THE ISLAMIC REPUBLIC OF PAKISTAN
LAHORE DEVELOPMENT AUTHORITY (LDA)
WATER AND SANITATION AGENCY LAHORE
(WASA LAHORE)

PREPARATORY SURVEY REPORT
ON
THE PROJECT FOR ENERGY SAVING
IN WATER SUPPLY SYSTEM
IN LAHORE

JULY 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

NJS CONSULTANTS CO., LTD

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SUMMARY

2-1 Basic Concept of the Project

(1) Objectives of the Project

Lahore, the capital of Punjab Province, is the second largest city in Pakistan after Karachi, with populations of 7.4 million in the urban area and 1.6 million in the rural area ("Punjab Development Statistics 2012" by the Bureau of Statistics). The population coverage by water supply was 89% in 2012/13.

As of April 2013, groundwater is the only source of water supply in the urban area in Lahore, which comes from 474 tubewells. The population growth rate of Lahore is around 3.0%, exceeding the provincial average and resulting in a concentration of population in the city area. To provide service to the residents of the urban area extension, WASA increased the number of tubewells in oepration. In addition, WASA aslo undertook the replacement of 20 to 30 tubewells annually because of the wells' reduced discharge capacities, considering that many of the wells have been in operation for a long period, or from 1979-2013. Obviously, increasing the number of tubewells in operation results in an increase in WASA's power cost and the electricity tariff, which are again reflected in the increase of the fuel price through the annual fuel adjustment mechanism. Consequently, the financial condition of WASA has deteriorated. The operating ratio in 2012/13 was 0.55 suggesting that the tariff revenue could not cover the O&M expenses and acumulative deficits have been offset by the subsidy from the provincial government. In view of the fact that tariff increase cannot be implemented, as this requires the approval of the provincial government, the challenge is to reduce the electricity expense, which takes the biggest slice of the O&M expense, through energy-saving measures in tubewell pump operations.

Tubewell pumping stations have the following problems:

Since almost tubewells has passed more than 15 years which is regarded as the time limit of replacement, the clogging of tubewell screens is expected. In addition to this, the rehabilitation of tubewells has not been done due to no regular cleaning up to now. Therefore, the decrease of tubewell discharge occurs at almost tubewells. As for tubewell pumps, there are many cases that these have not been properly selected so as to meet the requirement for capacity and head, thus causing the chronic drawdown of groundwater. There is also the problem of unstable power supply causing frequent motor burn-out and reducing pumping efficiency, all of which contribute to the increase in power expenses. The discharge decrease of tubewell pumping stations is considered to be caused by the deterioration of both tubewell and pump, the replacement of a tubewell pumping station has been done, when it has been over 15 years since its installation which is an average span of life based on the past experience or the discharge decrease is found.

Having groundwater as the only source of water supply has its share of problems, which are as follows:

The groundwater in Lahore has already in the state of over-pumping and the water level has been decreasing at a rate of 0.67 m/year on the average and 1.38 m/year at the critical area. In 2008, -30m water level contour was observed, but in 2013 -40m contour emerged and in 2031 -65m line was estimated based on the survey results. Although the secondary phenomena such as land subsidence, salt water intrusion, etc. have not yet been reported so far, the people are concerned on the allowable depth the drawdown of groundwater.

There is also the problem of arsenic pollution of groundwater, which has been identified since the beginning of 2000's. According to the PUIC survey in June 2010, 85% of the total number of samples collected by WASA exceeded the WHO guideline of 10 μg/L for arsenic. The JICA survey in July 2013 conducted for proposed 140 tubewells had 96% samples were above 10 μg/L. At this moment, the damage to human health has not yet been identified. To improve the situation on a long term perspective, WASA will start "the Feasibility Study for Construction of Water Treatment Plant to Treat the Surface Water Intake from the BRB Canal, Lahore" from this year to run for two years. On the short term however, there was the development and installation of 100 filtration plants at the tubewells with an arsenic concentration of above 20 μg/L to supply safe water for drinking and kitchen purposes through public faucet systems for two years starting from 2012. Furthermore, another 100 filtration plant installations are also planned, although such systems will result in the increase in O&M expenses.

As mentioned above, this project will be implemented with the following objectives.:

1) To acheive energy-saving through the planned replacement of pumping equipment.
2) To restore the production capacity through the replacement of existing tubewell pumping stations with low production capacities.

However, consideration will be made taking into account the present problrms in Lahore groundwater.

1) Attention will be given on the effects on the groundwater level
2) For tubewells with an arsenic concentration of not lower than 10 μg/L, WASA shall install the filtration plants to minimize the human health damage.

2. Implementation Agency of the Project

Water supply service is provided by the Water Supply and Sanitation Agency Lahore (WASA), a wing of Lahore Development Authority (LDA) under the direction of the Housing, Urban Development and Public Health Engineering (HUD&PHED), the Goverment of Punjab Province. In Lahore, WASA covers the urban area, the community-based organizations (CBO) cover the rural area under the supervision of HUD&PHED, and for cantonments, the military manages an independent water supply system. The implementing agency of this project is WASA.

3. Outline of the Project

In response to the request from the Federal Government of Pakistan, the Government of Japan has decided to carry out the Preliminary Survey on Energy Saving in Water Supply in Lahore. JICA has reviewed the project size and the relavance of contents, and based on that result, conducted the survey to prepare the proper preliminary design as a grant-aid project, formulate the implementation schedule, and estimate the project cost. JICA dispatched the survey team from June 27 – July 26, 2013 to confirm the project scope, from August 18 – October 1, 2013 to make preliminary design and for the explanation and discussion, and from February 25 – March 8, 2014 to explain and discuss the Draft Outline Report.

To achieve the objectives of the project, the contents of the project were fixed through the following approach:

1) For WASA's tubewell pumping stations, the screen clogging in the tubewell is assumed, since there was no practice of regular tubewell cleaning, thus affecting production capacity, which could not be verified from the currently available data. For tubewell pumps, the single specification by design capacity has been applied for the replacement of pumps resulting in no reflection of actual groundwater level at the particular location, As aresult, the pumps have not been operated at the optimum pumping efficiency point. For this reason, to reduce the power consumption as a whole, the pumping heads by pump size are set with one to two stages based on the estimated groundwater level zone so as to operate pumps at the optimum efficiency point.

2) The restoration of pumping capacity will be achieved by the full replacement of existing tubewell pumping stations, since the cause of low pumping capacity cannot be exactly identified, However, some tubewells' use are recommened to continued be used in cases where pumping capacity has maintained more than 95% of the design capacity and the pump lifespan is less than 15 from installation.

Th contents of the project were fixed in consideraion of the following:

1) Based on the currently available groundwater level data, the contour map of groundwater level was prepared. The WASA service area was divided into three zones based on the groundwater level of (1) shallower than -45 m, (2) between -45 m and -65 m, and (3) deeper than -65 m. The pumps were arranged so that low capacity (2 cfs) pumps were placed at in the shallow water level zone (1), middle capacity (3 cfs) pumps in the middle zone (2), and high capacity (4 cfs) pumps in the deeper water level zone (3), so as to mitigate the effect on groundwater level.

2) For arsenic pollution of groundwater, the WHO guidelines for an arsenic concentration of 10 μg/L were set as the adoption criteria for the project. Therefore, for the tubewells with an arsenic concentration of not lower than 10 μg/L, the installation of filtration plants by WASA is the precondition of the project. Although the tubewells showed an arsenic concentration of lower than 10 μg/L at the JICA survey in July 2013 were adopted for the project, this may still have the possibility to show an arsenic concentration of not lower than 10 μg/L in the water quality confirmation test to be conducted after its completion. The installation of filtration plants by WASA is also applied to such tubewells. WASA is responsible for the awareness campaign to promote the use of public faucets attached to filtration plants. For tubewells showing an arsenic concentration of not lower than 10 μg/L, the priority for the inclusion of the project is given to tubewells with lower arsenic concentration in order to minimize the human health damage when drinking tap water for those who will not use the public faucets.

In relation to the above, the energy audit instruments will be procured, and in the soft component, how to use the energy audit instruments, how to analyze the collected operational data and how to improve the operation manner based on the results will be studied with the support of the consultants.

The facility/equipment to be included in the project is summarized below.

1) Civil and Building

(a) Tubewell construction: 105 locations

- Tubewell (Capacity: 5.1~6.8m^3/min, Design SWL in 2031: < GL -35m): 8 wells
- Tubewell (Capacity: 5.1~6.8m^3/min, Design SWL in 2031: GL-35m~-65m)：87 wells
- Tubewell (Capacity: 3.4m^3/min, Design SWL in 2031: GL-35m~-65m)：10 wells

Note: It is assumed that a filtration plant will be installed at a tubewell with an arsenic concentration of above 20 μg/L by WASA.

(b) Tubewell Pumping Srtation Building: 105 locations

- Tubewell Pumping Station (Brick, Floor area: approx. 31.5 m2 with furniture)

(c) Connection Pipe Installation

- HDPE ϕ 200~ ϕ 300: 105 locations

2) Mechanical/Electrical Equipment Installation

(a) Tubewell Pump

- Tubewell pump (Discharge: 6.8m3/min, Head: 51/47m, Output: 90/75kW): 41units
- Tubewell pump (Discharge: 5.1m3/min, Head: 64/62m, Output: 90/75kW): 55 units
- Tubewell pump (Discharge: 3.4m3/min, Head: 64m, Output: 75kW): 9 units

(b) Pump Accessories

- Valve (check valve/sluice valve/air valve), Turbine type flow meter, Piping, etc.: 105 locations
- Disinfection equipment (Storage tank, diaphragm pump): 105 locations
- Motor as stand-by (90/75/55kW), Chainblock: One (1) unit for each town

(c) Electrical Equipment

- Power Control panel (for 90/75kW): 105panels
- Wiring: 105 locations
- Water level meter: 10 units
- Spare parts: One (1) set for each town

3) Instrument Supply for Energy Audit: Two (2) sets

- Power analyzer, Portable ultrasonic flow meter, water level meter, etc.

The undertaking by the Pakistani side are as follows:

(1) Installation of gate, fence, etc.
(2) Removal of abandoned existing tubewell pumping station
(3) Contributions to LESCO for power receiving and transformation
(4) Installation of 88 filtration plants
(5) Installation of some filtration plants and raw water transmission pipes from the new tubewell pumping station to a filtration plants when an arsenic concentration will be not lower than 10 μg/L in the water quality test for confirmation at the time of tubewell completion.

4. Construction Period and Rough Cost of the Project

The construction period required for project implementation is scheduled as follows: 1.5 months for ODA procedures between both governments, 4.5 months for detailed design, 4.0 months for bidding process, and 19 months for construction works totaling 29.0 months for all works including 2.0 months for the implementation of a soft component programme.

Part of overall works shall be undertaken by the Pakistani side under its cost which is tentatively estimated at approximately Rs.511.4 million.

5. Evaluation of the Project

(1) Relevance

At present, WASA fully relies on groundwater as its drinking water source, but is poised to start "the Feasibility Study for Construction of water Treatment Plant to Treat the Surface Water Intake from BRB Canal, Lahore" with the pre-requisite of introducing surface water as the new water source starting from 2013 for two years. This project comes after the confirmation of chronic groundwater level drawdown and arsenic pollution in the groundwater. Although the plans are to to shift from groundwater to surface water or to blend groundwater with surface water, this will take substantial time and huge cost for it to be realised. The present full reliance on groundwater has to be maintained and the number of tubewells has to be increased corresponding to the extension of the service area and the population growth.

Therefore, in the situation that there is no choice other than groundwater, this project has high certainty in using groundwater as its water supply source.

Almost all WASA's tubewells are connected to the distribution grid network, and it is difficult to identify the service area by tubewell. For this reason, the population who will be benefitted by 105 tubewells was calculated by multiplying the per unit water volume service population by the total water production of the 105 tubewells.

Per unit water volume service population: 5,772,000 persons / 1,980,000 m^3/day
= 2.9 person/m^3/day

Beneficial population = 2.9 person/m^3/day x516,000 m^3/day = 1,496,000 persons

Note: 516,000 m^3/day is the total water production for 14.6 hour operation
849,000 m^3/day (347 cfs) x 14.6/24 hour/day = 516,000 m^3/day

As stated earlier, the provincial government and WASA has set an arsenic concentration at 20 μg/L for the installtion of a filtration plant closer to the WHO Guideline of 10 μg/L for drinking water compared to the the Pakistani standard of 50 μg/L. The adoption criterion for the project is set at the WHO guideline for an arsenic concentration of lower than 10 μg/L.

The project has sufficient relevance when looking at the perspectives of (i) project necessity, size of population to be benefited, minimization of human health damage risk, and alignment with with the Pakistani target for filtration plant installation.

(2) Effectiveness

The power and energy expense shares 44.7% of the total operation and maintenance expense in 2012/13 which is the pressing issue to be improved for WASA. The project is aiming at energy-saving in WASA water supply service

Against the power consumption per unit water production of 0.317 kW/m^3 at existing 54 tubewell pumping stations, that for new 105 pumping stations is expected at 0.202 kW/m^3 on average, that is to say, 37% reduction in a power consumption as well as the reduction in repair and O&M expenses through the decrease of trouble frequency and motor burnout accidents by the provision of a protection unit.

The implementation of the project will contribute to the improvement of WASA Lahore management from this viewpoint.

As the other qualitative effects, the improvement of WASA's financial condition through the reduction of power consumption under the same water volume, decrease of trouble frequency by pump replacement and provision of an electric protection unit, decrease of less water distribution areas, improvement in the accuracy of non-revenue water (NRW), which has been so far calculated based on many assumptions, through the actual measurement using energy audit instruments, and reduction of greenhouse gas emission are expected.

6. Recommendations for the Future

Even though the project will have expected results, it is not intended to solve the fundamental problems that WASA faces. It is recommended that the provincial government and WASA address the following issues.

1) The problem of having only one source of water, which is groundwater, is taking its toll in Lahore as evidenced by progressive decline in groundwater levels as well as arsenic pollution. To solve these problems, the provincial government and WASA is going to start "the Feasibility Study for Construction of Water Treament Plant to Treat the Surface Water from BRB Canal, Lahore". Best efforts should be paid for its successful realization. Although the reliance on groundwater can gradually be reduced by the introduction of surface water, monitoring should be undertaken so that sufficient recharge of groundwater and restoration of water levels can be achieved.

2) At present, WASA has developed the installation of filtration plants at the tubewells with an arsenic concentration of above 20 μg/L and has a plan to extend the target to the tubewells with an arsenic concentration of above 10 μg/L to meet the WHO Guideline for drinking water. This policy is to remove the risk for human health damage and is strongly desired.

3) To keep the financial sustainability of WASA in which the expense largely exceeds the revenue, the increase of water tariff is necessary. If the tariff increase is delayed, the subsequent tariff increase requirement will grow, thus making it more difficult to implement the tariff increase, causing a vicious cycle. Therefore, early decision is required on this sensitive matter. In the situation that the tariff increase is difficult to implement, the subsidy from the provincial government is indispensable as the second best decision.

4) It is recommended that WASA address the life-span extension of a tubewell pumping station of which the life span is reportedly about 15 years. Since the pumping equipment is a mechanical equipment, a15-year life span seems to be reasonable. However, it is still possible to extend the life span of a tubewell; and the system can be changed from the present full replacement of the entire pumping station to the replacement of a pump only. To support this, it is necessary to establish the tubewell cleaning method suitable to the tubewells in Lahore and to establish a regular tubewell cleaning program from the the time it is commissioned. In addition, the actual measurement of water production should be done at least once a year for all the WASA tubewells and operation control should be established through the regular energy audit.

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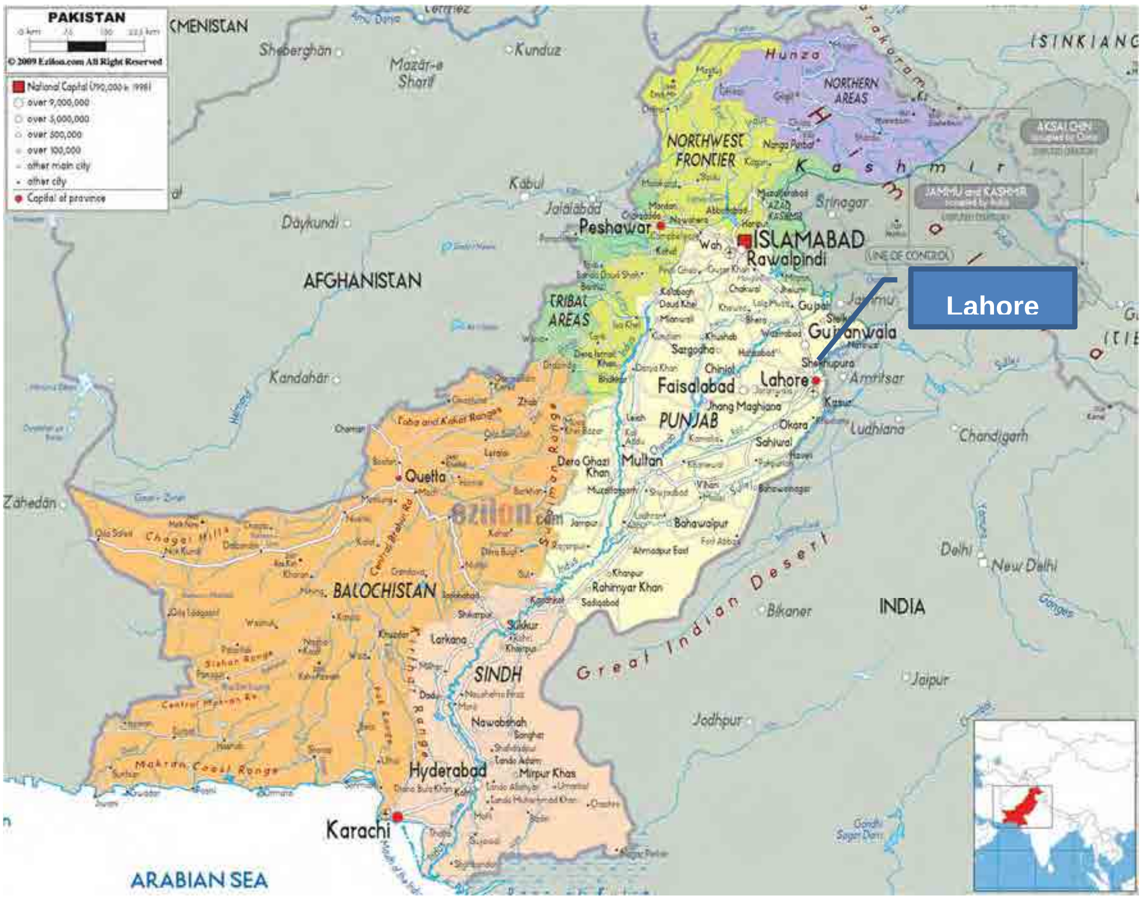

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ABBREVIATIONS

Abbreviation	Full Name
A.I.T.	Allama Iqbal Town
CDGL	City District Government Lahore
DIR	Director
DMD (Engg)	Deputy Managing Director (Engineering)
DMD (O&M)	Deputy Managing Director (Operation & Maintenance)
DOE	District of Environment
DWL	Dynamic Water Level
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EPD	Environmental Protection Department
ERD	Economic Affairs Division
FY	Fiscal Year
HUDPHED	Housing, Urban Development & Public Health Engineering
IEE	Initial Environmental Examination
JICA	Japan International Cooperation Agency
LDA	Lahore Development Authority
MD	Managing Director
LESCO	Lahore Electric Supply Company Limited
NHA	National Highway Authority
P&DD	Planning & Development Department
PD	Project Director
PHA	Parks & Horticulture Authority
PUIC	Punjab University, Institute of Chemistry
SDO	Sub-district Officer
SWL	Static Water Level
T/Ws	Tubewells
UU	The Urban Unit, P&DD
WB	The World Bank
WASA	Water and Sanitation Agency
WSP	Water and Sanitation Program
XEN	Executive Engineer
$Y - \Delta$	Star-delta

Abbreviation	Full Name
UNIT	
Cfs	cubic feet per second (ft^3/sec = 1.6992 m^3/min)
HP	Horse Power (=745.700 W)
NTU	Nephelometric Turbidity Units

CHAPTER 1 BACKGROUND OF THE PROJECT

1-1 Present Situation and Issues of the Sector

1-1-1 Present Situation and Issues

According to the WHO/UNICEF "Joint Monitoring Programme for Water Supply and Sanitation" (Updated April 2013), though access to sanitary water source in Pakistan has generally improved but there is a disparity in urban and rural areas. The report shows that the access to sanitary water has improved from 85% in 1990 to 91% in 2011, however only 58% in urban areas and 23% in rural areas have benefited as seen in Table 1-1. Access to water supply service defines a condition where people can use at least 20 liter of water per day and per capita within 1 km from their dwellings. The sanitary water sources also include an individual's faucet of piped water supply, public faucets, tubewells, protected dug wells, protected springs and harvested rainwater.

Table 1-1 Estimated Population Coverage by Water Supply in Pakistan

	Urban (%)		Rural (%)		Total (%)	
	1990	2011	1990	2011	1990	2011
Individual piped water supply	56	58	8	23	23	36
Other sanitary water source	39	38	73	66	62	55
Other unsanitary water source	4	4	8	7	7	6
Surface water	1	0	11	4	8	3

Source: WHO/UNICEF, "Joint Monitoring Programme for Water Supply and Sanitation" (Updated April 2013)

Currently, the quality of water supply service is not satisfying even in the urban areas. The water supply time is only five hours in Karachi, 14-18 hours in Lahore and 2.5 hours in Islamabad (Table 1-2).

As another issue, the operating ratio of revenue to expense in 10 major water supply and sewerage utilities is in the range of 0.22 to 0.97 which cannot cover the operating expenses. It is worth mentioning that the accumulated deficits have been offset by subsidies from the provincial government once in every four to five years.

The number of employees per 1,000 connections of water supply and sewerage is only seven in Karachi, four in Lahore, and ten in Islamabad, large difference was found among them.

Table 1-2 Comparison of Major Water Supply and Sewerage Utilities in Pakistan

	Unit	Islamabad	Punjab					Sindh		North-West Frontier	Balochistan
			Faisalabad	Gujranwala	Lahore	Multan	Rawalpindi	Karachi	North Siddh	Peshawar	Quetta
Established Year		**1960**	**1978**	**1997**	**1976**	**1992**	**1988**	**1983**	**2009**	**1980**	**1986**
Technical data											
Water source		**SW + GW**	**SW + GW**	**GW**	**GW**	**GW**	**SW + GW**	**SW**	**SW + GW**	**GW**	**GW**
No. of water connections	**nos.**	**67,827**	**110,452**	**29,375**	**587,595**	**43,996**	**92,468**	**1,090,000**	**30,000**	**15,064**	**67,660**
Residential	nos.	58,232	107,792	28,069	551,514	42,088	84,800	890,000	27,000	14,760	62,941
Commercial	nos.	8,995	2,317	1,240	32,584	1,903	7,763	140,000	3,000	304	3,647
Bulk/industrial	nos.	600	80	66	nil	5	5	60,000	nil	nil	45
Government	nos.	-	-	-	-	-	-	-	-	-	484
Charitable	nos.	-	-	-	3,497	-	-	-	-	-	
Annual Water Use											
Residential	%	50	41	60	97	60	43	82	30	N/A	93
Commercial	%	15	13	2	2	15	26	18	3		7
Industrial	%		15	3	1	3	-		-		-
Charitable	%	-	-	-	-	-	-	-	-		-
NRW	%	35	31	35		22	31		67		
No.of sewerage connections	**nos.**	**67,827**	**217,002**	**97,236**	**583,532**	**175,615**	**38,437**	**840,000**	**242,857**	**15,064**	**10,400**
Residential	nos.	58,232	201,452	90,294	543,664	161,266	34,646	N/A	218,571	14,760	N/A
Commercial	nos.	8,995	14,899	5,995	31,909	14,282	3,791	N/A	24,285	304	N/A
Bulk/industrial	nos.	600	651	947	4,603	67	nil	N/A	nil	nil	N/A
Charitable		-	-	-	3,356	-	-	-	-	-	-
Staff	**pers.**	**1,350**	**2,692**	**267**	**4,269**	**1,271**	**1,098**	**12,879**	**895**	**225**	**1,903**
Professional	pers.	40	99	25	208	34	35	674	17	17	95
Others	pers.	950	2,593	242	4,061	1,271	1,063	12,205	859	185	1,808
Financial data											
Total Revenue	**10^6 Rs.**	**844.020**	**735.027**	**276.975**	**1,977.500**	**298.540**	**494.101**	**4,004.730**	**7.546**	**46.818**	**346.028**
Annual revenue collection	10^6 Rs.	224.120	438.907	369.662	1,977.500	172.394	266.962	4,004.730	3.310	42.966	41.435
a) Current bill	10^6 Rs.	213.764	311.667	34.662	1,582.000	73.340	224.605	2,803.310	3.310	39.584	121.325
b) Arrears collection	10^6 Rs.	10.342	127.240	335.000	395.500	99.054	31.980	1,201.420	0.000	3.382	N/A
Nontariff income	10^6 Rs.	N/A	208.120	242.313	109.000	126.146	227.139	446.000	0.000	N/A	N/A
Provincial government	10^6 Rs.	617.000	88.000	84.992		nil	nil	nil	76.696	N/A	652.275
Total Expenditure	**10^6 Rs.**	**961.751**	**1,700.286**	**284.805**	**5,772.861**	**1,371.712**	**565.194**	**5,403.800**	**N/A**	**166.280**	**652.275**
Accumulative arrears	10^6 Rs.	N/A	2,217.750	335.000	2,167.184	663.598	700.000	35,127.000	N/A	3.382	346.028
Accumulative WAPDA arrears	10^6 Rs.	N/A	nil	nil	1,096.447	186.220		14,000.000	180.000	N/A	nil
Provincial ADP allocation	10^6 Rs.	N/A	1,286.191	369.000	1,414.316	594.435	47.000	1,185.860	520.000	N/A	nil
Annual capital expenditure	10^6 Rs.	961.751	879.237	284.805	1,368.938	665.080	26.179	1,671.000	171.360	N/A	652.275
Annual O&M expenditure	10^6 Rs.	961.751	115.901	34.493	4,403.923	33.113	193.568	3,732.800	273.309	N/A	89.010
Salary expenditure	10^6 Rs.	469.417	373.888	96.915	1,464.300	198.777	170.095	2,435.520	56.228	N/A	306.505
WAPDA billed amount	10^6 Rs.	321.457	331.260	127.760	2,088.500	237.371	201.531	3,087.000	205.000	N/A	256.700
WAPDA paid amount	10^6 Rs.	321.457	331.260		2,000.000		201.531		62.502	89.451	256.700
Releases	10^6 Rs.	N/A	879.237	369.000	890.783	335.791	47.000	1,175.100	649.603	N/A	N/A
Expenditures	10^6 Rs.	961.751	879.237	361.792	880.479	314.732	47.000	991.170	786.947	166.280	N/A
Ave. production cost of water/liter	Rs./L	0.0058	0.00471	1.088	0.007	0.004	0.0058	0.008	0.08	0.0079	0.0075
Ave. capital expenditure/conn./year	Rs./conn/yr	14.179	2.687	110.57	2,330.000	3,028	200	1,591.420	N/A	N/A	803.33
Operating Ratio		**0.88**	**0.43**	**0.97**	**0.34**	**0.22**	**0.87**	**0.74**	**N/A**	**0.28**	**0.53**
Annual Billing											
Residential	%	78	45	88	84	56	41	24	65	N/A	93
Commercial	%	22	1	5	16	32	30	76	10		7
Industrial	%		54	6	-	3	-		-		-
Others	%	-	-	1	0	9	29	-	25		-
Annual O&M Cost											
Salary	%	49	46	40	33	35	32	65	41	N/A	47
Power	%	33	40	45	46	54	28	7	30		39
Others	%	18	14	15	21	11	40	28	29		14
Consumer Service											
Ave. monthly water consumption/HH conn.	m^3/conn.	60	25.85	No metering	54.072	48.6	78.83	20.25	17	237	49.6
Ave. water bill / month / conn.	Rs./mo/conn	150	291.56	100	287.4	60	135	449	30	219	125
Ave. availability of water	hrs/day	2.5	6.5	14	14-18	5	8	5	8	9	1
No. of water & sewerage service complaints	nos.	3,000	24,911	15.721	170,670	33,742	10,220	38.744	10,828	10,890	14,400
No. of pipe breaks repaired	nos.	150	62	197	26,646	2,513	841	5.575	820	7,300	6,480
No. of sewerage blockages reported	nos.	1,200	515	15,350	144,024	29,214	4,574	6.277	7,120	2,541	105
Metering ratio		nil	1.47%	nil	7.75%	nil	nil	0.24	0	nil	nil
Population											
Total population	10^6	0.9	3.1	1.7	6.152	1.8	1.3	20	1.8	0.55	2.8
Population served	10^6	0.4	1.55	0.554	5.475	1.2	1.17	18	1.0	0.55	1.5
Population growth rate		5.19%	3.58%	3.00%	2.36%	2.79%	3%	4.02%	3%	3.51%	2.75%
Water Supply											
Annual production	10^6	110	87.1	91.171	655	35.51	97.74	1,078.56	30.991	17.64	1,204.75
Total distribution pipes	km	1,400	1,471	372	7,700	1,049	1,150	5,813	73	370	1,900
No. of treatment plants		7	2	nil	nil	nil	1	8	6	4	nil
Sewerage											
Total sewer pipes	km	1,628	1,711	380	4,940	1,204	250	5187	60	164.25	82
Annual sewage generated	10^6 m^3/yr	65	514.31	468.3	556	107.58	38.40	3784.75	47.416	34.28	nil
Wastewater collected	10^6 m^3/yr	13	390.88	468.3	855	107.58	nil	91.25	45.045	34.28	nil
No. of wastewater treatment plants		4	1	nil	nil	nil	nil	3	3	4	1
Level of wastewater treated											
Primary	10^6 m^3/yr	√	1.09	nil	screening	nil	nil	√	√	nil	nil
Secondary	10^6 m^3/yr	√	1.09	nil	nil	nil	nil	√	nil	nil	nil
Tertiary		nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
Service											
Water coverage		100%	50%	32%	89%	60%	90%	90%	40%	100%	70%
Sewerage coverage		100%	70%	65%	87.69%	60%	35%	80%	85%	100%	12.5%
Water availability	hrs/day	2.5	7	14	14-18	5	8	5	8	9	1
Per capita consumption	L/day	273	112.5	227	327	225	150	135	77	311.85	59
Efficiency											
Ave. unit producton cost	Rs./m^3	5.72	4.71	0.109	6.73	4.14	5.79	7.69	0.08	7.90	0.75
Billing efficiency		100%	92%	25%		30.90%	100%	70%	80%	100%	60%
Collection efficiency		95%	51%	40%	98%	88.6%	75%	43%	60%	92.78%	21%
Financial					80%						
Physical					64.14%						
Staffing ratio		10	8	5	4	6	8	7	3	7	24

Source: "Pakistan Water and Sanitation Operators Directory", WSP, Oct. 2012

SW: Surface Water GW: Groundwater

The number of connections in WASA Lahore with a population of 7.77 million is only about 620,000 which is ranked at the second place after Karachi. On the other hand, WASA Lahore fully relies on groundwater through 474 tubewells which over-pumping has resulted in a chronic drawdown of groundwater level. In addition to this, the arsenic pollution of groundwater is identified throughout the service area.

1-1-2 Development Plan

(1) Vision 2030

Below shows the Federal Government of Pakistan's vision of Urban Water Supply and Sanitation for 2030 declared in August 2007:

"The strategy for urban water supply would be based on meeting rapidly increasing demand for household and industrial water, increasing investments in new water delivery systems, upgrading and managing the existing systems more efficiently, ensuring provision of potable water to poor households, recycling of water, where feasible, and enhancing cost recovery. The sanitation improvement options would cover wastewater management and disposal of human wastes through cost efficient and affordable means, including improvement in the management of septic tanks. For solid waste, the strategy would be to develop integrated solid waste management systems, sanitary landfills, and to minimize waste through refuse recovery and electricity generation."

(2) National Drinking Water Policy

The National Drinking Water Policy (draft) declared in 2009 describes the present situation. It says that “Currently over 65 percent of Pakistan's population is considered to have access to safe drinking water. Huge disparities, however, exist with regard to drinking water coverage between urban and rural areas and provinces/regions. The quality of the drinking water supply is also poor, with bacterial contamination, arsenic, fluoride and nitrate being the parameters of major concern. Sustainability of the existing water supply systems is also a major issue in the sector.” The first objective of the policy is to “Provide access to safe and sustainable drinking water supply to the entire population of Pakistan by 2025. The Policy Principles say that (i) Access to safe drinking water is the basic human right of every citizen and that it is the responsibility of the Government to ensure its provision to all citizens and (ii) Water allocation for drinking purposes will be given priority over other uses”.

(3) Punjab Drinking Water Policy

The Punjab Drinking Water Policy declared in 2010 says as the policy principle that

- Drinking water allocation for domestic purposes will have priority over all other usages.

For Protection and Conservation of Water Resources,

- Measures will be taken to protect and conserve surface and groundwater resources as well as coastal waters in line with the provisions of the National Environment Policy and Pakistan Environmental Protection Act-1997

For the legislative aspect,

- As water resources become scarce and the growth in Punjab's population threatens to create an acute shortage of per capita availability of drinking water, the need to regulate drinking water and to save the aquifer through a comprehensive legislation is felt by the Government as well as by the civil society. The Government of the Punjab, with the consensus of all stakeholders (provincial departments, elected representatives, and the civil society) will enact the Punjab Municipal Water Act. This Act would provide a statutory, independent, institutional setup that will regulate policy principles; standards and the performance of service delivery agencies in the light of this policy. This law will be enacted and enforced by 2013.

- As water resources become scarce and the growth in Punjab's population threatens to create an acute shortage of per capita availability of drinking water, the need to regulate drinking water and to save the aquifer through a comprehensive legislation is felt by the Government as well as by the civil society. The Government of the Punjab, with the consensus of all stakeholders (provincial departments, elected representatives, and the civil society) will enact the Punjab Municipal Water Act. This Act would provide a statutory, independent, institutional setup that will regulate policy principles; standards and the performance of service delivery agencies in the light of this policy. This law will be enacted and enforced by 2013.

For the Institutional aspect,

- The Government will launch an institutional reform program which will not only focus on improvement in service delivery but also address allied issues such as rationalization of tariff, improvement in management of organization and introduction of performance monitoring systems so as to ensure that the WASAs are transformed into a progressive; accountable and financially viable institution by the year 2016. By the year 2016, the WASAs would also ensure installation of consumer meters on 100% connections. The Government will adopt measures to promote various proven community participation approaches to ensure community involvement in various aspects of service delivery.

(4) Development Plan in Lahore

As mentioned earlier, Lahore fully relies on groundwater which has caused other issues. The high number of 474 tubewells indicates over-pumped groundwater due to an increase in the City's population. However, the chronic drawdown of groundwater level and the arsenic pollution of groundwater have become obvious and the risk only relying on groundwater has been recognized by the Punjab Provincial Government and WASA. To address the groundwater issues WASA has taken some steps. A Feasibility Study for Construction of Water Treatment Plant in Lahore has being conducted in order to treat the surface water intake from BRB Canal. As the interim measures, WASA has extended the installation of filtration plants for tubewells with an arsenic concentration of not lower than 20 μg/L in groundwater. This helps WASA to supply safe water for drinking and cooking purposes through a public faucet system. Starting from the year of 2012, 100 filtration plants will be installed for two years which will be followed by another 100 filtration plants.

1-1-3 Social and Economic Conditions

Pakistan shares common borders with Iran and Afghanistan in west, China north, India in east and the Arabic Sea in south. It has a population of 180.7 million with a land area of 79.6 km^2 and is the fourth populated country in Asia. The literacy rate was 58% according to the Pakistan Economic White Paper in 2010/2011.

The major products are from the agriculture and textile industries. . The major export products are textile like cotton, cotton yam, knitwear, etc., food like rice and so on. The per capita GNI is US$1,372 based on the Pakistan Economic White Paper in 2010/2011. According to the Pakistan Central Bank Annual Report (2010/2011), the price increase rate was 13.9% per annum with an unemployment rate of 6.0%

Lahore is the capital of Punjab Province and the centre of policy and economy as well as the key military base due to its close location to India. According to the "Punjab Development Statistics (2012)" by the Punjab's Bureau of Statistics, there were 1,986 factories with a total employee of 166,470 in 2010. The factories with a size of 1,000 to 5,000 employees count only 15 and no factory with more than 5,000 employees. About half of employees are working at the factories with a size of less than 500 employees. Although the textile workers share about one–third of the total, but others are dispersed in a variety of fields.

1-2 Background and Outline of Request for Grant-aid Assistance

Given the issues with the WASA's usage of groundwater as the only source of water supply in its distribution grid directly after chlorination, the following measures should be taken as early as possible to improve the situation:

- 105 tubewell pumping stations have less pumping discharge and waste the power.
- Pakistan has been facing a serious power supply shortage. If any effective measures are not taken, the situation will be more serious. So far, WASA has taken the steps to install private power generators which in turn increases the fuel expense.
- During an increase in the fuel price, containment of both power cost and examination of the power over-consumption are indispensable.
- WASA laboratory does not have adequate modern apparatus to analyze arsenic and heavy metals. The arsenic-pollution of groundwater as the only water source is a social issue in Lahore This means that it is time to provide WASA laboratory with ICP for arsenic concentration analysis.
- It is necessary to check the pumping discharge. This can be done by installing a bulk flow meter to all tubewells. The workshop equipment for water meter verification and repair needs to be upgraded. This helps improve precise measurements of the supplied and consumed water.

Given the situation mentioned above, the request for grant-aid assistance was submitted to the Government of Japan with the contents as shown in Table 1-3.

Table 1-3 Outline of the Request by WASA

	Item	Contents
1	Replacement of pumps and motors and re-construction of tubewells	• Replacement of an existing 4 cfs (6.8 m^3/min) vertical turbine pump and motor × 25 sets • Replacement of an existing 2 cfs (3.4 m^3/min) vertical turbine pump and motor × 80 sets • Re-construction of tubewell accessories x 105 locations • Re-drilling of a tubewell x 67 locations
2	Procurement and installation of a photovoltaic power generation system for water supply	• 4 cfs (6.8 m^3/min) size x one set • 3 cfs (5.1 m^3/min) size x one set • 2 cfs (3.4 m^3/min) size x one set The system is composed of a tubewell, building, tubewell pump, electrical equipment and photovoltaic power generation system Note: cfs is the abbreviation of cubic feet per second (1 ft^3/sec = 1.6992 m^3/min)
3	Energy Audit Instruments	• Energy analyzer • Potable digital thacometer • Clamp meter • Thermo razor • Potable Ultrasonic flow meter • Vibration pen • Laptop PC Five sets of the above
4	Upgrading of WASA laboratory	• Office automation • Analytical apparatus

		• Apparatus for biological water quality test Others（COD/BOD analytical apparatus, ultraviolet apparatus）
5	Workshop and its equipment for water meter verification and repair	

1-3 Movement of Assistance by Japan

Table 1-4 Movement of Assistance by Japan to Pakistan

(1) Grant-aid Assistance

Project name	Amount（JY x10^8）	E/N Signing	G/A Signing	Status
Water supply for Faisalabad	44.42	2008/7/23		Completed
Water supply for Abodabad（D/D）	0.53	2010/2/17	2010/2/17	Completed
Water supply for Abodabad	36.44	2010/7/27	2010/9/14	Completed
Lahore sewerage and drainage equipment emergency restoration project	12.23	2010/8/26	2010/9/27	Completed
Faisalabad water supply augmentation project	7.99	2010/8/26	2010/9/27	Completed
Energy saving in water supply system in Lahore				On-going
Water transmission facility improvement for Faisalabad water supply				On-going
Gujranwala sewerage and drainage improvement project				On-going

(2) Loan assistance

Project name	Amount（JY x10^8）	L/A Signing
Metropolitan water supply project (Simuli)	57.50	1989/3/30
Metropolitan water supply project (Kampur)	125.18	1989/3/30
Karachi water supply improvement project	103.00	1994/11/22

(3) Development Study, Technical Assistance and others

Name of survey	Relevance with this project	Completed year
Preliminary survey for project formation (water supply and sewerage)	None	2007/12
The study on water supply and sewerage system in Karachi	None	2008/6
Preparatory study on Lahore water supply, sewerage and drainage improvement project	Propose the following works for Phase 1（2010-2017） • Formulation of master plan for alternative water source • UFW and NRW reduction through meter installation, etc. • Water quality improvement (installation of chlorine injection unit, etc.)	2010/7

	• Procurement of O&M equipment • Consulting service for the above	
Planning assistance in Lahore water supply, sewerage and drainage improvement project (Expert for loan project)	Establish the internal committee for energy cost reduction within WASA and discuss the measures	2010/4～2011/9
Institutional assistance in Lahore water supply, sewerage and drainage improvement project (Expert for loan project)	None	2012
WASA capability improvement project for Punjab WASAs	Capability development of O&M staff of major WASAs in Punjab Province	Under preparation

1-4 Movement of Assistance by Other Donor Countries

(1) Assistance by Other Donor Countries to WASA

Assistance by other donor countries to WASA in the past five years is shown in **Table 1-5**.

(2) Relevance to the Project

This project will be implemented in collaboration with WASA by installation of filtration plants for some tubewells. The cost of such plant installation will be covered by PC-1 under application to the Punjab Provincial Government by WASA.

Table 1-5 Movement of Assistance by Other Donor Countries

Project name	Agency	Contents	Period	Amount	Burden by recipient
Punjab cities improvement project	WB	Improvement of urban services in Punjab major cities（PCGIP）	2013/14～2017/18	UD$150mil. *	—

* The allocation to Lahore is US$ 42.7 mil. (29%), out of which, Rs.353.557 million is allocated to WASA and partly used for power cost as shown below.

<table>
<tr><th>EEPs object code</th><th>Description</th><th>Procurement plan on proposed repair & maintenance of EEPs of all departments under WASA</th><th>Procurement plan of WASA on reimbursement claimed against EEPs R&M schemes already executed in 2013-14</th></tr>
<tr><td>327</td><td>Water supplu lines</td><td>—</td><td rowspan="3">Rs. 78.195 mil.</td></tr>
<tr><td>331</td><td>R&M material for machinery and equipment</td><td>Rs.43.405 mil.</td></tr>
<tr><td>328-A</td><td>Drainage schemes</td><td>Rs.31.957 mil.</td></tr>
<tr><td>361-362</td><td>Power and energy</td><td>-</td><td>Rs.200.000 mil.</td></tr>
<tr><td>Total</td><td></td><td>Rs.75.362 mil.</td><td>Rs.278.195 mil.</td></tr>
</table>

CHAPTER 2 CONTENTS OF THE PROJECT

2-1 Basic Concept of the Project

(1) Objectives of the Project

Lahore, the capital of Punjab Province, is the second largest city in Pakistan after Karachi, with populations of 7.4 million in the urban area and 1.6 million in the rural area ("Punjab Development Statistics 2012" by the Bureau of Statistics). The population coverage by water supply was 89.1% in 2012/13.

As of April 2013, groundwater is the only source of water supply in the urban area in Lahore, which comes from 474 tubewells. The population growth rate of Lahore is around 3.0%, exceeding the provincial average and resulting in a concentration of population in the city area. To provide service to the residents of the urban area extension, WASA increased the number of tubewells in operation. In addition, WASA aslo undertook the replacement of 20 to 30 tubewells annually because of the wells' reduced discharge capacities, considering that many of the wells have been in operation for a long period, or from 1979-2013. Obviously, increasing the number of tubewells in operation results in an increase in WASA's power cost and the electricity tariff, which are again reflected in the increase of the fuel price through the annual fuel adjustment mechanism. Consequently, the financial condition of WASA has deteriorated. The operating ratio in 2012/13 was 0.55 suggesting that the tariff revenue could not cover the O&M expenses and acumulative deficits have been offset by the subsidy from the provincial government. In view of the fact that tariff increase cannot be implemented, as this requires the approval of the provincial government, the challenge is to reduce the electricity expense, which takes the biggest slice of the O&M expense, through energy-saving measures in tubewell pump operations.

Tubewell pumping stations have the following problems:

The tubewell pumping station is basically composed of the tubewell itself and the pumping equiment, both of which affect discharge capacity. The tubewell has a problem of screen clogging as tubewell cleaning has not been done since well construction was completed. Also WASA has no experience and knowledge on which method is effective as well as applicable to the WASA ttubewells. As for tubewell pumps, there are many cases that these have not been properly selected so as to meet the requirement for capacity and head, causing the chronic drawdown of groundwater. There is also the problem of unstable power supply causing frequent motor burn-out and reducing pumping efficiency, all of which contribute to the increase in power expenses. While observing pumping capacity, it is difficult to identify whether the cause of the problem is the tubewell or the pump. Since the lifespan of a tubewell pumping station is approximately 15 years, based on experience, then it is safe to recommend that all pumping stations with facilities that have been installed more than 15 years ago will have to be replaced.

Having groundwater as the only source of water supply has its share of problems, which are as follows:

The groundwater in Lahore has already in the state of over-pumping and the water level has been decreasing at a rate of 0.67 m/year on the average and 1.38 m/year at the critical area. In 2008, -30m water level contour was observed, but in 2013 -40m contour emerged and in 2031 -65m line was estimated based on the survey results. Although the secondary phenomena such as land subsidence, salt water intrusion, etc. have not yet been reported so far, the people are concerned on the allowable depth the drawdown of groundwater.

There is also the problem of arsenic pollution of groundwater, which has been identified since the beginning of 2000's. According to the PUIC survey in June 2010, 85% of the total number of samples collected by WASA exceeded the WHO guideline of 10 μg/L for arsenic. The JICA survey in July 2013 conducted for proposed 140 tubewells had 96% samples were above 10 μg/L. At this moment, the damage to human health has not yet been identified. To improve the situation on a long term perspective, WASA will start "the Feasibility Study for Construction of Water Treatment Plant to Treat the Surface Water Intake from the BRB Canal, Lahore" from this year to run for two years. On the short term however, there was the development and installation of 100 filtration plants at the tubewells with an arsenic concentration of above 20μg/L to supply safe water for drinking and kitchen purposes through public faucet systems for two years starting from 2012. Furthermore, another 100 filtration plant installations are also planned, although such systems will result in the increase in O&M expenses.

As mentioned above, this project will be implemented with the following objectives.:

1) To acheive energy-saving through the planned replacement of pumping equipment.
2) To restore the production capacity through the replacement of existing tubewell pumping stations with low production capacities.

However, consideration will be made taking into account the present problrms in Lahore groundwater.

1) Attention will be given on the effects on the groundwater level
2) For tubewells with an arsenic concentration of not lower than 10 μg/L, WASA shall install the filtration plants to minimize the human health damage.

(2) Implementation Agency of the Project

Water supply service is provided by the Water Supply and Sanitation Agency Lahore (WASA), a wing of Lahore Development Authority (LDA) under the direction of the Housing, Urban Development and Public Health Engineering (HUD&PHED), the Goverment of Punjab Province. In Lahore, WASA covers the urban area, the community-based organization (CBO) covers the rural area under the superintendence of HUD&PHED and for cantonments, the military manages independent water supply system. The implementing agency of this project is WASA.

(3) Evaluation of the Contents of the Request by the Pakistani Side

The contents of the request by the Pakistani side were evaluated as follows:

1) Groudwater Supply Using Solar Power Generation System

The study revealed that it would take 99 years to recover the initial investment for the groudwater supply using solar power generation system by the tariff difference through the reduction of power consumption, even in case of adopting the most economical system by connection to the commercial power grid. However, the system requires about every 15 year replacement. Therefore, the groudwater supply using solar power generation system is not economically feasible and is excluded from the project.

2) Replacement of Pumps and Motors for Tubewells and Replacement of Tubewells

At present, Lahore water supply fully relies on groundwater for water supply, but has faced the problems of chronic drawdown of groudwater level and arsenic pollution of groundwater. For these reasons, the shift of water source from groundwater to surface water or the mix of groundwater with surface water is under consideration and the provincial government and WASA through the “the Feasibility Study for Construction of Water Treatment Plant to Treat the Surface Water Intake from the BRB Canal, Lahore”. However, since it will take time and huge investment before the completion of the project, the full reliance on groundwater will be maintained. For this reason, the replacement of existing tubewell pumping stations with low water production capacity has been identified as urgent.

3) Energy Audit Instruments

Energy audit instruments in relation to the operation and maintenance of above tubewell pumping stations are indispensable in checking operational conditions, predict the timing of pump replacement, measure the project effect, and so on. Therefore, they are included in the project.

4) Inprovement of WASA Laboratory

Accurate analysis using the atomic absorption spectrometer, etc. for arsenic concentration analysis requires deep knowledge and experience on fundamental chemistry and analytical chemistry. However, taking into account the current analytical contents and level at WASA laboratory education background of staff concerned, frequency required for arsenic concentration analysis, the introduction of such analytical units are considered to be premature, therefore they are excluded from the project.

5) Workshop and Equipment for Meter Repair and Testing

Existing equipment to repair and test the water meters are not effectively used at the existing workshop and no technical competence is found among the staff concerned. Therefore, there is no sufficient technology to repair and test the water meter and bulk flow meters and it is identified to be difficult to maintain water meters with the existing equipment and system, therefore these are excluded from the project.

(4) Outline of the Project

In response to the request from the Federal Government of Pakistan, the Government of Japan has decided to carry out the Preliminary Survey on Energy Saving in Water Supply in Lahore. JICA has reviewed the project size and the relavance of contents, and based on that result, conducted the survey to prepare the proper preliminary design as the grant-aid project, formulate the implementation schedule, and estimated the project cost. JICA dispatched the survey team from June 27 – July 26, 2013 to confirm the project scope, from August 18 – October 1, 2013 to make preliminary design and for the explanation and discussion, and from February 25 – March 8, 2014 to explain and discuss the Draft Outline Report.

To achieve the objectives of the project, the contents of the project were fixed through the following approach:

1) For WASA's tubewell pumping stations, the screen clogging in the tubewell is assumed, since there was no practice of regular tubewell cleaning, thus affecting production capacity, which could not be verified from the currently available data. For tubewell pumps, the single specification by design capacity has been applied for the replacement of pumps resulting in no reflection of actual groundwater level at the particular location, As aresult, the pumps have not been operated at the optimum pumping efficiency point. For this reason, to reduce the power consumption as a whole, the pumping heads by pump size are set with one to two stages based on the estimated groundwater level zone so as to operate pumps at the optimum efficiency point.

2) The restoration of pumping capacity will be achieved by the full replacement of existing tubewell pumping stations, since the cause of low pumping capacity cannot be exactly identified, However, some tubewells' use are recommened to continued be used in cases where pumping capacity has maintained more than 95% of the design capacity and the pump lifespan is less than 15 from installation.

Th contents of the project were fixed in consideraion of the following:

1) Based on the currently available groundwater level data, the contour map of groundwater level was prepared. The WASA service area was divided into three zones based on the groundwater level of (1) shallower than -45 m, (2) between -45 m and -65 m, and (3) deeper than -65 m. The pumps were arranged so that low capacity (2 cfs) pumps were placed at in the shallow water level zone (1), middle capacity (3 cfs) pumps in the middle zone (2), and high capacity (4 cfs) pumps in the deeper water level zone (3), so as to mitigate the effect on groundwater level.

2) For arsenic pollution of groundwater, the WHO guideline for an arsenic concentration of lower than 10 μg/L was set as the adoption criteria for the project. Therefore, for the tubewells with an arsenic concentration of not lower than 10 μg/L, the installation of filtration plants by WASA is the precondition of the project. Although the tubewells showed an arsenic concentration of lower than 10 μg/L at the JICA survey in July 2013 were adopted for the project, this may still have the possibility to show an arsenic concentration of not lower than 10 μg/L in the water quality confirmation test to be conducted after its completion. The installation of filtration plants by WASA is also applied to such tubewells. WASA is responsible for the awareness campaign to promote the use of public faucets attached to filtration plants. For tubewells showing an arsenic concentration of not lower than 10 μg/L, the priority for the inclusion of the project is given to tubewells with lower arsenic concentration in order to minimize the human health damage when drinking tap water for those who will not use the public faucets.

In relation to the above, the energy audit instruments will be procured, and in the soft component, how to use the energy audit instruments, how to analyze the collected operational data and how to improve the operation manner based on the results will be studied with the support of the consultants.

The facility/equipment to be included in the project is summarized below.

1) Civil and Building

(a) Tubewell construction: 105 locations

・ Tubewell (Capacity: 5.1~6.8m^3/min, Design SWL in 2031: < GL -35m): 8 wells

・ Tubewell (Capacity: 5.1~6.8m^3/min, Design SWL in 2031: GL-35m~-65m) : 88 wells

・ Tubewell (Capacity: 3.4m^3/min, Design SWL in 2031: GL-35m~-65m) : 9 wells

Note: It is assumed that a filtration plant will be installed by WASA at a tubewell with an arsenic concentration of not lower than 10 μg/L.

(b) Tubewell Pumping Station Building: 105 locations

・ Tubewell Pumping Station (Brick, Floor area: approx. 31.5 m2 with furniture)

(c) Connection Pipe Installation

・ HDPEection Pi: 105 locations

2) Mechanical/Electrical Equipment Installation

(a) Tubewell Pump

・ Tubewell pump (Discharge: 6.8m3/min, Head: 51/47m, Output: 90/75kW): 41units

・ Tubewell pump (Discharge: 5.1m3/min, Head: 64/62m, Output: 90/75kW): 55 units

・ Tubewell pump (Discharge: 3.4m3/min, Head: 64m, Output: 75kW): 9 units

(b) Pump Accessories

・ Valve (check valve/sluice valve/air valve), Turbine type flow meter, Piping, etc.: 105 locations

・ Disinfection equipment (Storage tank, diaphragm pump): 105 locations

・ Motor as stand-by (90/75/55kW), Chainblock: One (1) unit for each town

(c) Electrical Equipment

・ Power Control panel (for 90/75kW): 105panels

・ Wiring: 105 locations

・ Water level meter: 10 units

・ Spare parts: One (1) set for each town

3) Instrument Supply for Energy Audit: Two (2) sets

・ Power analyzer, Portable ultrasonic flow meter, Water level meter, etc.

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Tubewells

The replacement of 105 tubewell pumping stations with less production capacity composed of a tubewell, pumping station building, mechanical equipment such as pump, motor, etc. and electrical equipment was requested by WASA Lahore. A total of 147 existing tubewell pumping stations were proposed as the candidates for the project. For this purpose, the exclusion criteria from the project and adoption criteria for the project were established to select 105 tubewells out of 147 tubewells in accordance with the procedures as described below.

(1) Exclusion Criteria from the Project

The exclusion criteria from the project are as follows:

1) Tubewell that an alternative tubewell has been already constructed by WASA
2) Tubewell with a pumping capacity almost equal to a design capacity
3) Tuvewell that the land for a pumping station is not available
4) Tubewell to be located in an private land
5) The drainage facility during a pumping test is not available
6) The tubewell site requiring the abandonment of an existing structure
7) The limited land space to construct a pumping station

1) Tubewell that an alternative tubewell has been already constructed by WASA (Ⓐ in **Figure 2-1**)

Due to the inadequate intelligence sharing within WASA, one site as shown in **Table 2-1** was reported that 22 alternative tubewells have been already constructed by WASA, and this shall be excluded from the project.

Table 2-1 Proposed Tubewell Being Already Replaced by WASA

No.	Location	Sub-District	Installation Year	Design Capacity (cfs)	Remarks
29	Khokhar Road No.III	Data Nagar	1996	4	-
9	Patiala Ground	Anarkali	1990	4	*
75	Shadman Market	Mozang	1990	4	*
142	E-Block Tajpura	Tajpura	1987	2	*
13	Royal Park	Anarkali	1995	4	*
45	B-I Block Gulberg (A-Block Gulberg)	Gulberg	1998	4	*
69	A-Block Johar town	Johar Town	2001	4	*
68	A-III Johar Town	Johar Town	1985	3	*

73	Jinah Park	Misri Shah	1996	4	*
74	Faiz Bagh	Misri Shah	1998	2	*
15	Salamatpura Takkia (Village)	Baghbanpura	1998	4	*
46	Mehboob Park, Ichra	Icchra	2001	4	*
88	Daras Barey Mian	Mughalpura	1997	4	*
106	Karim Park Old	Ravi Road	1990	4	*
25	Sharanwala Gate	City	1998	4	*
14	Suraya Jabeen Park	Baghbanpura	2003	4	*
109	Main Out Fall No.1	Ravi Road	1992	4	*
21	Iqbal Park-III	City	1998	4	*
132	Paracha Colony	Shahdara	1995	2	*
33	Latif Chowk (Wandala Road)	Farrukhabad	1994	4	*
139	Baghay Shah	Shimla Hill	1986	2	*
123	Chah Miran (Old)	Shadbagh	1995	4	*

Note: The tubewells with an asterisk (*) were added by WASA in the letter dated March 22, 2014.

2) Tubewell with a pumping capacity almost equal to a design capacity (Ⓑ in **Figure 2-1**)

Tubewells as listed in **Table 2-2** have been identified to have a pumping capacity almost equal to a design capacity through actual flow measurement during the study and to be still useable as these fall below the lifespan of 15 years, and are therfore are excluded from the project.

Table 2-2 Proposed Tubewells to Be Used Continuously

No.	Name of TW	Installation Year	Design capacity (A) (L/min)	Actual (B) (L/min)	Rate =(A)/(B)*100 (%)	WL from GL (m)
Design Capacity：4 cfs (6,798 L/min)						
5	Ravi Block	1998	6,798	7,160	105	25
36	D-1 Block-Ill (3-D-2)	1999	6,798	7,092	104	25
Design Capacity：2 cfs (3,360 L/min)						
35	3-D-1	2001	3,360	4,872	145	25
112	B-Block Sabzazar	2002	3,360	4,068	121	-
135	Larex Colony	2004	3,360	3,374	100	-

3) Tubewell that the land for a pumping station is not available (Ⓒ in **Figure 2-1**)

The sites proposed for alternative tubewell installation are public land owned by PHA (Parks and Horticulture Authority), CDGL (City District Government Lahore), AUQAF Dept., Education Dept., Forest Dept., Railway Dept., TMA, etc. other than WASA and are mostly located within the same premises as the existing ones. However, g three tubewells as shown in **Table 2-3** are reported that have no land available for alternative tubewell installation and are accordingly excluded from the project.

Table 2-3 Proposed Tubewells with No Land Availability

No.	Location	Sub-District	Installation Year	Design Capacity (cfs)	Remarks
53	Baba Farid Colony	Industrial Area	1996	4	-
54	Mian Fazal Haq Colony	Industrial Area	1999	4	-
104	Sardar Chapar	Ravi Road	1993	4	-

4) Private Land (Ⓓ in **Figure 2-1**)

Currently, the project is classified into Category C under the JICA Guidelines for Environmental and Social Consideration with a prospect that there is no special environmental and social issue, since the project is, in nature, to install alternative tubewells for existing ones and all the sites used for alternative tubewell installation are provided at public lands. Although three sites, namely Jia Musa (No.32), Sanda Patwar LKhana (No.63) and Paracha Colony (No.132) are reported as "sham lot" (community's common-beneficial land), the inquiry was made WASA for clarification of its nature. WASA confirmed in the letter with No. DMD(E)/1434-37 dated 08.11.2013, that "sham lot" is the government land, therefore there is no requirement of transfer the ownership to WAS and no procedure would be involved and WASA would not have to make any payment. Hence, there is no site requiring any compensation.

5) No Availability of Drainage Facility during A Pumping Test (Ⓔ in **Figure 2-1**)

In the pumping test at the completion of a tubewell, abundant groundwater pumped up is usually discharged into stormwater drainage facilities or a sewerage system. One site is excluded from the project due to non-availability of proper drainage facility nearby.

Table 2-4 Proposed Tubewell with No Availability of Drainage Facilities

No.	Location	Sub-District	Installation Year	Design Capacity (cfs)	Remarks
106	Akram Park, Bund Road	Ravi Road	1990	2	-

6) Tubewells requiring the removal of existing facilities (Ⓕ in **Figure 2-1**)

Since the proposed tubewells as shown in **Table 2-5** require the removal of some existing structures, they are excluded from the project.

Table 2-5 Proposed Tubewells Requiring the Removal of Existing Facilities

No.	Location	Sub-District	Installation Year	Design Capacity (cfs)	Existing Structure
59	Nonarian	Islampura	1987	4	Existing T/W
118	Juggian Shahab Din	Samanabad	1997	4	Existing T/W
134	Ghazi Muhala Children Park	Shimula Hill	1986	4	Fountain

7) Tubewells with limited site space (Ⓖ in **Figure 2-1**)

Since the sites for proposed tubewells as shown in **Table 2-6** are so limited to arrange a tubewell pumping station or conduct the construction work, these are excluded from the project.

Table 2-6 Proposed Tubewells with Limited Site Space

No.	Location	Sub-District	Installation Year	Design Capacity (cfs)	Remarks
18	Dhobi Ghat	Bagbanpura	1998	4	
42	Zafar Ali Road / Jail Road	Gulberg	1996	4	
102	Bilal Ganj	Ravi Road	1993	4	

(2) Adoption Criteria from the Project

The proposed tubewells to meet the following conditions will be adopted for the project among those not against the previous "(1) Exclusion Criteria from the Project"

1) Proposed tubewells with an existing filtration plant
2) Proposed tubewells with an arsenic concentration of lower than 10 μg/L in groundwater without a filtration plant
3) Proposed tubewells with a filtration plant to be installed by WASA in future, although an arsenic concentration is not lower than 10 μg/L in groundwater

1) Proposed tubewells with an existing filtration plant (Ⓗ in **Figure 2-1**)

It is expected that WASA will install 100 filtration plant within two years from 2012 to 2013, out of which 78 plants are already in operation, 16 plants are under installation, and the remaining six plants have not yet been fixed as to their locations, as of September 2013, including eight other plants which are not for the tubewells but for places such as zoo, school, etc. where the people gather.

As shown in **Figure 2-7**, out of remaining 110 tubewells not restricted with the above exclusion criteria, 13 tubewells have been already provided with a filtration plant.

Table 2-7 Proposed Tubewells with an Existing Filtration Plant

No.	Location of A Filtration Plant	Sub-Division	Installation Year	Design Capacity (cfs)	As. Conc,. (ug/L)
58	A-Block Gulsahn-e-Ravi	Islampura	1998	4	9
10	Rashi Bhawan (Pathi Ground)	Anarkali	2002	2	12
146	Q-Block Model Town EXT	Township	1986	4	15
70	Mustafa Town	Johar Town	1997	4	16
22	Chomala	City	2005	2	20
51	Block No.6 Sector-A-II Township	Industrial Area	1996	4	20
144	A-Block Tajpura	Tajpura	1986	2	21
93	Shah Kamal	Mughalpura	1998	4	23
121	Taj Pura Ground	Shadbagh	1995	4	23
6	Abdul Karim Road (Mela Ram Park)	Anarkali	2003	2	26
65	National Town Sandha (at Jhangir Park)	Islampura	1996	4	30
129	Takia Khusrianwala Shahdara	Shahdara	1989	4	33
26	Ali Park	City	1998	4	34

1) Proposed tubewells with arsenic concentration of lower than 10 μg/L in groundwater without a filtration plant (Ⓘ in **Figure 2-1**)

There are four tubewells where arsenic concentration in the groundwater is lower than 10μg/L, as shown **Table 2-8**. It should be noted that arsenic concentrations at specified tubewells varied in the respective surveys and that there is a possibility that the arsenic concentration will show a value of not lower than 10 μg/L at the water quality confirmatory test to be undertaken after the completion of a tubewell, even at tubewells with an arsenic concentration of lower than 10 μg/L in groundwater based on the JICA survey. In such a case, the installation of a filtration plant by WASA will be the pre-condition for project implementation.

Table 2-8 Proposed Tubewells with an Existing Filtration Plant

No.	Location of A Filtration Plant	Sub-Division	Installation Year	Design Capacity (cfs)	As. Conc,. (ug/L)
11	Circular Road (Guru Argum Nagar)	Anarkali	1988	4	<5
104	Sardar Chapal	Ravi Road	1993	4	6
127	Shish Mehal Road (at Nazmabad)	Shadbagh	1994	4	6
147	S-Block Model Town Ext.	Township	1996	4	9

3) Proposed tubewells with a filtration plant to be installed by WASA in the future,

although an arsenic concentration of not lower than 10 μg/L in groundwater (Ⓚ in **Figure 2-1**)

Since 2012, WASA has already commenced the installation of 100 filtration plants for the tubewells with an arsenic concentration of not lower than 20 μg/L in groundwater in the PUIC survey and these will be completed within 2013. In addition, PC-1 Form for another 100 filtration plant installations have already been submitted to the Punjab Provincial Government for approval. Water is supplied through a public faucet system, thus limiting the benefits to the people who are to fetch water from the public faucet, but not those connected to the piped water supply. Although water use is limited to drinking and cooking purposes, it is considered as an effective approach to remove the risk on the human health. Therefore, out of proposed tubewells with no plan to install a filtration plant but with an arsenic concentration of not lower than 10 μg/L in the groundwater, the balance will be selected from among tubewells under the condition that a filtration plant will be installed by WASA, and the priority is given to tubewells with lower arsenic concentrations in groundwater, to minimize the risk on the human health, taking into account that there are some people who drink the arsenic-polluted tap water in spite of the awareness campaign to use the public faucets connected to the filtration plant. As a result, 88 tubewells selected for the project have arsenic concentrations in the range of 10 μg/L to 44 μg/L as shown in **Table 2-9**. There are two tubewells with an arsenic concentration of 44 μg/L, the priority is given to an older one.

Table 2-9 Proposed Tubewells with a Condition for Installation of a Filtration Plant

No.	Location of A Filtration Plant	Sub-Division	Installation Year	Design Capacity (cfs)	As. Conc,. (ug/L)
114	D-Block Sabzazar	Sabzazar	1987	2	10
66	Rustam Park	Islampura	1993	4	15
28	Raheem Road Data Nagar	Data Nagar	1998	4	16
37	D-II Block-IV	Green Town	1997	4	16
63	Sanda Patwar Khana	Islampura	1997	4	16
7	Nisar Scheme Qila Gujjar Singh	Anarkali	1996	4	17
84	Sadi Park.	Mozang	1994	4	18
38	Tanki No.4 Township (Abandoned)	Green Town	1985	1	19
39	Tanki No.3 Township (No motor)	Green Town	1985	1	19
48	C-Block Muslim Town	Icchra	1998	4	19
79	Faseeh Road	Mozang	2002	4	19
82	Shah Jamal.	Mozang	1993	4	19
89	Kotli Pir Abdur Rehman	Mughalpura	2001	4	19
122	Shahab Stadium (Fazal pura)	Shadbagh	1998	4	19
1	Huma Block	A.I.T	2002	4	20
49	Fareed Colony Printing Press	Industrial Area	1999	4	20

No.	Location of A Filtration Plant	Sub-Division	Installation Year	Design Capacity (cfs)	As. Conc,. (ug/L)
119	Children Park	Shadbagh	1985	2	20
41	Henry Key (Old)	Gulberg	1986	2	21
52	Block No.4 Sector-A-II Township	Industrial Area	1993	4	21
97	Canal Bridge	Mustafabad	1995	4	21
137	Scotch Cornor / Upper Mall	Shimla Hill	2002	4	21
143	Ghaziabad Bus Stop	Tajpura	1980	4	21
31	Siddique Pura	Data Nagar	1995	4	22
40	Gawala Colony No.1	Green Town	1993	2	22
44	WASA Head Office (at FCC Block.)	Gulberg	1996	4	22
50	Nishtar Colony	Industrial Area	1987	2	22
56	Rifle Range	Islampura	1992	4	22
92	Gulshan Park	Mughalpura	1993	4	22
98	Gulistan Colony	Mustafabad	1995	4	22
108	Ibrahim Road	Ravi Road	1992	4	22
145	Jorrey Pull	Tajpura	1992	4	22
8	Dhobi Mandi	Anarkali	2004	2	23
55	B-Block Gulsahn-E-Ravi	Islampura	1998	4	23
61	Jaffria Colony	Islampura	1990	4	23
81	Sui Gas Engine Lytton Road (at Kot Adullah Shah)	Mozang	1986	4	23
85	Jail Road (Lahore Collage)	Mozang	1992	2	23
111	K-Block Sabzazar	Sabzazar	1987	2	23
138	Muhammad Nagar.	Shimla Hill	1990	4	23
3	Pak Block	A.I.T	1986	4	24
30	Hussain Park	Data Nagar	2002	4	24
43	M-Block Gulberg (at Gupel Nagae P-Bk.)	Gulberg	1997	4	24
57	Bilal Park Shamnagar	Islampura	1992	4	24
67	E-I Johar Town	Johar Town	2004	2	24
72	D-Block China Scheme (Gujjar Pura)	Misri Shah	1993	4	24
96	Achant Garh	Mughalpura	2003	2	24
116	Ittehad Colony Samanbad	Samanabad	1996	4	24
126	Shadbagh Well Centre-IV	Shadbagh	1995	4	24
136	Tegore Park	Shimla Hill	1992	4	24
4	Jahanzaib Block	A.I.T	1986	4	25
12	Hilton Hotel (at Mason Road.)	Anarkali	1977	4	25
19	Madhu Lal Hussain	Baghbanpura	1999	4	25
94	Lal Pul Fayyaz Park	Mughalpura	1998	4	25
117	Pir Buddan Shah Dholanwal	Samanabad	1991	4	25
77	Queens Road	Mozang	1992	4	26
90	Punj Pir	Mughalpura	1991	4	26
110	E-Block Sabzazar	Sabzazar	1987	2	26
115	N-Block,Samanabad	Samanabad	1995	4	26
17	Milap Street	Baghbanpura	1996	4	27

No.	Location of A Filtration Plant	Sub-Division	Installation Year	Design Capacity (cfs)	As. Conc,. (ug/L)
47	A-Block Muslim Town	Icchra	1993	4	27
60	Sodiwal Quarter	Islampura	1993	4	27
62	Rewaz Gardan	Islampura	1991	4	27
78	Shah Shamas Qari (at Patyala House.)	Mozang	1987	2	27
101	Mohni Road Salmat Mohalla	Ravi Road	1998	4	27
16	Shah Gohar Abad	Baghbanpura	1992	4	28
124	Shadbagh Well Centre-I	Shadbagh	1995	4	28
71	Kanji House Misri Shah	Misri Shah	1998	4	29
91	Sansi Quarter	Mughalpura	1996	4	29
24	Sabzi Mandi (F&V Market)	City	1993	4	30
131	Saeed Park.	Shahdara	1998	4	30
87	Angori Bagh Scheme-II	Mughalpura	2001	2	31
105	MC High School Sanda	Ravi Road	1997	4	31
140	Habib Ullah Road	Shimla Hill	1997	4	31
99	Dev Samaj Road (Commisioner Office)	Ravi Road	1998	4	32
141	Ahmad Block	Garden Town	2004	2	32
76	Katcha Temple Road (Abid Market)	Mozang	2004	2	33
80	Shadman-I Rehmania Park	Mozang	1995	4	33
2	Neelam Block	A.I.T	2007	4	34
20	Iqbal Park-I	City	1998	4	34
120	Yasrab Colony	Shadbagh	1994	4	34
125	Shadbagh Well Centre-II	Shadbagh	1995	4	34
113	A-Block Sabzazar	Sabzazar	1997	2	37
100	Islampura	Ravi Road	1991	4	38
23	Iqbal Partk Fort (Not sampled)	City	2002	4	39
27	Iqbal Park-II (Abandoned)	City	1998	4	39
86	Mujahidabad (Not sampled)	Mughalpura	1997	4	39
83	Shadman Mental Reservoir	Mozang	1978	4	40
130	G.T.Road Shahdara	Shahdara	1990	4	41
34	Farrukh Abad Disposal	Farrukhabad	1998	4	44

Note: The priority is given to tubewell with a lower arsenic concentration than others.

At the time of the second field survey, one tubewell was already replaced by WASA emergently, but at the time of explanation and discussion of the Draft Final Report, 21 tubewells were additionally replaced. Since such replacement will also extectedly occur in the selected 105 tubewells by the time of project implementation, the remaining five tubewells shall be the substitution A for such emergent replacement

Table 2-10 Proposed Tubewells for Substitution A

No.	Location of A Filtration Plant	Sub-Division	Installation Year	Design Capacity (cfs)	As. Conc,. (ug/L)
95	Seher Road	Mughalpura	2003	2	44
64	Raj Garh Office	Islampura	1978	4	45
32	Jia Musa	Farrukhabad	2003	2	54
133	Latif Park (Abandoned)	Shahdara	1993	2	59
128	Majeed Park Shahdara	Shahdara	1997	2	106

Nine tubewells excluded from the project with the reasons stated in the above (1) 3) to 7) shall be the subsitution B for emergent replacement with the condition that the cause for exclusion will be cleared, except for one tubewell that an alternative site cannot be arranged.

Table 2-11 Proposed Tubewells for Substitution B

No.	Location of A Filtration Plant	Sub-Division	Installation Year	Design Capacity (cfs)	As. Conc,. (ug/L)
54	Mian Fazal Haq Colony	Industrial Area	1999	4	15
102	Bilal Ganji	Ravi Road	1993	4	20
42	Zafar Ali Road / Jail Road	Gulberg	1996	4	21
53	Baba Farid Colony	Industrial Area	1996	4	24
134	Ghazi Muhala Children Park	Shimla Hill	1986	4	25
59	Nonarian	Islampura	1997	4	27
118	Juggian Shahab Din	Samanabad	1997	4	27
18	Dhobi Ghat.	Baghbanpura	1998	4	29
107	Akram Park, Bund Road	Ravi Road	1990	2	47

Note: Substitution A prevails over Substitution B.

(3) Selection of Tubewells for the Project

The algorithm for the selection of tubewells for the project is shown in **Figure 2-1** based on the criteria as described earlier.

The tubewells selected for the project through the above algorithm are composed of:

Group A: 13 tubewells with an existing filtration plant

Group B: 4 tubewells with an arsenic concentration of not lower than 10 μg/L

Group C: 88 tubewells with an arsenic concentration of not lower than 10μg/L under the condition that a filtration plant will be constructed by WASA

The following tubewells is the substitutions for those that will be emergently replaced by WASA.

Substitution A: 5 tubewells

Substitution B: 9 tubewells with the condition that the cause for exclusion will be cleared

Table 2-12 shows the summary of proposed tubewells with the reasons behind their exclusion from or adoption for the project; and **Figure 2-2** indicates the location of 105 tubewells selected for the Project.

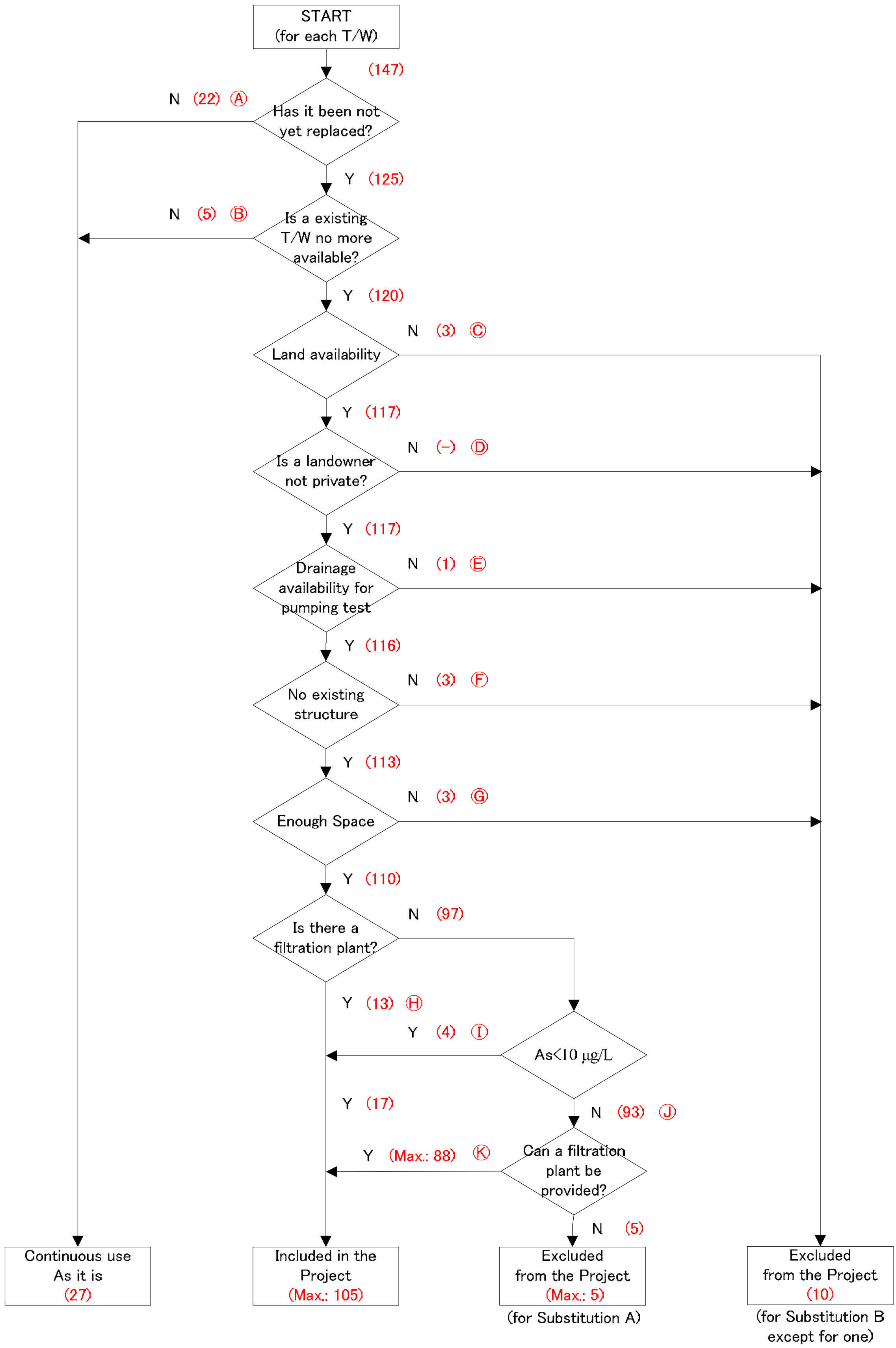


Figure 2-1 Algorithm for the Selection of Tubewells for the Project and Its Result

Table 2-12 Summary of Proposed Tubewells with Reasons of Exclusion from or Adoption for the Project

Sr. No.	Name of T/W	Arsenic (μg/L)	Site Conditions: Replaced	T/W Still Available	Land Availability	Private	Drainage Availability	Existing Structure	Limited Space	Filtration Plant	Arsenic Concentration ((μg/L) (July 2013)	Category	Situation
1	Huma Block	20									20	C	
2	Neelam Block	34									34	C	
3	Pak Block	24									24	C	
4	Jahanzaib Block	25									25	C	
5	Ravi Block	23		●							23		Still available
6	Abdul Karim Road (Mela Ram Park)	26								●	26	A	
7	Nisar Scheme Qila Gujjar Singh	17									17	C	
8	Dhobi Mandi	23									23	C	
9	Patiala Ground	5	●							●	5		To be replaced
10	Rashi Bhawan (Pathi Ground)	12								●	12	A	
11	Circular Road (Guru Argum Nagar)	5									5	B	
12	Hilton Hotel (at Mason Road.)	25									25	C	
13	Royal Park	17	●								17		To be replaced
14	Suraya Jabeen Park	33	●								33		To be replaced
15	Salamatpura Takkia (Village)	24	●							●	24		To be replaced
16	Shah Gohar Abad	28									28	C	
17	Milap Street	27									27	C	
18	Dhobi Ghat.	29							●	●	29	S-B	Alternative land will be arranged
19	Madhu Lal Hussain	25									25	C	
20	Iqbal Park-I	34									34	C	
21	Iqbal Park-III	39	●							●	39		To be replaced
22	Chomala	20								●	20	A	
23	Iqbal Partk Fort (Not sampled)	39									39	C	
24	Sabzi Mandi (F&V Market)	30									30	C	
25	Sharanwala Gate	32	●							●	32		To be replaced
26	Ali Park	34								●	34	A	
27	Iqbal Park-II (Abandoned)	39									39	C	
28	Raheem Road Data Nagar	16									16	C	
29	Khokhar Road No.III	29	●								29		Replaced
30	Hussain Park	24									24	C	
31	Siddique Pura	22									22	C	
32	Jia Musa	54									54	S-A	
33	Latif Chowk (Wandala Road)	44	●							●	44		To be replaced
34	Farrukh Abad Disposal	44									44	C	
35	3-D-I	16		●							16		Still available
36	D-I Block-III (Not sampled)	29		●							29		Still available
37	D-II Block-IV	16									16	C	
38	Tanki No.4 Township (Abandoned)	19									19	C	
39	Tanki No.3 Township (No motor)	19									19	C	
40	Gawala Colony No.1	22									22	C	
41	Henry Key (Old)	21									21	C	
42	Zafar Ali Road / Jail Road	21							●		21	S-B	Alternative land will be arranged
43	M-Block Gulberg (at Gupel Nagae P-Bk.)	24									24	C	
44	WASA Head Office (at FCC Block.)	22									22	C	
45	B-I Block Gulberg (A-Block Gulberg)	17	●								17		To be replaced
46	Mehboob Park, Ichra	27	●								27		To be replaced
47	A-Block Muslim Town	27									27	C	
48	C-Block Muslim Town	19									19	C	
49	Fareed Colony Printing Press	20									20	C	
50	Nishtar Colony	22									22	C	
51	Block No.6 Sector-A-II Township	20								●	20	A	
52	Block No.4 Sector-A-II Township	21									21	C	
53	Baba Farid Colony	24			●						24	S-B	Alternative land will be arranged
54	Mian Fazal Haq Colony	15			●						15	S-B	Alternative land will be arranged
55	B-Block Gulsahn-E-Ravi	23									23	C	
56	Rifle Range	22									22	C	
57	Bilal Park Shamnagar	24									24	C	
58	A-Block Gulsahn-e-Ravi	9								●	9	A	
59	Nonarian	27						●		●	27	S-B	Existing structure will be removed
60	Sodiwal Quarter	27									27	C	
61	Jaffria Colony	23									23	C	
62	Rewaz Gardan	27									27	C	
63	Sanda Patwar Khana	16									16	C	
64	Raj Garh Office	45									45	S-A	
65	National Town Sandha (at Jhangir Park)	30								●	30	A	
66	Rustam Park	15									15	C	
67	E-I Johar Town	24									24	C	
68	A-III Johar Town	23	●							●	23		To be replaced
69	A-Block Johar town	20	●								20		To be replaced
70	Mustafa Town	16								●	16	A	
71	Kanji House Misri Shah	29									29	C	
72	D-Block China Scheme (Gujjar Pura)	24									24	C	
73	Jinah Park	23	●								23		To be replaced
74	Faiz Bagh	23	●								23		To be replaced
75	Shadman Market	16	●							●	16		To be replaced
76	Katcha Temple Road (Abid Market)	33									33	C	
77	Queens Road	26									26	C	
78	Shah Shamas Qari (at Patyala House.)	27									27	C	
79	Faseeh Road	19									19	C	
80	Shadman-I Rehmania Park	33									33	C	

Table 2-12 Summary of Proposed Tubewells with Reasons of Exclusion from or Adoption for the Project (Cont'd)

Sr. No.	Name of T/W	Arsenic (μg/L)	Site Conditions: Replaced	T/W Still Available	Land Availability	Private	Drainage Availability	Existing Structure	Limited Space	Filtration Plant	Arsenic Concentration ((μg/L) (July 2013) 10 / 20 / 30 / 40 / 50 / ≥50	Category	Situation
81	Sui Gas Engine Lytton Road (at Kot Adullah Shah)	23									23	C	
82	Shah Jamal.	19									19	C	
83	Shadman Mental Reservoir	40									40	C	
84	Sadi Park.	18									18	C	
85	Jail Road (Lahore Collage)	23									23	C	
86	Mujahidabad (Not sampled)	39									39	C	
87	Angori Bagh Scheme-II	31									31	C	
88	Daras Barey Mian	30	●								30		To be replaced
89	Kotli Pir Abdur Rehman	19									19	C	
90	Punj Pir	26									26	C	
91	Sansi Quarter	29									29	C	
92	Gulshan Park	22									22	C	
93	Shah Kamal	23								●	23	A	
94	Lal Pul Fayyaz Park	25									25	C	
95	Seher Road	44								●	44	S-A	
96	Achant Garh	24									24	C	
97	Canal Bridge	21									21	C	
98	Gulistan Colony	22									22	C	
99	Dev Samaj Road (Commisioner Office)	32									32	C	
100	Islampura	38									38	C	
101	Mohni Road Salmat Mohalla	27									27	C	
102	Bilal Ganji	20							●		20	S-B	Alternative land will be arranged
103	Yasir Road	26			●						26		No available land
104	Sardar Chapal	6									6	B	
105	MC High School Sanda	31									31	C	
106	Karim Park Old	31	●							●	31		To be replaced
107	Akram Park, Bund Road	47					●				47	S-B	Arrangement for drainage will be made
108	Ibrahim Road	22									22	C	
109	Main Out Fall No.1	33	●							●	33		To be replaced
110	E-Block Sabzazar	26									26	C	
111	K-Block Sabzazar	23									23	C	
112	B-Block Sabzazar	27		●							27		Still available
113	A-Block Sabzazar	37									37	C	
114	D-Block Sabzazar	10									10	C	
115	N-Block,Samanabad	26									26	C	
116	Ittehad Colony Samanbad	24									24	C	
117	Pir Buddan Shah Dholanwal	25									25	C	
118	Juggian Shahab Din	27						●		●	27	S-B	Existing structure will be removed
119	Children Park	20									20	C	
120	Yasrab Colony	34									34	C	
121	Taj Pura Ground	23								●	23	A	
122	Shahab Stadium (Fazal pura)	19									19	C	
123	Chah Miran (Old)	26	●						●	●	26		To be replaced
124	Shadbagh Well Centre-I	28									28	C	
125	Shadbagh Well Centre-II	34									34	C	
126	Shadbagh Well Centre-IV	24									24	C	
127	Shish Mehal Road (at Nazmabad.)	6									6	B	
128	Majeed Park Shahdara	106									106	S-A	
129	Takia Khusrianwala Shahdara	33								●	33	A	
130	G.T.Road Shahdara	41									41	C	
131	Saeed Park.	30									30	C	
132	Paracha Colony	43	●								43		To be replaced
133	Latif Park (Abandoned)	59								●	59	S-A	
134	Ghazi Muhala Children Park	25						●			25	S-B	Existing structure will be removed
135	Larex Colony	27		●							27		Still available
136	Tegore Park	24									24	C	
137	Scotch Cornor / Upper Mall	21									21	C	
138	Muhammad Nagar.	23									23	C	
139	Baghay Shah	24	●						●		24		To be replaced
140	Habib Ullah Road	31									31	C	
141	Ahmad Block	32									32	C	
142	E-Block Tajpura	16	●							●	16		To be replaced
143	Ghaziabad Bus Stop	21									21	C	
144	A-Block Tajpura	21								●	21	A	
145	Jorrey Pull	22									22	C	
146	Q-Block Model Town EXT	15								●	15	A	
147	S-Block Model Town Ext.	9									9	B	

Note: **Category "A": Already has an existing filtration plant**
Category "B": An arsenic concentration is lower than the WHO guideline of 10 μg/L
Category "C": Included in the Project on the premise that WASA will install a filtration plant
Category "S-A": Substitution A
Category "S-B": Substitution B on the premise that cause for exclusion will be cleared

A	13
B	4
C	88
S-A	5
S-B	9

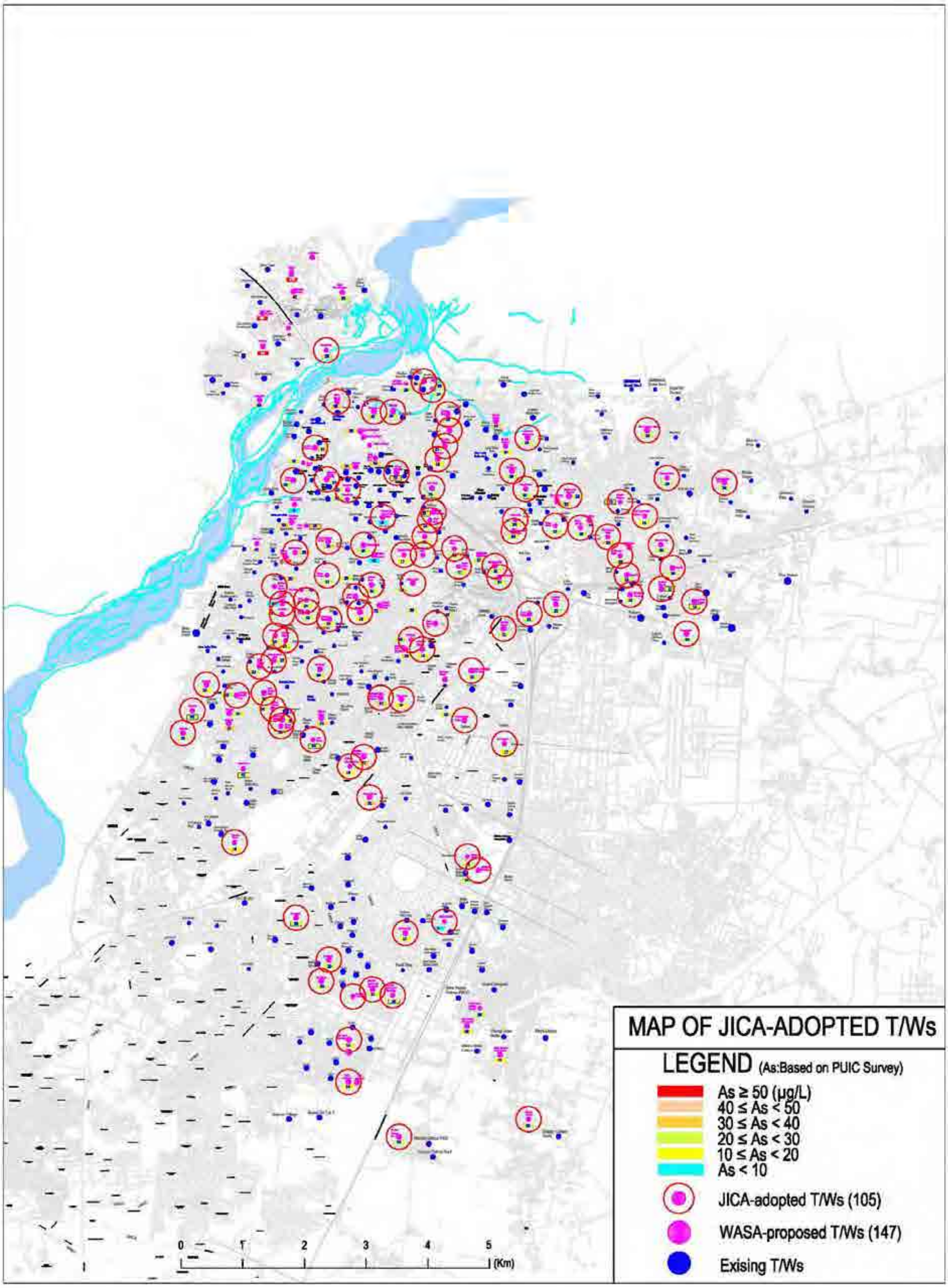


Figure 2-2 Location of 105 Tubewells Selected for the Project

2-2-1-2 Mechanical Equipment for Tubewell Pump Stations

(1) Tubewell Pump

1) Pump Type

The pumps to be installed at tubewells are commonly vertical shaft turbine pumps and submersible motor pumps. These pumps have different characteristics. To determine the appropriate pump type for tubewells application, it is necessary to understand the characteristics of the pumps, taking into account that the main purpose of the project is to maximise the energy saving in pump operation.

The general characteristics of pump types are compared in **Table 2-13**.

Table 2-13 Comparison of Pump Type

Title	Vertical shaft multistage turbine pump	Submersible motor pump
Stability of operation	Misalignment of shaft due to long shaft connecting pump and motor,	Stable
Pump efficiency	Good (approx. 80-83%)	Not good (approx. 74-79%)
Installation	Installation is difficult due to pump shaft is in the column pipe.	Installation is relatively easy
Maintenance for pump	Need to maintain pump gland	No need to maintain after installation
Maintenance for motor	Easy	Need to remove pump and column pipe with motor. (The motor is submerged)

Source: JICA Survey Team

In addition, the present repairing capability of pumps and motors at local workshops is shown in **Table 2-14**.

Table 2-14 Repairing Capability of Local Workshops

Title	Vertical shaft multistage turbine pump	Submersible motor pump
Pump	Possible	Possible
Motor	Possible	Impossible

From the above table, a submersible pump has advantages, such as stable operation, easy installation and easy pump maintenance, while a vertical shaft multistage turbine pump has good pump efficiency and motor maintenance. However, if motor burnout occurs, the local workshops can repair it in case of a turbine pump by rewinding; but this cannot be performed in case of a submersible pump.

WASA Lahore has used turbine pumps for tubewells in almost cases, and the exceptions at present are the 15 to 20 units of submersible pumps. The reason why WASA has been using turbine pumps is attributed to the repair capability of local workshops in case of frequent accidents of motor burnout. According to the annual record of motor repairing in 2012/13 at Shalimar Town O&M Office, WASA ordered the rewinding works for 20 units of turbine pump motors which is equivalent to 36% of a total of 55 pumps in the town. It means that on the average, one motor has encountered burnout once every three years. The causes of motor burnout are as follows:

- The power supply by LESCO is unstable due to frequent power failure, big voltage fluctuation, etc.
- Due to low voltage and so on, the wiring in the local control panels is modified so as to bypass the protection circuit in order to give the priority to the continuity of pump operation
- There is a high possibility that the rewinded motor can again have a burnout due to the reduction in efficiency and durability

Since it cannot be expected that such situation will be improved for the short-term, the vertical shaft multistage vertical pump shall be adopted due to the ease in rewinding burnout motors.

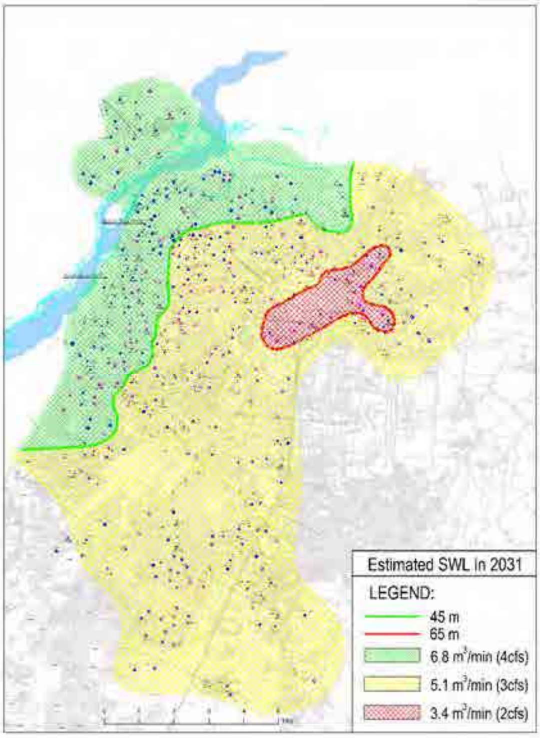
A high-efficiency motor has been considered as one method for efficient operation of a tubewell pump, but it is not adopted because of the current situation where burnout occurs very frequently.

2) Pump Capacity

Groundwater levels of tubewells in the target area of this project become deeper toward the center of Lahore and this situation has been progressing every year.

WASA had used the tubewell pumps with fixed capacities (mainly 6.8 m^3/min or 3.4 m^3/min), which had considered water demand in the area, but not the groundwater level. This caused the rapid drawdown of groundwater level in some areas. If this approach will continue to be applied in future, it is predicted that the drawdown of groundwater level will unavoidably progress at a faster rate than in the past.

Although increasing the water production from tubewells with deteriorated pump capacities is one of objectives of the project, to mitigate the groundwater level decline, the pumps are allocated with an idea that “the deeper the groundwater level, the lower the pump capacity”, taking into account the groundwater level by area. It is not unavoidable that the groundwater level will decline as the total water production itself will increase than the present, but it can mitigate or slow down its declining rate.



Source: JICA Survey Team

Figure 2-3 Pump Capacity

The design pump capacity of tubewells is set as shown in **Figure 2-3** on the basis of SWL in 2031 estimated in this survey.

To be installed at levels shallower than -45 m water level zone around the Ravi River are 6.8m^3/min (4 cfs) pumps, while 3.4 m3/min (2 cfs) pumps whall be installed in levels deeper than -65 m water level zone, and 5.1 m^3/min (3 cfs) pumps at the middle water level zone between -45 m to -65 m. By setting the design pump capacities at three steps, the total yield capacity can be kept close to the initial design capacity at a certain level. The comparison of pump capacities by zone under the proposed pump allocation is shown in **Table 2-15**.

Table 2-15 Comparison of Present and Proposed Pump Capacities

Zone	Content	Present Pump Capacity (Requested)		Proposed Pump Capacity	Quantity	Actual Pumpage (m^3/min)
		Design (cfs)	Actual (cfs)	Design (cfs)		
Shallower than -45m zone	Total	154	121.3	164	41	
	(not functioning)	(54)	(−)	(56)	(17)	−
	(operating)	(100)	(121.3)	(108)	(27)	206.1
	Rate (%)	100%	79%	106%		
-45m to -65m zone	Total	186	142.3	165	55	
	(not functioning)	(56)	(−)	(51)	(17)	−
	(operating)	(130)	(142.2)	(114)	(38)	241.6
	Rate (%)	100%	76%	89%		
Deeper than -65m zone	Total	36	18.7	18	9	
	(not functioning)	(−)	(−)	(−)	(−)	−
	(operating)	(36)	(18.7)	(18)	(9)	31.8
	Rate (%)	100%	52%	50%		
Whole area	Total	376	282.2	347	105	
	(not functioning)	(110)	(−)	(107)	(31)	−
	(operating)	(266)	(282.2)	(240)	(74)	479.5
	Rate (%)	100%	75%	92%		

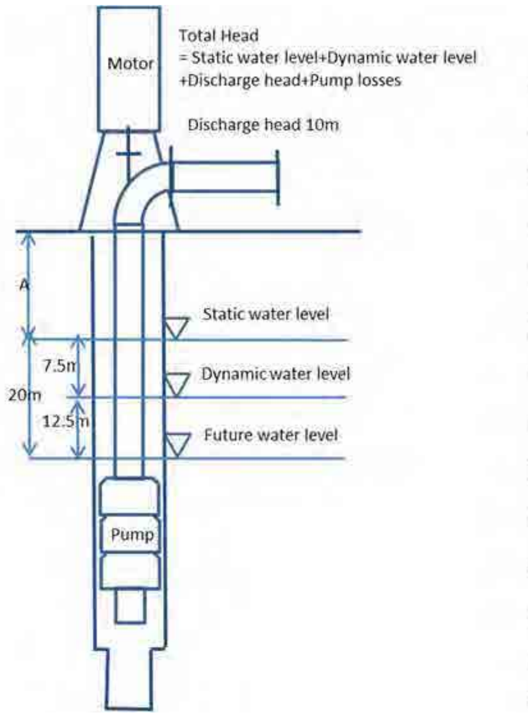
Source: JICA Survey Team

Note: The items in parentheses shows the breakdown of "Total".

The figures in the row of "Rate (%)" shows the percentage to the present design capacity which is set at 100%.

3) Pump Head

The idea for total pump head is shown in **Figure 2-4**. Since the pump head is set based on the present groundwater level, the pump discharge will be reduced when the groundwater level will slowly decline in the future.



Source: JICA Survey Team

Figure 2-4 Pump Head

Generally, the discharge pump head is composed of head difference between dynamic water level of a tubewell and discharge head such as high water level of a service reservoir, etc., pipeline friction loss, and pump loss and a residual head. The LDA design criteria define the minimum terminal pressure at 13.8 m (20 psi) and it is better to meet this requirement. However, the pipe is directly connected to grid distribution network and the pipe losses for each pump are difficult to calculate. The discharge head of an existing pump is set as approximately 10 m considering the actual measurement of some tubewells. In addition to the discharge head, the total pump head is determined by considering static head (water level in the tubewell to ground level), dynamic head and pump losses.

The concept of the total pump head is shown in **Figure 2-4**. However, it is unavoidable that the pump discharge will be reduced by the drawdown of groundwater level in a tubewells in the future.

The installation position of a pump is fixed based on the dynamic water level in 2031 which is set by the static water level in 2031 and loss during the operation (aquifer loss and tubewell loss). The water level and loss are different in the location. If the pump position is lowered more than required, longer the suction pipe and driving shaft are required causing the occurrence of vibration. For this reason, the pump will be set at 20 m below the static water level. When the dynamic water level will be lowered than this water level in the future, the suction pipe and driving shaft shall be lengthened at WASA's expense.

4) Pump Selection

Lahore WASA has procured a typical model of tubewell pumps with a capacity of 4 cfs (6.8 m^3/min = 408 m^3/hr) and discharge head of 64 m, when a new tubewell pump of 4 cfs is necessary. It is rather an inadequate pump selection for the particular model, although each tubewell has different well water levels.

The following table shows the comparison of pump efficiency and required power between WASA's standard 4 cfs pump and selected pumps for each typical application A/B/C as required for this project.

Also, operation points are shown in the pump performance curve in **Figure 2-16**.

Table 2-16 Typical Pump Operation for 6.8 m^3/min (4 cfs) Pumps

Operation		Capacity (m3/hr)	Head(m)	Efficiency (%)	Power (kW)	Diameter (mm)	Stage
Standard		408	64	82.5	21.7 x 4 = 86.8	260/252	4
A	Standard	408	57	77	22.5 x 4 = 90	260/252	4
	Selected			82	17 x 4 = 68	252/243	4
B	Standard	408	48	70	22 x 4 = 88	260/252	4
	Selected			83	16.5 x 3 = 49.5	260/252	3
C	Standard	408	33	60	22 x 4 = 88	260/252	4
	Selected			82	24 x 2 = 48	268/260	2

At Operation A, selected pump has smaller impellers than the standard pump and it improves pump efficiency from 77% to 82 %, reducing required power from 90 kW to 68 kW. Likewise, at Operation B, selected pump has three stages of impellers, instead four stages of a standard pump, and this improves pump efficiency from 70% to 83 %, reducing required power from 88 kW to 49.5 kW.

At Operation C, the standard pump is out of its operational range as shown in **Figure 2-5**. It has very high risks that the pump will be damaged by cavitation and the motor will be burnt due to over-current and over-heating. The selected pump with two stages of impellers improves pump efficiency from 60% to 82 %, thus reducing required power from 88 kW to 48 kW.

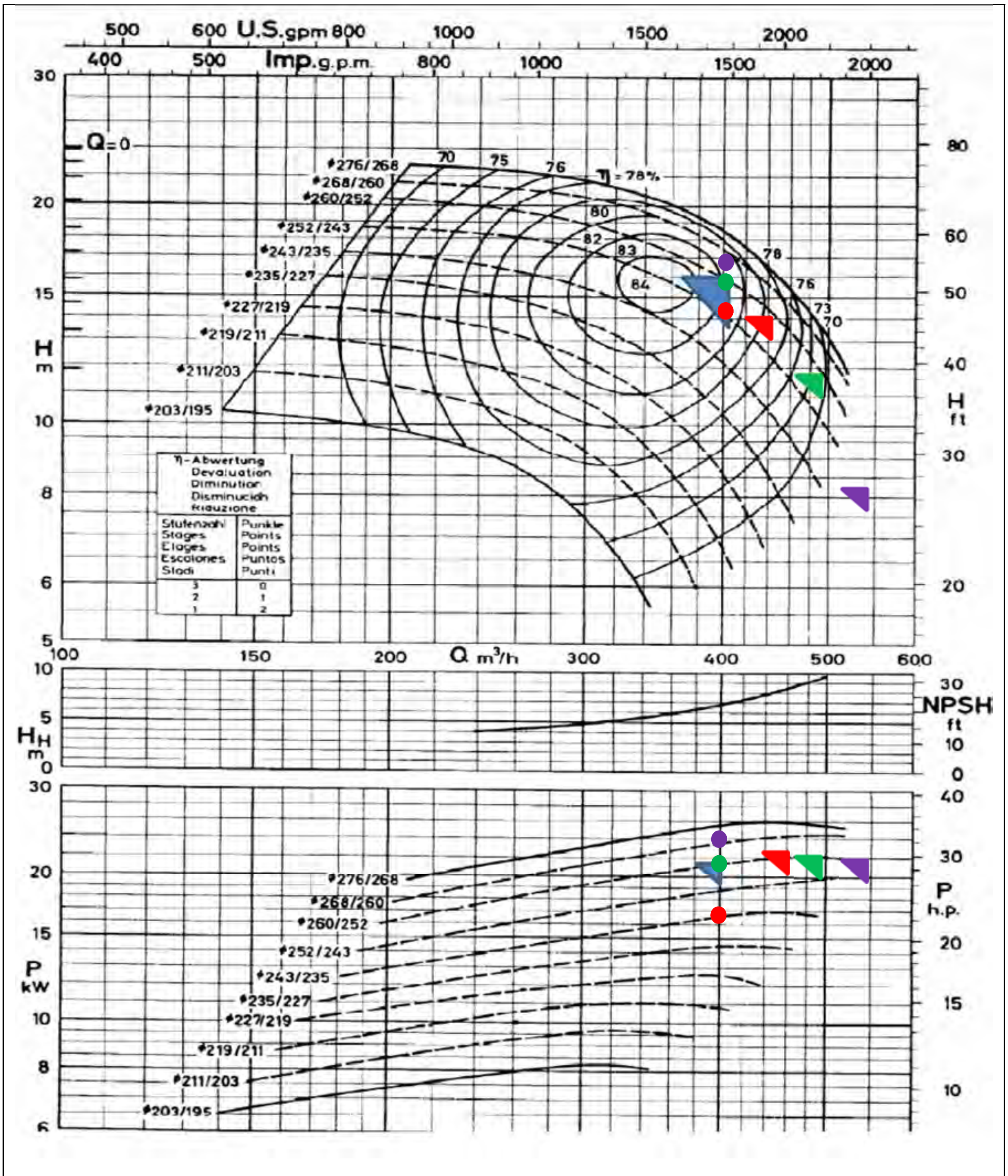


Figure 2-5 Typical Operation Points with 6.8 m^3/min (4 cfs) Pumps

Tubewell pumps will be installed at 105 tubewells in this project. It will be the best to select the most suitable and the highest efficiency pump at each tubewell, however, but this may affect the proper implementation of maintenance services due to wide variety of the pumps. Therefore one or two models will be selected for the pump capacity of 6.8 m^3/min (4 cfs), 5.1 m^3/min (3 cfs) and 3.4 m^3/min (2 cfs), in order to mitigate the difficulty of the maintenance.

(2) Disinfection equipment

Chlorine gas, sodium hypochlorite and calcium hypochlorite are commonly used as chemicals for disinfection in a water supply system. They are dosed by chlorinators or diaphragm pumps. The following table shows features of the chemicals and the systems.

Table 2-17 Characteristics of Chemicals and Systems

Chemical	Chlorine Gas	Sodium Hypochlorite (liquid)	Calcium Hypochlorite (solid)
Equipment	Chlorine Gas Cylinder Chlorinator Booster Pump Ejector	Storage Tank Diaphragm Pump	Storage Tank Diaphragm Pump Mixer
Feature (Advantage)	- Chemical is less cost.	- Chemicals are safe. - Dosing equipment is easy to handle. - Procurement is easy.	- Chemicals are safe. - Dosing equipment is easy to handle. -
(Disadvantage)	- Chlorine gas is easily to leak and make a serious damage. - Chlorine gas is difficult to handle. - Supply source shall be newly developed.	- Chemical is little more cost.	- Chemical is more cost. - Solid chemical is to be dissolved. - Supply source shall be newly developed.
Evaluation	Fair	Excellent	Good

Source: JICA Survey Team

The comparison shows the advantages of liquid sodium hypochlorite currently used in WASA than chlorine gas or solid calcium hypochlorite. However, most of the diaphragm pumps are currently out of order and it is recommended to provide a spare pump unit to secure the continuous operation.

The disinfection facilities shall consist of a storage tank with an one-day capacity and two diaphragm pumps (one as a duty and one as a standby).

2-2-1-3 Electrical Equipment for Tubewell Pump Stations

Thefollowing are taken into consideration in the design policy for the electrical components of the tubewell pumps.

1) Selection of transformer size that meets motor output rating and its starter type,
2) Selection of motor starter type that corresponds to the transformer size and other conditions,
3) Application of proper protection devices against the abnormal conditions due to short

circuit, overloads etc.,

4) Application of temperature sensors to motor stator windings as direct protection device for the motor and,
5) Application of static capacitors to improve power factor properly.

In addition to the above items, level transmitters are also studied to seek their necessity/suitability for monitoring the ground water levels at some proposed tubewell sites based on the three groups categorized as per their current ground water levels.

2-2-2 Basic Plan (Construction Plan / Procurement Plan)

(1) Tubewell Pump Stations

1) Tubewell

In the design of well structure for the well capacity of 6.8 m^3/min. (4 cfs) and 3.4 m^3/min.. (2 cfs), the following have to be satisfied from the safety point of view.

(a) Diameter of deep wells is designed as the quasi-standard specification of WASA deep wells. Thus, deep wells for 6.8 m^3/min. (4 cfs) have the specification of pump casings with the diameter of 20” (500 mm) and screen casings with diameter of 10” (250 mm); those for 3.4 m^3/min (2 cfs) have the specification of pump casings with the diameter of 18” (450 mm) and screen casings with the diameter of 8” (200 mm).
(b) Screen has vertical slit structure with opening ratio of 10 % and shall be of locally made.
(c) Planned drawdown of dynamic water level is designed by the measured maximum value of 18.75 m≒19 m in the study.
(d) Clearance between the pump suction and the screen casing is designed to be 3 m, based on experience.
(e) Extra length of pump room casing is set up as 8 m.
(f) Overlap length between the pump room casing and the screen casing in well structure is designed to be 9 m.
(g) Total length of screens is designed to be about 30 % of the total length of deep wells, and also, the inflow speed of groundwater into screens is supposed to be V= 0.03 m/sec. (USA standard value). In addition, the total length of screens is concretely designed so as to acquire planned pumping rate.
(h) Planned well depth does not exceed the maximum depth of existing wells

2) Specification of Project Well

The length of pump room casing is planned as shown below.

Actual length of pump room＝Static water level in projection year, 2031+Drawdown of dynamic water level + Clearance between pump suction and screen casing ＋Extra length of pump room

The length of pump room casing becomes 9 m longer than the actual length of pump room due to the overlap portion between the pump room and the screen casing by deep well structure (refer to “Figure 2 Standard Design of Project Well”). Standard well design is categorized by two groups on 6.8 m^3/min (4 cfs) and 3.4 m^3/min (2 cfs), based on the design conditions such as static water level in 2031 and the necessary screen length (namely, according to possible intake amount by well structure).

Static water level in 2031 is in the wide range of -25 m to -65 m, and they are classified into two categories of water levels of -35 m～-65 m, and less than -35 m, and the standard specification of wells is outlined by considering aquifer conditions of construction sites of deep wells and advantages on construction works. In the designing, static water level adopted as planning value is the deepest one in each category. **Table 2-18** shows the standard design specification for project wells and **Figure 2-6** indicates standard design drawings.

Table 2-18 Specification of Standard Design for Project Well

No	Adopted SWL in 2031	SWL*	DWL**	Span between Screen and Pump room	Extra Length	Length of Pump Room (A)	Overlap Length (B)	Total Length of Pump Room Casing (C=A+B)	Total Length of Screen Casing (E=B+D)	Screen Length (D=S+L)	Total Length of Deep Well (F=A+B+D)
Deep wells with capacity of 6.8 m^3/min（4 cfs）											
1	-35 m～ -65m	65 m	19 m	3 m	8 m	95 m	9 m	104 m	155 m	75 m	250 m
2	<-35m	35 m	19 m	3 m	8 m	65 m	9 m	74 m	155 m	75 m	220 m
Deep wells with capacity of 3.4 m^3/min（2 cfs）											
1	-35 m～ >-65m	65 m	19 m	3 m	8 m	95 m	9 m	104 m	95 m	48 m	200 m
2	<-35m	35 m	19 m	3 m	8 m	65 m	9 m	74 m	95 m	48 m	170 m

(Note) SWL* and DWL** show the depth under ground surface to convert length at well structure, and omit minus sign.
The symbols of A,B,D,F are shown in “Figure 2 Standard Design Drawing of Project Wells.

In the specifications of project wells, the well design with the capacity of 3.4 m^3/min. (2 cfs) is basically adopted in the lowest area with groundwater levels of less than – 65 m in 2031, and in other area, the well design with capacity of 6.8 m^3/min. (4 cfs) is adopted.

In the standard design of deep wells, the length of the pump casing, screen length, and well depth are designed taking into consideration the lowering / declining status of groundwater levels in the projection year, 2031 and by the calculated results of possible well yield, based on well structures.

Calculation of possible well yield for the design of screen length

$$Q = 2\pi r \times L \times Sop \times (1 - Clogr) \times V$$

Q: Possible well yield (m^3/sec)

r: Well radius (m)

L: Screen length (m)

Sop: Opening ratio of screens (10%)

Clogr: Clogging ratio of screens (30%)

V: Inflow velocity into screens (USA standard = 0.03 m/sec)

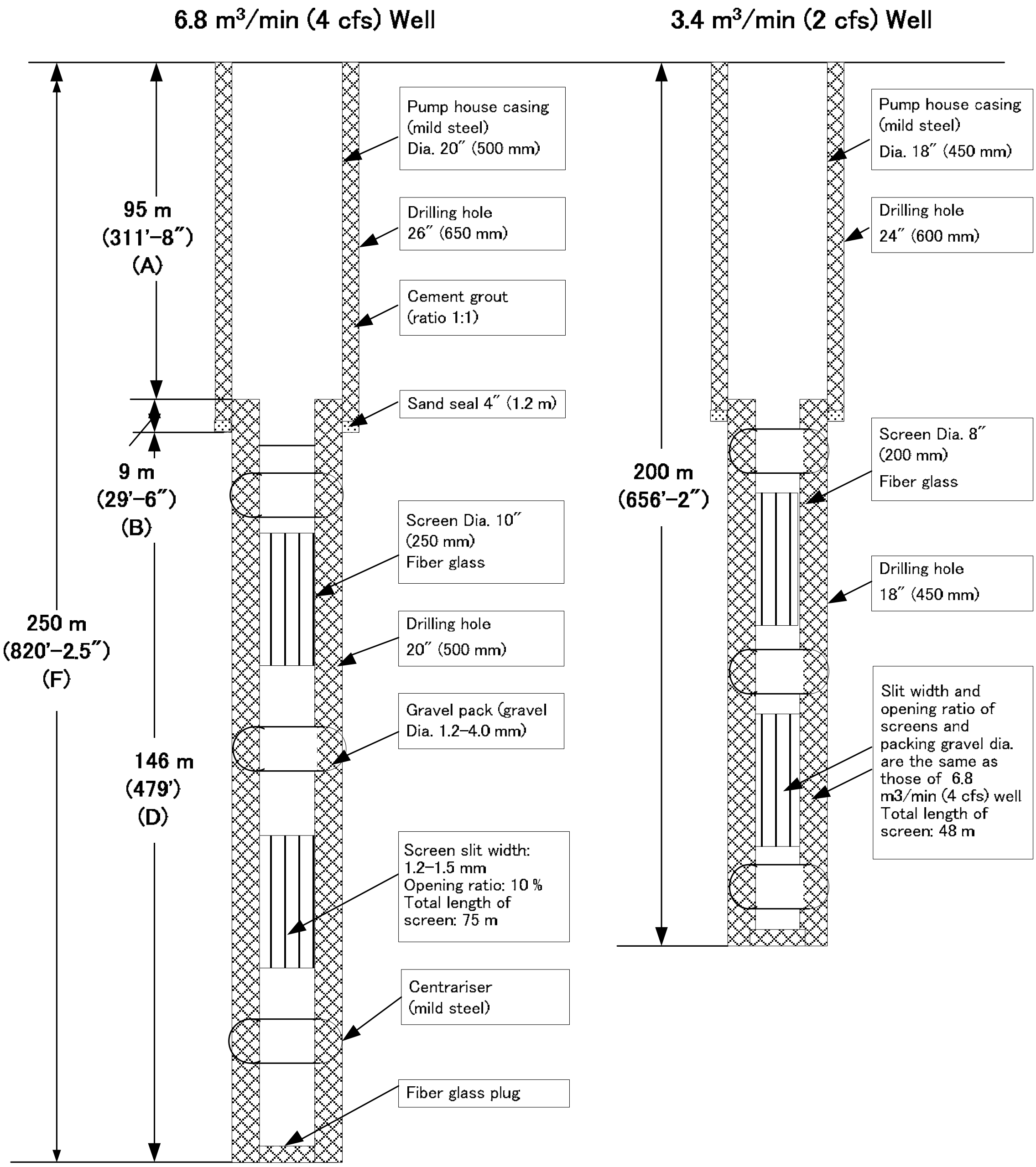


Figure 2-6 Standard Design of Project Wells

- The above drawing shows the maximum cases of well depth in case of static water level of -35～-65m.
- In case of the static water level of less than -35m, the standard well depth with capacity of 6.8 m^3/min. (4 cfs)becomes 220 m, and that with capacity of 3.4 m^3/min.（2 cfs）becomes 170m. In these wells, other specifications excluding well depth are the same as that of the above specification.

(2) Mechanical Equipment for Tube Well Pump Station

1) Tubewell Pump

According to the design concept, the pump specifications shall be in the following.

Table 2-19 Scope of water amount and quantity

Discharge	Pump head	Quantity
6.8 m3/min (4 cfs)	51 to 47 m	41
5.1 m3/min (3 cfs)	64 to 42 m	55
3.4 m3/min (2 cfs)	64 m	9

Source: JICA Survey Team

For easy maintenance, size of the pump impeller shall be reduced and the pump model also shall be reduced. Thus quantity of the pump models shall be from among five types as shown below.

Table 2-20 Pump Specification and quantity

No.	Specifications	Quantity
1	6.8 m3/min x 51 m, 90 kW (120 HP)	20
2	6.8 m3/min x 47 m, 75 kW (120 HP)	21
3	5.1 m3/min x 64 m, 90 kW (120 HP)	9
4	5.1 m3/min x 62 m, 75 kW (100 HP)	46
5	3.4 m3/min x 64 m, 55 kW (75 HP)	9

Source: JICA Survey Team

To improve lifting performance of the pump, a motorized chain block is provided at each Town Office of WASA.

2) Motor for tube well pump

Motor output shall be two sizes such as 75kW(100HP) and 90kW(120HP). All motors shall be equipped with a thermal sensor to measure the temperature of the motor coils.

Moreover, a spare motor for each motor size shall be kept in each WASA O&M Town Office considering the frequency of motor brunout. By having the spare motors, the time for rewinding motors can take longer. Then WASA can order from the local motor rewinders that provide proper performance so that motor life span can be extended with improving the quality of the motor after its repair.

3) Chlorine dosing facility

The chlorine shall be injected to pump discharge pipe by a diaphragm pump. The direct chlorine injection to the tubewells shall not be carried out to protect the pumps from chlorine-caused corrosion. The cholrine storage tank shall be installed at pump house.

According to the present system of WASA, the sodium hypochlorite delivered to the WASA workshop is distributed to the WASA Sub-Division Office by small containers. A chemical storage tank with a capacity of 250 L and a pump with the maximum discharge capacity of 560 mL/min will be installed so as to keep a dosing rate of 1 mg/L. A chemical storage tank has a capacity of three days for 24-hour injection with a dosing rate of 1 mg/L at the 6.8 m^3/min (4 cfs) tubewell pumping station. The spare for diaphragm pumps shall be one unit for each town totaling five units.

Table 2-21 Chlorine dosing facility

Pump Discharge	Storage Tank	Diaphragm Pump
6.8 m^3/min (4cfs)	250 L	35 units
5.1 m^3/min (3cfs)	250 L	60 units
3.4 m^3/min (2cfs)	250 L	10 units

Source: JICA Survey Team

(3) Electrical Equipment for Tubewell Pump Stations

1) Transformer

The transformer as a power supply source is to be sized based on the requirement not only during steady or motor running stage but also during start-up phase of the motor. The voltage drop during motor start-up and the cost of the transformer and the applied starter type is shown in **Tables 2-22**, **2-23** and **2-24** for each motor output rating.

The transformers are sized at 200 kVA for driving the 90 kW motors (**Table 2-22**), at 200 kVA for driving the 75 kW motors (**Table 2-23**), and at 100 kVA for driving the 55 kW motors (**Table 2-24**), respectively.

Table 2-22 Comparison of Transformer in Capacity for 90 kW Motor

90 kW Motor	Option 1. 400 kVA Transformer and Star – delta starter	Option 2. 200 kVA Transformer and Star – delta starter	Option 3. 200 kVA Transformer and Soft Starter
Voltage Dip During Motor Start-up	6.9%	13.9%	8.1%
Installation Cost	PRs 2,496,000	PRs 1,850,000	PRs 2,101,000
Overall Evaluation	More expensive than other options.	Beyond 10 % in voltage dip	Best option

Table 2-23 Comparison of Transformer in Capacity for 75 kW Motor

75 kW Motor	Option 1. 200 kVA Transformer and Star – delta starter	Option 2. 200 kVA Transformer and Star – delta starter	Option 3. 100 kVA Transformer and Soft Starter
Voltage Dip During Motor Start-up	9.2%	5.3%	15.3%
Installation Cost	PRs 1,773,000	PRs 1,978,000	PRs 1,581,000
Overall Evaluation	Best option	More expensive than other options.	Beyond 10% in voltage dip and overload on the transformer during steady stage.

Table 2-24 Comparison of Transformer in Capacity for 55 kW Motor

55 kW Motor	Option 1. 100 kVA Transformer and Star – delta starter	Option 2. 100 kVA Transformer and Soft Starter	Option 3. 200 kVA Transformer and Star – delta starter
Voltage Dip During Motor Start-up	11.2%	6.5%	10.8%
Installation Cost	PRs 1,324,000	PRs 1,469,000	PRs 1,721,000
Overall Evaluation	Beyond 10% in voltage dip	Best option	Beyond 10% in voltage dip and most expensive among the three options.

<u>Installation and its cost of Power Supply Facilities at Proposed Sites</u>

The meeting between WASA and the JICA Study Team last 16 September 2013 confirmed that the installation, including the cost of the following items concerned with the power supply at the proposed tubewell sites would be executed by LESCO and be borne by WASA.

2) Selection of Motor Starter

There are motor starter types available for driving the motors as follows;

(a) Direct on-line starter

The direct on-line starter applies full voltage of the power source to the motors during motor start-up, and can generate the biggest torque among the motor starter types with 6 to 7 times current as that of the steady motor running stage. The large current during motor start-up results in worsening voltage dip on the transformer. The direct on-line method may be applicable to small capacity motors.

(b) Open-Transition Star-Delta Starter

The closed-transition star-delta starter type as one of voltage reducing starter types applies $1/\sqrt{3}$ voltage of the power source to the motor during start-up period, which results in reducing one-third of both the starting current and the starting torque of the motors, and contributes to reduction of transformer capacity as well.

(c) Closed Transition Star-Delta Starter

The closed-transition star-delta starter is almost similar to the open-transition star-delta starter, but it can mitigate momentary large current flowing to the motor for the moment of changing-over from the star connection to the delta connection.

(d) Reactor Starter

The reactor starter utilizes reactor coils to reduce the starting voltage to the motor during the start-up period, meanwhile the reactor coils are bypassed after the completion of motor start-up for the loads to shift to the steady running state. The starting voltage applied to the motors can be adjustable as per the winding ratios of the reactors.

(e) Auto-transformer Starter

The auto-transformer starter utilizes single winding transformers to reduce the starting voltage to the motor during the start-up period, meanwhile the reactor coils are bypassed after the completion of motor start-up for the motor to shift to the steady running state. The starting voltage can be adjustable in the same manner as the reactor starter as mentioned above.

(f) Soft Starter

The soft starter utilizes power semi-conductors to reduce the starting voltage to the motors, meanwhile the power semi-conductors are bypassed after the completion of motor start-up for the loads to shift to the steady running state. The starting current, ramp times of starting and stopping time etc., can be adjusted to seek the appropriate starting procedure for the motors so that it can achieve smooth start-up and stop at less impact to the motors.

Under this project, the closed-transition star-delta or the soft starter are applied to each motor rating taking into consideration the simple configuration and the voltage dip on the transformer during the motor start-up period. The motor starters are selected for each motor rating as follows according to the comparison tables of transformer described in section 1).

(a) 90 k W motor; Soft starter
(b) 75 k W motor; Closed-transition starter
(c) 55 kW motor; Soft starter

3) Protection Devices

There are protection devices planned to be mounted in the pump starter panels under this project to prevent the motors and other electrical components from electrical abnormal conditions and electrical faults, which may be observed in any electrical system.

(a) Lightning Arrestors (Surge Protection Devices)

The lightning arresters protect the motors from lightning inductive surge and/or surge-induced by opening and/or closing the upstream electric circuits in the manner of bypassing the abnormal current to earth.

(b) Overvoltage and Under-voltage Relays

The overvoltage and under-voltage relay are mounted in the pump starter panel to protect the motor from the overvoltage and the under-voltage.

(c) Earth Leakage Circuit Breaker

The earth leakage circuit breaker is mounted in the pump starter panel to protect operating staff and the motor from the over current due to earth leakage. Further, it trips off to limit the electrical faults upon detecting short circuit to protect the motor, the transformer, cables and other electrical components from burning and any damage.

(d) Thermal Relay

The thermal relay is to be mounted in the starter circuit to prevent the motors from over current due to overload on the motor. The set point of overcurrent is adjustable according to the motor conditions.

(e) Temperature Sensor on Motor Stator Windings

The motor starter circuit trips off upon the detection of a set point temperature of the motor stator windings, to which the temperature sensors are fixed for measuring directly the winding temperature. It may be expected that the temperature sensors fixed on to the motor windings could reduce motor burning accidents drastically because of directly measuring the motor winding temperature.

(f) Protection Earth

The protection earth is required to be established securely and robustly for the earth leakage circuit breaker to function properly. Further, the neutral point of the transformer is also required to be securely earthed in cooperation with LESCO.

4) Static Capacitors for Power Factor Improvement

The static capacitors targeting power factor equal or over than 0.9 are installed in the pump starter panel in order to avoid payment to LESCO for penalties due to low power factors at the power supply points The static capacitors with 0.99 power factors are installed considering the local conditions, meanwhile an automatic power factor controller is mounted to prevent the motor from over exciting by achieving the appropriate power factor.

5) Level Monitor of Ground Water Table

The water utilities, including WASA in Lahore area, has relied on ground water as the water sources. Relying on the ground water has resulted in lowering the ground water level in the last five years according to data available from 2008 to 2013.

It is inevitable for WASA management that the ground water level should be continuously monitored as long as the ground water is used as water source. Under this project, the three-level transmitters for each of the three categorized proposed tubewells are planned to be installed so that WASA can continuously monitor the ground water level.

(4) Energy Audit Equipment

The Energy Management Cell will be the section handling the energy auditing, and the cell is consists of Executive Engineer, two electrical Sub-Divisional Officers etc. This cell will be enlarged and two officers lead two teams of energy auditing for regular inspection of the operating tube well pump stations. Therefore two sets of energy audit equipment shall be supplied for this activity.

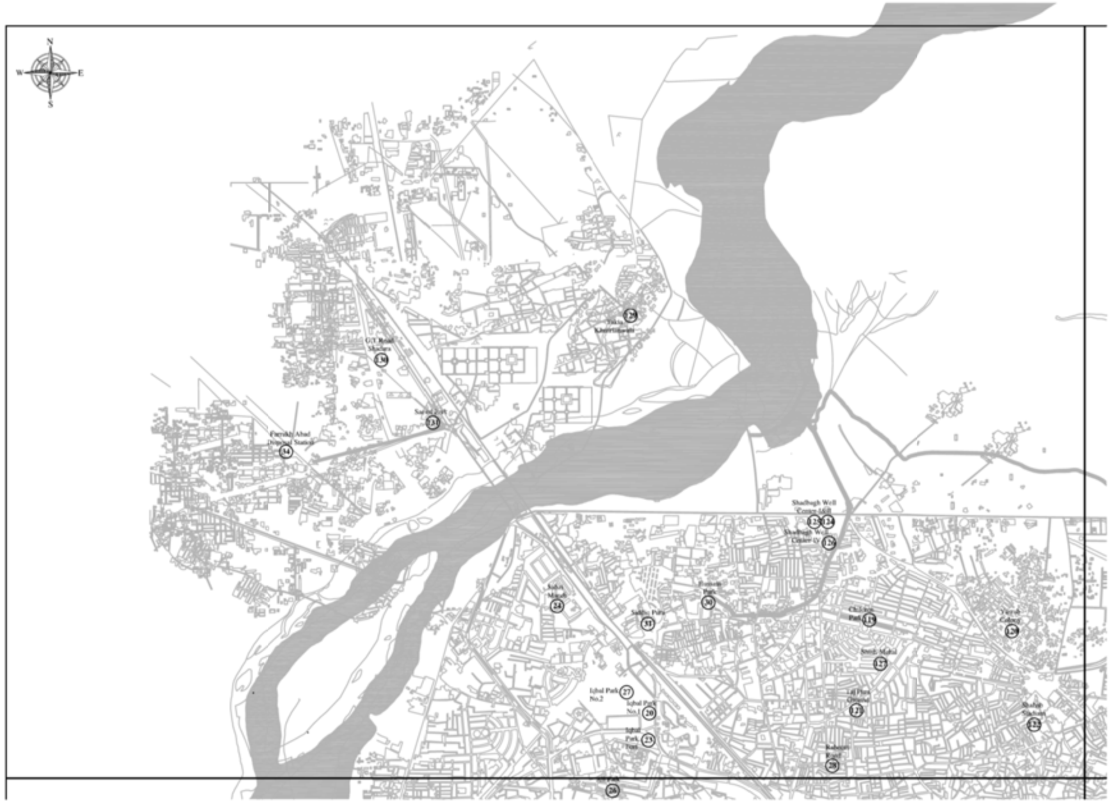
Power analyzer, flow meter, level meter, pressure meter etc. are necessary to collect data and a laptop computer to analyze the data.

Table 2-25 Energy Audit Instruments

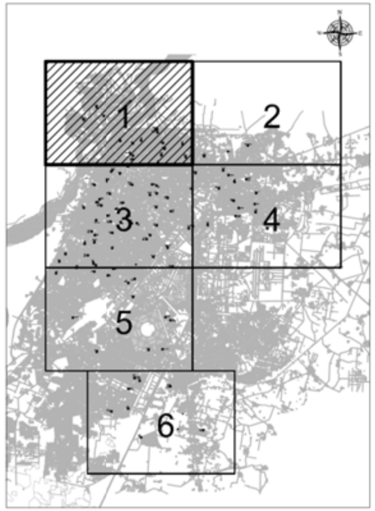
No.	Name	No. of Units	Measurement Parameter
1	Power Analyzer	2	Current, Voltage, Power Consumption, Power factor, etc.
2	Potable Flow Meter (Ultrasonic)	2	Flow
3	Pressure Logger	2	Pressure at pump delivery
4	Potable Level Meter	2	Static water level, Dynamic water level
5	Tachometer	2	Pump revolution
6	Thermo Meter (Laser)	2	Temperature
7	Vibration Meter	2	Vibration
8	Lap-top computer	2	Data Analysis

2-2-3 Outline Design Drawings

The typical drawing are shown below, For the site plan , only two drawings are shown herein as examples, but all the site plan drawings are filed in **Appendix 8.**



LOCATION PLAN OF RENEWAL WELLS (1)
NOT TO SCALE



INDEX MAP
NOT TO SCALE

LEGEND

(100) : RENEWAL WELL & WELL NO.

PROJECT NAME STUDY FOR THE OUTLINE DESIGN SURVEY ON THE PROJECT FOR ENERGY SAVING IN WATER SUPPLY SYSTEM IN LAHOL IN THE ISLAMIC REPUBLIC OF PAKISTAN ラホール給水設備エネルギー効率化計画　概略設計	
DRAWING TITLE LOCATION PLAN OF RENEWAL WELLS (1), INDEX MAP	SCALE NOT TO SCALE DRAWING NO. 1 / 75

LOCATION PLAN OF RENEWAL WELLS (2)

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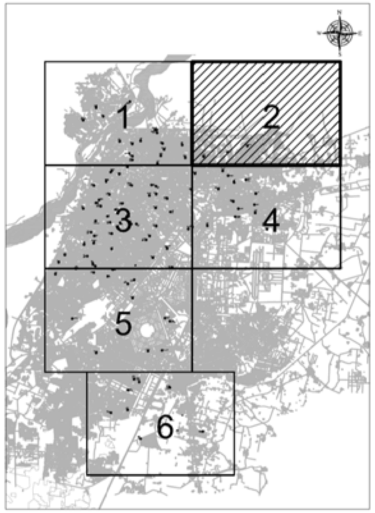

INDEX MAP

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LEGEND

(100) : RENEWAL WELL & WELL NO.

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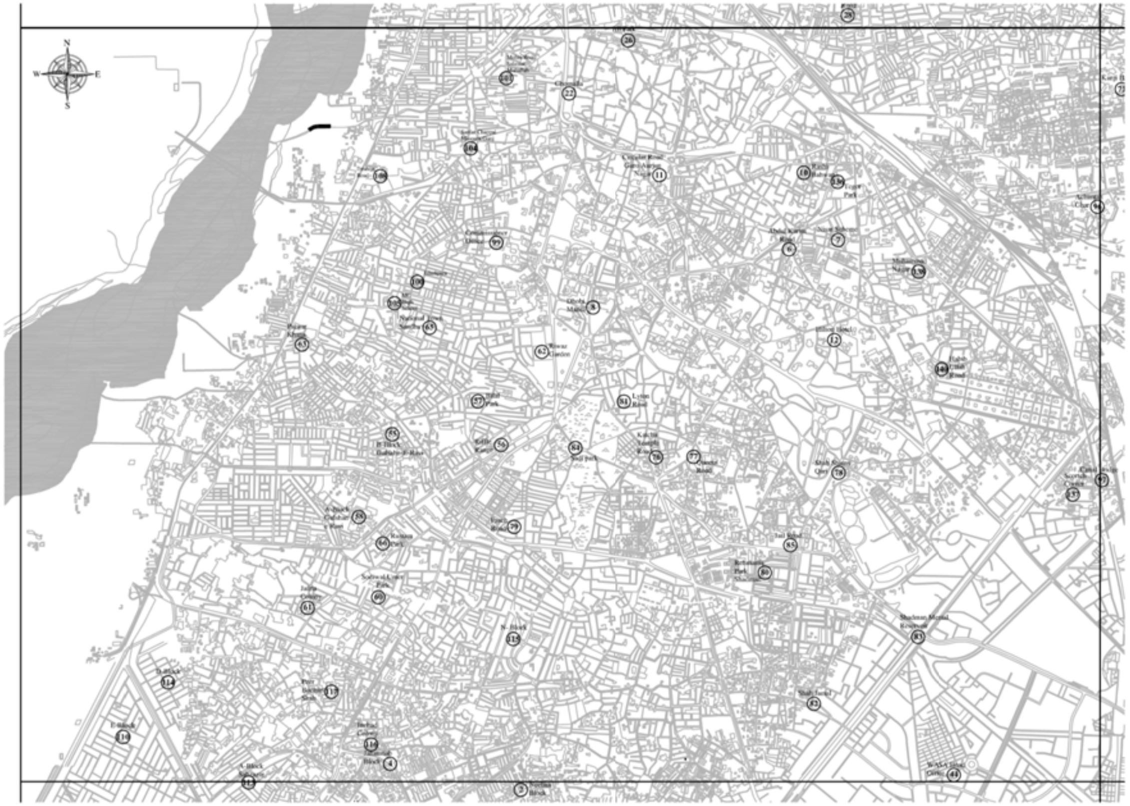

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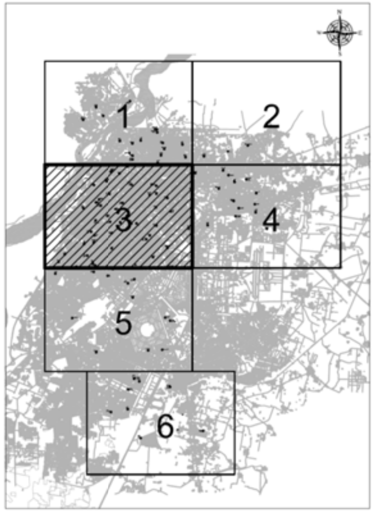

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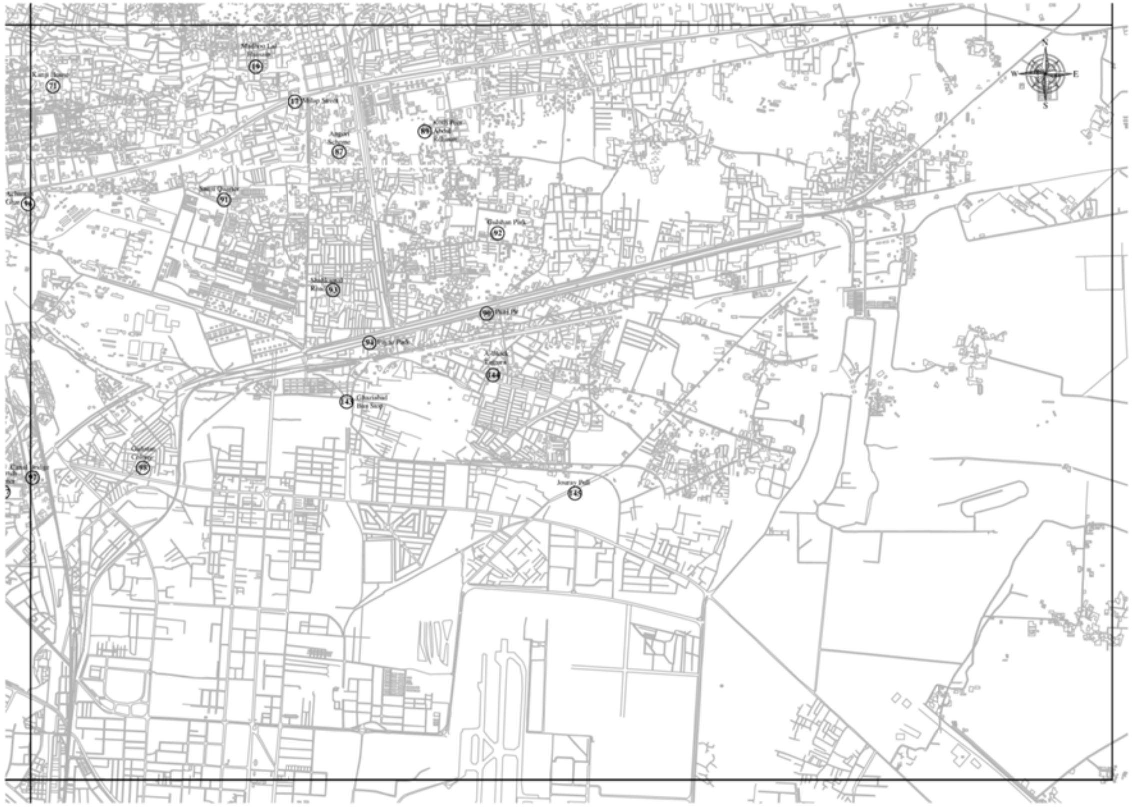

LOCATION PLAN OF RENEWAL WELLS (4)

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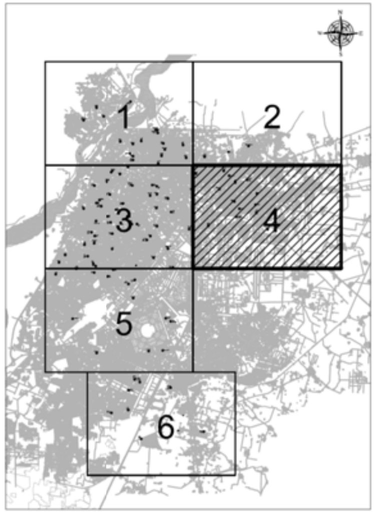

INDEX MAP

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(100) : RENEWAL WELL & WELL NO.

PROJECT NAME STUDY FOR THE OUTLINE DESIGN SURVEY ON THE PROJECT FOR ENERGY SAVING IN WATER SUPPLY SYSTEM IN LAHOL IN THE ISLAMIC REPUBLIC OF PAKISTAN ラホール給水設備エネルギー効率化計画 概略設計	
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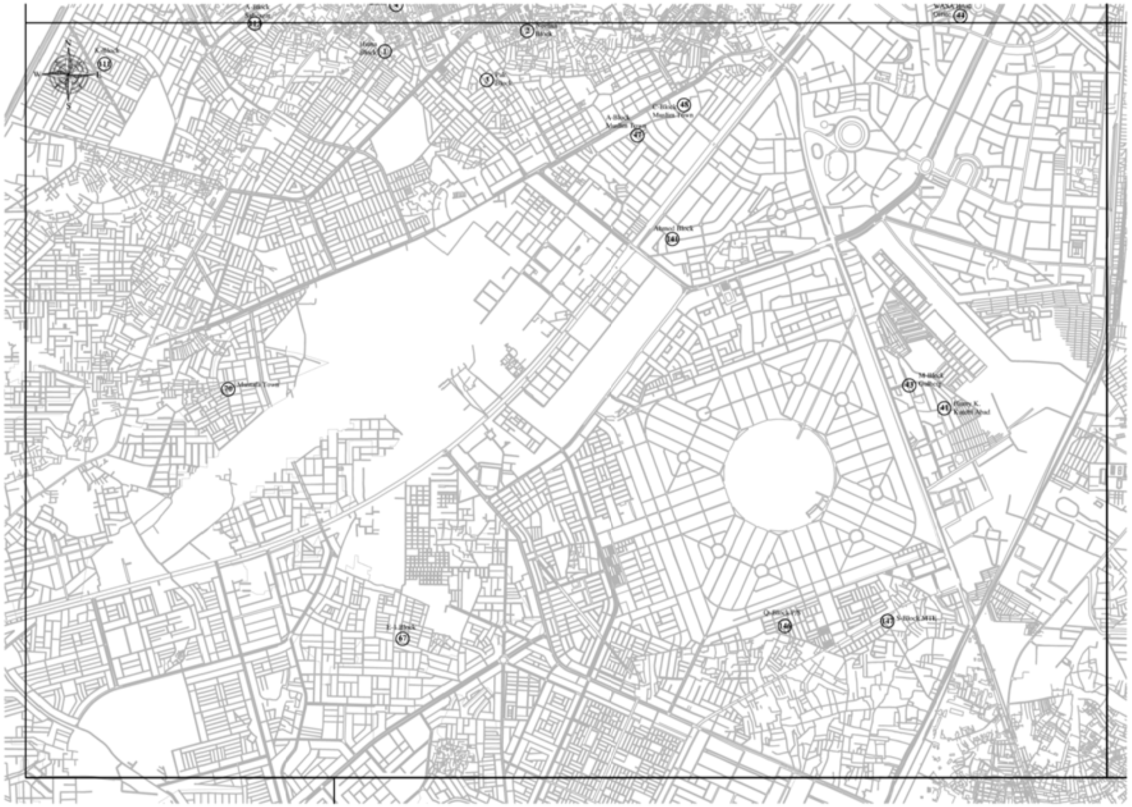

LOCATION PLAN OF RENEWAL WELLS (5)

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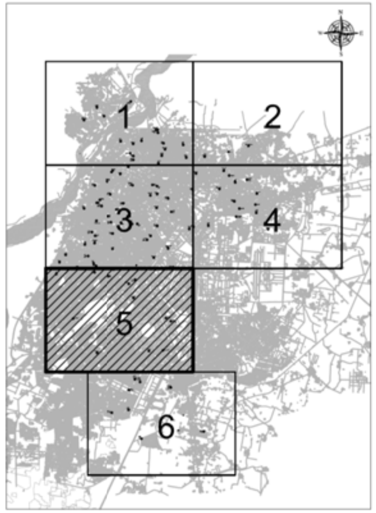

INDEX MAP

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(100) : RENEWAL WELL & WELL NO.

PROJECT NAME STUDY FOR THE OUTLINE DESIGN SURVEY ON THE PROJECT FOR ENERGY SAVING IN WATER SUPPLY SYSTEM IN LAHOL IN THE ISLAMIC REPUBLIC OF PAKISTAN ラホール給水設備エネルギー効率化計画　概略設計	
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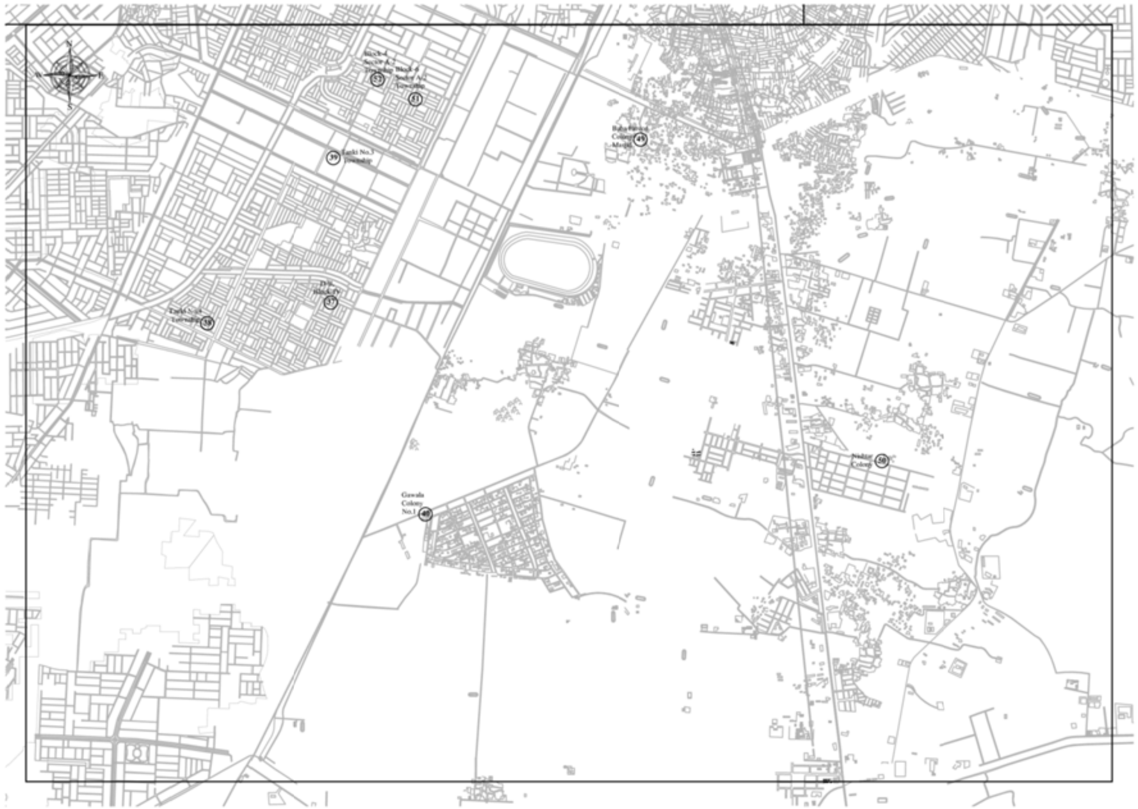

LOCATION PLAN OF RENEWAL WELLS (6)

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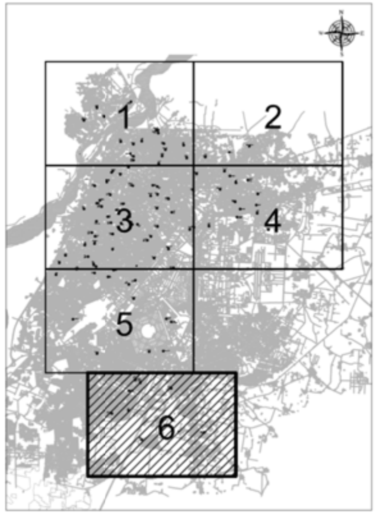

INDEX MAP

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(100) : RENEWAL WELL & WELL NO.

PROJECT NAME STUDY FOR THE OUTLINE DESIGN SURVEY ON THE PROJECT FOR ENERGY SAVING IN WATER SUPPLY SYSTEM IN LAHOL IN THE ISLAMIC REPUBLIC OF PAKISTAN ラホール給水設備エネルギー効率化計画　概略設計	
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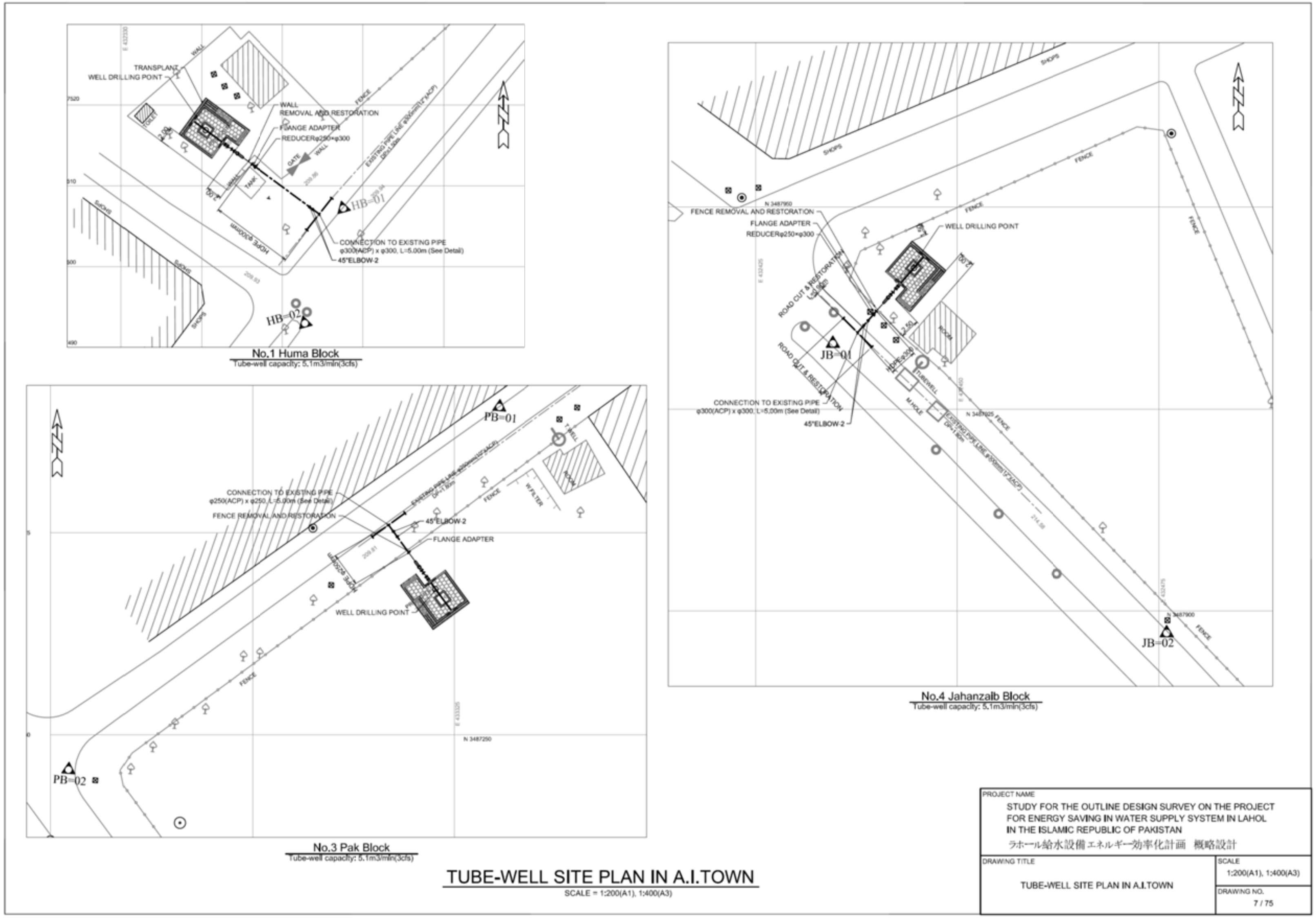
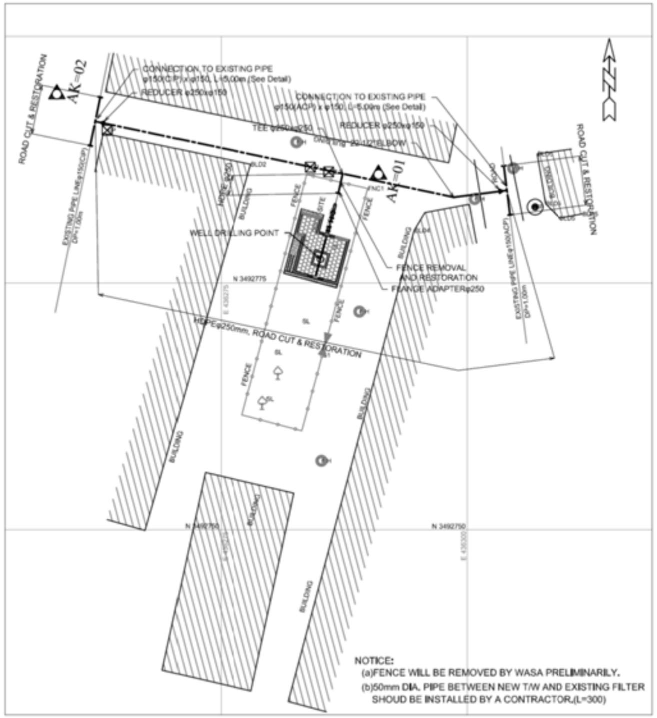
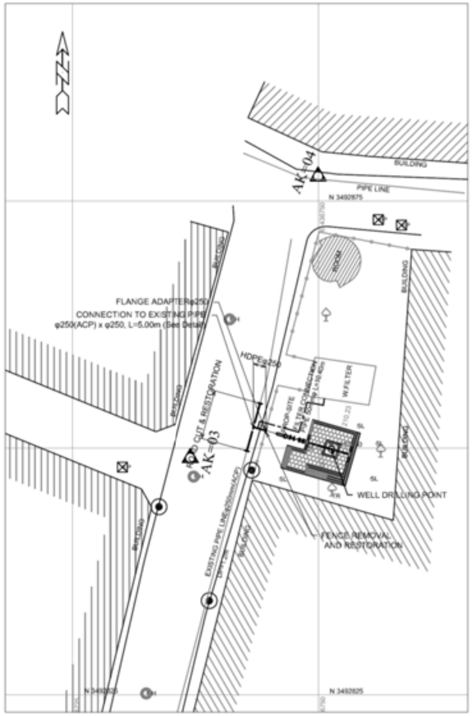

No.1 Huma Block
Tube-well capacity: 5.1m3/min(3cfs)
TRANSPLANT
WELL DRILLING POINT
WALL
REMOVAL AND RESTORATION
FLANGE ADAPTER
REDUCERφ250×φ300
CONNECTION TO EXISTING PIPE
φ300(ACP) x φ300, L=5.00m (See Detail)
45°ELBOW-2
HB-01
HB-02
SHOPS
FENCE
No.3 Pak Block
Tube-well capacity: 5.1m3/min(3cfs)
CONNECTION TO EXISTING PIPE
φ250(ACP) x φ250, L=5.00m (See Detail)
FENCE REMOVAL AND RESTORATION
45°ELBOW-2
FLANGE ADAPTER
WELL DRILLING POINT
PB-01
PB-02
N 3487250
No.4 Jahanzaib Block
Tube-well capacity: 5.1m3/min(3cfs)
FENCE REMOVAL AND RESTORATION
FLANGE ADAPTER
REDUCERφ250×φ300
WELL DRILLING POINT
ROAD CUT & RESTORATION
CONNECTION TO EXISTING PIPE
φ300(ACP) x φ300, L=5.00m (See Detail)
45°ELBOW-2
JB-01
JB-02
SHOPS
FENCE
TUBE-WELL SITE PLAN IN A.I.TOWN
SCALE = 1:200(A1), 1:400(A3)
PROJECT NAME
STUDY FOR THE OUTLINE DESIGN SURVEY ON THE PROJECT
FOR ENERGY SAVING IN WATER SUPPLY SYSTEM IN LAHOL
IN THE ISLAMIC REPUBLIC OF PAKISTAN
ラホール給水設備エネルギー効率化計画　概略設計
DRAWING TITLE
TUBE-WELL SITE PLAN IN A.I.TOWN
SCALE
1:200(A1), 1:400(A3)
DRAWING NO.
7 / 75



No.6 Abdul Karim Road(Mela Ram Park)
Tube-well capacity: 5.1m3/min(3cfs)

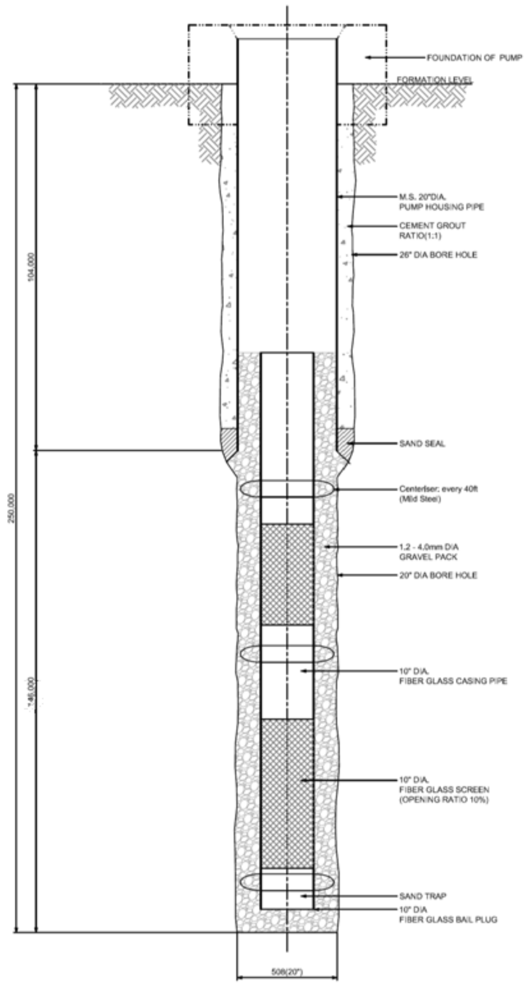


No.7 Nisar Scheme Qila Gujjar Singh
Tube-well capacity: 5.1m3/min(3cfs)

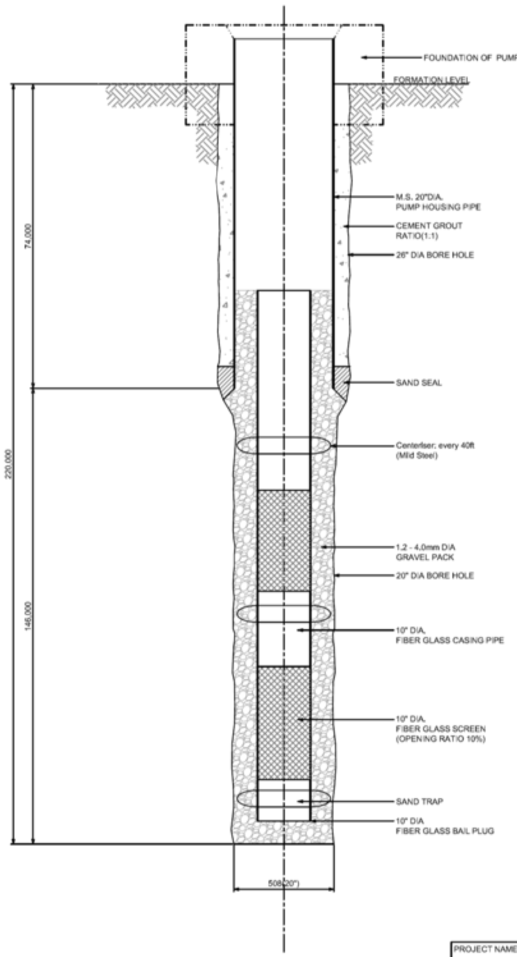
TUBE-WELL SITE PLAN IN ANARKALI(1)

SCALE = 1:200(A1), 1:400(A3)

PROJECT NAME	
STUDY FOR THE OUTLINE DESIGN SURVEY ON THE PROJECT FOR ENERGY SAVING IN WATER SUPPLY SYSTEM IN LAHOL IN THE ISLAMIC REPUBLIC OF PAKISTAN ラホール給水設備エネルギー効率化計画　概略設計	
DRAWING TITLE	SCALE 1:200(A1), 1:400(A3)
TUBE-WELL SITE PLAN IN ANARKALI(1)	DRAWING NO. 8 / 75



(a) 5.1-6.8 m^3/min(3-4 cfs) CAPACITY WELLS
Applies to Static Water Level from -35m to -65m
NOT TO SCALE



(b) 5.1-6.8 m^3/min(3-4 cfs) CAPACITY WELLS
Applies to Static Water Level shallower than -35m
NOT TO SCALE

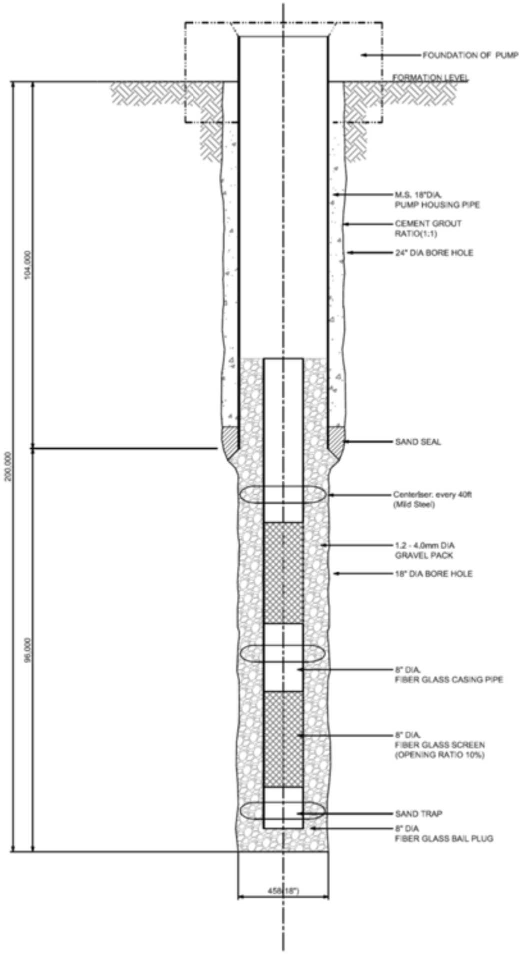
NOTE.

1. SUITABLE SCREENABLE AQUIFER MATERIAL & TOTAL DEPTH OF WELL TO BE DESIGNED AT SITE AFTER STRATA ANALYSIS.
2. PUMP HOUSING LENGTH MAY BE VARIED +10% ACCORDING TO LOCATION AND PRESENCE OF AQUIFER MATERIAL
3. SCREEN SHOULD BE INSTALLED MORE THAN 75m BASED ON THE RESULT OF ELECTRICAL LOGGING.

SCHEMATIC SECTION OF WELL(1)

PROJECT NAME
STUDY FOR THE OUTLINE DESIGN SURVEY ON THE PROJECT FOR ENERGY SAVING IN WATER SUPPLY SYSTEM IN LAHOL IN THE ISLAMIC REPUBLIC OF PAKISTAN
ラホール給水設備エネルギー効率化計画　概略設計

DRAWING TITLE	SCALE
SCHEMATIC SECTION OF WELL(1)	NOT TO SCALE
	DRAWING NO. 65 / 75



3.4 m^3/min(2 cfs) CAPACITY WELLS

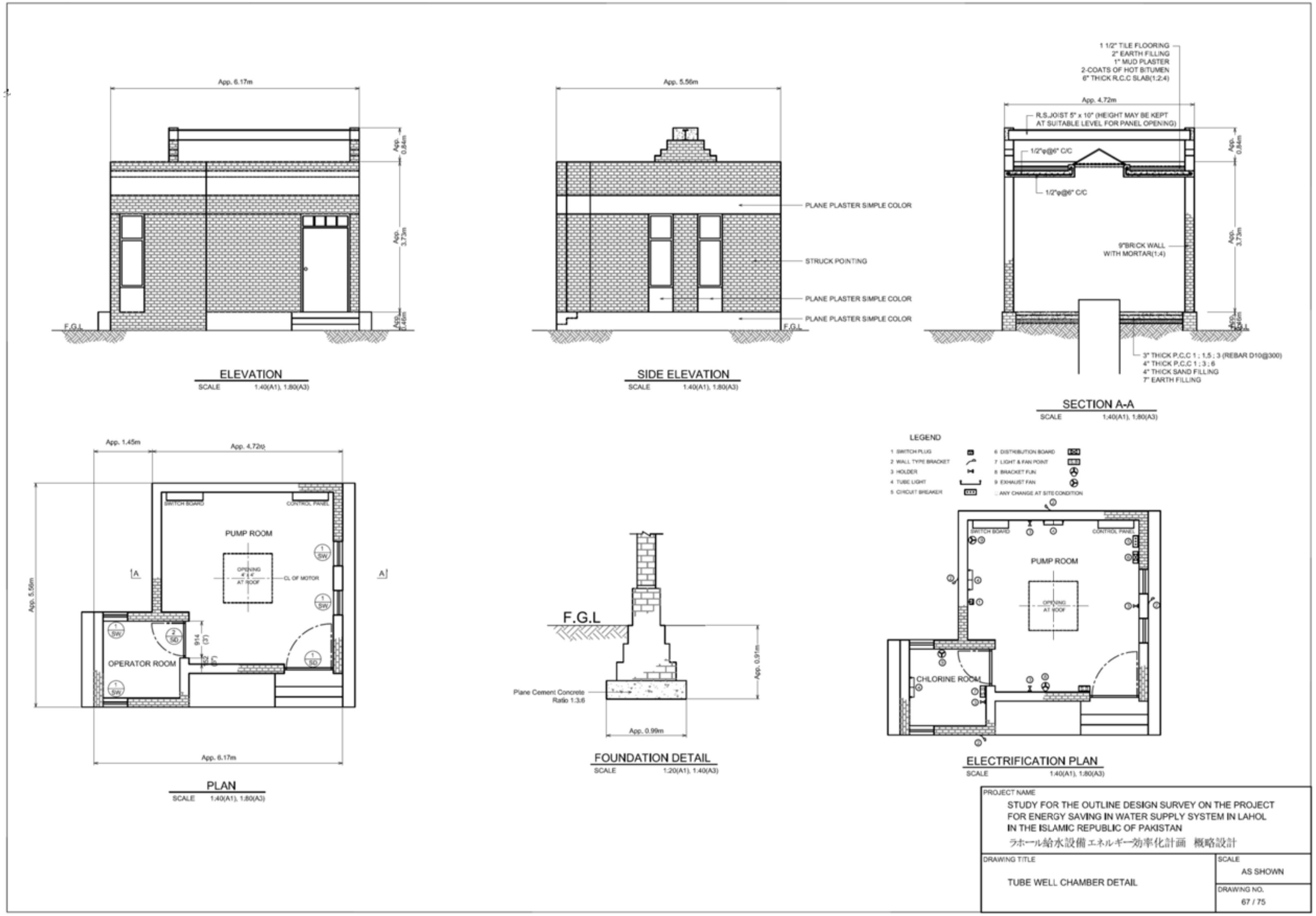
Applies to Static Water Level from -35m to -65m
NOT TO SCALE

NOTE.

1. SUITABLE SCREENABLE AQUIFER MATERIAL & TOTAL DEPTH OF WELL TO BE DESIGNED AT SITE AFTER STRATA ANALYSIS.
2. PUMP HOUSING LENGTH MAY BE VARIED +10% ACCORDING TO LOCATION AND PRESENCE OF AQUIFER MATERIAL
3. SCREEN SHOULD BE INSTALLED MORE THAN 75m BASED ON THE RESULT OF ELECTRICAL LOGGING.

SCHEMATIC SECTION OF WELL(2)

PROJECT NAME	
STUDY FOR THE OUTLINE DESIGN SURVEY ON THE PROJECT FOR ENERGY SAVING IN WATER SUPPLY SYSTEM IN LAHOL IN THE ISLAMIC REPUBLIC OF PAKISTAN ラホール給水設備エネルギー効率化計画　概略設計	
DRAWING TITLE	SCALE NOT TO SCALE
SCHEMATIC SECTION OF WELL(2)	DRAWING NO. 66 / 75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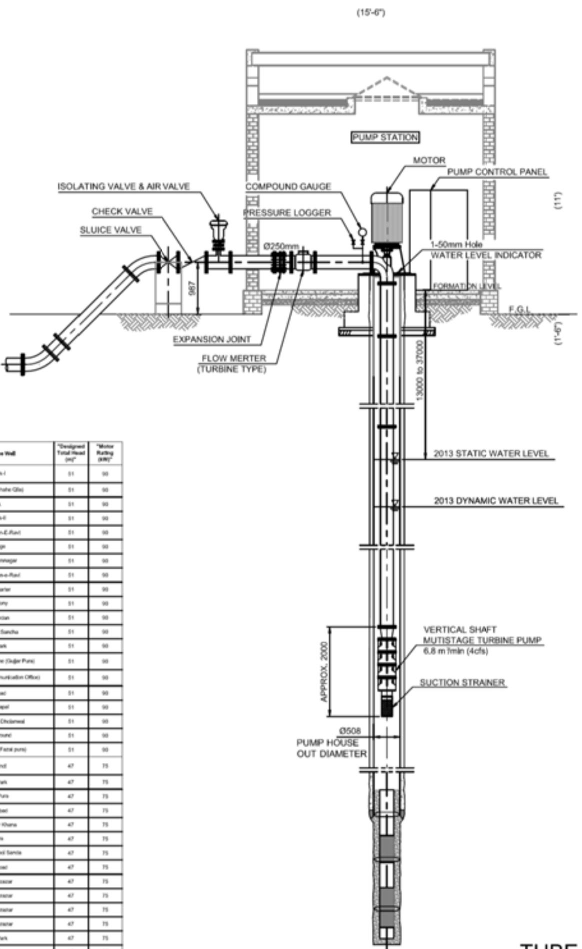
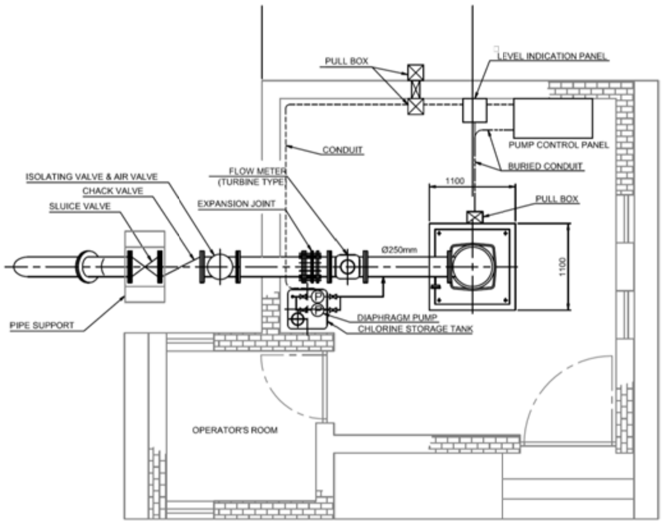
SCALE 1:40(A1), 1:80(A3)
SIDE ELEVATION
SCALE 1:40(A1), 1:80(A3)
SECTION A-A
SCALE 1:40(A1), 1:80(A3)
PLAN
SCALE 1:40(A1), 1:80(A3)
FOUNDATION DETAIL
SCALE 1:20(A1), 1:40(A3)
ELECTRIFICATION PLAN
SCALE 1:40(A1), 1:80(A3)
PUMP ROOM
OPERATOR ROOM
CHLORINE ROOM
F.G.L
Plane Cement Concrete Ratio 1:3:6
PLANE PLASTER SIMPLE COLOR
STRUCK POINTING
PROJECT NAME
STUDY FOR THE OUTLINE DESIGN SURVEY ON THE PROJECT FOR ENERGY SAVING IN WATER SUPPLY SYSTEM IN LAHOL IN THE ISLAMIC REPUBLIC OF PAKISTAN
ラホール給水設備エネルギー効率化計画 概略設計
DRAWING TITLE
TUBE WELL CHAMBER DETAIL
SCALE
AS SHOWN
DRAWING NO.
67 / 75



PUMP RAYOUT
NOT TO SCALE

	WAS No.	Name of Tube Well	"Designed Total Head (m)"	"Motor Rating (kW)"
ITEM 1	20	Iqbal Park-I	51	90
	23	Iqbal Park fort (Shahe Qila)	51	90
	26	Ali Park	51	90
	27	Iqbal Park-II	51	90
	55	B-Block Gulsahn-E-Ravi	51	90
	56	Rifle Range	51	90
	57	Bilal Park Shamnagar	51	90
	58	A-Block Gulsahn-e-Ravi	51	90
	60	Sodiwal Quarter	51	90
	61	Jaffria Colony	51	90
	62	Rewaz Garden	51	90
	65	National Town Sandha	51	90
	66	Rustam Park	51	90
	72	D-Block China Scheme (Gujjar Pura)	51	90
	99	Dev Samaj Road (Communication Office)	51	90
	101	Mohni Road	51	90
	104	Sardar Chapal	51	90
	117	Pir Sucdan Shah Dholanwal	51	90
	121	Taj Pura Ground	51	90
	122	Shahab Stadium (Fazal pura)	51	90
ITEM 2	24	Sabzi Mandi	47	75
	30	Hussain Park	47	75
	31	Siddique Pura	47	75
	34	Farrukh Abad	47	75
	63	Sanda Patwar Khana	47	75
	100	Islampura	47	75
	105	M. C. High School Sanda	47	75
	108	Ibrahim Road	47	75
	110	E-Block Sabzazar	47	75
	111	K-Block Sabzazar	47	75
	113	A-Block Sabzazar	47	75
	114	D-Block Sabzazar	47	75
	119	Children Park	47	75
	120	Yasrab Colony	47	75
	124	Shadbagh Well Centre-I	47	75
	125	Shdbagh well Center-II	47	75
	126	Shadbagh Well Centre-IV	47	75
	127	Shish Mehal Road	47	75
	129	Takia Khuarianwala Shahdara UC-6	47	75
	130	G.T.Road Shahdara	47	75
	131	Saeed Park.	47	75



FLOOR PLAN
SCALE 1 : 50

□ Level Indication Panel and Level Transmitter shall be installed only at the following sites.

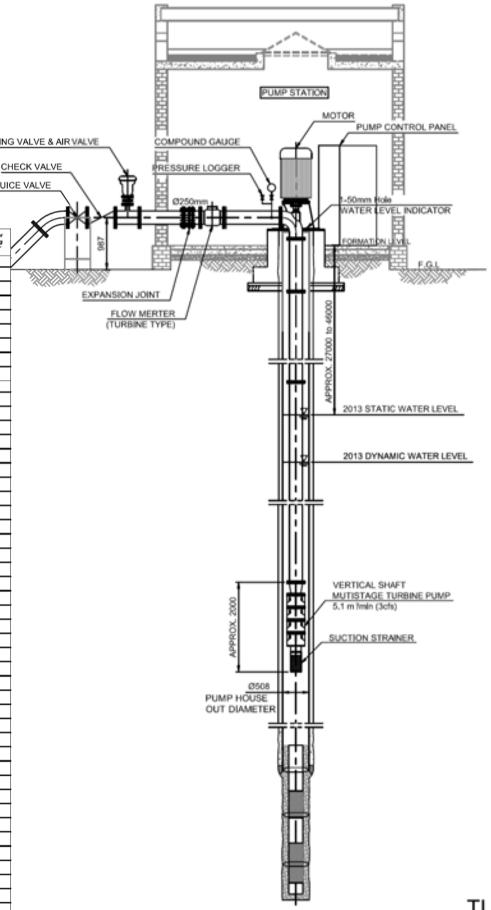
Well No.	Name of Tube Well
24	Sabzi Mandi
34	Farrukh Abad Disposal
57	Bilal Park Shamnagar

TUBE WELL PUMP GENERAL DRAWING (1)

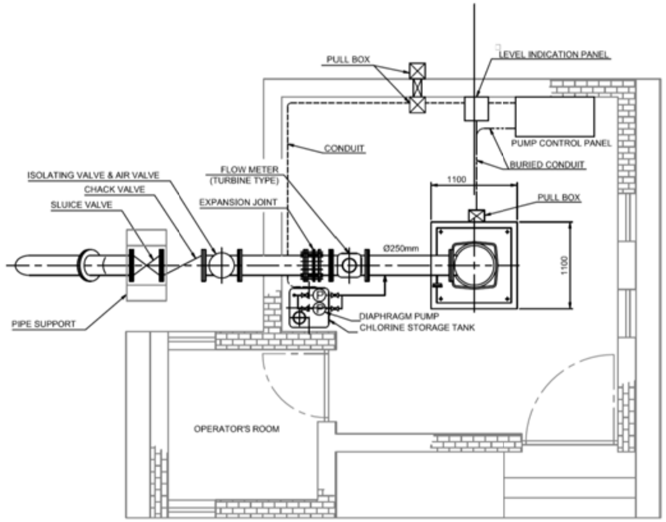
6.8 m /min³ (4 cfs) CAPACITY WELLS

PROJECT NAME	
STUDY FOR THE OUTLINE DESIGN SURVEY ON THE PROJECT FOR ENERGY SAVING IN WATER SUPPLY SYSTEM IN LAHOL IN THE ISLAMIC REPUBLIC OF PAKISTAN ラホール給水設備エネルギー効率化計画 概略設計	
DRAWING TITLE TUBE WELL PUMP GENERAL DRAWING (1)	SCALE AS SHOWN DRAWING NO. 69 / 75

	Well No.	Name of Tube Well	"Designed Total Head (m)"	"Motor Rating (kW)"
ITEM 3	44	WASA Head Office	64	90
	47	A-Block Muslim Town	64	90
	48	C-Block Muslim Town	64	90
	80	Shadman-I Rehmania Park	64	90
	82	Shah Jamal.	64	90
	83	Shadman Mental Reservoir	64	90
	85	Jail Road (Lahore Collage)	64	90
	140	Habib Ullah Road	64	90
	141	Ahmad Block	64	90
ITEM 4	1	Huma Block	62	90
	2	Neelam Block	62	90
	3	Pak Block	62	90
	4	Jahanzaib Block	62	90
	6	Abdul Karim Road (Mela Ram Park)	62	90
	7	Nisar Scheme Qila Gujjar Singh	62	90
	8	Dhobi Mandi	62	90
	10	Rashi Bhawan (Pathi Ground)	62	90
	11	Circular Road (Guru Argum Nagar)	62	90
	12	Hilton Hotel	62	90
	16	Shah Gohar Abad	62	90
	17	Milap Street	62	90
	19	Madhu Lal Hussain	62	90
	22	Chomala	62	90
	28	Raheem Road Data Nagar	62	90
	37	D-II Block-IV	62	90
	38	Tanki No.4 Township	62	90
	39	Tanki No.3 Township	62	90
	40	Gawala Colony No.1	62	90
	41	Henry Key (Old)	62	90
	43	M-Block Gulberg	62	90
	49	Fareed Colony Printing Press	62	90
	50	Nishtar Colony	62	90
	51	Block No.6 Sector-A-II Township	62	90
	52	Block No.4 Sector-A-II Township	62	90
	67	E-I Johar Town	62	90
	70	Mustafa Town	62	90
	71	Kanji House Misri Shah	62	90
	76	Katch Temple Road (Abid Market)	62	90
	77	Queens Road	62	90
	78	Shah Shamas Qari	62	90
	79	Faseeh Road	62	90
	81	Sui Gas Engine Lytton Road	62	90
	84	Sadi Park.	62	90
	87	Angori Bagh Scheme-II	62	90
	90	Punj Pir	62	90
	92	Gulshan Park	62	90
	98	Achant Garh	62	90
	115	N-Block,Samanabad	62	90
	116	Ittehad Colony Samanbad	62	90
	136	Tegore Park	62	90
	138	Muhammad Nagar.	62	90
	143	Ghaziabad Bus Stop	62	90
	145	Jorrey Pull	62	90
	146	Q-Block Model Town EXT	62	90
	147	S-Block Model Town Ext.	62	90



PUMP RAYOUT
NOT TO SCALE



FLOOR PLAN
SCALE 1 : 50

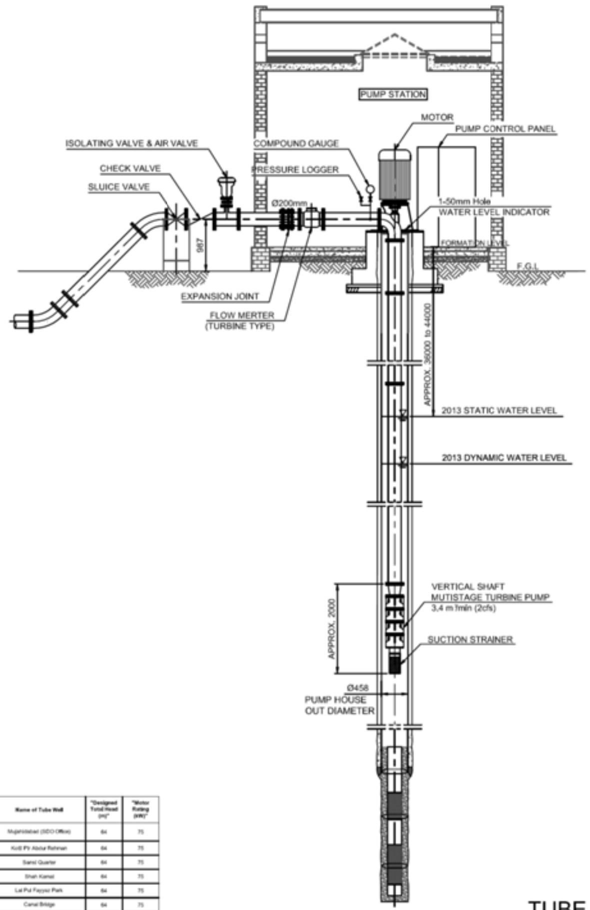
□ Level Indication Panel and Level Transmitter shall be installed only at the following sites.

Well No.	Name of Tube Well
12	Hillton Hotel
38	Tanki No.4 Township
43	M-Block Gulberg
48	C-Block Muslim Town
71	Kanji House Misri Shah

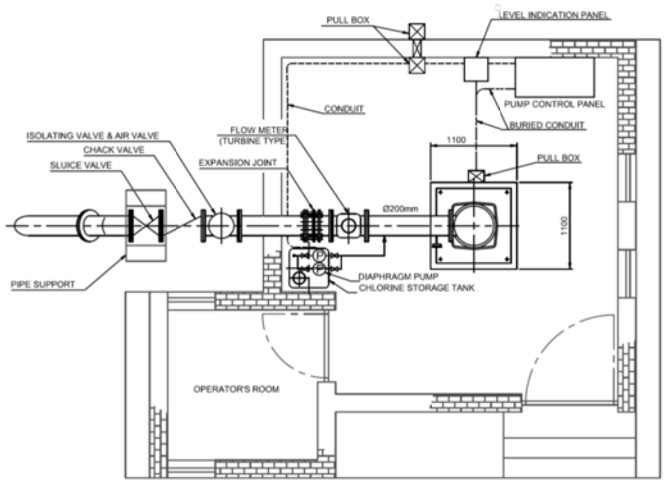
TUBE WELL PUMP GENERAL DRAWING (2)

5.1 m^3/min (3 cfs) CAPACITY WELLS

PROJECT NAME	STUDY FOR THE OUTLINE DESIGN SURVEY ON THE PROJECT FOR ENERGY SAVING IN WATER SUPPLY SYSTEM IN LAHOL IN THE ISLAMIC REPUBLIC OF PAKISTAN ラホール給水設備エネルギー効率化計画 概略設計
DRAWING TITLE	TUBE WELL PUMP GENERAL DRAWING (2)
SCALE	AS SHOWN
DRAWING NO.	70 / 75



PUMP RAYOUT
NOT TO SCALE



FLOOR PLAN
SCALE 1 : 50

□ Level Indication Panel and Level Transmitter shall be installed only at the following sites.

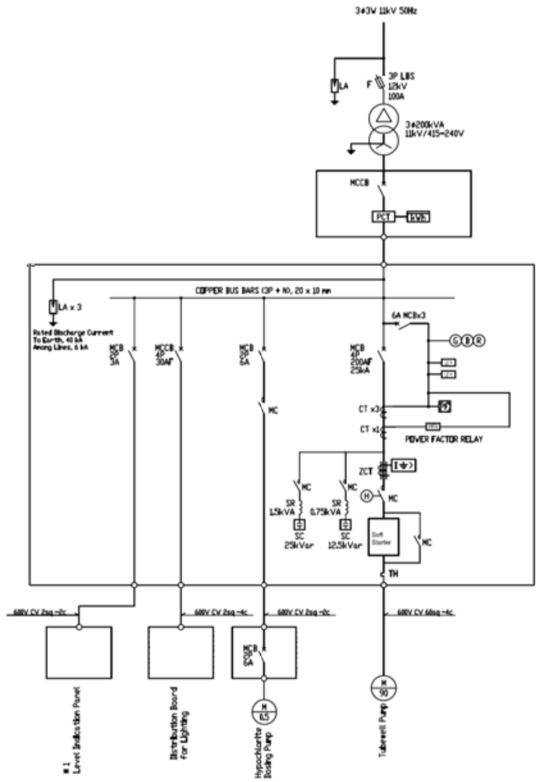
Well No.	Name of Tube Well
89	Kotli Pir Abdur Rehman
97	Canal Bridge

	Well No.	Name of Tube Well	"Designed Total Head (m)"	"Motor Rating (kW)"
ITEM 5	86	Mujahidabad (SDO Office)	64	75
	89	Kotli Pir Abdur Rehman	64	75
	91	Sanst Quarter	64	75
	93	Shah Kamal	64	75
	94	Lal Pul Fayyaz Park	64	75
	97	Canal Bridge	64	75
	98	Gulistan Colony	64	75
	137	Scotch Corner / Upper Mall	64	75
	144	A-Block Tajpura	64	75

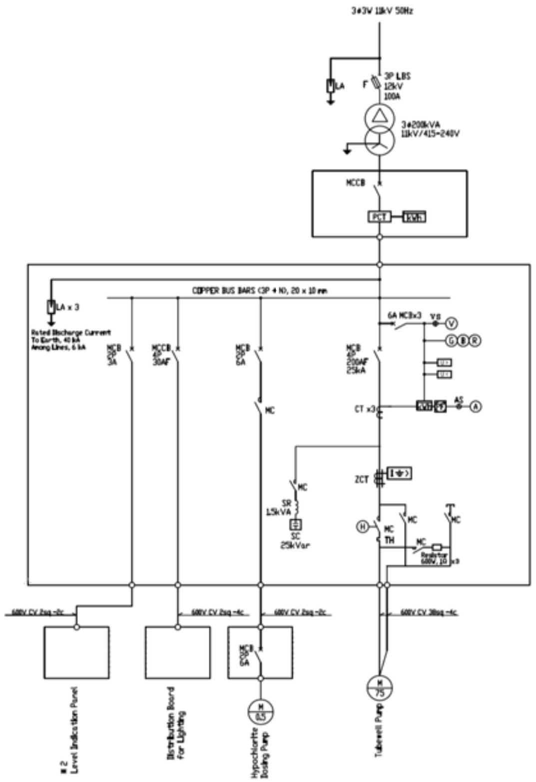
TUBE WELL PUMP GENERAL DRAWING (3)

3.4 m /min³(2 cfs) CAPACITY WELLS

PROJECT NAME STUDY FOR THE OUTLINE DESIGN SURVEY ON THE PROJECT FOR ENERGY SAVING IN WATER SUPPLY SYSTEM IN LAHOL IN THE ISLAMIC REPUBLIC OF PAKISTAN ラホール給水設備エネルギー効率化計画　概略設計	
DRAWING TITLE TUBE WELL PUMP GENERAL DRAWING (3)	SCALE AS SHOWN DRAWING NO. 71 / 75



PUMP CONTROL PANEL FOR 90 kW MOTOR (SOFT STARTER)



PUMP CONTROL PANEL FOR 75 kW MOTOR (STAR–DELTA)

LEGEND

SYMBOL	DESCRIPTION
LBS	LOAD BREAK SWICTH
LA	LIGHTNING ARRESTER
F	FUSE
PCT	POTENTIAL CURRENT TRANSFORMER
CT	CURRENT TRANSFORMER
SC	STATIC CAPACITOR
SR	SERIES REACTORS
ZCT	ZERO PHASE CURRENT TRANSFORMER
TH	THERMAL RELAY
MC	ELECTOROMAGNETIC CONTACTOR
MCCB	MOLDED CASE CIRCUIT BREAKER
MCB	MINIATURE CIRCUIT BREAKER
M	MOTOR
	OVER VOLTAGE RELAY
	UNDER VOLTAGE RELAY
	WATT HOUR METER
PF	POWER FACTOR METER
	OVER CURRENT GROUND RELAY
A	AMMETER
V	VOLT METER
G B R	PHASE LAMPS
H	HOUR METER
	AMMETER SWITCH
	VOLTMETER SWITCH

*1 Level Indication Panel and Level Transmitter shall be installed only at the following sites.

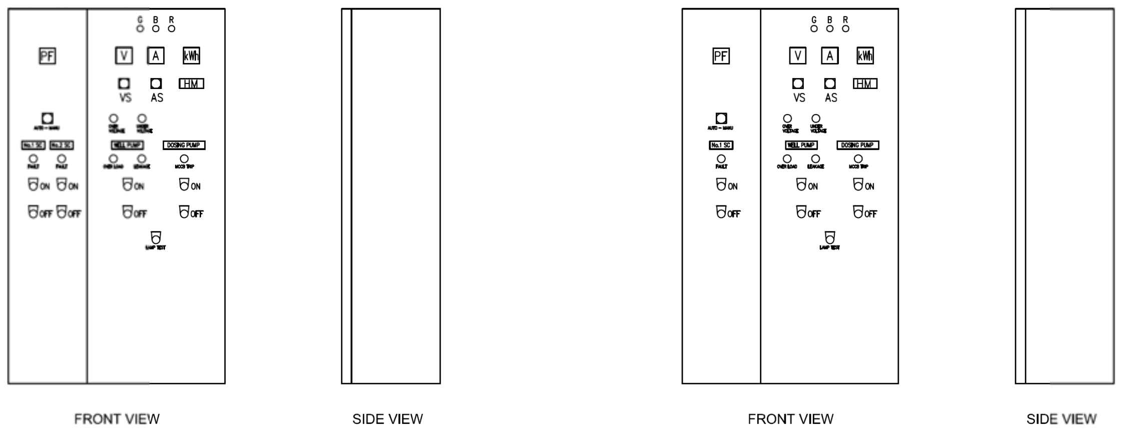
SITE NO.	SITE NAME	SUB DIVISIONS
12	Hilton Hotel	Anarkali
38	Tanki No.4 Township	Green Town
43	M-Block Gulberg	Gulberg
48	C-Block Muslim Town	Icchra
57	Bilal Park Shamnagar	Islampura
71	Kanji House Misri Shah	Misri Shah

*2 Level Indication Panel and Level Transmitter shall be installed only at the following sites.

SITE NO.	SITE NAME	SUB DIVISIONS
24	Sabzi Mandi	City
34	Farrukh Abad Disposal	Farrukhabad
89	Kotli Pir Abdur Rehman	Mughalpura
97	Canal Bridge	Mustafabad

PROJECT NAME
STUDY FOR THE OUTLINE DESIGN SURVEY ON THE PROJECT FOR ENERGY SAVING IN WATER SUPPLY SYSTEM IN LAHOL IN THE ISLAMIC REPUBLIC OF PAKISTAN
ラホール給水設備エネルギー効率化計画　概略設計

DRAWING TITLE: SINGLE LINE DIAGRAM
SCALE: NON
DRAWING NO.: 72 / 75



PUMP CONTROL PANEL FOR 90kW (SOFT STARTER)

PUMP CONTROL PANEL FOR 75kW (STAR DELTA)

LEGEND

SYMBOL	DESCRIPTION
V	VOLT METER
A	AMPERE METER
VS	VOLT METER SWITCH
AS	AMPERE METER SWITCH
kWh	WATT HOUR METER
HM	HOUR METER
PF	POWER FACTOR METER
G B R	PHASE LAMPS
	CHANGE OVER SWITCH
	PUSH BUTTON
○	INSDICATION LAMP

PROJECT NAME	STUDY FOR THE OUTLINE DESIGN SURVEY ON THE PROJECT FOR ENERGY SAVING IN WATER SUPPLY SYSTEM IN LAHOL IN THE ISLAMIC REPUBLIC OF PAKISTAN ラホール給水設備エネルギー効率化計画　概略設計
DRAWING TITLE	PUMP CONTROL PANEL OUTLINE
SCALE	1:20
DRAWING NO.	73 / 75

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

The implementation agency on the Pakistani side is WASA Lahore. The Project Implementing Unit (PIU) shall be established to be composed of concerned organizations and will be consistently in charge of this project on behalf of WASA. Following are the major roles of PIU.

- To act as the “front desk” of WASA for this project
- To liaise and coordinate with the concerned directorates in WASA
- To liaise and coordinate with the concerned departments under the national government, the provincial government, the City District of Greater Lahore, and the Lahore Development Authority, etc.
- To be the counterpart of the Japanese Consultant in arranging for the design and and bidding works;
- To secure the budgets and human resources under responsibility of the Pakistani side.

The PIU will be organized in the WASA Gunj Bukhsh Town O&M Office. The WASA Head Office will assist in PIU management.

The Consultant, on behalf of WASA, will undertake the detailed design, bidding procedures and construction supervision in order that the construction work can proceed smoothly and the scope of work be completed within the given construction period.

In the detailed design stage, the Consultant will assign engineers with specializations in sin tubewell, civil structure, mechanical equipment, electrical equipment and quantity survey, all of whom will be under the supervision of the chief engineer. Detailed discussions with directorates concerned in WASA as regards the contents of the project will be required. Therefore, the work for detailed design and preparation of tender documents will be carried out in Lahore and in Japan.

In the bidding stage, the bidding will be executed by the Consultants at the Consultants’ office in Japan witnessed by the representatives of WASA and JICA in accordance with the JICA’s Guidelines for Bidding. The Consultant will assist in the subsequent negotiation and contract signing between WASA and the successful bidder in compliance with the procedures required for JICA approval.

In the construction stage, the Consultant will send a supervising engineer, who will be stationed in Lahore, and who will act as the chief supervisor to undertake the arrangements regarding all works with WASA. The Consultant will also dispatch specialists in tubewell, piping, mechanical equipment and electrical equipment to assist the construction supervision, as required at the time of completion of the major facilities/equipment and during inspection for interim and final payment.

The main part of the project is to replace the existing tubewell pumping stations including the tubewell, building, and mechanical and electrical equipment with new ones, and to install water transmission pipes between the new tubewell pumping stations and existing grid distribution network or filtration plants in a coordinated manner. Therefore, it is considered appropriate that a Japanese civil engineering contractor with enough experience in the construction of water supply facilities undertake the project works. In selecting the contractor, the open bid system will be adopted and the pre-qualification and selection criteria for bidders will be defined during the preparatory work for bidding through discussions with WASA.

During construction works, the Japanese Contractor shall dispatch engineers headed by the project manager, who will direct the construction works at the site with local contractors.

The construction works of a tubewell pumping station will embrace a variety of processes with different nature from the commencement to the completion. One construction team for a tubewell pumping station is composed of the following clues:

(a) Drilling of a tubewell
(b) Finishing of a tubewell including a variety of tests
(c) Building of a tubewell pumping station
(d) Interior works of a tubewell pumping station
(e) Installation of mechanical equipment
(f) Installation of electrical equipment

I don't have a clue what you mean by or how you use the word “clue”.

Therefore, each clue will move to another site in turn whenever performing his responsibility. It is supposed that five construction teams will work separately in parallel to construct 105 tubewells in total for 19 months.

2-2-4-2 Implementation Conditions

(1) Consideration in Construction

Following are special conditions for construction.

- The construction sites for 105 tubewell pumping stations will be divided into five zones, and one construction team will be assigned to each zone to construct the tubewell pumping stations in parallel.

- To fix the number of filtration plants required for the project in the early stage of the construction works, Group B pumping stations shall be given the priority for construction.
- Project progress needs many types of approvals and permissions from concerned government offices such as the central government, provincial government, the City District Government of Lahore (CDGL), the Lahore Development Authority (LDA), etc. for road occupancy, pipe installation, road reinstatement, etc. and coordination with the organizations concerned will be coursed through the PIU.
- In the detailed design stage, the Consultant's Office will be established at one of WASA offices to have easy access and coordination meetings and discussions on the design issues with the PD, other PIU members and directorates concerned of WASA, as required.
- The Contractor's Office and the stockyard of construction materials will be set up at the premises of some WASA Town O&M Offices.
- The Consultants will locate its office at the Contractor's Office and a supervisory engineer will be stationed during the construction period.
- Interim and completion inspections, to be done by the spot engineers and supervisor depending on the works, will be scheduled according to the progress of each site.
- Basically, daytime works will be considered.
- Safety measures shall be strictly enforced to ease traffic conditions of pedestrian and vehicles in the project sites especially for the pipeline routes. Open excavated trenches for pipe laying shall be backfilled and temporarily restored within the same day.
- More than 1.5 m deep excavation for pipe installation shall be conducted, keeping the excavation slope required for safety.
- For tubewells with an arsenic concentration of more than 20 μg/L in the water quality test after the completion, WASA shall be responsible for the installation work of raw water transmission pipes from a tubewell pumping station to a filtration plant, while the Contractor shall provide a branch on the raw water transmission pipe from a tubewell pumping station to the grid distribution network.
- The defect liability period shall commence from the date of a completion certificate is prepared and issued after the completion inspection.

(2) Procurement Conditions

The following are special conditions for procurement.

- The first priority of procurement shall be given to the products of Pakistan. Japanese products will have the second priority. In case that the products are not available in Pakistan or Japan, the product from the third countries will be procured in consideration of cost supremacy.

- Materials for water transmission pipes from the tubewell pumping station to the grid distribution network shall be of HDPE (High Density Polyethylene Pipe) manufactured and generally available in Pakistan.
- Transportation of imported material shall be the section between Karachi and Lahore. Re-packing for the convenient number or shape will be considered from the seaport to the construction site so as to make land transportation possible, as required.

2-2-4-3 Scope of Works

General work sharing for Japan's Grant Aide Scheme is as shown in **Table 2-26**,

Table 2-26 Major Undertakings to Be Taken by Each Government

No.	Items	Japan	Pakistan
1	To acquire lands at the sites for the water treatment plant and water towers		●
2	To clear, level and reclaim the site when needed		●
3	To construct gates and perimeter fences around the water treatment plant and water towers		●
4	To construct the parking lot		●
5	To construct roads		
	1) Within the site	●	
	2) Outside the site		●
6		●	
7	Water transmission pipe from a tubewell pumping station to an existing water distribution grid	●	
8	Water transmission pipe from a tubewell pumping station to a filtration plant	●	
9	Installation of a filtration plant		●
10	Water transmission pipe from a tubewell pumping station to a filtration plant to be constructed in case of an arsenic concentration of above 10μg/L in the water quality test at the completion of a tubewell		●
11	To provide a stock yard of the construction materials and equipment		●
12	To provide facilities for the distribution of electricity, water supply, drainage and other incidental facilities		
	1) Electricity		
	a. To construct permanent electric power receiving wiring for tubewell pumping stations		●
	b. The drop wiring and internal wiring within the site	●	
	c. The main circuit breaker and transformer		●
	2) Water Supply		
	a. The city water distribution main to the site	●	
	b. The supply system within the site (receiving and/or elevated tanks)	●	
	c. The clean water for pressure test and flushing	●	
13	To organize the Project Implementation Unit (PIU) and to allocate the staff for operation and maintenance before the commencement of the soft component programs		●
14	To bear the following commissions to a bank of Japan for the banking services		

	based upon the B/A		
	1) Advising commission of A/P		●
	2) Payment of banking commission for the Authorization to Pay (A/P) and payment to a Japanese bank based upon the Banking Arrangement (B/A)		●
15	To ensure prompt unloading and customs clearance at the port of disembarkation in recipient country		
	1) Marine (Air) transportation of the products from Japan to the recipient country	●	
	2) To facilitate prompt customs clearance and to pay the custom duties on the equipment and materials required in the implementation of the Project at the port of offloading, and support for smooth delivery of the equipment and materials		●
	3) Internal transportation from the port of disembarkation to the project site	●	
16	To facilitate the Japanese nationals involved in the Project in accordance with the verified contracts to obtain relevant visas and stay permits in Pakistan		●
17	To pay internal taxes and other levies on the equipment and materials brought into Pakistan and services provided by the Japanese nationals in accordance with the verified contracts		●
18	To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant Aid		●
19	To bear all the expenses, other than those to be borne by the Grant Aid, necessary for construction of the facilities as well as for the transportation and installation of the equipment		●

Table 2-27 Scope of the Project Works

Category	Contents	Japan	Pakistan
Tubewell pumping station	Drilling of tubewells	●	
	Finishing of tubewells including a variety of tests	●	
	Building a pumping station	●	
	Interior works of a pumping station	●	
	Installation of mechanical equipment	●	
	Installation of electrical equipment including the installation of flow meters	●	
	Piping around pumping equipment including accessories	●	
Water transmission pipe	Water transmission pipe from a tubewell pumping station to water distribution grid	●	
	Water transmission pipe from a tubewell pumping station to a filtration plant	●	
	Water transmission pipe from a tubewell pumping station to a filtration plant to be constructed in case of an arsenic concentration of above 20 μg/L in the water quality test at the completion of a tubewell		●
Filtration plant	Installation of a filtration plant		●
Procurement materials	Energy auditing instruments	●	

2-2-4-4 Consultant Supervision

If the Government of Japan (GOJ) decides to implement the project based on the result of the basic design study, E/N (the exchange of notes) of GA (grant agreement) for the project will be concluded between GOJ and the Government of Pakistan (GOP). The contract between GOP and a Japanese consultants will be subsequently prepared and the Consultant will start the detailed design after the verification of the contact by GOJ.

(1) Detailed Design

Upon commencement of the work, the Consultants will conduct detailed site survey and topographical survey. Project cost will also be estimated and detailed design report will be prepared. The project design period will total 4.5 months which will consist of 2.0 months for site survey and 2.5 months for detailed analysis in Japan including project cost estimation.

(2) Bidding Works

The Consultants will prepare the bid documents for approval of WASA.

Invitation for P/Q (pre-qualification) for Japanese Contractor will be appear in Japan newspapers only. The Consultants will issue the bid documents to all candidate bidders. Bids will be opened after 45 days from the bid documents issued with presence of WASA and JICA. The Consultants will assist WASA until the construction agreement signed with successful bidder. The GOJ will verify the said contact and the construction works will be commenced.

The bidding works need 4.0 months including; 1.5 months for document preparation and approval, and 2.5 months from document distribution, and evaluation. The Consultants will take following responsibilities.

- The Consultants will receive the P/Q documents from the eligible contractors more than one week after P/Q publication,
- The Consultants will evaluate the received P/Q documents immediately and inform the bidding schedule to the candidate bidders.
- The Consultants, on behalf of WASA, will conduct the bid opening at Tokyo after 45 days from the document distributed. WASA and JICA will presence at the bid opening, and the consultants will submit the bidding report to JICA immediately.
- The Consultants, on behalf of WASA, will evaluate the bid documents submitted by the contractors and arrange them in order, the lowest bidder less than the sealing price technically. The consultants will recommend the said bidder to WASA as a successful contractor.
- The Consultants will assist WASA to conclude the construction agreement including governmental verification, etc.

(3) Supervisions for Construction and Procurement

Facility construction includes the tubewell, civil, mechanical and electrical works. The Consultants will dispatch the chief supervisor and a tubewell specialist, a pipeline engineer, a mechanical engineer and an electrical engineer. The Consultants also assign Pakistani engineers and specialists to support Japanese engineers.

The chief supervisor will be assigned at the construction commencement time and stay on site during the whole construction period. Other specialist/engineers and will be assigned shortly to inspect the procurement materials and the work completion.

The Consultants will implement the project well coordinating with concerned organizations of the Pakistani side, Japanese side (Contractor, JICA, etc.) and others.

(4) Operational Guidance

The Contractor will prepare the operation and maintenance manual of facility/equipment installed under the project and carry out the initial training at the completion of the said facility/equipment.

The Consultants will explain the design concepts and facility functions and carry out the technical guidance to the WASA staff on proper operation and maintenance of a tubewell pumping station and procedure of energy audit as a soft component.

2-2-4-5 Quality Control Plan

Facility and materials/ equipment shall be required to have a quality and functions in accordance with the general specifications, particular specifications, drawings and standards mentioned in the bid documents, which shall be studied and prepared in the detailed design stage. Followings will be required for the construction works.

Table 2-28 Quality Control Items and Method

Category	Item	Method	Remarks
Pipe Materials	Strength, Appearance, Dimensions	Confirmation of Product Inspection Result Visual Inspection, Dimensional Inspection Gauging Inspection	Pakistan Standard/ISO
Pipe Works	Torque Leakage	Torque Wrench Water Pressure Test	Pakistan Standard/ISO, WASA Standard for Piping Works
Concrete	Gravel, Cement, Water Flesh Concrete Concrete Strength	Pakistan Standard/ISO	Pakistan Standard/ISO
Reinforcing Bar	Strength	Tensile Strength Test Bar Arrangement Inspection	Pakistan Standard/ISO

Facility		Dimensional Inspection	Pakistan Standard/ISO
Tubewell	Water Quality	Water Quality Test at the Completion	WHO Guideline, National Standards for Drinking Water Quality (Pakistan)
	Pumping Discharge	Pumping Test at the Completion	JGS 1315
Mechanical and Electrical Equipment	Pump	Performance Test	Discharge, Pressure, Current
	Control Panel	Control Test	Confirmation of Panel Control
	Instruments	Performance Test	Confirmation of Control and Calibration

2-2-4-6 Procurement Plan

(1) Civil and Building Material

1) Construction Material

All the materials for tubewell construction such as casing, gravel, sand, cement, etc. and for building such as brick, reinforcing bar, etc. are locally available in Pakistan.

2) Piping Material for Connection

The HDPE pipe (High Density Polyethylene Pipe) used for the connection between a new tubewell pumping station and a grid distribution network is locally manufactured and generally used in WASA.

The connection with an existing pipe must be done under the condition of non-suspension water in principle, but in some sites, there is a connection with a large–size pipe such as 600 mm in diameter which may result in an extensive influence on water supply in Lahore. Therefore, the non-suspension water method shall be applied to such a site. The tee special used in the method is not manufactured locally, therefore, it will be procured from Japan.

3) Construction Machinery

(a) Tubewell Drilling Machinery

The local tubewell contractors have several units of tubewell drilling machines and backhoes, respectively, and other excavation machines like a crane can be procured by lease. Therefore, all the construction machineries shall be procured locally.

(b) Drilling Machine for Non-suspension Water Method

The pipe connection work using the non-suspension water method requires the exclusive drilling machine to drill an existing pipe which is not locally available. Therefore, this machine shall be procured in Japan for temporary use in Pakistan during the construction period.

(2) Mechanical and Electrical Equipment

1) Tubewell Pumping Equipment

(a) Pumping Equipment

At existing tubewells in Lahore, all the vertical multistage turbine pumps are locally manufactured and used which are delivered to WASA Lahore by one specific manufacturing company due to its specialty in pump type and reliability on quality. The type is a vertical shaft turbine pump generally used, but it is rare to use it in the deep wells with a long shaft under the ground. Due to the constraint of a long shaft under the ground, the manufacturer is limited to only one company even in Japan. Although the number of manufacturers is limited both in Pakistan and Japan, the pump shall be procured from either Pakistan or Japan to encourage the competition in the bidding.

When assuming the procurement of a pump from Pakistan or Japan, the origin countries of its motor are supposed as shown in **Table 2-29.**

Table 2-29 Procurement Countries of Tubewell Pumping Equipment

Procurement Country of A Pump	Origin Country of A Pump	Origin Country of A Motor
Pakistan	Pakistan	Czecho / China
Japan	Japan	Japan / Taiwan / Korea

Source: JICA Survey Team

(b) Valves around a Pump

Around a pump, three types of valves – check valve, sluice valve and air valve – are installed on the delivery pipeline. Although all the existing valves used around a pump are made in Pakistan and are locally available, it is found that some check valves are not functioning correctly and the reliability, an evidence that quality is not so high in Pakistan. Therefore, valves shall be procured from Japan.

(c) Flow Meter for a Pump

The turbine-type integral flow meter are attached to the delivery pipe from an existing pump but not manufactured locally. Therefore, it shall be procured from Japan.

(d) Piping around a Pump

At the existing pipeline around a pump, the locally-manufactured cast iron pipe is generally used. Therefore, the piping material around a pump shall be procured locally.

2) Disinfection Equipment

As studied in **2-2-1-2** (2), application of chlorine gas was comprehensively examined, the same method as the existing, diaphragm pumps, will be adopted due to the risk of leakage. Since many diaphragm pumps are damaged, standby pump will be installed at all tubewell pump stations. Then a duty pump is damaged, standby pump will be used to continue disinfection to water supply system. Spare parts and training program will be provided to repair the pumps.

The disinfectant injection pump (diaphragm pump) used at the existing tubewell pumping station is not locally manufactured but imported from other countries. Therefore, disinfection equipment shall be procured from Japan.

3) Electrical equipment

Since the local power control panel is simple and functions only for on-off operation. Therefore, these shall be procured locally, taking into account the ease in maintenance and repair, as well as in obtaining of spare parts.

Table 2-30 summarizes the list of materials to be procured by this project.

(3) Procurement of Instruments

All the instruments for energy audit are not locally manufactured, therefore, they shall be procured from Japan.

Table 2-30 Summary of Construction Material and Equipment Procurement

Items to be procured		Procured from:			Remarks
Category	Materials	Pakistan	Japan	The third country	
Piping material	Cast iron pipe (straight pipe、specials and connecting material)	●			Exposed on the ground
	Valves around a pump (sluice valve, check valve, air valve)		●		
	Turbine type bulk flow meter		●		
	Cast iron manhole cover, valve box	●			
	High density polyethylene pipe (HDPE)	●			
	Hard vinyl chloride pipe	●			
	FRP casing pipe	●			

Material for civil works	Cement, aggregate, sand, flame	●			
	Reinforcing bar	●			
	Brick	●			
	Fuel (light oil, gasoline, diesel oil)	●			
Mechanical and electrical equipment	Pump	●	●		
	Motor	●	●	●	
	Chlorine injection unit (chemical tank, injection pump)		●		
	Control panel	●			
	Water level meter	●			
Construction machinery	Excavator, crane, dump car, etc.	●			
Drilling machine	Non-suspension water type driller		●		

Table 2-31 Summary of O&M Equipment Procurement

Materials to be procured		Procured from:			Remarks
Category	Name	Pakistan	Japan	The third country	
Energy auditing instruments	Power analyzer		●		
	Portable ultrasonic flow meter		●		
	Pressure gauge		●		
	Portable water level meter		●		
	Tachometer		●		
	Razor type thermometer		●		
	Vibration meter		●		
	Laptop personal computer		●		

2-2-4-7 Operational Guidance Plan

Prior to the turn-over of the facilities, the start-up and commissioning program will be carried out in order to verify the function and operation of the equipment installed in, such as pumps, electrical panels and chlorination equipment installed at the tubewell pump stations. In this program, the Contractor will provide the required guidance/trainings mainly on how to operate the equipment and in troubleshooting. Operational guidance training will initially be conducted to the operating staff of WASA.

Table 2-32 Initial Operational Guidance

Facility	Contents	Remarks
Tubewell Pump	Pump: Function test, ON-OFF operation, Daily inspection Flow meter: Function test	
Electrical facilities	Electrical panel: Function test, Daily Inspection Water level indicator: Function test	
Chlorination equipment	Set-up of dosing rates, Daily inspection	
Transmission/ Distribution Pipelines	Valves: Function test, Valve operation	

2-2-4-8 Soft Component Plan

The soft component involves the transfer of knowledge and technology for energy audit of tubewell pump stations. Knowing that the pumping stations are the most important water supply facility in Lahore, the transfer of technology will contribute to improved and energy–efficient water supply operations.

Therefore, through the soft component, energy audit equipment supplied in this project will be utilized to monitor operational conditions of the pump stations, to analyse the data, to improve operation and maintenance and ultimately achieve efficient operation. Moreover, the soft component supports WASA's preparation of the implementation plan as well as independently promote and establish energy efficient operation.

Soft component is expected to achieve the objectives of "energy audit.".

- WASA's employees in Energy Control Unit and maintenance teams properly understand the operation and energy consumption in pump stations, implement adequate and efficient operation and maintenance, and establish rehabilitation and replacement plans.

The soft component will be direct-assistance type in Lahore by two Japanese water supply consultants (mechanical and electrical engineers). Their assignment will be for 2.63 man-months including preparatory work in Japan. Local engineers will be also engaged in assisting Japanese engineers for 1.63 months. The activities are shown in **Table 2-33**.

The soft component will be implemented after the signing of the contract and when the energy audit equipment is supplied at the site, or from April 2016 to September 2016, seven months after the contract has been signed and will run for sixmonths. Planning and scheduling of the soft component implementation will commence in Japan.

Table 2-33 Activities of Soft Component

Results	Technology/ Field	Current Technology and Required Technology	Activities	Method	Input	Report
Result 1 Energy audit of pump stations can be properly implemented using energy audit equipment.	**Technology:** - tubewell pumping, water distribution, operation, maintenance, energy audit **Field:** - mechanical, electrical	・It is necessary to improve operational efficiency of tubewell pump stations in order to reduce the electricity cost and improve WASA's operation. ・However, no sufficient measure was taken to improve efficiency and reduce electricity cost, due to lack of technology and fund. ・Energy, hydraulic/electricity energy, energy audit and efficiency of pump operation shall be understood and data collection and analysis shall be implemented.	◇Function of tubewell pump stations and distribution system ◇Pump operation and its flow, pressure, water level etc. ◇Energy audit ◇Use of energy audit equipment ◇Measuring of pump operation **[Training item]** Function of tubewell pump stations and distribution system, energy audit and use of its equipment	- Classroom Training - OJT at Pumping Stations	- Mechanical/Electrical engineers (Japanese consultant) Planning/preparation/imple-mentation/reporting Mechanical: 1.07 M/M Electrical: 0.73 M/M - Engineer (Pakistani) Engineer: 0.87M/M	・Energy audit analysis manual ・Energy audit measuring log sheet ・Energy audit report ・operation improvement plan for existing pump station
Result 2 Proper operation and maintenance will be planned and implemented using energy audit.		・Methods to improve efficiency of pump operation and reduce electricity cost are not identified and taken. ・Energy audit shall be understood and efficient pump operation shall be implemented.	◇Analysis of energy audit measurement ◇Problems of current pump operation ◇Improvement plan for efficient pump operation **[Training item]** Analysis method for energy audit, identifying operational problems, planning of efficient pump operation			
Result 3 Implementation plan will be established for efficient operation, rehabilitation and replacement.	**Technology:** - tubewell pumping, water distribution, operation, maintenance, energy audit **Field:** - mechanical	・Particular measures to improve pump operation cannot be planned due to lack of technology. ・Energy audit shall be understood and pump improvement plans shall be established.	◇Study of the existing stations for improvement ◇Rehabilitation and replacement plans for the existing stations **[Training item]** Investigation of the existing stations, Planning for rehabilitation and replacement	- Classroom Training - OJT at Pumping Stations	- Mechanical engineers (Japanese consultant) Planning/preparation/implem entation/reporting Mechanical: 0.83 M/M - Engineer (Pakistani) Engineer: 0.76M/M	・Rehabilitation /replacement plan for existing stations ・Soft component completion report

Note: Target group shall be M&E Engineers/ Mechanic / Electrician /Labour (total : 15 WASA's employees).
Soft component shall be implemented from April 2016 to September 2016.

Firstly, the necessity of an energy audit for Lahore WASA shall be explained after which the training materials on how to use the energy audit equipment will be described; and lastly, the data collection shall be conducted. Using the materials, training shall be conducted in a classroom setting and at the site, so WASA employees can collect all necessary data and analyse the data on their own. In analysing the data, factors such as insufficient pump operation shall be identified and an improvement plan shall be established. After this training, WASA will collect operational data for ten existing pump stations. The consultant working for construction supervision shall confirm the progress of the training, while the consultant in Japan shall advise by e-mail, if necessary.

By confirming data collected and analysed, WASA's capacity will be improved and be more consistent. Also, by using the results, the technical assistance shall be implemented to improve pump operation and rehabilitation/replacement plans, if required.

Implementation Schedule of Soft Component is shown in **Table 2-34**.

Table 2-34 Implementation Schedule of Soft Component

	Engineer	2015					
		April	May	June	July	August	September
Result 1 Energy audit of pump stations	Mech.	4 days		28 days			
Result 2 Proper O&M plan using energy audit	Elect.			22 days			
Result 3 rehabilitation and replacement plan	Mech.					18 days	
Reporting	Mech.						7 days
Data Collection (by WASA)							
Report Submission			▲ Training Manuals				▲ Completion Report

□ In Japan
■ In Pakistan

2-2-4-9 Implementation Schedule

(1) Construction Condition of Local Contractor

The construction of around 16 water wells has been outsourced by WASA. In the city area of Lahore, there are many well contractors. WASA has selected 12 authorized contractors based on their construction capability and work experience. Three construction companies were also checked in this study. It was confirmed that these companies owned handmade rigs, wing bits, and drill pipes. They have demonstrated capability to construct the project wells. There is also an electric logging firm which seems to have sufficient implementation capability as observed from having its own equipment and and organised data.

It is possible to procure well construction materials. Project plan specifies the mild steel as well casing for pump room, the FRP as screen casing and screen and bottom plug, and screen slits to be manufactured by machine cutting.

(2) Construction Period and Implementation Schedule of the Project

Considering local conditions, constructing one WASA well will take approximately 1.1 months, including construction works such as site preparation, mobilization for equipment and materials, drilling hole, well development, pumping test (step drawdown test, continuous pumping test, and recovery test), and demobilization,. The construction of the pump house will take around 1.6 months, while the setting of machines and electric equipment such as pump, motor, and panel will require 0.4 month.

The entire construction period in the project schedule is estimated to be 19 months, excluding the period for detailed design, bidding and contract procedures. The 105 wells to be reconstructed are scheduled to be completed within this period. To increase work efficiency for well construction, the work shall be conducted by two teams – a drilling team and pumping test team. Drilling rigs are planned to be shifted to another site at about 0.6 month.

In the construction period, after the completion of a last well, two months will needed to construct the pump house and to set the pump, motors and panel.

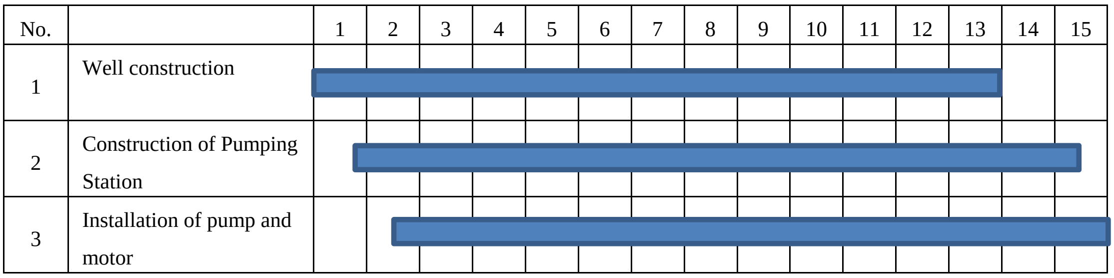
The well number to be possibly constructed by a well drilling team within 15 months

15 months / (21 days/well drilling/team) = 21.4 drilling holes≒21 drilling holes

The drilling team number necessary for well construction

105 wells（well number planned）/21（the well number /well drilling team）= 5 teams

Based on the above calculation, 5 drilling teams are needed to construct the 105 planned wells if total construction period is 16 months requiringthe same number of teams assigned for pumping test, the construction of pump house, and the installation of pumps and motors and panels. **Figure 2-7** shows the outline of construction schedule.



Note: The construction works are to be conducted by 5 teams performing well drilling, pump house construction, and setting of pump and motor and panel. Though construction period for each team is actually staggered, this table indicates the period as a series of works.

Figure 2-7 Outline of Construction Schedule

(3) Overall Project Implementation Schedule

The overall schedule of project implementation is shown in **Figure 2-8**. Is is expected to take nine months for detailed design and bidding process and 19 months for construction works.

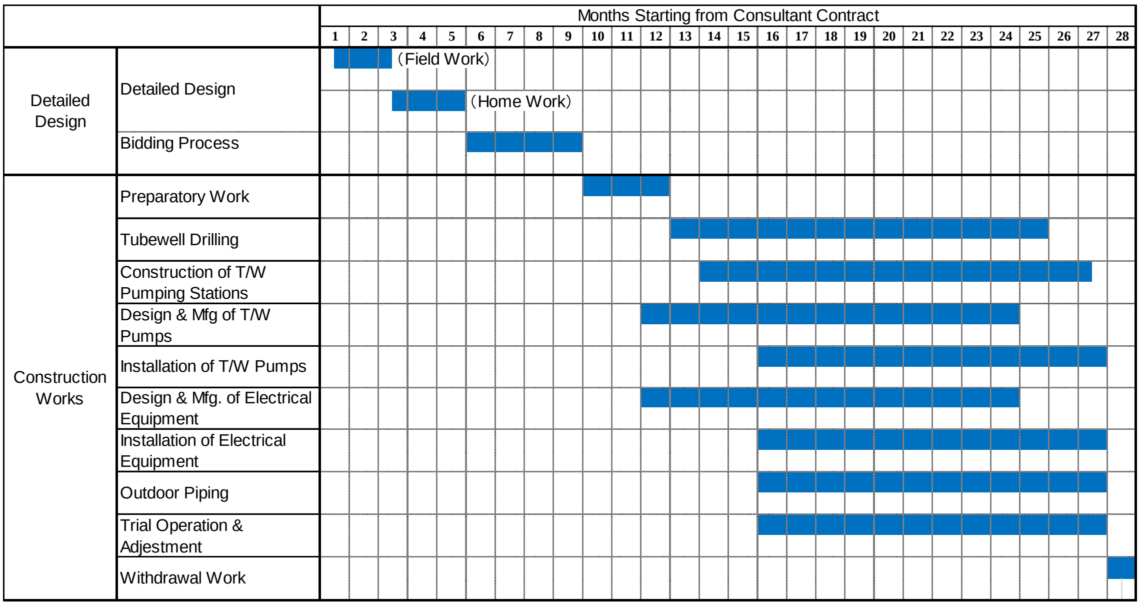


Figure 2-8 Schedule of Project Implementation

2-3 Obligations of Recipient Country

The following works shall be undertaken by the Pakistani side:

(1) Installation Works of Gate, Fence, etc.

Generally, WASA doesn't provide any gate, fence, etc. for the tubewell pumping station. If this will materialize, it shall be undertaken by the Pakistani side.

(2) Removal Works of Abandoned Existing Tubewell Pumping Station

The abandoned existing tubewell pumping station is handled by WASA on the case-by-case basis. More often than not, some are left as they are, while a few are brought down and the land is cleared after the removal of mechanical and electrical equipment. The removal works of abandoned existing pumping station shall be undertaken by the Pakistani side, if any.

In case that the existing tubewell pumping station will be abandoned and the new one will be constructed in the same or different premises, it is recommended to backfill the existing tubewell with natural soil, since if existing tubewell will be left as it is, to avoid anything dropping into the casing and causing the pollution of surrounding groundwater. After backfilling, the pumping and electrical equipment will be removed and the pumping station will be demolished. The concrete base will be crushed with a construction machinery for disposal to the general solid waste dumping site. If the tubewell pumping station will remain, the door shall be firmly locked so as not to allow the entry of residents and the casing hole shall be covered with a concrete slab when the pump will be removed.

(3) Contributions to LESCO for Power Receiving and Transformation Works

The regulations of LESCO (regional power distribution company) states that the power receiving and transformation works shall be undertaken by the company and that the user is responsible to pay the contributions for such works to LSECO. Even with WASA works, the contract amount of a local contractor includes such contributions as reimbursable cost. Therefore, the total amount of contributions for such power receiving and transformation works imposed by LESCO shall be borne by WASA but the cost for secondary wiring and electric equipment after the transformer installed by LESCO near the new tubewell pumping stations shall be included in the project.

(4) Installation Cost of 88 Filtration Plants

WASA will bear the cost of the installation of filtration plants including public faucets as a prerequisite to project implementation.

2-4 Project Operational Plan

The project aims to restore the pumping capacity of 105 identified wells by replacing the existing tubewell pumping stations whose capacities have declined with the construction of new tubewells and installation of new pumps. During the implementation of the project the O&M team in charge of the existing tubewell pumping station will close oerations but will transfer to another tubewell site, hence there will e not requirement for new staff. Operational requriements will also remain the same, as the pump types are similar, except for the following:

- The water level indicator will be installed at ten tubewells and WASA will have to check the groundwater levels, namely both static water level (SWL) and dynamic water level (DWL) by reading the scale, at the same day once a month to understand the entire movement of groundwater drawdown.
- An operator currently monitors the hours of operation are through on-off mechanism of the pump at the existing tubewells. At the new tubewells, the hour meter will be provided with each pump and the operator will have to read and record the hour meter daily forrecording.
- All the filtration plants are maintained by the supplier under the operation and maintenance contract with WASA. All the equipment is automatically operated based on the water levels set in a effluent storage tank and daily consumption is read and recorded on the logbook by a operator. When arsenic-adsorbent will be full in capacity and an arsenic concentration will be close the WHO drinking water guideline of 10 μg/L, the exchange of adsorbent is required.

2-5 Project Cost Estimation

2-5-1 Initial Investment

For the overall project cost, the Pakistani side shall partially bear the costs according to the work sharing between both governments. The following is the project cost to be borne by the Pakistani side.

(1) Project Cost Borne by the Pakistani Side

The project cost borne by the Pakistani side is estimated at approximately Rs.395.4 million (=JPY 385.8 million).

(2) Assumption of Cost Estimation

Based on TSS at State Bank of Pakistan for PKR-JPY and Mitsubishi UFJ Research and Consulting for US$-JPY for three months from June to August, 2013.

Estimation Time:	August 2013
Exchange Rate:	US$ 1 = JPY 99.38
	Rs. 1 = JPY 0.9756

Table 2-35 Project Cost Borne by the Pakistani Side

	Item	Cost (Rs.)	Cost (JPY)
1	Installation of gate, fence, etc.	–	–
2	Removal of abandoned tubewell pumping station	–	–
3	Contribution to LESCO for power receiving and transformation	147.1 million	143.5 million
4*	Installation of filtration plants	364.3 million	355.4 million
5	Installation of raw water transmision pipes from tubewell pumping stations		
	Total	511.4 million	498.9 million

*1 Out of 88 filtration plants, 20 plants have been already included in PC-1 submitted to the Punjab Government on November 26, 2013 and the rest requires another PC-1.

*2 The Punjab Government and WASA have a policy to install a filtration plant for a tubewell with an arsenic concentration of more than 20 μg/L at present and more than 10 μg/L in future. Since JICA proposal meets this policy, the budget of filtration plants required for JICA grant-aid project is ensured through PC-1 approval.

2-5-2 Operation and Maintenance Cost

(1) Operation and Maintenance Cost

Operational costs for Lahore WASA water supply consists of employment cost, electricity, maintenance cost and etc. This Project is to re-construct the existing aging 105 tubewell pump stations, there is no planned change in the number of personnel, thus personel costs remain unchanged.

Electricity for every tubewell is monthly billed by LESCO and paid by WASA. The tubewell pump stations are categorized “Tariff D – Agriculture” “D-1 (b) Agricultural 5 kW & above” by LESCO’s tariff. The tariff mainly consists of 1) Fixed Charges (Rs/kW/M) 200 Rs、2) Variable Charges (Rs/kWh) Peak – Rs 18.00 / Off-Peak – Rs 12.20, and 3) Low Power Factor Penalty (variance from requirement of 0.9). Currently the government provides subsidy for facilities in this category, then, the tariff is reduced to 1) Fixed Charges (Rs/kW/M) 200 Rs, 2) Variable Charges (Rs/kWh) Peak – Rs 7.65、Off-Peak – Rs 1.85 and 2) Variable Charges (Rs/kWh) Rs 10.35 /kWh for both Peak and Off-Peak. GST and some other charges are about 25% on the tariff, and it is approx. Rs 13 /kWh.

Table 2-36 Estimated Expense for Electricity at 105 Proposed Tubewells

Water Production (13.5 hours per day)	kW consumption per m^3	Electricity Rs./kWh	Electricity per day Rs.	Annual Electricity Rs.
34,680 m^3/hr x 13.5 hrs	0.202	13	1,229,400	448,731,000

One tubewell pumping station requires four operators for three shifts.

Table 2-37 Estimated Expense for Personnel at 105 Proposed Tubewells

Type of Work	No. of Employees (pers.)	Salary Rs./month	Annual Personnel Expense Rs.
Pump Operator	105 x 4 shifts = 420	6,500	32,760,000

Maintenance cost is estimated from the out-sourcing cost, especially for the mechanical/electrical repair works given to the private sector at Shalimar Town (55 tubewells) in 2012/2013 for one year.

Table 2-38 Estimated Expenses for Maintenance at 105 Proposed Tubewells

Item	Annual Cost in Shalimar Town		Annual maintenance Cost for 105 tubewells	
	Nos.	Rs.		Rs.
Electrical repair	64	7,690,580	105 / 55 x 30% = 60% (considering nos. of wells and age of facilities)	4,614,000
Motor re-winding	35	4,741,986		2,845,000
Mechanical repair	26	2,494,079		1,496,000
			Total	8,955,000

(2) Revenue by Water Tariff

Water tariff shall be collected by supplying water from new 105 tubewell pump stations to the service area customers. The revenue is estimated as follows.

Typical 1 m^3 water tariff is estimated using water tariff at Gunj Buksh Town in Jan/Feb 2009. The major consumers were domestic user of 5,001-20,000 gallon (22.7 – 90.9m^3) per month and domestic user of 5,001-20,000 gallon (22.7 – 90.9m^3) per month.

Then average tariff for 1 m3 is calculated.

$$(\text{Rs } 20.86 \times 0.92 + \text{Rs } 48.85 \times 0.08) / 4.546 = \text{Rs } 23.10 /m^3$$

Table 2-39 Estimated Revenue at 105 Proposed Tubewells

Water Production (13.5 hours per day)	Water Tariff Rs./m^3	Revenue per day Rs.	Annual revenue Rs.
34,680 m^3/hr x 13.5 hrs	5.08	2,378,400	868,116,000

Therefore, the revenue from water tariff from the 105 tubewells is estimated at 0.87 billion Rs per year.

As stated earlier, the operation and maintenance expenses of the 105 tubewell pumping stations amount to 0.50 billion Rs. per year. Although it seems that there is a profit of 0. 37

billion Rs. per year, there is in fact a deficit if administrative and indirect expenses are taken into account. Therefore, it is necessary to increase the water tariff and to balance the expense with the revenue.

WASA is responsible for water supply, sewerage and drainage. Balancing revenue with expenses considers a variety of factors, making it difficult to simply compare the expense and revenue items directly for 105 tubewell pumping stations. However, the approach for pump selection proposed herein is intended to save energy, and will have a considerable impact in reducing power consumption per unit water production by about 37.5%. This is applicable to other existing pumping stations, and is recommended when replacing existing tubewell pumping stations in the future.

2-6 Considerations for the Implementation of theTechnical Assistance Project

The objective of this project is to restore a water supply capacity by constructing alternative tubewell pumping stations respectively for existing 105 stations which have decreased the discharge capacity in the Lahore water supply system which fully relies on groundwater. However, the groundwater source of Lahore has two problems of yearly drawdown of water level and arsenic pollution. The former is attributed to over-pumping of groundwater and as long as groundwater abstraction will be continued, it will be difficult to stop the progress of such drawdown of water level. While, the latter takes the course that the situation of arsenic pollution has been deteriorated whenever the water quality tests have been conducted expanding the target and upgrading the analytical accuracy. For this reason, the Punjab Government and WASA has started to install filtration plants for tubewells with an arsenic concentration of more than 20 μg/L, in spite of having the national drinking water standard of 50 μg/L for arsenic, to supply safe water for drinking and cooking purposes through the public faucets, although the people have to fetch water with a water container. Its water quality meets the WHO drinking water guideline of 10 μg/L for arsenic. In future, the target will be extended to tubewells with an arsenic concentration of more than 10 μg/L. However, it should be noted that the people who cannot fetch water are still exposed to the risk drinking the arsenic-polluted tap water. In addition, WASA which cannot cover the O&M expenses by tariff revenue even at present, will has borne the new financial burden for O&M of new filtration plants. To change such a situation drastically, it is strongly recommended to develop the surface water source for shifting from groundwater to surface water or blending groundwater with surface water. The Punjab Government and WASA are now conducting “the Feasibility Study for Construction of Water Treatment Plant to Treat Surface Water Intake from BRB Canal, Lahore” with a budgetary amount of Rs. 10,000,000 and a study period of six months. In the situation that WASA will has to continue to fully rely on groundwater until the surface water induction will be realized, this project is indispensable, but it is necessary to progress the project in collaboration with the installation of filtration plants under the control of WASA.

CHAPTER 3 PROJECT EVALUATION

3-1 Pre-conditions for Project Implementation

The biggest issue in this project is the growing arsenic pollution of groundwater considering that this is Lahore's source of drinking water. The joint survey of WASA and PUIC in November 2011 revealed that only 67 tubewells (14.8%) out of 459 tubewells met the WHO drinking water guideline of 10 μg/L for an arsenic concentration, while the JICA survey in July 2013 showed that only six tubewells (5.7%) out of 140 tubewells sampled (sampling couldn't be done at 7 tubewells) cleared the standard. The number of tubewells exceeding the Pakistan drinking water standard of 50 μg/L for an arsenic concentration were 14 in the PUIC survey and two in the JICA survey, respectively. However, because of strong public opinion, WASA has commenced the installation of filtration plants to remove arsenic and supply safer water to the people for drinking and cooking use through a public faucet system, although the people are required to fetch water from such public faucets. At present, filtration plants are installed in tubewells with an arsenic concentration in groundwater set at 20 μg/L. This is also used to select the tubewells for the project, in keeping the consistency with the WASA's policy. The tubewells with an arsenic concentration of not lower than 20μg/L in groundwater are required in the project for filtration plant has been already installed or will be installed in near future. Therefore, to ensure the sustainability, the operation and maintenance of those filtration plants is the pre-condition of the project. However, even at present, WASA has not covered the expenditures for facility operation and maintenance by the tariff revenue and such situation will be expectedly deteriorated by the addition of filtration plants. For this purpose, the Punjab Provincial Government is required to assure that subsidy to WASA be continued or to approve the WASA's request for water tariff increase in order to establish the sustainability of water supply service.

3-2 Necessary Inputs by Recipient Country

The necessary inputs that the recipient country has to address independently for the project are listed below:

1) Acquisition of land for tubewells
2) Installation of gate, fence, etc. for tubewell pumping stations
3) Demolishment and removal of existing tubewell pumping stations
4) Payment of contributions for power receiving and transformation to LESCO
5) Installation of 60 filtration plants
6) Installation of filtration plants required when an arsenic concentration of groundwater

at the completed tubewell will exceed 20 μg/L

7) Operational data collection and analysis at tubewell pumping stations through the planned use of energy audit instruments and improvement of operational control methods

3-3 Important Assumptions

(1) Assurance of Sustainability in WASA Water Supply Service

At present WASA Lahore fully relies on groundwater as its source for water supply service, but its tariff revenue cannot cover for the expenses for operation and maintenance, necessitating a regular increase of water tariff as inevitable for WASA. However, it is very hard to get the approval of the Punjab Provincial Government due to political considerations. For this reason, the government provides subsidy to WASA to offset deficits whenever these crop up. Because of this financial condition, WASA has extended the provision of filtration plants as a measure against arsenic pollution at existing tubewells and this project itself is a collaborative pre-condition for the installation of additional filtration plants. In the future, the operation and maintenance expense of the filtration plants form part of the existing expenses, and further deterioration of WASA financial condition will continue. To ensure the sustainability in water supply service by WASA, the sustained subsidy to WASA by the provincial government will be indispensable. Otherwise, the water tariff increase mechanism should be established as early as possible to cover at least the operation and maintenance expense.

(2) Awareness Campaign to Promote the Use of Filtration Plants and Their Strategic Layout

To cope with the arsenic pollution of groundwater, WASA has to install the filtration plants. As a minimum requirement, this is to supply drinking and cooking water to the people by a public faucet system thereby protecting the people from the health risk caused by arsenic. It means that only the people who fetch water from the public faucets can benefit of such a system. However, some people still keep drinking arsenic-polluted water from household taps within especially for homes located far from such public faucets. It is important, therefore, the provide an awareness campaign on on the health risks of drinking arsenic-polluted water and encourage the people to fetch and use the water from the public faucets. As an added measre, the filtration plants can also be located closer to the service area, rather than being in proximity with the tubewell pumping station. The Punjab Government and WASA has an idea to introduce surface water for water supply from the long-term viewpoint and are going to start the feasibility study for surface water induction as stated in **2-6**. Therefore the installation of filtration plants is the interm measures by the realization of surface water induction.

3-4 Project Evaluation

3-4-1 Relevance

Lahore is the second biggest city in Pakistan with a population of 5,209,000 persons in the urban area, 1,110,000 persons in the rural area according to the census conducted in March. As estimated by the Bureau of Statistics (Punjab), the population is estimated at 7.397,000 for the urban area and 1,618,000 in the rural area as of the end of December 2012. There is approximately an increase of 2,700,000 in the last 15 years giving average population growth rates of 2.56% for 1998-2007 and 2.17% for 2008-2012. Although, the population growth rate has declined, this is again expected to increase in future, impacting on water demand increase.

At present, WASA fully relies on groundwater as its drinking water source, but is poised to start “the Feasibility Study for Construction of water Treatment Plant to Treat the Surface Water Intake from BRB Canal, Lahore” with the pre-requisite of introducing surface water as the new water source starting from 2013 for two years. This project comes after the confirmation of chronic groundwater level drawdown and arsenic pollution in the groundwater. Although the plans are to to shift from groundwater to surface water or to blend groundwater with surface water, this will take substantial time and huge cost for it to be realised. The present full reliance on groundwater has to be maintained and the number of tubewells has to be increased corresponding to the extension of the service area and the population growth.

Therefore, in the situation that there is no choice other than groundwater, this project has high certainty in using groundwater as its water supply source.

Almost WASA’s tubewells are connected to the distribution grid network and it is difficult to identify the service area by tubewell. For this reason, the beneficial population covered by 105 tubewells was calculated multiplying the service population per unit water volume by total water production at 105 tubewells.

Service population per unit water volume: 5,772,000 persons / 1,980,000 m^3/day
= 2.9 person/m^3/day

Beneficial population = 2.9 person/m^3/day x516,000 m^3/day = 1,496,000 persons

Note: 516,000 m^3/day is the total water production at the present operation time of 14.6 hour which depends on the power supply condition in Lahore.
849,000 m^3/day (347 cfs) x 14.6/24 hour/day = 516,000 m^3/day

As stated earlier, the provincial government and WASA has set an arsenic concentration at 20 μg/L for the installtion of a filtration plant closer to the WHO Guideline of 10 μg/L for drinking water compared to the the Pakistani standard of 50 μg/L. The adoption criterion for the project is set at the WHO guideline for an arsenic concentration of 10 μg/L so as to meet the policy of the provincial government and WASA.

The project has sufficient relevance when looking at the perspectives of (i) project necessity, size of population to be benefited, minimization of human health damage risk, and alignment with with the Pakistani target for filtration plant installation.

3-4-2 Effectiveness

As mentioned in **2-1-1** (3), the expenses for light, power and energy share 44.7% in the total expenses in 2012/13 and energy saving is the pressing matter in WASA Lahore management.

The water production of 92 tubewells out of 147 were measured using ultrasonic flow meters The average water production was 4.15 m^3/min (2.4 cfs) or approximately 61% at 6.8 m^3/min (4 cfs) tubewells and 2.98 m^3/min (1.74 cfs) or approximately 88% at 3.4 m^3/min (2 cfs) tubewells, respectively. The power consumption per unit water production was 0.305 kW/m^3 on the average and lower in 3.4 m^3/min (2 cfs) tubewells than that in 6.8 m^3/min (4 cfs) tubewells in general.

Both water production and dynamic water level were measured at 16 tubewells. It is revealed that the operational efficiency varied in the range of 22% to 71% and was 52% on the average. Taking into account that the tubewell pumping efficiency was 72%, assuming a pump efficiency of 80% and a motor efficiency of 90%, respectively, the operational efficiency has declined significantly at most tubewell pumping stations.

The power consumption per unit water production is 0.317 kW/m^3 at the existing 54 tubewell pumping stations; however, that for new 105 pumping stations is expected to be at 0.202 kW/m^3 on average. This approximately reduces power consumption by 36.3% as well as the reduction in repair and O&M expenses through less frequency of trouble such as motor burnout accidents by the provision of a protection unit. The implementation of the project will contribute to the improvement of WASA Lahore management from this viewpoint t (see **Appendix 6. (3)**).

As for the other qualitative effects, the following are expected: (i) the improvement of WASA's financial condition through the reduction of power consumption under the same water volume; (ii) decrease of trouble frequency by pump replacement and provision of an electric protection unit; (iii) increase of water in those areas that used to experience water shortages; (iv) improvement in the accuracy of non-revenue water (NRW), which has been so far calculated based on many assumptions, through the actual measurement using energy audit instruments; and (v) reduction of greenhouse gas emission.

3-5 Recommendations for the Future

Even though the project will have expected results, it is not intended to solve the fundamental problems that WASA faces. It is recommended that the provincial government and WASA address the following issues.

1) The problem of having only one source of water, which is groundwater, is taking its toll in Lahore as evidenced by progressive decline in groundwater levels as well as arsenic pollution. To solve these problems, the provincial government and WASA is going to start “the Feasibility Study for Construction of Water Treament Plant to Treat the Surface Water from BRB Canal, Lahore”. Best efforts should be paid for its successful realization. Although the reliance on groundwater can gradually be reduced by the introduction of surface water, monitoring should be undertaken so that sufficient recharge of groundwater and restoration of water levels can be achieved.

2) At present, WASA has developed the installation of filtration plants at the tubewells with an arsenic concentration of above 20 μg/L and has a plan to extend the target to the tubewells with an arsenic concentration of above 10 μg/L to meet the WHO Guideline for drinking water. This policy is to remove the risk for human health damage and is strongly desired.

3) To keep the financial sustainability of WASA in which the expense largely exceeds the revenue, the increase of water tariff is necessary. If the tariff increase is delayed, the subsequent tariff increase requirement will grow, thus making it more difficult to implement the tariff increase, causing a vicious cycle. Therefore, early decision is required on this sensitive matter. In the situation that the tariff increase is difficult to implement, the subsidy from the provincial government is indispensable as the second best decision.

4) It is recommended that WASA address the life-span extension of a tubewell pumping station of which the life span is reportedly about 15 years. Since the pumping equipment is a mechanical equipment, a15-year life span seems to be reasonable. However, it is still possible to extend the life span of a tubewell; and the system can be changed from the present full replacement of the entire pumping station to the replacement of a pump only. To support this, it is necessary to establish the tubewell cleaning method suitable to the tubewells in Lahore and to establish a regular tubewell

cleaning program from the the time it is commissioned. In addition, the actual measurement of water production should be done at least once a year for all the WASA tubewells and operation control should be established through the regular energy audit.