigated agriculture and make it environmentally sustainable. A prerequisite for this research is the creation of a reliable, up-to-date, empirically-based information database on private and public tubewells (e.g., location, service areas, discharge, operations, water quality, etc.) organized on the basis of surface irrigation units.

Because private and public tubewell operations already interpenetrate surface irrigation systems over large areas of the Punjab, the ways these systems function as de facto conjunctive use irrigated agriculture environments need to be delimited and better understood. For example, if periods when either tubewells or the surface system critical to meeting crop water needs are accurately defined, then effective management intervention that reduces variability in the operation of the respective systems at those times would improve the reliability of irrigation supplies to farmers during such periods.

To date, IIMI's, field-based tubewell research on private and public tubewells in Punjab jointly implemented with the PID's Irrigation Research Institute (IRI) and the Directorate of Land Reclamation (DLR), has been exceptional. For the first time in Pakistan, primary tubewell data collection has been geographically organized with respect to surface hydrological units (i.e., distributary canal command areas) rather than along administrative or political unit boundaries. Additionally, the collection of time-series data on both private and public tubewell operations and on groundwater quality as well as certain other aquifer conditions, has been initiated for large samples drawn from those units. These data can also be linked in both space and time with other field measurements and observations of canal system operations and irrigated agriculture both above and below the outlet, over large areas of Punjab's Lower Chenab Canal System.

The Research Locale: Lagar Distributary Command

LAGAR IS ONE of seven distributaries in the Farooqabad Sub-Division, Upper Gugera Division, Lower Chenab Canal (LCC) system. It offtakes from the right bank of Upper Gugera (UG) Branch Canal at RD 108000 (linear distance in feet from Sagar Head). Lagar is 62,218 ft (18,950 m) long and its subordinate channel Jhinda Minor, offtaking from RD 29 is 11,309 ft (3,447 m) long. Lagar has a design discharge of 38 cusecs (1.08 m^3s) and supplies 30 outlets, including 6 offtaking from Jhinda Minor which has a design discharge of 9 cusecs (255 lps) (see Map). Discharge into Lagar is not regulated by a gated structure; *karries* (horizontal stop-logs) are used to control flow from UG Branch into the channel.

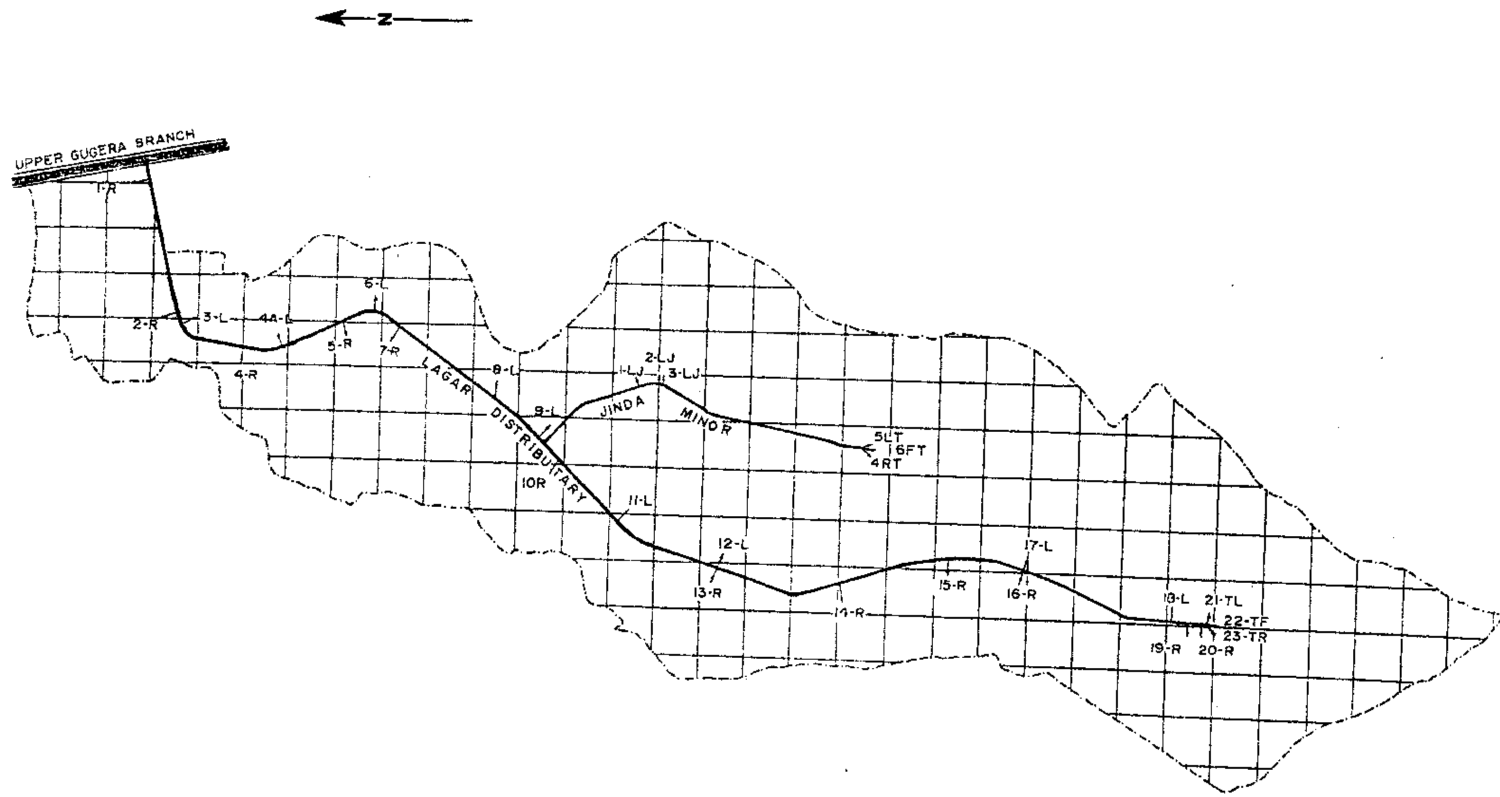
Lagar's outlets serve a Culturable Commanded Area (CCA) – the design canal irrigable area – of 16,356 acres (6,619 ha) within a Gross Command Area (GCA) of 18,408 acres (7,450 ha). The average sanctioned (or designed) discharge of its outlets is 1.13 cusecs (32 lps) for an average service area (CCA) of 545 acres (221 ha). Like other channels of the LCC system in Farooqabad Sub-Division, Lagar was designed as a 50 percent intensity canal. This means that the effective "duty of water" or water allocation, is 1 cusec per 528 acres (1 lps per 7.5 ha). Five outlets are an exception to this design standard; here the "duty of water" is slightly less, at 1 cusec per 352 acres (1 lps per 5 ha), or 75 percent intensity. Several Lagar watercourses have been improved through the On-Farm Water Management Programme of the Punjab Agriculture Department. In early 1985, the lower one-third of Lagar Distributary was lined by the PID in an effort to improve the supply of surface water to tail outlets (Murray-Rust 1987).

Virtually every Lagar Distributary outlet is (or has been) served by one or more public tubewells that substantially supplement canal water supplies. The large numbers of private tubewells that have also been installed throughout the distributary command area further supplement available surface water supplies.

The majority of public tubewells in Lagar command were installed under the first Salinity Control and Reclamation Project (SCARP-I) implemented by the Water and Power Development Authority (WAPDA) in 1961-62. Lagar SCARP tubewells are in either the Khanqah Dogran (KD) or Shahkot (SKT) Sub-Divisions of the SCARP-I project area. KD public tubewells in Lagar command have been terminated under the SCARP Transition Pilot Project (STPP).

The so-called Rasul tubewells are a legacy of an early Punjab Irrigation Department experiment first proposed in the 1930s but not implemented until the 1950s, to recapture canal seepage and return it to the canal system. The single Rasul tubewell in Lagar's command area was a rebored well converted to directly serve a watercourse command; it was also terminated in early 1990 under STPP. Other public tubewells identified as FAO wells were installed under the FAO-funded Chuharkana Tubewell Scheme. This experimental program to control waterlogging through deep drainage, a precursor of SCARP, was implemented in the mid-1950s. Most FAO wells in Lagar command have also been rebored.

Lagar Distributary command area map.



Approximate scale 1:83500

The Process of Tubewell Data Collection

THE FIRST ELEMENT of research on tubewell irrigation undertaken and completed in the service area of Lagar Distributary, was a census of all tubewells. It was apparent from previous field work on Lagar Distributary at the watercourse level, that many tubewells were sited outside of the Distributary's strictly defined irrigable area or CCA, a result of individual and collective farmer efforts to expand overall irrigated acreage. Thus, the tubewell census was planned for and implemented throughout the entire gross commanded area of the Distributary. IIMI field staff used both direct field observation and extensive interviews with farmers to identify and precisely locate all tubewells and tubewell bores, whether operational or abandoned. The basic census data were subsequently entered into a computer database file; the contents of that file are reported elsewhere in this paper.

Seemingly a straight-forward procedure, the tubewell census proved to be a more difficult and time-consuming exercise than expected. Available watercourse command maps (*chak* plans) were significantly out-of-date, and though readily available for reference from the local *patwari* and the Head Draftsman's office of the ID's Upper Gugera Division, were often in conflict with information provided by local informants. Multiple borepoints usually identifiable only by a discharge pipe rising less than a meter above the land surface, were nearly impossible to spot from any distance once such crops as sugarcane, wheat, rice, maize or cotton were well-established in their growth stage. Although nearly always cooperative when interviewed, tubewell owners were often unavailable or too busy with other activities to be interviewed. Finally, the continued installation of new tubewells, coupled with the occasional abandonment of existing wells, has meant several resurveys to keep the tubewell census database reasonably up-to-date.

Following the completion of the first Lagar tubewell census in mid-1988, a reliable basis existed for organizing and implementing the collection of other primary tubewell data in the Distributary command. Four clusters of watercourse commands located respectively in the head, middle and tail reaches of the Distributary and on Jhinda Minor, were defined as the sample areas for more detailed tubewell studies. In total, 15 watercourse commands plus the service area of an abandoned public tubewell in the head reach area were included.

Beginning in mid-August 1988, Irrigation Research Institute field teams assisted by IIMI Pakistan field staff, initiated the task of determining a variety of physical parameters through direct measurements of all private tubewells in these Lagar watercourses. All public tubewells that were operational anywhere in Lagar command during this period were measured as well. This field work was largely completed over the following two and one-half months, and by early 1989, two more primary data sets became available for entry into computer database files.

One set is comprised of data essential for any assessment of tubewell irrigation operations, including for example, tubewell discharge and drawdown. The second set is the result of water chemistry analyses done by the Directorate of Land Reclamations technicians on groundwater samples drawn from each public and private tubewell measured by IRI. These data are also reported and discussed later in this paper.

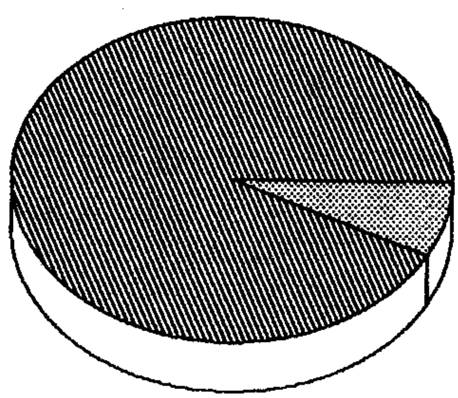
By late 1988, IIMI Pakistan field staff were engaged in the year-long two-season program to systematically monitor the operations of more than 175 private and public tubewells in the four sample watercourse clusters and elsewhere in Lagar Distributary's command area. A variety of methodologies were adopted for this purpose. Working electric meters of electric powered tubewells were calibrated and periodically recalibrated against time, so that well working hours could be determined for specific intervals, and average daily operating hours calculated. More than 70 automatic recording vibration meters were installed on mainly private diesel tubewells and PTO borepoints. Direct readings of these meters give operational hours between reading intervals. Operational data for all other tubewells were collected by daily and alternate-day interviews of farmers.

When combined with the basic tubewell data reported in this paper, this detailed information on private and public tubewell operations has filled in a critical "missing link" for comprehending both the range and diversity of actual irrigation operations within Lagar Distributary command. The key management issues that have emerged in what is clearly a conjunctive use environment can be identified, and appropriate interventions defined with reasonable confidence. Initial results from analyses of the different Lagar Distributary data sets now available, have been reported elsewhere (Johnson and Vander Velde 1989; Johnson 1990; Kijne and Vander Velde 1990).

Discussion of Primary Tubewell Data

TUBEWELL CENSUS DATA collected by IIMI Pakistan in the command area of Lagar Distributary, beginning in 1988 and continued through 1989, reveal that of the 399 operational tubewells identified, 368 were privately owned (Figure 1). In these surveys, tubewells are defined as operational if the well is observed operating and/or the owner states that the well is operational. The latter is particularly important in the case of installed bore points commonly operated by a tractor power take-off or sometimes, by a portable high-speed diesel engine. Because these wells are used much less frequently, the owner's statement that he uses or intends to use the bore for irrigation purposes is usually the determining factor.

Figure 1. Tubewells by ownership type: Lagar Distributary.



Source: IIMI TW Census.

Within the Lagar command area, 37 public tubewells were also installed, either as SCARP wells in the Shahkot and Khanqah Dogran Sub-Divisions of the SCARP-1 project area, or as part of such earlier vertical drainage and canal recharge programs as the FAO Chuharkana Scheme and the Rasul Tubewell Project. Of these 37 public tubewells, 31 remain operational to a variable degree and are under the authority of the Punjab Irrigation Department. Of the six abandoned public tubewells, two were terminated through the SCARP Transition Pilot Project in Khanqah Dogran Sub-Division. Appendix A provides the complete census list through October 1989, for private and public tubewells for Lagar Distributary.

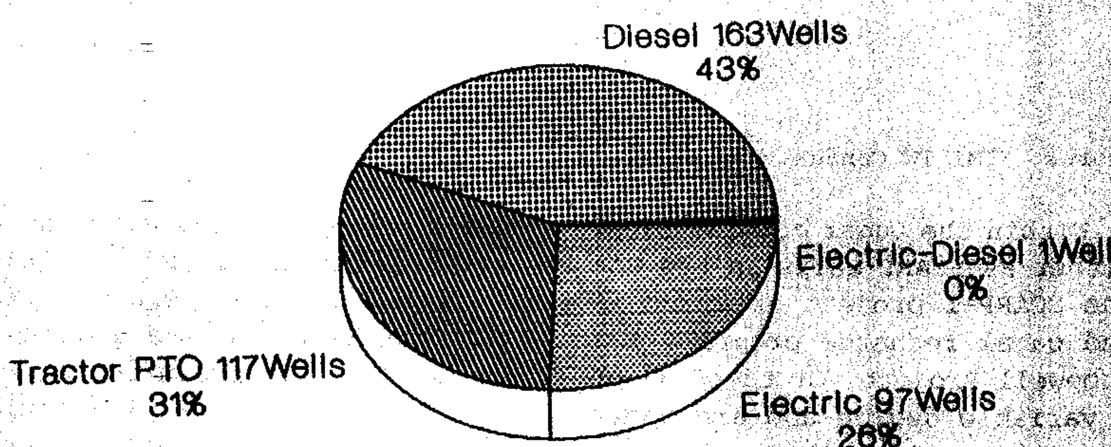
The bores of public tubewells are typically much deeper than those of private tubewells, usually 300 feet (90 m) as compared to the 100 feet (30 m) average depth of private tubewells. The public tubewells also use electrically powered turbine pumps and, at least at the time of their installation in the late 1950s to the early 1960s, each had a discharge substantially greater than that of the average private tubewell.

Type, Age and Density of Tubewells

All private tubewells in Lagar Distributary command use centrifugal pumps. However, three different technologies are used as sources of power: electric motors, both slow and high speed diesel engines, and direct tractor power take-off. In Table 1, the distribution of Lagar's 368 private tubewells by watercourse and technology type are shown; the gross command area (GCA) and culturable command area (CCA) for each watercourse are also given, and the resulting private tubewell density in each case has been calculated.

Previous official publications have usually reported that about one-third of private tubewells are driven by electric motors, and two-thirds by diesel (e.g., Agricultural Statistics of Pakistan 1985). Almost no mention is made of tubewells that are driven by tractor power take-off units. In Lagar's command area, tubewells with electric motors comprise about 26 percent, diesel engine-powered wells, 43 percent, and tractor-driven wells, 30 percent of all private tubewells. Figure 2 illustrates the distribution of private tubewells in Lagar command by power source as of end-1989.

Figure 2. Private tubewells by power source: Lagar Distributary.



Source: IIMI TW Census.

Table 1. Operational private tubewells in Lagar Distributary by watercourse command and type of power, 1989.

Water-course[1]	GCA[2] (acres)	CCA (acres)	Power Type				Density (per '00 acres GCA)
			PTO	Diesel	Electric	Total	
1R	862	761	2	0	4	6	0.7
KD216	270		5	6	1	12	4.4
2R	672	533	7	4	17	28	4.2
3L	494	307	2	0	2	4	0.8
4R	728	562	6	7	0	13	1.8
5R	599	590	4	13	1	18	3.0
6L	778	646	3	5	3	11	1.4
7R	677	614	2	3	2	7	1.0
8L	650	518	2	4	5	11	1.7
9L	554	492	1	6	3	10	1.8
J1L	212	204	3	0	6	9	4.2
J2L	877	856	8	18	2	28	3.2
J3L	406	364	1	5	2	8	2.0
J4TL	689	570	2	2	6	10	1.5
J5TF	788	788	4	7	4	15	1.9
J6TR	293	291	0	1	2	3	1.0
10R	1,204	990	4	6	11	21	1.0
11L	442	435	2	2	7	11	2.5
12L	407	354	0	7	4	11	2.7
13R	605	535	4	5	1	10	1.6
14R	603	594	1	8	1	10	1.7
15R	489	408	1	3	3	7	1.4
16R	460	443	6	1	0	7	1.5
17L	1,079	1,065	11	6	0	17	1.6
18L	992	932	8	3	1	12	1.2
19R	456	395	6	5	0	11	2.4
20R	677	479	4	6	1	11	1.6
21TL	709	694	3	18	0	21	3.0
22TF	671	660	7	4	8	19	2.8
23TR	335	319	4	2	1	7	2.1
TOTAL	18,678	16,399	113	157	98	368	2.0

[1]Refer to the map of Lagar Distributary for the approximate locations of the watercourses listed here.

[2]As recorded in *Outlet Register*, Farooqabad Sub-Division, Upper Gugera Division, Punjab Irrigation Department.

These data need to be treated with some caution, because continuous field observations in Lagar Distributary command have shown that many farmers will readily change their tubewell power source when opportunities (e.g., the breakdown of a diesel engine, a new subsidy program) present themselves. (For example, although the total number of private tubewells in watercourse command 2R remained constant from 1988 thru 1989 at 28, the number of electric powered tubewells increased by 6 because of incentives offered by the SCARP Transition Pilot Project within which area the watercourse command falls.) Hence, the motive power composition of the private tubewell population in Lagar's command area can be expected to change more frequently within a single year, than will the total number of operational private tubewells.

The tractor-driven private tubewells are particularly interesting for several reasons: 1) they have been largely ignored in official publications, yet they comprise a significant portion (31%) of all private tubewells in the canal command; 2) they have the lowest installation costs, excluding the cost of a tractor, but the highest operating costs;

3) despite high operating costs, in many parts of Lagar command (e.g., the former command area of public tubewell KD-216) they are the sole source of irrigation water for some farmers; 4) they reflect a mix of operational arrangements, e.g., a farmer owns one tractor and several bores, several farmers share a single tractor for their bores, tenants own the bore but the landowner provides the tractor, and bore owners rent tractor services. Tractor-driven wells, however, are seldom the wells of choice. Nearly all PTO bore owners interviewed reported they would prefer electric motors if they could afford to obtain the connection.

The data in Table 1 also reveal that by the end of 1989, the overall density of private tubewells in Lagar's command area was about 2.0 wells per 100 acres (4.9 wells per 100 ha) GCA, or 2.2 wells per 100 acres (5.5 wells per 100 ha) CCA. These densities result in averages of 50.0 acres (20.2 ha) GCA and 44.6 acres (18.1 ha) CCA per well. In 1980, WAPDA estimated tubewell densities in the command area of Gugera Branch Canal (Lagar Distributary offtakes from Upper Gugera Branch Canal) at 3 wells per 1,000 acres (7.4 wells per 1,000 ha) GCA, less than one-sixth the present density. Further, the highest density of tubewells anywhere in the Punjab was then thought to be only 11 wells per 1,000 acres (27.2 wells per 1,000 ha) GCA, roughly one-quarter of the present densities in the two Lagar watercourse commands.

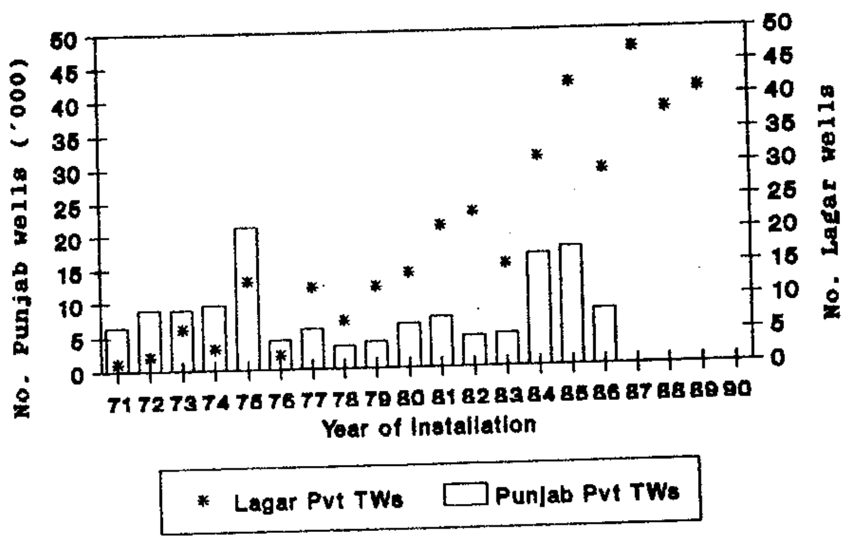
In its 1985 feasibility reports for the SCARP Transition Pilot Project, Associated Engineering Consultants (ACE) reported a private tubewell density of 1.25 wells per 100 acres GCA and about 1.3 wells per 100 acres CCA within the Khanqah Dogran pilot area (including a portion of Lagar Distributary command) of the public tubewell SCARP-I project area. These figures are equal to about 80 acres GCA and 75 acres CCA per private tubewell. Even allowing for a substantial growth rate in private tubewells between the time when these studies were completed and 1989, the total number of private tubewells identified through IIMI's tubewell census of the command area of Lagar Distributary appears to be much greater than official reports would suggest. The conclusion is that previous estimates and sample counts of private tubewells in this area have been too low, and growth in numbers of these wells, at least in some parts of Punjab in the 1980s, has been explosive.

Each private tubewell owner in Lagar's command area was asked the year and month in which his tubewell was first installed. Although many farmers remembered only the approximate month, especially if the tubewell had been installed more than five years earlier, the great majority were confident of the year of installation. Table 2 tabulates these data. Clearly, there has been considerable variation from year to year in the total number installed, and the apparent rate of installation in the 1980s has been relatively high. However, at the same time, private tubewells were also being abandoned for a variety of reasons, so it is difficult to determine with confidence the annual growth rate in numbers of private tubewells in Lagar's command area over the past two decades. A comparison of the growth in private tubewell development for Punjab and the distribution of currently operational private tubewells in Lagar command by year of development, are shown in Figure 3.

Table 2. Age of private tubewells in Lagar Distributary command.

	Year tubewell reported installed										
	Pre-1971	1971	1972	1973	1974	1975	1976	1977	1978	1979	
Number	7	1	2	6	3	13	2	12	7	12	
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Unknown
Number	14	21	23	15	31	42	29	47	38	41	4

Figure 3. Private tubewell development: Punjab Province and Lagar Distributary.

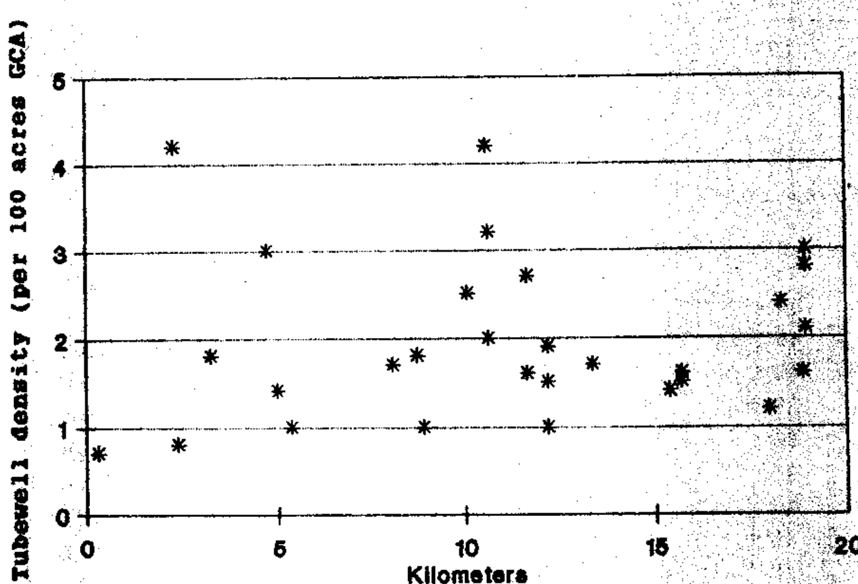


Source: Punjab Data: WAPDA, 1988.
Lagar Data : IIMI Censuses, 1988-89.

Between watercourse commands, private tubewell densities in Lagar's command area vary dramatically, from a low of less than one (0.7) to more than 4 (4.2) per 100 acres GCA per well. Past researchers have suggested that private tubewell densities increase toward the tail areas of watercourses and distributaries (WAPDA 1980:90). The plausible explanation given for such a pattern is that these areas tend to be persistently short of surface water supplies, and farmers compensate by installing private tubewells.

The density of private tubewells in each watercourse service area as a function of the *mogha* (outlet) location along Lagar, in distance from the distributary head is shown in Figure 4. For example, watercourse 1R is located at RD 1052 (i.e., 1,052 feet [321 m] from Lagar Distributary's offtake from Upper Gugera Branch Canal; Jhinda Minor watercourses also are included at their locations relative to Lagar Head). These data do not appear to confirm the existence of a close relationship between the location of a watercourse relative to Distributary head and the density of private tubewells in it.

Figure 4. Density of private tubewells, 1989: Lagar Distributary watercourses.



Source: IIMI census data.

Other data on the distribution of surface water in Lagar command do reveal that tail watercourses are commonly short in surface supplies, whereas head-end watercourses are comparatively rich in surface water. This apparent contradiction may be explained however by other factors, such as differences in predominant cropping patterns between watercourses, or the presence or absence of a working public tubewell in the watercourse command.

Tubewell Discharge, Drawdown and Water Table Depth

For selected watercourse command areas of Lagar Distributary, the Irrigation Research Institute and the Punjab Irrigation Department in collaboration with IIMI, collected detailed data on tubewell discharges, the depth to water table, and drawdown for both public and private tubewells. The complete set of data is given in Appendix B, with a brief description of each data category. Table 3 shows the minimum, average and maximum values for these parameters in the case of each sampled watercourse. Based on 163 private tubewells sampled in Lagar's command area (out of 368 operational private tubewells), the average discharge for private tubewells is 1.07 cfs (30.3 lps), with a minimum measured discharge of 0.30 cfs (8.5 lps) and the maximum at 1.89 cfs (53.5). Variation in private tubewell discharge for different Lagar Distributary commands is shown in Figure 5.

Table 3. Discharge, drawdown and depth-to-water table of tubewells in surveyed watercourses of Lagar Distributary.

Water-course[1]	Depth-to-water table[2] (feet)			Discharge[3] (ft /sec)			Drawdown[4] (feet)			No. of wells measured	Public well discharge (ft /sec)
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max		
1R	7.4	8.1	9.0	1.2	1.3	1.4	11.8	14.1	16.9	4	2.09
KD216	9.4	10.3	11.0	0.0	1.2	1.4	7.3	11.8	16.4	6	*
2R	5.5	10.2	13.8	0.3	1.1	1.7	5.3	11.9	18.8	25	*
3L	-	-	-	-	-	-	-	-	-	0	1.25
4R	9.1	10.7	13.1	0.7	1.0	1.3	5.7	8.4	12.4	12	2.63
5R	-	-	-	-	-	-	-	-	-	0	2.23[5]
6L	-	-	-	-	-	-	-	-	-	0	4.25[5]
7R	-	-	-	-	-	-	-	-	-	0	2.93[5]
8L	6.0	7.9	13.3	0.5	1.1	1.9	10.7	14.2	20.4	10	3.86
9L	8.6	9.5	11.3	0.9	1.2	1.4	11.6	17.9	21.7	6	1.65
J1L	8.5	10.9	12.0	0.9	1.1	1.4	7.1	13.4	18.6	7	*
J2L	6.0	7.1	8.5	0.8	1.3	1.6	7.5	14.5	18.1	12	3.37[5]
J3L	6.3	8.8	12.0	0.7	1.1	1.6	7.7	11.8	15.7	7	*
J4TR	-	-	-	-	-	-	-	-	-	0	-
J5TF	-	-	-	-	-	-	-	-	-	0	*
J6TR	-	-	-	-	-	-	-	-	-	0	-
10R	6.1	13.1	17.5	0.5	1.0	1.5	7.0	13.6	19.7	16	4.86[5]
11L	11.5	13.5	14.5	0.6	0.9	1.4	5.8	9.9	15.0	9	2.31
12L	-	-	-	-	-	-	-	-	-	0	1.69
13R	-	-	-	-	-	-	-	-	-	0	2.18
14R	-	-	-	-	-	-	-	-	-	0	1.82
15R	-	-	-	-	-	-	-	-	-	0	0.33
16R	14.0	15.3	16.8	0.6	0.9	1.2	9.6	12.4	14.5	3	1.70[5]
17L	-	-	-	-	-	-	-	-	-	0	4.67[5]
18L	-	-	-	-	-	-	-	-	-	0	4.80[5]
19R	16.0	17.8	21.0	0.7	1.0	1.3	6.0	8.6	10.8	7	1.90
20R	15.0	16.2	19.3	0.7	1.0	1.4	4.9	8.6	15.3	10	*
21TL	7.8	10.8	17.8	0.5	1.1	1.9	6.9	11.4	18.0	15	1.67
22TF	13.1	15.6	17.5	0.6	1.0	1.4	5.3	10.8	17.5	14	1.91
23TR	-	-	-	-	-	-	-	-	-	0	-

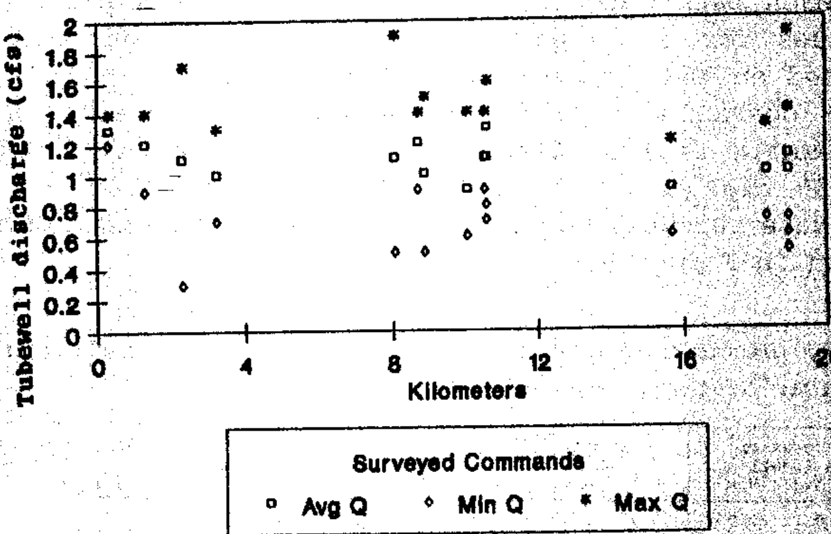
1. Refer to the map for the approximate locations of the watercourses listed here in Lagar's command area.
2. Depth-to-water table was measured directly by lifting the pump from the casing and physically measuring the water table's depth in the bore.
3. Discharge was calculated based on water pressure at the wall of the discharge pipe.
4. Dynamic drawdown was estimated by the amount of suction head generated by the pump after operating for a fixed period of time.
5. These discharge measurements are the total of two public wells.

'*' Watercourses where the public tubewell has been abandoned.

The average discharge of private tubewells in Lagar's command area is basically the same as that reported by the Irrigation Research Department for the Punjab as a whole, based on its survey work between 1970 and 1980. For the 27 public tubewells measured (of the 31 operational), the average discharge was 2.01 cfs (56.9 lps), the lowest public tubewell discharge was 0.33 cfs (9.3 lps), and the maximum, 3.86 cfs (109.3 lps).

Extrapolating these average discharge values over all operating private and public tubewells in Lagar's command area, the present total

Figure 5. Private tubewell discharges: Lagar Distributary watercourse commands.



Source: IRI and IIMI data.

operational capacity for public tubewells is 62.31 cfs (1.76 m^3s). For private tubewells, the total installed operational capacity is more than 6 times greater, an estimated 393.76 cfs (11.15 m^3s). Public tubewells comprise only about 14 percent of the currently installed groundwater pumping capacity in Lagar Distributary command.

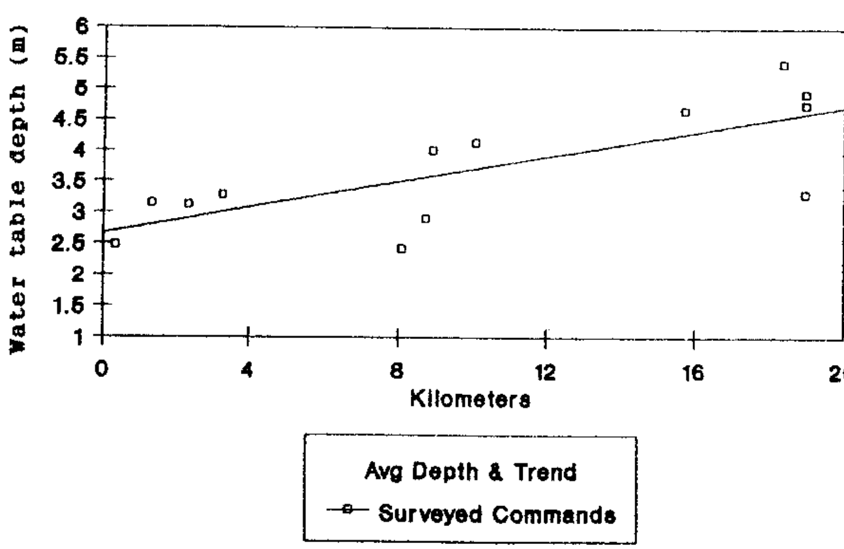
By contrast, the sanctioned full supply discharge for Lagar Distributary is only 38 cfs (1.08 m^3s). In theory, existing tubewell capacity is capable of providing 12 times more water than the surface system. Of course, surface flows are more or less continuous, whereas most tubewells (particularly private tubewells) are operated only a fraction of the time. Hence, the proportion of irrigation water each source (the surface system, public tubewells and private tubewells) contributes to the total supply available to, and used by, farmers' depends largely upon the frequency and duration of public and private tubewell pumping at different locations in the Distributary command.

In all locations of Lagar's command area, the water table was located at depths greater than 5 ft (1.5 m), and in many locations the depths exceeded 10 ft (3 m). The depth to the water table for the various wells sampled was measured in *kharif* season, over the period August-October, a time of year generally recognized as being when the water table comes nearest the surface. The overall conclusion from these data is that Lagar's command area does not suffer from the effects of waterlogging.

A closer look at the average depth to the water table as a function of watercourse command areas reveals a considerable degree of variation, ranging from 7.1 ft (2.2 m) in Jhinda Minor's 2L command area to 17.8 ft (5.4 m) for the command area of watercourse 19R.

In Figure 6, the average depth to the water table has been plotted for surveyed watercourses as a function of their location along Lagar's canal (excluding Jhinda Minor watercourses). It is apparent that there is a general and significant decline in water table levels from head to tail in Lagar's command. It is also clear from these data that watercourses on the left side of the Distributary have generally higher water table levels, compared to those on the right side. Because surface water must flow downslope, one can conclude that between Lagar head and tail, there is at least a 9.7-ft (3-m) drop in the average level of the water table.

Figure 6. Depth to water table: Lagar Distributary watercourse commands.

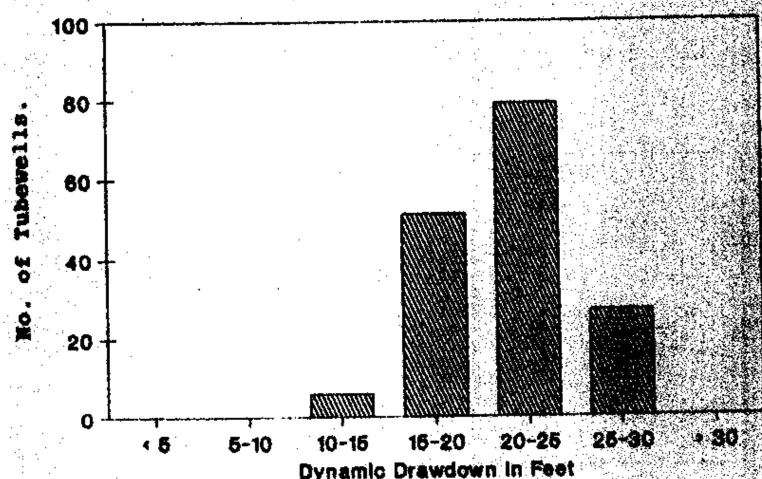


Source: IRI and IIMI data.

The observed gradient in water table levels also implies that there is groundwater movement from the head and left side of Lagar's command area, toward the Distributary tail and right side. This suggests that the primary source of recharge to the aquifer underlying Lagar's command area is seepage from the two very large unlined channels, Upper Gugera Branch Canal and QB Link Canal, whose alignment is roughly north to southeast of Lagar, and not from water losses within the command area. This tentative conclusion is further supported by the fact that the total installed pumping capacity in Lagar's command area dwarfs the actual amount of surface water entering the command area. It is therefore highly unlikely that seepage losses from the Distributary canal system are supplying the bulk of groundwater pumped by tubewells in Lagar's command area.

Centrifugal pumps can only lift water when the water table is sufficiently close to the pump, because they rely on suction to pull up the water. Hence, when the water table is more than about 24 ft (7.3 m) below the pump, centrifugal pumps begin to experience pumping difficulties. Generally, discharge is reduced, and in severe cases, pump impeller blades can be damaged by cavitation. In Figure 7, the distribution of the dynamic depth to water table (depth to water table plus drawdown) is shown for all private tubewells sampled in Lagar Distributary command.

Figure 7. Dynamic drawdown of private tubewells: Lagar Distributary command.



Source: IRI-IIMI data.

From this histogram, it is apparent that many of Lagar's private tubewells are operating at or very near their effective limits. Some farmers circumvent this problem by digging pits in order to install their pump closer to the water level. Although such pump pits are to be found in Lagar's command area, they are not as common as Figure 7 suggests they should be.

Tubewell Water Quality Conditions

Water samples were also drawn from all surveyed tubewells in Lagar command, for water quality analysis. The complete set of data from chemical analyses of these wells is given in Appendix C. In Table 4, average, maximum and minimum values for the three most important water quality parameters, electric conductivity (EC), residual sodium chloride (RSC) and the SAR ratio, are given on a watercourse basis.

Table 4. Quality of groundwater pumped by private and public tubewells in sampled watercourse commands of Lagar Distributary.

Water-course	Private tubewells										Public tubewells		
	SAR			RSC			EC			No. of wells sampled	Average		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max		SAR	RSC	EC
1R	0.4	1.9	3.7	0.0	0.08	0.3	760	803	910	4	0.9	0.0	480
KD216	3.0	6.2	9.0	0.5	2.79	4.4	990	1,040	1,160	7	-	-	-
2R	1.9	4.5	8.4	0.1	1.37	2.8	600	1,003	1,400	25	-	-	-
3L	-	-	-	-	-	-	-	-	-	-	4.8	2.0	1,200
4R	4.4	7.9	13.3	1.1	3.06	6.0	1,000	1,492	1,900	-	5.6	2.2	1,000
5R	-	-	-	-	-	-	-	-	-	-	4.2	1.1	1,160
6L	-	-	-	-	-	-	-	-	-	-	7.7	3.2	1,325
7R	-	-	-	-	-	-	-	-	-	-	6.1	2.4	1,065
8L	3.3	6.9	12.4	0.6	2.40	3.8	880	1,290	2,100	10	4.7	1.7	960
9L	6.0	9.3	14.0	2.4	3.63	6.4	1,200	1,416	1,610	6	4.9	1.6	965
J1L	6.5	8.8	10.7	2.4	3.07	4.0	1,100	1,284	1,420	7	-	-	-
J2L	5.7	7.9	10.2	1.9	3.13	4.7	760	1,111	1,370	12	8.1	3.4	1,120
J3L	7.9	9.5	10.8	2.7	3.35	4.3	1,150	1,387	1,570	8	-	-	-
J4TR	-	-	-	-	-	-	-	-	-	-	-	-	-
J5TF	-	-	-	-	-	-	-	-	-	-	-	-	-
J6TR	-	-	-	-	-	-	-	-	-	-	-	-	-
10R	1.9	5.5	10.2	0.0	2.41	4.9	860	1,285	1,750	16	5.3	1.5	1,160
11L	3.6	7.5	12.9	0.6	3.00	6.4	1,100	1,435	1,650	9	5.1	1.3	1,130
12L	-	-	-	-	-	-	-	-	-	-	8.3	3.3	1,390
13R	-	-	-	-	-	-	-	-	-	-	6.5	2.4	1,180
14R	-	-	-	-	-	-	-	-	-	-	8.7	3.2	1,210
15R	-	-	-	-	-	-	-	-	-	-	12.0	4.2	1,600
16R	5.3	9.5	16.4	1.9	3.90	6.9	1,030	1,610	2,100	3	8.4	3.2	1,430
17L	-	-	-	-	-	-	-	-	-	-	9.4	2.7	1,585
18L	-	-	-	-	-	-	-	-	-	-	12.5	2.5	1,650
19R	9.2	12.2	13.8	2.3	3.86	5.1	1,500	1,688	1,810	8	11.5	3.0	1,750
20R	8.5	11.6	15.6	2.1	3.10	4.9	1,560	1,777	2,030	10	9.4	3.0	1,690
21TL	6.0	9.3	14.9	1.1	1.83	3.0	1,270	1,586	1,800	15	-	-	-
22TF	8.1	12.1	18.8	0.0	2.65	4.5	1,500	2,059	3,000	13	-	-	-
23TR	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes: Min = Minimum.
Avg = Average.
Max = Maximum.

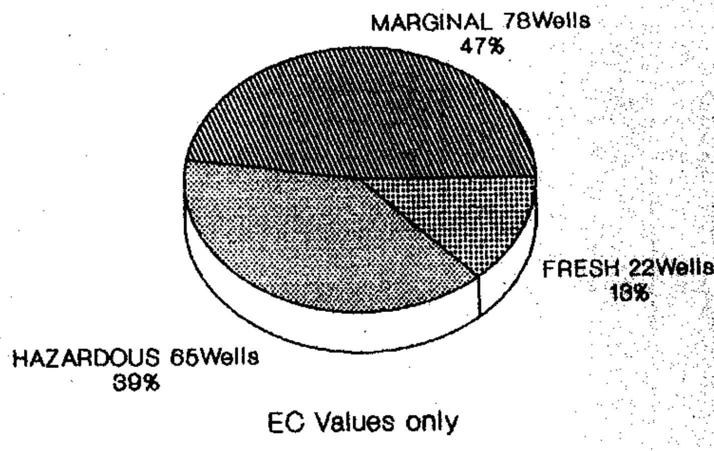
The Directorate for Land Reclamation, Punjab Irrigation Department, uses the following standards for evaluating the suitability of groundwater for irrigation purposes:

	Fresh	Marginal	Hazardous
EC:	< 1000	1000 - 1500	> 1500
RSC:	< 1.25	1.25 - 2.50	> 2.50
SAR:	< 10.0	10 - 15.0	> 15.0

In Figure 8, the distribution of private tubewells based on these standards is shown. In these terms, the majority of private tubewells in Lagar Distributary's watercourse commands pump water unsuitable for irrigation purposes.

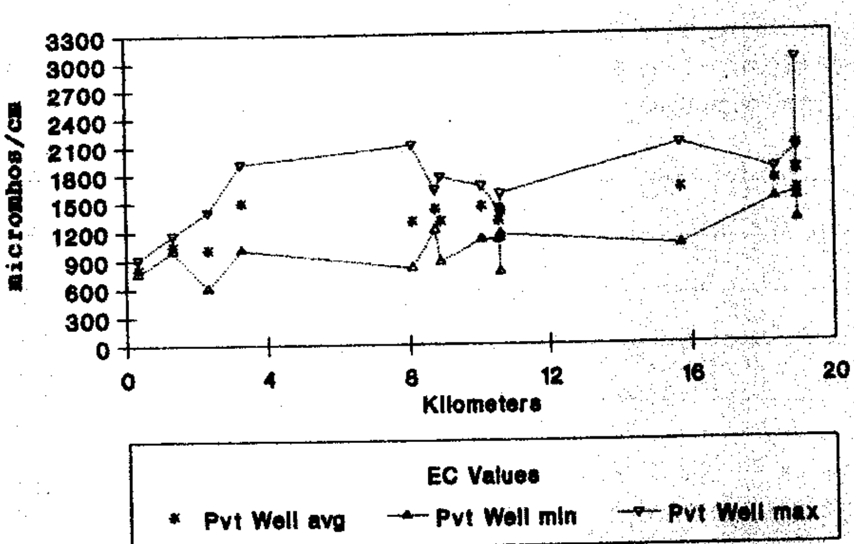
There is a very marked deterioration in the water quality pumped by private tubewells as one moves from command areas near the head of Lagar Distributary to tail-end commands. Figure 9 plots the private tubewell average of one water quality indicator, EC, for each watercourse as a

Figure 8. Private tubewell water quality: Lagar Distributary command.



Source: DLR, Punjab Irrigation Department standards.

Figure 9. Private tubewell water quality: Lagar Distributary watercourses.



Source: DLR data, 1988.

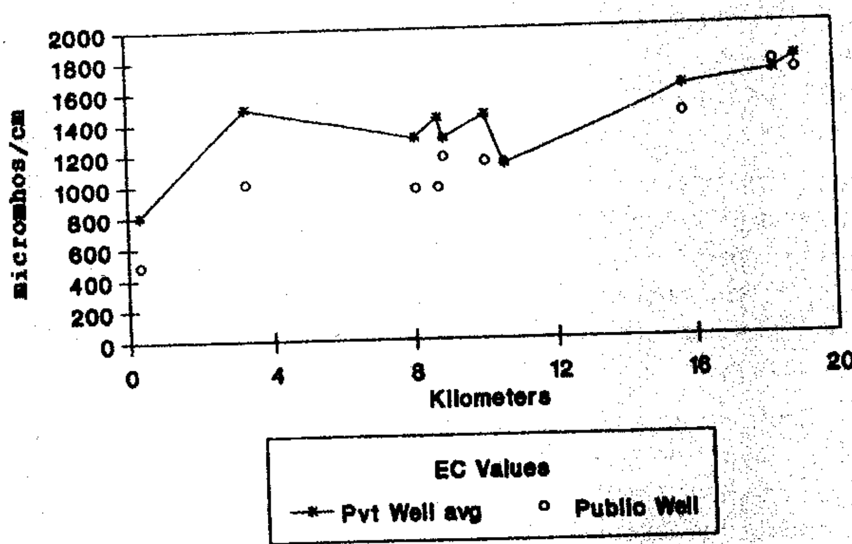
function of the watercourse's position along Lagar's channel. As the graph clearly indicates, the water quality of the average private tubewell measured in terms of its EC, declines from "fresh" in head-end watercourses, to "marginal" in the middle reach of the canal, to "hazardous" or "unfit" in the tail-reach commands.

This finding appears to be generally consistent with the earlier tentative conclusion that the primary source of recharge to the groundwater aquifer underlying Lagar Distributary command, is seepage from the two very large channels that traverse roughly north to south near its head and eastern boundary. This tends to support the hypothesis that there is slow groundwater movement from the head toward the tail of the Distributary.

A comparison of the average water quality (EC and SAR) pumped by private tubewells in a given watercourse command, with that pumped by the public tubewell in the same command, reveals that in all but one case, the public tubewell provides groundwater of better quality than does the average private tubewell in the watercourse's command area. This is a somewhat surprising finding, insofar as public tubewells typically pump water from depths more than twice that of private tubewells. Conventional wisdom in the Punjab setting holds that the greater the depth from which water is pumped, the worse the quality of water. The data for Lagar tubewells strongly suggest that aquifer water quality conditions are not so easily explained.

In Figure 10, one water quality parameter, EC, is displayed for each watercourse for which both private and public tubewell data are available. The average, minimum, and maximum EC values for private tubewells are shown along with those of the comparable public tubewell. For the 10 watercourses depicted, in only one case is the value determined for the public tubewell greater than the average for private tubewells, and even then, the difference is well below 5 percent. Interestingly, in three cases, the public tubewell's EC value is either the same or lower than that of the best private tubewell. Since farmers typically abandon their tubewells when water quality deteriorates to unacceptable levels, these differences in public and private tubewell water quality are even more striking.

Figure 10. Private and public tubewell water quality: Lagar Distributary watercourses.



Source: DLR data, 1988.

Conclusions and Implications for Further Research

SEVERAL IMPORTANT CONCLUSIONS concerning groundwater development in at least the Rechna Doab region of Punjab follow from even a cursory examination of the data reported in this paper. Based upon a complete tubewell census of Lagar Distributary's command area, private tubewell densities are significantly higher than hitherto reported in this area. Additional tubewell census surveys in distributary canal commands elsewhere in the Doab and Punjab, would provide a far more reliable basis than currently exists for determining whether or not this finding is locally specific or more widespread than was previously known.

Accurate census data when combined with the discharge measurements made by the Irrigation Research Institute for private and public tubewells in Lagar command show that the total installed capacity of private tubewells is not only more than six times as great as that of public tubewells, but that it exceeds by more than 12 times the amount of canal water authorized for Lagar Distributary. This finding strongly suggests that groundwater must now play a far greater role in irrigated agriculture in this and similar distributary canal commands than hitherto suspected, for it is highly improbable that farmers would make such a level of investment in private irrigation infrastructure, were it not either necessary or profitable for them to do so. The reasons for such a level of groundwater development are likely to be complex and certain to require further detailed comparative study.

The proportion that each source – private tubewells, public tubewells and the surface system – contributes to the total irrigation supply reaching farmers' fields, depends upon how many public and private tubewells are pumped. IIMI Pakistan closely monitored tubewell operations for about 40 percent of the private tubewells and all public tubewells in the command area of Lagar Distributary for the *rabi* season, 1988-89 and the *kharif* season, 1989. Analyses of those data are substantially complete and initial results have already been reported elsewhere (Vander Velde and Johnson 1989; Johnson 1990; Vander Velde and Kijne 1990).

At least for Lagar Distributary command, much greater variation in the actual levels of utilization of private tubewells exists than was previously estimated, and the overall contribution of groundwater to total irrigation supplies appears to be about 70 percent. Such findings strongly imply that increasing numbers of Punjab farmers do not pump groundwater merely to offset deficiencies in water supplies during crop sowing and maturation periods, as is still widely assumed. However, considerable additional research is needed before it can be known with confidence just how widespread these conditions are.

The water quality data resulting from the combined efforts of the Irrigation Research Institute, the Directorate of Land Reclamation and IIMI Pakistan, are especially interesting, and they are potentially the most important data reported in the paper for irrigated agriculture in Punjab. The data show that an unexpectedly large number of private tubewells pump groundwater of marginal quality, which by present standards is hazardous for crops. Limited studies have been initiated by IIMI to determine the possible consequences of using such water for agricultural production within Lagar and other distributary commands. However, it is only when such national and provincial research institutions as PARC (Pakistan Agricultural Research Council) and AARI (Ayub Agricultural Research Institute) initiate more extensive and detailed studies, that these effects are likely to be known with any confidence.

IIMI and IRI/DLR have implemented further collaborative field work to determine whether or not such marginal to poor quality of water tapped by private tubewells in Lagar's command is typical of other parts of Punjab's Rechna Doab. If that proves to be the case, then the reliance placed upon large quantities of groundwater for irrigation in these locales is certain to have important consequences for the long-term sustainability of irrigated agriculture in the region.

Finally, perhaps the most unexpected finding from these data is the observed difference between the quality of water pumped by deep public tubewells, and that pumped by private tubewells from more shallow aquifers. Once more, this suggests that additional primary research needs to be undertaken to establish if this is a local phenomenon or is prevalent across larger areas of the Punjab. Detailed groundwater hydrology research is also required to determine the causes of such differences, and whether the condition is essentially static, or dynamic and continuing to change. If it is the latter, then a sustained groundwater monitoring and analysis program would seem warranted.

Although at this juncture plausible explanations may be provided for this situation, perhaps the most serious and threatening possibility is that the unexpectedly poor quality of the shallow groundwater aquifer in Lagar command reflects the gradual, progressive accumulation of salts comparatively close to the soil surface. In that case, further deterioration in the groundwater water quality situation for private tubewells seems certain, unless effective preventive and control measures are soon implemented.

References

Government of Pakistan. 1986. Agricultural statistics of Pakistan 1985. Ministry of Food, Agriculture and Co-operatives. Food and Agriculture Division (Planning Unit), Islamabad.

Johnson, Robert L. 1989. Private tube well development in Pakistan's Punjab: Review of past public programs/policies and relevant research. Country Paper No. 1. International Irrigation Management Institute. Colombo, Sri Lanka.

Johnson, Robert L. 1990. Latent groundwater demand in Pakistan's Punjab: Theory, quantification and applications. Unpublished Ph.D. dissertation. Cornell University. Ithaca, New York.

Kijne, Jacob W. and Edward J. Vander Velde. 1990. Salinity in Punjab watercourse commands and irrigation system operations: A prolegomenon for improved irrigation management in Pakistan. IIMI Internal Program Review. Colombo, Sri Lanka.

Murray-Rust, D. Hammond. 1987. The impact of lining on water distribution in Ghordour and Lagar distributaries. IIMI Review. Vol. 1, No. 1. pp. 6-9.

Vander Velde, Edward J. and Robert Johnson. 1989. Issues in conjunctive management of groundwater and surface irrigation systems in Punjab, Pakistan: An initial assessment. IIMI Internal Program Review. Colombo, Sri Lanka.

Appendix A

Lagar Distributary Tubewell Census

THIS APPENDIX PROVIDES the complete list of operational public and private tubewells for Lagar Distributary through October 1989. Both the "NMR" and the "TUBID" are unique tubewell identifiers. The "NMR" is simply a data record number arbitrarily assigned to each tubewell. However, the "TUBID" is a unique, spatially-referenced identification label constructed for each tubewell based on specific location information.

For example, the first tubewell entry in the Lagar Distributary listing has NMR = 1 and TUBID = L/10R/185/18/A. The "L" identifies the fact that this tubewell is in the command area of Lagar Distributary; "10R" identifies the watercourse command in which it is located – in this case, the 10th watercourse from the Distributary head on the right side of the channel, downstream from the head. The last grouping, "185/18/A" means that this tubewell is in square number 185, *kila* (field) number 18 of that watercourse command, and that it was the first ("A") tubewell identified in that *kila*. If a second tubewell were also present in the same watercourse with the same square and kila number, then it would be identified as "L/10R/185/18/B." If a third tubewell was later developed in the same specific location, then "C" would be substituted for B to define it.

The "OWNER" gives the name of the owner as reported to IIMI field staff. Although many tubewells have multiple owners, for recording purposes only the first owner's name – when given – was used in most cases. Farmers often own more than one tubewell, but because the same name is not always reported, and different transliteration conventions are used in representing Punjabi names in Roman script, names actually recorded may not match.

"WCOURSE" refers to the watercourse command area in which the tubewell is located; likewise "SQUARE" and "KILA" refer to the tubewell's square and kila number, respectively. Square and kila information is as reported by the farmer and, in most cases, confirmed by field investigations using maps obtained from the local *patwari*, if available. Substantial field work has demonstrated that farmers' information alone is not always reliable in this respect. "PUBPRV" identifies whether the tubewell is privately owned ("P") or public. Public SCARP tubewells are denoted by an "S," Rasul program tubewells by an "R," and tubewells dating from the early FAO Chuharkana Program by an "F." Under "TYPE," the tubewell power source is identified; an "E" refers to electric motors, "D" to slow and high speed diesel engines, and "B" to tractor-driven bore points.

"BOREDEP" and "STARTY" identify the farmer reported depth of the bore (in feet) and the installation year for the tubewell, respectively. It should be noted that the installation year of the tubewell is not in all cases the same as the installation year of the bore the farmer is presently using. Bores often fail within a relatively short period of time, and it is common for a currently operating tubewell to be on its second, third, or even fourth bore.

If information is missing from any data category, the fact is denoted by a period (".").

In their totality, these data are accurate for Lagar Distributary command through 1989. However, a few additional entries that reflect data from continuing field observations in a limited number of Lagar watercourse commands throughout 1990, are included. Please refer to the map of Lagar Distributary for approximate watercourse locations.

Lagar Distributary Tubewell Census

NMR	TUBID	OWNER	WCOURSE	SQUARE	KILA	PUBPRV	TYPE	BOREDEP	STARTY
1	L/10R/226/5/A	FAO NO. 21	10R	226	5	F	E	300	65
2	L/10R/298/17/A	FAO NO. 24	10R	298	17	F	E	300	65
3	L/10R/185/18/A	GHULAM MUHD	10R	185	18	P	B	100	83
4	L/10R/191/22/A	MUHD TUFAIL	10R	191	22	P	E	100	74
5	L/10R/215/1/A	MUHD SABAR ARAIN	10R	215	1	P	B	95	88
6	L/10R/215/7/A	HAJI SARDAR	10R	215	7	P	E	100	82
7	L/10R/218/17/A	GHAFOOR WIRK	10R	218	17	P	D	95	70
8	L/10R/220/23/A	MOLVI ABDUL REHMAN	10R	220	23	P	E	90	82
9	L/10R/222/16/A	MUSHTAQ	10R	222	16	P	E	100	86
11	L/10R/225/14/A	IBRAHEEM OLAKH	10R	225	14	P	E	100	73
12	L/10R/253/8/A	MUHD HUSSAIN SHAH	10R	253	8	P	E	80	77
13	L/10R/254/14/A	JAVAID S/O KHOSHI	10R	254	14	P	D	95	70
14	L/10R/255/24/A	MOHD IQBAL	10R	255	24	P	D	90	88
15	L/10R/255/16/A	NIAMAT	10R	255	16	P	E	93	86
16	L/10R/256/5/A	MUHD HANIF QURESHI	10R	256	5	P	E	100	83
17	L/10R/288/11/A	HAJI SARDAR	10R	288	11	P	B	95	88
18	L/10R/294/1/A	BASHIR SECRETARY	10R	294	1	P	E	100	86
19	L/10R/297/15/A	HAJI SARDAR	10R	297	15	P	E	100	72
376	L/10R/263/19/A	MOHAMMAD ANWAR	10R	263	19	P	D	.	89
377	L/10R/223/10/A	IMDAD	10R	223	10	P	D	.	89
486	L/10R/288/9/A	SIDDIQ-UR-REHMAN	10R	288	9	P	D	.	89
487	L/10R/220/24/A	RIAZAT	10R	220	24	P	E	.	89
509	L/10R/298/4/A	SHARIF RAJPUT	10R	298	4	P	B	.	89
639	L/10R/189/16/A	ARIF	10R	189	16	P	D	.	90
20	L/11L/285/1/A	YOUSAF ALI	11L	285	1	P	E	85	75
21	L/11L/286/8/A	SCARP SKT-85	11L	286	8	S	E	282	61
22	L/11L/298/22/A	MUKHTAR	11L	298	22	P	E	80	77
23	L/11L/314/20/A	AKBAR ALI	11L	314	20	P	E	100	78
24	L/11L/315/16/A	ABDUL GHAFFAR RAJPUT	11L	315	16	P	E	108	78
25	L/11L/317/16/A	MERAJ DIN	11L	317	16	P	D	110	84
26	L/11L/317/19/A	MEHDI KHAN	11L	317	19	P	B	95	87
27	L/11L/317/9/A	MUHD ASHRAF	11L	317	9	P	E	100	87
28	L/11L/324/17/A	BASHIR AHMED	11L	324	17	P	E	110	84
29	L/11L/324/5/A	BHUTTA & LATIF	11L	324	5	P	E	110	78
30	L/11L/325/16/A	ABDUL LATIF	11L	325	16	P	D	100	87
372	L/11L/285/11/A	ABDUL RAHIM	11L	285	11	P	B	120	87
31	L/12L/104/15/A	SLAMAT	12L	104	15	P	D	100	85
32	L/12L/105/19/A	GHULAM MUHD	12L	105	19	P	E	100	83
33	L/12L/128/18/A	NAWAB	12L	128	18	P	E	112	80
34	L/12L/130/19/A	MUHD SIDDIQ FEROZPURI	12L	130	19	P	D	95	88
35	L/12L/2/5/A	REHMAT	12L	2	5	P	D	100	88
36	L/12L/49/10/A	MAJEED ASHRAF	12L	49	10	P	D	100	86
37	L/12L/49/23/A	SCARP SKT-86A	12L	49	23	S	E	300	61
38	L/12L/5/1/A	ASHRAF	12L	5	1	P	E	100	86
39	L/12L/75/21/A	NAZAR	12L	75	21	P	D	100	85
40	L/12L/76/21/A	MUHD HUSSAIN	12L	76	21	P	D	112	77
41	L/12L/76/22/A	MUHD SARDAR	12L	76	22	P	D	100	82
42	L/12L/8/15/A	INYAT	12L	8	15	P	E	100	84
43	L/13R/23/19/A	ABDUL GHANI	13R	23	19	P	B	95	84
44	L/13R/27/2/A	MUHD SHER	13R	27	2	P	D	110	84
45	L/13R/28/19/A	ABDUL GHAFOOR	13R	28	19	P	D	100	84
46	L/13R/44/1/A	MERAJ DIN	13R	44	1	P	B	150	75
47	L/13R/45/25/A	SCARP SKT-86	13R	45	25	S	E	350	61
48	L/13R/50/19/A	GHULAM MUHD	13R	50	19	P	E	120	77
49	L/13R/52/13/A	ABDULLAH	13R	52	13	P	B	130	82
50	L/13R/52/2/A	MERAJ DIN	13R	52	2	P	B	100	87
51	L/13R/72/9/A	JAN MUHD	13R	72	9	P	D	110	85
52	L/13R/98/12/A	MUHD TUFAIL	13R	98	12	P	D	120	80
53	L/13R/98/13/A	GHULAM MUHD	13R	98	13	P	D	100	87
54	L/14R/106/10/A	MUHD SHAFI	14R	106	10	P	D	120	81
55	L/14R/106/23/A	SCARP SKT-87	14R	106	23	S	E	350	61
56	L/14R/107/12/A	WAZIR	14R	107	12	P	D	100	87
57	L/14R/108/25/A	MUHD JAFFER	14R	108	25	P	D	120	87
58	L/14R/125/20/A	GHULAM RASUL	14R	125	20	P	D	120	82
59	L/14R/127/18/A	ILAM DIN	14R	127	18	P	D	100	87
60	L/14R/135/12/A	GHULAM GHOUS	14R	135	12	P	D	120	87
61	L/14R/135/25/A	MUHD SHAFI	14R	135	25	P	D	90	87
62	L/14R/136/7/A	REHMAT ULLAH	14R	136	7	P	D	120	84
63	L/14R/178/12/A	MUHD RAMZAN	14R	178	12	P	B	314	87
64	L/14R/178/23/A	MUHD AFZAL	14R	178	23	P	E	120	81
65	L/15R/119/22/A	KHURSHEED AHMED	15R	119	22	P	E	110	76
66	L/15R/125/15/A	MUHD HUSSAIN	15R	125	15	P	D	130	78
67	L/15R/148/15/A	BAHDAR ALI	15R	148	15	P	D	100	87
68	L/15R/39/12/A	IFTIKHAR	15R	39	12	P	E	120	84
69	L/15R/39/17/A	ISMAIL	15R	39	17	P	D	100	86

NMR	TUBID	OWNER	WCOURSE	SQUARE	KILA	PUBPRV	TYPE	BOREDEP	STARTY
70	L/15R/39/4/A	SCARP SKT-88A	15R	39	4	S	E	250	61
71	L/15R/68/24/A	SIDDIQ KHAN	15R	68	24	P	E	110	87
72	L/15R/68/5/A	MUHD YOUSAF	15R	68	5	P	B	120	82
73	L/16R/67/4/A	MUHD YOUSAF	16R	67	4	P	B	130	79
74	L/16R/89/13/A	SIDDIQ BHATTI	16R	89	13	P	D	110	88
75	L/16R/89/3/A	SCARP SKT-88	16R	89	3	S	E	300	61
76	L/16R/92/6/A	SIDDIQ HUNJRAH	16R	92	6	P	B	120	88
77	L/16R/97/21/A	MUHD MANZOOR	16R	97	21	P	B	110	87
476	L/16R/././.	MUHD SHAFI	16R	.	.	P	B	.	.
477	L/16R/././.	ANWAR CHATTA	16R	.	.	P	B	.	89
478	L/16R/././.	MUSTAFA	16R	.	.	P	B	.	89
78	L/17L/103/11/A	GHULAM MUHD RAJPUT	17L	103	11	P	D	120	85
79	L/17L/103/12/A	MUHD MUNSHA JAT	17L	103	12	P	D	110	88
80	L/17L/104/2/A	GHULAM RASUL	17L	104	2	P	B	110	85
81	L/17L/115/1/A	ALTAF HUSSAIN	17L	115	1	P	D	110	82
82	L/17L/116/11/A	ANWAR RAJPUT	17L	116	11	P	B	120	87
83	L/17L/117/15/A	ABDUL NABI KHAN	17L	117	15	P	B	120	87
84	L/17L/127/4/A	GHULAM SARWAR RAJPUT	17L	127	4	P	B	120	77
85	L/17L/129/18/A	HAJI REHMAT ULLAH	17L	129	18	P	B	120	79
86	L/17L/130/10/A	KARAM ELAHI	17L	130	10	P	D	120	82
87	L/17L/130/23/A	MUHD SHAFI	17L	130	23	P	B	100	81
88	L/17L/133/3/A	GHULAM MUHD HINJRA	17L	133	3	P	D	120	77
89	L/17L/58/5/A	ARIF ALI BHATTI	17L	58	5	P	B	120	83
90	L/17L/69/21/A	SCARP SKT-89	17L	69	21	S	E	300	61
91	L/17L/72/24/A	ABDUL HAMEED	17L	72	24	P	D	100	88
92	L/17L/85/24/A	MUHD ASHRAF	17L	85	24	P	B	130	77
93	L/17L/87/5/A	SHABIR AHMAD RAJPUT	17L	87	5	P	B	120	75
94	L/17L/98/12/A	MUHD YOUSAF ARAIN	17L	98	12	P	B	120	88
95	L/17L/98/25/A	SCARP SKT-89A	17L	98	25	S	E	300	61
479	L/17L/85/24/A	ASHRAF PATWARI	17L	85	24	P	B	.	.
96	L/18L/12/6/A	ALLAH DAD	18L	12	6	P	E	150	75
97	L/18L/145/25/A	SCARP SKT-90A	18L	145	25	S	E	256	84
98	L/18L/151/24/A	MUHD ALI	18L	151	24	P	B	125	84
99	L/18L/158/11/A	MUHD ALI	18L	158	11	P	B	125	84
100	L/18L/16/2/A	SCARP SKT-90	18L	16	2	S	E	300	62
101	L/18L/161/8/A	WALI MUHD	18L	161	8	P	B	125	84
102	L/18L/17/10/A	NIAZ JAT	18L	17	10	P	D	125	82
103	L/18L/2/22/A	ANWAR	18L	2	22	P	B	125	80
104	L/18L/26/10/A	ANWAR	18L	26	10	P	D	125	82
105	L/18L/26/9/A	AKBAR JAT	18L	26	9	P	B	125	85
106	L/18L/36/7/A	NIAZ JAT	18L	36	7	P	D	100	73
107	L/18L/37/15/A	NIAZ JAT	18L	37	15	P	B	125	84
108	L/18L/37/15/B	NIAZ JAT	18L	37	15	P	B	125	84
480	L/18L/././.	MUHD MANZOOR	18L	.	.	P	B	.	88
109	L/19R/23/17/A	NOORA / MUBARIK KAJLA	19R	23	17	P	B	120	81
110	L/19R/36/11/A	GHUALAM ALI DERATHE	19R	36	11	P	D	100	80
111	L/19R/36/20/A	ISA	19R	36	20	P	D	100	84
112	L/19R/41/18/A	SCARP SKT-91	19R	41	18	S	E	350	62
113	L/19R/45/3/A	ASHIQ SHAH	19R	45	3	P	B	100	85
114	L/19R/45/5/A	NOORA / MUHD CHEEMA	19R	45	5	P	D	110	86
115	L/19R/46/5/A	PIR SHAH	19R	46	5	P	D	100	86
117	L/19R/60/20/A	ABBAS	19R	60	20	P	B	120	87
118	L/19R/69/1/A	AQOOB	19R	69	1	P	B	110	85
119	L/19R/69/20/A	INYAT	19R	69	20	P	B	100	78
373	L/19R/45/5/B	MUHD YOUSAF	19R	45	5	P	B	.	88
503	L/19R/46/8/A	HAYAT	19R	46	8	P	D	.	89
120	L/1R/100/5/A	ZULFIQAR ALI	1R	100	5	P	E	100	60
121	L/1R/17/18/A	RASUL 31A	1R	17	18	R	E	300	58
122	L/1R/19/17/A	KHALIL AHMED	1R	19	17	P	B	110	84
123	L/1R/20/1/A	NAZIR HUSSAIN	1R	20	1	P	E	100	87
124	L/1R/72/14/A	ANWAR SAEED	1R	72	14	P	E	100	81
125	L/1R/73/18/A	JALAL DIN	1R	73	18	P	E	110	85
508	L/1R/17/24/A	ASHRAF GUJAR	1R	17	24	P	B	.	89
128	L/20R/112/11/A	MUHD ASHRAF	20R	112	11	P	E	120	75
129	L/20R/113/19/A	RAJA	20R	113	19	P	D	100	85
131	L/20R/117/2/A	MUHAMMAD	20R	117	2	P	B	120	88
134	L/20R/63/2/A	MUHD CHERIK	20R	63	2	P	D	110	85
135	L/20R/66/7/A	MUHD MANSHA	20R	66	7	P	D	120	81
136	L/20R/79/6/A	RANA KHALIL-UR-REHMAN	20R	79	6	P	D	100	73
138	L/20R/82/12/A	RASOOL	20R	82	12	P	B	120	81
139	L/20R/86/10/A	NOOR MUHD	20R	86	10	P	D	100	86
381	L/20R/88/4/A	SHER / ADIL	20R	88	4	P	D	.	89
507	L/20R/86/22/A	MAHLA	20R	86	22	P	B	.	89
513	L/20R/64/9/A	YAR MOHAMMAD	20R	69	9	P	B	.	89
140	L/21TL/48/19/A	SHAMAS DIN JAT	21TL	48	19	P	D	120	87
141	L/21TL/48/20/A	FAQIR MUHD	21TL	48	20	P	D	100	88
142	L/21TL/49/23/A	MUHD YOUSAF JAT	21TL	49	23	P	D	125	82
143	L/21TL/50/13/A	SARDAR KHAN	21TL	50	13	P	B	100	88
144	L/21TL/51/8/A	MUHD IBRAHEEM JAT	21TL	51	8	P	D	100	75
145	L/21TL/52/19/A	MUHD SIDDIQ	21TL	52	19	P	D	125	80

NMR	TUBID	OWNER	WCOURSE	SQUARE	KILA	PUBPRV	TYPE	BOREDEP	STARTY
146	L/21TL/53/9/A	ABDUL RASHEED RAJPUT	21TL	53	9	P	D	100	88
147	L/21TL/55/4/A	MUHD ASGHAR	21TL	55	4	P	D	120	83
148	L/21TL/55/5/A	SCARP SKT-92A	21TL	55	5	S	E	300	61
149	L/21TL/63/14/A	MUHD SIDDIQ / NOOR	21TL	63	14	P	D	125	79
150	L/21TL/63/16/A	SHARIF KHAN	21TL	63	16	P	D	125	79
151	L/21TL/64/20/A	KHALID JAVED	21TL	64	20	P	D	110	71
152	L/21TL/64/3/A	ALI MUHD JAT	21TL	64	3	P	D	100	88
153	L/21TL/66/24/A	ALI AHMED JAT	21TL	66	24	P	D	120	81
154	L/21TL/79/1/A	MUHD AKRAM	21TL	79	1	P	D	120	79
155	L/21TL/80/19/A	MUHD YASIN	21TL	80	19	P	D	120	75
156	L/21TL/81/2/A	SARDAR KHAN	21TL	81	2	P	B	100	83
462	L/21TL/62/24/A	SARDAR KHAN / HUSSAIN	21TL	62	24	P	D	.	82
488	L/21TL/64/1/A	HUSSAIN	21TL	64	1	P	D	.	89
511	L/21TL/33/11/A	FAKHAR DIN	21TL	33	11	P	D	.	89
512	L/21TL/60/14/A	MOHD YOUSAF GUJAR	21TL	60	14	P	D	.	89
514	L/21TL/65/21/A	ATTA ULLAH	21TL	65	21	P	B	.	89
611	L/21TL/33/23/A	SARDAR MOHAMMAD	21TL	33	23	P	B	.	90
624	L/21TL/61/11/A	HAJI MOHD ALSAM	21TL	61	11	P	D	.	90
625	L/21TL/51/2/A	AMANAT	21TL	51	2	P	D	.	90
626	L/21TL/51/3/A	NASIR-UD-DIN	21TL	51	3	P	B	.	90
627	L/21TL/54/2/A	AKBAR	21TL	54	2	P	D	.	90
628	L/21TL/55/12/A	RAO ILYAS	21TL	55	12	P	D	.	90
629	L/21TL/96/2/A	M.ASLAM RAO	21TL	96	2	P	B	.	90
630	L/21TL/34/17/A	IDREES	21TL	34	17	P	D	.	90
631	L/21TL/81/13/A	KHALID JAVAID	21TL	81	13	P	B	.	90
157	L/22TF/115/22/A	FURZUND	22TF	115	22	P	D	100	88
158	L/22TF/116/19/A	IDREES	22TF	116	19	P	D	100	88
159	L/22TF/118/15/A	MUHD HUSSAIN	22TF	118	15	P	B	110	87
160	L/22TF/124/9/A	NAKE MUHD	22TF	124	9	P	B	90	85
161	L/22TF/125/12/A	BASHIR KHAN	22TF	125	12	P	B	90	87
162	L/22TF/126/21/A	ALI MUHD	22TF	126	21	P	D	100	87
163	L/22TF/149/11/A	MUHD ASLAM RAO	22TF	149	11	P	B	90	86
164	L/22TF/152/12/A	ARSHAD KHAN	22TF	152	12	P	E	90	87
165	L/22TF/156/25/A	MUHD RAFI	22TF	156	25	P	E	90	81
166	L/22TF/157/1/A	MUHD ASLAM	22TF	157	1	P	B	90	85
167	L/22TF/157/7/A	ARIF BHATTI	22TF	157	7	P	B	90	86
168	L/22TF/181/14/A	MUHD YOUSAF	22TF	181	14	P	E	120	83
169	L/22TF/56/16/A	MUHD ASLAM RAO	22TF	56	16	P	E	100	83
170	L/22TF/85/12/A	MUHD AKRAM	22TF	85	12	P	E	90	81
171	L/22TF/85/2/A	SCARP SKT-93	22TF	85	2	S	E	350	62
172	L/22TF/92/15/A	MUHD ASLAM	22TF	92	15	P	E	90	80
173	L/22TF/118/15/B	SHAH MUHD	22TF	118	15	P	E	100	83
174	L/22TF/118/14/A	ALLAH DITTA	22TF	118	14	P	E	90	81
489	L/22TF/117/5/A	MAHMOOD KHAN	22TF	117	5	P	D	.	89
490	L/22TF/85/14/A	MOHD ASHRAF	22TF	85	14	P	B	.	89
175	L/23TR/119/15/A	MUHD HUSSAIN	23TR	119	15	P	B	100	87
176	L/23TR/122/8/A	ANWAR HUSSAIN	23TR	122	8	P	E	120	80
177	L/23TR/152/22/A	KHAN BAHADAR	23TR	122	22	P	D	120	85
178	L/23TR/156/8/A	GULZAR KHAN	23TR	156	8	P	B	120	85
180	L/23TR/56/24/A	SCARP SKT-93A	23TR	56	24	S	E	300	62
181	L/23TR/59/21/A	MUHD DIN	23TR	59	21	P	D	120	85
182	L/23TR/91/11/A	ABDUL HAQ	23TR	91	11	P	B	110	85
481	L/23TR/91/15/A	GHULAM CHUSTI	23TR	91	15	P	B	.	88
183	L/2R/22/19/A	LUSHKAR ALI	2R	22	19	P	E	100	76
184	L/2R/24/19/A	BASHIR AHMED	2R	24	19	P	D	110	83
185	L/2R/25/17/A	MUHD ANWAR	2R	25	17	P	E	100	82
186	L/2R/27/19/A	MUHD SHAFI	2R	27	19	P	E	100	87
187	L/2R/29/16/A	BASHIR AHMED	2R	29	16	P	E	100	84
188	L/2R/29/9/A	HAJI FAZAL KARIM	2R	29	9	P	E	120	86
189	L/2R/31/10/A	KHAIR DIN (LOHAR)	2R	31	10	P	D	100	85
192	L/2R/31/6/A	MUHD SHARIF	2R	31	6	P	E	100	87
194	L/2R/34/15/A	ABDUL AZIZ	2R	34	15	P	E	120	80
195	L/2R/37/14/A	FAQIR HUSSAIN	2R	37	14	P	E	120	86
197	L/2R/41/12/A	SARDAR MUHD	2R	41	12	P	B	100	87
198	L/2R/46/23/A	SADAR DIN	2R	46	23	P	D	100	87
199	L/2R/58/23/A	ALI MUHD	2R	58	23	P	E	120	87
200	L/2R/59/16/A	GHULAM NABI	2R	59	16	P	E	100	87
201	L/2R/61/20/A	MUHD SHAHBAZ	2R	61	20	P	E	110	87
202	L/2R/61/25/A	RASHEED AHMED	2R	61	25	P	E	100	86
203	L/2R/61/8/A	HAJI ALLAH DAD	2R	61	8	P	E	110	87
205	L/2R/62/4/A	SHARIF (LOHAR)	2R	62	4	P	D	120	82
206	L/2R/63/4/A	INYAT KHAN	2R	63	4	P	B	100	85
207	L/2R/64/20/A	MUHD HUSSAIN	2R	64	20	P	B	110	87
208	L/2R/64/4/A	BASHIR KHAN	2R	64	4	P	B	110	83
209	L/2R/65/8/A	MUHD SIDDIQUE KHAN	2R	65	8	P	B	110	83
210	L/2R/66/16/A	GHULAM NABI	2R	66	16	P	E	110	87
211	L/2R/66/8/A	SADIQ (MOCHI)	2R	66	8	P	B	110	82
212	L/2R/67/7/A	RASHEED AHMED	2R	67	7	P	E	105	88
213	L/2R/68/14/A	BASHIR JAT	2R	68	14	P	ED	110	79
485	L/2R/24/8/A	IMDAD HUSSAIN	2R	24	8	P	E	.	89

NMR	TUBID	OWNER	WCOURSE	SQUARE	KILA	PUBPRV	TYPE	BOREDEP	STARTY
506	L/2R/46/24/A	ABDUL GHAFOOR	2R	46	24	P	B	.	89
179	L/3L/./././.	ABDUL WAHID	3L	.	.	P	B	.	86
214	L/3L/60/5/A	FAO 7	3L	60	5	F	E	250	58
215	L/3L/61/2/A	FAO 7A	3L	61	2	F	E	250	58
216	L/3L/57/9/A	RAJA AND RANA	3L	57	9	P	B	100	75
380	L/4AL/8/21/A	GHULAM DASTGIR	4AL	8	21	P	E	.	.
469	L/4AL/72/17/A	IJAZ HUSSAIN	4AL	72	17	P	E	.	.
217	L/4R/22/23/A	RAMZAN	4R	22	23	P	B	120	87
218	L/4R/22/9/A	RAHMET ALI	4R	22	9	P	D	110	88
219	L/4R/22/9/B	SARDAR	4R	22	9	P	D	120	85
220	L/4R/23/10/A	NAZEER	4R	23	10	P	D	110	79
221	L/4R/23/12/A	ASGHAR	4R	23	12	P	B	120	80
222	L/4R/25/18/A	GHULAM MUHD	4R	25	18	P	D	90	84
223	L/4R/35/8/A	MUHD SIDDIQ	4R	35	8	P	D	110	86
224	L/4R/45/8/A	INYAT	4R	45	8	P	B	100	87
225	L/4R/46/2/A	MUKHTAR	4R	46	2	P	B	110	86
226	L/4R/46/20/A	RAHMET ALI	4R	46	20	P	B	70	86
227	L/4R/56/1/A	MUHD YAQOOB	4R	56	1	P	D	110	88
228	L/4R/60/15/A	GHULAM RASUL	4R	60	15	P	D	120	85
229	L/4R/8/21/A	MUHD KHAN	4R	8	21	P	B	100	67
230	L/4R/8/23/A	FAO 14	4R	8	23	F	E	250	67
231	L/5R/49/18/A	AFZAL KHAN	5R	49	18	P	B	100	85
232	L/5R/50/12/A	AMJAD KHAN	5R	50	12	P	D	95	85
233	L/5R/51/20/A	MUHD ANWAR	5R	51	20	P	D	90	84
234	L/5R/54/20/A	FAO 13	5R	54	20	F	E	250	62
235	L/5R/58/13/A	AFZAL KHAN RAJPUT	5R	58	13	P	B	100	88
236	L/5R/58/24/A	FAO 16	5R	58	24	F	E	250	87
237	L/5R/65/7/A	MUHD ALI	5R	65	7	P	D	100	85
238	L/5R/66/21/A	ASHFAQ SHAH	5R	66	21	P	D	100	84
239	L/5R/66/8/A	SHARAFIT ALI DOGAR	5R	66	8	P	D	90	88
240	L/5R/67/3/A	TUFAIL KHAN	5R	67	3	P	D	100	85
241	L/5R/68/5/A	BASHIR KHAN	5R	68	5	P	D	100	85
242	L/5R/69/1/A	MUHD AFZAL KHAN / FATEH.K5R	69	1	P	D	100	85	.
243	L/5R/69/25/A	MUHD AMIN	5R	69	25	P	E	90	67
244	L/5R/71/2/A	MAQBOOL KHAN	5R	71	2	P	D	90	87
245	L/5R/71/22/A	MUKHTAR ALI	5R	71	22	P	D	90	85
246	L/5R/75/13/A	MUBARIK ALI	5R	75	13	P	D	95	83
247	L/5R/81/25/A	MUHD SHAFI	5R	81	25	P	D	90	86
248	L/5R/82/5/A	SARWAR KHAN AWAN	5R	82	5	P	B	90	85
470	L/5R/52/1/A	STAR SHAH	5R	52	1	P	B	95	89
471	L/5R/52/17/A	RAHMET ALI MEHR	5R	52	17	P	D	90	89
249	L/6L/119/21/A	ABDUL RASHEED	6L	119	21	P	E	150	87
250	L/6L/119/6/A	ABDUL RASHEED	6L	119	6	P	E	80	70
251	L/6L/120/24/A	FAO 12	6L	120	24	F	E	350	60
252	L/6L/134/11/A	BASHIR SHAH	6L	134	11	P	D	85	87
253	L/6L/136/9/A	IJAZ KHAN	6L	136	9	P	E	85	85
254	L/6L/165/8/A	SAIDULLAH	6L	165	8	P	D	85	86
255	L/6L/88/15/A	MALIK MUHD YOUSAF	6L	88	15	P	D	90	85
256	L/6L/90/21/A	ISHFAQ SHAH	6L	90	21	P	D	90	88
257	L/6L/91/24/A	FAO 11	6L	91	24	F	E	350	65
472	L/6L/53/17/A	NIAZ AHMED	6L	53	17	P	D	.	89
473	L/6L/./././.	IMANUT	6L	.	.	P	B	.	89
474	L/6L/./././.	BERKET	6L	.	.	P	B	.	89
475	L/6L/./././.	MAQDOAL SHAH	6L	.	.	P	B	.	89
258	L/7R/108/13/A	SHAUKAT ALI SHAH	7R	108	13	P	D	92	88
259	L/7R/128/12/A	HASSAN ALI	7R	128	12	P	B	105	73
260	L/7R/130/16/A	FAO 20	7R	130	16	F	E	300	66
261	L/7R/130/9/A	SHAMUS-UD-DIN	7R	130	9	P	D	85	82
262	L/7R/132/10/A	FAO 19	7R	132	10	F	E	300	67
263	L/7R/151/16/A	BASHIR AHMED	7R	151	16	P	E	95	82
264	L/7R/151/5/A	YOUSAF KHAN	7R	151	5	P	D	100	75
265	L/7R/152/7/A	HABIB JILANI	7R	152	7	P	B	85	88
266	L/7R/159/11/A	ZULFIQAR ALI	7R	159	11	P	E	95	73
267	L/8L/193/12/A	SCARP SKT-83	8L	193	12	S	E	250	62
268	L/8L/213/2/A	NAZIR AHMED DOGAR	8L	213	2	P	D	80	80
269	L/8L/213/23/A	MANZOOR DOGAR	8L	213	23	P	D	80	84
270	L/8L/229/25/A	ZAHOOR AHMED	8L	229	25	P	E	80	85
271	L/8L/230/21/A	ZAHOOR AHMED	8L	230	21	P	E	80	85
272	L/8L/230/8/A	MUHD ISLAM DOGAR	8L	230	8	P	B	100	84
273	L/8L/246/15/A	BASHIR ROMA	8L	246	15	P	D	85	87
274	L/8L/246/21/A	TALIB HUSSAIN	8L	246	21	P	B	100	88
275	L/8L/247/15/A	WALI MUHD ARIAN	8L	247	15	P	D	135	74
276	L/8L/249/2/A	ELAHI BAKHSHE AWAN	8L	249	2	P	E	80	85
277	L/8L/273/15/A	NASEEB GUJAR	8L	273	15	P	E	100	84
278	L/8L/277/21/A	MUHD JAMIL GUJAR	8L	277	21	P	E	90	84
279	L/9L/227/14/A	SCARP SKT-84	9L	227	14	S	E	250	61
280	L/9L/251/8/A	ALLAH DITTA ARIAN	9L	251	8	P	D	90	88
281	L/9L/282/2/A	MOLVI ABDUL RASHEED	9L	282	2	P	D	90	79
282	L/9L/282/9/A	SADIQ AWAN	9L	282	9	P	D	90	78
283	L/9L/311/11/A	MUHD AKRAM	9L	311	11	P	E	90	80

NMR	TUBID	OWNER	WCOURSE	SQUARE	KILA	PUBPRV	TYPE	BOREDEP	STARTY
284	L/9L/332/1/A	HAJI FAQIR MUHD RAJPUT	9L	332	1	P	E	90	81
285	L/9L/337/24/A	KHADAM HUSSAIN	9L	337	24	P	D	85	85
286	L/9L/84/14/A	ASHFAQ RAJPUT	9L	84	14	P	E	100	80
497	L/9L/282/12/A	SHER MOHD S/O QASIM	9L	282	12	P	B	.	89
501	L/9L/250/3/A	SARDAR MOHD	9L	250	3	P	D	.	89
502	L/9L/250/7/A	NOOR MOHD S/O SHAMAS DIN 9L	250	7	P	D	.	89	
287	L/J1L/229/16/A	MUHD RAFIQ	J1L	229	16	P	B	130	61
288	L/J1L/305/11/A	ABDUL REHMAN	J1L	305	11	P	E	250	73
289	L/J1L/305/13/A	MUHD IQBAL	J1L	305	13	P	E	150	79
290	L/J1L/305/23/A	MUHD HUSSAIN	J1L	305	23	P	E	150	81
292	L/J1L/306/21/A	MUHD EHSAN	J1L	306	21	P	E	120	85
293	L/J1L/309/1/A	MUHD IDREES	J1L	309	1	P	E	100	83
294	L/J1L/310/6/A	AHMED ALI AWAN	J1L	310	6	P	E	90	84
374	L/J1L/305/5/A	ASHIQ	J1L	305	5	P	B	.	86
504	L/J1L/269/20/A	ABDUL REHMAN	J1L	269	20	P	B	.	89
295	L/J2L/22/11/A	BILAL SHAH	J2L	22	11	P	E	100	79
296	L/J2L/23/11/A	SCARP SKT-94A	J2L	23	11	S	E	300	61
297	L/J2L/23/16/A	NASEER CHEEMA	J2L	23	16	P	D	100	84
298	L/J2L/24/24/A	REHMAT ALI	J2L	24	24	P	D	130	85
299	L/J2L/25/17/A	SCARP SKT-94B	J2L	25	17	S	E	300	61
300	L/J2L/26/7/A	SANTA CHEEMA	J2L	26	7	P	D	120	82
301	L/J2L/28/24/A	ABDUL MAJEED	J2L	28	24	P	D	100	81
302	L/J2L/37/24/A	MANZOOR	J2L	37	24	P	D	100	85
303	L/J2L/37/7/A	GHULAM ALI	J2L	37	7	P	D	100	86
304	L/J2L/38/13/A	MANSHA	J2L	38	13	P	D	100	86
305	L/J2L/43/1/A	IBRAHEEM	J2L	43	1	P	D	120	82
306	L/J2L/55/20/A	MOLADAD	J2L	55	20	P	D	100	82
307	L/J2L/73/2/A	FAQIR HUSSAIN	J2L	73	2	P	B	130	82
308	L/J2L/75/25/A	SANTA / BAGA	J2L	75	25	P	B	120	79
309	L/J2L/76/10/A	RATAN KHAN	J2L	76	10	P	B	100	81
310	L/J2L/86/2/A	FATEH MUHD	J2L	86	2	P	B	100	81
311	L/J2L/89/15/A	ABDULLAH	J2L	89	15	P	B	100	81
351	L/J2L/36/22/A	SARDAR	J2L	36	22	P	D	100	84
352	L/J2L/37/2/A	GHULAM ALI	J2L	37	2	P	B	100	88
353	L/J2L/44/14/A	MUHD SHAFI THUKRA	J2L	44	14	P	D	100	86
378	L/J2L/22/24/A	ASLAM CHEEMA	J2L	22	24	P	D	.	89
491	L/J2L/40/18/A	FAKHRA SULTANA	J2L	40	18	P	B	.	89
492	L/J2L/22/17/A	KALA S/O REHMAT	J2L	22	17	P	D	.	89
493	L/J2L/40/21/A	FAKHRA SULTANA	J2L	40	21	P	D	.	83
494	L/J2L/27/1/A	MOHD S/O MANAH	J2L	27	1	P	D	.	89
498	L/J2L/75/16/A	ASHIQ	J2L	75	16	P	D	.	89
499	L/J2L/60/8/A	MALLAH	J2L	60	8	P	D	.	89
500	L/J2L/29/18/A	ABDUL GHAFOOR AWAN	J2L	29	18	P	B	.	89
510	L/J2L/55/1/A	AHID KHAN	J2L	55	1	P	D	.	89
515	L/J2L/22/19/A	ASHIQ S/O REHMAT	J2L	22	19	P	E	.	89
312	L/J3L/15/10/A	SADDIQ DOGAR	J3L	15	10	P	D	100	84
313	L/J3L/15/2/A	MANZOOR KHAN	J3L	15	2	P	B	100	75
315	L/J3L/16/3/A	GEORGE MASEA	J3L	16	3	P	E	100	77
316	L/J3L/24/3/A	BOTA BHATTI	J3L	24	3	P	D	100	84
317	L/J3L/26/7/A	AKRAM KHAN	J3L	26	7	P	D	110	86
318	L/J3L/39/1/A	WALI MUHD	J3L	39	1	P	E	110	86
319	L/J3L/40/10/A	ASHRAF KHAN	J3L	40	10	P	D	110	81
320	L/J3L/42/13/A	IFTIKHAR	J3L	42	13	P	D	100	77
321	L/J4TR/28/22/A	QAMAR HUSSAIN	J4TR	28	22	P	E	100	72
322	L/J4TR/30/11/A	MUHD BOTA RAJPUT	J4TR	30	11	P	E	100	85
323	L/J4TR/31/15/A	SAFDER KHAN	J4TR	31	15	P	D	100	88
324	L/J4TR/34/./A	ABDUL GHAFFAR QURESHI	J4TR	34	.	P	B	120	77
325	L/J4TR/36/25/A	RAFIQ KHAN	J4TR	36	25	P	E	100	81
326	L/J4TR/37/5/A	SCARP SKT-95	J4TR	37	5	S	E	300	61
327	L/J4TR/46/16/A	RANA MUZAFFAR	J4TR	46	16	P	E	115	81
328	L/J4TR/49/23/A	MUHD SHAFI	J4TR	49	23	P	D	120	84
329	L/J4TR/53/5/A	ABDUL REHMAN	J4TR	53	5	P	E	100	82
330	L/J4TR/66/5/A	RANA MUZAFFAR	J4TR	66	5	P	E	100	75
348	L/J6TL/60/1/A	QAMAR KHAN	J4TR	60	1	P	B	100	87
331	L/J5TF/10/10/A	MUHD KHAN	J5TF	10	10	P	E	100	78
332	L/J5TF/10/14/A	MAQBOOL AHMED KHAN	J5TF	10	14	P	E	100	77
333	L/J5TF/11/9/A	RAMZAN KHAN	J5TF	11	9	P	E	100	79
334	L/J5TF/13/14/A	ABDUL RAHIM	J5TF	13	14	P	E	100	77
335	L/J5TF/27/8/A	KHAN MUHD	J5TF	27	8	P	B	110	86
336	L/J5TF/28/8/A	ARSHID ARAIN	J5TF	28	8	P	D	100	85
337	L/J5TF/29/1/A	HADI KHAN	J5TF	29	1	P	B	100	85
338	L/J5TF/30/14/A	ABDUL MAJID	J5TF	30	14	P	D	100	87
339	L/J5TF/31/22/A	ABDUL ASIS KHAN	J5TF	31	22	P	D	100	87
340	L/J5TF/32/6/A	ABDUL GHAFOOR KHAN	J5TF	32	6	P	B	120	85
341	L/J5TF/41/11/A	AFZAL KHAN / MUBARAK ALI	J5TF	41	11	P	D	100	87
342	L/J5TF/43/25/A	UMAR KHAN	J5TF	43	25	P	B	110	88
343	L/J5TF/44/13/A	SHAFIQ KHAN	J5TF	44	13	P	D	120	86
344	L/J5TF/53/2/A	SARDAR	J5TF	53	2	P	D	110	88
345	L/J5TF/8/13/A	AFZAL KHAN	J5TF	8	13	P	D	114	82
347	L/J6TL/55/20/A	ABID ALI	J6TL	55	20	P	E	100	75

NMR	TUBID	OWNER	WCOURSE	SQUARE	KILA	PUBPRV	TYPE	BOREDEP	STARTY
349	L/J6TL/61/16/A	INYAT TAILY	J6TL	61	16	P	D	100	75
350	L/J6TL/64/4/A	ASHRAF KHAN	J6TL	64	4	P	E	100	74
354	L/KD216/11/15/A	MUHD HANIF	KD216	11	15	P	D	110	87
355	L/KD216/12/20/A	INYAT ALI	KD216	12	20	P	D	120	88
356	L/KD216/22/25/A	MUKHTAR AHMED	KD216	22	25	P	B	120	88
357	L/KD216/22/7/A	MERAJ DIN	KD216	22	7	P	B	110	86
358	L/KD216/23/15/A	ABDUL HAQUE	KD216	23	15	P	E	110	84
359	L/KD216/23/8/A	GHULAM SARWAR	KD216	23	8	P	B	110	80
360	L/KD216/7/22/A	HAJI MEHR DIN	KD216	7	22	P	D	100	80
361	L/KD216/8/11/A	MUKHTAR AHMED	KD216	8	11	P	B	120	88
362	L/KD216/8/23/A	HAJI FAZAL KARIM	KD216	8	23	P	D	100	81
366	L/KD216/25/16/A	MERAJ DIN	KD216	25	16	P	B	120	88
379	L/KD216/21/9/A	ABDUL RASHEED	KD216	21	9	P	D	.	89
505	L/KD216/24/9/A	AKRAM GUJAR	KD216	24	9	P	D	.	89

Appendix B

Lagar Distributary Tubewell Physical Data

DATA CONCERNING CERTAIN physical characteristics of 193 public and private tubewells in Lagar Distributary command are given in this appendix. These data were collected through direct measurements carried out by the Irrigation Research Institute (IRI) of the Punjab Irrigation and Power Department, late in *Kharif* season, 1988.

As in the primary census listing of tubewells in Lagar Distributary command (Appendix A), each well is first individually identified by its "NMR" and its "TUBID." This information is followed by the column "DATE" which gives the date on which the measurements were taken. The tubewell discharge as measured by IRI in cubic feet per second is entered under "DISCHARGE." (English units of measurement continue to be the standard for the Punjab Irrigation Department as well as for other irrigation agencies in Pakistan; therefore, the primary measurement data in this Appendix are given as originally reported by IRI. Conversion to international metric standards is easily and quickly done, however.)

Entries under "STATICNSL" give the measured depth to water table from the natural land surface of each well. If the tubewell was operating when it was visited by the IRI team, it was turned off and suitable time allowed for the water in the bore to return to its natural level before this measurement was made. "STATICCLP" indicates the depth to water table for each tubewell as measured from the pump. Because pumps are often placed at the bottom of dug pits, this depth is usually less than the depth to water table measured from the natural land surface.

The depth of the water table when the pump is operating, measured from the level of the pump, is given in the column headed "DYNAMIC." If the tubewell was not in operation when the IRI team arrived to make these measurements, it was operated for a period sufficient for the water table to stabilize at its dynamic position. The difference between the values for "STATICCLP" and "DYNAMIC" is "DRAWDOWN." All depths are measured in feet.

When any of the foregoing measurements could not be taken for various reasons, the entry under the appropriate column(s) is a period (".").

Lagar Distributary Physical Data

NMR	TUBID	DATE	DISCHARGE	STATICNSL	STATICCLP	DYNAMIC	DRAWDOWN
1	L/10R/226/5/A	4/08/88	2.29	16.5	19.4	43.8	24.4
2	L/10R/298/17/A	7/08/88	2.56	14.0	17.2	43.2	26.0
3	L/10R/185/18/A	15/08/88	0.99	6.1	2.0	18.1	16.1
4	L/10R/191/22/A	15/08/88	0.91	10.6	8.6	28.3	19.7
5	L/10R/215/1/A	15/08/88	1.43	10.5	8.5	24.9	16.4
6	L/10R/215/7/A	15/08/88	0.67	8.2	8.2	21.5	13.3
7	L/10R/218/17/A	15/08/88	1.11	6.7	4.8	21.5	16.7
8	L/10R/220/23/A	15/08/88	1.02	16.7	6.2	19.2	13.0
9	L/10R/222/16/A	15/08/88	0.94	16.5	12.5	26.0	13.5
11	L/10R/225/14/A	15/08/88	1.20	14.2	13.2	21.5	8.3
12	L/10R/253/8/A	15/08/88	0.45	14.7	14.7	24.9	10.2
13	L/10R/254/14/A	15/08/88	1.19	17.5	14.5	21.5	7.0
14	L/10R/255/14/A	15/08/88	0.80	14.7	13.2	27.1	13.9
15	L/10R/255/16/A	15/08/88	0.93	15.7	9.7	18.1	8.4
16	L/10R/256/5/A	15/08/88	1.05	16.3	12.3	24.9	12.6
17	L/10R/288/11/A	15/08/88	1.33	15.4	12.4	28.3	15.9
18	L/10R/294/1/A	15/08/88	1.48	11.7	11.7	29.4	17.7
19	L/10R/297/15/A	15/08/88	0.93	14.5	13.0	27.1	14.1
20	L/11L/285/1/A	17/08/88	0.76	14.0	12.3	18.3	6.0
21	L/11L/286/8/A	4/08/88	2.31	16.5	17.5	32.5	15.0
22	L/11L/298/22/A	20/08/88	0.62	14.0	13.1	24.0	10.9
23	L/11L/314/20/A	21/08/88	1.02	13.3	12.2	20.3	8.1
24	L/11L/315/16/A	21/08/88	1.10	13.3	6.1	21.1	15.0
25	L/11L/317/16/A	20/08/88	0.60	14.3	14.2	20.0	5.8
27	L/11L/317/9/A	20/08/88	0.75	14.5	13.0	22.6	9.6
28	L/11L/324/17/A	21/08/88	1.07	13.5	10.3	22.3	12.0
29	L/11L/324/5/A	21/08/88	0.87	13.5	10.5	17.1	6.6
30	L/11L/325/16/A	21/08/88	.	.	.	.	.
372	L/11L/285/11/A	15/09/88	1.38	11.5	11.5	26.3	14.8
37	L/12L/49/23/A	4/08/88	1.69	16.3	18.6	31.3	12.7
47	L/13R/45/25/A	5/08/88	2.18	16.6	19.5	41.6	22.1
55	L/14R/106/23/A	7/08/88	1.82	17.4	21.0	40.8	19.8
70	L/15R/39/4/A	8/08/88	0.33	17.1	18.7	35.3	16.6
74	L/16R/89/13/A	4/09/88	0.73	16.8	15.4	28.6	13.2
75	L/16R/89/3/A	9/08/88	1.70	15.4	16.8	26.0	9.2
76	L/16R/92/6/A	4/09/88	1.24	14.0	11.0	20.6	9.6
77	L/16R/97/21/A	4/09/88	0.62	15.0	14.4	28.6	14.5
90	L/17L/69/21/A	9/08/88	2.18	19.5	22.6	43.1	20.5
95	L/17L/98/25/A	8/08/88	2.49	18.6	21.6	31.6	10.0
97	L/18L/145/25/A	10/08/88	2.04	15.8	18.5	32.3	13.8
100	L/18L/16/2/A	9/08/88	2.76	19.8	22.0	32.2	10.2
109	L/19R/23/17/A	30/08/88	.	.	.	.	.
110	L/19R/36/11/A	20/09/88	1.28	16.0	12.0	22.8	10.8
111	L/19R/36/20/A	30/08/88	0.99	21.0	15.0	22.8	7.8
112	L/19R/41/18/A	30/08/88	1.90	18.0	21.0	32.0	11.0
113	L/19R/45/3/A	30/08/88	0.93	18.0	14.5	20.5	6.0
114	L/19R/45/5/A	30/08/88	1.19	19.5	13.5	22.8	9.3
115	L/19R/46/5/A	1/09/88	1.10	19.0	16.2	26.2	10.0
117	L/19R/60/20/A	31/08/88	0.83	16.0	15.0	21.7	6.7
118	L/19R/69/1/A	31/08/88	.	16.0	15.2	.	.
119	L/19R/69/20/A	30/08/88	0.69	16.8	15.0	24.6	9.6
120	L/1R/100/5/A	15/09/88	1.34	9.0	7.7	21.5	13.8
121	L/1R/17/18/A	15/09/88	2.09	8.3	.	21.5	13.2
122	L/1R/19/17/A	15/08/88	1.21	7.4	7.4	24.3	16.9
125	L/1R/73/18/A	15/08/88	1.24	7.4	7.4	19.2	11.8
126	L/1R/75/23/A	15/08/88	1.40	8.6	4.8	18.6	13.8
128	L/20R/112/11/A	29/08/88	1.06	16.0	11.5	18.8	7.3
129	L/20R/113/19/A	28/08/88	0.73	16.0	11.0	17.1	6.1
130	L/20R/116/11/A	31/08/88	0.98	19.3	13.3	25.2	11.9
131	L/20R/117/2/A	17/09/88	1.38	15.7	14.7	30.0	15.3
132	L/20R/119/1/A	30/08/88	0.85	16.0	13.0	21.7	8.7
134	L/20R/63/2/A	29/08/88	0.95	.	13.5	20.6	7.1
135	L/20R/66/7/A	29/08/88	1.01	.	15.0	21.7	6.7
136	L/20R/79/6/A	16/10/88	1.02	15.5	15.5	20.6	5.1
137	L/20R/79/6/B	11/08/88	.	18.0	21.0	.	.
138	L/20R/82/12/A	17/09/88	1.18	15.0	11.0	24.0	13.0
139	L/20R/86/10/A	29/08/88	0.67	16.0	10.0	14.9	4.9
140	L/21TL/48/19/A	15/08/88	1.31	9.9	7.3	14.7	7.4
141	L/21TL/48/20/A	15/09/88	1.48	9.7	7.3	19.2	11.9
142	L/21TL/49/23/A	15/08/88	1.52	9.1	7.1	22.6	15.5
143	L/21TL/50/13/A	15/08/88	1.14	9.1	5.1	18.1	13.0
144	L/21TL/51/8/A	15/09/88	1.11	10.1	9.1	21.5	12.4
145	L/21TL/52/19/A	15/08/88	1.06	11.8	8.8	15.8	7.0
146	L/21TL/53/9/A	15/08/88	1.11	12.9	8.9	21.5	12.6
147	L/21TL/55/4/A	15/08/88	0.75	17.8	10.8	21.5	10.7
148	L/21TL/55/5/A	12/08/88	1.67	17.2	19.6	26.6	7.0

NMR	TUBID	DATE	DISCHARGE	STATICNSL	STATICCLP	DYNAMIC	DRAWDOWN
150	L/21TL/63/16/A	15/08/88	1.14	11.8	7.8	18.1	10.3
151	L/21TL/64/20/A	15/08/88	1.20	11.4	7.8	23.7	15.9
152	L/21TL/64/3/A	15/09/88	1.89	10.0	8.0	26.0	18.0
153	L/21TL/66/24/A	15/08/88	0.51	7.8	7.8	14.7	6.9
154	L/21TL/79/1/A	15/09/88	1.02	7.8	6.8	17.0	10.2
155	L/21TL/80/19/A	15/08/88	0.79	10.7	7.1	18.1	11.0
156	L/21TL/81/2/A	15/08/88	0.93	12.1	8.1	15.8	7.7
157	L/22TF/115/22/A	11/10/88	0.98	.	.	22.8	.
158	L/22TF/116/19/A	23/08/88	1.38	13.1	3.1	20.6	17.5
159	L/22TF/118/15/A	26/09/88	1.13	15.2	15.2	21.7	6.5
160	L/22TF/124/9/A	28/08/88	0.80	16.0	9.5	23.4	13.9
161	L/22TF/125/12/A	28/08/88	0.81	16.0	13.7	19.0	5.3
162	L/22TF/126/21/A	20/09/88	0.75	16.0	14.5	22.8	8.3
163	L/22TF/149/11/A	17/10/88	1.06	16.0	12.0	22.0	10.0
165	L/22TF/156/25/A	20/09/88	0.78	15.0	15.0	23.0	8.0
168	L/22TF/181/14/A	28/08/88	1.12	16.0	10.0	22.3	12.3
169	L/22TF/56/16/A	23/08/88	0.87	17.0	11.0	21.6	10.6
170	L/22TF/85/12/A	23/08/88	1.30	17.5	9.0	21.7	12.7
171	L/22TF/85/2/A	30/08/88	1.91	18.4	21.2	31.2	10.0
172	L/22TF/92/15/A	29/08/88	1.25	15.0	10.0	21.7	11.7
173	L/22TF/118/15/B	22/08/88	1.17	15.0	9.0	22.3	13.3
174	L/22TF/118/14/A	23/08/88	0.58	15.6	15.5	25.7	10.2
180	L/23TR/56/24/A	11/08/88	.	18.7	21.3	.	.
184	L/2R/24/19/A	15/08/88	0.94	8.3	8.3	17.0	8.7
185	L/2R/25/17/A	15/08/88	1.42	9.9	9.4	17.0	7.6
186	L/2R/27/19/A	15/08/88	1.38	6.8	6.8	18.1	11.3
187	L/2R/29/16/A	15/08/88	0.49	5.5	5.5	20.9	15.4
188	L/2R/29/2/A	15/08/88	1.41	10.0	9.0	19.8	10.8
189	L/2R/31/10/A	11/10/88	0.71	13.0	13.0	18.3	5.3
190	L/2R/31/16/A	15/09/88	.	.	.	.	.
191	L/2R/31/5/A	15/08/88	0.30	13.8	11.3	23.7	12.4
192	L/2R/31/6/A	15/09/88	0.76	13.8	12.8	22.6	9.8
193	L/2R/32/2/A	15/08/88	0.78	11.3	8.3	23.7	15.4
194	L/2R/34/15/A	11/10/88	1.08	12.0	11.0	21.7	10.7
195	L/2R/37/14/A	15/08/88	1.13	9.4	9.4	19.2	9.8
196	L/2R/37/9/A	15/09/88	.	.	.	.	.
197	L/2R/41/12/A	15/09/88	1.67	11.0	10.0	26.0	16.0
198	L/2R/46/23/A	15/08/88	0.82	8.1	8.1	20.3	12.2
199	L/2R/58/23/A	15/09/88	1.30	10.7	8.7	22.6	13.9
200	L/2R/59/16/A	15/09/88	1.17	8.8	8.8	23.7	14.9
201	L/2R/61/20/A	15/08/88	1.23	8.8	8.8	17.0	8.2
202	L/2R/61/25/A	15/08/88	1.05	9.4	9.4	23.7	14.3
203	L/2R/61/8/A	15/08/88	0.83	8.8	8.8	14.7	5.9
204	L/2R/62/2/A	15/09/88	.	.	.	.	.
206	L/2R/63/4/A	15/09/88	1.25	10.3	9.3	23.7	14.4
207	L/2R/64/20/A	15/09/88	0.64	10.4	9.4	18.1	8.7
208	L/2R/64/4/A	15/09/88	1.07	11.3	11.3	24.9	13.6
209	L/2R/65/8/A	11/10/88	1.18	11.3	8.3	21.7	13.4
211	L/2R/66/8/A	15/09/88	1.38	9.3	8.3	27.1	18.8
212	L/2R/67/7/A	14/10/88	1.15	13.0	10.5	20.6	10.1
213	L/2R/68/14/A	15/09/88	1.15	11.2	9.2	24.9	15.7
215	L/3L/61/2/A	15/09/88	1.25	11.8	6.3	18.1	11.8
217	L/4R/22/23/A	16/08/88	1.12	11.0	12.0	18.1	6.1
218	L/4R/22/9/A	17/08/88	0.83	12.0	12.5	18.2	5.7
219	L/4R/22/9/B	15/08/88	.	.	.	.	.
220	L/4R/23/10/A	13/08/88	0.87	11.0	11.5	23.9	12.4
221	L/4R/23/12/A	13/08/88	1.14	11.0	10.0	18.5	8.5
222	L/4R/25/18/A	13/08/88	0.73	9.1	9.0	17.1	8.1
223	L/4R/35/8/A	16/08/88	0.81	12.0	11.8	19.4	7.6
224	L/4R/45/8/A	20/08/88	1.07	9.5	7.8	19.4	11.6
225	L/4R/46/2/A	15/08/88	1.32	11.0	10.0	18.5	8.5
226	L/4R/46/20/A	22/08/88	1.02	10.0	8.1	17.7	9.6
227	L/4R/56/1/A	13/08/88	0.83	9.2	8.2	16.2	8.0
228	L/4R/60/15/A	22/08/88	0.88	9.2	9.3	18.3	9.0
229	L/4R/8/21/A	15/08/88	1.20	13.1	11.1	17.1	6.0
230	L/4R/8/23/A	08/10/88	2.63	13.2	16.5	50.0	33.5
234	L/5R/54/20/A	09/10/88	2.33	11.5	14.0	41.6	27.6
251	L/6L/120/24/A	15/09/88	1.43	.	.	23.7	.
257	L/6L/91/24/A	15/09/88	2.82	9.0	.	32.6	23.6
260	L/7R/130/16/A	09/10/88	1.80	.	11.5	17.1	5.6
262	L/7R/132/10/A	16/10/88	1.13	14.0	10.0	17.7	7.7
267	L/8L/193/12/A	15/09/88	3.86	13.2	.	31.2	18.0
268	L/8L/213/2/A	15/09/88	1.15	8.7	5.7	21.5	15.8
269	L/8L/213/23/A	15/09/88	1.06	6.4	4.9	17.0	12.1
270	L/8L/229/25/A	15/09/88	.	.	.	.	.
271	L/8L/230/21/A	15/09/88	0.95	8.8	8.8	26.0	17.2
272	L/8L/230/8/A	15/09/88	1.16	6.1	4.8	18.1	13.3
273	L/8L/246/15/A	15/09/88	0.61	7.1	5.1	15.8	10.7
274	L/8L/246/21/A	15/09/88	1.86	6.0	4.5	24.9	20.4
275	L/8L/247/15/A	15/09/88	1.32	6.0	4.0	17.0	13.7

NMR	TUBID	DATE	DISCHARGE	STATICNSL	STATICCLP	DYNAMIC	DRAWDOWN
276	L/8L/249/2/A	15/09/88	0.92	8.7	8.7	20.3	11.6
277	L/8L/273/15/A	15/09/88	1.29	8.3	8.3	22.6	14.3
278	L/8L/277/21/A	15/09/88	0.53	13.3	8.8	21.5	12.7
279	L/9L/227/14/A	14/10/88	1.65	14.5	17.5	35.7	18.2
280	L/9L/251/8/A	15/08/88	1.37	11.3	9.3	23.7	14.4
281	L/9L/282/2/A	15/08/88	.	.	.	.	.
282	L/9L/282/9/A	15/08/88	0.97	8.8	6.8	26.0	19.2
283	L/9L/311/11/A	15/08/88	1.39	8.7	5.7	27.1	21.4
284	L/9L/332/1/A	15/08/88	1.13	10.1	7.6	19.2	11.6
285	L/9L/337/24/A	15/08/88	1.34	8.6	6.6	28.3	21.7
286	L/9L/84/14/A	15/08/88	0.86	9.4	9.4	28.8	19.4
287	L/J1L/229/16/A	11/09/88	1.34	11.7	11.7	24.0	12.3
288	L/J1L/305/11/A	09/09/88	1.34	12.0	11.0	25.1	14.1
289	L/J1L/305/13/A	15/09/88	0.99	8.5	8.5	27.1	18.6
290	L/J1L/305/23/A	08/09/88	0.90	11.5	11.0	25.7	14.7
291	L/J1L/305/25/A	15/09/88	.	.	.	.	.
292	L/J1L/306/21/A	08/09/88	0.96	10.7	9.5	16.6	7.1
293	L/J1L/309/1/A	08/09/88	1.35	11.2	10.0	27.1	17.1
294	L/J1L/310/6/A	05/09/88	0.91	10.7	11.7	21.7	10.0
295	L/J2L/22/11/A	11/09/88	1.36	8.5	7.0	25.1	18.1
296	L/J2L/23/11/A	12/10/88	1.25	11.0	10.5	21.2	10.7
297	L/J2L/23/16/A	12/09/88	0.79	6.2	4.7	20.6	15.9
298	L/J2L/24/24/A	10/10/88	0.75	8.0	7.0	14.5	7.5
299	L/J2L/25/17/A	12/10/88	2.12	9.5	12.5	30.0	17.5
300	L/J2L/26/7/A	12/09/88	1.62	6.1	4.6	18.3	13.7
302	L/J2L/37/24/A	07/09/88	1.27	7.0	6.0	22.9	16.9
303	L/J2L/37/7/A	07/09/88	1.40	7.5	7.5	22.9	15.4
304	L/J2L/38/13/A	07/09/88	1.59	6.0	5.5	19.4	13.9
305	L/J2L/43/1/A	14/09/88	1.49	6.7	6.7	22.9	16.2
306	L/J2L/55/20/A	11/09/88	1.10	7.0	6.5	18.3	11.8
307	L/J2L/73/2/A	11/09/88	1.34	8.0	8.0	18.3	10.3
351	L/J2L/36/22/A	11/09/88	1.32	6.6	3.0	21.1	18.1
353	L/J2L/44/14/A	07/09/88	1.27	7.5	6.5	22.9	16.4
312	L/J3L/15/10/A	05/09/88	0.88	11.2	11.2	18.9	7.7
313	L/J3L/15/2/A	10/10/88	1.29	9.0	9.7	22.9	13.2
315	L/J3L/16/3/A	05/09/88	1.50	12.0	5.0	18.3	13.5
316	L/J3L/24/3/A	14/09/88	1.57	8.0	7.2	22.9	15.7
317	L/J3L/26/7/A	12/09/88	0.72	7.2	7.2	14.9	7.7
318	L/J3L/39/1/A	05/09/88	0.88	8.2	8.2	17.7	9.5
319	L/J3L/40/10/A	14/09/88	1.16	6.3	6.1	21.1	15.0
346	L/J5TF/9/1/A	15/09/88	.	.	.	.	.
354	L/KD216/11/15/A	15/09/88	1.29	10.3	8.3	22.6	14.3
356	L/KD216/22/25/A	14/10/88	1.21	11.0	12.0	20.5	11.4
357	L/KD216/22/7/A	15/08/88	0.89	10.8	9.7	17.0	7.3
358	L/KD216/23/15/A	15/09/88	1.41	10.7	10.7	27.1	16.4
360	L/KD216/7/22/A	15/08/88	1.05	9.7	8.7	19.2	10.5
362	L/KD216/8/23/A	15/08/88	1.33	9.4	9.4	20.3	10.9
363	L/KD216/22/5/A	15/09/88	.	.	.	.	.

Appendix C

Lagar Distributary Tubewell Water Quality

THIS APPENDIX CONTAINS the complete set of water quality data resulting from the analysis of groundwater samples taken from public tubewells and a large sample of private tubewells in Lagar Distributary command. The groundwater samples were drawn by the Irrigation Research Institute late in *Kharif* season, 1988, at the same time as tubewell data given in Appendix B were collected. The water quality analysis of these samples was done by the Soil and Water Laboratory, Directorate for Land Reclamation (DLR) of the Punjab Irrigation and Power Department.

As in the primary census listing of tubewells in Lagar Distributary command (Appendix A), "NMR" and its "TUBID" are unique identifiers of the specific tubewell from which the sample was drawn. The sample code number used by the Soil and Water Laboratory in their analysis is identified under "LABNO."

The headings for the chemical and water quality parameters measured are largely self-explanatory. Units of measurement for these headings are as follows:

* Ca, Mg, Na, CO_3, HCO_3, Cl, SO_4, and total cations/anions (CATIO) are measured in milliequivalents per liter;
* Dissolved solids ("DS") are in parts per million;
* EC (electrical conductivity) is in micromhos per cm at 25^{o}C;
* RSC (residual calcium carbonate) is in milliequivalents per liter;
* SAR (sodium absorption ratio) is dimensionless.

Trace measures of chemical characteristics are entered as "T" and any missing values are denoted by a period (".").

Based upon the results of the sample analysis, the Soil and Water Laboratory determined whether the water of a tubewell was "fit" ("F") or "unfit" ("U") for irrigation purposes. This classification is indicated under the heading "FIT." The standards used to determine the irrigation suitability of tubewell water are those adopted by the Punjab Irrigation Department and used by DLR in their work. They are specified in the main text.

Lagar Distributary Tubewell Water Quality Data

NMR	TUBID	LABNO	CA	MG	NA	CO3	HCO3	CL	SO4	CATIO	DS	EC	PH	RSC	SAR	FIT
1	L/10R/.../../.	143	1.5	2.6	7.3	0.0	5.6	1.3	4.5	11.4	704	1100	7.6	1.5	5.1	F
2	L/10R/.../../.	144	1.5	2.8	8.2	0.0	5.7	1.7	5.1	12.5	780	1220	7.4	1.4	5.6	F
3	L/10R/185/18/A	191	1.7	3.9	7.3	0.0	7.4	1.2	4.3	12.9	800	1250	7.5	1.8	4.3	F
4	L/10R/191/22/A	198	1.0	3.2	12.6	0.0	8.1	1.8	6.9	16.8	1017	1590	7.6	3.9	8.7	U
5	L/10R/215/1/A	201	1.3	4.1	12.8	0.0	9.2	1.6	7.4	18.2	1120	1750	7.7	3.8	7.8	U
6	L/10R/215/7/A	199	1.4	3.6	6.2	0.0	6.7	1.0	3.5	11.2	697	1090	7.6	1.7	3.9	F
7	L/10R/218/17/A	195	1.8	2.8	6.8	0.0	6.4	1.1	3.9	11.4	704	1100	7.4	1.8	4.5	F
8	L/10R/220/23/A	202	1.1	2.9	10.6	0.0	7.3	1.7	5.6	14.6	902	1410	7.8	3.3	7.5	U
9	L/10R/222/16/A	193	1.1	3.7	7.8	0.0	7.0	1.1	4.5	12.6	781	1230	7.7	2.2	4.4	F
11	L/10R/225/14/A	197	1.6	3.1	8.1	0.0	7.4	1.2	4.2	12.8	800	1250	7.5	2.7	5.3	U
12	L/10R/253/8/A	196	1.7	4.4	4.7	0.0	6.5	1.0	3.3	10.8	672	1050	7.5	0.4	2.7	F
13	L/10R/254/14/A	194	1.1	3.5	6.3	0.0	7.2	1.0	2.7	10.9	678	1060	8.0	2.6	4.1	U
14	L/10R/255/14/A	203	1.4	4.2	6.3	0.0	7.2	1.0	3.7	11.9	736	1150	7.7	1.6	3.7	F
15	L/10R/255/16/A	190	1.7	3.9	3.2	0.0	5.3	0.9	2.6	8.8	550	860	7.9	0.0	1.9	F
16	L/10R/256/5/A	192	1.4	1.6	12.6	0.0	7.9	1.6	6.1	15.6	960	1500	7.9	4.9	10.2	U
17	L/10R/288/11/A	204	1.6	2.9	9.0	0.0	6.9	1.6	5.0	13.5	832	1300	7.8	2.4	6.0	F
18	L/10R/294/1/A	200	1.5	4.1	12.3	0.0	8.7	2.3	6.9	17.9	1088	1700	7.4	3.1	7.3	U
19	L/10R/297/15/A	189	1.1	3.1	8.8	0.0	6.6	1.8	4.6	13.0	812	1270	7.9	2.4	6.0	F
372	L/11L/285/11/A	312	0.6	1.6	13.6	1.2	7.4	2.7	4.5	15.8	960	1500	8.9	6.4	12.9	U
20	L/11L/285/1/A	205	1.2	3.7	10.6	0.0	8.2	1.7	5.6	15.5	941	1470	7.4	3.3	6.8	U
21	L/11L/286/8/A	131	1.7	2.5	7.4	0.0	5.5	1.6	4.5	11.6	723	1130	7.3	1.3	5.1	F
22	L/11L/298/22/A	206	1.5	3.6	6.1	0.0	5.7	1.6	3.9	11.2	704	1100	8.2	0.6	3.8	F
23	L/11L/314/20/A	210	1.1	3.5	12.6	0.0	7.8	2.1	7.3	17.2	1056	1650	7.4	3.2	8.3	U
24	L/11L/315/16/A	209	1.4	3.1	11.2	0.0	6.8	2.2	6.7	15.7	960	1500	7.4	2.3	7.4	F
25	L/11L/317/16/A	208	1.6	4.5	6.4	0.0	6.7	1.3	4.5	12.5	774	1210	7.3	0.6	3.6	F
27	L/11L/317/9/A	213	0.9	2.1	9.8	0.0	7.0	1.5	4.3	12.8	800	1250	8.0	4.0	8.0	U
28	L/11L/324/17/A	212	1.8	3.1	12.2	0.0	8.1	2.1	6.9	17.1	1037	1620	7.6	3.2	7.8	U
29	L/11L/324/5/A	211	1.7	2.7	12.6	0.0	7.8	2.2	7.0	17.0	1037	1620	7.4	3.4	8.5	U
37	L/12L/49/23/A	133	1.3	2.1	10.9	0.0	6.7	1.9	5.7	14.3	889	1390	7.6	3.3	8.3	U
47	L/13R/45/25/A	132	1.2	2.3	8.6	0.0	5.9	1.6	4.6	12.1	755	1180	8.1	2.4	6.5	F
55	L/14R/106/23/A	134	1.2	1.4	10.0	0.0	5.8	1.8	5.0	12.6	774	1210	7.8	3.2	8.7	U
70	L/15R/39/4/A	136	1.0	1.8	14.2	0.0	7.0	2.9	7.1	17.0	1024	1600	7.8	4.2	12.0	U
74	L/16R/89/13/A	275	1.4	2.1	7.1	T	5.4	1.4	3.8	10.6	659	1030	8.5	1.9	5.3	F
75	L/16R/89/3/A	135	1.0	2.5	11.2	0.0	6.7	2.6	5.4	14.7	915	1430	7.3	3.2	8.4	U
76	L/16R/92/6/A	326	1.0	1.8	19.4	0.0	9.7	4.4	8.1	22.2	1344	2100	7.9	6.9	16.4	U
77	L/16R/97/21/A	274	2.5	3.6	12.0	0.0	9.0	3.1	6.0	18.1	1088	1700	7.9	2.9	6.8	U
90	L/17L/69/21/A	137	1.0	2.5	11.6	0.0	6.6	2.9	5.6	15.1	928	1450	7.8	3.1	8.7	U
95	L/17L/98/25/A	138	1.2	2.6	14.0	0.0	6.0	5.5	6.3	17.8	1100	1720	7.8	2.2	10.1	U
97	L/18L/145/25/A	140	1.1	1.3	14.7	0.0	4.9	6.7	5.5	17.1	1049	1640	8.2	2.5	13.4	U
100	L/18L/16/2/A	139	1.1	1.9	14.3	0.0	5.5	5.8	6.0	17.3	1062	1660	7.8	2.5	11.6	U
110	L/19R/36/11/A	276	1.5	2.0	12.2	0.0	6.9	3.3	5.5	15.7	960	1500	8.1	3.4	9.2	U
111	L/19R/36/20/A	216	1.2	1.4	13.2	0.0	7.0	3.1	5.7	15.8	960	1500	7.4	4.4	11.5	U
112	L/19R/41/18/A	141	1.6	1.8	15.0	0.0	6.4	5.6	6.4	18.4	1120	1750	7.3	3.0	11.5	U
113	L/19R/45/3/A	219	1.6	1.6	14.9	0.0	5.5	6.4	6.2	18.1	1107	1730	7.4	2.3	11.7	U
114	L/19R/45/5/A	215	1.4	1.7	16.0	0.0	7.3	4.8	7.0	19.1	1158	1810	7.4	4.2	12.8	U
115	L/19R/46/5/A	214	1.2	1.3	15.0	0.0	5.8	6.2	5.5	17.5	1075	1680	7.7	3.3	13.4	U
117	L/19R/60/20/A	217	1.0	1.5	15.3	0.0	7.5	3.9	6.4	17.8	1088	1700	7.8	5.0	13.7	U
118	L/19R/69/1/A	277	1.1	1.6	16.1	T	7.8	4.1	6.9	18.8	1145	1790	8.4	5.1	13.8	U
119	L/19R/69/20/A	218	1.4	2.3	15.3	0.0	6.9	5.3	6.8	19.0	1152	1800	7.4	3.2	11.2	U
120	L/1R/100/5/A	147	1.6	3.7	2.5	0.0	4.7	0.7	2.4	7.8	486	760	7.6	0.0	1.5	F
121	L/1R/17/18/A	259	1.3	2.3	1.2	T	3.1	0.5	1.2	4.8	307	480	8.4	0.0	0.9	F
122	L/1R/19/17/A	145	1.7	5.3	0.8	0.0	5.2	0.6	2.0	7.8	486	760	7.9	0.0	0.4	F
125	L/1R/73/18/A	148	1.4	2.6	5.3	0.0	4.3	1.0	4.0	9.3	582	910	8.0	0.3	3.7	F
126	L/1R/75/23/A	146	1.4	3.7	2.9	0.0	4.5	0.9	2.6	8.0	499	780	7.7	0.0	1.8	F
128	L/20R/112/11/A	222	1.4	1.9	14.3	0.0	6.6	5.1	5.9	17.6	1081	1690	7.6	3.3	11.1	U
129	L/20R/113/19/A	223	1.7	2.3	14.2	0.0	6.9	4.3	7.0	18.2	1113	1740	7.6	2.9	10.0	U
130	L/20R/116/11/A	224	1.8	3.1	16.6	0.0	7.2	5.7	8.6	21.5	1299	2030	7.4	2.3	10.0	U
131	L/20R/117/2/A	327	1.7	2.4	12.2	0.0	6.6	4.0	5.7	16.3	998	1560	7.5	2.5	8.5	F
132	L/20R/119/1/A	226	1.7	2.6	16.3	0.0	7.1	5.4	8.1	20.6	1254	1960	7.8	2.8	11.1	U
134	L/20R/63/2/A	220	1.4	1.4	15.6	0.0	4.9	7.0	6.5	18.4	1126	1760	7.6	2.1	13.2	U
135	L/20R/66/7/A	221	1.5	1.4	15.6	0.0	6.1	6.0	6.4	18.5	1126	1760	8.0	3.2	12.9	U
136	L/20R/79/6/A	328	1.3	1.6	16.6	0.0	6.5	7.0	6.0	19.5	1184	1850	8.0	3.6	13.8	U
137	L/20R/79/6/B	142	1.5	2.7	13.6	0.0	7.2	3.5	7.1	17.8	1081	1690	7.9	3.0	9.4	U
138	L/20R/82/12/A	278	0.9	1.4	16.8	T	7.2	4.5	7.4	19.1	1165	1820	8.6	4.9	15.6	U
139	L/20R/86/10/A	225	1.4	2.0	13.3	0.0	6.8	4.6	5.3	16.7	1024	1600	8.0	3.4	10.2	U
140	L/21TL/48/19/A	233	1.6	1.8	12.0	0.0	5.6	4.1	5.7	15.4	941	1470	8.1	2.2	9.2	F
141	L/21TL/48/20/A	238	1.2	2.0	13.2	0.0	4.3	4.5	7.6	16.4	1011	1580	8.3	1.1	10.4	U
142	L/21TL/49/23/A	231	2.3	2.3	13.2	0.0	6.1	4.6	7.1	17.8	1088	1700	7.7	1.5	8.7	U
143	L/21TL/50/13/A	236	1.9	2.9	14.2	0.0	5.9	5.4	7.7	19.0	1152	1800	7.5	1.1	9.1	U
144	L/21TL/51/8/A	280	2.0	3.1	12.3	0.0	6.2	3.9	7.3	17.4	1062	1660	8.1	1.1	7.7	U
145	L/21TL/52/19/A	228	1.7	1.9	11.6	0.0	5.8	3.6	5.8	15.2	941	1470	7.9	2.2	8.6	F
146	L/21TL/53/9/A	237	1.5	3.9	12.6	0.0	6.5	4.1	7.4	18.0	1120	1750	8.1	1.1	7.6	U
147	L/21TL/55/4/A	227	1.5	2.5	14.3	0.0	7.0	4.0	7.3	18.3	1120	1750	7.9	3.0	10.1	U
150	L/21TL/63/16/A	234	1.6	1.9	13.3	0.0	6.1	5.0	5.7	16.8	1037	1620	7.8	2.6	10.0	U
151	L/21TL/64/20/A	229	1.6	2.8	13.3	0.0	6.1	4.5	7.1	17.7	1075	1680	7.7	1.7	8.9	U
152	L/21TL/64/3/A	281	1.7	2.6	8.8	0.0	5.5	3.3	4.3	13.1	813	1270	8.3	1.2	6.0	F
153	L/21TL/66/24/A	232	1.6	1.6	11.0	0.0	4.9	4.8	4.5	14.2	877	1370	8.0	1.7	8.7	F
154	L/21TL/79/1/A	279	1.8	1.7	10.0	0.0	4.8	3.9	4.8	13.5	832	1300	8.0	1.3	7.5	F
155	L/21TL/80/19/A	235	0.8	1.2	14.9	0.0	5.0	5.2	6.7	16.9	1037	1620	8.3	3.0	14.9	U
156	L/21TL/81/2/A	230	1.2	2.1	15.2	0.0	5.9	5.1	7.5	18.5	1120	1750	8.2	2.6	11.8	U
158	L/22TF/116/19/A	245	1.6	3.6	19.0	0.0	7.8	6.8	9.6	24.2	1536	2400	7.7	3.6	11.8	U

NMR	TUBID	LABNO	CA	MG	NA	CO3	HCO3	CL	SO4	CATIO	DS	EC	PH	RSC	SAR	FIT
159	L/22TF/118/15/A	285	1.9	1.0	12.8	0.0	5.9	4.3	5.5	15.7	960	1500	8.3	3.0	10.6	U
160	L/22TF/124/9/A	242	1.3	2.2	14.0	0.0	7.3	4.0	6.2	17.5	1088	1700	7.4	3.8	10.6	U
161	L/22TF/125/12/A	244	1.3	1.0	14.0	0.2	4.9	3.5	7.7	16.3	1024	1600	8.6	2.8	13.0	U
162	L/22TF/126/21/A	282	1.4	3.1	18.9	0.0	6.8	7.4	9.2	23.4	1427	2230	8.1	2.3	12.6	U
163	L/22TF/149/11/A	329	1.6	2.3	18.4	0.0	7.2	6.7	8.4	22.3	1344	2100	7.6	3.3	13.2	U
164	L/22TF/152/12/A	283	1.2	1.3	21.0	0.6	6.4	7.3	9.2	23.5	1427	2230	8.5	4.5	18.8	U
165	L/22TF/156/25/A	284	3.2	2.4	24.3	0.0	6.7	11.7	11.5	29.9	1792	2800	8.0	1.1	14.5	U
168	L/22TF/181/14/A	243	2.4	2.8	25.5	0.0	7.3	13.1	10.3	30.7	1920	3000	7.9	2.1	15.8	U
169	L/22TF/56/16/A	246	1.4	1.8	13.6	0.0	7.6	3.3	5.9	16.8	1024	1600	7.5	4.4	10.7	U
170	L/22TF/85/12/A	239	1.4	2.7	13.6	0.0	6.4	4.2	7.1	17.7	1101	1710	8.0	2.3	9.5	U
172	L/22TF/92/15/A	240	1.3	4.8	14.3	0.0	7.4	5.1	7.9	20.4	1248	1950	7.5	1.3	8.2	U
173	L/22TF/92/25/A	241	3.2	2.8	14.0	0.0	6.0	5.3	8.7	20.0	1248	1950	7.9	0.0	8.1	U
184	L/2R/24/19/A	163	1.5	2.5	10.3	0.0	6.3	1.9	6.1	14.3	896	1400	7.9	2.3	7.3	F
185	L/2R/25/17/A	161	1.0	2.4	8.6	0.0	6.2	1.5	4.3	12.0	742	1160	8.0	2.8	6.6	U
186	L/2R/27/19/A	160	2.0	3.6	8.4	0.0	6.1	1.9	6.0	14.0	864	1350	7.9	0.5	5.0	F
187	L/2R/29/16/A	158	1.7	2.3	7.4	0.0	6.2	1.2	4.0	11.4	704	1100	7.6	2.2	5.2	F
188	L/2R/29/2/A	162	2.2	2.8	8.3	0.0	7.5	1.7	4.1	13.3	819	1280	7.3	2.5	5.2	F
189	L/2R/31/10/A	322	1.3	2.5	4.6	0.0	4.9	0.9	2.6	8.4	525	820	7.8	1.1	3.3	F
191	L/2R/31/5/A	159	2.3	2.9	6.4	0.0	6.2	1.4	4.0	11.6	716	1120	7.5	1.0	3.9	F
192	L/2R/31/6/A	270	1.5	2.3	7.1	0.0	6.1	1.3	3.5	10.9	672	1050	8.3	0.2	5.1	F
193	L/2R/32/2/A	164	1.0	1.9	7.4	0.0	5.6	1.2	3.5	10.3	640	1000	8.0	2.7	6.1	U
194	L/2R/34/15/A	157	1.7	2.2	6.3	0.0	5.5	1.1	3.6	10.2	627	980	7.6	1.6	4.5	F
194	L/2R/34/15/A	321	1.4	2.4	6.4	0.0	6.0	1.1	3.1	10.2	627	980	8.0	2.2	4.6	F
195	L/2R/37/14/A	156	1.5	3.0	3.8	0.0	4.8	0.9	2.6	8.3	512	800	7.6	0.3	2.5	F
197	L/2R/41/12/A	262	1.4	2.8	2.8	0.0	4.7	0.5	1.8	7.0	448	700	8.3	0.5	1.9	F
198	L/2R/46/23/A	155	1.8	2.7	8.0	0.0	5.1	1.6	5.8	12.5	768	1200	7.7	0.6	5.3	F
199	L/2R/58/23/A	269	1.6	3.1	4.6	0.0	4.8	1.2	3.3	9.3	576	900	8.3	0.1	3.0	F
200	L/2R/59/16/A	268	1.3	2.6	6.5	T	6.6	1.3	5.0	12.9	800	1250	8.5	2.7	4.6	U
201	L/2R/61/20/A	152	1.8	3.0	5.6	0.0	5.7	1.3	3.4	10.4	646	1010	7.7	0.9	3.6	F
202	L/2R/61/25/A	154	1.5	3.0	5.8	0.0	5.5	1.2	3.6	10.3	640	1000	7.8	1.0	3.8	F
203	L/2R/61/8/A	153	1.8	3.4	6.1	0.0	6.1	1.3	3.9	11.3	704	1100	7.4	0.9	3.8	F
206	L/2R/63/4/A	266	1.1	2.5	6.1	T	5.7	1.1	2.9	9.7	608	950	8.5	2.1	4.5	F
207	L/2R/64/20/A	263	1.1	2.5	6.6	T	5.5	1.1	3.6	10.2	627	980	8.5	1.9	4.9	F
208	L/2R/64/4/A	265	1.2	2.1	5.8	T	5.5	0.9	2.7	9.1	563	880	8.5	2.2	4.5	F
209	L/2R/65/8/A	320	1.7	2.9	3.7	0.0	4.9	1.0	2.4	8.3	518	810	7.7	0.3	8.4	F
211	L/2R/66/8/A	264	1.5	2.4	3.8	0.0	4.7	0.7	2.3	7.7	480	750	8.2	0.8	2.7	F
212	L/2R/67/7/A	325	1.2	1.6	6.6	0.0	5.2	1.0	3.2	9.4	576	900	7.8	2.4	5.6	F
213	L/2R/68/14/A	267	1.3	1.9	2.9	T	3.9	0.5	1.7	6.1	384	600	8.4	0.7	2.3	F
215	L/3L/61/2/A	254	1.6	3.3	7.5	0.0	6.9	1.3	4.2	12.4	768	1200	8.2	2.0	4.8	F
217	L/4R/22/23/A	168	1.1	2.4	10.6	0.0	6.4	2.0	5.7	14.1	870	1360	7.5	2.9	8.0	U
218	L/4R/22/9/A	175	1.0	2.6	14.0	0.0	8.7	1.9	7.0	17.6	1075	1680	7.6	5.1	9.2	U
220	L/4R/23/10/A	166	1.1	2.5	10.9	0.0	6.9	1.6	6.0	14.5	896	1400	7.9	3.3	8.1	U
221	L/4R/23/12/A	170	1.0	3.0	6.3	0.0	5.3	1.0	4.0	10.3	640	1000	7.2	1.3	4.4	F
222	L/4R/25/18/A	167	1.2	2.8	6.6	0.0	5.1	1.2	4.3	10.6	659	1030	7.3	1.1	4.6	F
223	L/4R/35/8/A	169	1.1	3.8	12.0	0.0	6.3	2.0	8.6	16.9	1043	1630	8.1	1.4	7.6	U
224	L/4R/45/8/A	172	0.7	3.8	13.2	0.0	7.9	2.2	7.6	17.7	1081	1690	7.2	3.4	8.8	U
225	L/4R/46/2/A	171	1.0	2.4	14.6	0.0	8.3	2.4	7.3	18.0	1100	1720	7.6	4.9	11.2	U
226	L/4R/46/20/A	173	1.0	3.6	11.2	0.0	7.8	1.7	6.3	15.8	973	1520	7.2	3.2	7.4	U
227	L/4R/56/1/A	176	0.7	5.0	9.2	0.0	8.4	1.3	5.2	14.9	915	1430	7.4	2.7	5.4	U
228	L/4R/60/15/A	174	1.0	4.9	10.2	0.0	7.3	2.0	6.8	16.1	992	1550	8.0	1.4	6.5	F
229	L/4R/8/21/A	165	1.0	2.2	16.8	0.0	9.2	2.3	8.5	20.0	1216	1900	7.8	6.0	13.3	U
230	L/4R/8/23/A	314	1.6	1.6	7.1	0.0	5.4	1.2	3.7	10.3	640	1000	8.0	2.2	5.6	F
234	L/5R/54/20/A	313	2.1	3.0	6.8	0.0	6.2	1.6	4.1	11.9	742	1160	7.5	1.1	4.2	F
251	L/6L/120/24/A	256	1.5	2.3	14.2	T	8.3	2.7	7.0	18.0	1088	1700	8.4	4.5	10.3	U
257	L/6L/91/24/A	255	1.1	2.2	6.4	T	5.2	1.0	3.5	9.7	608	950	8.4	1.9	5.0	F
260	L/7R/130/16/A	316	1.1	1.4	7.8	0.0	4.9	1.6	3.8	10.3	640	1000	7.6	2.4	7.0	F
262	L/7R/132/10/A	315	1.5	2.7	7.5	0.0	6.5	1.4	3.8	11.7	723	1130	7.6	2.3	5.2	F
267	L/8L/193/12/A	257	1.4	2.1	6.3	T	5.2	1.1	3.5	9.8	614	960	8.5	1.7	4.7	F
268	L/8L/213/2/A	271	2.5	3.0	6.6	0.0	7.3	1.1	3.7	12.1	749	1170	8.0	1.8	4.0	F
269	L/8L/213/23/A	177	0.7	5.6	6.0	0.0	6.9	1.1	4.3	12.3	755	1180	7.3	0.6	3.3	F
271	L/8L/230/21/A	178	0.9	4.2	6.3	0.0	6.5	1.1	3.8	11.4	704	1100	7.3	1.4	3.9	F
272	L/8L/230/8/A	180	1.8	1.4	7.0	0.0	5.5	1.1	3.6	10.2	640	1000	7.3	2.3	5.5	F
273	L/8L/246/15/A	182	1.2	3.0	18.0	0.0	7.7	3.0	11.5	22.2	1344	2100	7.8	3.5	12.4	U
274	L/8L/246/21/A	183	1.2	1.9	10.6	0.0	6.9	1.8	5.0	13.7	844	1320	7.7	3.8	8.5	U
275	L/8L/247/15/A	181	1.7	2.7	13.6	0.0	7.2	2.5	8.3	18.0	1088	1700	7.6	2.8	9.1	U
276	L/8L/249/2/A	179	1.8	4.6	6.0	0.0	7.4	1.1	3.9	12.4	768	1200	7.4	1.0	3.3	F
277	L/8L/273/15/A	303	0.9	0.5	7.5	T	4.4	1.1	3.4	8.9	563	880	8.5	3.0	8.9	U
278	L/8L/277/21/A	272	1.0	0.8	10.0	T	5.6	2.0	5.2	12.8	800	1250	8.5	3.8	10.5	U
279	L/9L/227/14/A	317	1.2	2.2	6.4	0.0	5.0	1.5	3.3	9.8	608	950	7.6	1.6	4.9	F
280	L/9L/251/8/A	207	0.9	2.0	7.5	0.0	5.7	1.1	3.6	10.4	646	1610	7.6	2.8	6.2	U
282	L/9L/282/9/A	184	1.8	2.1	8.5	0.0	6.3	1.7	4.4	12.4	768	1200	7.3	2.4	6.0	F
283	L/9L/311/11/A	185	1.3	1.7	12.2	0.0	6.6	2.2	6.4	15.2	934	1460	7.6	3.6	9.9	U
284	L/9L/332/1/A	186	1.1	1.1	12.8	0.0	6.2	2.3	6.5	15.0	928	1450	7.5	4.0	12.2	U
285	L/9L/337/24/A	187	1.2	2.1	9.7	0.0	5.9	1.9	5.2	13.0	819	1280	7.8	2.6	7.5	U
286	L/9L/84/14/A	188	0.7	1.3	14.0	0.0	8.4	1.7	5.9	16.0	960	1500	7.6	6.4	14.0	U
287	L/J1L/229/16/A	291	1.4	0.7	9.2	T	4.7	2.4	4.2	11.3	704	1100	8.4	2.6	9.0	U
288	L/J1L/305/11/A	286	2.6	1.2	9.0	0.0	6.2	1.8	4.8	12.8	793	1240	8.3	2.4	6.5	F
289	L/J1L/305/13/A	247	2.6	1.0	10.3	0.0	6.9	1.8	5.2	13.9	890	1390	7.8	3.3	7.7	U
290	L/J1L/305/23/A	287	2.2	1.1	10.9	T	6.4	2.4	5.4	14.2	877	1370	8.5	3.1	8.5	U
292	L/J1L/306/21/A	290	1.2	0.9	11.0	0.6	5.5	2.2	4.8	13.1	813	1270	8.6	4.0	10.7	U
293	L/J1L/309/1/A	289	1.8	0.9	9.7	T	5.2	2.4	4.8	12.4	768	1200	8.5	2.5	8.3	F
294	L/J1L/310/6/A	288	2.0	0.6	12.2	T	6.2	2.6	6.0	14.8	909	1420	8.6	3.6	10.7	U
295	L/J2L/22/11/A	293	1.0	0.8	5.8	0.0	3.9	1.1	2.6	7.6	486	760	8.3	2.1	6.1	F
296	L/J2L/23/11/A	318	1.1	0.7	8.3	0.0	5.6	1.2	3.3	10.1	627	980	7.6	3.8	8.7	U
297	L/J2L/23/16/A	294	1.2	1.2	8.0	T	5.2	1.3	3.9	10.4	653	1020	8.5	2.8	7.3	U
298	L/J2L/24/24/A	330	2.0	2.2	9.7	0.0	6.2	2.4	5.3	13.9	864	1350	7.4	2.2	6.7	F

NMR	TUBID	LABNO	CA	MG	NA	CO3	HCO3	CL	SO4	CATIO	DS	EC	PH	RSC	SAR	FIT
299	L/J2L/25/17/A	319	1.5	1.8	9.7	0.0	6.2	1.9	4.9	13.0	806	1260	7.9	2.9	7.5	U
300	L/J2L/26/7/A	295	1.0	1.3	8.0	T	5.8	1.1	3.4	10.3	640	1000	8.6	3.5	7.4	U
302	L/J2L/37/24/A	300	1.4	0.6	8.0	T	4.4	1.6	4.0	10.0	627	980	8.5	2.4	8.0	F
303	L/J2L/37/7/A	299	1.6	0.7	6.1	T	4.2	1.2	3.0	8.4	531	830	8.5	1.9	5.7	F
304	L/J2L/38/13/A	296	1.4	1.0	8.3	T	6.4	1.1	3.2	10.7	665	1040	8.5	4.0	7.5	U
305	L/J2L/43/1/A	297	1.9	1.0	11.3	0.0	6.7	2.4	5.1	14.2	877	1370	8.3	3.8	9.4	U
306	L/J2L/55/20/A	298	1.6	1.0	11.0	T	6.7	2.1	4.8	13.6	845	1320	8.5	4.1	9.6	U
351	L/J2L/36/22/A	301	1.6	1.3	7.7	0.0	5.3	1.5	3.8	10.6	659	1030	8.3	2.4	6.4	F
353	L/J2L/44/14/A	302	1.8	0.7	11.3	0.6	6.6	2.1	4.5	13.8	857	1340	8.6	4.7	10.1	U
307	L/J2L/73/2/A	292	1.1	1.3	11.2	0.4	5.6	2.7	4.9	13.6	832	1300	8.6	3.6	10.2	U
312	L/J3L/15/10/A	306	1.4	1.1	9.8	0.4	5.0	2.0	4.9	12.3	768	1200	8.6	2.9	8.7	U
313	L/J3L/15/2/A	305	1.0	0.8	10.0	0.6	4.7	2.0	4.5	11.8	736	1150	8.7	3.5	10.5	U
315	L/J3L/16/3/A	304	1.3	1.2	10.3	T	5.2	2.3	5.3	12.8	800	1250	8.5	2.7	9.2	U
316	L/J3L/24/3/A	307	1.6	2.2	10.9	T	6.5	2.4	5.8	14.7	909	1420	8.4	2.7	7.9	U
317	L/J3L/26/7/A	308	1.1	1.6	12.6	T	6.4	2.6	6.3	15.3	947	1480	8.5	3.7	10.8	U
318	L/J3L/39/1/A	309	1.3	1.7	13.3	T	7.3	2.5	6.5	16.3	1005	1570	8.5	4.3	10.8	U
319	L/J3L/40/10/A	310	1.5	2.1	11.6	T	6.6	2.5	6.1	15.2	934	1460	8.4	3.0	8.6	U
320	L/J3L/42/13/A	311	1.1	2.4	13.0	T	7.5	2.0	7.0	16.5	1005	1570	8.4	4.0	9.8	U
354	L/KD216/11/15/A	273	0.9	1.0	8.8	0.6	5.7	1.2	3.2	10.7	672	1050	8.7	4.4	9.0	U
355	L/KD216/12/20/A	323	1.4	1.9	7.0	0.0	5.9	1.1	3.3	10.3	633	990	7.6	2.6	5.4	U
356	L/KD216/22/25/A	324	1.0	2.2	8.8	0.0	7.0	1.3	3.7	12.0	742	1160	8.0	3.8	6.9	U
357	L/KD216/22/7/A	149	0.8	1.1	8.3	0.0	5.7	1.1	3.4	10.2	640	1000	8.0	3.8	8.5	U
358	L/KD216/23/15/A	261	1.1	2.1	7.3	0.0	5.7	1.2	3.6	10.5	653	1020	8.3	2.5	5.7	F
360	L/KD216/7/22/A	151	1.4	2.5	7.0	0.0	5.8	1.3	3.8	10.9	678	1060	7.6	1.9	5.0	F
362	L/KD216/8/23/A	150	2.2	3.1	5.0	0.0	5.8	1.1	3.4	10.3	640	1000	8.0	0.5	3.0	F