School of Post Graduate Studies

Addis Ababa Institute of Technology

WELL FAILURE ASSESSMENT: THE CASE OF AKAKI PHASE IIIB WELL FIELD

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Thesis Submitted to Addis Ababa Institute of Technology, School of Post Graduate Studies in partial fulfillment of the requirements for the Degree of Master of Science in Civil Engineering under Hydraulic Engineering stream.

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Declaration and Copyright

I hereby declare to the Senate of Addis Ababa University that this thesis is entirely original work and all other materials are duly acknowledged. This work has not been submitted for academic degree award at any University.

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ABSTRACT

The vast expansion of the city increase the shortage of water and Addis Ababa Water and Sewerage Authority has implemented the short term and medium term plane to overcome the deficit occurred in the city. The plans implemented are the development of groundwater and the expansion of Legadadi Dam. Even if these projects are functional the shortage of potable water has not yet been solved as many of the developed groundwater has a failure problem and decline in the yield. Among the failures observed were the wells in Akaki Phase IIIB development. Identifying the reason behind the failure problem will not only bring about a solution to the problem but also become a lesson for future well development. Thus research tries to find out the reason of malfunction and the decline of the yield of the developed groundwater of Akaki phase IIIB. For the analysis the current situation of the wells in the field and the primary data used in the hydraulic parameter and well yield estimation were collected and scrutinized. Accordingly the efficiency and the yield of each well were obtained from step drawn down test and the transmissivity of the aquifer were estimated from time draw dawn and recovery test analysis. These values at first were compared with the adopted efficiencies, yields and transmissivity values for the possible identification behind well failure.

From the analysis for 8 wells the efficiency obtained from step drawdown test is less than the value assigned in their design report which brings about inappropriate yields and transmissivity estimation. This indicates that the recommendation in the design report were inappropriate and do not represent the capacity of the well. Besides for almost all of the investigated 11 wells the estimated transmissivity has 10% to 120% variation from the values in the design report. The result clearly show that the standard procedure of adopting single well test for study and design will bring about error in the yield estimation which in turn bring about failure as long as the operation follows the result of such study approach.

<u>Key Words</u>: - Addis Ababa Water Supply, Akaki Phase IIIB; Single well test; Transmissivity; well failure; well Efficiency and well yield

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List of Abbreviations

AAWSA	Addis Ababa Water Supply & Sewerage Authority
AESL	Associated Engineering Services Limited
B	Saturated aquifer thickness
DD	Drawdown
L/s	Litter per second
Pp.	Partial penetration
Sa	Observed Drawdown
Sc	Corrected Drawdown
SL-PW	South Legedadi project well
WWDSE	Water Works Design and Supervision Enterprises

1 INTRODUCTION

Water is essential for life on Earth, and the largest source of fresh water lies under the Earth's surface. There is a tendency to think of groundwater as being the primary water source in arid regions and of surface water in humid regions (Todd, 2005). Water exists in virtually every accessible environment on or near the earth's surface. It's in blood, trees, air, glaciers, streams, lakes, oceans, rocks, and soil. The total amount of water on the planet is about $1.4 \times 10^9 km^3$, and its distribution among the main reservoirs is of the fresh water reservoirs, glacial ice and groundwater are by far the largest. Groundwater and surface water are the two reservoirs mostly used by humans because of their accessibility. Fresh groundwater is about 100 times more plentiful than fresh surface water, but we use more surface water because it is so easy to find and use. Much of the total groundwater volume is deep in the crust and too saline for most uses (Fetter, 1988,1980).

Groundwater is the main source of domestic water supply in Ethiopia which covers 85% of the water supply. Groundwater sources have natural protection from pollution and mostly require no treatment before supplied to the users. These help the schemes to be less expensive, more sustainable and are good alternatives of piped water supply. A well-constructed deep well can serve communities for more than 20 years. Groundwater is the most important source of water supply for the great majority of the population and in some arid and semi-arid regions; it is the only source of water in Ethiopia. Despite its immense importance, the government has given less attention to the groundwater sector. As a result, the hydrogeology of the country is poorly understood as compared to surface water systems. The only source of hydro-geological information at the national level is the hydro-geological map of Ethiopia at 1:2,000,000 scale and very few areas are mapped in detail. The available studies of the groundwater resources are very limited. Therefore, studies of the groundwater resources of the country in terms of quantity, quality, management, aquifer characteristics and water balance are of great importance (paul pavelic, 2012).

Addis Ababa is the capital city of Ethiopia and Africa. Therefore, the city consists of governmental and non-governmental organization offices, different institution, and public and private health center and several commercial and industrial companies. For the first time, the modern water supply provision was introduced 15 years after the establishment of the city. At that time the source selected was groundwater and served the city for almost 58 years. Then the first surface water development with treatment plant at Gefersa has been established in 1930 with the objective of coping up the increased demand of its population (PLAN, 2011).

At present Addis Ababa City Administration is supplied with surface water from the Legadadi, Dire and Gefersa reservoirs, and groundwater has been pumped from Akaki well field located to the south of Addis Ababa and other wells and springs located within the city. The current total daily production is estimated to be 599,000m^3/day.

A current report on ground water availability shows decline of water levels in well area as the rate of withdrawal of water in the area has increased and failure problem of the developed groundwater occurred. To overcome this problem safe groundwater generalization and perfect study of the aquifer is fundamental for sustainability of the resource in the city.

All of the four aquifers listed below occur in Addis Ababa area: a water table aquifer, a confined aquifer, a semi-confined or leaky artesian aquifer, a perched aquifer. An effort is being made to increase the supply of groundwater and where management of the resource may be necessary in the future, it is essential to get more information on aquifers than has been the case up to the present. This need for more information on geology and aquifers is important in the choice of drilling method (ENGINEERING, 1984).

AADWWSP phase IIIB is one of the water supply projects implemented to alleviate the prevailing unsatisfactory water supply situation at the capital city, which is an important service for one of the most water deficit areas of the city-western & central Addis Ababa. The project is based on ground water source, specifically of 24 deep wells in Akaki well field with a discharge of 70,000m^3/day.

Akaki area well field is located south and west of the existing Akaki well field. According to the draft report of ground water resource development on prospective sites (Water Works Design and Supervision Enterprise, February 2010) three potential well fields (WF-01, WF-02, and WF-03) have been identified and studied.

The combined exportable water resource potential of the well fields is estimated to be 223,200m^3/day. The proposed boreholes are deep wells with average drilling depth of 450 m and average safe yield per well is estimated to be 60 l/s.

Considering 90% exportable potential, as the well fields are studied relatively well, it is possible to abstract about 200,880 m^3/day from Akaki area well fields of which about 83,000m^3/day has already been developed.

About 1,597m^3/day is being injected in to the existing Akaki system since 2009 and about 73,000m^3/day is planned to be introduced in to the system beginning July 2011.The remaining 126,283 m^3/day is expected to be developed within a short time and will be introduced to the system as soon as possible(WWDSE).

1.1 Description of the study area

Akaki well phase IIIB is located in Oromiya Regional State, Akaki Kality Sub city south of Addis Ababa about20km from the city center. It is one of the water supply projects implemented to alleviate the prevailing unsatisfactory water supply situation at the capital city, which is an important service for one of the most water deficit areas of the city-western & central Addis Ababa. The estimated population size proposed to use the project or direct beneficiaries of the project is 700,000. The project is based on ground water source, specifically of 24 deep wells in Akaki well field with a discharge of 70,000m^3/day. The conveyance system starts from Gelan area to Keraniyo through Hana Mariam, Kara Kore & Alem Bank area. And the primary distribution stretched from Keraniyo to Army Hospital through Betel &Alem Bank. The transmission line extends from CT-2 collection reservoir, near the well field to Alem bank via Hana Mariam and Lebu. The distribution line extends from K4 10,000m^3 collector reservoirs to Alem Bank, Betel and Torhayloch (Armey Hospital) different size existing reservoir. Raw water supply is derived from twenty four (24) boreholes found in Akaki well field. Each well has been provided with a submersible pump, which delivers water through DCI pipes to two 2000m3 capacity reservoirs (CT4 and CT3). Out of the 24 boreholes, the water from six boreholes is pumped to CT4 (Merero) & the rest to CT3 reservoir (Endode area). From CT4 the water flows by gravity to CT3 & all together the water will lead to CT2 pump station, around Glean condominium. The figure below shows the well field of the existing and the new Akaki area.

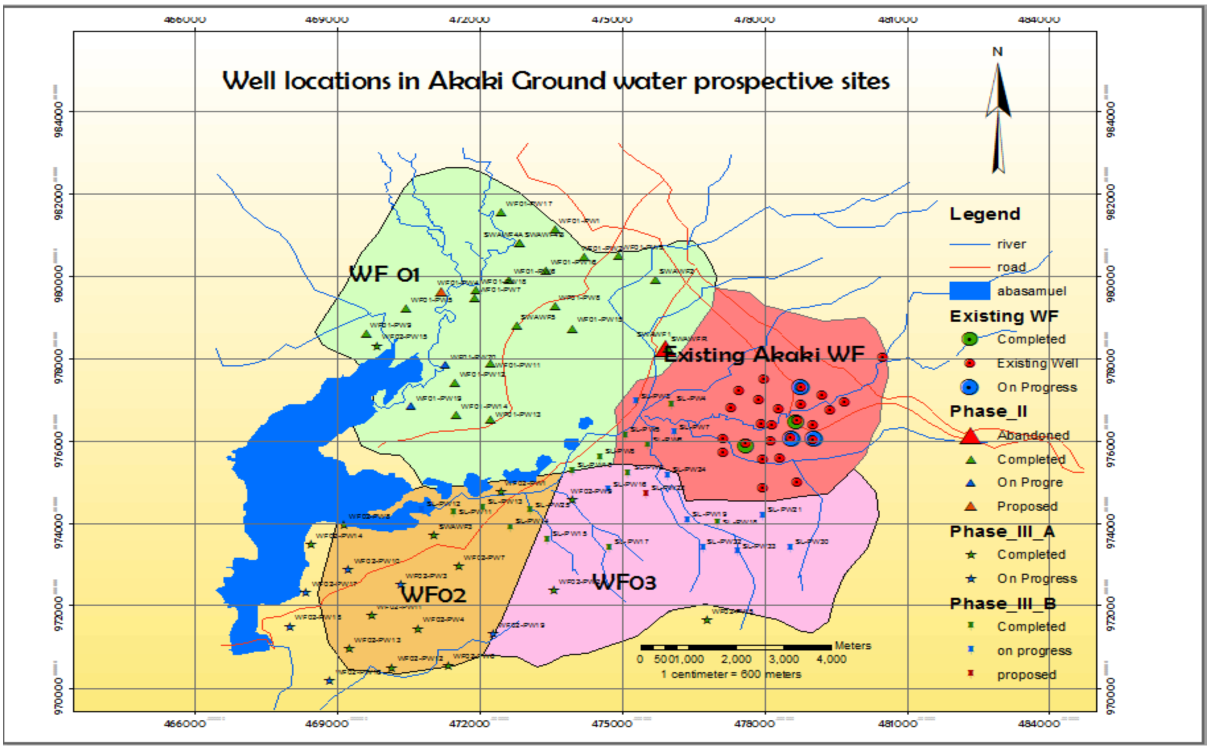

Figure 1: Location of bore holes drilled at Akaki ground water prospective area (WWDSE 2014).

1.2 Statement of the problem

The main source of water production for domestic and nondomestic use in Addis Ababa is groundwater and surface water. On the past study of Umbrella there is conflict on the development of surface water and groundwater. The existing situation of water supply system in Addis Ababa city shows shortage of water supply. To overcome this unbalance between demand and supply of Addis Ababa Water and sewerage Authority (AAWSA) had devised water supply development plans of short term and medium term. The planned and implemented water source development projects for the short term are (1) Legedadi Treatment plant Expansion project and (2) Ground water Development projects. Even if the project has been implemented the water demand for Addis Ababa city is greater than the water production. Many of the wells developed in the city in particular the phase IIIB project of Akaki well field are facing failure (malfunction and decline of yield) problem which in turn will reduce the production of the water supply. In this phase project the recent performance report indicates 66% of the wells are either yield below the expected amount or totally stopped working. This research will try to identify the causes behind failure of these wells. In understanding why these wells are not performing well, this study envisions two prospects. The first being, wells might have already failed during the study and design phase in the prospect that the well test data interpretation were not carefully carried out. The second being during the day to day operation of the well in the prospect that wells are forced to yield beyond their capacity. The failure during study and design may be due to inappropriate hydraulic parameter estimation; in appropriate pumping rate for the test, are among the different other causes. Failure after the well construction may be due to pump malfunction, shortage of electric supply and/or in appropriate pumping rate. And this study will answer the questions like why the constructed well works below their expected yield? What are the reasons for malfunctioning of the well? And is there any method to improve the failure of the well?

1.3 Objective of the research

1.3.1 General objective

The primary objective of this research is to identify causes behind failure of wells in phase IIIB project of Akaki well filed.

1.3.2 Specific objective

- Identifying the Causes of failure.
    - Failures during study and design.
    - Failures during day to day operation of the wells
- To identify lessons that can be learned for future understanding of failures.

1.4 Significance of the study

In general, this research will be significant for AAWSA (Addis Ababa Water and Sewerage Authority) to identify the different reasons which could lead for malfunction of the wells and the decline of the yield and improve the groundwater development of the city moreover this findings can be used as a guide for possible water production improvement for government and non-government organizations providing them reliable data that can be used for taking productive decision and design for future exploration.

1.5 Structure of the thesis

This thesis is organized in five chapters. Chapter one deals with the general introduction, objective and problem studies and the description of the study area, significant of the research. Chapter two deals with literature review of privies studies related with this topic and standard method of Theis and Cooper-Jacob are considered. Chapter three gives an overview on the study area and the methodology to be followed in the study of the thesis are described in details and also discussed about the kind of data collected and adjustment done before used for analysis. The adjustment includes correction for drawdown for well loss using well efficiency, correction for partial penetration using kozeny correction factor. The analysis is done using Excel and the aquifer parameters were determined using cooper-Jacobs method, Recovery method and Theis method. Chapter four presents the result and analysis of the failure of the well and decline of the yield and also comparing the outcome with results given in the WWDSE report on Addis Ababa groundwater development. Chapter five present the general conclusions, summery of the major results of the work and recommendations.

2 LITERATURE REVIEW

2.1 Groundwater

Groundwater is an important source of water supply throughout the world. Its use in irrigation, industries, municipalities, and rural homes continues to increase. Fresh water makes up only 2.5% of all the water on earth, but not all of this water is available for human use. The water in polar ice caps, other forms of ice and snow, soil moisture, marshes, biological systems, and the atmosphere are not readily available. As a result, only the 10,530,000 km^3 of groundwater, 91,000 km^3 of fresh water in lakes, and the 2,120 km^3 of water in rivers are considered attainable for use and comprise a total of 10,623,120 km^3. Consequently, groundwater comprises 99% of the earth's available fresh water. It is uncertain when mankind first started extracting groundwater by artificial means such as wells or infiltration galleries. Early humans most likely drank from surface streams. They may also have discovered groundwater through the discharge of natural springs in some parts of the world, and used this source in addition to surface streams. As streams dried up in hot weather, people learned to dig into the alluvium to find water below the surface (W.Delleur, 2007).

2.2 Water production in Addis Ababa

Addis Ababa is supplied with both surface water and ground water. Surface water is mobilized at the Gefersa Dam that provides water to the Gefersa WTP and at the Legedadi and Dire dams that provide water to the Legedadi WTP. Both WTP are located respectively at the North West and North East of the City.

Ground Water is mobilized by many wells in the city and by various well field at Akaki located at the South of the city. Presently some extension works are under construction and should be fully operational before year 2016. The following table shows what the production design capacity are and compares them to the water demand as estimated in the Business Plan.

Table 1: water Rationing in Addis Ababa 2016

2016	m^3/day
Gefersa WTP	30000
Legedadi WTP	165000
City Wells	62000
Akaki Field Well 1	83000
Akaki Field Well 2	70000
Akaki Field Well 3	70000
Legedadi Extension	30000
Total	510000
Water Demand (BP)	543602
With NRW	30.10%
NRW	122000
Deficit (Rationing)	33602

This table is based on the short term previsions in terms of water resources mobilization (ongoing projects) and the business plan in terms of water demand. It clearly shows that it is very urgent:

- To plan new water resources
- To reduce dramatically the water losses.

Both actions have been initiated.

During the past years there was a continuous conflict between the developments of surface Water and groundwater. Most of the former master plans need to be updated and the issue is not clearly addressed. Water III proposes the development of surface water but many people still believe that the ground water needs to be mobilized first because the mobilization is easier and investment cost is lower.

After reviewing the various existing reports the TC would like to present the following shortcut to summaries the pros and the cons.

- Addis Ababa urgently needs additional resources.
- Surface water is traditionally more expensive in terms of investment and less expensive in terms of operation because the surface water is provided to Addis Ababa by gravity
- New surface resources have already been designed in the last master plan WATER III: Gerbi and Sibilu dams and Wosserbi Water Treatment Plan.
- The operation of the well fields is more and more expensive when the cost of electricity is increasing.
- The production capacity of the ground water aquifer is unknown and the recharge of the aquifer has never been fully studied.
- In the former master plans the use of the ground water has always been considered as a provisional solution to fill the gap as the mobilization of additional surface water resources has not yet been made.

Based on these considerations it may happen that the wells gradually fall out of service and it would be wise to develop new surface water schemes in the short term (application of the “precautionary principle”).

But this principle has an urgent implication in terms of operation: there would be no objection to the provisional extension of the well fields if there was a reliable monitoring of the level of the water table, which is not presently the case.

On one side there is a serious risk of overusing the ground water resources but on the other side, there is also serious risk to deteriorate the surface water quality due to the gradual pollution of the catchment areas of the dams.

2.2.1 A brief review of previous groundwater studies in Addis Ababa

Although development of groundwater in Addis Ababa for domestic, industrial and municipal water use has a long history, no systematic investigation had been made until the 1990s.

A summary of groundwater investigation, prior to 1984, which included inventory of 175 wells and assessment of existing data of geology, hydrogeology, geophysics, drilling and groundwater development was made by the Associated Engineering Services Limited (AESL, 1984).

However, the most comprehensive groundwater studies in and around Addis Ababa was conducted during 1989 – 1991 by SEURECA (1991). The study focused on three potential sites labeled as Area A, B and C situated west of Addis Ababa (Area A) and southeast of Addis Ababa (Areas B & C).

Based on the recommendation of SEURECA, a total of twenty test and piezometer boreholes were drilled. Furthermore, they incorporated additional existing wells, bringing the total number of wells to 257.

Further recommendation by SEURECA was made to develop 146 boreholes in areas designated as “A, B and C”.

Subsequently, Tahal consulting Engineers and Shawel consult conducted groundwater feasibility study of Akaki town water supply project and they extended area “B” southward and designated as area “D”. Three boreholes (EP-1, EP-2, and EP-3) were drilled in area B while borehole EP-4 drilled close to area D exceptionally exhibited thick section of scoria aquifer.

In 1993, the AESL reviewed the work done by Seureca (1991) and Tahal et.al (1992) in area A, B, C and D but also included additional well field Area” E” around Sululta. Among all these well fields, Area D and D extension (adjoining area D to the South) were recommended for further well field development for water supply of Addis Ababa. As a result, 25 production boreholes were drilled by a Chinese company, COMPLANT, during 1995-1997.

In 1998, the AESL and HBT AGRA joint venture were commissioned to conduct hydro geological study and groundwater modeling for area D and D extension. Surface geophysics survey with the vertical electrical sounding method was also employed to define the lateral and vertical extent of the aquifer. Although the hydrogeological study was conducted, the project was terminated due to contractual reasons.

In 2000, the BCEOM and SEURECA, joint venture conducted modeling of the Akaki well field (area D) to simulate the response of the well field under various circumstances including hydrological study of Akaki catchment to estimate aquifer recharge.

According to well yield data indicated on such previous reports can be noted that well yields are highly variable from place to place and this variability is even notable along adjacent wells.

Even when considering individual wells, the specific capacity (which is measure of yield per unit drawdown) shows variation with time. Generally, well yield in volcanic aquifers of the project area varies directly with the aquifer potential which in turn is related to the degree of fracturing and weathering.

Moreover, in some cases extrapolation of yields has been made to estimate potential well yield, in the event where higher capacities of pumping equipment is unavailable and in most cases judgment was made based on the pump tests conducted after drilling is completed. However, such projection of yields has been found to be very misleading especially in volcanic aquifers.

2.2.2 The historical groundwater development of Addis Ababa

Ground water use for municipal purposes in AAWSA started some fifteen years ago mainly located at Akaki and on selected locations of the city periphery specifically to be used as emergency supply in order to curb the acute shortage of the water supply problem resulted from:

- The unexpected fast city development pattern exhibited in the city
- The delay in implementing the planned water supply master plan mainly focused on developing surface water

- Some existing privately owned wells and springs manly located at the foothills of Addis Ababa were not used properly.

With this old Akaki well field, wells and springs located within and the periphery of Addis Ababa has been used to augment the system and continues at present.

The main issue is that the production capacity is not well known and some hydro geologists consider that the present levels of production are not guaranteed for the future.

The main issue for the operation of the ground water is that there is no monitoring of the level of the water table of the aquifer.

Ground Water: Main Suggestions and Advices

- Organizes the monitoring of the level of the aquifer:
- Improve the O&M of the wells: preventive maintenance, statistics on failure, statistics on alarm, processing the data provided by the Scada systems.
- New surface resources and ground water resources need to be mobilized
- Simultaneously (precautionary principle).

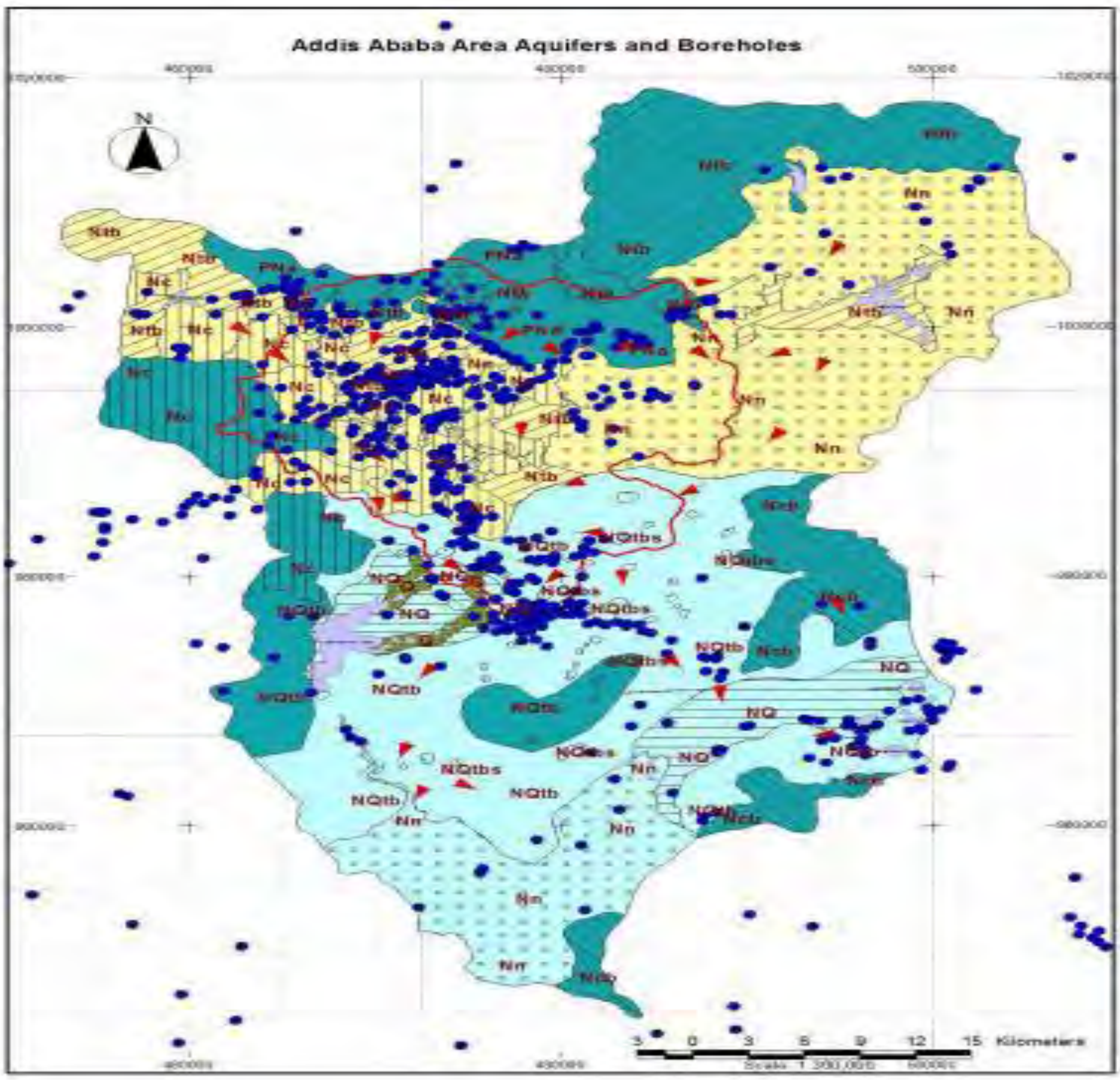

Figure 2: Borehole location in different part of the city (Adapted from AG Consult).

2.2.3 Main gaps regarding the operation and management of the groundwater in AAWSA

The following brief observations were made;-

- Lack of systematic and planned implementation of the ground water schemes Supported through long term master plan.
- Lack of systematic monitoring of the well field aquifer characteristics either through the test wells and/or through the production wells; this includes:
- no sufficient exercise has been made to have good knowledge about the aquifer through modeling supported by the test wells and

- no attempt has been made to determine the extent of ground water development in the future using the information available through the existing production wells
- Current operation of each well is not supported with actual simulation of the

Aquifer capacity with the scenario of all the wells are operational that has

- There is no day to day systematic data extracting, organizing and processing of the key operational parameters stored in the monitoring system of the wells for sustainable operation of the whole system.
- Insufficient preparation and organization in respect to preventive maintenance & supply of spare parts.
- Lack of trained personnel's, technicians for operation and maintenance
- Disorganized working space of the electro-mechanical workshops for the pump.

Maintenance

- Improper use of operation parameters and lack of key performance indicators for operation and maintenance of pumps, motors, control systems and ancillary Equipment's (Michel Vermersch, 2013).

2.3 Aquifer and their types

A permeable stratum or geological formation of permeable material, which is capable of yielding appreciable quantities of ground water under gravity, is known, as an aquifer. The term "appreciable quantity" is relative. Depending upon the availability of groundwater, there are three main types of aquifer: confined, unconfined, and leaky (Kruseman, 2000).

2.3.1 Confined aquifer

A confined aquifer is bounded above and below by an aquiclude. In a confined aquifer, the pressure of the water is usually higher than that of the atmosphere, so that if a well taps the aquifer, the water in it stands above the top of the aquifer, or even above the ground surface. We then speak of a free-flowing or artesian well (Kruseman, 2000).

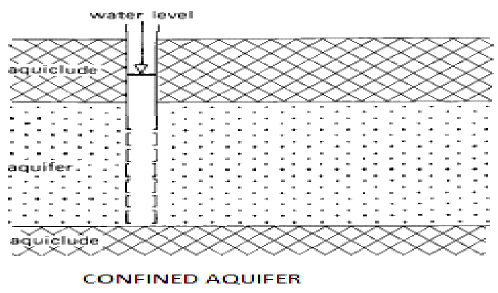

Figure 3: confined aquifer

2.3.2 Unconfined aquifer

An unconfined aquifer also known as a water table aquifer, is bounded below by an aquiclude, but is not restricted by any confining layer above it. Its upper boundary is the water table, which is free to rise and fall. Water in a well penetrating an unconfined aquifer is at atmospheric pressure and does not rise above the water table (Kruseman, 2000).

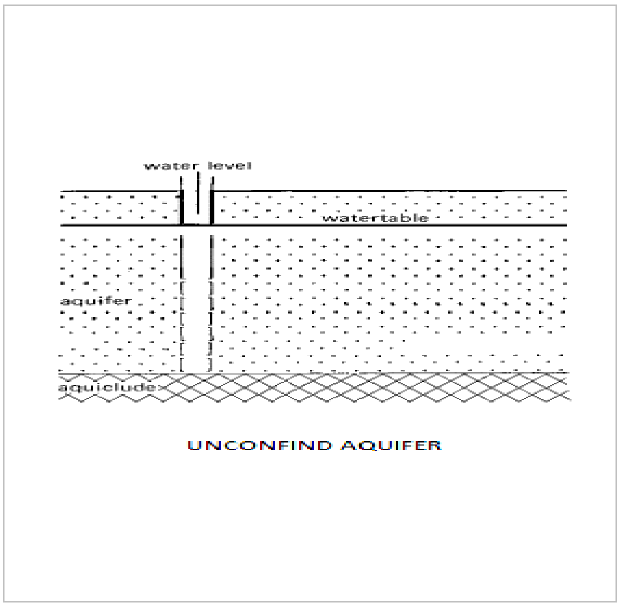

Figure 4: unconfined aquifer

2.3.3 Leaky aquifer

A leaky aquifer also known as a semi-confined aquifer, is an aquifer that’s upper and lower boundaries are aquitards, or one boundary is an aquitard and the other is an aquiclude. Water is free to move through the aquitards, either upward or downward. If a leaky aquifer is in hydrological equilibrium, the water level in a well tapping it may coincide with the watertable.The water level may also stand above or below the water table, depending on the recharge and discharge condition (Kruseman, 2000).

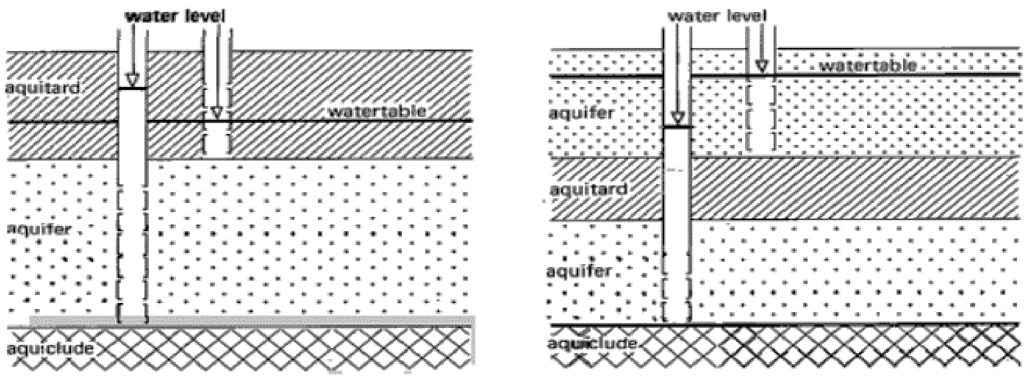

Figure 5.leaky aquifer

2.4 Aquifer characteristics influencing yield of well

The properties of the aquifer that influence well performance are depth, areal extent, number of water bearing formations exposed to the well, and the hydraulic properties of the aquifer. An aquifer performs two functions, viz., storage and as a conduit. The properties of an aquifer may be expressed in terms of its hydraulic conductivity, transmissibility, storage coefficient and specific yield. In case of semi-confined aquifers, two additional properties viz., leakage factor and hydraulic resistance, are also important.

2.4.1 Transmissivity

Transmissivity is the product of the average hydraulic conductivity K and the saturated Thickness of the aquifer D. Consequently, transmissivity is the rate of flow under a unit hydraulic gradient through a cross-section of unit width over the whole saturated Thickness of the aquifer. The effective transmissivity, as used for fractured media, is defined as

$$T = \sqrt{Tf(x)Tf(y)}$$

Where f refers to the fractures and **x** and y to the principal axes of permeability Transmissivity has the dimensions of Length^3/Time x Length or Length^2/Time and is, for example, expressed in m$^2{}_{/d}$ or m^2/s (Kruseman, 2000).

2.4.2 Specific storage

The specific storage of a saturated confined aquifer is the volume of water that a unit volume of aquifer releases from storage under a unit decline in hydraulic head. This release of water from storage under conditions of decreasing head h stems from the compaction of the aquifer due to increasing effective stress o, and the expansion of the water due to decreasing pressure p. Hence, the earlier-defined compressibility of material and water play a role in these two mechanisms. The specific storage is defined as

$$S_s = \rho g(\alpha + n\beta)$$

Where p is the mass density of water (M/L3), g is the acceleration due to gravity (N/L3), and the other symbols are as defined earlier. The dimension of specific storage is Length-' (Kruseman, 2000).

2.5 Pumping test

Pumping tests are a commonly used method to determine the transmissivity (and, if the thickness of the aquifer is known, the hydraulic conductivity) and the storage coefficient of an aquifer. Pumping tests can be Single well or Multiple well. Information on the water bearing formations and the well can be obtained by conducting pumping tests. These tests are of two types: (i) aquifer tests, and (ii) well tests.

The aquifer test is carried out primarily to determine the aquifer parameters such as hydraulic conductivity, transmissibility, storage coefficient, specific yield, leakage factor and hydraulic resistance. Well tests provide information about the well characteristics as well as transmissibility and storage coefficient or specific yield. It enables to determine the head loss due to flow into the screen and well. These can be determined by step drawdown test (A.M.MICHAEL, 2008).

2.5.1 Single well pumping tests

A single well pumping test involves pumping at a constant or variable rate and measuring changes in water levels during pumping and recovery. Such tests are used to determine T and K when water level recovery is too rapid for slug tests and no observation wells or piezometers are available.

A simplistic single well test consists of pumping at a constant rate and measuring drawdown. When the water level has stabilized, steady flow conditions can be assumed and the following variation of the Theim equation can be used for estimating T (modified from Boonstra and de Ridder, 1981):

$$T.\frac{43.08Q}{S_w}$$

Where: Q = the constant well discharge in feet3/day.

Sw= the stabilized drawdown inside the well at steady flow in feet.

T = the transmissivity.

The equation can be applied to data for both confined and unconfined zones; however, for unconfined zones, drawdown (s_w) must be corrected to sw' = sw - (s^2w/2D), where D is the saturated zone thickness in feet. Appreciable error can be made in calculating for T using this equation, especially if well construction is unknown or inaccurate or if the screen is partially clogged (Boonstra and de Ridder, 1981). The equation, T = KD can be utilized to determine K.

The drawdown in a pumped well is influenced by well loss and well-bore storage. Well loss is responsible for drawdown being greater than expected from theoretical calculations and can be classified as linear or non-linear. Linear loss is caused by compaction and/or plugging of subsurface material during well construction and installation and head loss in the filter pack and screen. Non-linear loss includes head loss from friction within the screen and suction pipe. Since well-bore storage is large when compared to an equal volume of formation material, it must be considered when analyzing drawdown data from single well pumping tests (Kruseman and deRidder, 1991).

Papadopulos and Cooper (1967) observed that the influence of well-bore storage on drawdown decreases with time (t) and becomes negligible at t > $25rc^2$, where rc is the radius of the unscreened part of the well where the water level is changing. The effects of well-bore storage on early-time drawdown data can be determined by a log-log plot of drawdown (s_w) verses time (t). Borehole storage effects exist if the early-time drawdown data plots as a unit-slope straight-line (Kruseman and de Ridder, 1991).

Analysis of recovery test data (residual drawdown) is invaluable with a single well pumping test. Methods for analysis are straight line methods, which are the same as for conventional pumping tests. However, with single well tests, one must account for the effects of well-bore storage when evaluating recovery (Kruseman and de Ridder, 1991).

Single well tests are more common than aquifer tests using monitoring wells due to the obvious advantage that only one well is needed. However, in practice, only transmissivity can be estimated, due to the high sensitivity of the (effective) well radius.

Some of the disadvantages of single well tests are:

- Well construction (e.g. partial penetration) can lead to an underestimation of aquifer transmissivity.
- Storativity cannot be reliably determined; and
- Single well test analyses typically make no allowance for leakage, or other recharge/no-flow boundaries (SMITH, 2008).

2.5.2 Multiple well pumping tests

A multiple well test is implemented by pumping a well continuously and measuring water level changes in both the pumped and observation wells during pumping or subsequent recovery. Properly designed and conducted multiple well tests can be used to define the overall hydro geologic regime of the area being investigated, including T, S and/or specific yield of a zone. They also can help design municipal well fields, predict rates of ground water flow, determine interconnectivity between saturated zones, and design a remediation system. Two basic types are constant discharge and variable discharge. The former is performed by pumping at a constant rate for the duration of the test, while the latter is distinguished by changes in rate. Measurements obtained from the pumping well generally are less desirable for calculating hydraulic properties because of the irregularities induced from the operation of the pump and well bore storage. Obtaining data from observation well(s) allows for characterization of the pumped zone over a larger area (strickland, 2006).

2.6 Duration of the pumping test

The question of how many hours to pump the well in a pumping test is difficult to answer because the period of pumping depends on the type of aquifer and the degree of accuracy desired in establishing its hydraulic characteristics. Economizing on the period of pumping is not recommended because the cost of running the pump a few extra hours is low compared with the total costs of the test. Besides, better and more reliable data are obtained if pumping continues until steady or pseudo-steady flow has been attained. At the beginning of the test, the cone of depression develops rapidly because the pumped water is initially derived from the aquifer storage immediately around the well. But as pumping continues, the cone expands and deepens more slowly because, with each additional meter of horizontal expansion, a larger volume of stored water becomes available. This apparent stabilization of the cone often leads inexperienced observers to conclude that steady state has been reached. Inaccurate measurements of the drawdown in the piezometers - drawdown that are becoming smaller and smaller as pumping continue - can lead to the same wrong conclusion. In reality, the cone of depression will continue to expand until the recharge of the aquifer equals the pumping rate. In some tests, steady-state or equilibrium conditions occur a few hours after the start of pumping; in others, they occur within a few days or weeks; in yet others, they never occur, even though pumping continues for years. It is our experience that, under average conditions, a steady state is reached in leaky aquifers after 15 to 20 hours of pumping; in a confined aquifer, it is good practice to pump for 24 hours; in an unconfined aquifer, because the cone of depression expands slowly, a longer period is required, say **3** days. It is not absolutely necessary to continue pumping until a steady state has been reached, because methods are available to analyze unsteady-state data. Nevertheless, it is good practice to strive for a steady state, especially when accurate information on the aquifer characteristics is desired, say as a basis for the construction of a pumping station for domestic water supplies or other expensive works. If a steady state has been reached, simple equations can be used to analyze the data and reliable results will be obtained. Besides, the longer period of pumping required to reach steady state may reveal the presence of boundary conditions previously unknown, or in cases of fractured formations, will reveal the specific flows that develop during the test. Preliminary plotting of drawdown data during the test will often show what is happening and may indicate how much longer the test should continue (Kruseman, 2000).

2.7 Well Testing and Performance

Testing of well performance and aquifer characteristics is conducted after developing the well and allowing for recovery and stabilization of the water level in the well. Figure 5 shows hydrographs and the corresponding drawdown for a pumping test designed for that purpose.

The first part of the test, which has three steps, is designed to determine the well characteristics such as well loss and need for possible redevelopment. The duration of each step should be the same, usually not more than 6 to 8 hours. Data recorded during the first step are used to initially assess the transmissivity and the storage coefficient of the aquifer. The size of the pump and the long-term pumping rate for the second part of the test are selected based on drawdown development during the three-step test. The second part of the test should be performed after a complete recovery of the hydraulic head in the well and with a maximum feasible pumping rate. Duration of this part of the test, which is designed to determine the overall aquifer transmissivity for an extensive radius of influence, depends on specific project requirements and may vary from24 hours to several weeks in case of aquifer development for major water supply purpose. Long term pumping with a maximum rate should uncover aquifer characteristics that may be less obvious after a short test: distant boundaries, leakage, presence of dual porosity, or changes in storage. Both the drawdown and the recovery data should be used to find the aquifer parameters.

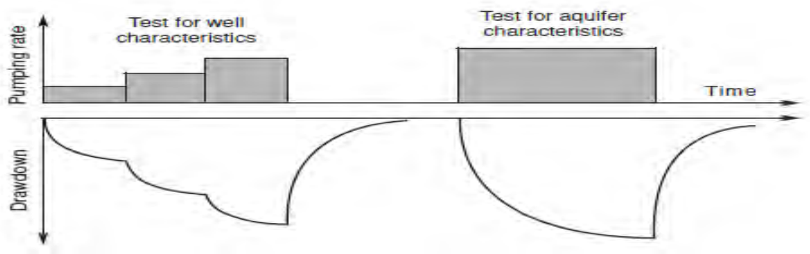

Figure 6: pumping rate hydrographs and drawdown curves for a pumping test designed to determine well and aquifer characteristics

Well loss is the difference between the actual measured drawdown in the pumping well and the theoretical drawdown due to groundwater flow through the aquifer's porous media. This theoretical drawdown is also called the formation loss. Equations of theoretical drawdown should be applicable to the actual aquifer (formation) conditions, such as confined, unconfined, leaky, with delayed gravity response, quasi steady state, or transient. Well loss is the result of various factors, such as an inevitable disturbance of the porous medium near the well during drilling, an improper well development (e.g., drilling fluid is left in the formation and mud cake along the borehole is not removed), a poorly designed gravel pack or well screen, and turbulent flow through the gravel pack and the well screen. Well loss is always present in pumping wells, and its evaluation is an important part in deciding if the well performance is satisfactory or not. All wells will experience a decrease in well efficiency sooner or later, as indicated by an increased well loss. Three-step pumping test is the only reliable means of quantifying the well loss, and it should be performed not only after well completion but also periodically during well exploitation to evaluate the well performance and needs for possible well rehabilitation (kersic, 2009).

The total measured drawdown (*s*w) at a well is combination of the linear losses and turbulent losses:

$$\mathbf{sw} = \boldsymbol{AQ} + \boldsymbol{BQ^2}$$

Where A= coefficient of the linear losses,

B = coefficient of turbulent losses, and

Q = pumping rate

The turbulent losses are usually assumed to be quadratic, but other powers may be used to describe it. The linear losses (*A*) include both the formation loss (*A*0) and the linear loss (A_1) in the near-screen zone:

$$\mathrm{A} = A0 + A1$$

For practical purposes A_1 can usually be ignored. The formation loss or the theoretical drawdown in the well (*s*0) is determined by using the appropriate equation for the specific flow condition. For example, in case of a quasi-steady-state flow in a confined aquifer, the equation is as follows:

$$so = \frac{Q}{2\pi T} \ln \frac{R}{rw}$$

Where s_0= drawdown due to groundwater flow through the aquifer porous media

T = transmissivity

R = radius of well influence

*r*w= well radius

The coefficient of linear formation loss (A_0) can be calculated as follows:

$$Ao = \frac{1}{2\pi T} \ln \frac{R}{rw}$$

2.7.1 Well Efficiency

Well efficiency is the ratio between the theoretical drawdown and the actual drawdown measured in the well. It is expressed in percent:

$$\text{Well Efficiency} = \frac{\text{Theoretical Drawdown (s0)}}{\text{Measured Drawdown (sw)}} * 100\%$$

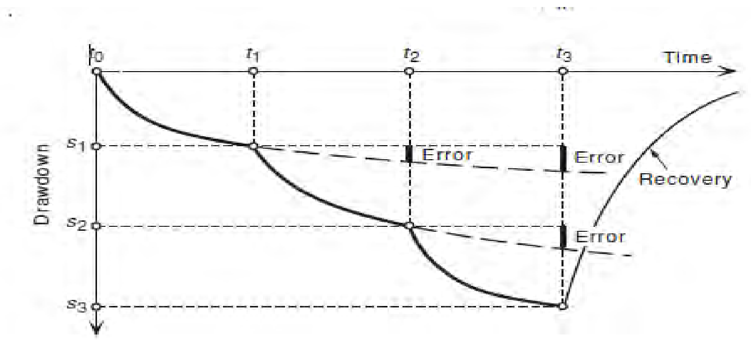

Figure 7: components of drawdown recorded at the end of each step showing errors made if drawdown s_1, s_2, and s_3 where used directly to draw graph Q versus S/Q

$$\mu = \frac{s_t}{s_a}$$

Where: $S_{a=s_t+s_w}$

$$\mu = \frac{s_t}{s_{t+s_w}}$$

$$\mu(S_{t+}S_W) = St$$

$S_{W=\left(\frac{1-\mu}{\mu}\right)s_t}$ Or $S_{t=\left(\frac{\mu}{1-\mu}\right)s_t}$

$$S_{a=}(\frac{\mu}{1-\mu}+1)S_W$$

$$S_{a=}(\frac{1}{1-\mu})S_W$$

$$S_{W=}(1-\mu)S_a$$

As explained earlier, the theoretical drawdown is determined by applying an appropriate equation of groundwater flow toward a well (theoretical drawdown equals the formation loss). It can also be found graph analytically as explained earlier. In general, the difference between the theoretical drawdown and the measured drawdown increases with increasing pumping rate as shown in Fig. 6. Consequently, well efficiency decreases with an increasing pumping rate. Determining well efficiency and well loss is highly recommended because it provides valuable information about the well performance and can be used to make an informed decision regarding the well pumping rate, maintenance, and rehabilitation. A well efficiency of 70 percent or more is usually considered acceptable. If a newly developed well has less than 65 percent efficiency, it should not be approved without a thorough analysis of the possible underlying reasons. This may include well redevelopment followed by new performance testing (kersic, 2009).

The relationship between drawdown and discharge can be expressed as the specific capacity of a well $\frac{Q}{S_W}$ which describes the productivity of both the aquifer and the well. The specific capacity is not a constant but decreases as pumping continues also decreases with increasing Q The well efficiency, Ew, is defined as the ratio of the aquifer head loss to the total head losses; it reads when expressed as a percentage.

$$E_w = \left\{ \frac{B_1 Q}{BQ + CQ^P} \right\}$$

The well efficiency according to Equation above can be assessed when both the results of a step-drawdown and those of an aquifer test are available. The former are needed for the values of *B*, *C*, and *P* and the latter for the value of *B*1.

In practice, only the results of a step-drawdown test are usually available. The substitution of the *B*, *C*, and *P* values into Equation above would overestimate the well efficiency, because *B* >*B*1. For these cases, Driscoll (1986) introduced another parameter, *Lp*, being the ratio of the laminar head loss to the total head losses; it reads when expressed as a percentage (W.Delleur, 2007)

$$L_P = \left\{ \frac{B_1 Q}{BQ + CQ^P} \right\} * 100$$

2.7.2 Step-Drawdown Tests

A step drawdown test provides a measure of well performance that can be used to estimate well's efficiency and determine an optimal pumping rate for the well, as well as provide an estimate of maximum yield under various water level conditions.

Water levels in a pumping well decrease with pumping duration as well as increased pumping rate. This water level decrease, or drawdown, is made up of two components: aquifer loss and well loss.

a. Aquifer loss is head loss caused as water flows towards a well screen. Here the flow is assumed to be laminar, and the loss is proportional to the resistance provided by the material forming the aquifer.
b. Well loss is often associated with non-linear head loss where water flow is turbulent. Turbulent flow occurs when water passes rapidly through the well screen, and can occur in parts of the aquifer immediately adjacent to the screen. Additional turbulent losses can occur in the pump and rising column. The higher the flow the more turbulence and so the percentages of non-linear well losses increase with pumping rate.

In a step drawdown test, water is initially pumped at a known, low rate and water levels and time recorded until drawdown begins to stabilize. The pumping rate is then increased and water levels are again recorded until the drawdown again begins to stabilize. A step test should have at least three steps that cover a wide range of flows, preferably matching or exceeding the proposed design flow.

Step drawdown test data can be analyses with the Eden-Hazel (1973) method, which is based on the Jacob straight line method to give an estimate of transmissivity (Smith, 2008).

2.7.3 Recovery tests

A recovery test is undertaken to determine aquifer characteristics, based on rising water levels (recovery) after the pump is turned off after a constant discharge test. A recovery analysis uses the average pumping rate during the pumping period and, therefore, the recovery data are unaffected by short period flow variations during the pumping period. It is a useful check of aquifer test parameters derived from the pumping period. A recovery test starts at the moment the pump is turned off and continues until water levels recover to at least 80% of the initial static level. Water level measurements are made more frequently immediately after the pump is turned off and less frequently with time as for a constant discharge test (Smith, 2008).

A recovery test is particularly useful for the following reasons:

- Constant discharge during pumping is sometimes difficult to achieve, particularly during the first few minutes of pumping. Recovery occurs at a constant rate, and can be us independently verify results from early time data.
- If the pump unexpectedly fails, the subsequent recovery data can instead be used for analysis, providing good records of the pumping rates are kept.
- If test results for the pumping period appear anomalous, a recovery test can independently verify aquifer characteristics.
- Single well tests suffer from turbulence in the pumped well and hence invalid water-level measurements. Recovery data may result in a better analysis.

2.8 Aquifer Analyses and approximation of hydraulic parameter

It is relatively easy to calculate hydraulic characteristics if the aquifer system (i.e. aquifer plus well) are precisely known. This is generally not the case, so interpreting a pumping test is primarily a matter of identifying an unknown system. System identification includes the construction of diagnostic plots and specialized plots. Diagnostic plots are log-log plots of the drawdown versus time since pumping started. Specialized plots are semi-log plots of drawdown versus time, or drawdown versus distance to the well; they are specific for a given flow regime. Both plots must be constructed, because the diagnostic value lies in the typical combination of the log-log and semi-log plots .The choice of a theoretical model is a crucial step in the interpretation of pumping tests. If the wrong model is chosen, the hydraulic characteristics calculated for the real aquifer will not be correct. Unfortunately the theoretical solutions of well flow problems are not unique. Some models developed for different aquifer systems, yield similar responses when required to handle a given stress. This means that besides the log-log and semi-log plots of the drawdown versus time, all other relevant hydro geological information, e.g. lithology, boundary conditions, should be taken into account (v.s.kovalevsky, 2004).

In this thesis, the method used for the determination of the aquifer parameters are Theis curve-matching method, Cooper-Jacob straight line method and residual/recovery drawdown vs. time method are used to determine the hydraulic parameters of the aquifer by analyzing aquifer test data.

2.8.1 Theis analysis method

The solution for the determination of aquifer properties under unsteady state flow conditions was developed by Theis (1935), by introducing the time factor and storage coefficient. Theis noted that, when a well penetrating an extensive confined aquifer is pumped at a constant rate, the influence of the discharge extends outward with time. The rate of decline of the head times the storage coefficient summed over the area of influence equals the discharge. Since the water must come from a reduction of storage within the aquifer, the head will continue to decline as long as the aquifer is effectively infinite. Therefore, unsteady flow exists. However, the rate of decline decreases continuously, as the area of influence expands.

Theis' equation for unsteady state flow in aquifers, derived from the analogy between the flow of ground water and conduction of heat, is based on the following assumptions which are in addition to the assumptions mentioned for the Thiem-Dupuit Eqs.

- The aquifer is confined.
- The flow to a well is in the unsteady state, i.e. neither the drawdown difference with time is negligible nor is the hydraulic gradient constant with time.
- The water removed from storage is discharged instantaneously with the decline of head.
- The well diameter is very small, i.e., the storage in the well can be neglected.

The differential equation governing the unsteady state radial flow in a non-leaky confined aquifer, in polar coordinate notations is:

$$\frac{\partial^2 h}{\partial r^2} + \frac{1}{r}\frac{\partial h}{\partial r} = \frac{S}{T}\frac{\partial h}{\partial t}$$

In which,

T = transmissibility of the aquifer, m2/s
S = storage coefficient, dimensionless
h = hydraulic head at (*r*, *t*)
r = radial distance of the piezometers from the centre of the pumped well, m
t = elapsed time after pumping is started, s

Theis (1935) obtained the solution of Eq. above, based on the analogy between ground water flow and heat conduction, and for boundary conditions *h* = *ho* before pumping and *h* *ho* as *r* _ ∞ as pumping begins (*t* > 0), which may be written as

$$h0 - h = \frac{Q}{4\pi T}\int_{r^2 s/4tT}^{\infty} \frac{e^{-u}}{u} du$$

In which

$$u = \frac{r^2 S}{4Tt}$$

And Q= constant discharge rate, m^3/s

The exponential integral is written symbolically as *W* (*u*) which in this usage, is generally read 'well function of *u*' or 'Theis well function'. The Theis well function, may be written as

$$S = \frac{Q}{4\pi T} W(u)$$

In which, S=the unsteady state drawdown, m

The step-by-step procedures to be followed for determining the hydraulic properties of confined aquifers are as follows:

1. A 'type curve' (Fig. 2.8) of the Theis well function is prepared on double logarithmic paper by plotting values of *W* (*u*) against *u*, using the Table of Function (Appendix A) of Theis (1935).

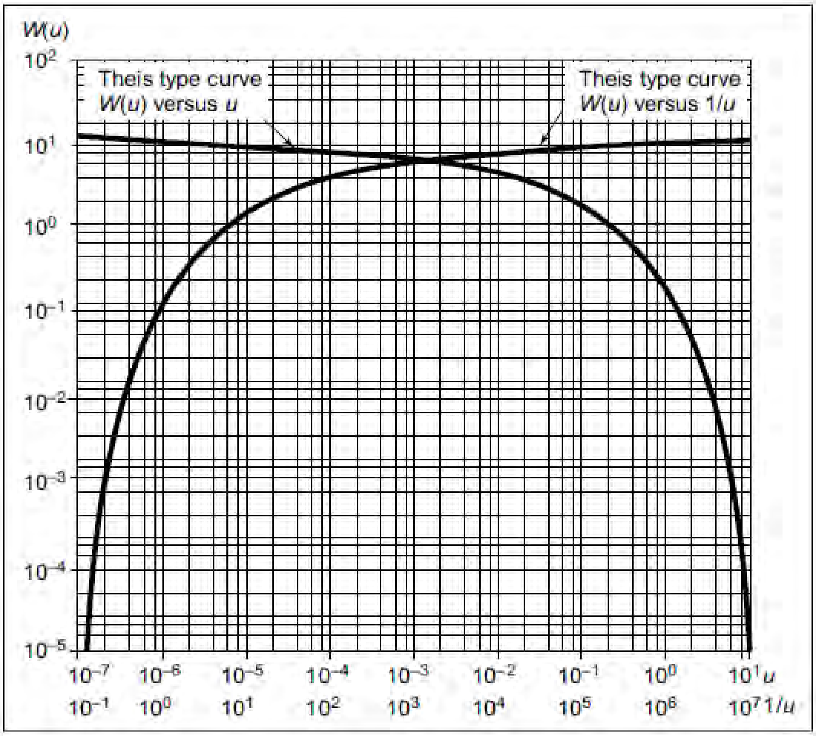

Figure 8 : Theis type curves for W (U) verse U and W (U) verses 1/u

2. The values of *s* against t/r^2 are plotted on another double logarithmic paper on the same scale as that used for the type curve. The observed data plot is placed over the type curve. Keeping the coordinate axes of both data plot and type curve parallel, the position of best match between the data plot and type curve (Fig. 2.9) is located.

3. An arbitrary match point A on the overlapping portion of the two sheets of graph papers is

Selected and coordinates *W* (*u*), 1/*u*, *s* and t/r^2 for these match points are determined. The calculations are greatly simplified if the point is selected when the coordinates of the type curve *W* (*u*) = 1 and 1/*u* = 10.

2 The value of *W* (*u*), *s* and *Q* are substituted

In Eq.$S = \frac{Q}{4\pi T}W(u)$ to obtain the value of transmissibility, T

$$T = \frac{Q}{4\pi S}W(u)$$

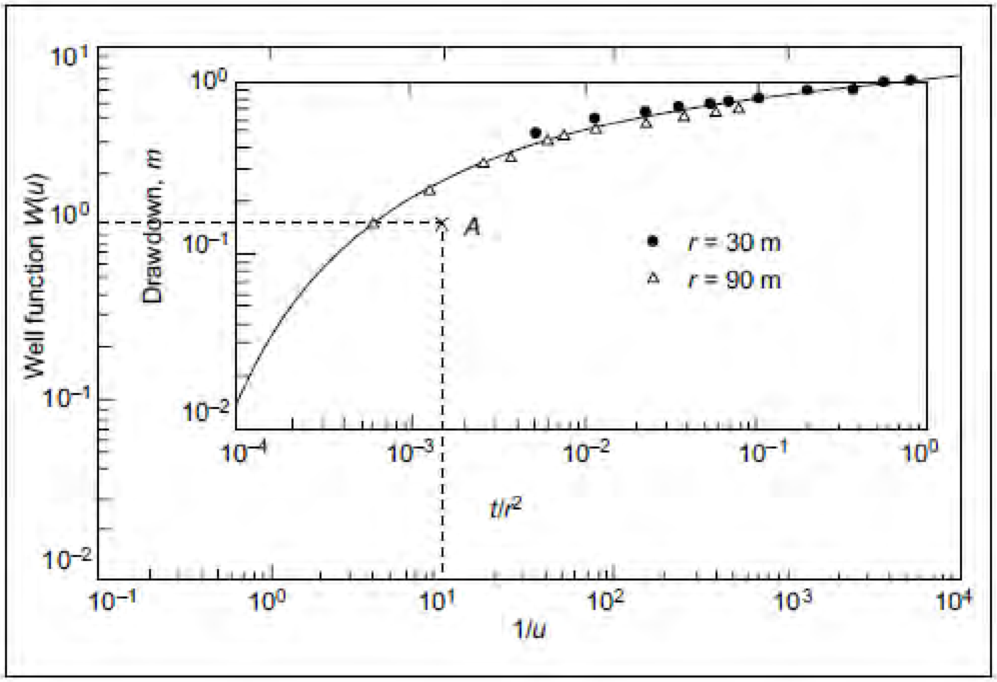

Figure 9: plot of S (drawdown) versus t/r^2 superimposed on Theis type of curve W (u) versus 1/u

5. The value of S is calculated by substituting the values of T, $t/r2$ and u in Eq$u = \frac{r^2S}{4Tt}$

$$S = 4Tu\frac{t}{r^2}$$

2.8.2 Cooper-Jacob Method

It was observed by Cooper and Jacob (1946) that for small values of r and large values of t, u is so small, that the series of $W(u)$ in Eq.$S = \frac{Q}{4\pi T}W(u)$ Becomes negligible after the first two terms. Therefore, for small values of u ($u < 0.01$) the drawdown can be approximated by using the following relationship:

$$S = \frac{Q}{4\pi T}(-0.5772 - \log e\frac{r^2S}{4Tt})$$

$$= \frac{Q}{4\pi T}(\log_e \frac{4Tt}{r^2 S} - 0.5772)$$

Which reduces to? $S = \frac{2.30Q}{4\pi T}\log_{10}(\frac{t_2}{t_1})$

If s_1 and s_2 are the drawdown at time t_1 and t_2, since pumping started

$$S2 - S1 = \frac{2.30Q}{4\pi t}\log 10(\frac{t2}{t1})$$

If the time-drawdown data on a pumping well is plotted on a semi-log paper

(Fig. 2.10) and for convenience t_1 and $t_2$are chosen one log cycles apart,

$$\log 10\frac{t_2}{t_1} = 1, \text{and if } S_{2-}S_{1=}\Delta S, \text{then}$$

$$\Delta S = \frac{2.30Q}{4\pi T}$$

$$T = \frac{2.30Q}{4\pi\Delta S}$$

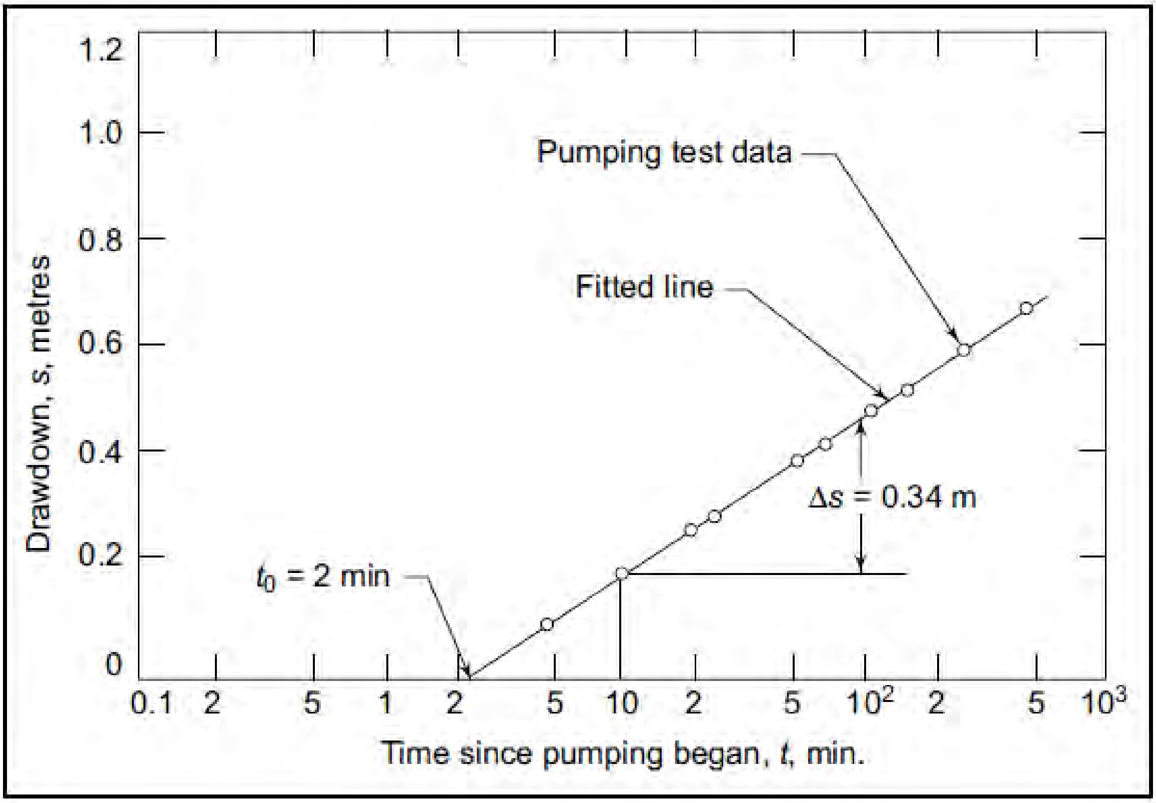

Figure 10 : Cooper-Jacob method for solution of non-equilibrium equation

From equation $S = \frac{2.30Q}{4\pi T}\log_{10}(\frac{t_2}{t_1})$

$$S = 0 \; when \; \log_{10}\frac{2.25Tt}{r^2S} = 0$$

i.e. when $\frac{2.25\mathrm{Tt}}{\mathrm{r^2S}} = 1$

Therefore, a plot of drawdown *s* versus the logarithm of *t* forms a straight line. Projecting this line to *s* = 0, where *t* = *t*0, the time for *s* = 0 can be noted and *S* can be computed as

$$S = \frac{2.25Tt_0}{r^2}$$

2.8.3 Recovery Test

When the pump is stopped at the end of a pumping test, the water level in the well and in the observation wells start rising. This is referred to as the recovery of ground water level. The fall in water level (drawdown) below the original static water level (before pumping) and during the recovery period are known as residual drawdown. Figure 2.13 shows a schematic diagram of change in water level with time during and after pumping.

The transmissibility of the aquifer can be calculated by analyzing the residual drawdown, which will provide an independent check on pumping test results. The rate of recharge to the well during the recovery period is assumed to be constant, whereas it becomes difficult to control the pumping rate in the field. Moreover, in case of recovery test, measurements of recovery can also be made in the well in the absence of an observation well. The residual drawdown *s* can be calculated as follows (Theis, 1935):

$$S' = \frac{Q}{4\pi T}(W(u) - W(u'))$$

Where,

$$Su = \frac{r^2 S}{4Tt} \text{And} u' = \frac{r^2 S}{4Tt'}$$

Figure 12 defines *t* and *t*'. For small value of *r* and large values of *t*'

Equation can $S' = \frac{Q}{4\pi T}\left(W(u) - W(u')\right)$be approximated as

$$S' = \frac{2.30Q}{4\pi T}\log\frac{t}{t'}$$

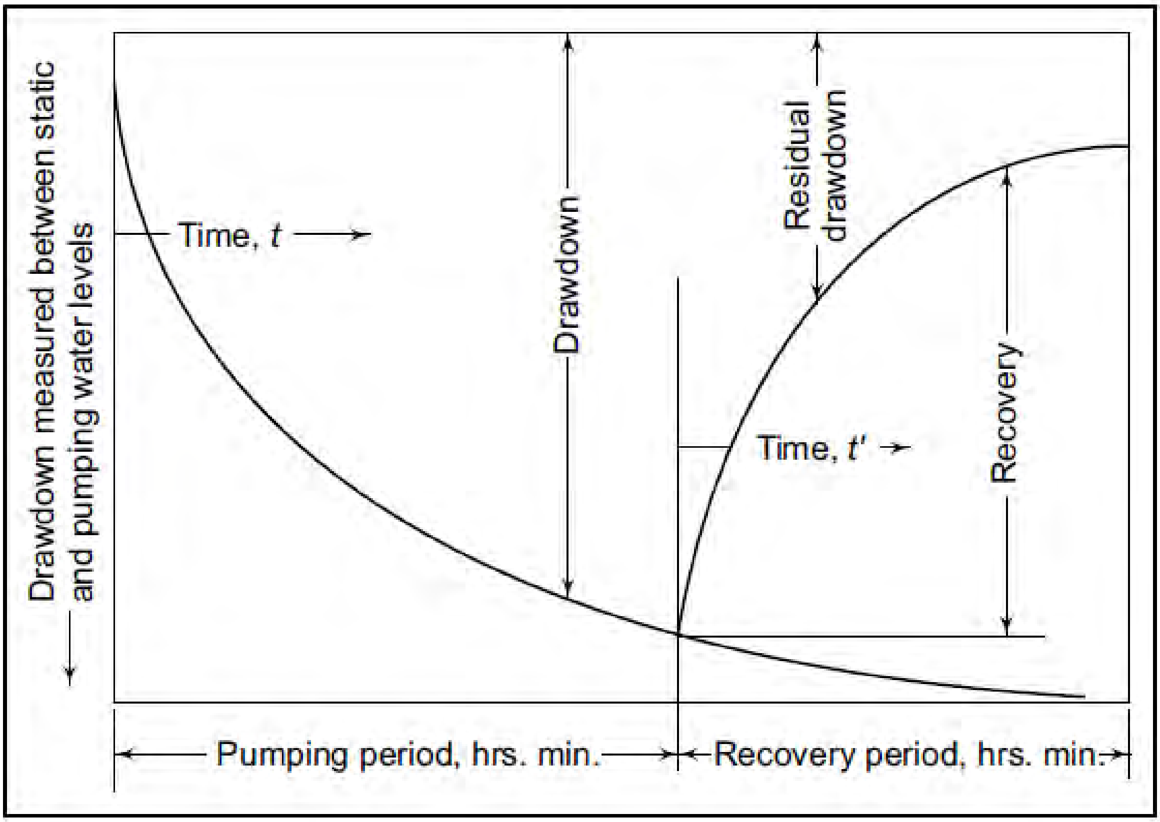

Figure 11: the drawdown and recovery curves near observation well near a pumping well

The residual drawdown S' versus $\frac{t}{t'}$ are plotted on a semi – logarithmic paper. The slope of the straight line so plotted equals 2.30Q/4πT, so that for $\Delta S'$, the residual drawdown per log cycle of t/t', the transmissibility becomes.

$$T = \frac{2.30Q}{4\pi\Delta S'}$$

The recovery test method cannot be used to determine the comparable value of S (A.M.MICHAEL, 2008).

2.9 WELL REHABILITATION

A new well, properly drilled, cased, and developed, will give years of satisfactory service with little attention. Many wells fail, however; that is, they yield decreasing quantities of water with time. Well rehabilitation refer to the treatment of a production well by mechanical, chemical, or other means to recover as much as possible of the lost production capacity.

One case of failure is depletion of the groundwater supply. Not a fault of the well, this trouble can sometimes be remedied by decreasing pumping drafts, resetting the pump, or deepening the well. A second cause of well trouble results from faulty well construction. Such items as poor casing connections, improper perforations or screens, incomplete placement of gravel packs, and poorly seated wells are typical of difficulties encountered. Depending on the particular situation as determined from a television or photographic survey of the well. It may be possible to repair the well, but sudden failures involving entrance of sand or collapses of a casing often require replacement of the entire well.

The third and most prevalent cause of well failure results from corrosion or incrustation of well screen. Corrosion may result from direct chemical action of the groundwater or from electrolytic action caused by the presence of two different metals in the well. The effects of corrosion can be minimized by selecting nonmetallic well screens or ones of corrosion resistant metal (such as nickel, cooper, or stainless steel), and by providing cathodic protection. If the damage is localized, it may be possible to insert a liner inside the screen to prevent excessive sand pumping (Todd, 2005).

2.10 Partial Penetration

When an aquifer is pumped by a partially penetrating well, the assumption that the well receives water from horizontal flow is no longer valid. Due to a contraction of flow lines, partial penetration causes the flow velocity in the immediate vicinity of the well to be higher than it would be otherwise, leading to an extra loss of head. This effect is strongest at the well face, and decreases with increasing distance from the well. According to Hantush (1962) the drawdown due to pumping in a confined aquifer can be described by

$$s(r,t) = \frac{Q}{4\pi T}(W(u) + f_s \qquad (9)$$

And

$$f_s = \frac{2D}{\pi(b-d)}\sum_{n=1}^{\infty}(\frac{1}{n})W\left(u,\frac{n\pi r}{D}\right) * [\sin(\frac{n\pi b}{D}) - \sin(\frac{n\pi d}{D})](\cos\frac{n\pi z}{D}) \qquad (10)$$

Where W (u, nπr/D) is the dimensionless Hantush well function, b and b' are the penetration depths in m of the pumped well and of the piezometers, d and d'are the non-screened parts in m of the pumped well and of the piezometer, and $z = (b' + d')/2$

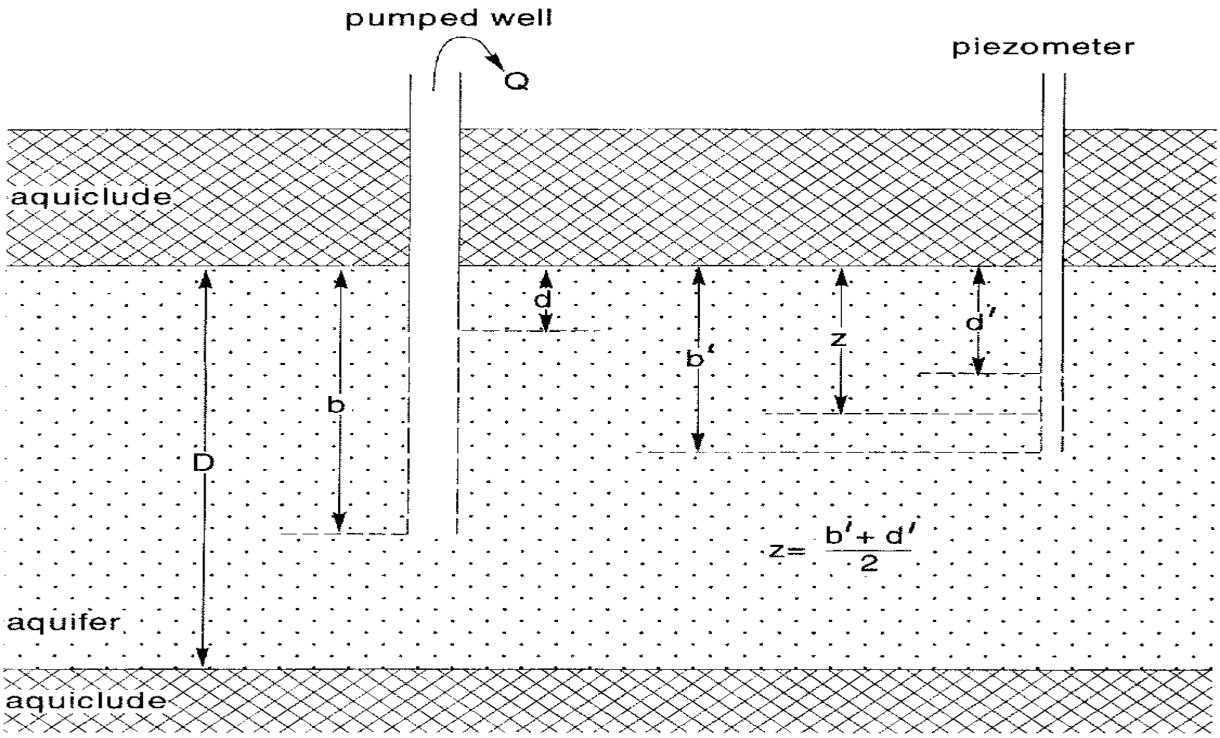

Figure 12 : Schematic illustration of the parameters used for the analysis of partially penetrating wells.

In Figure (13), the expression $W(u) + fs$ is plotted versus $1/u$ on semi-log paper. This figure shows that, for large values of $1/u$, this expression exhibits a straight-line segment. For this segment, Equation (10) reduces to

$$f_s = \frac{4D}{\pi(b-d)} \sum_{n=1}^{\infty} \left(\frac{1}{n}\right) K0\left(\frac{n\pi r}{D}\right) * [\sin(\frac{n\pi b}{D}) - \sin(\frac{n\pi d}{D})](\cos\frac{n\pi z}{D})$$

For a particular well/piezometer configuration, Equation (11) yields constant values for *fs*. The Hantush'smodification of the Jacob equation was based on this phenomenon. Hantush (1962) showed that for the straight-line segment, Equation (9) can be approximated by

$$s(r,t) = \frac{2.3Q}{4\pi T}\log\frac{2.25Tt}{r^2 S}e^{f_s} \quad (12)$$

Equation (12) can be used to describe the drawdown behavior in a confined aquifer with partially penetrating well, provided that $t > D2S/2T$. Equation (12) can also be applied to unconfined aquifers. It is then assumed that due to partial penetration the drawdown are small compared with the initial

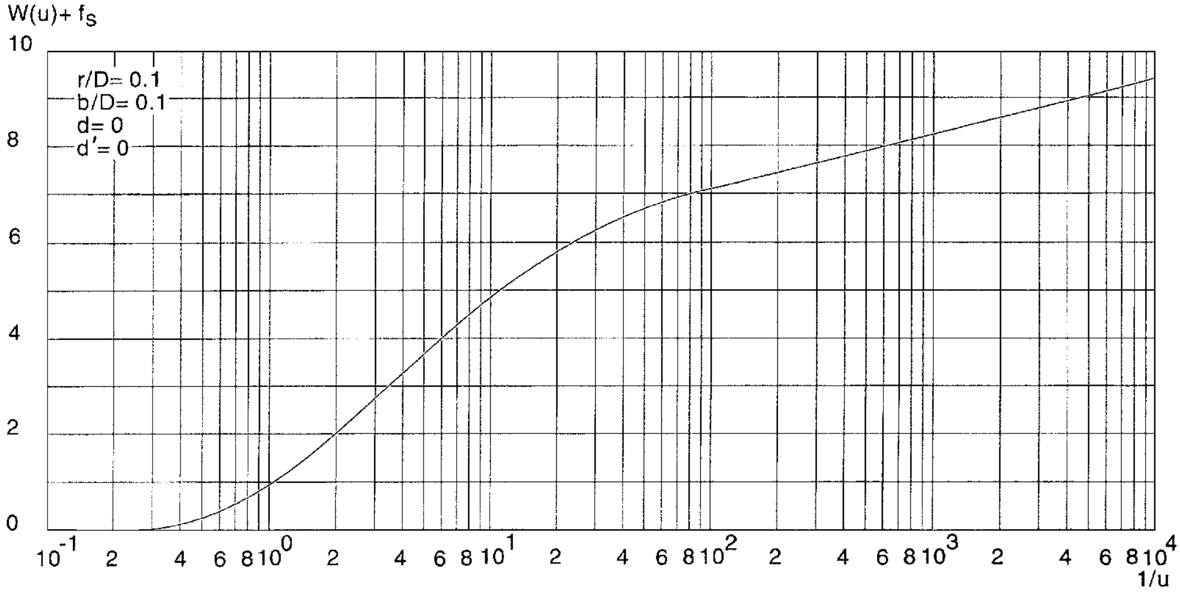

Figure 13 : Hantush well function W (u) + f_s versus 1/u for partially penetrating wells in confined aquifers

Saturated thickness of the aquifer. The only changes required are that the Storativity S be replaced by the specific yield Sy of the unconfined aquifer, and that the transmissivity T be defined as the transmissivity of the initial saturated thickness of the aquifer. For leaky aquifers, the drawdown behavior can be described by (Weeks, 1969).

$$s(r,t) = \frac{Q}{4\pi T}[W\left(u, \frac{r}{L}\right) + fs](13)$$

The pumping time should also be long to apply Equation (13) (t> D2S/2T) (W.Delleur, 2007).

3 RESEARCH METHODOLOGY

The general methodology involves the points shown in Figure 14. At first relevant data (mainly pumping test data) are collected. These data are checked for quality that involves personal and observation error correction. After which the pump test will be analyzed by making use of standard methods. (Theis, cooper-Jacob methods and Theis recovery method). As these methods need some data correction related to partial penetration and un-confined-ness (if they exist) it will be done. The outcome of these test analysis (hydraulic parameters of the aquifer) are finally compared with the measured (the values in the well completion report) for critical evaluation of the parameters. These critical evaluations will let us understand whether the well fails during the design and construction or during its day to day operation.

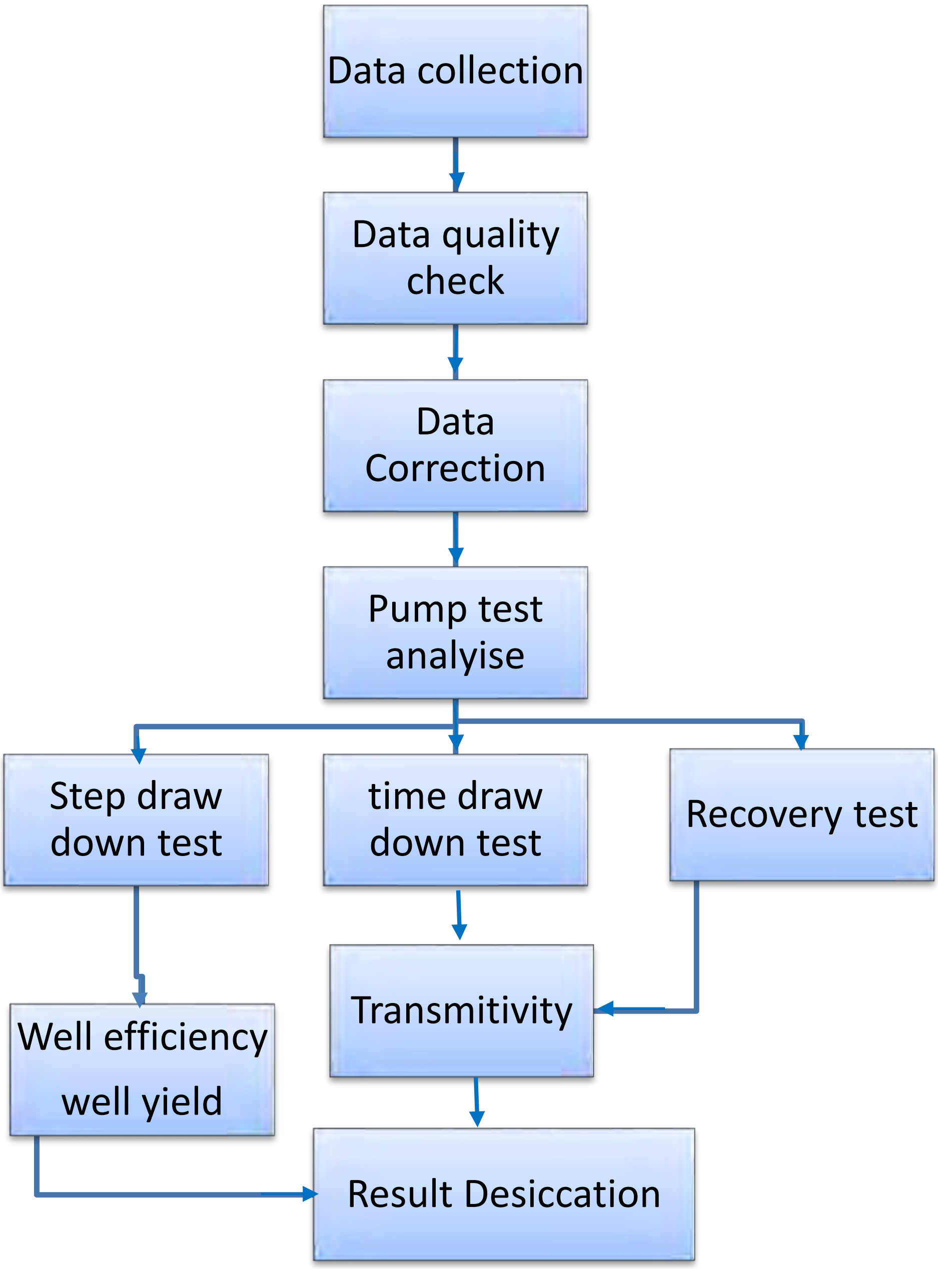

Figure 14: Summary of Research Methodology

3.1 Description of the Study area

Akaki well field is located south of the city of Addis Ababa about 20km from the city center. Addis Ababa deep wells water supply of phase III B project lies within the UTM coordinates of (475965, 480234) East and (974672, 978362) North and the average elevation is about2,070m a.s.l. totally twenty four wells develop in the area which cover 14.5 km^2.The average target depths intended to drill at the site under the contract agreements was 500m production wells however there was possibility of increasing or decreasing the drilling depth by 10% production wells under the contract Agreements. It was arranged and managed to drill to the maximum depth up to 623m in order to get more information about the extent of the aquifer, water quality variation and the aquifer thickness (WWDSE, 2015).

3.2 Data collection

A successful groundwater investigation depends on field data. However, to minimize additional fieldwork each groundwater study should start with the collection and analysis of the available information and documentation. These researches primarily focus on primary data collected while the pump test was conducted in the Akaki Deep well in January, 2013. Hence the primary pump test data like the step drawdown test data, constant pumping test data, recovery test data and the coordinate of each well were collected from Water works Design and Supervision Enterprise (WWDSE). The secondary data collected were information on the current status of the wells in Akaki well field IIIB. This information was obtained from Addis Ababa water and Sewerage Authority (AAWSA) as shown in Table 2.

Table 2: Wells operation report on phase IIIB

It.no	Name of well	Location	Q l/s	operating	Not operate	Reason for in operation
1	SL-PW-12	CT-2	79		✓	High water level drop
2	SL-PW-3	CT-2	53	✓		
3	SL-PW-4	CT-2	66	✓		The well isn't working full time due to water level drop
4	SL-PW-5	CT-2	71	✓		
5	SL-PW-6	CT-2	72		✓	High water level drop
6	SL-PW-7	CT-2	37	✓		
7	SL-PW-8	CT-2	80	✓		

8	SL-PW-9	CT-2	59	✓		The well isn't working full time due to water level drop
9	SL-PW-10	CT-2	40	✓		
10	SL-PW-11	CT-2	84		✓	High water level drop
11	SL-PW-13	CT-2	83		✓	EM,Pump Pulled out
12	SL-PW-14	CT-2	56		✓	EM,Motor starter fault condition
13	SL-PW-15	CT-2	32	✓		
14	SL-PW-16	CT-2	80		✓	EM,Motor problem and the pump is going to be pulled out
15	SL-PW-17	CT-2			✓	EM,power not connected,pump not yet started
16	SL-PW-18	CT-2	51	✓		
17	SL-PW-19	CT-2			✓	EM,Motor starter fault condition

18	SL-PW-21	CT-2	82		✓	EM,Water level sensor problem
19	SL-PW-22	CT-2			✓	High water level drop
20	SL-PW-24	CT-2	85	✓		
21	SL-PW-25	CT-2		✓		The well isn't working full time due to water level drop
22	SL-PW-30	CT-2	46	✓		
23	SL-PW-32	CT-2	40	✓		
24	SL-PW-33	CT-2	34	✓		

The summary of the data collected are as shown in table 3. Their detail could be seen from Annex -8.

Table 3 : Akaki phase IIIB well project information

No	Prospective site/well field	Well Index	Well type	Coordinate UTM Zone 37 Adindan		Elev, m	Contractor	Depth, m	Static water level, m	Dynamic water level, m	Draw down, m	Q, test, (l/S)
				UTM east	UTM north							
1	Akaki	SL-PW-03	production well	475276	976930	2052	CGCOC	582	54.32	128.99	74.67	75.44
2	Akaki	SL-PW04	production well	476037	976861	2068	CGCOC	595	55.18	91.25	36.07	88
3	Akaki	SL-PW-05	production well	475058	976100	2062	CGCOC	502	48.79	68.99	20.2	91
4	Akaki	SL-PW-06	production well	475528	975870	2059	CGCOC	600	52.02	86.4	34.38	86.5
5	Akaki	SL-PW-07	production well	476098	976183	2076	CGCOC	550	53.52	131.03	77.51	46.7
6	Akaki	SL-PW-08	production well	474528	975585	2057	CGCOC	569	49.06	73.5	24.44	95
7	Akaki	SL-PW-09	production well	473954	975244	2068	CGCOC	600	64.54	78.72	14.18	70.43
8	Akaki	SL-PW-10	production well	473954	975244	2053	CGCOC	591	49.28	133.39	84.11	55
9	Akaki	SL-PW-11	production well	471453	974241	2048	CGCOC	335	50.04	63.35	13.31	112.7
10	Akaki	SL-PW-12	production well	475507	974697	2046	CGCOC	320	49.45	55.95	6.5	113.48
11	Akaki	SL-PW-13	Production well	472078	974359	2050	CGCOC	319	51.65	57.57	5.92	106
12	Akaki	SL-PW-14	Production well	472640	973882	2072	CGCOC	518.5	70.25	98.33	28.08	84.9
13	Akaki	SL-PW-15	Production well	473428	973584	2078	CGCOC	623	70.55	134.5	63.95	32.35
14	Akaki	SL-PW-16	production well	474702	974792	2069	CGCOC	59.5	69.98	97	27.02	98
15	Akaki	SL-PW-17	Production well	474733	973382	2072	CGCOC	501	78.54	124.67	124.67	34.55

16	Akaki	SL-PW-18	production well	477023	973986	2090	CGCOC	503	84.85	114.61	29.76	66.17
17	Akaki	SL-PW-19	production well	476375	974046	2091	CGCOC	568	90.5	147.06	56.56	27
18	Akaki	SL-PW-21	production well	477959	974168	2103	CGCOC	501	98.47	108.3	9.83	90.23
19	Akaki	SL-PW-22	Production well	475507	974679	2070	CGCOC	51.5	76.65	120.13	43.48	72.34
20	Akaki	SL-PW-24	Production well	475941	975137	2063	CGCOC	551	65	71.67	6.67	102
21	Akaki	SL-PW-25	Production well	473071	974284	2060	CGCOC	552	56.08	61.61	5.53	109
22	Akaki	SL-PW-30	Production well	478528	973384	2113	CGCOC	518	132.4	133.72	1.32	46
23	Akaki	SL-PW-32	Production well	476725	973381	2111	CGCOC	170	110	149.74	39.74	47.67
24	Akaki	SL-PW-33	Production well	477415	973284	2112	CGCOC	453	116.38	139.69	23.31	37.34

3.3 Data quality checking

The quality of data collected from different organization will be checked for possible data collection errors. The quality of the data can be checked by viewing with eyes and draw the graphs time versus draw down on semi-log graph on excel spread sheet and compare with the usual straight line shape. From the collected data eight (SL-PW-08, SL-PW-09, SL-PW-10, SL-PW-13, SL-PW-15, SL-PW-18, SL-PW-32 and SL-PW-33) have a data quality problem. As the observed data show a larger variation from expected straight line relationship.

3.4 Pump-test analyses

The proposition that the wells might fail during the study time can be verified by carefully analyzing the pump test data collected. Pump tests can be analyzed on the basis of the type of test conducted. In Akaki well field three types of tests have been conducted (the step draw down, the constant discharge and recovery tests). With the exception of the step drawdown analysis the two tests can be analyzed on the basis of both Theis's Curve-Fitting method and cooper Jacob method. Additional analysis for recovery data, step draw down tests and time draw down test will be conducted as long as these data are available for a well. The water-level data collected before, during, and after the test should first be expressed in appropriate units. The measurement units of the International System are recommended but there is no fixed rule for the units in which the field data and hydraulic characteristics should be expressed. Transmissivity, for instance, can be expressed in m^2/s or m^2/d. Field data are often expressed in units other than those in which the final results are presented. Time data, for instance, might be expressed in seconds during the first minutes of the test, minutes during the following hours, and actual time later on, while water-level data might be expressed in different units of length appropriate to the timing of the observations. It will be clear that before the field data can be analyzed, they should first be converted: the time data into a single set of time units (e.g. minutes) and the drawdown data into a single set of length units (e.g. meters), or any other unit of length that is suitable (Kruseman, 2000).

Before being used in the analysis, the observed water levels may have to be corrected for external influences (i.e. those not related to the pumping). To find out whether this is necessary, one has to analyze the local trend in the hydraulic head or water table. The most suitable data for this purpose are the water-level measurements taken in a 'distant' piezometer during the test, but measurements taken at the test site for some days before and after the test can also be used. If, after the recovery period, the same constant water level is observed as during the pre-testing period, it can safely be assumed that no external events influenced the Hydraulic head during the test. If, however, the water level is subject to unidirectional or rhythmic changes, it will have to be corrected (Kruseman, 2000).

Presentation of Data Time drawdown, and distance information should be presented in the form of graphical plots. These graphical plots are necessary for any further analysis because calculation of hydraulic properties and characterization of the hydro-geologic regime is most easily interpreted through analysis of the shapes of data arrays on the plots.

Many analytical solutions are available for interpreting aquifer pumping test data. The assumptions incorporated within each solution must be evaluated with respect to consistency with site conditions including: the type of pumping and observation wells (fully- or partially-penetrating); the pumping rate (constant versus variable); and aquifer conditions (confined or unconfined). The physical characteristics of the aquifers, the necessary parameters such as the aquifer's design discharge, transmissivity and storage coefficient are computed. Such duty of an approximating the aquifers parameters for each well is concluded via curve–fitting by basic EXCEL tool. With the intention of carrying analysis on the pumping test data.

Theis methods analysis:-Theis (1935), which describes transient (time-dependent) groundwater flow toward a fully penetrating well in a confined aquifer, is the basis for most methods of transient pumping test analysis. It is also often used to calculate pumping rates of well when assuming certain values of drawdown, aquifer transmissivity, and storage coefficient. *Theis type curve* is a log-log graph of $W(u)$ versus u, and is used to match data observed in the field.

Theis introduced a graphical method, which gives T and S if other terms are known. Field data of drawdown (s) versus time (t) for a monitoring well is plotted separately on a log-log graph with the same scale as the theoretical curve. Keeping coordinate axes of the curves parallel, the field data is matched to the type curve. Once a satisfactory match is found, a *match point* on the overlapping graphs is selected. The match point is defined by four coordinates, the values of which are read on two graphs' (u) and u on the type curve graph, s and t on the field graph. The match point can be any point on the overlapping graphs. The transmissivity is calculated using Theis equation.

Drawdown s from a given observation borehole at distance r from the pumped well is plotted (y-axis) against t/r^2 (x-axis) on translucent log–log graph paper.

The Theis type curve is prepared by plotting values of W (u) (y-axis) against corresponding values of 1/ u (x-axis) on similar log-log paper.

The real data (on translucent paper) are superimposed on the type curve (at the same scale) and manipulated until a match is obtained.

Cooper and Jacob methods: - Cooper and Jacob (1946) attempted to simplify Theis's equation, such that a solution using a single sheet of semi-log graph paper was possible. Is based on the Theis formula from $u = r^2S/4KDt$, it will be seen that u decreases as the time of pumping t increases and the distance from the well **r** decreases. Accordingly, for drawdown observations made in the near vicinity of the well after a sufficiently long pumping time, the terms beyond in u in the series become so small that they can be neglected. So for small values of u ($u < 0.01$).

It was noted by Cooper and Jacob that for small values of r and large values of t, u is small the straight- line approximation for this method should be restricted to small values of u ($u<0.01$) to avoid large errors. The major advantage of this method is its simplicity. It only requires semi-log graph paper or a standard software spreadsheet package. It suffers from the same limitations and assumptions as the Theis method, however and one major assumption in addition: the Cooper–Jacob approximation is only valid for a situation where u is small (say, $u < 0.05$); that is, where r is small and/or t is large. In practice, however, this condition is often satisfied (and at small values of t, the time–drawdown response is often swamped by well-bore storage effects in any case).

Theis recovery method:-When the pump is shut down after a pumping test, the water levels in the well and the piezometers will start to rise. This rise in water levels is known as residual drawdown'**s'.** It is expressed as the difference between the original water level before the start of pumping and the water level measured at a time t' after the cessation of pumping.

It is always good practice to measure the residual drawdown's during the recovery period. Recovery-test measurements allow the transmissivity of the aquifer to be calculated, thereby providing an independent check on the results of the pumping test, although costing very little in comparison with the pumping test.

Residual drawdown data are more reliable than pumping test data because recovery occurs at a constant rate, whereas a constant discharge during pumping is often difficult to achieve in the field.

Aquifer Test 3.5 Software: Aquifer Test software was included in this research paper as one way of comparing the results obtained by manual curve fitting method applied on MS Excel 2013.

3.4.1 Data correction

Prior to using the drawdown data collected from a pumping test, it may be necessary to correct for either external sources or effects induced by the test. Barometric pressure changes, tidal or river fluctuations, natural recharge and discharge, and unique situations (e.g., a heavy rainfall) may all exert an influence. In confined and leaky ground water zones, changes in hydraulic head may be due to influences of tidal or river-level fluctuations, surface loading, or changes in atmospheric pressure.

Diurnal fluctuations in water levels can occur in unconfined zones due to the differences between night and day evapotranspiration. Corrections to measurements may be needed for unconfined ground water zone data due to a decrease in saturated thickness caused by the pumping test. Also, corrections may be necessary if the pumping well partially penetrates the zone tested. By identifying pre-test water level trends in zone(s) of interest, long and short-term variations can be eliminated from the data if their impacts are significant during the pumping phase.

To determine if corrections are necessary, measurements should be taken during the test in observation wells unaffected by the pumping. Hydrographs of the pumping and observation wells covering a sufficient period of pre-test and post-recovery periods can help determine if the data needs to be corrected and also to correct the drawdown data. If the same constant water level is observed during the pre-testing and post-recovery periods, it can safely be assumed that no external events exerted an influence (Kruseman and de Ridder, 1990).

From the collected data to correct the measured draw down caused by partial penetration the Kozeny correction factors are used the well which need correction for partial penetration are SL-PW-11 , SL-PW-12, SL-PW-24 , SL-PW-25, SL-PW-30.

To correct the measured draw down for the well loss efficiencies are calculated from step drawdown test data to use the efficiencies as a correction factor the well which use their efficiencies as a correction factor are SL-PW-03, SL-PW-04, SL-PW-06,SL-PW-07,SL-PW-08,SL-PW-14,SL-PW-16,SL-PW-07,SL-PW-19,SL-PW-21 and SL-PW-22.

3.4.1 Result interpretation

The final step is to interpret the results obtained which involves comparing the hydro-geologic parameters and well efficiency and well yields with the designed (as existing in the well completion reports) for possible failure in the design and study and/or post construction failure. The interpretation will suggest possible learning outcomes for future understanding of failures.

Out of the twenty-four well-developed in Akaki phase IIIB for 16 well the standard method of aquifer analysis by the three methods is performed in order to obtain the hydraulic parameter of the aquifer and also to compare the result with the completion report. These results help to now if the well is failed due to the design or day to day operation.

4 Result and Discussion

The intention of this paper is to find out the cause of the well failure in Addis Ababa at the area of Akaki project phase IIIB. The descriptions of this area is seen in detail in chapter three of this thesis the data of the well monitoring report is collected from AAWSA which show the failure of the well due to different reason are shown in table-2. As stated in the methodology part, for wells having step drawdown test the well efficiency curves (efficiency as a function of discharge) are expected to be developed. Besides the hydraulic parameters for wells with time drawdown and recovery date are also computed for thorough understanding of the well failure. Accordingly out of the twenty-four well-developed in Akaki phase IIIB 11 wells were selected for well efficiency estimation and for 16 wells the standard method of aquifer analysis by the three methods is performed in order to obtain the hydraulic parameter of the aquifer.

4.1 Data Quality

Among the 24 boreholes seen 18 have full step drawdown data thus these wells are used for further scrutiny. Among these wells seven wells are found to have data quality problem as such the slope of discharge versus efficiency obtained for five of them (SL-PW-05, SL-PW-09, SL-PW-10, SL-PW-13, SL-PW-15) were negative, which could not happen unless there is a data collection/observation problem. For the remaining two wells (SL-PW-18, and SL-PW-32) the efficiency obtained were much larger than 100%. Thus 11 wells were used for well efficiency based analysis of cause of well failure in the Akaki well field.

For the five of the 24 wells that do not have step drawdown data (SL-PW-11,SL-PW- 12,SL-PW- 24, SL-PW-25,SL-PW- 30) the aquifer parameters were scrutinized for the possible interpretation of cause of failure. These wells are found to have no data quality problem.

4.2 Well Efficiency

A step drawdown test provides a measure of well performance that can be used to estimate well's efficiency and determine an optimal pumping rate for the well, as well as provide an estimate of maximum yield under various water level conditions. Determining well efficiency and well loss is highly recommended because it provides valuable information about the well performance and can be used to make an informed decision regarding the well pumping rate, maintenance, and rehabilitation. For the wells with step draw down data the efficiency of the well is computed as per the methodology described in section 3.4.1.The step drawdown data collected for the 11 wells can be seen from appendix -1. From these data of step draw down the total draw down at the end of each time step (Sw) obtained for the step discharge (Q) for the eleven wells is drawn as shown in figure 15-25. In these figures the best fit straight line with its r^2 value is also depicted. From these straight lines the computed intercept (B) and well loss coefficient (C) values are as shown in Table 4.

Table 4 values of DSw, Sw, Q, Sw/Q, B and C for 11 wells

Well Name	DSw	Sw	Q(m3/s)	Sw/Q	B	C
SL-PW-03	34.70	34.70	4171.392	0.008319	0.0036	1.00E-06
	12.60	47.30	5188.32	0.009117		
	10.49	57.79	5938.272	0.009732		
	9.94	67.73	6236.352	0.01086		
SL-PW-04	5.91	5.91	4372.704	0.001352	0.0003	3.00E-07
	5.70	11.61	5556.384	0.00209		
	1.25	12.86	6389.280	0.00202		
	3.58	16.44	7603.200	0.002168		
SL-PW-06	15.12	15.12	4171.4	0.003625	0.0031	1.00E-07
	3.765471	18.89	5055.3	0.003736		
	6.091274	24.98	6085.2	0.004105		
	5.022236	29.99	7430.4	0.004037		
SL-PW-07	29.27	29.27	2179.01	0.013433	0.01	1.00E-06
	7.838	37.108	2924.64	0.012688		
	12.57203	49.68019	3689.28	0.013466		
	20.85347	70.53366	4362.336	0.016169		
	9.9	9.9	4320	0.002292		

SL-PW-08	4.583182	14.48318	5719.68	0.002532	0.0016	2.00E-07
	3.527755	18.01094	6955.2	0.00259		
	6.145766	24.1567	8153.568	0.002963		
SL-PW-14	14.42	14.42	4795.2	0.003007	0.0021	2.00E-07
	4.28	18.70	5659.2	0.003305		
	3.20	21.90	6480	0.00338		
	4.05	25.95	7344	0.003535		
SL-PW-16	15.27	15.27	6099.84	0.002503	0.0018	1.00E-7
	2.46	17.73004	6998.4	0.002533		
	2.613	20.3434	7776	0.002616		
	2.997	23.34024	8467.2	0.002757		
SL-PW-17	12.61	12.62	1641.6	0.007688	0.00009	4.00E-06
	3.82812	16.44812	2132.352	0.007714		
	10.7112	27.15932	2553.12	0.010638		
	11.48322	38.64254	2985.12	0.012945		
SL-PW-19	13.16	13.16	1323.65	0.009942	0.0044	4.00E-06
	9.44	22.60	1734.05	0.013035		
	3.63	26.24	2162.59	0.012133		
	10.51	36.75	2332.8	0.015754		
SL-PW-21	4.27	4.27	5011.2	0.000852	0.0003	1.00E-07
	1.50116	5.77116	5961.6	0.000968		
	2.38015	8.15131	6912	0.001179		
	1.02558	9.17689	7862.4	0.001167		

SL-PW-22	19.98	19.98	3888	0.005139	0.0022	7.00E-07
	2.270281	22.25028	4579.2	0.004859		
	6.610465	28.86075	5270.4	0.005476		
	12.07072	40.93147	6220.8	0.00658		

The well efficiency computed for the 11 wells for their expected yield estimated in their study and design document is as shown in table 5. A well efficiency of 70 percent or more is usually considered acceptable. If a newly developed well has less than 65 percent efficiency, it should not be accepted to operate. A step drawdown test is performed to see the design of the well and also to test out 80% and 65% efficiency of the project and try to evaluate the result obtained from the step drawdown and compute it with the data of the completion report. Such approach will tell, if the failure has resulted during the study phase rather than during operation.

Out of the eleven well of Akaki phase IIIB project which was shown in the above table seven of the well are below 65% (See table 5). this efficiency result tell us the well has already failed during the design time and the remaining four of the well is accepted because the efficiency are greater than 65% could be considered fit for operation with the suggested discharge.

The two component of drawdown in pumped well are: the aquifer losses and the well losses. The drawdown is corrected for the entire well by using well efficiency. The corrected drawdown data is used to estimate the hydraulic parameters in three standard methods. The eleven step drawdown test graphs and the efficiency analysis are shown below and the row step drawdown data for all well are attached in appendix-1.

Table 5 efficiency and yield of 65% and 85% for 11 well

Well name	B	C	Q^1(l/s)	$\eta^2=B/(B+CQ)$	Q^3(l/s)	Q^4(l/s)
SL-PW-03	0.0036	1.00E-06	75.44	35.58	19	8.5
SL-PW-04	0.0003	3.00E-07	88	11.62	23	11
SL-PW-06	0.0031	1.00E-07	86.5	80.67	193	89.9
SL-PW-07	0.01	1.00E-06	46.5	71.6	61.9	28.89
SL-PW-08	0.0016	2.00E-07	95	49.54	49.79	23.15
SL-PW-14	0.0021	2.00E-07	84.9	58.84	65.19	29
SL-PW-16	0.0018	1.00E-07	98	68	110	52
SL-PW-17	0.00009	4.00E-06	34.55	10	2	0.919

SL-PW-19	0.0044	4.00E-06	27	33.70	7	3.2
SL-PW-21	0.0003	1.00E-07	90.23	28	19	8
SL-PW-22	0.0022	7.00E-07	72.34	34	20	9

[1]Yield as indicated in the well completion report

[2] efficiency of the well during operation

[3]Expected Yield for 65% efficiency

[4] Expected yield for 85% Efficiency

The two component of drawdown in pumped well are: the aquifer losses and the well losses. The drawdown is corrected for the entire well by using well efficiency. The corrected drawdown data is used to estimate the hydraulic parameters in three standard methods. The eleven step drawdown test graphs and the efficiency analysis are shown below and the row step drawdown data for all well are attached in appendix-1.

From table 2 information obtained from AAWSA some of the well fail due to different reasons the motor failure problem occurred in well index SL-PW-13, SL-PW-14, SL-PW-16, SL-PW-19 the pump test which is performed by WWDSE shown in table 5 the yield estimated in the well completion report is greater than the yield this research has obtained (Q^3 In Table 5). These larger operation discharges create larger drawdown in the well than envisioned, which ultimately bring about motor failure. Thus to keep the motor safely, each of the wells shall be operated at or below the 65% efficiency discharge as recommended in Table 5.

From the secondary data obtained from AAWSA water level drop problem occur in well SL-PW-04, SL-PW-06, SL-PW-21 and SL-PW-22.These wells are not working full time due to water level drop this problem happened due to high pumping rate beyond their capacity, which make the developed well fail before their design life. Well index SL-PW-06 and SL-PW-16 have greater potential when compared with the result of WWDSE. To keep the developed wells in a sustainable way AAWSA has to pump the well with the discharge of suggested shown in the above Table.

A) SL-PW-03

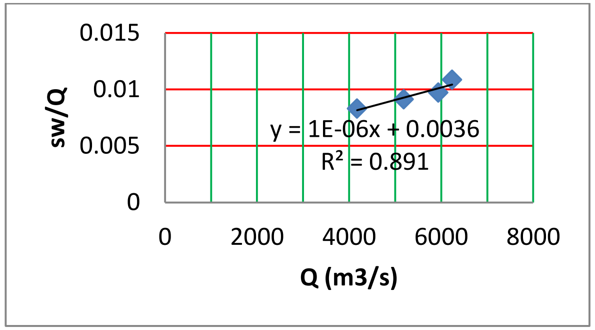

Figure 15 graph of Sw/Q verse Q

B) SL-PW-04

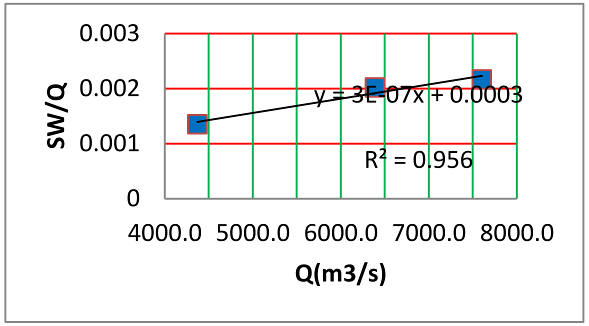

Figure 16 graph of Sw/Q verse Q

C) SL-PW-06

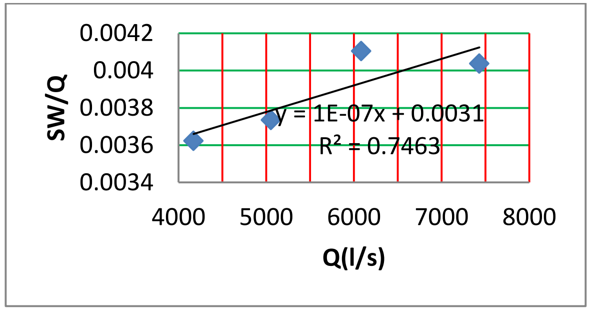

Figure 17 graph of Sw/Q verse Q

D) SL-PW-07

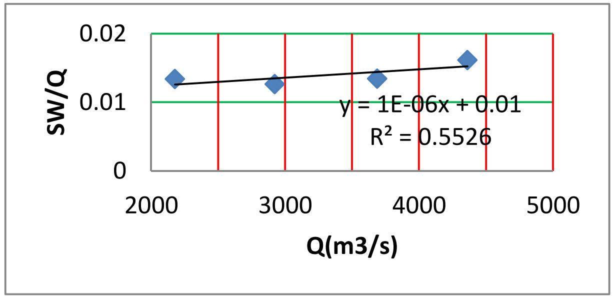

Figure 18 graph of Sw/Q verse Q

E) SL-PW-08

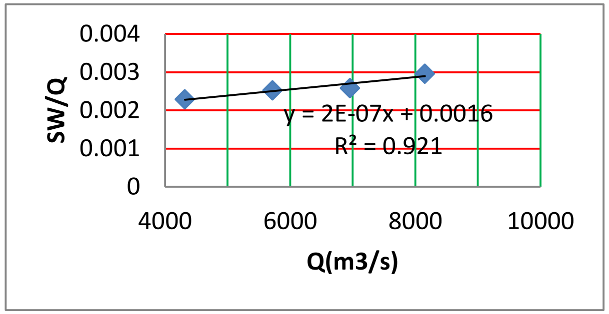

Figure 19 graph of Sw/Q verse Q

F) SL-PW-14

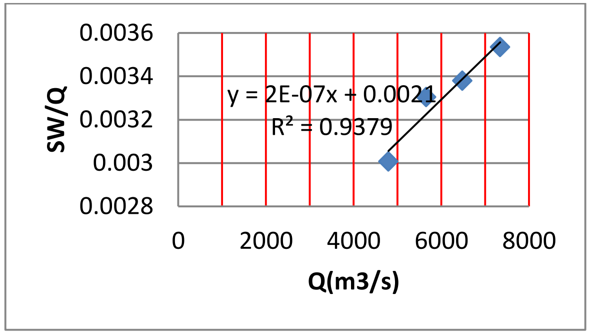

Figure 20 graph of Sw/Q verse Q

G) SL-PW-16

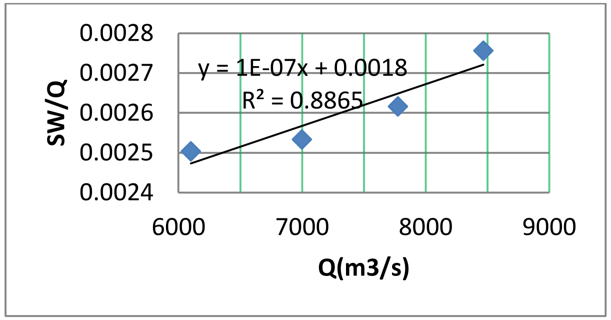

Figure 19 graph of Sw/Q verse Q

H) SL-PW-17

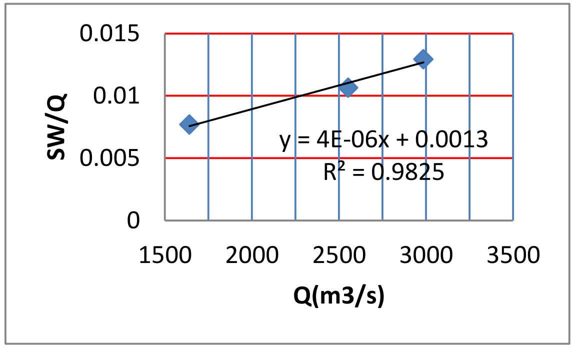

Figure 22 graph of Sw/Q verse Q

I) SL-PW-19

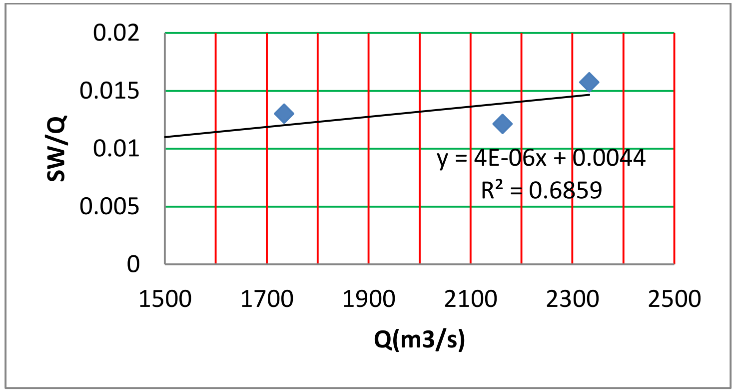

Figure 23 graph of Sw/Q verse Q

J) SL-PW-21

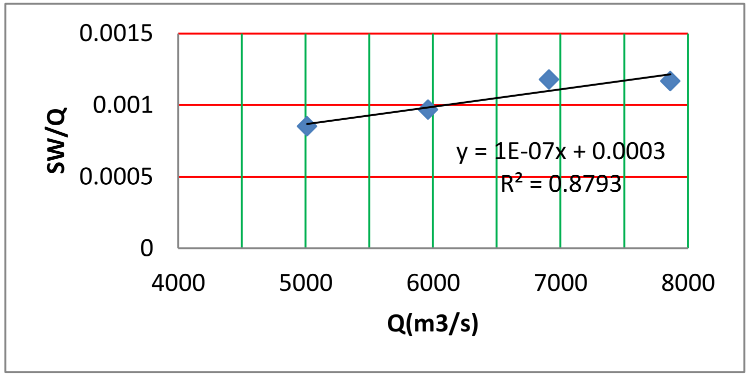

Figure 24 graph of Sw/Q verse Q

K) SL-PW-22

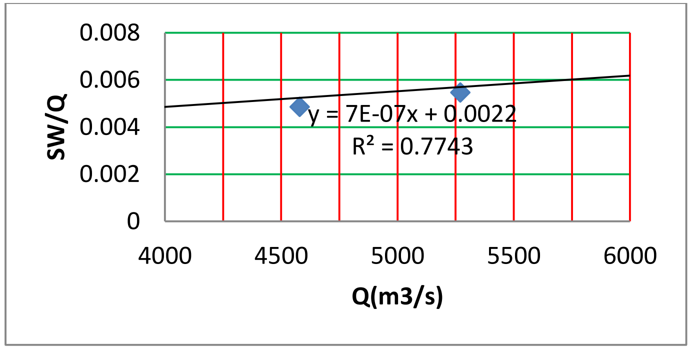

Figure 20 graph of Sw/Q verse Q

4.3 Partial penetration

Out of twenty-four well developed in Akaki phase IIIB project five of the well need Kozeny correction factor to correct the measured drawdown for the head loss caused by partial penetration. The step drawdown test data are not included in the WWDSE report for well SL-PW-11, SL-PW-12, SL-pw-24, SL-PW-25 and SL-PW-30. In order to compute the hydraulic parameter the partial penetration correction is performed. By arranging the blind and screen for each of the five well the observed drawdown is adjusted the arithmetic and geometric mean values are obtained from the casing arrangement of blind and screen but for the correction of the drawdown we use the geometric mean as a Kozeny correction factor. List of the correction factor are shown in the table below.

The casing arrangement collected from WWDSE and the analyses calculated for the correction are attached in the appendix -2 for the five well of Akaki phase IIIB.

Table 6 Kozeny correction factor for partial penetration of five well

Well ID	Arithmetic mean	Geometric mean
SL-PW-11	0.676	0.603433
SL-PW-12	0.6606	0.55279
SL-PW-24	0.856	0.837879
SL-PW-25	0.698	0.648321
SL-PW-30	0.564	0.535667

4.4 Unconfined Aquifer Correction

All unconfined aquifer changed to confined aquifer by using the Jacob (1944) correction

$$S_c = \mathrm{Sa}(1 - \frac{\mathrm{S_a}}{2\mathrm{b}})$$

Where Sc is the corrected drawdown in m, Sa the observed drawdown in m, and b is the saturated aquifer thickness in m prior to pumping. This correction is only needed when the maximum drawdown at the end of the test is larger than 5% of the original aquifer thickness.

From the well of Akaki Phase IIIB Some of it need correction for unconfined aquifer (SL-PW-03,SL-PW-04,SL-PW-06,SL-PW-07,SL-PW-8,SL-PW-14,SL-PW-17,SL-PW-19,SL-PW-22,SL-PW-24,SL-PW-11) by looking their plot of drawdown verses time & by studying their well log formation, correction for unconfined was made and attached in appendix-7 in order to use confined aquifer formulas for aquifer which are considered to be unconfined.

4.5 Transmissivity and Storativity result for Akaki phase IIIB wells

The object of this thesis is to find out the cause behind the well failure in Akaki phase IIIB project and to evaluate the hydraulic parameter with the design document if the failure is at the beginning or due to day to day operation. The transmissivity and Storativity values both for observed and corrected drawdown are shown by the three methods using Excel 2013 and the result are computed with the documents of WWDSE. The percent of transmissivity increase and decrease for both corrected and observed drawdown are evaluated shown in the table 36 and 37.

Most of the well developed in our city is single well test due to economic reason and has no observation well and it is difficult to calculate Storativity from single well test by using Theis recovery method. The Storativity of the 16 wells is also calculated by using the method Theis ,Cooper-Jacob and all of the well developed in Akaki phase IIIB project don't have observation well the values of Storativity by using Theis recovery method is not performed.

4.6 Transmissivity and Storativity values using Cooper-Jacob method

The cooper-Jacob method is the simplest method than Theis method and the method is apply for eleven of the Akaki deep well in the semi-log plot of the drawdown vs. time the best fit line is done using Trend line tool which gives the equation of the line and R^2 values. The plot for all of eleven well is shown in figure A-27 to figure A-38 in the appendix-4 part. Figure A-27 to figure A-38 show the semi-log plots of the observed and corrected drawdown the correction is for well loss drawdown. And figure A-39 to figure A-42 show the semi-log plots of the observed drawdown and corrected drawdown where the correction is done for the effects of partial penetration.

The result of the transmissivity and Storativity values for eleven wells using well efficiency to determine the drawdown loss in the well for both corrected and uncorrected drawdown shown in table 7 and for the reaming five well using kozeny correction factors to correct the drawdown are shown in Table 8.

Table 7 Transmissivity and Storativity values by cooper-Jacob method using efficiency correction factor

Well index	Pumping rate (m3/day)	Well efficiency %	Best fit Line for observed DD			Best fit Line for corrected DD			Transmissivity m2/day		Storativity	
			slope	intercept	R-square	slope	intercept	R-square	Observed DD	Corrected DD	Observed DD	Corrected DD
SL-PW-03	6048	35.5	0.39	24.57	0.899	1.5	63.881	0.881	346.77152	1343.746	1.12E-21	5.76E-15
SL-PW-04	6048	17.7	0.862	5.562	0.954	3.27	6.878	0.935	184.989	1255.24	4.388636	0.036062
SL-PW-06	7257.6	81.2	0.6084	22.661	0.994	0.7753	27.774	0.982	780.379	13750.63	1.47E-15	4.5E-16
SL-PW-07	3974.4	71.6	0.7	49.47	0.924	1.8	64.64	0.676	175.7071	9883.522	3.01E-16	-
SL-PW-08	8203	49.4	0.817	9.355	0.977	0.608	21.45	0.949	1073.766	1106.957	1.57E-13	0.855088
SL-PW-14	6912	60.3	0.283	14.38	0.991	0.479	23.94	0.990	1217.371	1373.481	1.18E-21	2.26E-12
SL-PW-16	8462.7	68	0.791	11.63	0.987	0.980	18.49	0.969	686.919	851.831	2.44011E-06	3.08E-08
SL-PW-17	2985.12	10	0.263	2.456	0.995	2.613	24.70	0.997	90.91	973.5586	0.000556218	0.001059
SL-PW-19	2160	34	1.330	7.685	0.995	5.403	13.18	0.979	31.81	109.48	0.012690681	0.068823
SL-PW-21	7776	28	0.080	1.985	0.979	0.191	8.196	0.952	3224.57	7734.93	8.91327E-10	6.14E-18
SL-PW-22	6048	34	0.248	12.84	0.758	1.101	35.26	0.791	436.936	3319.204	1.66093E-11	2.63E-38

Table 8 Transmissivity and Storativity values by cooper-Jacob method using Kozeny correction factor

Well index	Pumping rate (m3/day)	Radius of well in meters	Kozeny correction factor	Best fit Line for observed DD			Best fit Line for corrected DD			Transmissivity (m2/day)		Storativity	
				Slope	Intercept	R-square	Slope	Intercept	R-square	observed	corrected	observed	corrected
SL-PW-11	9737.3	0.48	0.676	0.72	2.20	0.988	1.035	3.41	0.994	1080.56	748.449	0.341757982	0.187691
SL-PW-12	9797.76	0.48	0.553	0.27	1.98	0.916	0.60	1	0.918	2887.707	1301.638	0.012690681	1.6622873
SL-PW-24	8812.8	0.48	0.837879	0.42	3.94	0.948	0.329	4.359	0.950	1677.752	2127.732	0.000937565	2.67E-05
SL-PW-25	9417.6	0.48	0.64832	0.669	0.398	0.986	0.669	2.937	0.980	1120.22	1120.22	4.36786	0.097675
SL-PW-30	3999.456	0.48	0.540	0.011	0.659	0.839	0.017	1.220	0.517	28416.66	18721.56	6.53E-24	5.74E-30

4.7 Transmissivity value using Theis recovery method

Todd (1980) points out that the initial recovery rate of a borehole after pumping stops can be a way of recognizing an inefficient well is to note its initial recovery rate when pumping is stopped. Where the well loss is large, this drawdown component recovers rapidly by drainage into the well from the surrounding aquifer. A rough rule of thumb is: if a pump is shut off after 1 hour of pumping and 90 percent or more of the drawdown is recovered after 5 minutes, it can be concluded that the well is unacceptably inefficient. For this research the middle time and the late time data are used because of the above reason the early time data are not used for calculation.

The hydraulic parameter values calculated are shown in the table 9 and 10 for both corrected and observed drawdown and the figure is shown in appendix part of this documents.

Table 9 Transmissivity values by Theis recovery method using efficiency correction factor

Well index	Pumping rate (m3/d)	Well efficiency (%)	Best fit Line for observed DD			Best fit Line for corrected DD			Transmissivity m2/day	
			slope	intercept	R-square	slope	intercept	R-square	Observed DD	Corrected DD
SL-PW-03	6048	35.5	1.09	2.45	0.976	3.938	3.64	0.943	477.172	504.55
SL-PW-04	6048	17.7	1.813	0.544	0.982	5.098	-1.139	0.966	333.7162	672.25
SL-PW-06	7257.6	81.2	0.782	-0.82	0.983	0.648	-0.211	0.984	1779.493	292.22
SL-PW-07	3974.4	71.6	0.89	-0.03	0.989	1.313	-0.054	0.986	355.9225	323.0569
SL-PW-08	8203	49.4	0.275	-0.165	0.979	0.791	-1.129	0.982	2375.17	2602.278
SL-PW-14	6912	60.3	0.1187	0.929	0.974	0.287	1.207	0.965	4917.687	2727.707
SL-PW-16	8462.7	68	0.451	1.087	0.983	0.68	1.60	0.985	1492.981	992.1697
SL-PW-17	2985.12	10	0.195	0.149	0.994	1.85	1.83	0.996	1218.196	1037.33
SL-PW-19	2160	34	2.624	-2.970	0.995	8.014	-8.623	0.992	65.60585	84.55
SL-PW-21	7776	28	0.013	-0.005	0.976	0.06	-0.05	0.961	13222.1	2841.113
SL-PW-22	6048	34	0.042	0.021	0.976	0.215	-0.224	0.832	11459.16	2506.69

Table 10 Transmissivity values by Theis recovery method using Kozeny correction factor

Well index	Pumping rate(m3/day)	Radius of well in meters	Kozeny correction factor	Best fit Line for observed DD			Best fit Line for corrected DD			Transmissivity (m2/day)	
				Slope	Intercept	R-square	Slope	Intercept	R-square	observed	corrected
SL-PW-11	9737.3	0.48	0.676	0.193	1.744	0.964	1.358	0.076	0.957	4014.869	570.5122
SL-PW-12	9797.76	0.48	0.553	0.055	0.141	0.987	0.111	0.218	0.966	13489.29	7017.83
SL-PW-24	8812.8	0.48	0.837879	-0.21	5.722	0.894	-0.6	7.913	0.932	-3339.56	-1168.84
SL-PW-25	9417.6	0.48	0.64832	0.2.61	2.792	0.902	0.548	3.889	0.927	2871.375	1365.577
SL-PW-30	3999.456	0.48	0.540	0.108	-0.433	0.987	0.042	-0.018	0.658	2946.913	7577.776

4.8 Transmissivity and Storativity values using Theis method

This method require the over lapping of the two curves, W(U) VS U plot and S VS r^2/t plot. The method is done manually due to this some values of transmissivity and Storativity different from the cooper-Jacob method and the Theis recovery method.

The plots of the overlap of the type curve and drawdown curve for all of the 16 well is shown in the appendix the drawdown plots contain the correction for well loss using well efficiency and unconfined aquifer in figure 33 and figure 34 partial penetration in addition unconfined aquifer correction.

The result of transmissivity values using the Theis method is shown both for corrected and uncorrected drawdown in table 11 and 12 by using a correction factor of efficiency and Kozeny correction factor.

Table 11 Transmissivity and Storativity by Theis method using efficiency correction factor

Well index	Well efficiency (%)	Transmissivity m2/day		Storativity	
		Observed DD	Corrected DD	observed	corrected
SL-PW-03	35.5	388.47	3051.09		
SL-PW-04	17.7	201.67	301.01		
SL-PW-06	81.2	134.45	172.87	0.100939	0.480181
SL-PW-07	71.6	287.521	275.019	0.107928	0.138899
SL-PW-08	49.4	725.75	6531.71		
SL-PW-14	60.3	134.45	172.87	0.100939	0.480181
SL-PW-16	68	269.513	192.509		
SL-PW-17	10	47.5097	212.097		
SL-PW-19	34	24.56	156.26	0.006201	0.03946
SL-PW-21	28	114.59	85.94		
SL-PW-22	34	96.26	120.32		

Table 12 Transmissivity and Storativity values by Theis method using Kozeny correction factor

Well index	Geometric mean	Transmissivity m2/day		Storativity	
		Observed DD	Corrected DD	observed	corrected
SL-PW-11	0.60343	19.34	860.99		
SL-PW-12	0.55279	77968.1	15593.62		
SL-PW-24	0.837879	637.48	350.62	0.100939	0.480181
SL-PW-25	0.648321	749.43	394.44	0.107928	0.138899
SL-PW-30	0.535667	3536.29	3536.29		

Table 13 Summery of Transmissivity and Storativity values by the three methods and percent increase and decrease of transmissivity

Transmissivity(m^2/day)							Storativity Evaluated	
Well index	WWDSE	Method used	Corrected	Geometric mean		Transmissivity % Increase and Decrease	Method used	Corrected
				WWDSE	Corrected			
SL-PW-03	448	Cooper-Jacob	1343.75	238.5288	1274.166	534.177	Cooper-Jacob	0.000627
	127	Theis recovery	504.55				Theis	-
		Theis	3051.09					
SL-PW-04	150	Cooper-Jacob	1255.24	133.0413	633.3049	476.0213	Cooper-Jacob	4.396
	118	Theis recovery	672.25				Theis	
		Theis	301.01					
SL-PW-06	747	Cooper-Jacob	13750.6	770.6204		122.357	Cooper-Jacob	4.5E-16

	795	Theis recovery	292.22		942.9083		Theis	
		Theis	208.63					
SL-PW-07	309	Cooper-Jacob	9883.52	272.3233	957.6019	351.6416	Cooper-Jacob	0.000433
	240	Theis recovery	323.0569				Theis	
		Theis	275.02					
SL-PW-08	1380	Cooper-Jacob	1106.957	1462.532	2659.727	181.8577	Cooper-Jacob	1.57E-13
	1550	Theis recovery	2602.278				Theis	
		Theis	6531.71					
SL-PW-14	1010	Cooper-Jacob	1373.481	1333.267	956.3779	-139.408	Cooper-Jacob	1.18E-21
	1760	Theis recovery	2727.707				Theis	
		Theis	233.49					

SL-PW-16	720	Cooper-Jacob	851.83	686.7314	625.57	-109.7769	Cooper-Jacob	2.44E-06
	655	Theis recovery	1492.98				Theis	
		Theis	192.5					
SL-PW-17	90.7	Cooper-Jacob	973.5586	104.7602	598.326	571.1387	Cooper-Jacob	0.000556
	121	Theis recovery	1037.33				Theis	
		Theis	212.097					
SL-PW-19	32.5	Cooper-Jacob	109.48	31.12073	113.092	363.3976	Cooper-Jacob	0.00300632
	29.8	Theis recovery	84.55				Theis	
		Theis	156.26					
SL-PW-21	4040	Cooper-Jacob	9328.67	6904.491	2196.71	-314.3105	Cooper-Jacob	8.913E-10

	11800	Theis recovery	13222.1				Theis	
		Theis	85.94					
SL-PW-22	1170	Cooper-Jacob	3319.204	1560	1000.363	-155.9434	Cooper-Jacob	1.66E-11
	2080	Theis recovery	2506.69				Theis	
		Theis	120.32					

Table 14 Summery of Transmissivity by three method using Kozeny correction factor

Well index	WWDSE	Method used	Corrected DD	Geometric mean		Present increase and decrease transmissivity
				WWDSE	corrected	
SL-PW-11	635	Cooper-Jacob	901.62	752.1868	1108.39	147.3557
	891	Theis recovery	1754.18			
		Theis	860.96			
	140	Cooper-Jacob	2887.70			

SL-PW-12	1970	Theis recovery	13489.29	525.1666	8468.95	6049.25
		Theis	15593.62			
SL-PW-24	2450	Cooper-Jacob	1677.75	1791.508	11437.26	638.4152
	1310	Theis recovery				
		Theis	350.66			
SL-PW-25	792	Cooper-Jacob	1120.22	774.3023	1340.833	173.1666
	757	Theis recovery	2871.375			
		Theis	749.43			
SL-PW-30	165000	Cooper-Jacob	28416.66	55547.28	6665.46	-833.36
	18700	Theis recovery	2946.93			
		Theis	3536.29			

Table 15 Transmissivity and Storativity by Aquifer test software 3.5

Well index	Transmissivity m2/day				Storativity	
	Theis method	Theis Recovery method	Cooper Jacob method	Geometric mean	Theis method	Cooper-Jacob method
SL-PW-03	1370	1120	1120	1197.803	2.26E-9	1.49E-14
SL-PW-04	163	1120	135	291.0135	9.82E-3	4.09E-2
SL-PW-06	191	763	420	394.0963	6.39E-8	3.90E-16
SL-PW-07	44.8	399	92.9	118.4192	7.961E-8	1.85E-16
SL-PW-08	270	791	560	492.6927	9.02E-8	2.14E-14
SL-PW-14	324	1110	317	484.8891	8.54E-8	4.96E-6
SL-PW-16	50.3	149	75.7	82.78469	1.66E-6	1.16E-10
SL-PW-17	31.2	300	43.5	74.11766	6.02E-5	4.54E-5
SL-PW-19	18.7	242	18.3	43.58824	4.33E-3	4.76E-3
SL-PW-21	924	917	1600	1106.761	3.08E-7	5.55E-14
SL-PW-22	14.2	712	42.8	75.63754	9.90E-3	2.15E-1
SL-PW-11	7870	206	7210	2269.4767	1.09E-1	2.07E-1
SL-PW-12	2510	1180	1540	2394.71	2.11E-4	8.19E-2
SL-PW-24	15.90	1610	1530	339.603	5.30E+2	1.966+2
SL-PW-25	1030	1720	838	1140.783	6.54E-2	3.52E-1
SL-PW-30	3460	7110	9040	6058.587	2.65E-3	3.58E-13

Table 16 Summery of Transmissivity for Excel and Aquifer test 3.5 software

Well index	Transmissivity m2/day			Percent (increase or decrease)
	WWDSE Geometric mean	Geometric mean Corrected using Excel Spread sheet	Geometric mean(Aquifer) test 3.5 software	
SL-PW-03	238.5288	1274.166	1197.803	534.177
SL-PW-04	133.0413	633.3049	291.0135	476.0213

SL-PW-06	770.6204	942.9083	394.0963	122.357
SL-PW-07	272.3233	957.6019	118.4192	351.6416
SL-PW-08	1462.532	2659.727	492.6927	181.8577
SL-PW-14	1333.267	956.3779	383.023	-139.408
SL-PW-16	686.7314	625.57	620.5717	-109.7769
SL-PW-17	104.7602	598.326	82.80056	571.1387
SL-PW-19	31.12073	113.092	43.58824	363.3976
SL-PW-21	6904.491	2196.71	1106.761	-314.3105
SL-PW-22	1560	1000.363	75.45956	-155.9434
SL-PW-11	752.1868	1108.39	2269.4767	147.3557
SL-PW-12	140	8469.95	2394.71	6049.25
SL-PW-24	1791.508	11437.26	339.603	638.4152
SL-PW-25	774.3023	1340.833	1140783	173.1666
SL-PW-30	55547.28	6665.46	6058.587	-833.36

Summary of hydraulic parameters by using Excel-spread sheet is calculated both for the uncorrected and corrected drawdown data estimation of Transmissivity are performed and the geometric mean result obtained by the three methods is compare with the result of WWDSE. The 16 well calculated transmissivity values are as shown in table 13 and 14. The results clearly show that there is clear variation from the one in the designed documents of WWDSE. The percentage increase and decrease of transmissivity is also shown in the same Tables.

The overestimated transmissivity are seen in SL-PW-14, SL-PW-16, SL-PW-21, SL-PW-22 and SL-PW-30. The underestimated transmissivity are seen in SL-PW-03, SL-PW-04, SL-PW-06, SL-PW-07, SL-PW-08, SL-PW-17, SL-PW-19, SL-PW-11, SL-PW-24 and SL-PW-25. Over estimation of transmissivity imply that the well is expected to be pumped beyond its yielding capacity. Conversely the under estimated transmissivity will make the yield to be lower than the capacity of the aquifer.

5 Conclusion and Recommendation

5.1 Conclusion

Two approaches step drawdown test analysis and time drawdown analysis on the data collected during the study and design phase of Akaki phase IIIB were conducted. The sole objective is to address the problem behind well failure that has been reported by AAWSA in this field. The two approaches were first modeled in excel spreadsheet, with the objective of finding the transmissivity of the aquifers where the well is drilled and the associated well yield. The results of this analysis were compared with the values estimated in the well completion reports. The study was conducted on the basis of single well test, where by both pumping and observation of drawdown takes place in a single well.

The transmissivity values obtained in this research has great variation from the study of WWDSE which accounts for 10 to 200%. Among the 16 wells analyzed 11 have underestimated transmissivity whereas the 5 wells are expected to have overestimated transmissivity. The overestimated transmissivity envisions good aquifer with better yield than the capacity of the aquifer. The underestimated transmissivity values found to have lower yield than their discharging capacity. However due to the effect of design and construction of the wells, the aquifer yield are found to be diminished.

The well efficiencies' were also computed for the expected yield (as suggested in the well completion report). The results clearly show that majority of the wells (8 out of the 11 tested wells) found to work well below the recommended operational efficiency. In this research the result obtunds for the yield and Transmissivity show as one of the reason for failure of the well. A well is considered acceptable if it works above 65% efficiency. Besides three of the tested wells are working with the recommended efficiency range. Such result clearly show that the eight wells has already failed during design and construction phase as long as they are expected to yield the values recommended in their well completion report. Such huge yield expectation from the wells will create a larger draw down in the well that the pump inside the well will no longer be submersible. As such the pump will get damaged ("burned out"). This research also suggests the optimum rate these so called "failed wells" can operate with 65 % efficiency. Accordingly the wells can operate as long as these recommended yields are respected.

In the development of Akaki deep well concern is not given for efficiency of the well attention is given for yield and this make the developed well to fail without completing its life time. From the well developed in Akaki even if there efficiency is less than the standard it is not abounded it is still working too much beyond its capacity.

In general, the groundwater sources of the Akaki Phase IIIB need proper management and operation of the well. The developed groundwater has to be standardized in order to reduce the failure of the well. this study has identified AAWSA has some gap on the operation and management of groundwater the gap observed are lack of systematic and planned monitoring and implementation of groundwater the well field aquifer characteristic either through the test wells and/or through the production wells.

5.2 Recommendation

Due to economic reason most of the groundwater developed in the city follows a single well test system. Such approach has a very serious drawback in aquifer property determination. Such approach, beside drawback in standard analysis and result interpretation challenges, in this study case have resulted in inappropriate well yield and transmissivity estimation. Thus for such huge projects delivering water supply for 700000 peoples adopting single well test shall be changed to multiple well test.

During the development of groundwater attention has to be given for the well yield and the hydraulic characteristic estimations. Result interpretation and complying with the standard well pumping test approaches shall be strictly followed.

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APPINDEIX-01 Step Drawdown Test Raw Data

Step Draw Down Test SL-PW-03										
step 1			**step-2**		**Step-3**			**step 4**		
Q=48.28l/s			**Q=60.05l/s**		**Q=68.73**			**Q=72.18l/s**		
Time, min	**Drawdown, m**	**T1=T+120**	water level	Drawdown(m)	**T2=T1+120**	water level	Drawdown(m)	**T3=T2+120**	water level	Drawdown (m)
0	0	120	0	34.7	240	0	49.23	360	0	61.41
1	26.37	121	9.47	44.17	241	7.03	56.26	361	4.69	66.1
2	27.78	122	9.98	44.68	242	7.7	56.93	362	7.29	68.7
3	28.34	123	10.53	45.23	243	8.14	57.37	363	7.99	69.4
4	28.65	124	11.34	46.04	244	8.33	57.56	364	8.76	70.17
5	29.14	125	11.7	46.4	245	8.58	57.81	365	8.96	70.37
6	29.33	126	11.89	46.59	246	8.78	58.01	366	9.12	70.53
7	29.86	127	11.94	46.64	247	8.91	58.14	367	9.33	70.74
8	30	128	11.98	46.68	248	9.04	58.27	368	9.58	70.99
9	30.25	129	12.06	46.76	249	9.16	58.39	369	9.63	71.04
10	30.37	130	12.15	46.85	250	9.21	58.44	370	9.68	71.09
12	30.95	132	12.34	47.04	252	9.28	58.51	372	9.82	71.23
14	31.23	134	12.48	47.18	254	9.53	58.76	374	9.93	71.34
16	31.86	136	12.61	47.31	256	9.85	59.08	376	10.08	71.49
18	32.29	138	12.71	47.41	258	10.1	59.33	378	10.17	71.58

20	32.47	140	12.76	47.46	260	10.28	59.51	380	10.22	71.63
25	32.53	145	12.87	47.57	265	10.51	59.74	385	10.39	71.8
30	32.58	150	13.03	47.73	270	10.6	59.83	390	10.52	71.93
35	32.91	155	13.15	47.85	275	10.82	60.05	395	10.6	72.01
40	33.27	160	13.27	47.97	280	10.94	60.17	400	10.76	72.17
45	33.31	165	13.36	48.06	285	11.08	60.31	405	10.84	72.25
50	33.47	170	13.44	48.14	290	11.16	60.39	410	10.96	72.37
55	33.51	175	13.55	48.25	295	11.2	60.43	415	11.04	72.45
60	33.55	180	13.67	48.37	300	11.29	60.52	420	11.09	72.5
70	33.7	190	13.8	48.5	310	11.46	60.69	430	11.24	72.65
80	33.95	200	13.93	48.63	320	11.58	60.81	440	11.38	72.79
90	34.29	210	14.14	48.84	330	11.74	60.97	450	11.44	72.85
100	34.49	220	14.25	48.95	340	11.84	61.07	460	11.55	72.96
120	34.7	240	14.53	49.23	360	12.18	61.41	480	11.76	73.17
121	34.82	241		49.25	361		61.41	481		73.19
122	34.84	242		49.27	362		61.42	482		73.19
123	34.84	243		49.28	363		61.44	483		73.20
124	34.84	244		49.29	364		61.45	484		73.22
125	34.86	245		49.31	365		61.47	485		73.23
126	34.90	246		49.33	366		61.48	486		73.24
127	34.90	247		49.34	367		61.50	487		73.24
128	34.91	248		49.35	368		61.52	488		73.26
129	34.93	249		49.37	369		61.53	489		73.27

130	34.95	250		49.38	370		61.55	490		73.28
132	34.98	252		49.41	372		61.58	492		73.30
134	35.00	254		49.44	374		61.61	494		73.32
136	35.04	256		49.47	376		61.64	496		73.34
138	35.07	258		49.49	378		61.67	498		73.36
140	35.10	260		49.52	380		61.70	500		73.38
145	35.18	265		49.59	385		61.78	505		73.43
150	35.25	270		49.66	390		61.85	510		73.48
155	35.33	275		49.73	395		61.93	515		73.53
160	35.41	280		49.80	400		62.01	520		73.59
165	35.48	285		49.87	405		62.08	525		73.64
170	35.56	290		49.94	410		62.16	530		73.69
175	35.63	295		50.01	415		62.24	535		73.74
180	35.71	300		50.08	420		62.31	540		73.79
190	35.86	310		50.22	430		62.46	550		73.90
200	36.02	320		50.36	440		62.62	560		74.00
210	36.17	330		50.50	450		62.77	570		74.10
220	36.32	340		50.64	460		62.92	580		74.21
240	36.63	360		50.92	480		63.23	600		74.41

Step Draw Down Test SL-PW-04										
step 1 Q=50.61l/s		step 2 Q=64.3l/s			step 3 Q=73.95l/s			step 4 Q=88l/s		
Time, min	**water level, m**	**T1=T+120**	**Drawdown ,m**	**water level, m**	**T2=T1+120**	**Drawdow n,m**	**water level, m**	**T3=T2+120**	**Drawdown ,m**	**wate r level, m**
0	0	120	5.91	0	240	13.31	0	360	17.67	0
1	2.42	121	7.89	1.98	241	14.03	0.72	361	19.35	1.68
2	2.52	122	8	2.09	242	14.22	0.91	362	19.5	1.83
3	2.62	123	8.04	2.13	243	14.35	1.04	363	19.61	1.94
4	2.67	124	8.36	2.45	244	14.42	1.11	364	19.61	1.94
5	2.72	125	8.51	2.6	245	14.52	1.21	365	19.74	2.07
6	2.76	126	8.6	2.69	246	14.54	1.23	366	19.82	2.15
7	2.86	127	8.74	2.83	247	14.62	1.31	367	19.88	2.21
8	2.91	128	8.84	2.93	248	14.88	1.57	368	20	2.33
9	2.96	129	8.92	3.01	249	14.9	1.59	369	20.02	2.35
10	3.02	130	9.03	3.12	250	14.94	1.63	370	20.07	2.4
12	3.14	132	9.19	3.28	252	14.96	1.65	372	20.15	2.48
14	3.29	134	9.37	3.46	254	15	1.69	374	20.27	2.6
16	3.41	136	9.5	3.59	256	15.03	1.72	376	20.39	2.72
18	3.5	138	9.64	3.73	258	15.09	1.78	378	20.48	2.81
20	3.58	140	9.76	3.85	260	15.2	1.89	380	20.59	2.92
25	3.78	145	10.13	4.22	265	15.43	2.12	385	20.67	3
30	4	150	10.34	4.43	270	15.56	2.25	390	20.97	3.3
35	4.19	155	10.77	4.86	275	15.67	2.36	395	21.37	3.7
40	4.33	160	10.81	4.9	280	15.87	2.56	400	20.55	2.88
45	4.5	165	11.04	5.13	285	15.99	2.68	405	21.77	4.1
50	4.67	170	11.39	5.48	290	16.09	2.78	410	21.92	4.25
55	4.83	175	11.48	5.57	295	16.36	3.05	415	22.08	4.41
60	4.91	180	11.62	5.71	300	16.46	3.15	420	22.19	4.52
70	5.14	190	12.02	6.11	310	16.66	3.35	430	22.49	4.82
80	5.35	200	12.26	6.35	320	16.91	3.6	440	22.78	5.11

90	5.49	210	12.57	6.66	330	17.05	3.74	450	23.04	5.37	
100	5.64	220	12.8	6.89	340	17.22	3.91	460	23.28	5.61	
120	5.91	240	13.31	7.4	360	17.67	4.36	480	23.7	6.03	
121	5.94	241	13.34		361	17.67		481	23.76		
122	5.95	242	13.37		362	17.69		482	23.77		
123	5.96	243	13.39		363	17.71		483	23.79		
124	5.98	244	13.42		364	17.74		484	23.81		
125	5.99	245	13.44		365	17.75		485	23.84		
126	6.00	246	13.47		366	17.78		486	23.85		
127	6.02	247	13.49		367	17.80		487	23.88		
128	6.03	248	13.52		368	17.82		488	23.90		
129	6.05	249	13.55		369	17.84		489	23.92		
130	6.06	250	13.57		370	17.86		490	23.94		
132	6.09	252	13.62		372	17.90		492	23.99		
134	6.12	254	13.67		374	17.94		494	24.03		
136	6.15	256	13.72		376	17.98		496	24.08		
138	6.17	258	13.77		378	18.02		498	24.12		
140	6.20	260	13.83		380	18.06		500	24.17		
145	6.27	265	13.95		385	18.17		505	24.28		
150	6.34	270	14.08		390	18.27		510	24.39		
155	6.41	275	14.21		395	18.37		515	24.50		
160	6.48	280	14.34		400	18.48		520	24.61		
165	6.55	285	14.46		405	18.58		525	24.73		
170	6.62	290	14.59		410	18.68		530	24.84		
175	6.69	295	14.72		415	18.78		535	24.95		
180	6.77	300	14.84		420	18.89		540	25.06		
190	6.91	310	15.10		430	19.09		550	25.28		
200	7.05	320	15.35		440	19.30		560	25.51		
210	7.19	330	15.61		450	19.51		570	25.73		
220	7.33	340	15.86		460	19.71		580	25.95		
240	7.61	360	16.37		480	20.12		600	26.40		

Step Draw Down Test SL-PW-06										
step 1 Q=48.28l/s		step 2 Q=58.5l/s			step 3 Q=70.43l/s			step 4 Q=86l/s		
Time, min	Drawdow(m)	T1=T+120	Drawdown,m	water level	T2=T1+120	Drawdown,m	water level	T3=T2+120	Drawdown,m	water level
0	0	120	15.12	0	240	19.51	0	360	25.93	0
1	12.67	121	21.72	6.6	241	24.92	5.41	361	29.67	3.74
2	12.74	122	21.74	6.62	242	25.41	5.9	362	30.27	4.34
3	12.76	123	21.77	6.65	243	25.41	5.9	363	30.41	4.48
4	13.42	124	21.79	6.67	244	25.41	5.9	364	30.47	4.54
5	13.77	125	21.81	6.69	245	25.41	5.9	365	30.51	4.58
6	14.17	126	21.86	6.74	246	25.4	5.89	366	30.55	4.62
7	14.31	127	21.87	6.75	247	26.39	6.88	367	30.57	4.64
8	14.32	128	21.93	6.81	248	25.42	5.91	368	30.6	4.67
9	14.42	129	21.95	6.83	249	25.43	5.92	369	30.6	4.67
10	14.57	130	21.97	6.85	250	25.45	5.94	370	30.63	4.7
12	14.82	132	18.57	3.45	252	25.49	5.98	372	30.65	4.72
14	14.88	134	18.72	3.6	254	25.5	5.99	374	30.67	4.74
16	15	136	18.9	3.78	256	25.52	6.01	376	30.7	4.77
18	15.01	138	19.07	3.95	258	25.53	6.02	378	30.72	4.79
20	15.04	140	19.14	4.02	260	25.55	6.04	380	30.74	4.81
25	15.13	145	19.23	4.11	265	25.6	6.09	385	30.8	4.87
30	15.17	150	19.26	4.14	270	25.64	6.13	390	30.81	4.88
35	15.2	155	19.29	4.17	275	25.65	6.14	395	30.87	4.94
40	15.22	160	19.32	4.2	280	25.67	6.16	400	30.89	4.96
45	15.24	165	19.34	4.22	285	25.7	6.19	405	30.92	4.99
50	14.99	170	19.37	4.25	290	25.73	6.22	410	30.93	5
55	14.94	175	19.35	4.23	295	25.75	6.24	415	30.95	5.02
60	15.02	180	19.37	4.25	300	25.77	6.26	420	30.98	5.05
70	14.9	190	19.39	4.27	310	25.79	6.28	430	31.03	5.1
80	14.96	200	19.41	4.29	320	25.81	6.3	440	31.11	5.18
90	14.96	210	19.43	4.31	330	25.83	6.32	450	31.12	5.19
100	14.97	220	19.44	4.32	340	25.87	6.36	460	31.17	5.24
120	15.12	240	19.51	4.39	360	25.93	6.42	480	31.32	5.39
121	15.10	241	19.50		361	25.93		481	31.31	

122	15.10	242	19.51		362	25.93		482	31.31	
123	15.11	243	19.51		363	25.94		483	31.33	
124	15.12	244	19.52		364	25.94		484	31.33	
125	15.12	245	19.52		365	25.94		485	31.33	
126	15.13	246	19.52		366	25.95		486	31.34	
127	15.14	247	19.52		367	25.95		487	31.35	
128	15.14	248	19.53		368	25.95		488	31.36	
129	15.14	249	19.53		369	25.96		489	31.36	
130	15.15	250	19.53		370	25.96		490	31.37	
132	15.16	252	19.54		372	25.96		492	31.38	
134	15.17	254	19.54		374	25.97		494	31.39	
136	15.18	256	19.55		376	25.98		496	31.41	
138	15.19	258	19.55		378	25.98		498	31.42	
140	15.21	260	19.56		380	25.99		500	31.43	
145	15.23	265	19.57		385	26.00		505	31.47	
150	15.26	270	19.59		390	26.02		510	31.50	
155	15.29	275	19.60		395	26.04		515	31.53	
160	15.31	280	19.61		400	26.05		520	31.56	
165	15.34	285	19.63		405	26.07		525	31.59	
170	15.37	290	19.64		410	26.08		530	31.62	
175	15.39	295	19.66		415	26.10		535	31.66	
180	15.42	300	19.67		420	26.11		540	31.69	
190	15.47	310	19.70		430	26.14		550	31.75	
200	15.53	320	19.73		440	26.17		560	31.82	
210	15.58	330	19.75		450	26.21		570	31.88	
220	15.64	340	19.78		460	26.24		580	31.94	
240	15.74	360	19.84		480	26.30		600	32.07	

Step Draw Down Test SL-PW-07											
step 1 Q=25.22l/s		step 2 Q=33.85l/s			step 3 Q=42.7l/s			step 4 Q=50.49l/s			
Time, min	Drawdown(m)	T1=T+120	Drawdown(m)	water level	T2=T1+120	Drawdown(m)	water lavel	T3=T2+120	Drawdown(m)	water level
0	0	120	29.27	0	240	37.31	0	360	50.02	0
1	17.25	121	34.11	4.84	241	45.65	8.34	361	50.95	0.93
2	24.27	122	34.55	5.28	242	46.07	8.76	362	64.12	14.1
3	25.15	123	35.01	5.74	243	47.33	10.02	363	65.42	15.4
4	25.75	124	35.95	6.68	244	47.77	10.46	364	66.05	16.03
5	26.06	125	36.41	7.14	245	48.02	10.71	365	67.22	17.2
6	26.62	126	36.87	7.6	246	48.27	10.96	366	67.68	17.66
7	27.67	127	36.94	7.67	247	48.57	11.26	367	67.87	17.85
8	28.23	128	36.96	7.69	248	48.6	11.29	368	68.11	18.09
9	18.46	129	37.01	7.74	249	48.63	11.32	369	68.16	18.14
10	28.6	130	37.03	7.76	250	48.67	11.36	370	68.42	18.4
12	28.78	132	37.05	7.78	252	48.78	11.47	372	68.92	18.9
14	28.86	134	37.11	7.84	254	48.82	11.51	374	69.02	19
16	28.87	136	37.12	7.85	256	48.9	11.59	376	69.15	19.13
18	28.95	138	37.15	7.88	258	48.92	11.61	378	69.19	19.17
20	28.97	140	37.15	7.88	260	48.97	11.66	380	69.32	19.3
25	29.01	145	37.16	7.89	265	49.1	11.79	385	69.45	19.43
30	29.05	150	37.17	7.9	270	49.19	11.88	390	69.57	19.55
35	29.07	155	37.18	7.91	275	49.31	12	395	70.05	20.03
40	29.1	160	37.19	7.92	280	49.35	12.04	400	70.18	20.16
45	29.12	165	37.19	7.92	285	49.41	12.1	405	70.41	20.39
50	29.13	170	37.2	7.93	290	49.46	12.15	410	70.67	20.65
55	29.15	175	37.22	7.95	295	49.49	12.18	415	70.8	20.78
60	29.17	180	37.24	7.97	300	49.51	12.2	420	70.91	20.89
70	29.18	190	37.24	7.97	310	49.53	12.22	430	71.02	21
80	29.2	200	37.26	7.99	320	49.58	12.27	440	71.22	21.2
90	29.22	210	37.28	8.01	330	49.69	12.38	450	71.69	21.67
100	29.24	220	37.29	8.02	340	49.87	12.56	460	71.99	21.97
120	29.27	240	37.31	8.04	360	50.02	12.71	480	72.08	22.06

121	29.27	241	37.32		361	50.04		481	72.260	
122	29.28	242	37.32		362	50.06		482	72.261	
123	29.28	243	37.32		363	50.07		483	72.242	
124	29.28	244	37.32		364	50.07		484	72.240	
125	29.28	245	37.32		365	50.09		485	72.307	
126	29.28	246	37.32		366	50.09		486	72.284	
127	29.28	247	37.32		367	50.10		487	72.300	
128	29.29	248	37.32		368	50.11		488	72.322	
129	29.29	249	37.32		369	50.12		489	72.338	
130	29.29	250	37.32		370	50.13		490	72.340	
132	29.29	252	37.33		372	50.15		492	72.377	
134	29.30	254	37.33		374	50.17		494	72.405	
136	29.30	256	37.33		376	50.19		496	72.432	
138	29.30	258	37.33		378	50.21		498	72.461	
140	29.31	260	37.34		380	50.23		500	72.492	
145	29.31	265	37.34		385	50.28		505	72.561	
150	29.32	270	37.35		390	50.33		510	72.633	
155	29.33	275	37.35		395	50.38		515	72.705	
160	29.34	280	37.36		400	50.43		520	72.777	
165	29.35	285	37.36		405	50.48		525	72.848	
170	29.36	290	37.37		410	50.53		530	72.920	
175	29.36	295	37.37		415	50.58		535	72.991	
180	29.37	300	37.38		420	50.63		540	73.062	
190	29.39	310	37.39		430	50.73		550	73.205	
200	29.41	320	37.40		440	50.83		560	73.348	
210	29.42	330	37.41		450	50.93		570	73.491	
220	29.44	340	37.43		460	51.03		580	73.634	
240	29.47	360	37.45		480	51.23		600	73.920	

Step Draw Down Test SL-PW-08										
step 1 Q=50l/s		step 2 Q=66.2l/s			step 3 Q=80.50l/s			step 4 Q=94.37l/s		
Time, min	**water level**	**T1=T+120**	**Drawdown(m)**	**water level**	**T2=T1+120**	**Drawdown(m)**	**water level**	**T3=T2+120**	**Drawdown(m)**	**water level**
0	0	120	9.9	0	240	14.76	0	360	18.6	0
1	7.33	121	13.64	3.74	241	18.14	3.38	361	23.13	4.53
2	8.08	122	13.76	3.86	242	18.16	3.4	362	23.55	4.95
3	8.31	123	13.78	3.88	243	18.18	3.42	363	23.67	5.07
4	8.47	124	13.85	3.95	244	18.18	3.42	364	23.8	5.2
5	8.55	125	13.88	3.98	245	18.19	3.43	365	23.88	5.28
6	8.69	126	13.99	4.09	246	18.19	3.43	366	23.93	5.33
7	8.73	127	14.01	4.11	247	18.2	3.44	367	23.97	5.37
8	8.81	128	14.04	4.14	248	18.21	3.45	368	24.04	5.44
9	8.88	129	14.08	4.18	249	18.22	3.46	369	24.07	5.47
10	8.96	130	14.12	4.22	250	18.22	3.46	370	24.12	5.52
12	9.03	132	14.19	4.29	252	18.13	3.37	372	24.17	5.57
14	9.14	134	14.3	4.4	254	18.17	3.41	374	24.23	5.63
16	9.22	136	14.3	4.4	256	18.22	3.46	376	24.3	5.7
18	9.23	138	14.35	4.45	258	18.25	3.49	378	24.33	5.73
20	9.24	140	14.37	4.47	260	18.28	3.52	380	24.36	5.76
25	9.32	145	14.38	4.48	265	18.31	3.55	385	24.4	5.8
30	9.46	150	14.44	4.54	270	18.34	3.58	390	24.46	5.86
35	9.5	155	14.45	4.55	275	18.36	3.6	395	24.53	5.93
40	9.54	160	14.46	4.56	280	18.38	3.62	400	24.56	5.96
45	9.57	165	14.49	4.59	285	18.4	3.64	405	24.6	6
50	9.61	170	14.52	4.62	290	18.42	3.66	410	24.63	6.03
55	9.66	175	14.54	4.64	295	18.44	3.68	415	24.66	6.06
60	9.71	180	14.61	4.71	300	18.46	3.7	420	24.7	6.1
70	9.75	190	14.62	4.72	310	18.48	3.72	430	24.75	6.15
80	9.79	200	14.66	4.76	320	18.52	3.76	440	24.82	6.22
90	9.83	210	14.66	4.76	330	18.55	3.79	450	24.88	6.28
100	9.88	220	14.73	4.83	340	18.57	3.81	460	24.9	6.3
120	9.9	240	14.76	4.86	360	18.6	3.84	480	24.97	6.37
121	9.92	241	14.77		361	18.61		481	24.99	

122	9.92	242	14.77		362	18.61		482	24.98	
123	9.92	243	14.78		363	18.61		483	24.99	
124	9.92	244	14.77		364	18.61		484	24.99	
125	9.93	245	14.78		365	18.62		485	25.00	
126	9.93	246	14.78		366	18.62		486	25.00	
127	9.93	247	14.78		367	18.62		487	25.00	
128	9.93	248	14.79		368	18.62		488	25.01	
129	9.93	249	14.79		369	18.62		489	25.01	
130	9.93	250	14.79		370	18.62		490	25.01	
132	9.94	252	14.80		372	18.63		492	25.02	
134	9.94	254	14.80		374	18.63		494	25.03	
136	9.95	256	14.81		376	18.64		496	25.03	
138	9.95	258	14.81		378	18.64		498	25.04	
140	9.96	260	14.82		380	18.64		500	25.05	
145	9.97	265	14.83		385	18.65		505	25.07	
150	9.98	270	14.84		390	18.66		510	25.08	
155	9.99	275	14.86		395	18.67		515	25.10	
160	10.00	280	14.87		400	18.68		520	25.12	
165	10.01	285	14.88		405	18.69		525	25.14	
170	10.02	290	14.89		410	18.70		530	25.15	
175	10.03	295	14.91		415	18.71		535	25.17	
180	10.05	300	14.92		420	18.72		540	25.19	
190	10.07	310	14.94		430	18.73		550	25.22	
200	10.09	320	14.97		440	18.75		560	25.26	
210	10.11	330	15.00		450	18.77		570	25.29	
220	10.13	340	15.02		460	18.79		580	25.33	
240	10.18	360	15.07		480	18.82		600	25.40	

Step Draw Down Test SL-PW-14										
step 1 Q=55.5l/s		step 2 Q=65.5l/s			step 3 Q=75l/s			step 4 Q=85l/s		
Time, min	water level,m	T1=T+120	water level	Drawdown(m)	T2=T1+120	water level,m	Drawdown(m)	T3=T2+120	water level,m	Drawdown(m)
0	0	120	14.42	0	240	19.17	0	360	22.5	0
1	8.08	121	18.75	4.33	241	22.18	3.01	361	25.81	3.31
2	8.82	122	18.86	4.44	242	22.19	3.02	362	25.89	3.39
3	9.58	123	18.89	4.47	243	22.2	3.03	363	26	3.5
4	10.46	124	18.9	4.48	244	22.22	3.05	364	26.05	3.55
5	10.85	125	18.9	4.48	245	22.22	3.05	365	26.1	3.6
6	11.6	126	18.9	4.48	246	22.24	3.07	366	26.15	3.65
7	11.9	127	18.9	4.48	247	22.24	3.07	367	26.16	3.66
8	12.53	128	18.9	4.48	248	22.25	3.08	368	26.16	3.66
9	12.97	129	18.9	4.48	249	22.25	3.08	369	24.37	1.87
10	13.21	130	18.9	4.48	250	22.27	3.1	370	26.18	3.68
12	13.4	132	18.9	4.48	252	22.28	3.11	372	26.19	3.69
14	13.47	134	18.9	4.48	254	22.3	3.13	374	26.21	3.71
16	13.56	136	18.9	4.48	256	22.33	3.16	376	26.23	3.73
18	13.63	138	18.9	4.48	258	22.35	3.18	378	26.26	3.76
20	13.67	140	18.9	4.48	260	22.4	3.23	380	26.29	3.79
25	13.83	145	18.95	4.53	265	22.43	3.26	385	26.32	3.82
30	13.89	150	18.95	4.53	270	22.44	3.27	390	26.37	3.87
35	12.88	155	18.97	4.55	275	22.44	3.27	395	26.4	3.9
40	13.97	160	18.99	4.57	280	22.45	3.28	400	26.46	3.96
45	14.05	165	19.01	4.59	285	22.45	3.28	405	26.49	3.99
50	14.08	170	19.03	4.61	290	22.45	3.28	410	26.5	4
55	14.09	175	19.03	4.61	295	22.47	3.3	415	26.5	4
60	14.12	180	19.05	4.63	300	22.48	3.31	420	26.51	4.01
70	14.17	190	19.08	4.66	310	22.48	3.31	430	26.55	4.05
80	14.27	200	19.1	4.68	320	22.48	3.31	440	26.58	4.08
90	14.3	210	19.15	4.73	330	22.48	3.31	450	26.6	4.1
100	14.36	220	19.17	4.75	340	22.49	3.32	460	26.61	4.11
120	14.42	240	19.17	4.75	360	22.5	3.33	480	26.62	4.12

121	14.44	241	19.19		361	22.50		481	26.63	
122	14.44	242	19.19		362	22.50		482	26.63	
123	14.44	243	19.19		363	22.50		483	26.63	
124	14.45	244	19.19		364	22.50		484	26.63	
125	14.45	245	19.19		365	22.50		485	26.63	
126	14.45	246	19.19		366	22.50		486	26.63	
127	14.46	247	19.19		367	22.50		487	26.63	
128	14.46	248	19.19		368	22.50		488	26.63	
129	14.47	249	19.19		369	22.50		489	26.63	
130	14.47	250	19.19		370	22.50		490	26.63	
132	14.48	252	19.20		372	22.51		492	26.64	
134	14.48	254	19.20		374	22.51		494	26.64	
136	14.49	256	19.20		376	22.51		496	26.64	
138	14.50	258	19.20		378	22.51		498	26.64	
140	14.51	260	19.20		380	22.51		500	26.64	
145	14.53	265	19.21		385	22.51		505	26.65	
150	14.55	270	19.21		390	22.52		510	26.65	
155	14.56	275	19.22		395	22.52		515	26.65	
160	14.58	280	19.22		400	22.52		520	26.66	
165	14.60	285	19.23		405	22.52		525	26.66	
170	14.62	290	19.23		410	22.53		530	26.67	
175	14.64	295	19.24		415	22.53		535	26.67	
180	14.66	300	19.24		420	22.53		540	26.68	
190	14.70	310	19.25		430	22.54		550	26.68	
200	14.74	320	19.26		440	22.54		560	26.69	
210	14.77	330	19.27		450	22.55		570	26.70	
220	14.81	340	19.28		460	22.55		580	26.71	
240	14.89	360	19.30		480	22.56		600	26.72	

Step Draw Down Test SL-PW-17										
step 1 Q=19l/s		step 2 Q=24.68l/s			step 3 Q=29.55l/s			step 4 Q=34.55l/s		
Time, min	Drawdown(m)	T1=T+120	Drawdown(m)	water level(m)	T2=T1+120	Drawdown(m)	water level(m)	T3=T2+120	Drawdown(m)	water level(m)
0	0	120	12.62	0	240	16.4	0	360	27.63	0
1	2.05	121	14.8	2.18	241	21.72	5.32	361	30.4	2.77
2	6.51	122	15.21	2.59	242	22.01	5.61	362	32.71	5.08
3	9.3	123	15.45	2.83	243	22.52	6.12	363	34.02	6.39
4	10.1	124	15.55	2.93	244	22.72	6.32	364	34.47	6.84
5	10.9	125	15.61	2.99	245	24.35	7.95	365	35.13	7.5
6	10.9	126	15.66	3.04	246	24.59	8.19	366	35.85	8.22
7	10.93	127	15.73	3.11	247	24.93	8.53	367	36.31	8.68
8	11.02	128	15.78	3.16	248	25.15	8.75	368	36.51	8.88
9	11.06	129	15.81	3.19	249	25.32	8.92	369	36.67	9.04
10	11.17	130	15.87	3.25	250	25.4	9	370	36.84	9.21
12	11.24	132	15.91	3.29	252	25.57	9.17	372	37.04	9.41
14	11.35	134	15.87	3.25	254	25.62	9.22	374	37.19	9.56
16	11.42	136	15.87	3.25	256	25.75	9.35	376	37.3	9.67
18	11.48	138	15.92	3.3	258	25.88	9.48	378	37.44	9.81
20	11.58	140	15.94	3.32	260	25.99	9.59	380	37.57	9.94
25	11.68	145	16.06	3.44	265	26.19	9.79	385	37.77	10.14
30	11.82	150	16.12	3.5	270	26.37	9.97	390	37.81	10.18
35	11.97	155	16.17	3.55	275	26.58	10.18	395	38.15	10.52
40	12.1	160	16.17	3.55	280	26.7	10.3	400	38.4	10.77
45	12.12	165	16.19	3.57	285	26.8	10.4	405	38.62	10.99
50	12.18	170	16.14	3.52	290	26.92	10.52	410	38.72	11.09
55	12.34	175	16.14	3.52	295	26.95	10.55	415	38.84	11.21
60	12.4	180	16.07	3.45	300	27.01	10.61	420	39.06	11.43
70	12.62	190	16.18	3.56	310	27.15	10.75	430	39.31	11.68
80	12.74	200	16.22	3.6	320	27.27	10.87	440	39.5	11.87
90	12.59	210	16.25	3.63	330	27.38	10.98	450	39.87	12.24
100	12.6	220	16.34	3.72	340	27.5	11.1	460	39.88	12.25

120	12.62	240	16.4	3.78	360	27.63	11.23	480	40.12	12.49
121	12.60	241	16.41		361	27.67		481	40.20	
122	12.59	242	16.42		362	27.67		482	40.20	
123	12.61	243	16.42		363	27.68		483	40.19	
124	12.61	244	16.42		364	27.68		484	40.21	
125	12.60	245	16.43		365	27.70		485	40.24	
126	12.60	246	16.43		366	27.70		486	40.23	
127	12.60	247	16.44		367	27.71		487	40.25	
128	12.60	248	16.44		368	27.72		488	40.27	
129	12.60	249	16.45		369	27.73		489	40.28	
130	12.60	250	16.45		370	27.73		490	40.29	
132	12.60	252	16.46		372	27.75		492	40.31	
134	12.60	254	16.47		374	27.77		494	40.34	
136	12.60	256	16.48		376	27.78		496	40.36	
138	12.60	258	16.48		378	27.80		498	40.39	
140	12.60	260	16.49		380	27.82		500	40.41	
145	12.60	265	16.51		385	27.86		505	40.47	
150	12.60	270	16.54		390	27.90		510	40.53	
155	12.59	275	16.56		395	27.94		515	40.60	
160	12.59	280	16.58		400	27.98		520	40.66	
165	12.59	285	16.60		405	28.02		525	40.72	
170	12.59	290	16.62		410	28.06		530	40.78	
175	12.59	295	16.64		415	28.10		535	40.84	
180	12.59	300	16.66		420	28.14		540	40.91	
190	12.59	310	16.71		430	28.23		550	41.03	
200	12.58	320	16.75		440	28.31		560	41.15	
210	12.58	330	16.79		450	28.39		570	41.28	
220	12.58	340	16.83		460	28.47		580	41.40	
240	12.57	360	16.92		480	28.64		600	41.65	

Step Draw Down Test SL-PW-19										
step 1 Q=15.32l/s		step 2 Q=20.07l/s			step 3 Q=25.30l/s			step 4 Q=27l/s		
Time(min)	Drawdown (m)	T1=T+120	Drawdown (m)	water level	T2=T1+120	Drawdown (m)	water level	T3=T2+120	Drawdown (m)	water level
0	0	120	13.16	0	240	23.93	0	360	30.56	0
1	0.69	121	13.49	0.33	241	25.34	1.41	361	33.35	2.79
2	4.54	122	14.42	1.26	242	25.49	1.56	362	33.86	3.3
3	6.14	123	15.12	1.96	243	25.61	1.68	363	34.24	3.68
4	6.39	124	15.34	2.18	244	25.74	1.81	364	34.51	3.95
5	6.6	125	15.45	2.29	245	25.89	1.96	365	34.75	4.19
6	6.87	126	15.56	2.4	246	26	2.07	366	34.97	4.41
7	6.99	127	16.64	3.48	247	26.09	2.16	367	35.19	4.63
8	7.15	128	17.05	3.89	248	26.16	2.23	368	35.39	4.83
9	7.39	129	17.34	4.18	249	26.28	2.35	369	35.6	5.04
10	7.55	130	17.43	4.27	250	26.43	2.5	370	35.72	5.16
12	7.74	132	17.84	4.68	252	26.64	2.71	372	36.11	5.55
14	7.98	134	18.21	5.05	254	26.75	2.82	374	36.39	5.83
16	8.25	136	18.52	5.36	256	26.92	2.99	376	36.76	6.2
18	8.61	138	18.76	5.6	258	27.04	3.11	378	37.04	6.48
20	8.85	140	19.11	5.95	260	27.23	3.3	380	37.31	6.75
25	9.46	145	19.62	6.46	265	27.52	3.59	385	38.06	7.5
30	10.05	150	20.16	7	270	27.75	3.82	390	38.5	7.94
35	10.45	155	20.52	7.36	275	27.99	4.06	395	39.04	8.48
40	10.89	160	20.79	7.63	280	28.23	4.3	400	39.52	8.96
45	11.27	165	21.32	8.16	285	28.36	4.43	405	39.91	9.35
50	11.58	170	21.76	8.6	290	28.55	4.62	410	40.23	9.67
55	11.86	175	21.96	8.8	295	28.89	4.96	415	40.59	10.03
60	12.05	180	22.04	8.88	300	29.08	5.15	420	40.91	10.35
70	12.48	190	22.32	9.16	310	29.32	5.39	430	41.53	10.97
80	12.64	200	22.88	9.72	320	29.69	5.76	440	42.22	11.66
90	12.85	210	23.24	10.08	330	30	6.07	450	42.56	12
100	13.02	220	23.54	10.38	340	30.22	6.29	460	42.91	12.35
120	13.16	240	23.93	10.77	360	30.56	6.63	480	43.52	12.96
121	13.24	241	24.09		361	30.67		481	43.65	

122	13.24	242	24.07		362	30.66		482	43.64	
123	13.24	243	24.08		363	30.67		483	43.67	
124	13.24	244	24.10		364	30.69		484	43.71	
125	13.27	245	24.16		365	30.73		485	43.76	
126	13.27	246	24.15		366	30.73		486	43.77	
127	13.28	247	24.19		367	30.75		487	43.81	
128	13.29	248	24.21		368	30.78		488	43.84	
129	13.31	249	24.24		369	30.80		489	43.87	
130	13.31	250	24.25		370	30.81		490	43.90	
132	13.34	252	24.31		372	30.86		492	43.97	
134	13.36	254	24.36		374	30.89		494	44.04	
136	13.38	256	24.40		376	30.93		496	44.10	
138	13.40	258	24.45		378	30.97		498	44.17	
140	13.42	260	24.50		380	31.01		500	44.23	
145	13.47	265	24.62		385	31.11		505	44.40	
150	13.53	270	24.74		390	31.21		510	44.56	
155	13.58	275	24.86		395	31.31		515	44.73	
160	13.63	280	24.99		400	31.41		520	44.89	
165	13.69	285	25.11		405	31.51		525	45.05	
170	13.74	290	25.23		410	31.61		530	45.22	
175	13.79	295	25.35		415	31.71		535	45.38	
180	13.85	300	25.47		420	31.81		540	45.55	
190	13.95	310	25.71		430	32.01		550	45.87	
200	14.06	320	25.96		440	32.21		560	46.20	
210	14.17	330	26.20		450	32.41		570	46.53	
220	14.27	340	26.44		460	32.61		580	46.86	
240	14.49	360	26.93		480	33.01		600	47.51	

Step Draw Down Test SL-PW-21										
step 1 Q=58l/s		step 2 Q=69l/s			step 3 Q=80l/s			step 4 Q=91l/s		
Time, min	**water level**	**T1=T+120**	**Drawdown(m)**	**water level**	**T2=T1+120**	**Drawdown(m)**	**water level**	**T3=T2+120**	**Drawdown (m)**	**water level**
0	0	120	4.27	0	240	5.78	0	360	8.25	0
1	1	121	4.6	0.33	241	7.5	1.72	361	8.4	0.15
2	2.4	122	5.46	1.19	242	7.7	1.92	362	8.7	0.45
3	4.15	123	5.52	1.25	243	7.73	1.95	363	9.1	0.85
4	4.16	124	5.57	1.3	244	7.79	2.01	364	9.14	0.89
5	4.17	125	5.6	1.33	245	7.82	2.04	365	9.19	0.94
6	4.2	126	5.61	1.34	246	7.84	2.06	366	9.2	0.95
7	4.21	127	5.63	1.36	247	7.86	2.08	367	9.21	0.96
8	4.21	128	5.64	1.37	248	7.88	2.1	368	9.22	0.97
9	4.23	129	5.66	1.39	249	7.91	2.13	369	9.23	0.98
10	4.25	130	5.66	1.39	250	7.92	2.14	370	9.25	1
12	4.27	132	5.66	1.39	252	7.93	2.15	372	9.27	1.02
14	4.29	134	5.67	1.4	254	7.95	2.17	374	9.29	1.04
16	4.3	136	5.68	1.41	256	7.97	2.19	376	9.31	1.06
18	4.3	138	5.69	1.42	258	8	2.22	378	9.32	1.07
20	4.32	140	5.7	1.43	260	8.02	2.24	380	9.34	1.09
25	4.36	145	5.71	1.44	265	8.05	2.27	385	9.34	1.09
30	4.37	150	5.72	1.45	270	8.07	2.29	390	9.34	1.09
35	4.37	155	5.73	1.46	275	8.1	2.32	395	9.35	1.1
40	4.37	160	5.75	1.48	280	8.12	2.34	400	9.37	1.12

45	4.37	165	5.75	1.4 8	285	8.14	2.36	405	9.39	1.14
50	4.37	170	5.75	1.4 8	290	8.15	2.37	410	9.4	1.15
55	4.37	175	5.75	1.4 8	295	8.16	2.38	415	9.42	1.17
60	4.38	180	5.75	1.4 8	300	8.18	2.4	420	9.44	1.19
70	4.25	190	5.75	1.4 8	310	8.19	2.41	430	9.46	1.21
80	4.27	200	5.75	1.4 8	320	8.21	2.43	440	9.47	1.22
90	4.27	210	5.76	1.4 9	330	8.22	2.44	450	9.47	1.22
100	4.27	220	5.76	1.4 9	340	8.23	2.45	460	9.48	1.23
120	4.27	240	5.78	1.5 1	360	8.25	2.47	480	9.4	1.15
121	4.2 7	241	5.78		361	8.25		481	9.42	
122	4.2 7	242	5.78		362	8.25		482	9.42	
123	4.2 7	243	5.78		363	8.25		483	9.41	
124	4.2 7	244	5.78		364	8.26		484	9.41	
125	4.2 7	245	5.78		365	8.26		485	9.41	
126	4.2 7	246	5.78		366	8.26		486	9.40	
127	4.2 7	247	5.78		367	8.26		487	9.40	
128	4.2 7	248	5.78		368	8.26		488	9.40	
129	4.2 7	249	5.78		369	8.26		489	9.40	
130	4.2 7	250	5.79		370	8.26		490	9.39	
132	4.2 7	252	5.79		372	8.26		492	9.39	

134	4.27	254	5.79		374	8.27		494	9.38	
136	4.27	256	5.79		376	8.27		496	9.38	
138	4.27	258	5.79		378	8.27		498	9.37	
140	4.27	260	5.79		380	8.27		500	9.37	
145	4.27	265	5.80		385	8.28		505	9.36	
150	4.27	270	5.80		390	8.28		510	9.35	
155	4.27	275	5.80		395	8.29		515	9.33	
160	4.27	280	5.81		400	8.29		520	9.32	
165	4.27	285	5.81		405	8.30		525	9.31	
170	4.28	290	5.82		410	8.30		530	9.30	
175	4.28	295	5.82		415	8.31		535	9.28	
180	4.28	300	5.82		420	8.31		540	9.27	
190	4.28	310	5.83		430	8.32		550	9.25	
200	4.28	320	5.84		440	8.33		560	9.22	
210	4.28	330	5.85		450	8.34		570	9.20	
220	4.28	340	5.85		460	8.35		580	9.17	
240	4.28	360	5.87		480	8.37		600	9.12	

Step Draw Down Test SL-PW-22										
step 1 Q=45/s		step 2 Q=53l/s			step 3 Q=61l/s			step 4 Q=72l/s		
Time, min	**Drawdown(m)**	**T1=T+120**	**Drawdown (m)**	**water level**	**T2=T1+120**	**Drawdown (m)**	**water level**	**T3=T2+120**	**Drawdown (m)**	**water level**
0	0	120	19.98	0	240	22.8	0	360	30.02	0
1	11.78	121	21.48	1.5	241	26.78	3.98	361	36.27	6.25
2	14.4	122	21.55	1.57	242	27.09	4.29	362	37.83	7.81
3	15.5	123	21.59	1.61	243	27.3	4.5	363	38.6	8.58
4	16.73	124	21.66	1.68	244	27.43	4.63	364	39.07	9.05
5	16.9	125	21.71	1.73	245	27.56	4.76	365	39.38	9.36
6	17.28	126	21.77	1.79	246	27.64	4.84	366	39.74	9.72
7	17.38	127	21.86	1.88	247	27.7	4.9	367	40.07	10.05
8	17.4	128	21.89	1.91	248	27.77	4.97	368	40.31	10.29
9	17.45	129	21.92	1.94	249	27.82	5.02	369	40.49	10.47
10	17.75	130	21.96	1.98	250	27.9	5.1	370	40.62	10.6
12	17.9	132	22.01	2.03	252	27.98	5.18	372	40.85	10.83
14	18.11	134	22.08	2.1	254	28.1	5.3	374	40.98	10.96
16	18.21	136	22.11	2.13	256	28.6	5.8	376	41.1	11.08
18	18.29	138	22.15	2.17	258	28.98	6.18	378	41.17	11.15
20	18.45	140	22.2	2.22	260	29.4	6.6	380	41.25	11.23
25	18.71	145	22.25	2.27	265	29.59	6.79	385	41.32	11.3
30	19	150	22.29	2.31	270	29.67	6.87	390	41.45	11.43
35	19.05	155	22.32	2.34	275	29.75	6.95	395	41.75	11.73
40	19.1	160	22.37	2.39	280	29.86	7.06	400	41.8	11.78
45	19.12	165	22.43	2.45	285	29.88	7.08	405	41.82	11.8
50	19.25	170	22.48	2.5	290	29.91	7.11	410	41.83	11.81
55	19.38	175	22.5	2.52	295	29.93	7.13	415	41.85	11.83
60	19.44	180	22.52	2.54	300	29.94	7.14	420	41.88	11.86
70	19.62	190	22.54	2.56	310	29.95	7.15	430	41.98	11.96
80	19.78	200	22.58	2.6	320	29.96	7.16	440	42.05	12.03
90	19.85	210	22.62	2.64	330	29.98	7.18	450	42.17	12.15
100	19.94	220	22.74	2.76	340	30	7.2	460	42.23	12.21
120	19.98	240	22.8	2.82	360	30.02	7.22	480	42.25	12.23
121	20.04	241	22.82		361	30.02		481	42.30	

122	20.02	242	22.82		362	30.03		482	42.30	
123	20.03	243	22.83		363	30.03		483	42.29	
124	20.03	244	22.83		364	30.03		484	42.29	
125	20.04	245	22.84		365	30.03		485	42.31	
126	20.04	246	22.84		366	30.03		486	42.30	
127	20.04	247	22.85		367	30.03		487	42.30	
128	20.05	248	22.85		368	30.03		488	42.31	
129	20.05	249	22.86		369	30.03		489	42.31	
130	20.05	250	22.86		370	30.04		490	42.31	
132	20.07	252	22.87		372	30.04		492	42.32	
134	20.07	254	22.88		374	30.04		494	42.33	
136	20.08	256	22.89		376	30.04		496	42.33	
138	20.09	258	22.90		378	30.05		498	42.34	
140	20.10	260	22.91		380	30.05		500	42.35	
145	20.12	265	22.94		385	30.06		505	42.36	
150	20.14	270	22.96		390	30.06		510	42.38	
155	20.16	275	22.99		395	30.07		515	42.40	
160	20.19	280	23.01		400	30.08		520	42.41	
165	20.21	285	23.04		405	30.08		525	42.43	
170	20.23	290	23.06		410	30.09		530	42.45	
175	20.25	295	23.09		415	30.09		535	42.46	
180	20.27	300	23.11		420	30.10		540	42.48	
190	20.31	310	23.16		430	30.11		550	42.51	
200	20.36	320	23.21		440	30.13		560	42.54	
210	20.40	330	23.26		450	30.14		570	42.58	
220	20.44	340	23.31		460	30.15		580	42.61	
240	20.53	360	23.41		480	30.18		600	42.67	

APPINDIX-02 Casing Arrangement

SL-PW-11

from(m)	to(m)	Length(m) (B)	blinded length(m)	screen length(m) (L)	2l/r	L/B	[7COS(3.1L/2B)]	SQRT(R/2L)	Mult Col (H*I)	F
0.55	104.75	105.3	105.3	0						
105	116.45	11.7	0	11.7	184.252	0.1	6.913905563	0.07367055	0.509351248	0.15094
116	122.3	5.85	5.85	0	0					
122	139.85	17.55	0	17.55	276.378	0.75	2.682646026	0.06015175	0.161365866	0.87102
140	145.75	5.9	5.85	0	0					
146	151.55	5.85	0	5.85	92.126	0.5	4.951717884	0.1041859	0.515899163	0.75795
152	157.4	5.85	5.85	0	0					
157	169.1	11.7	0	11.7	184.252	0.667	3.503217823	0.07367055	0.258083995	0.83872
169	180.8	11.7	11.7	0	0					
181	192.5	11.7	0	11.7	184.252	0.5	4.951717884	0.07367055	0.364795796	0.6824
193	204.2	11.7	11.7	0	0					
204	215.9	11.7	0	11.7	184.252	0.5	4.951717884	0.07367055	0.364795796	0.6824

216	227.6	11.7	11.7	0	0					
228	245.15	17.55	0	17.55	276.378	0.6	4.117202112	0.06015175	0.247656932	0.74859
245	251	5.85	5.85	0	0					
									art	0.676
									geo	0.60343

SL-PW-12

from(m)	to(m)	Length(m) (B)	blined length(m)	screen length(m) (L)	2I/r	L/B	[7COS(3.1L/2B)]	SQRT(R/2L)	Mult Col (H*I)	F
(+)0.55	98.9	99.45	99.45	0						
98.9	116.45	17.55	0	17.55	276.378	1	6.806784588	0.060151755	0.409440038	1.40944
116.45	134	17.55	17.55	0						
134	151.55	17.55	0	17.55	276.378	0.5	4.951717884	0.060151755	0.297854521	0.648927
151.55	163.24	11.69	11.69	0						
163.24	174.95	11.71	0	11.71	184.4094	0.5004	4.948397108	0.07363909	0.364395462	0.682781
174.95	192.5	17.55	17.55	0						
192.5	204.2	11.7	0	11.7	184.252	0.4	5.664429267	0.073670553	0.417301638	0.566921
204.2	210.05	5.85	5.85	0						
210.05	221.75	11.7	0	11.7	184.252	0.6667	3.503217823	0.073670553	0.258083995	0.838723

221.75	233.45	11.7	11.7	0						
233.45	245.15	11.7	0	11.7	184.252	0.5	4.951717884	0.073670553	0.364795796	0.682398
245.15	251	5.85	11.7	0						
251	253	2	0	2	31.49606	0.146	6.816943901	0.178185297	1.214679172	0.323311
253	315	62	62	0						
315	320	5	0	5	78.74016	0.0746	6.95200888	0.112694277	0.783451612	0.133093
									art	0.6606
									geo	0.55279

SL-PW-24

from(m)	to(m)	Length(m) (B)	blined length(m)	screen length(m) (L)	2I/r	L/B	[7COS(3.1L/2B)]	SQRT(R/2L)	Mult Col (H*I)	F
(+)1	120.8	121.8	122.8	0						
120.8	138.35	17.55	0	17.55	276.378	1	6.865537419	0.06015175	0.412974124	1.412974
138.35	150.05	11.7	11.7	0						
150.05	167.6	17.55	0	17.55	276.378	0.6	4.117202112	0.06015175	0.247656932	0.748594
167.6	173.45	5.85	5.85	0						
173.45	191	17.55	0	17.55	276.378	0.75	2.682646026	0.06015175	0.161365866	0.871024
191	196.85	5.85	5.85	0						
196.85	214.4	17.55	0	11.7	184.252	0.666667	3.503217823	0.07367055	0.258083995	0.838723

214.4	220.25	5.85	5.85	0						
220.25	231.95	11.7	0	11.7	184.252	0.666667	3.503217823	0.07367055	0.258083995	0.838723
231.95	243.65	11.7	11.7	0						
243.65	261.2	17.55	0	17.55	276.378	0.6	4.117202112	0.06015175	0.247656932	0.748594
261.2	267.05	5.85	11.7	0						
267.05	284.6	17.55	0	17.55	276.378	0.6	4.117202112	0.06015175	0.247656932	0.748594
284.6	296.3	11.7	11.7	0						
296.3	313.85	17.55	0	17.55	276.378	0.6	4.117202112	0.06015175	0.247656932	0.748594
313.85	325.55	11.7	11.7	0						
325.55	343.1	17.55	0	17.55	276.378	0.6	4.117202112	0.06015175	0.247656932	0.748594
343.1	348.95	5.85	5.85	0						
									art	0.856
									geo	0.837879

SL-PW-25

from(m)	to(m)	Length(m) (B)	blinded length(m)	screen length(m) (L)	2I/r	L/B	[7COS(3.1L/2B)]	SQRT(R/2L)	Mult Col (H*I)	F
0.5	112.75	113.75	113.75	0						
112.75	130.3	17.55	0	17.55	276.378	1	6.846433043	0.06015175	0.411824962	1.411825
130.3	142	11.7	11.7	0						
142	159.55	17.55	0	17.55	276.378	0.6	4.117202112	0.06015175	0.247656932	0.748594
159.55	171.25	11.7	11.7	0						
171.25	188.8	17.55	0	17.55	276.378	0.6	4.117202112	0.06015175	0.247656932	0.748594
188.8	200.5	11.7	11.7	0						
200.5	212.2	11.7	0	11.7	184.252	0.5	4.951717884	0.07367055	0.364795796	0.682398
212.2	223.9	11.7	11.7	0						
223.9	241.45	17.55	0	17.55	276.378	0.6	4.117202112	0.06015175	0.247656932	0.748594
241.45	247.3	5.85	5.85	0						
					2I/r	L/B	[7COS(3.1L/2B)]	SQRT(R/2L)		
247.3	259	11.7	11.7	0						
259	264.85	5.85	0	5.85	92.126	1	6.063106661	0.1041859	0.631690198	1.63169

264.85	276.55	11.7	11.7	0						
276.55	288.25	11.7	0	11.7	184.252	0.5	4.951717884	0.07367055	0.364795796	0.682398
288.25	311.65	23.4	23.4	0						
311.65	323.35	11.7	0	11.7	184.252	0.33333	6.063106661	0.07367055	0.446672423	0.482224
323.35	340.9	17.55	17.55	0						
340.9	352.6	11.7	0	11.7	184.252	0.4	5.664429267	0.07367055	0.417301638	0.566921
352.6	364.3	11.7	11.7	0						
364.3	370.15	5.85	0	5.85	92.126	0.33333	6.063106661	0.1041859	0.631690198	0.543897
370.15	387.7	17.55	17.55	0						
387.7	399.4	11.7	0	11.7	184.252	0.4	5.664429267	0.07367055	0.417301638	0.566921
399.4	416.95	17.55	17.55	0						
416.95	422.8	5.85	0	5.85	92.126	0.25	6.467689896	0.1041859	0.673842065	0.418461
422.8	434.5	11.7	11.7	0						
434.5	440.35	5.85	0	5.85	92.126	0.33333	6.063106661	0.1041859	0.631690198	0.543897
440.35	457.9	17.55	17.55	0						
457.9	469.6	11.7	0	11.7	184.252	0.4	5.664429267	0.07367055	0.417301638	0.566921
469.6	487.15	17.55	17.55	0						
487.15	498.85	11.7	0	11.7	184.252	0.4	5.664429267	0.07367055	0.417301638	0.566921

498.85	516.4	17.55	17.55	0						
516.4	522.25	5.85	0	5.85	92.126	0.25	6.467689896	0.1041859	0.673842065	0.418461
522.25	533.95	11.7	11.7	0						
533.95	539.8	5.85	0	5.85	92.126	0.33333	6.063106661	0.1041859	0.631690198	0.543897
539.8	551.5	11.7	11.7	0						
									art	0.698
									geo	0.648321

SL-PW-30

from(m)	to(m)	Length(m) (B)	blined length(m)	screen length(m) (L)	2l/r	L/B	[7COS(3.1L/2B)]	SQRT(R/2L)	Mult Col (H*I)	F
0.35	110.8	111.15	111.15	0						
110.8	122.5	11.7	0	11.7	184.252	0.09523 8	6.921894888	0.07367055	0.509939826	0.143804
122.5	140.05	17.55	17.55	0	0					
140.05	157.6	17.55	0	17.55	276.378	0.5	4.951717884	0.06015175	0.297854521	0.648927
157.6	169.3	11.7	11.7	0	0					
169.3	186.85	17.55	0	17.55	276.378	0.6	4.117202112	0.06015175	0.247656932	0.748594
186.85	198.55	11.7	11.7	0	0					

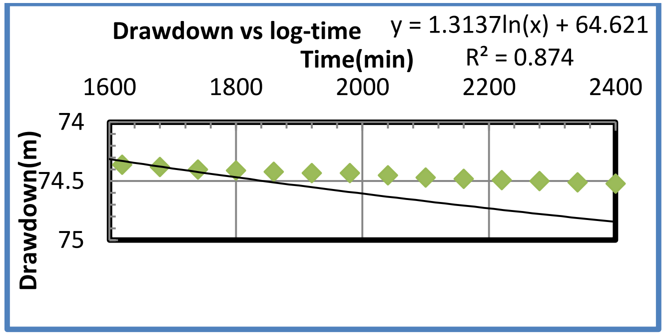
198.55	216.1	17.55	0	11.7	184.252	0.5	4.951717884	0.07367055	0.364795796	0.682398
216.1	227.8	11.7	11.7	0	0					
227.8	239.5	11.7	0	11.7	184.252	0.5	4.951717884	0.07367055	0.364795796	0.682398
239.5	245.35	5.85	5.85	0	0					
245.35	257.05	11.7	11.7	0						
257.05	262.9	5.85	0	5.85	92.1259 8	0.33333 3	6.063106661	0.1041859	0.631690198	0.543897
262.9	280.45	17.55	17.55	0						
280.45	292.15	11.7	0	11.7	184.252	0.4	5.664429267	0.07367055	0.417301638	0.566921
292.15	309.7	17.55	17.55	0						
309.7	321.4	11.7	0	11.7	184.252	0.4	5.664429267	0.07367055	0.417301638	0.566921
321.4	338.95	17.55	17.55	0						
338.95	344.8	5.85	0	5.85	92.1259 8	0.25	6.467689896	0.1041859	0.673842065	0.418461
344.8	362.35	17.55	17.55	0						
362.35	374.05	11.7	0	11.7	184.252	0.4	5.664429267	0.07367055	0.417301638	0.566921
374.05	391.6	17.55	17.55	0						
391.6	403.3	11.7	0	11.7	184.252	0.4	5.664429267	0.07367055	0.417301638	0.566921
403.3	420.85	17.55	17.55	0						
420.85	432.55	11.7	0	11.7	184.252	0.4	5.664429267	0.07367055	0.417301638	0.566921
432.55	444.25	11.7	11.7	0						

444.25	455.95	11.7	0	11.7	184.252	0.5	4.951717884	0.07367055	0.364795796	0.682398
455.95	473.5	17.55	17.55	0						
473.5	479.35	5.85	0	5.85	92.1259 8	0.25	6.467689896	0.1041859	0.673842065	0.418461
479.35	491.05	11.7	11.7	0						
491.05	502.75	11.7	0	11.7	184.252	0.5	4.951717884	0.07367055	0.364795796	0.682398
502.75	514.45	11.7	11.7	0						
514.45	520.3	5.85	0	5.85	92.1259 8	0.33333 3	6.063106661	0.1041859	0.631690198	0.543897
520.3	532	11.7	11.7	0						
									art	0.564
									geo	0.535667

APPINDIX-03 Best Fit line for Cooper-Jacob method

a) Observed Drawdown

b) Corrected Drawdown



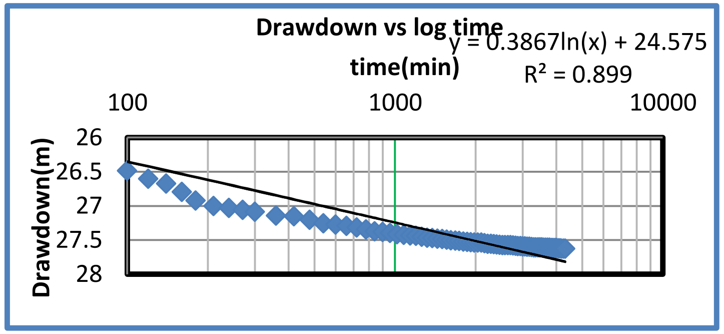
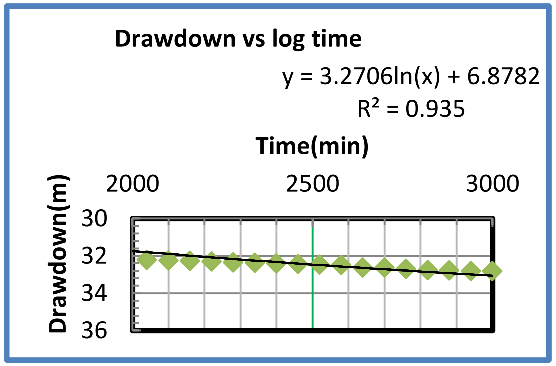


Figure 21 A- Best fit line for (a & b) For SL-PW-03

C) Observed Drawdown

d) Corrected Drawdown



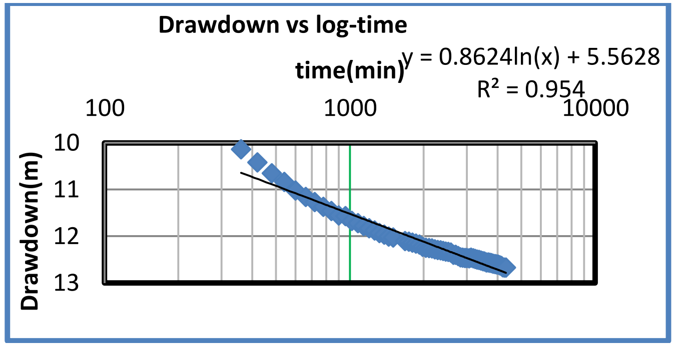
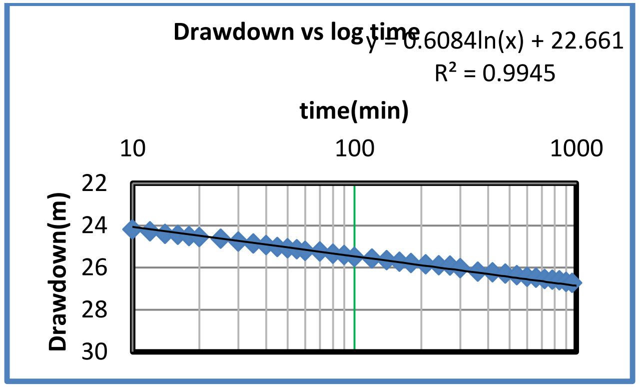


Figure 22 A-Best fit line (c & d) for SL-PW-04

e) Observed Drawdown



f) Corrected Drawdown

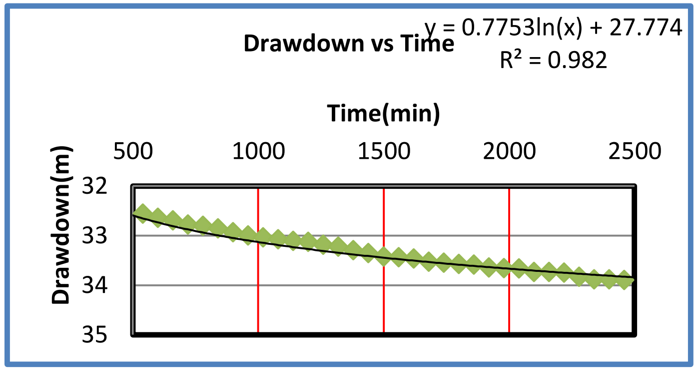
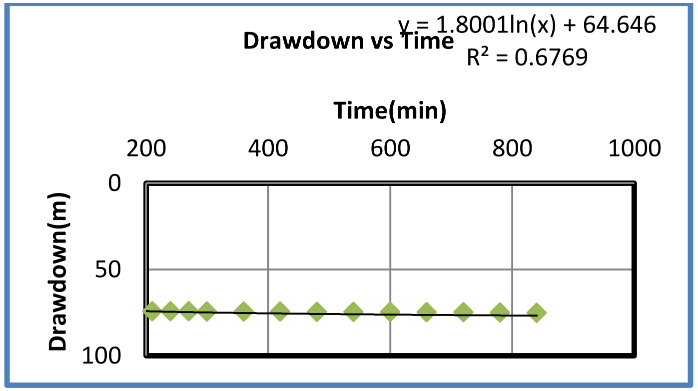


Figure 23 A-Best fit line (e & f) for SL-PW-06

g) Observed Drawdown



h) Corrected Drawdown

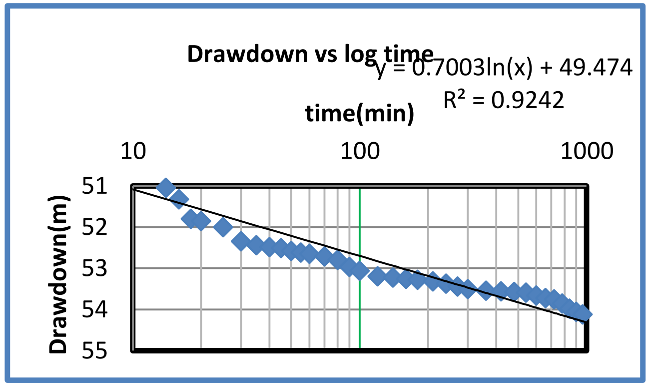
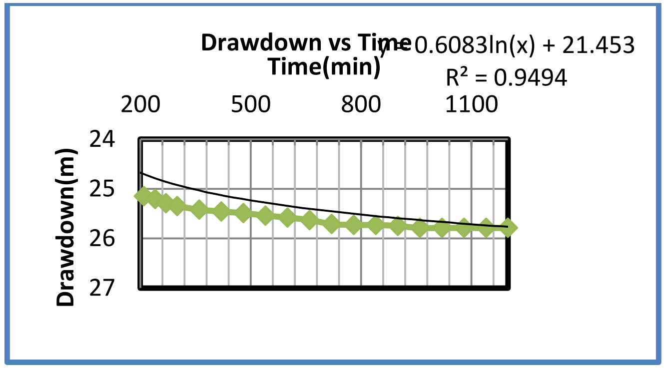


Figure 24 A-Best fit line (g & h) for SL-PW-07

i) Observed Drawdown

j) Corrected Drawdown



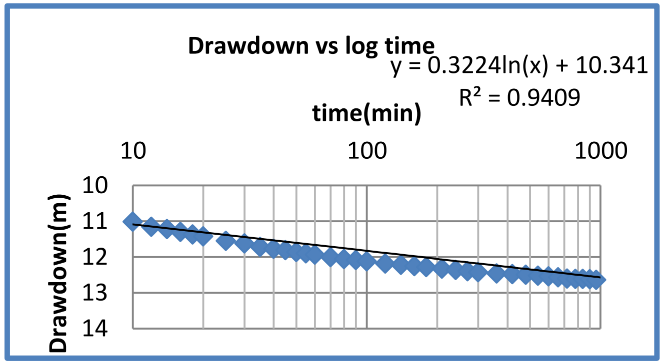
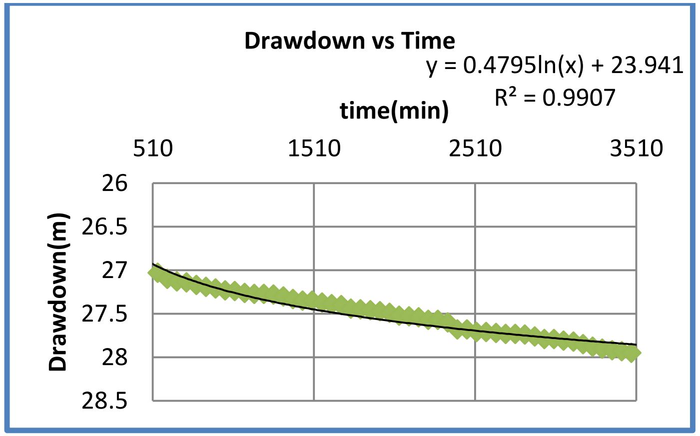


Figure 25 A-Best fit line (i & j) for SL-PW-08

K) Observed Drawdown

l) Corrected Drawdown



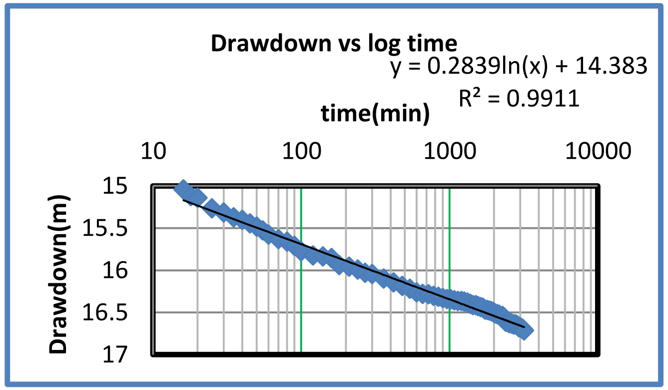
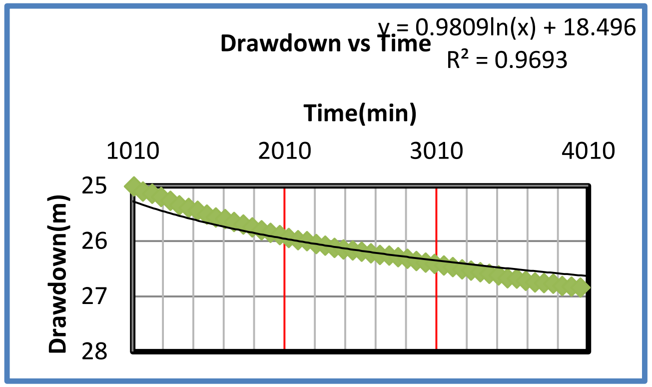


Figure 26 A-Best fit line (k & l) for SL-PW-14

m) Observed Drawdown



n) Corrected Drawdown

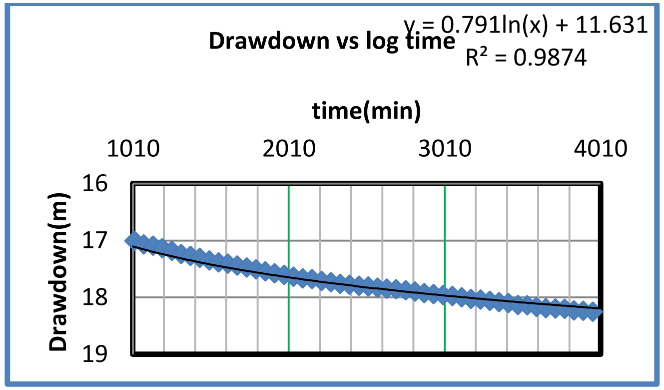
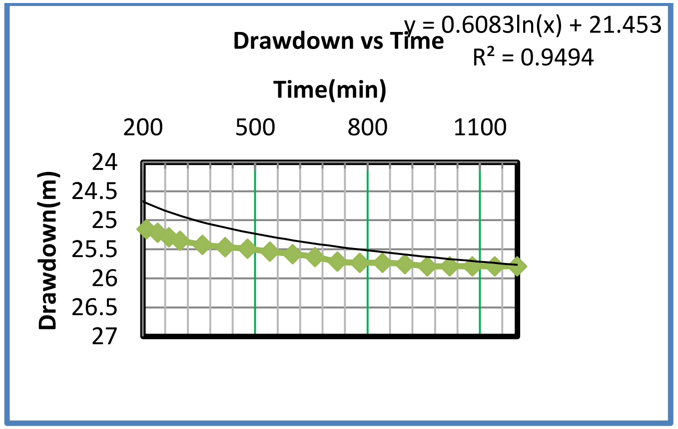


Figure 27 A Best fit lines (m & n) for SL-PW-16

o) Observed Drawdown



p) Corrected Drawdown

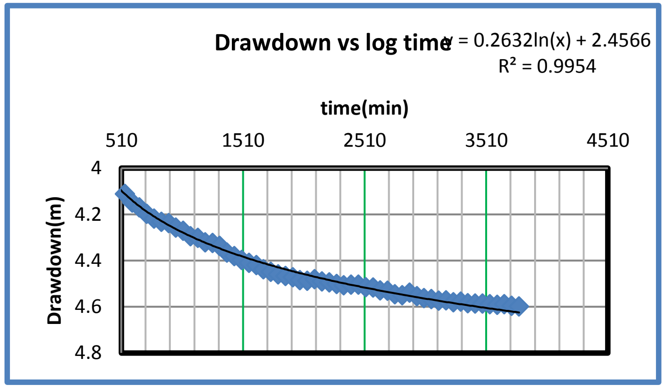
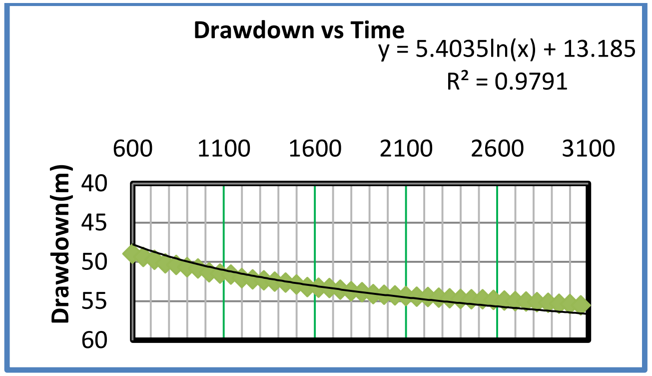


Figure 28 A-Best fit line (o & p) for SL-PW-17

q) Observed Drawdown



r) Corrected Drawdown

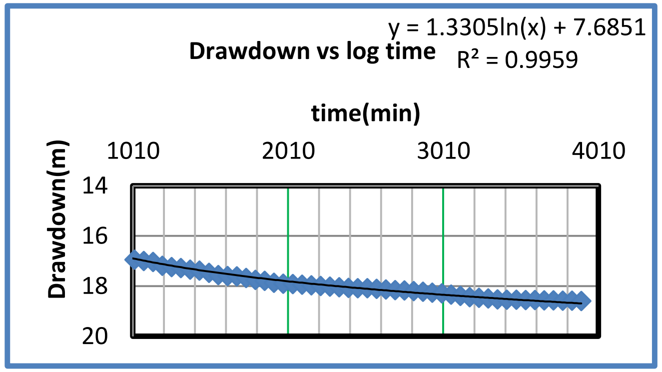
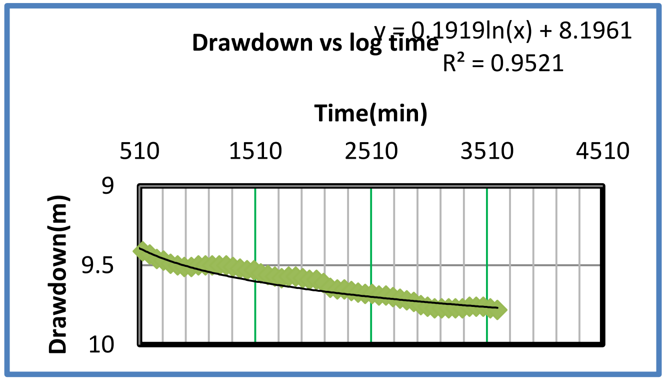


Figure 29 A-Best fit line (q & r) for SL-PW-19

s) Observed Drawdown



t) Corrected Drawdown

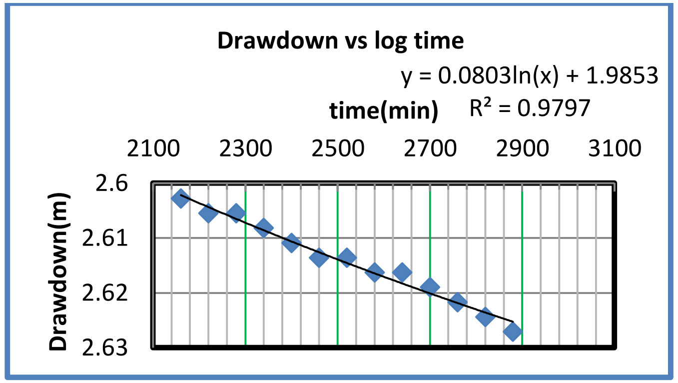
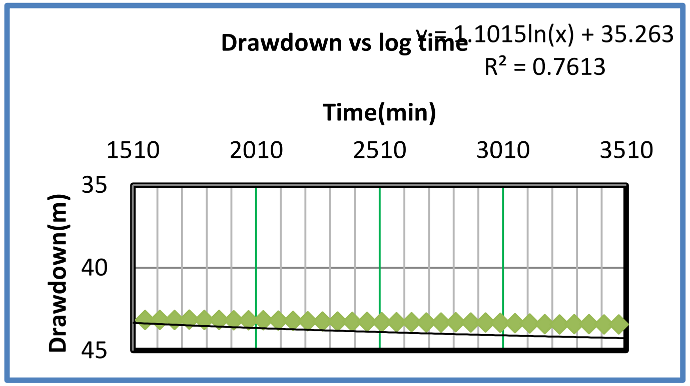


Figure 30 A- Best fit line (s & t) for SL-PW-21

u) Observed Drawdown



v) Corrected Drawdown

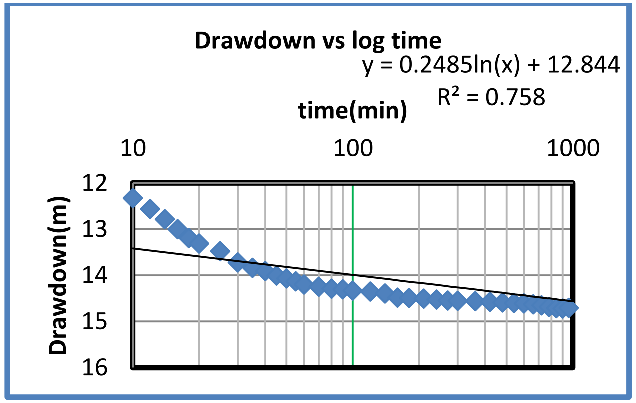
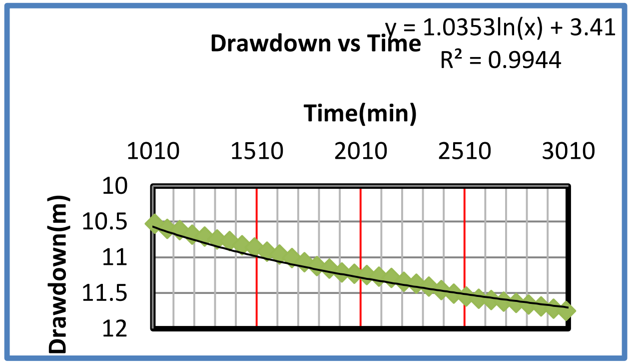


Figure 31 A-Best fit line (u & v) for SL-PW-22

w) Observed Drawdown



x) Corrected Drawdown

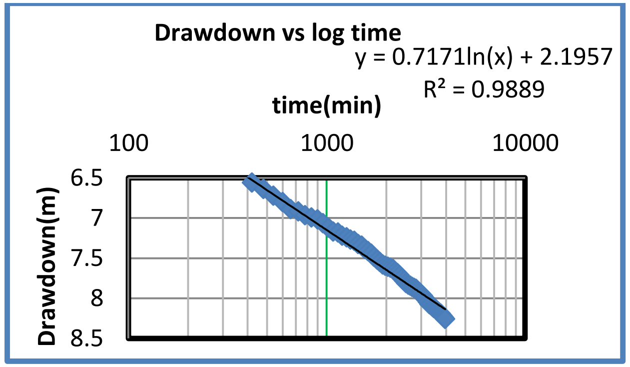
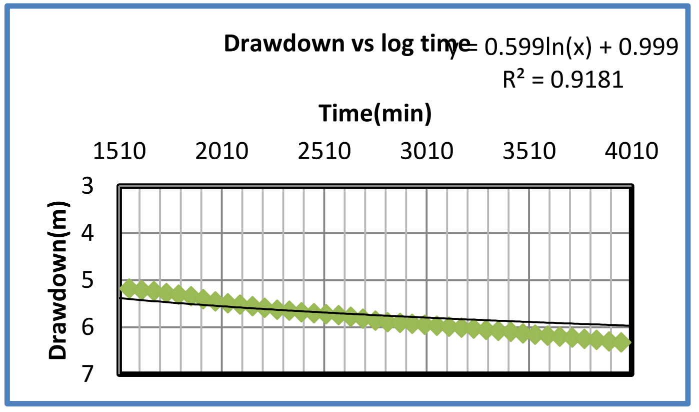


Figure 32 A-Best fit line (w & x) for SL-PW-11

y) Observed Drawdown



z) Corrected Drawdown

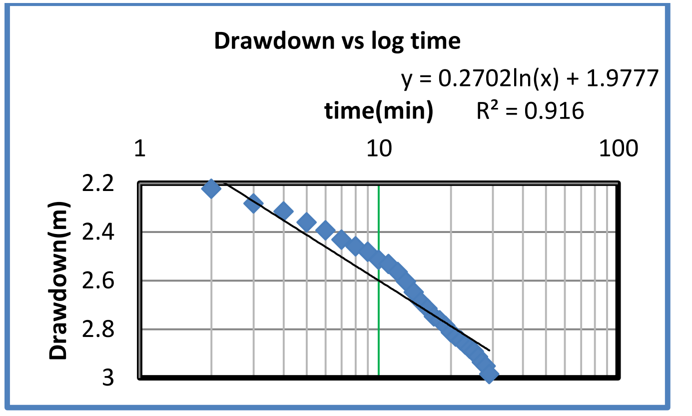
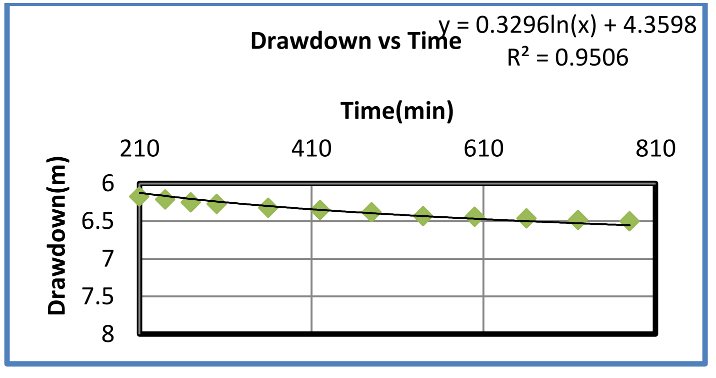


Figure 33 A-Best fit line (y & z) for SL-PW-12

A') Observed Drawdown



B') Corrected Drawdown

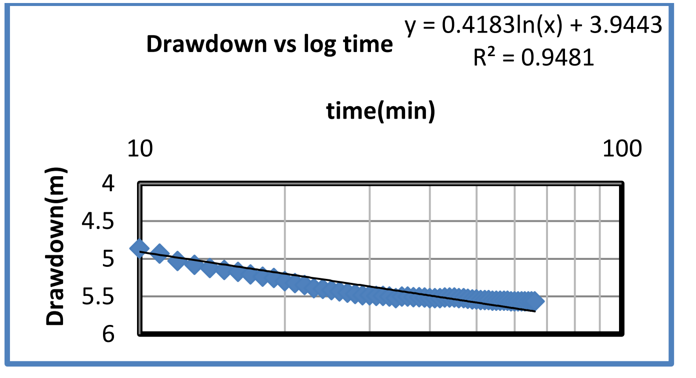
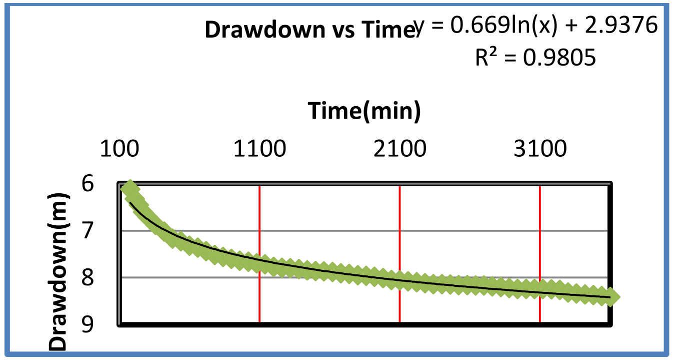


Figure 34 A-Best fit line (A' & B') SL-PW-24

C’) Observed Drawdown



d’) Corrected Drawdown

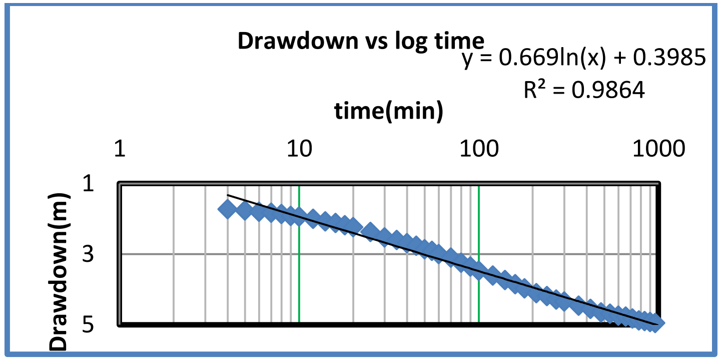
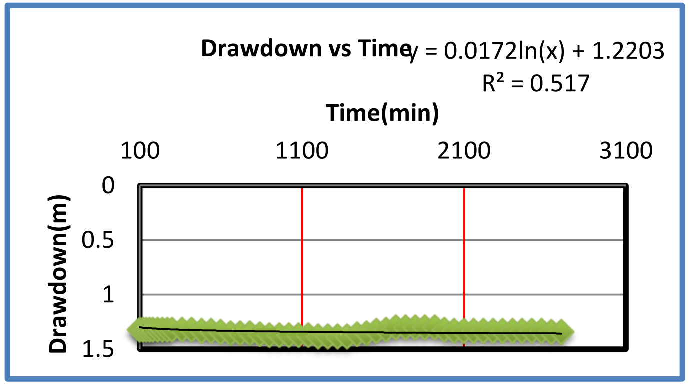


Figure 35 A- Best fit line (c' & d') for SL-PW-25

E’) Observed Drawdown



f’) Corrected Drawdown

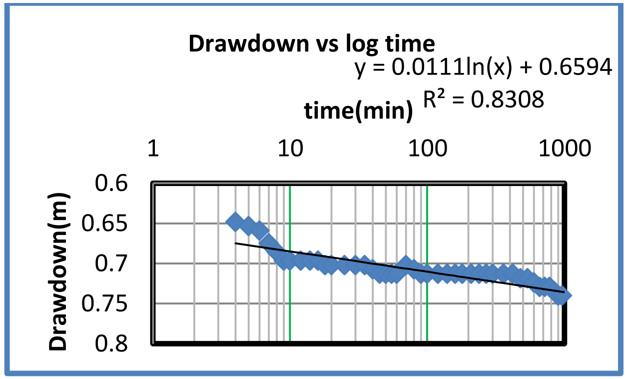
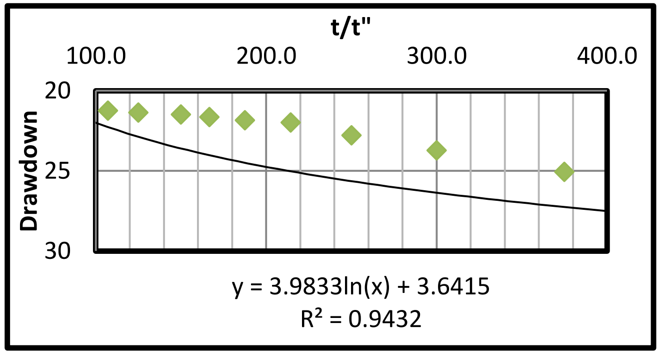


Figure 36 A- Best fit line (E' & f') for SL-PW-30

APPINDIX-04 Best fit line for Residual Drawdown

a) Observed Residual Drawdown



b) Corrected Residual Drawdown

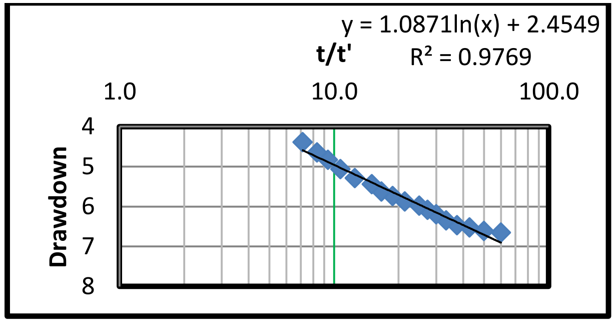
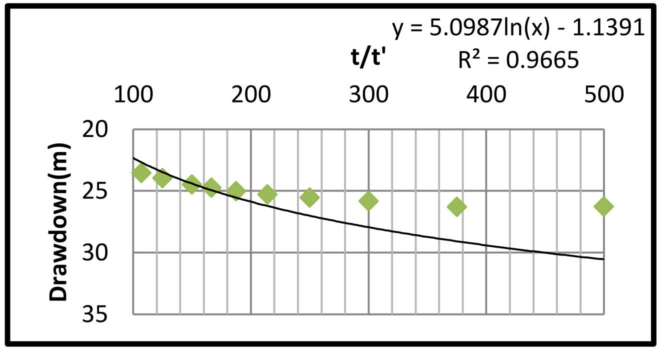


Figure 37-B Residual Drawdown plot for SL-PW-03(a & b)

b) Observed Residual Drawdown



c) Corrected Residual Drawdown

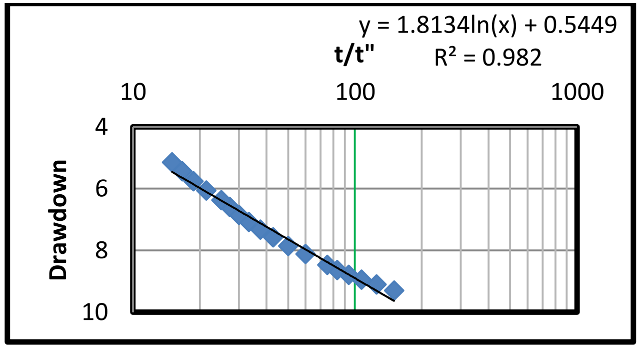
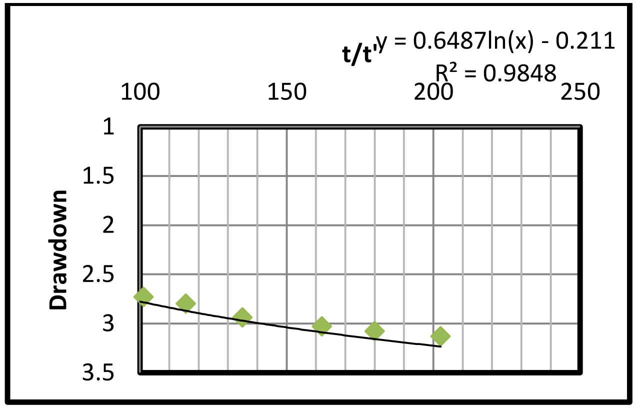


Figure 38- B Residual Drawdown plot for SL-PW-04 (c & d)

e) Observed Residual Drawdown



f) Corrected Residual Drawdown

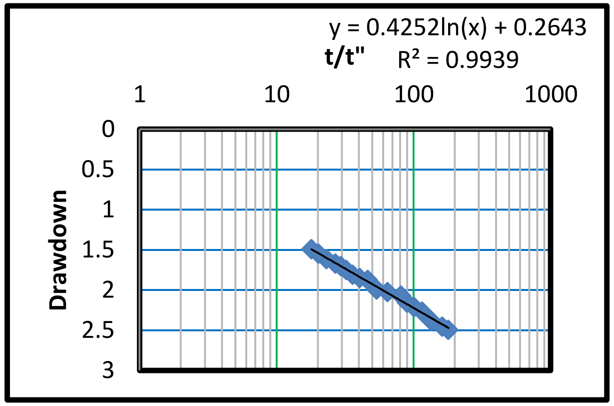
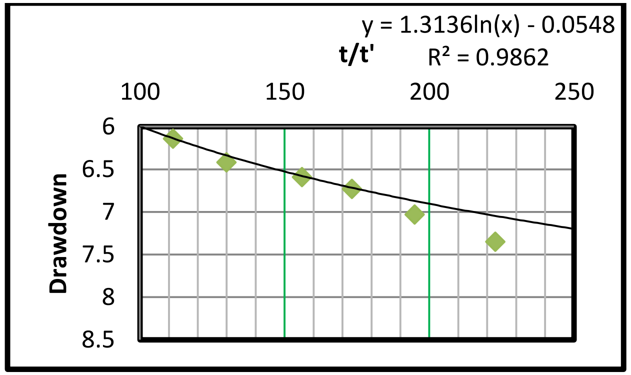


Figure 39 -B Residual Drawdown plot for SL-PW-06(e & f)

g) Observed Residual Drawdown



h) Corrected Residual Drawdown

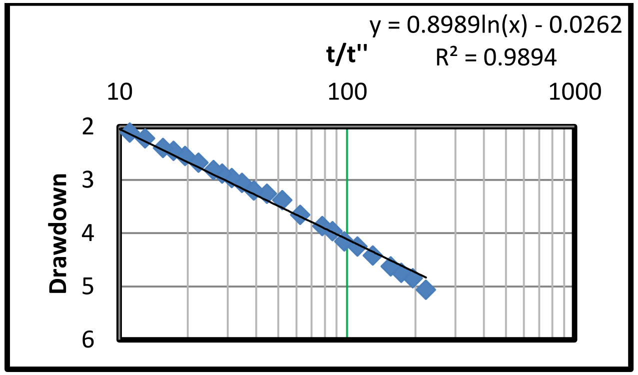
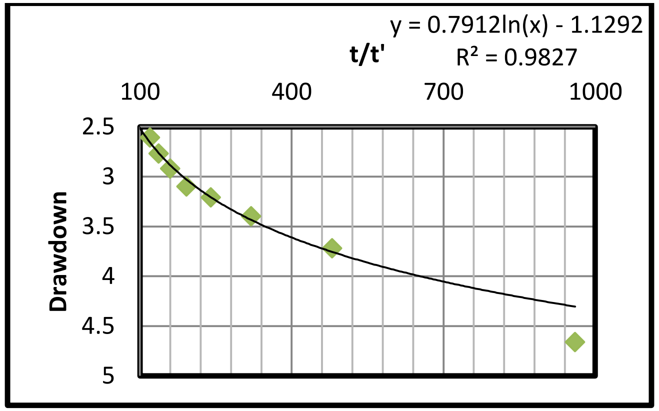


Figure 40 -B Residual Drawdown plot for SL-PW-07 (g & h)

I) Observed Residual Drawdown



j) Corrected Residual Drawdown

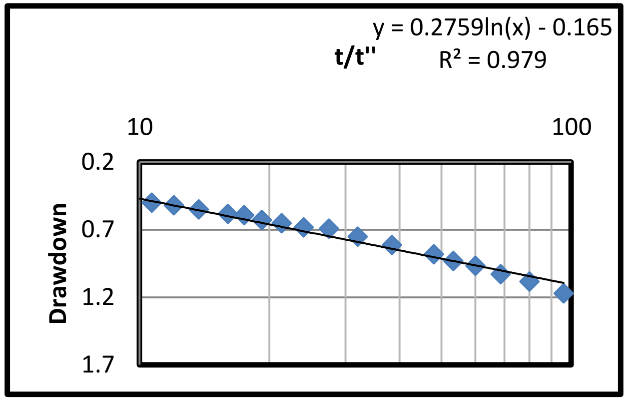
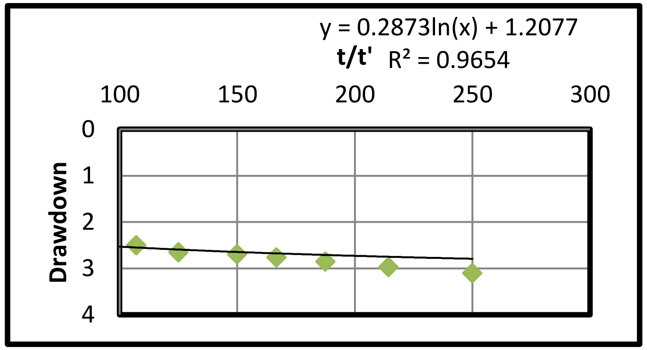


Figure 41 -B Residual Drawdown plot for SL-PW-08 (i & j)

K) Observed Residual Drawdown



l) Corrected Residual Drawdown

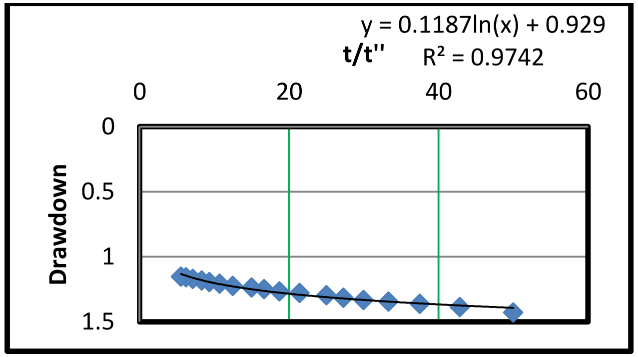
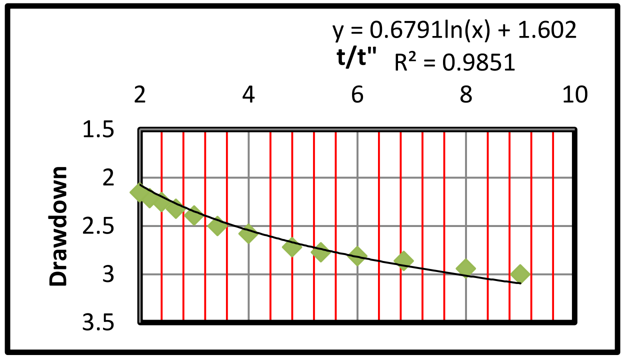


Figure 42-B Residual Drawdown plot for SL-PW-14 (k & l)

m) Observed Residual Drawdown

n) Corrected Residual Drawdown



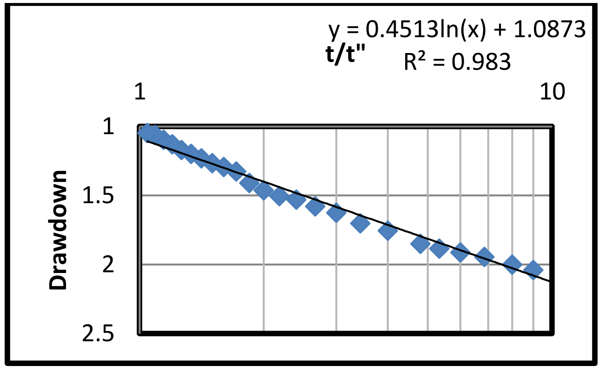
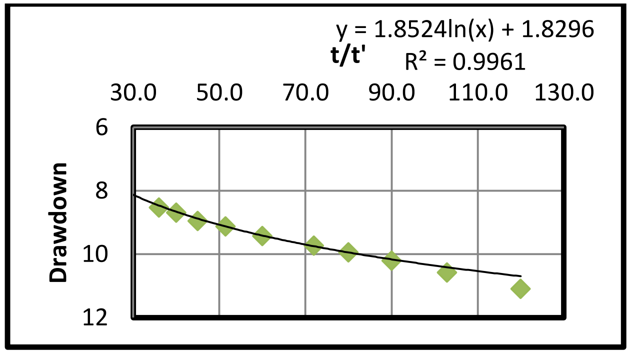


Figure 43 - B Residual Drawdown plot for SL-PW-16 (m & n)

o) Observed Residual Drawdown

p) Corrected Residual Drawdown



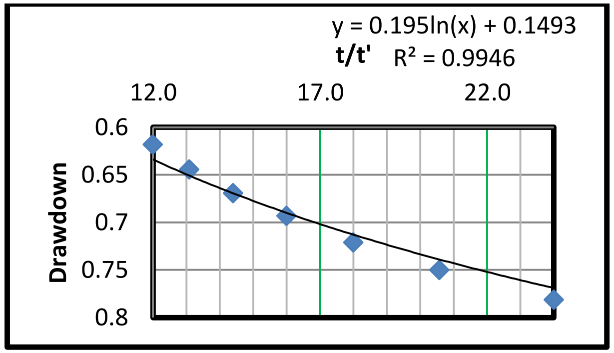
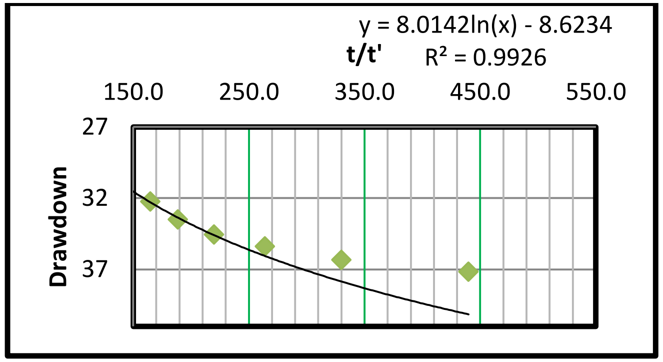


Figure 44 -B Residual Drawdown plot for SL-PW-17 (o & p)

q) Observed Residual Drawdown



r) Corrected Residual Drawdown

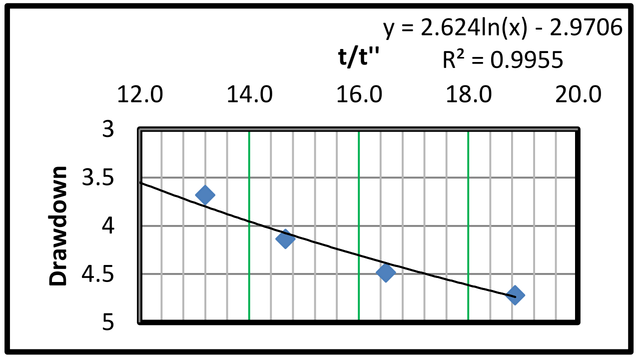
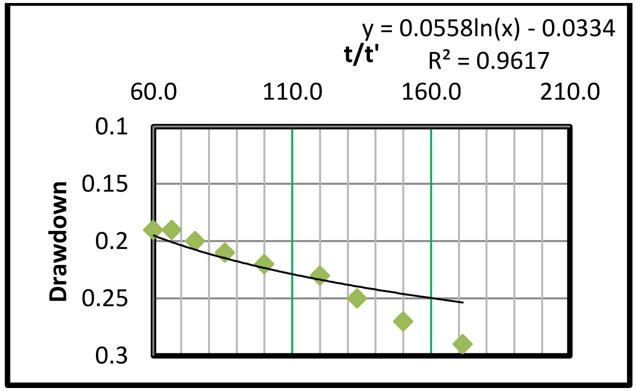


Figure 45 -B Residual Drawdown plot for SL-PW-19 (q & r)

s) Observed Residual Drawdown



t) Corrected Residual Drawdown

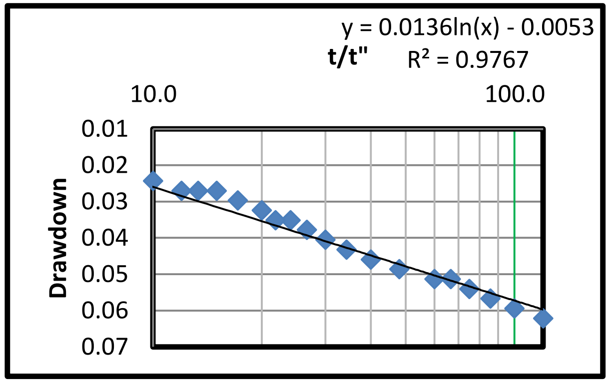
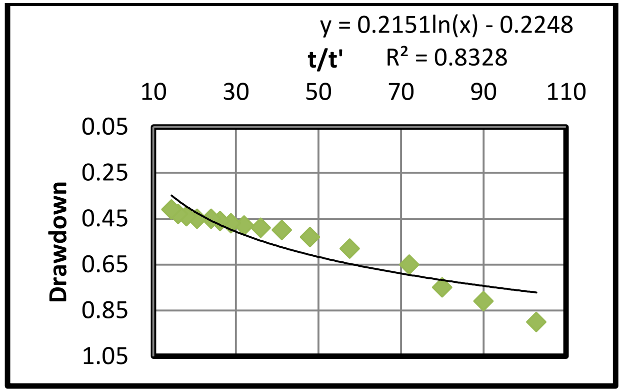


Figure 46 -B Residual Drawdown plot for SL-PW-21 (s & t)

u) Observed Residual Drawdown



v) Corrected Residual Drawdown

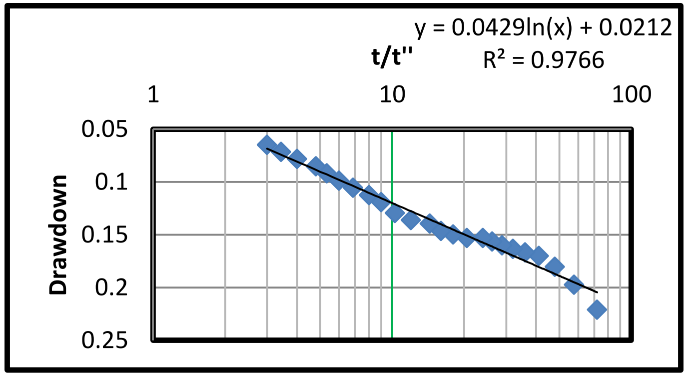
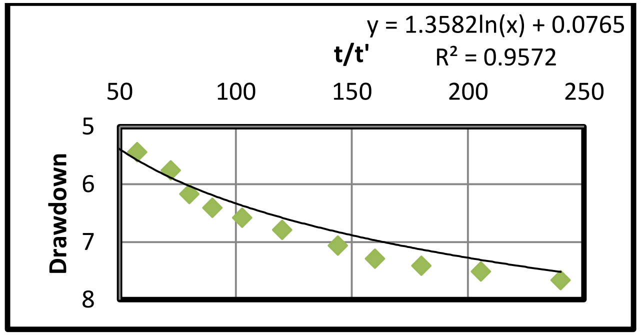


Figure 47 -B Residual Drawdown plot for SL-PW-22 (u & v)

w) Observed Residual Drawdown



x) Corrected Residual Drawdown

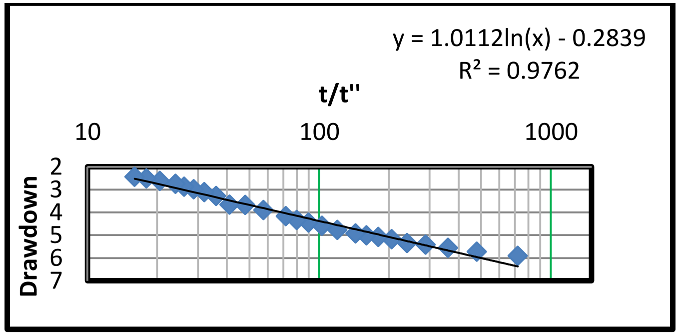
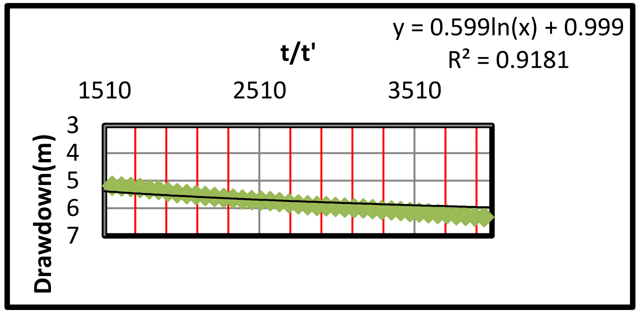


Figure 48 -B Residual Drawdown plot for SL-PW-11 (w & x)

y) Observed Residual Drawdown



z) Corrected Residual Drawdown

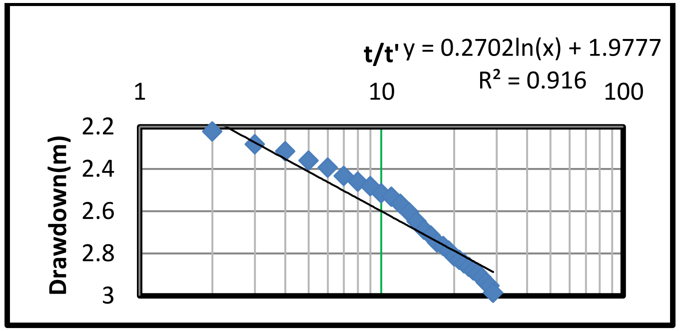
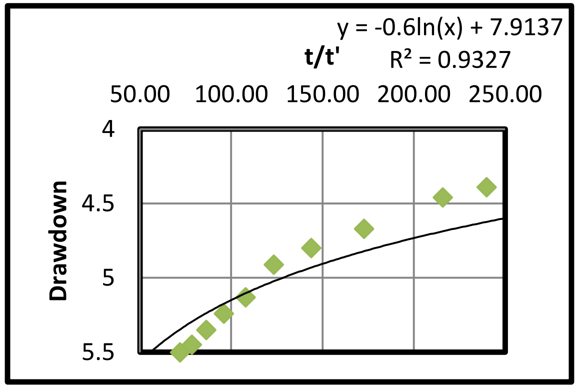


Figure 49 -B Residual Drawdown plot for SL-PW-12 (y & z)

A') Observed Residual Drawdown



B') Corrected Residual Drawdown

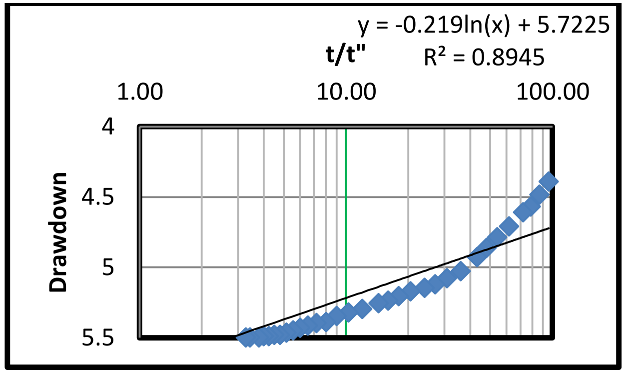
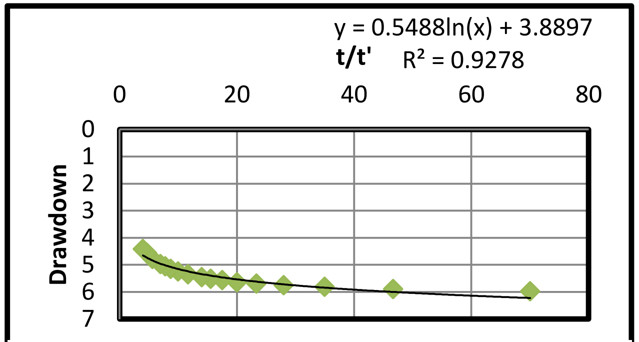


Figure 50 - B Residual Drawdown plot for (A' & B')

C') Observed Residual Drawdown



D') Corrected Residual Drawdown

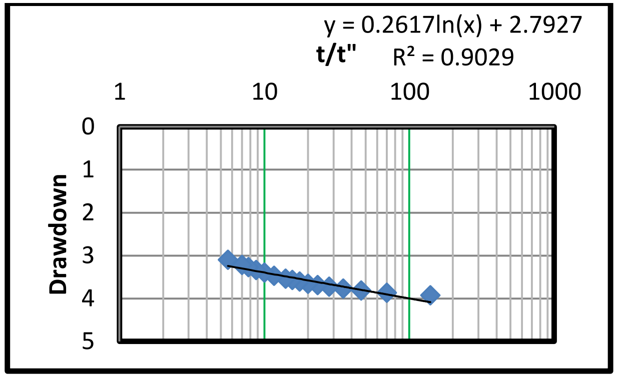
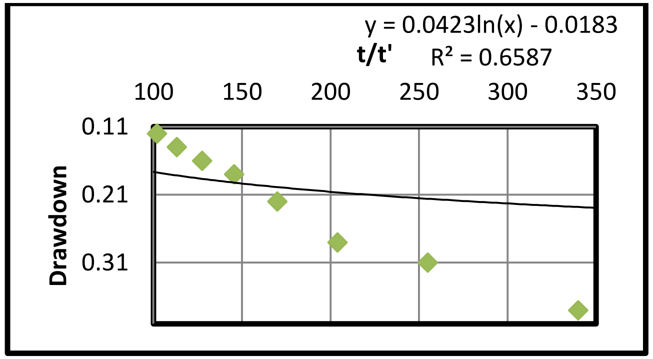


Figure 51 - B Residual Drawdown for SL-PW-25

E') Observed Residual Drawdown



F') Corrected Residual Drawdown

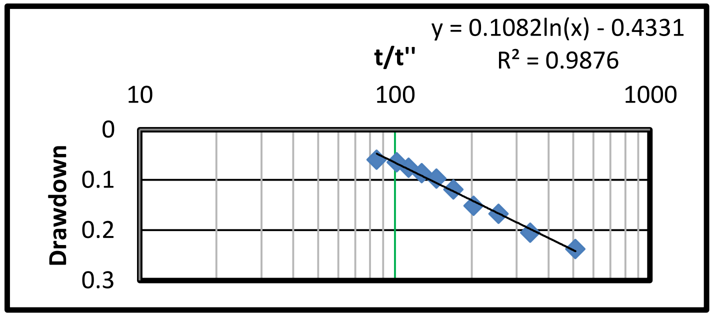
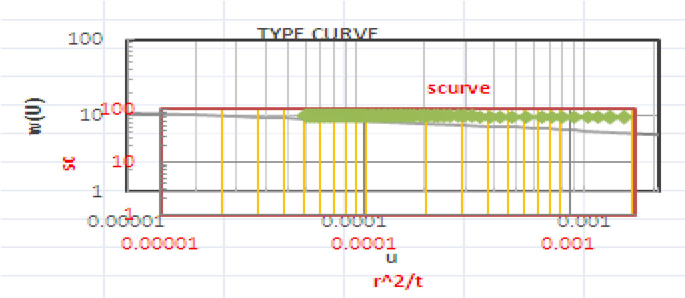


Figure 52 - B Residual Drawdown plot for SL-PW-30 (E' & F')

APPINDIX-05 Best fit line for Theis method

a) Overlap of observed Drawdown



b) Overlap of Corrected Drawdown

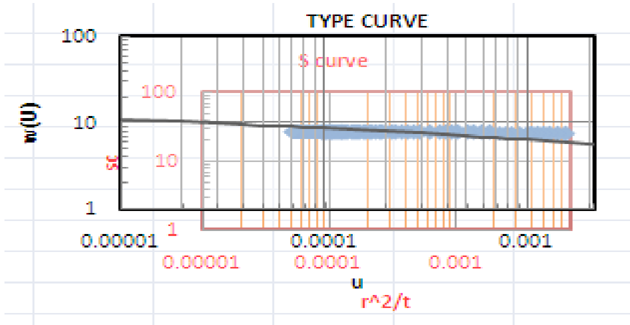
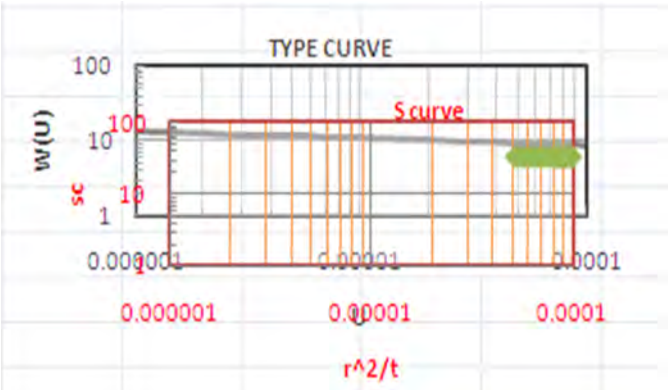


Figure 53 - C Type curve and S curve for SL-PW-03(a & b)

c) Overlap of observed Drawdown



d) Overlap of corrected Drawdown

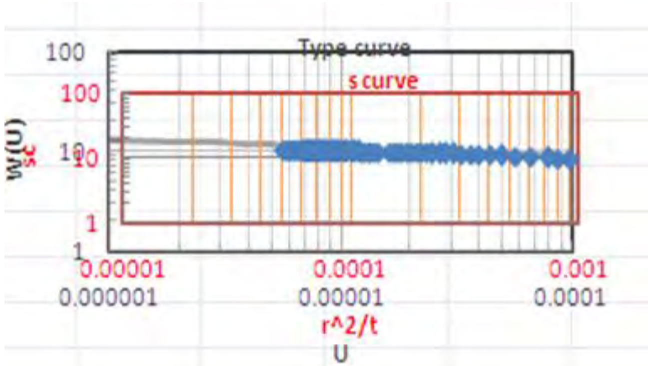
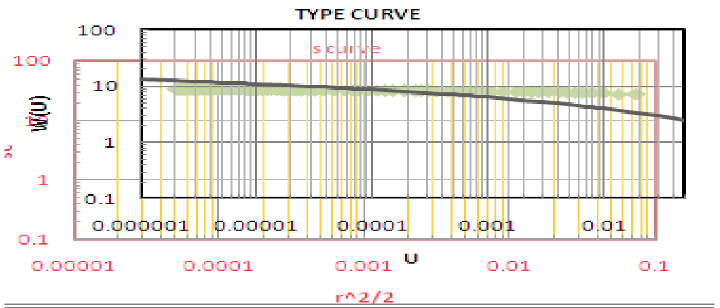


Figure 54 - C Type curve and S curve for SL-PW-04(c & d)

e) Overlap of observed Drawdown

f) Overlap of corrected Drawdown



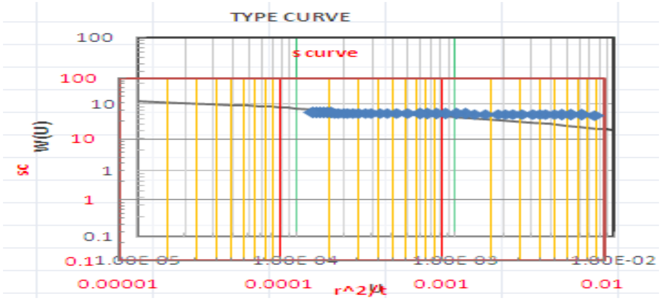
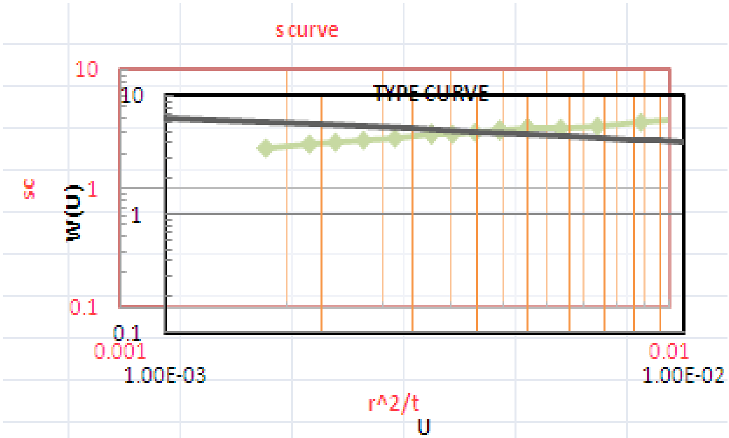


Figure 55 - C Type curve and s curve for SL-PW-07 (e & f)

g) Overlap of observed Drawdown

h) Overlap of corrected Drawdown



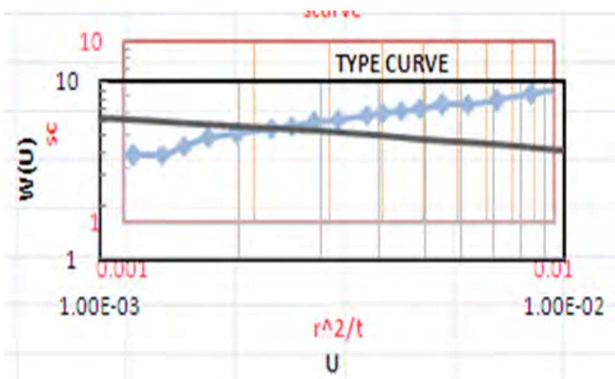
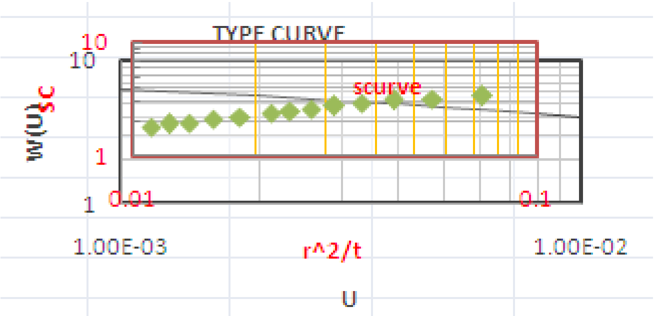


Figure 56 - C Type curve and s curve for SL-PW-07(g & h)

I) Overlap of observed Drawdown



j) Overlap of corrected Drawdown

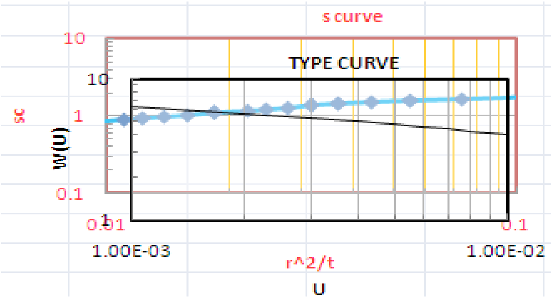
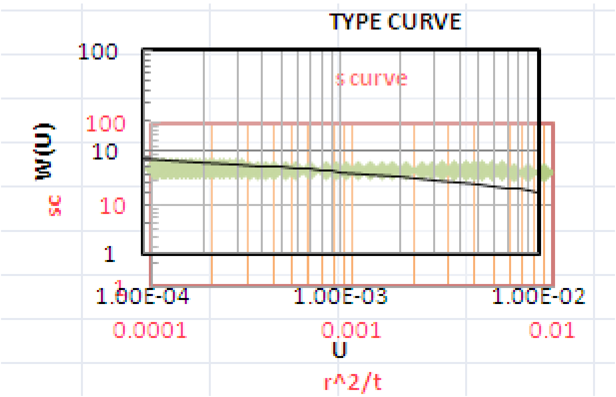


Figure 57 - C Type curve and S curve for SL-PW-08 (i & j)

K) Overlap of observed Drawdown



l) Overlap of corrected Drawdown

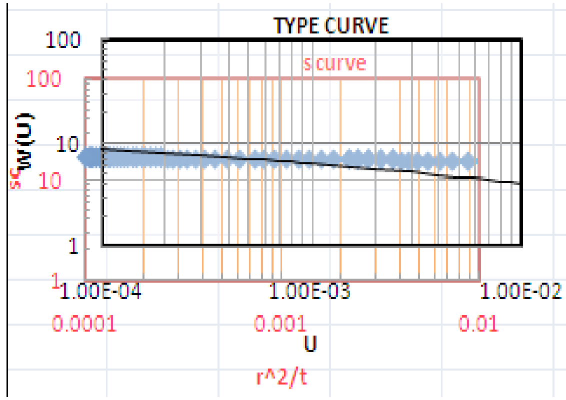
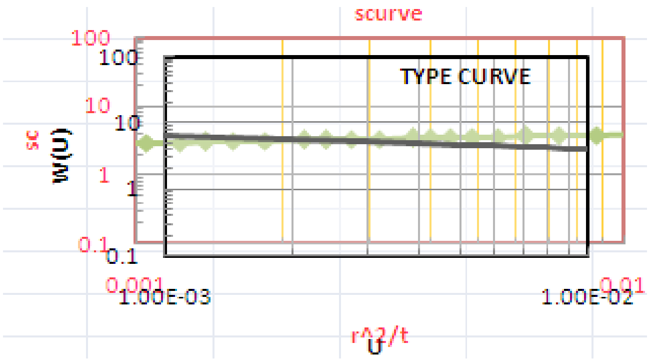


Figure 58 - C Type curve and s curve for SL-PW-14 (k & l)

m) Overlap of observed Drawdown



n) Overlap of corrected Drawdown

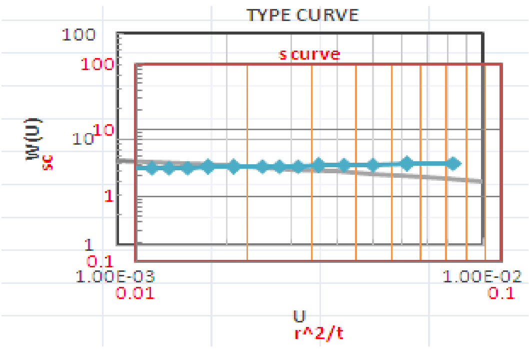
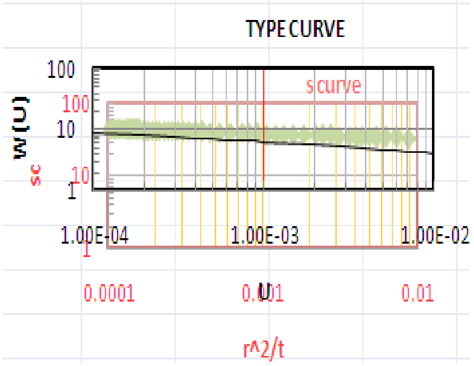


Figure 59 - C Type curve and s curve for SL-PW-16 (m & n)

o) Overlap of observed Drawdown



p) Overlap of corrected Drawdown

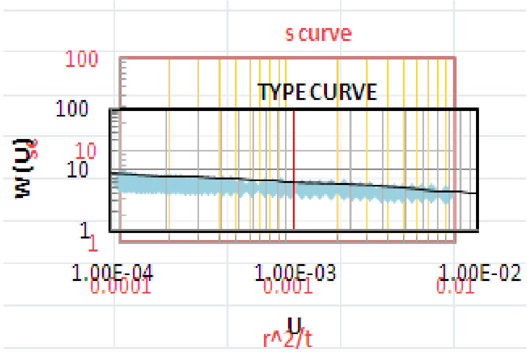
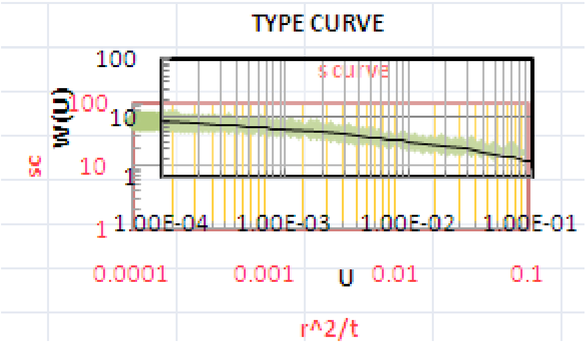


Figure 60 - C Type curve and S curve for SL-PW-19(o & p)

q) Overlap of observed Drawdown



r) Overlap of corrected Drawdown

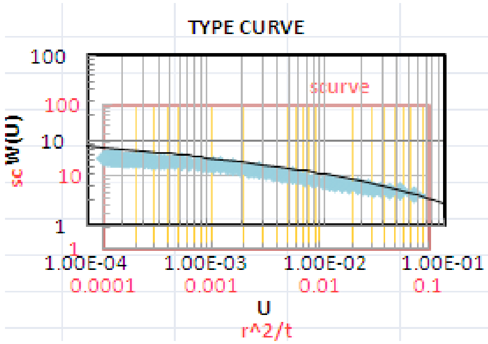
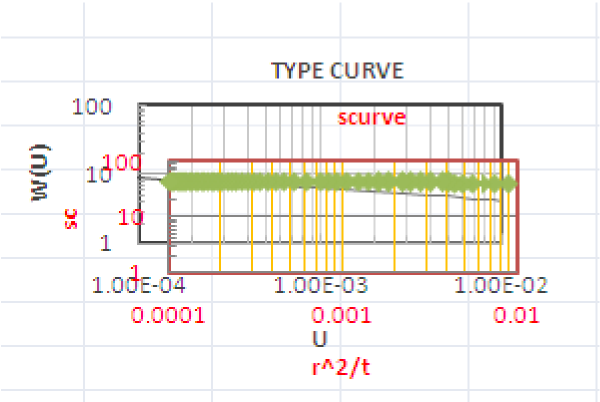


Figure 61 - C Type curve and S curve for SL-PW-21(q & r)

s) Overlap of observed Drawdown



t) Overlap of corrected Drawdown

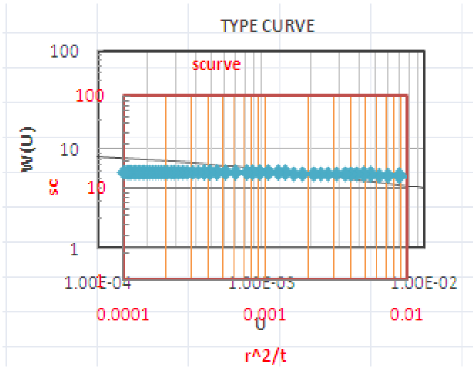
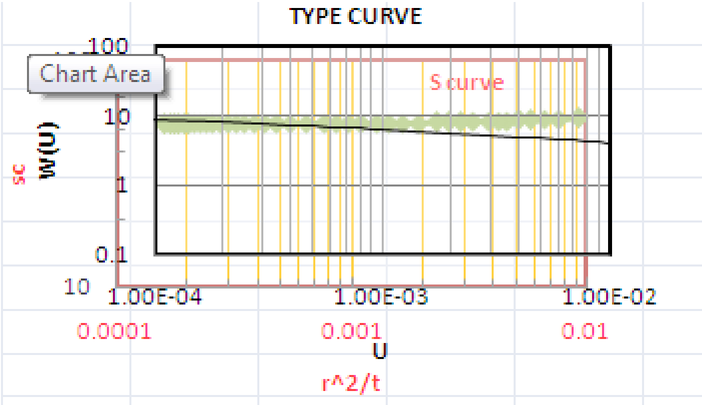


Figure 62 - C Type curve and S curve for SL-PW-22 (s & t)

u) Overlap of observed Drawdown



v) Overlap of corrected Drawdown

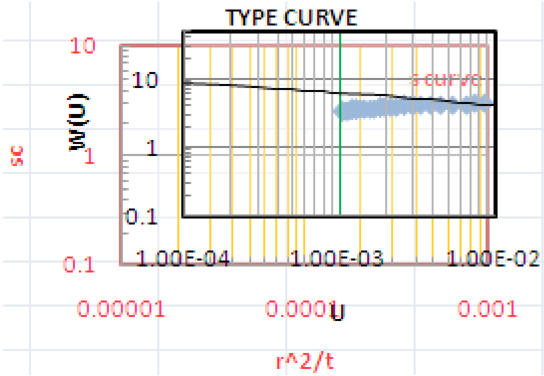
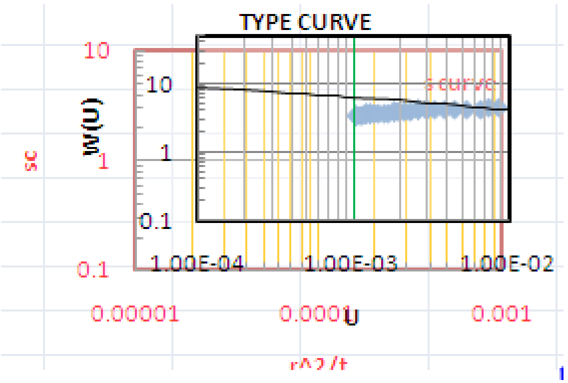


Figure 63 - C Type curve and S curve for SL-PW-11 (u & v)

w) Overlap of observed Drawdown



x) Overlap of corrected Drawdown

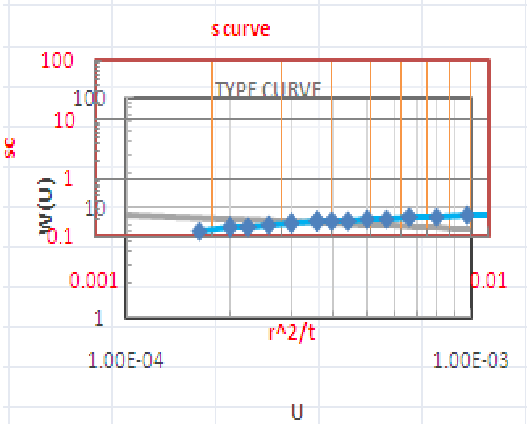
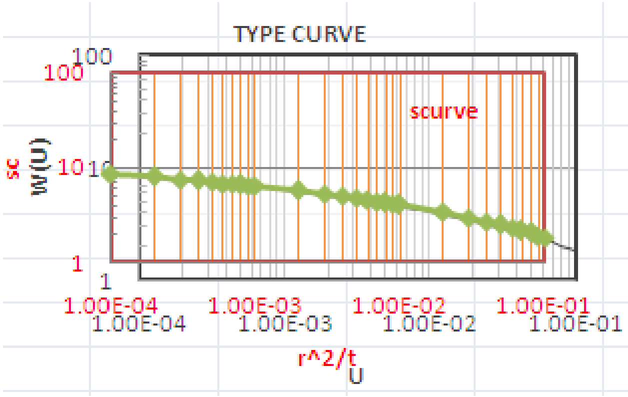


Figure 64 -C Type curve and S curve for SL-PW-12 (w & x)

y) Overlap of observed Drawdown



z) Overlap of corrected Drawdown

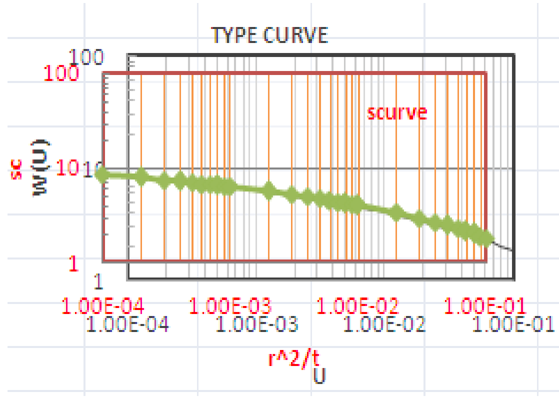
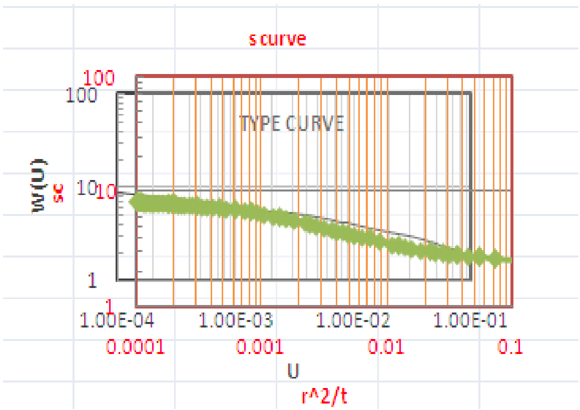


Figure 65 - C Type curve and S curve for SL-PW-24(y & z)

A') Overlap of observed Drawdown



B') Overlap of corrected Drawdown

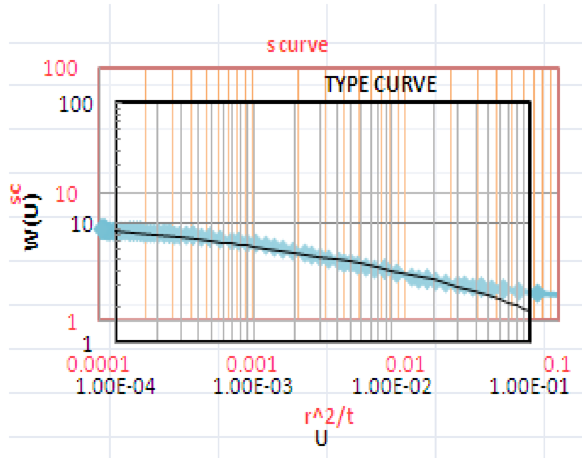
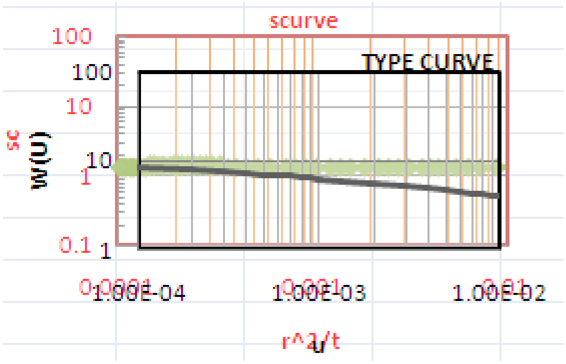


Figure 66 -C Type curve and S curve for SL-PW-25 (A' & B')

C') Overlap of observed Drawdown

D') Overlap of corrected Drawdown



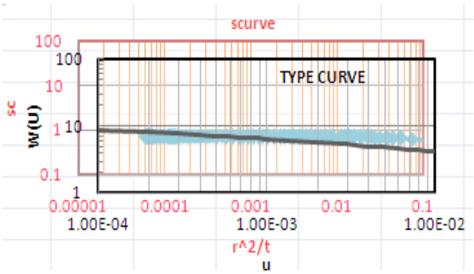


Figure 67 - C Type curve and S curve for SL-PW-30 (C' & D')

APPINDIX-06 Raw Constant Pumping and Recovery Test Data

Table 17 Constant pumping test SL-PW-03

Time(min)	Water level,(m)	Drawdown,(m)	Unconfined sc	corrected DD (sc)
0	54.32	0	0	0.00
1	102.96	48.64	32.80	12.13
2	108.31	53.99	34.47	12.75
3	110.01	55.69	34.92	12.92
4	111.98	57.66	35.39	13.10
5	113.31	58.99	35.69	13.20
6	114.88	60.56	36.00	13.32
7	116.58	62.26	36.30	13.43
8	117.71	63.39	36.48	13.50
9	118.34	64.02	36.57	13.53
10	118.68	64.36	36.62	13.55
12	119.63	65.31	36.74	13.60
14	120.23	65.91	36.82	13.62
16	120.69	66.37	36.87	13.64
18	120.95	66.63	36.90	13.65
20	121.19	66.87	36.92	13.66
25	122.05	67.73	37.01	13.69
30	122.82	68.5	37.08	13.72
35	123.5	69.18	37.13	13.74
40	123.85	69.53	37.15	13.75
45	124.01	69.69	37.16	13.75
50	124.15	69.83	37.17	13.75
55	124.38	70.06	37.19	13.76
60	124.53	70.21	37.20	13.76
70	124.99	70.67	37.22	13.77
80	125.49	71.17	37.25	13.78
90	125.69	71.37	37.26	13.79
100	125.9	71.58	37.27	13.79
120	126.22	71.9	37.28	13.79
140	126.41	72.09	37.29	13.80
160	126.74	72.42	37.30	13.80
180	127.08	72.76	37.31	13.80
210	127.3	72.98	37.31	13.81
240	127.37	73.05	37.31	13.81
270	127.45	73.13	37.31	13.81
300	127.53	73.21	37.32	13.81
360	127.68	73.36	37.32	13.81
420	127.71	73.39	37.32	13.81
480	127.85	73.53	37.32	13.81
540	127.98	73.66	37.32	13.81
600	128.03	73.71	37.32	13.81
660	128.09	73.77	37.32	13.81
720	128.15	73.83	37.33	13.81
780	128.23	73.91	37.33	13.81
840	128.3	73.98	37.33	13.81
900	128.32	74	37.33	13.81
960	128.37	74.05	37.33	13.81
1020	128.41	74.09	37.33	13.81
1080	128.44	74.12	37.33	13.81
1140	128.46	74.14	37.33	13.81
1200	128.48	74.16	37.33	13.81
1260	128.52	74.2	37.33	13.81
1320	128.55	74.23	37.33	13.81

1380	128.57	74.25	37.33	13.81
1440	128.59	74.27	37.33	13.81
1500	128.61	74.29	37.33	13.81
1560	128.63	74.31	37.33	13.81
1620	128.65	74.33	37.33	13.81
1680	128.67	74.35	37.33	13.81
1740	128.68	74.36	37.33	13.81
1800	128.7	74.38	37.33	13.81
1860	128.72	74.4	37.33	13.81
1920	128.73	74.41	37.33	13.81
1980	128.74	74.42	37.33	13.81
2040	128.75	74.43	37.33	13.81
2100	128.75	74.43	37.33	13.81
2160	128.77	74.45	37.33	13.81
2220	128.79	74.47	37.33	13.81
2280	128.8	74.48	37.33	13.81
2340	128.81	74.49	37.33	13.81
2400	128.82	74.5	37.33	13.81
2460	128.83	74.51	37.33	13.81
2520	128.84	74.52	37.33	13.81
2580	128.84	74.52	37.33	13.81
2640	128.85	74.53	37.33	13.81
2700	128.85	74.53	37.33	13.81
2760	128.86	74.54	37.33	13.81
2820	128.87	74.55	37.33	13.81

2880	128.88	74.56	37.33	13.81
2940	128.88	74.56	37.33	13.81
3000	128.9	74.58	37.33	13.81
3060	128.9	74.58	37.33	13.81
3120	128.91	74.59	37.33	13.81
3180	128.91	74.59	37.33	13.81
3240	128.92	74.6	37.33	13.81
3300	128.93	74.61	37.33	13.81
3360	128.93	74.61	37.33	13.81
3420	128.94	74.62	37.33	13.81
3480	128.94	74.62	37.33	13.81
3540	128.94	74.62	37.33	13.81
3600	128.95	74.63	37.33	13.81
3660	128.95	74.63	37.33	13.81
3720	128.95	74.63	37.33	13.81
3780	128.95	74.63	37.33	13.81
3840	128.96	74.64	37.33	13.81
3900	128.96	74.64	37.33	13.81
3960	128.96	74.64	37.33	13.81
4020	128.96	74.64	37.33	13.81
4080	128.97	74.65	37.33	13.81
4140	128.97	74.65	37.33	13.81
4200	128.98	74.66	37.33	13.81
4260	128.98	74.66	37.33	13.81
4320	128.98	74.66	37.33	13.81

Table 18 Recovery test SL-PW-03

Time (min)	Water level,(m)	Drawdown(m)	Unconfed Sc	t/t"	Sc
0	128.9 9	74.67	37.33	#DIV /0!	13.4 4
1	98.35	44.03	31.046 87	1500 .0	11.1 8
2	87.67	33.35	25.901 42	750. 0	9.32
3	82.15	27.83	22.643 09	500. 0	8.15
4	79.38	25.06	20.854 24	375. 0	7.51
5	78.04	23.72	19.952	300. 0	7.18
6	77.09	22.77	19.297 77	250. 0	6.95
7	76.29	21.97	18.737 47	214. 3	6.75
8	76.15	21.83	18.638 54	187. 5	6.71
9	75.95	21.63	18.496 75	166. 7	6.66
10	75.79	21.47	18.382 93	150. 0	6.62
12	75.68	21.36	18.304 48	125. 0	6.59
14	75.55	21.23	18.211 56	107. 1	6.56
16	75.18	20.86	17.945 86	93.8	6.46
18	74.76	20.44	17.642 03	83.3	6.35
20	74.44	20.12	17.408 95	75.0	6.27
25	72.8	18.48	16.192 9	60.0	5.83
30	72.69	18.37	16.110 04	50.0	5.80
35	72.45	18.13	15.928 71	42.9	5.73
40	72.28	17.96	15.799 8	37.5	5.69
45	71.96	17.64	15.556 09	33.3	5.60
50	71.54	17.22	15.234 14	30.0	5.48
55	71.22	16.9	14.987 26	27.3	5.40
60	70.92	16.6	14.754 57	25.0	5.31
70	70.65	16.33	14.544 11	21.4	5.24
80	70.26	15.94	14.238 4	18.8	5.13
90	69.96	15.64	14.001 84	16.7	5.04
100	69.44	15.12	13.588 96	15.0	4.89
120	69.02	14.7	13.252 84	12.5	4.77
140	68.38	14.06	12.736 11	10.7	4.58
160	67.74	13.42	12.213 89	9.4	4.40
180	67.23	12.91	11.793 82	8.3	4.25
210	66.52	12.2	11.203 21	7.1	4.03
240	65.9	11.58	10.681 95	6.3	3.85
270	65.71	11.39	10.521 18	5.6	3.79
300	65.6	11.28	10.427 88	5.0	3.75

360	64.82	10.5	9.761653	4.2	3.51
420	64.18	9.86	9.208918	3.6	3.32
480	63.62	9.3	8.720774	3.1	3.14
540	63.11	8.79	8.27256	2.8	2.98
600	62.55	8.23	7.776391	2.5	2.80
660	62	7.68	7.284993	2.3	2.62
720	61.51	7.19	6.84379	2.1	2.46
780	61.05	6.73	6.426672	1.9	2.31
840	60.58	6.26	5.99756	1.8	2.16
900	60.22	5.9	5.666877	1.7	2.04

960	59.9	5.58	5.371479	1.6	1.93
1020	59.44	5.12	4.944441	1.5	1.78
1080	59.02	4.7	4.552063	1.4	1.64
1140	58.81	4.49	4.354987	1.3	1.57
1200	58.33	4.01	3.902311	1.3	1.40
1260	58	3.68	3.589306	1.2	1.29
1320	57.68	3.36	3.284393	1.1	1.18
1380	57.23	2.91	2.853289	1.1	1.03
1440	56.96	2.64	2.593324	1.0	0.93
1500	56.4	2.08	2.051026	1	0.74

Table 19 constant pumping test SL-PW-04

Constant Test				
Time (min)	Water level, m	Drawdown (m)	Unconfined sc	sc
0	55.18	0	0	0.000
1	64.51	6.33	5.73	2.177
2	65.23	7.05	6.30	2.396
3	65.82	7.64	6.76	2.571
4	66.35	8.17	7.17	2.724
5	66.68	8.5	7.42	2.818
6	67.07	8.89	7.70	2.928
7	67.35	9.17	7.91	3.005
8	67.67	9.49	8.14	3.093
9	67.91	9.73	8.31	3.158
10	68.18	10	8.50	3.230
12	69.66	11.48	9.50	3.611
14	69.08	10.9	9.12	3.465
16	69.45	11.27	9.37	3.559
18	69.8	11.62	9.60	3.646
20	70.11	11.93	9.80	3.722
25	71.15	12.97	10.45	3.970
30	71.56	13.38	10.70	4.064
35	72.15	13.97	11.04	4.196
40	72.83	14.65	11.43	4.344
45	73.17	14.99	11.62	4.416
50	73.74	15.56	11.93	4.533
55	74.18	16	12.16	4.621
60	74.62	16.44	12.39	4.707
70	75.42	17.24	12.78	4.857
80	76.09	17.91	13.10	4.978
90	76.74	18.56	13.39	5.090
100	77.35	19.17	13.66	5.190
120	78.51	20.33	14.13	5.370
140	79.33	21.15	14.44	5.488
160	80.44	22.26	14.83	5.635
180	80.99	22.81	15.01	5.703
210	81.8	23.62	15.25	5.796
240	82.64	24.46	15.49	5.885
270	83.32	25.14	15.66	5.951
300	83.86	25.68	15.79	6.000
360	84.85	26.67	16.00	6.081
420	85.59	27.41	16.14	6.134
480	86.21	28.03	16.25	6.174
540	86.69	28.51	16.32	6.202
600	87.17	28.99	16.39	6.227
660	87.54	29.36	16.43	6.244
720	87.83	29.65	16.47	6.257
780	88.09	29.91	16.49	6.268
840	88.33	30.15	16.52	6.277
900	88.58	30.4	16.54	6.285
960	88.62	30.44	16.54	6.287
1020	88.89	30.71	16.57	6.295
1080	89.02	30.84	16.58	6.299
1140	89.17	30.99	16.59	6.303
1200	89.3	31.12	16.60	6.307
1260	89.43	31.25	16.60	6.310
1320	89.57	31.39	16.61	6.313
1380	89.66	31.48	16.62	6.315
1440	89.76	31.58	16.62	6.317
1500	89.83	31.65	16.63	6.318
1680	90.02	31.84	16.64	6.322
1740	90.06	31.88	16.64	6.322

1800	90.11	31.93	16.64	6.323
1860	90.17	31.99	16.64	6.324
1920	90.21	32.03	16.64	6.325
1980	90.35	32.17	16.65	6.327
2040	90.39	32.21	16.65	6.327
2100	90.42	32.24	16.65	6.328
2160	90.44	32.26	16.65	6.328
2220	90.48	32.3	16.65	6.328
2280	90.52	32.34	16.66	6.329
2340	90.54	32.36	16.66	6.329
2400	90.58	32.4	16.66	6.330
2460	90.61	32.43	16.66	6.330
2520	90.64	32.46	16.66	6.330
2580	90.66	32.48	16.66	6.330
2640	90.8	32.62	16.66	6.332
2700	90.79	32.61	16.66	6.332
2760	90.86	32.68	16.66	6.332
2820	90.94	32.76	16.66	6.333
2880	90.96	32.78	16.67	6.333
2940	90.98	32.8	16.67	6.333
3000	90.98	32.8	16.67	6.333
3060	90.99	32.81	16.67	6.333

3120	90.95	32.77	16.67	6.333
3180	91	32.82	16.67	6.333
3240	91.02	32.84	16.67	6.333
3300	91.07	32.89	16.67	6.333
3360	91.09	32.91	16.67	6.334
3420	91.11	32.93	16.67	6.334
3480	91.16	32.98	16.67	6.334
3540	91.18	33	16.67	6.334
3600	91.22	33.04	16.67	6.334
3660	91.23	33.05	16.67	6.334
3720	91.24	33.06	16.67	6.334
3780	91.27	33.09	16.67	6.334
3840	91.3	33.12	16.67	6.334
3900	91.32	33.14	16.67	6.334
3960	91.34	33.16	16.67	6.334
4020	91.36	33.18	16.67	6.334
4080	91.39	33.21	16.67	6.335
4140	91.43	33.25	16.67	6.335
4200	91.5	33.32	16.67	6.335
4260	91.51	33.33	16.67	6.335
4320	91.52	33.34	16.67	6.335

Table 20 Recovery test SL-PW-04

Time (min)	Water level,(m)	Water level,(m)	Unconfined (sc)	Sc	t/t'
0	91.52	33.34	0	0	#DIV/0!
1	86.24	28.06	16.25191	6.175725	1500
2	85.41	27.23	16.11013	6.12185	750
3	84.44	26.26	15.91825	6.048937	500
4	84.47	26.29	15.92461	6.051352	375
5	83.99	25.81	15.81966	6.011469	300
6	83.72	25.54	15.75758	5.987881	250
7	83.46	25.28	15.69574	5.964382	214.28
8	83.2	25.02	15.63187	5.940111	187.5
9	82.9	24.72	15.55566	5.91115	166.66
10	82.65	24.47	15.49008	5.886231	150
12	82.13	23.95	15.34768	5.83212	125
14	81.72	23.54	15.22969	5.787281	107.1429
16	81.29	23.11	15.10052	5.738198	93.75
18	80.89	22.71	14.97539	5.690646	83.33333
20	80.47	22.29	14.83883	5.638755	75
25	79.54	21.36	14.51762	5.516697	60
30	78.84	20.66	14.25875	5.418324	50
35	78.12	19.94	13.97714	5.311313	42.85714
40	77.46	19.28	13.70534	5.208029	37.5
45	76.8	18.62	13.42047	5.09978	33.33333
50	76.21	18.03	13.15476	4.998809	30
55	75.51	17.33	12.82597	4.873868	27.27273
60	74.94	16.76	12.54738	4.768004	25
70	74.11	15.93	12.12429	4.607229	21.42857
80	73.32	15.14	11.70239	4.44691	18.75
90	72.47	14.29	11.22755	4.266469	16.66667
100	71.72	13.54	10.79058	4.100419	15
120	70.42	12.24	9.993185	3.79741	12.5

140	69.39	11.21	9.325415	3.543658	10.71429
160	68.19	10.01	8.507299	3.232774	9.375
180	67.44	9.26	7.974043	3.030136	8.333333
210	66.34	8.16	7.161416	2.721338	7.142857
240	65.36	7.18	6.406869	2.43461	6.25
270	64.74	6.56	5.914625	2.247558	5.555556
300	63.9	5.72	5.229322	1.987142	5
360	62.8	4.62	4.299898	1.633961	4.166667
420	61.9	3.72	3.512466	1.334737	3.571429
480	61.2	3.02	2.883221	1.095624	3.125
540	60.58	2.4	2.313617	0.879175	2.777778
600	60.32	2.14	2.07132	0.787101	2.5
660	62.18	4	3.760048	1.428818	2.272727
720	60.07	1.89	1.836429	0.697843	2.083333
780	59.93	1.75	1.704072	0.647547	1.923077
840	59.81	1.63	1.590154	0.604259	1.785714
900	59.67	1.49	1.456705	0.553548	1.666667
960	59.44	1.26	1.236191	0.469752	1.5625
1020	59.11	0.93	0.917029	0.348471	1.470588
1080	58.82	0.64	0.633857	0.240866	1.388889
1140	58.66	0.48	0.476545	0.181087	1.315789
1200	58.45	0.27	0.268907	0.102185	1.25
1260	58.34	0.16	0.159616	0.060654	1.190476
1320	58.29	0.11	0.109819	0.041731	1.136364
1380	58.23	0.05	0.049963	0.018986	1.086957

Table 21 Constant test SL-PW-06

Time (min)	Water level,(m)	Drawdown (m)	unconfined sc	sc
0	52.58	0	0	0
1	78.65	26.07	25.44923	20.61
2	79.9	27.32	26.63827	21.57
3	79.92	27.34	26.65727	21.59
4	80.12	27.54	26.84725	21.74
5	81.29	28.71	27.95714	22.64
6	81.54	28.96	28.19397	22.83
7	81.65	29.07	28.29814	22.92
8	81.7	29.12	28.34548	22.95
9	81.78	29.2	28.42122	23.02
10	81.88	29.3	28.51588	23.09
12	82	29.42	28.62944	23.18
14	82.14	29.56	28.7619	23.29
16	82.2	29.62	28.81866	23.3431
18	82.27	29.69	28.88486	23.3967

20	82.34	29.76	28.95106	23.4503
25	82.42	29.84	29.02671	23.5116
30	82.6	30.02	29.19687	23.6494
35	82.71	30.13	29.30082	23.7336
40	82.81	30.23	29.39531	23.8102
45	82.91	30.33	29.48978	23.8867
50	82.99	30.41	29.56534	23.9479
55	83.04	30.46	29.61256	23.9861
60	83.14	30.56	29.70699	24.0626
70	83.18	30.6	29.74475	24.0932
80	83.3	30.72	29.85803	24.185
90	83.38	30.8	29.93354	24.2461
100	83.49	30.91	30.03734	24.3302
120	83.59	31.01	30.13168	24.4066
140	83.68	31.1	30.21657	24.4754
160	83.77	31.19	30.30145	24.5441
180	83.86	31.28	30.38632	24.6129

210	83.92	31.34	30.44289	24.6587
240	83.98	31.4	30.49945	24.7045
270	84.01	31.43	30.52773	24.7274
300	84.16	31.58	30.66909	24.841
360	84.35	31.77	30.8481	24.986
420	84.39	31.81	30.88578	25.017
480	84.48	31.9	30.97054	25.086
540	84.57	31.99	31.05529	25.154
600	84.66	32.08	31.14002	25.223
660	84.71	32.13	31.18709	25.2615
720	84.79	32.21	31.26239	25.3225
780	84.82	32.24	31.29062	25.3454
840	84.87	32.29	31.33767	25.3835
900	84.95	32.37	31.41295	25.4444
960	85.01	32.43	31.4694	25.4902
1020	85.05	32.47	31.50703	25.5206
1080	85.09	32.51	31.54465	25.5511

1140	85.12	32.54	31.57287	25.5740
1200	85.14	32.56	31.59168	25.5892
1260	85.2	32.62	31.64811	25.6349
1320	85.24	32.66	31.68572	25.6654
1380	85.31	32.73	31.75154	25.7187
1440	85.37	32.79	31.80795	25.7644
1500	85.44	32.86	31.87376	25.8177
1560	85.45	32.87	31.88316	25.8253
1620	85.48	32.9	31.91135	25.8482
1680	85.54	32.96	31.96774	25.8938
1740	85.56	32.98	31.98654	25.9091
1800	85.59	33.01	32.01473	25.93193
1860	85.6	33.02	32.02413	25.93954
1920	85.66	33.08	32.08051	25.98521
1980	85.67	33.09	32.0899	25.99282
2040	85.68	33.1	32.0993	26.00043
2100	85.75	33.17	32.16506	26.0537

2160	85.75	33.17	32.16506	26.0537
2220	85.76	33.18	32.17445	26.0613
2280	85.85	33.27	32.25899	26.1297
2340	85.9	33.32	32.30595	26.1678
2400	85.9	33.32	32.30595	26.1678
2460	85.91	33.33	32.31534	26.1754
2520	85.92	33.34	32.32473	26.1830
2580	85.93	33.35	32.33412	26.1906
2640	85.94	33.36	32.34351	26.1982
2700	85.95	33.37	32.3529	26.2058
2760	85.99	33.41	32.39046	26.2362
2820	86.03	33.45	32.42802	26.2667
2880	86.05	33.47	32.4468	26.2819
2940	86.06	33.48	32.45619	26.2895
3000	86.08	33.5	32.47496	26.3047
3060	86.1	33.52	32.49374	26.3199
3120	86.12	33.54	32.51252	26.3351

3180	86.15	33.57	32.54068	26.3579
3240	86.15	33.57	32.54068	26.3579
3300	86.17	33.59	32.55945	26.3731
3360	86.2	33.62	32.58761	26.3959
3420	86.25	33.67	32.63453	26.4339
3480	86.22	33.64	32.60638	26.4111
3540	86.24	33.66	32.62515	26.4263
3600	86.24	33.66	32.62515	26.4263
3660	86.24	33.66	32.62515	26.4263
3720	86.26	33.68	32.64392	26.4415
3780	86.27	33.69	32.6533	26.4491
3840	86.29	33.71	32.67207	26.46438
3900	86.3	33.72	32.68146	26.47198
3960	86.33	33.75	32.70961	26.49478
4020	86.33	33.75	32.70961	26.49478
4080	86.33	33.75	32.70961	26.49478
4140	86.33	33.75	32.70961	26.49478

4200	86.34	33.76	32.71899	26.50238
4260	86.36	33.78	32.73776	26.51758
4320	86.4	33.82	32.77529	26.5479

Table 22 Recovery test for well SL-PW-06

Time(min)	Water level (m)	residual drawdown(m)	unconfined RR DD(sc)	t/t'	sc
0	86.4	34.38	33.3004	#DIV/0!	26.97333
1	85.3	33.28	32.26838	1620	26.13739
2	84.1	32.08	31.14002	810	25.22342
3	80.75	28.73	27.97609	540	22.66063
4	76.2	24.18	23.64597	405	19.15324
5	72.45	20.43	20.04877	324	16.2395
6	70.5	18.48	18.16807	270	14.71614
7	67.24	15.22	15.00842	231.4286	12.15682
8	55.15	3.13	3.121052	202.5	2.528052
9	55.1	3.08	3.071335	180	2.487782
10	55.05	3.03	3.021614	162	2.447508
12	54.96	2.94	2.932105	135	2.375005
14	54.82	2.8	2.792839	115.7143	2.2622
16	54.75	2.73	2.723193	101.25	2.205786
18	54.68	2.66	2.653537	90	2.149365
20	54.57	2.55	2.544061	81	2.060689
25	54.52	2.5	2.494291	64.8	2.020376
30	54.48	2.46	2.454473	54	1.988123
35	54.33	2.31	2.305126	46.28571	1.867152

40	54.3	2.28	2.275252	40.5	1.842954
45	54.25	2.23	2.225458	36	1.802621
50	54.18	2.16	2.155739	32.4	1.746148
55	54.12	2.1	2.095972	29.45455	1.697737
60	54.08	2.06	2.056124	27	1.66546
70	54.01	1.99	1.986383	23.14286	1.60897
80	53.93	1.91	1.906668	20.25	1.544401
90	53.86	1.84	1.836908	18	1.487895
100	53.72	1.7	1.69736	16.2	1.374862
120	53.51	1.49	1.487972	13.5	1.205257
140	53.3	1.28	1.278504	11.57143	1.035588
160	53.2	1.18	1.178728	10.125	0.95477
180	53.12	1.1	1.098895	9	0.890105
210	53.05	1.03	1.029031	7.714286	0.833515
240	52.91	0.89	0.889277	6.75	0.720314
270	52.82	0.8	0.799415	6	0.647527
300	52.73	0.71	0.70954	5.4	0.574727
360	52.69	0.67	0.66959	4.5	0.542368
420	52.67	0.65	0.649614	3.857143	0.526187
480	52.6	0.58	0.579693	3.375	0.469551
540	52.59	0.57	0.569703	3	0.46146
600	52.58	0.56	0.559714	2.7	0.453368

Table 23 Constant Pumping Test for well SL-PW-07

Constant test				
Time (min)	Water level,(m)	Drawd own (m)	unconfined sc	sc
0	53.52	0	0	
1	106.18	52.66	34.406474	24.77
2	117.31	63.79	37.005086	26.64
3	118.78	65.26	37.22638	26.802993
4	120.16	66.64	37.408236	26.93393
5	121.21	67.69	37.52981	27.021463
6	122.41	68.89	37.650979	27.108705
7	123.63	70.11	37.754733	27.183408
8	122.74	69.22	37.680977	27.130303
9	123.31	69.79	37.729415	27.165179
10	123.65	70.13	37.756271	27.184515
12	123.7	70.18	37.760092	27.187266
14	124.41	70.89	37.8108	27.223776
16	124.8	71.28	37.835829	27.241797
18	125.46	71.94	37.873626	27.26901
20	125.54	72.02	37.877817	27.272028
25	125.74	72.22	37.887928	27.279308
30	126.22	72.7	37.910045	27.295232
35	126.35	72.83	37.915513	27.299169
40	126.41	72.89	37.917961	27.300932
45	126.45	72.93	37.919568	27.302089
50	126.54	73.02	37.923104	27.304635
55	126.6	73.08	37.925403	27.30629
60	126.64	73.12	37.926909	27.307374
70	126.73	73.21	37.930221	27.309759
80	126.85	73.33	37.93447	27.312818
90	127.08	73.56	37.942085	27.318301
100	127.21	73.69	37.946081	27.321179
120	127.4	73.88	37.951522	27.325096
140	127.44	73.92	37.952607	27.325877
160	127.48	73.96	37.95367	27.326643
180	127.52	74	37.954713	27.327393
210	127.57	74.05	37.955987	27.32831
240	127.65	74.13	37.957956	27.329728
270	127.74	74.22	37.960071	27.331251
300	127.83	74.31	37.962079	27.332697
360	127.88	74.36	37.963149	27.333467
420	127.9	74.38	37.963568	27.333769
480	127.93	74.41	37.964186	27.334214
540	127.95	74.43	37.964591	27.334506
600	128.04	74.52	37.966351	27.335773
660	128.13	74.61	37.968004	27.336963
720	128.18	74.66	37.968876	27.337591
780	128.32	74.8	37.971143	27.339223
840	128.49	74.97	37.973549	27.340955
900	128.6	75.08	37.974903	27.34193
960	128.68	75.16	37.975787	27.342567
1020	128.75	75.23	37.976492	27.343074
1080	128.86	75.34	37.97747	27.343778
1140	128.94	75.42	37.978081	27.344218
1200	129.09	75.57	37.978999	27.344879
1260	129.17	75.65	37.979367	27.345145
1320	129.25	75.73	37.979652	27.345349
1380	129.39	75.87	37.979947	27.345562
1440	129.41	75.89	37.979968	27.345577
1500	129.45	75.93	37.979994	27.345596
1560	129.48	75.96	37.98	27.3456

Table 24 Recovery Test for Well SL-PW-07

Time(min)	recovery test water leavel	Drawdown (m)	Unconfined sc	SC	t/t'
0	131.03	77.51	37.9641858	27.3342137	#DIV/0!
1	73.48	19.96	17.3375566	12.4830408	1560
2	72.17	18.65	16.3604891	11.7795521	780
3	65.1	11.58	10.6973223	7.70207204	520
4	62.47	8.95	8.42273236	6.0643673	390
5	61.44	7.92	7.507109	5.40511848	312
6	60.87	7.35	6.99440166	5.03596919	260
7	60.55	7.03	6.70469128	4.82737773	222.8571
8	60.25	6.73	6.43186348	4.63094171	195
9	60.11	6.59	6.30413836	4.53897962	173.3333
10	59.94	6.42	6.14869668	4.42706161	156
12	59.66	6.14	5.89184571	4.24212891	130
14	59.42	5.9	5.67086625	4.0830237	111.4286
16	59.29	5.77	5.55085242	3.99661374	97.5
18	59.02	5.5	5.30088204	3.81663507	86.66667
20	58.89	5.37	5.18018365	3.72973223	78
25	58.6	5.08	4.91013165	3.53529479	62.4
30	58.21	4.69	4.54521261	3.27255308	52
35	58.05	4.53	4.39492299	3.16434455	44.57143
40	57.96	4.44	4.31023697	3.10337062	39
45	57.76	4.24	4.12166403	2.9675981	34.66667
50	57.64	4.12	4.00826751	2.88595261	31.2
55	57.52	4	3.89468141	2.80417062	28.36364
60	57.43	3.91	3.80936743	2.74274455	26
70	57.24	3.72	3.62890995	2.61281517	22.28571
80	57.06	3.54	3.45751185	2.48940853	19.5

90	56.93	3.41	3.33345906	2.40009052	17.33333
100	56.85	3.33	3.25700829	2.34504597	15.6
120	56.6	3.08	3.01755661	2.17264076	13
140	56.45	2.93	2.87349065	2.06891327	11.14286
160	56.18	2.66	2.61342549	1.88166635	9.75
180	55.9	2.38	2.34271459	1.6867545	8.666667
210	55.86	2.34	2.30395735	1.65884929	7.428571
240	55.79	2.27	2.23608149	1.60997867	6.5
270	55.72	2.2	2.16814113	1.56106161	5.777778
300	55.58	2.06	2.03206688	1.46308815	5.2
360	55.44	1.92	1.8957346	1.36492891	4.333333
420	55.35	1.83	1.80795616	1.30172844	3.714286
480	55.31	1.79	1.76890929	1.27361469	3.25
540	55.22	1.7	1.68097683	1.21030332	2.888889

Table 25 Constant Pumping Test for Well SL-PW-08

Constant Test			
Time(min)	Water level, m	Drawdown, m	sc
0	49.19	0	0
1	68.6	19.41	9.5109
2	69.84	20.65	10.1185
3	70.1	20.91	10.2459
4	70.47	21.28	10.4272
5	70.8	21.61	10.5889
6	70.99	21.8	10.682
7	71.17	21.98	10.7702
8	71.36	22.17	10.8633
9	71.52	22.33	10.9417
10	71.65	22.46	11.0054
12	71.95	22.76	11.1524
14	72.07	22.88	11.2112
16	72.23	23.04	11.2896
18	72.38	23.19	11.3631
20	72.5	23.31	11.4219
25	72.75	23.56	11.5444
30	72.9	23.71	11.6179
35	73.09	23.9	11.711
40	73.2	24.01	11.7649
45	73.28	24.09	11.8041
50	73.39	24.2	11.858
55	73.45	24.26	11.8874
60	73.54	24.35	11.9315
70	73.67	24.48	11.9952

80	73.78	24.59	12.0491
90	73.84	24.65	12.0785
100	73.91	24.72	12.1128
120	74.04	24.85	12.1765
140	74.11	24.92	12.2108
160	74.18	24.99	12.2451
180	74.25	25.06	12.2794
210	74.34	25.15	12.3235
240	74.4	25.21	12.3529
270	74.48	25.29	12.3921
300	74.54	25.35	12.4215
360	74.61	25.42	12.4558
420	74.65	25.46	12.4754
480	74.68	25.49	12.4901
540	74.73	25.54	12.5146
600	74.77	25.58	12.5342
660	74.82	25.63	12.5587
720	74.9	25.71	12.5979
780	74.92	25.73	12.6077
840	74.92	25.73	12.6077
900	74.94	25.75	12.6175
960	74.98	25.79	12.6371
1020	74.98	25.79	12.6371
1080	74.98	25.79	12.6371
1140	74.98	25.79	12.6371
1200	74.98	25.79	12.6371
1260	74.98	25.79	12.6371
1320	75	25.81	12.6469
1380	75.02	25.83	12.6567
1440	75.03	25.84	12.6616
1500	75.04	25.85	12.6665
1680	75.1	25.91	12.6959

1740	75.14	25.95	12.7155
1800	75.15	25.96	12.7204
1860	75.16	25.97	12.7253
1920	75.18	25.99	12.7351
1980	75.2	26.01	12.7449
2040	75.2	26.01	12.7449
2100	75.2	26.01	12.7449
2160	75.2	26.01	12.7449
2220	75.22	26.03	12.7547
2280	75.25	26.06	12.7694
2340	75.26	26.07	12.7743
2400	75.27	26.08	12.7792
2460	75.28	26.09	12.7841
2520	75.3	26.11	12.7939
2580	75.32	26.13	12.8037
2640	75.33	26.14	12.8086
2700	75.33	26.14	12.8086
2760	75.35	26.16	12.8184
2820	75.35	26.16	12.8184
2880	75.36	26.17	12.8233
2940	75.36	26.17	12.8233
3000	75.37	26.18	12.8282
3060	75.38	26.19	12.8331
3120	75.39	26.2	12.838
3180	75.4	26.21	12.8429
3240	75.41	26.22	12.8478
3300	75.41	26.22	12.8478
3360	75.42	26.23	12.8527
3420	75.43	26.24	12.8576
3480	75.44	26.25	12.8625
3540	75.45	26.26	12.8674
3600	75.46	26.27	12.8723

3660	75.47	26.28	12.8772
3720	75.48	26.29	12.8821
3780	75.5	26.31	12.8919
3840	75.54	26.35	12.9115
3900	75.55	26.36	12.9164
3960	75.55	26.36	12.9164
4020	75.55	26.36	12.9164
4080	75.55	26.36	12.9164
4140	75.56	26.37	12.9213
4200	75.57	26.38	12.9262
4260	75.58	26.39	12.9311
4320	75.6	26.41	12.9409

Table 26 Recovery Test for Well SL-PW-08

Time (min)	Water level,(m)	Drawdown, m	sc	t/t’
0	75.6	26.41	12.9409	#DIV/0!
1	53.85	4.66	2.2834	960
2	52.91	3.72	1.8228	480
3	52.59	3.4	1.666	320
4	52.4	3.21	1.5729	240
5	52.29	3.1	1.519	192
6	52.11	2.92	1.4308	160
7	51.96	2.77	1.3573	137.1429
8	51.8	2.61	1.2789	120
9	51.68	2.49	1.2201	106.6667
10	51.58	2.39	1.1711	96
12	51.4	2.21	1.0829	80
14	51.29	2.1	1.029	68.57
16	51.16	1.97	0.9653	60
18	51.09	1.9	0.931	53.33
20	50.99	1.8	0.882	48
25	50.85	1.66	0.8134	38.4
30	50.72	1.53	0.7497	32
35	50.6	1.41	0.6909	27.42
40	50.58	1.39	0.6811	24
45	50.52	1.33	0.6517	21.33

50	50.47	1.28	0.6272	19.2
55	50.4	1.21	0.5929	17.45
60	50.38	1.19	0.5831	16
70	50.31	1.12	0.5488	13.7
80	50.25	1.06	0.5194	12
90	50.21	1.02	0.4998	10.66
100	50.18	0.99	0.4851	9.6
120	50.11	0.92	0.4508	8
140	49.98	0.79	0.3871	6.85
160	49.95	0.76	0.3724	6
180	49.88	0.69	0.3381	5.33
210	49.86	0.67	0.3283	4.57
240	49.84	0.65	0.3185	4

270	49.83	0.64	0.3136	3.55
300	49.81	0.62	0.3038	3.2
360	49.79	0.6	0.294	2.66
420	49.77	0.58	0.2842	2.28
480	49.73	0.54	0.2646	2
540	49.71	0.52	0.2548	1.77
600	49.69	0.5	0.245	1.6
660	49.66	0.47	0.2303	1.45
720	49.63	0.44	0.2156	1.33
780	49.6	0.41	0.2009	1.23
840	49.58	0.39	0.1911	1.14
900	49.55	0.36	0.1764	1.06
960	49.51	0.32	0.1568	1

Table 27 Constant Pumping Test for Well SL-PW-17

Time (min)	Water level(m)	Drawdown m	unconfined sc	sc
0	78.54	0	0	0
1	92.8	14.26	13.778658	1.3778658
2	98.62	20.08	19.125575	1.9125575
3	99.76	21.22	20.154128	2.0154128
4	102.34	23.8	22.459187	2.2459187
5	104.67	26.13	24.513807	2.4513807
6	105.92	27.38	25.605478	2.5605478
7	107.05	28.51	26.585983	2.6585983
8	107.13	28.59	26.65517	2.665517
9	108.76	30.22	28.058261	2.8058261
10	109.28	30.74	28.50322	2.850322
12	109.77	31.23	28.92134	2.892134
14	110.19	31.65	29.278835	2.9278835
16	110.85	32.31	29.838911	2.9838911
18	110.96	32.42	29.932057	2.9932057
20	111.49	32.95	30.380047	3.0380047
25	111.76	33.22	30.607756	3.0607756
30	112.84	34.3	31.515145	3.1515145
35	112.97	34.43	31.623995	3.1623995
40	112.95	34.41	31.607254	3.1607254
45	113.35	34.81	31.941714	3.1941714
50	113.62	35.08	32.167046	3.2167046
55	113.47	34.93	32.041904	3.2041904
60	113.62	35.08	32.167046	3.2167046
70	114.64	36.1	33.015187	3.3015187
80	114.74	36.2	33.098073	3.3098073
90	115.32	36.78	33.577878	3.3577878
100	115.72	37.18	33.90785	3.390785
120	115.75	37.21	33.932568	3.3932568
140	116.05	37.51	34.179507	3.4179507
160	116.43	37.89	34.491685	3.4491685
180	116.56	38.02	34.598326	3.4598326
210	116.94	38.4	34.909587	3.4909587
240	117.4	38.86	35.285461	3.5285461
270	117.85	39.31	35.652195	3.5652195
300	118.04	39.5	35.806751	3.5806751
360	118.64	40.1	36.293699	3.6293699
420	118.98	40.44	36.568879	3.6568879
480	119.34	40.8	36.859651	3.6859651
540	119.65	41.11	37.109545	3.7109545
600	120.02	41.48	37.407211	3.7407211
660	120.23	41.69	37.575868	3.7575868
720	120.51	41.97	37.80042	3.780042
780	120.72	42.18	37.96859	3.796859
840	120.86	42.32	38.080587	3.8080587
900	120.91	42.37	38.120564	3.8120564
960	121.11	42.57	38.280352	3.8280352
1020	121.25	42.71	38.39209	3.839209
1080	121.48	42.94	38.57546	3.857546
1140	121.56	43.02	38.639182	3.8639182
1200	121.75	43.21	38.7904	3.87904
1260	121.78	43.24	38.814261	3.8814261
1320	121.9	43.36	38.909662	3.8909662
1380	122.19	43.65	39.139934	3.9139934
1440	122.34	43.8	39.258884	3.9258884
1500	122.51	43.97	39.393565	3.9393565
1560	122.63	44.09	39.488551	3.9488551
1620	122.74	44.2	39.575562	3.9575562
1680	122.92	44.38	39.71782	3.971782
1740	123.02	44.48	39.796786	3.9796786
1800	123.14	44.6	39.891483	3.9891483
1860	123.2	44.66	39.938806	3.9938806
1920	123.26	44.72	39.986112	3.9986112
1980	123.39	44.85	40.088549	4.0088549
2040	123.41	44.87	40.104302	4.0104302
2100	123.34	44.8	40.04916	4.004916
2160	123.44	44.9	40.127927	4.0127927
2220	123.48	44.94	40.159421	4.0159421
2280	123.55	45.01	40.214516	4.0214516
2340	123.61	45.07	40.261723	4.0261723

2400	123.58	45.04	40.238121	4.0238121
2460	123.58	45.04	40.238121	4.0238121
2520	123.69	45.15	40.324638	4.0324638
2580	123.7	45.16	40.3325	4.03325
2640	123.83	45.29	40.434667	4.0434667
2700	123.84	45.3	40.442522	4.0442522
2760	123.99	45.45	40.5603	4.05603
2820	124.04	45.5	40.599536	4.0599536
2880	123.92	45.38	40.505351	4.0505351
2940	124.08	45.54	40.630916	4.0630916
3000	124.16	45.62	40.693653	4.0693653
3060	124.21	45.67	40.732849	4.0732849
3120	124.28	45.74	40.787703	4.0787703
3180	124.26	45.72	40.772032	4.0772032
3240	124.34	45.8	40.834702	4.0834702
3300	124.31	45.77	40.811204	4.0811204
3360	124.38	45.84	40.866025	4.0866025

3420	124.4	45.86	40.881683	4.0881683
3480	124.4	45.86	40.881683	4.0881683
3540	124.42	45.88	40.89734	4.089734
3600	124.45	45.91	40.920822	4.0920822
3660	124.43	45.89	40.905168	4.0905168
3720	124.49	45.95	40.952124	4.0952124
3780	124.52	45.98	40.975596	4.0975596
3840	124.56	46.02	41.006885	4.1006885
3900	124.54	46	40.991242	4.0991242
3960	124.6	46.06	41.038167	4.1038167
4020	124.61	46.07	41.045986	4.1045986
4080	124.58	46.04	41.022527	4.1022527
4140	124.63	46.09	41.061623	4.1061623
4200	124.65	46.11	41.077258	4.1077258
4260	124.64	46.1	41.069441	4.1069441
4320	124.67	46.13	41.092891	4.1092891

Table 28 Recovery Test for well SL-PW-17

Time(min)	Water level (m)	Drawdown (m)	unconfined sc	sc	t/t''
0	124.67	46.13	41.092891	4.1092891	#DIV/0!
1	103.03	24.49	23.070315	2.3070315	720.0
2	97.25	18.71	17.881367	1.7881367	360.0
3	92.72	14.18	13.704044	1.3704044	240.0
4	91.07	12.53	12.158365	1.2158365	180.0
5	90.23	11.69	11.366523	1.1366523	144.0
6	89.63	11.09	10.798876	1.0798876	120.0
7	89.12	10.58	10.315037	1.0315037	102.9
8	88.74	10.2	9.9537282	0.9953728	90.0
9	88.48	9.94	9.7061232	0.9706123	80.0
10	88.27	9.73	9.5059009	0.9505901	72.0
12	87.96	9.42	9.2099531	0.9209953	60.0
14	87.66	9.12	8.9231189	0.8923119	51.4
16	87.49	8.95	8.7603903	0.876039	45.0
18	87.23	8.69	8.5112467	0.8511247	40.0
20	87.07	8.53	8.3577685	0.8357769	36.0
25	86.73	8.19	8.031225	0.8031225	28.8
30	86.35	7.81	7.6656169	0.7665617	24.0
35	86.04	7.5	7.3668513	0.7366851	20.6
40	85.75	7.21	7.0869491	0.7086949	18.0
45	85.47	6.93	6.8163208	0.6816321	16.0
50	85.23	6.69	6.5840584	0.6584058	14.4
55	84.98	6.44	6.3418283	0.6341828	13.1
60	84.72	6.18	6.0895952	0.6089595	12.0
70	84.48	5.94	5.8564806	0.5856481	10.3
80	84.27	5.73	5.6522816	0.5652282	9.0
90	83.98	5.44	5.3699493	0.5369949	8.0
100	83.73	5.19	5.1262399	0.512624	7.2
120	83.52	4.98	4.9212953	0.4921295	6.0

140	83.33	4.79	4.7356893	0.4735689	5.1
160	83.03	4.49	4.4422793	0.4442279	4.5
180	82.73	4.19	4.1484432	0.4148443	4.0
210	82.47	3.93	3.8934406	0.3893441	3.4
240	82.28	3.74	3.7068901	0.370689	3.0
270	82.13	3.59	3.5594927	0.3559493	2.7
300	82.03	3.49	3.4611686	0.3461169	2.4
360	81.75	3.21	3.1856093	0.3185609	2.0
420	81.43	2.89	2.8702298	0.287023	1.7
480	81.26	2.72	2.7024873	0.2702487	1.5
540	81.07	2.53	2.5148485	0.2514849	1.3
600	80.82	2.28	2.2676949	0.2267695	1.2
660	80.81	2.27	2.2578026	0.2257803	1.1
720	80.8	2.26	2.2479099	0.224791	1.0

Table 29 Constant Pumping Test for Well SL-PW-19

Time (min)	Water level,(m)	Drawdown (m)	unconfined sc	sc
0	90.5	0	0	0
1	101.7	11.2	10.937298	3.6093085
2	106.02	15.52	15.015559	4.9551346
3	107.91	17.41	16.775219	5.5358222
4	109.03	18.53	17.81092	5.8776035
5	109.9	19.4	18.611812	6.1418978
6	110.66	20.16	19.308847	6.3719195
7	111.06	20.56	19.674736	6.4926629
8	111.55	21.05	20.122037	6.6402721
9	112.11	21.61	20.632006	6.808562
10	112.39	21.89	20.886498	6.8925444
12	113.15	22.65	21.575607	7.1199504
14	113.86	23.36	22.217195	7.3316742
16	114.55	24.05	22.838686	7.5367663
18	115.26	24.76	23.47611	7.7471162
20	115.83	25.33	23.986316	7.9154844
25	117.56	27.06	25.526506	8.4237468
30	118.6	28.1	26.446366	8.7273009
35	120.4	29.9	28.027728	9.2491502
40	121.28	30.78	28.795899	9.5026466
45	121.99	31.49	29.413309	9.7063919
50	122.7	32.2	30.028607	9.9094404
55	123.4	32.9	30.633173	10.108947
60	123.94	33.44	31.09815	10.262389
70	125.42	34.92	32.366269	10.680869
80	126.65	36.15	33.413199	11.026356
90	127.8	37.3	34.386304	11.34748
100	128.52	38.02	34.992732	11.547602
120	130.07	39.57	36.290869	11.975987
140	131.35	40.85	37.355293	12.327247
160	132.33	41.83	38.165604	12.594649
180	133.45	42.95	39.086749	12.898627
210	133.24	42.74	38.914434	12.841763
240	135.05	44.55	40.393555	13.329873
270	135.4	44.9	40.67799	13.423737
300	136.35	45.85	41.44744	13.677655
360	137.27	46.77	42.188989	13.922366
420	138.06	47.56	42.822924	14.131565
480	138.94	48.44	43.526003	14.363581
540	139	48.5	43.573822	14.379361
600	139.45	48.95	43.931984	14.497555
660	139.86	49.36	44.257572	14.604999
720	140.22	49.72	44.542872	14.699148
780	140.68	50.18	44.906634	14.819189
840	140.9	50.4	45.080293	14.876497
900	141.18	50.68	45.301021	14.949337
960	141.36	50.86	45.442744	14.996106
1020	141.83	51.33	45.812159	15.118013
1080	141.99	51.49	45.937707	15.159443
1140	142.1	51.6	46.023958	15.187906
1200	142.56	52.06	46.384097	15.306752
1260	142.72	52.22	46.509155	15.348021
1320	142.85	52.35	46.610686	15.381526
1380	143.02	52.52	46.74335	15.425305
1440	143.13	52.63	46.829127	15.453612
1500	143.4	52.9	47.039455	15.52302
1560	143.7	53.2	47.272796	15.600023
1620	143.8	53.3	47.350492	15.625662
1680	143.85	53.35	47.389325	15.638477
1740	144.03	53.53	47.529035	15.689577
1800	144.25	53.75	47.699607	15.74087
1860	144.38	53.88	47.800305	15.774101
1920	144.6	54.1	47.970555	15.830283
1980	144.71	54.21	48.055604	15.858349
2040	144.76	54.26	48.094246	15.871101
2100	144.85	54.35	48.163775	15.894046
2160	144.92	54.42	48.21783	15.911884
2220	145	54.5	48.279581	15.932262
2280	145.08	54.58	48.341306	15.952631

2340	145.15	54.65	48.395293	15.977864	3360	146.62	56.12	49.524284	16.343014
2400	145.22	54.72	48.44926	15.988256	3420	146.66	56.16	49.554878	16.35311
2460	145.28	54.78	48.495501	16.003515	3480	146.67	56.17	49.562526	16.355634
2520	145.28	54.78	48.495501	16.003515	3540	146.7	56.2	49.585466	16.363204
2580	145.35	54.85	48.549429	16.021312	3600	146.7	56.2	49.585466	16.363204
2640	145.41	54.91	48.595637	16.03656	3660	146.72	56.22	49.600757	16.36825
2700	145.5	55	48.664921	16.059424	3720	146.74	56.24	49.616047	16.373295
2760	145.55	55.05	48.703398	16.072121	3780	146.76	56.26	49.631335	16.378341
2820	145.63	55.13	48.764938	16.09243	3840	146.78	56.28	49.646621	16.383385
2880	145.7	55.2	48.818764	16.110192	3900	146.8	56.3	49.661906	16.388429
2940	145.82	55.32	48.91099	16.140627	3960	146.85	56.35	49.70011	16.401036
3000	145.9	55.4	48.97244	16.160905	4020	146.85	56.35	49.70011	16.401036
3060	146.06	55.56	49.095259	16.201436	4080	146.86	56.36	49.70775	16.403557
3120	146.18	55.68	49.187304	16.23181	4140	146.89	56.39	49.730666	16.41112
3180	146.35	55.85	49.317597	16.274807	4200	146.9	56.4	49.738304	16.41364
3240	146.41	55.91	49.363554	16.289973	4260	146.95	56.45	49.776487	16.426241
3300	146.52	56.02	49.447769	16.317764	4320	147.06	56.56	49.860453	16.45395

Table 30 Recovery Test for well SL-PW-19

Time (min)	Water level,(m)	Drawdown (m)	unconfined RRDD	SC	t/t''
0	147.06	56.56	49.860453	16.45395	#DIV/0!
1	129.53	39.03	35.839757	11.82712	1320.0
2	128.93	38.43	35.337089	11.661239	660.0
3	127.67	37.17	34.276578	11.311271	440.0
4	126.84	36.34	33.574355	11.079537	330.0
5	125.9	35.4	32.775581	10.815942	264.0
6	125.05	34.55	32.050099	10.576533	220.0
7	124	33.5	31.149738	10.279414	188.6
8	122.75	32.25	30.071859	9.9237134	165.0
9	122.03	31.53	29.44803	9.7178497	146.7
10	121.83	31.33	29.274358	9.6605382	132.0
12	120.83	30.33	28.403489	9.3731514	110.0
14	119.45	28.95	27.194812	8.9742878	94.3
16	118.73	28.23	26.561031	8.7651401	82.5
18	117.8	27.3	25.739183	8.4939305	73.3
20	116.88	26.38	24.922609	8.2244608	66.0
25	114.6	24.1	22.883644	7.5516025	52.8
30	112.68	22.18	21.149733	6.979412	44.0
35	111	20.5	19.619895	6.4745654	37.7
40	110.28	19.78	18.960632	6.2570084	33.0
45	109.42	18.92	18.170332	5.9962096	29.3
50	107.98	17.48	16.840104	5.5572343	26.4
55	107.04	16.54	15.967075	5.2691348	24.0
60	106.36	15.86	15.333215	5.0599611	22.0
70	104.8	14.3	13.871749	4.5776771	18.9
80	104.08	13.58	13.193788	4.3539499	16.5
90	103.03	12.53	12.201202	4.0263968	14.7
100	101.65	11.15	10.889639	3.5935808	13.2
120	100.38	9.88	9.6755719	3.1929387	11.0

140	99.09	8.59	8.4354699	2.7837051	9.4
160	98.58	8.08	7.9432746	2.6212806	8.3
180	97.44	6.94	6.8391338	2.2569142	7.3
210	96.12	5.62	5.5538547	1.832772	6.3
240	95.03	4.53	4.4870243	1.480718	5.5
270	94.8	4.3	4.2612775	1.4062216	4.9
300	94.52	4.02	3.9861562	1.3154316	4.4
360	93.8	3.3	3.2771937	1.0814739	3.7
420	93.35	2.85	2.8329895	0.9348865	3.1
480	92.84	2.34	2.3285328	0.7684158	2.8
540	92.48	1.98	1.9717897	0.6506906	2.4
600	92.12	1.62	1.6145039	0.5327863	2.2
660	91.87	1.37	1.3660693	0.4508029	2.0
720	91.65	1.15	1.1472304	0.378586	1.8
780	91.48	0.98	0.9779887	0.3227363	1.7
840	91.31	0.81	0.808626	0.2668466	1.6
900	91.23	0.73	0.728884	0.2405317	1.5
960	91.11	0.61	0.6092207	0.2010428	1.4
1020	90.98	0.48	0.4795175	0.1582408	1.3
1080	90.87	0.37	0.3697133	0.1220054	1.2
1140	90.76	0.26	0.2598584	0.0857533	1.2
1200	90.63	0.13	0.1299646	0.0428883	1.1
1260	90.55	0.05	0.0499948	0.0164983	1.0

Table 31 Constant Pumping Test for well SL-PW-21

Constant Test			
Time(min)	Water level(,m)	Drawdown, (m)	SC
0	98.47	0	0
1	105.1	6.63	1.7901
2	105.82	7.35	1.9845
3	106.2	7.73	2.0871
4	106.46	7.99	2.1573
5	106.61	8.14	2.1978
6	106.73	8.26	2.2302
7	106.84	8.37	2.2599
8	106.9	8.43	2.2761
9	107	8.53	2.3031
10	107.02	8.55	2.3085
12	107.09	8.62	2.3274
14	107.15	8.68	2.3436
16	107.21	8.74	2.3598
18	107.24	8.77	2.3679
20	107.3	8.83	2.3841
25	107.38	8.91	2.4057
30	107.4	8.93	2.4111
35	107.45	8.98	2.4246
40	107.5	9.03	2.4381
45	107.53	9.06	2.4462
50	107.55	9.08	2.4516
55	107.58	9.11	2.4597
60	107.6	9.13	2.4651
70	107.61	9.14	2.4678
80	107.63	9.16	2.4732
90	107.64	9.17	2.4759
100	107.65	9.18	2.4786
120	107.68	9.21	2.4867
140	107.74	9.27	2.5029
160	107.76	9.29	2.5083
180	107.78	9.31	2.5137
210	107.8	9.33	2.5191
240	107.8	9.33	2.5191
270	107.81	9.34	2.5218
300	107.81	9.34	2.5218
360	107.81	9.34	2.5218
420	107.82	9.35	2.5245
480	107.84	9.37	2.5299
540	107.88	9.41	2.5407
600	107.9	9.43	2.5461
660	107.93	9.46	2.5542
720	107.94	9.47	2.5569
780	107.96	9.49	2.5623
840	107.97	9.5	2.565
900	107.98	9.51	2.5677
960	107.98	9.51	2.5677
1020	107.97	9.5	2.565
1080	107.97	9.5	2.565
1140	107.97	9.5	2.565
1200	107.97	9.5	2.565
1260	107.97	9.5	2.565
1320	107.98	9.51	2.5677
1380	107.99	9.52	2.5704
1440	108	9.53	2.5731
1500	108	9.53	2.5731
1560	108.02	9.55	2.5785
1620	108.03	9.56	2.5812
1680	108.04	9.57	2.5839

1740	108.05	9.58	2.5866
1800	108.04	9.57	2.5839
1860	108.04	9.57	2.5839
1920	108.05	9.58	2.5866
1980	108.06	9.59	2.5893
2040	108.06	9.59	2.5893
2100	108.08	9.61	2.5947
2160	108.11	9.64	2.6028
2220	108.12	9.65	2.6055
2280	108.12	9.65	2.6055
2340	108.13	9.66	2.6082
2400	108.14	9.67	2.6109
2460	108.15	9.68	2.6136
2520	108.15	9.68	2.6136
2580	108.16	9.69	2.6163
2640	108.16	9.69	2.6163
2700	108.17	9.7	2.619
2760	108.18	9.71	2.6217
2820	108.19	9.72	2.6244
2880	108.2	9.73	2.6271
2940	108.22	9.75	2.6325
3000	108.23	9.76	2.6352

3060	108.24	9.77	2.6379
3120	108.24	9.77	2.6379
3180	108.24	9.77	2.6379
3240	108.24	9.77	2.6379
3300	108.24	9.77	2.6379
3360	108.23	9.76	2.6352
3420	108.23	9.76	2.6352
3480	108.23	9.76	2.6352
3540	108.24	9.77	2.6379
3600	108.25	9.78	2.6406
3660	108.25	9.78	2.6406
3720	108.26	9.79	2.6433
3780	108.26	9.79	2.6433
3840	108.27	9.8	2.646
3900	108.27	9.8	2.646
3960	108.28	9.81	2.6487
4020	108.28	9.81	2.6487
4080	108.29	9.82	2.6514
4140	108.29	9.82	2.6514
4200	108.3	9.83	2.6541
4260	108.3	9.83	2.6541
4320	108.3	9.83	2.6541

Table 32 Recovery Test for Well SL-PL-21

Time (min)	Water level(m)	Drawdown ,(m)	sc	t/t''
0	108.3	9.83	2.6541	#DIV/0!
1	99.4	0.93	0.2511	1200.0
2	99	0.53	0.1431	600.0
3	98.95	0.48	0.1296	400.0
4	98.83	0.36	0.0972	300.0
5	98.8	0.33	0.0891	240.0
6	98.78	0.31	0.0837	200.0
7	98.76	0.29	0.0783	171.4
8	98.74	0.27	0.0729	150.0
9	98.72	0.25	0.0675	133.3
10	98.7	0.23	0.0621	120.0
12	98.69	0.22	0.0594	100.0
14	98.68	0.21	0.0567	85.7
16	98.67	0.2	0.054	75.0
18	98.66	0.19	0.0513	66.7
20	98.66	0.19	0.0513	60.0
25	98.65	0.18	0.0486	48.0
30	98.64	0.17	0.0459	40.0
35	98.63	0.16	0.0432	34.3
40	98.62	0.15	0.0405	30.0
45	98.61	0.14	0.0378	26.7
50	98.6	0.13	0.0351	24.0
55	98.6	0.13	0.0351	21.8
60	98.59	0.12	0.0324	20.0
70	98.58	0.11	0.0297	17.1
80	98.57	0.1	0.027	15.0
90	98.57	0.1	0.027	13.3
100	98.57	0.1	0.027	12.0
120	98.56	0.09	0.0243	10.0
140	98.56	0.09	0.0243	8.6
160	98.56	0.09	0.0243	7.5
180	98.55	0.08	0.0216	6.7
210	98.55	0.08	0.0216	5.7
240	98.54	0.07	0.0189	5.0
270	98.53	0.06	0.0162	4.4
300	98.53	0.06	0.0162	4.0

360	98.52	0.05	0.0135	3.3
420	98.52	0.05	0.0135	2.9
480	98.51	0.04	0.0108	2.5
540	98.51	0.04	0.0108	2.2
600	98.51	0.04	0.0108	2.0
660	98.5	0.03	0.0081	1.8
720	98.5	0.03	0.0081	1.7
780	98.5	0.03	0.0081	1.5
840	98.49	0.02	0.0054	1.4
900	98.49	0.02	0.0054	1.3
960	98.49	0.02	0.0054	1.3
1020	98.48	0.01	0.0027	1.2
1080	98.48	0.01	0.0027	1.1

Table 33 Constant Pumping Test for well SL-PW-22

Time (min)	Water level,(m)	Drawdown (m)	unconfined sc	sc
0	76.65	0	0	0
1	99.35	22.7	22.2096	7.551
2	104.52	27.87	27.1307	9.224
3	107.4	30.75	29.8501	10.14
4	108.88	32.23	31.2414	10.62
5	110.15	33.5	32.4319	11.02
6	110.75	34.1	32.9933	11.21
7	111.4	34.75	33.6007	11.424
8	112.04	35.39	34.198	11.627
9	112.5	35.85	34.6268	11.773
10	112.9	36.25	34.9993	11.899
12	113.6	36.95	35.6506	12.121
14	114.25	37.6	36.2545	12.326
16	114.88	38.23	36.839	12.525
18	115.45	38.8	37.3672	12.704
20	115.8	39.15	37.6912	12.815
25	116.3	39.65	38.1537	12.972
30	117	40.35	38.8004	13.192
35	117.35	40.7	39.1234	13.301
40	117.55	40.9	39.3079	13.364
45	117.85	41.2	39.5845	13.458
50	118.02	41.37	39.7411	13.511
55	118.21	41.56	39.9161	13.571
60	118.42	41.77	40.1095	13.637
70	118.56	41.91	40.2383	13.681
80	118.67	42.02	40.3395	13.715
90	118.71	42.06	40.3763	13.727
100	118.8	42.15	40.4591	13.756
120	118.87	42.22	40.5235	13.777
140	118.99	42.34	40.6338	13.8155

160	119.25	42.6	40.8728	13.89675
180	119.28	42.63	40.9004	13.90613
210	119.31	42.66	40.9279	13.9155
240	119.38	42.73	40.9923	13.93737
270	119.43	42.78	41.0382	13.95298
300	119.45	42.8	41.0566	13.95923
360	119.48	42.83	41.0841	13.9686
420	119.52	42.87	41.1208	13.98109
480	119.56	42.91	41.1576	13.99358
540	119.59	42.94	41.1851	14.00294
600	119.62	42.97	41.2127	14.01231
660	119.68	43.03	41.2678	14.03104
720	119.74	43.09	41.3228	14.04977
780	119.85	43.2	41.4238	14.0841
840	119.92	43.27	41.4881	14.10594
900	119.94	43.29	41.5064	14.11218
960	119.9	43.25	41.4697	14.0997
1020	119.86	43.21	41.433	14.08722
1080	119.85	43.2	41.4238	14.0841
1140	119.85	43.2	41.4238	14.0841
1200	119.74	43.09	41.3228	14.04977
1260	119.8	43.15	41.3779	14.06849
1320	119.8	43.15	41.3779	14.06849
1380	119.74	43.09	41.3228	14.04977
1440	119.76	43.11	41.3412	14.05601
1500	119.78	43.13	41.3596	14.06225
1560	119.8	43.15	41.3779	14.0684
1620	119.8	43.15	41.3779	14.0684
1680	119.8	43.15	41.3779	14.0684
1740	119.79	43.14	41.3687	14.0653
1800	119.81	43.16	41.3871	14.0716
1860	119.81	43.16	41.3871	14.0716

1920	119.82	43.17	41.3963	14.0747
1980	119.82	43.17	41.3963	14.0747
2040	119.83	43.18	41.4055	14.0778
2100	119.85	43.2	41.4238	14.0841
2160	119.87	43.22	41.4422	14.0903
2220	119.88	43.23	41.4513	14.0934
2280	119.9	43.25	41.4697	14.0997
2340	119.9	43.25	41.4697	14.0997
2400	119.91	43.26	41.4789	14.1028
2460	119.92	43.27	41.4881	14.1059
2520	119.93	43.28	41.4972	14.1090
2580	119.94	43.29	41.5064	14.1121
2640	119.94	43.29	41.5064	14.1121
2700	119.95	43.3	41.5156	14.1153
2760	119.95	43.3	41.5156	14.1153
2820	119.94	43.29	41.5064	14.1121
2880	119.95	43.3	41.5156	14.1153
2940	119.96	43.31	41.5248	14.1184
3000	119.98	43.33	41.5431	14.12466
3060	120	43.35	41.5615	14.1309
3120	120.02	43.37	41.5798	14.13713
3180	120.05	43.4	41.6073	14.14649
3240	120.07	43.42	41.6257	14.15273
3300	120.05	43.4	41.6073	14.14649
3360	120.05	43.4	41.6073	14.14649
3420	120.07	43.42	41.6257	14.15273
3480	120.08	43.43	41.6348	14.15585
3540	120.09	43.44	41.644	14.15897
3600	120.09	43.44	41.644	14.15897
3660	120.1	43.45	41.6532	14.16209
3720	120.11	43.46	41.6624	14.16521
3780	120.1	43.45	41.6532	14.16209

3840	120.11	43.46	41.6624	14.16521
3900	120.11	43.46	41.6624	14.16521
3960	120.11	43.46	41.6624	14.16521
4020	120.11	43.46	41.6624	14.16521
4080	120.12	43.47	41.6715	14.16832

4140	120.12	43.47	41.6715	14.16832
4200	120.12	43.47	41.6715	14.16832
4260	120.12	43.47	41.6715	14.16832
4320	120.13	43.48	41.6807	14.17144

Table 34 Recover Test Well For SL-PW-22

Time(min)	Water level,(m)	Water level,(m)	unconfined sc	sc	t/t''
0	120.13	43.48	41.680713	14.171443	#DIV/0!
1	84.88	8.23	8.1655355	2.7762821	1440
2	82.08	5.43	5.4019379	1.8366589	720
3	80.47	3.82	3.8061117	1.294078	480
4	79.58	2.93	2.9218294	0.993422	360
5	79	2.35	2.344744	0.797213	288
6	78.8	2.15	2.1456006	0.7295042	240
7	78.5	1.85	1.8467426	0.6278925	205.7143
8	78.17	1.52	1.5178011	0.5160524	180
9	78.02	1.37	1.3682137	0.4651926	160
10	77.89	1.24	1.2385366	0.4211024	144
12	77.75	1.1	1.0988484	0.3736085	120
14	77.55	0.9	0.8992291	0.3057379	102.8571
16	77.46	0.81	0.8093756	0.2751877	90
18	77.4	0.75	0.7494646	0.254818	80
20	77.3	0.65	0.6495979	0.2208633	72
25	77.23	0.58	0.5796798	0.1970911	57.6
30	77.18	0.53	0.5297327	0.1801091	48
35	77.15	0.5	0.4997621	0.1699191	41.14286
40	77.14	0.49	0.4897715	0.1665223	36
45	77.13	0.48	0.4797807	0.1631254	32
50	77.12	0.47	0.4697898	0.1597285	28.8
55	77.11	0.46	0.4597986	0.1563315	26.18182
60	77.1	0.45	0.4498073	0.1529345	24
70	77.1	0.45	0.4498073	0.1529345	20.57143
80	77.09	0.44	0.4398157	0.1495374	18
90	77.08	0.43	0.429824	0.1461402	16
100	77.06	0.41	0.40984	0.1393456	14.4
120	77.05	0.4	0.3998477	0.1359482	12

140	77.03	0.38	0.3798626	0.1291533	10.28571
160	77	0.35	0.3498834	0.1189604	9
180	76.98	0.33	0.3298964	0.1121648	8
210	76.96	0.31	0.3099085	0.1053689	6.857143
240	76.94	0.29	0.28992	0.0985728	6
270	76.92	0.27	0.2699306	0.0917764	5.333333
300	76.9	0.25	0.2499405	0.0849798	4.8
360	76.88	0.23	0.2299497	0.0781829	4
420	76.86	0.21	0.209958	0.0713857	3.428571
480	76.84	0.19	0.1899656	0.0645883	3
540	76.82	0.17	0.1699725	0.0577906	2.666667
600	76.81	0.16	0.1599756	0.0543917	2.4
660	76.8	0.15	0.1499786	0.0509927	2.181818
720	76.78	0.13	0.1299839	0.0441945	2
780	76.77	0.12	0.1199863	0.0407953	1.846154
840	76.75	0.1	0.0999905	0.0339968	1.714286
900	76.72	0.07	0.0699953	0.0237984	1.6
960	76.71	0.06	0.0599966	0.0203988	1.5
1020	76.96	0.31	0.3099085	0.1053689	1.411765
1080	76.67	0.02	0.0199996	0.0067999	1.333333
1140	76.66	0.01	0.0099999	0.0034	1.263158

Table 35 Constant Pumping Test for Well SL-PW-11

Time(min)	Water level,(m)	Drawdown (m)	sc for partial penetration
0	50.04	0	0
1	52.7	2.66	1.79816
2	53.07	3.03	2.04828
3	53.31	3.27	2.21052
4	53.56	3.52	2.37952
5	53.75	3.71	2.50796
6	53.9	3.86	2.60936
7	54.08	4.04	2.73104
8	54.21	4.17	2.81892
9	54.31	4.27	2.88652
10	54.45	4.41	2.98116
12	54.68	4.64	3.13664
14	54.91	4.87	3.29212
16	55.08	5.04	3.40704
18	55.24	5.2	3.5152
20	55.4	5.36	3.62336
25	55.73	5.69	3.84644
30	56.05	6.01	4.06276
35	56.31	6.27	4.23852
40	56.54	6.5	4.394
45	56.71	6.67	4.50892
50	56.9	6.86	4.63736
55	57.09	7.05	4.7658
60	57.22	7.18	4.85368
70	57.52	7.48	5.05648
80	57.73	7.69	5.19844
90	57.92	7.88	5.32688
100	58.08	8.04	5.43504
120	58.36	8.32	5.62432
140	58.58	8.54	5.77304
160	58.77	8.73	5.90148
180	58.92	8.88	6.00288
210	59.07	9.03	6.10428
240	59.23	9.19	6.21244
270	59.34	9.3	6.2868
300	59.46	9.42	6.36792
360	59.63	9.59	6.48284
420	59.74	9.7	6.5572
480	59.86	9.82	6.63832
540	59.98	9.94	6.71944
600	60.1	10.06	6.80056
660	60.23	10.19	6.88844
720	60.27	10.23	6.91548
780	60.34	10.3	6.9628
840	60.38	10.34	6.98984
900	60.42	10.38	7.01688
960	60.49	10.45	7.0642
1020	60.57	10.53	7.11828
1080	60.64	10.6	7.1656
1140	60.66	10.62	7.17912
1200	60.72	10.68	7.21968
1260	60.75	10.71	7.23996
1320	60.79	10.75	7.267
1380	60.81	10.77	7.28052
1440	60.87	10.83	7.32108
1500	60.9	10.86	7.34136
1560	60.96	10.92	7.38192
1620	61	10.96	7.40896

1680	61.05	11.01	7.44276
1740	61.11	11.07	7.48332
1800	61.16	11.12	7.51712
1860	61.2	11.16	7.54416
1920	61.25	11.21	7.57796
1980	61.27	11.23	7.59148
2040	61.29	11.25	7.605
2100	61.31	11.27	7.61852
2160	61.33	11.29	7.63204
2220	61.38	11.34	7.66584
2280	61.41	11.37	7.68612
2340	61.45	11.41	7.71316
2400	61.5	11.46	7.74696
2460	61.55	11.51	7.78076
2520	61.59	11.55	7.8078
2580	61.62	11.58	7.82808
2640	61.64	11.6	7.8416
2700	61.66	11.62	7.85512
2760	61.68	11.64	7.86864
2820	61.7	11.66	7.88216
2880	61.73	11.69	7.90244
2940	61.76	11.72	7.92272
3000	61.79	11.75	7.943

3060	61.83	11.79	7.97004
3120	61.87	11.83	7.99708
3180	61.9	11.86	8.01736
3240	61.94	11.9	8.0444
3300	61.98	11.94	8.07144
3360	62	11.96	8.08496
3420	62.03	11.99	8.10524
3480	62.05	12.01	8.11876
3540	62.07	12.03	8.13228
3600	62.09	12.05	8.1458
3660	62.12	12.08	8.16608
3720	62.14	12.1	8.1796
3780	62.16	12.12	8.19312
3840	62.19	12.15	8.2134
3900	62.22	12.18	8.23368
3960	62.25	12.21	8.25396
4020	62.28	12.24	8.27424
4080	62.3	12.26	8.28776
4140	62.32	12.28	8.30128
4200	63.33	13.29	8.98404
4260	62.34	12.3	8.3148
4320	62.35	12.31	8.32156

Table 36 Recovery Test for Well SL-PW-11

Time (min)	Water level (m)	Residual DD,(m)	sc	t/t'
0	62.35	12.31	8.21077	#DIV/0!
1	59.58	9.54	6.36318	1440
2	58.78	8.74	5.82958	720
3	58.5	8.46	5.64282	480
4	58.26	8.22	5.48274	360
5	58.05	8.01	5.34267	288
6	57.95	7.91	5.27597	240
7	57.7	7.66	5.10922	205.71
8	57.55	7.51	5.00917	180
9	57.45	7.41	4.94247	160
10	57.33	7.29	4.86243	144
12	57.1	7.06	4.70902	120
14	56.83	6.79	4.52893	102.85
16	56.62	6.58	4.38886	90
18	56.45	6.41	4.27547	80
20	56.21	6.17	4.11539	72
25	55.8	5.76	3.84192	57.6
30	55.48	5.44	3.62848	48
35	55.45	5.41	3.60847	41.14286
40	54.89	4.85	3.23495	36
45	54.64	4.6	3.0682	32
50	54.46	4.42	2.94814	28.8
55	54.3	4.26	2.84142	26.18182
60	54.1	4.06	2.70802	24
70	53.92	3.88	2.58796	20.5714
80	53.75	3.71	2.47457	18
90	53.64	3.6	2.4012	16
100	53.51	3.47	2.31449	14.4
120	53.39	3.35	2.23445	12
140	53.3	3.26	2.17442	10.28571
160	53.23	3.19	2.12773	9
180	53.17	3.13	2.08771	8
210	53.11	3.07	2.04769	6.857143
240	53.08	3.04	2.02768	6
270	53.04	3	2.001	5.333333
300	52.99	2.95	1.96765	4.8
360	52.97	2.93	1.95431	4
420	52.95	2.91	1.94097	3.428571
480	52.94	2.9	1.9343	3
540	52.92	2.88	1.92096	2.666667
600	52.91	2.87	1.91429	2.4
660	52.88	2.84	1.89428	2.181818
720	52.86	2.82	1.88094	2
780	52.84	2.8	1.8676	1.846154
840	52.81	2.77	1.84759	1.714286
900	52.78	2.74	1.82758	1.6
960	52.75	2.71	1.80757	1.5
1020	52.74	2.7	1.8009	1.411765
1080	52.71	2.67	1.78089	1.333333
1140	52.69	2.65	1.76755	1.263158
1200	52.67	2.63	1.75421	1.2

1260	52.65	2.61	1.74087	1.142857
1320	52.63	2.59	1.72753	1.090909

1380	52.58	2.54	1.69418	1.043478
1440	52.54	2.5	1.6675	1

Table 37 Constant Pumping Test for Well SL-PW-12

Time (min)	Water level,(m)	Drawdown (m)	Sc(pp)
0	49.45	0	0
1	52.5	3.05	1.68601
2	52.6	3.15	1.741289
3	52.62	3.17	1.752344
4	52.63	3.18	1.757872
5	52.64	3.19	1.7634
6	52.65	3.2	1.768928
7	52.65	3.2	1.768928
8	52.66	3.21	1.774456
9	52.68	3.23	1.785512
10	52.7	3.25	1.796568
12	52.7	3.25	1.796568
14	52.72	3.27	1.807623
16	52.72	3.27	1.807623
18	52.74	3.29	1.818679
20	52.76	3.31	1.829735
25	52.78	3.33	1.840791
30	52.8	3.35	1.851847
35	52.84	3.39	1.873958
40	52.86	3.41	1.885014
45	52.88	3.43	1.89607
50	52.9	3.45	1.907126
55	52.92	3.47	1.918181
60	52.95	3.5	1.934765
70	52.97	3.52	1.945821
80	53.03	3.58	1.978988
90	53.06	3.61	1.995572
100	53.09	3.64	2.012156
120	53.16	3.71	2.050851
140	53.2	3.75	2.072963
160	53.24	3.79	2.095074
180	53.27	3.82	2.111658
210	53.3	3.85	2.128242
240	53.38	3.93	2.172465
270	53.4	3.95	2.183521
300	53.47	4.02	2.222216
360	53.58	4.13	2.283023
420	53.64	4.19	2.31619
480	53.72	4.27	2.360413
540	53.78	4.33	2.393581
600	53.85	4.4	2.432276
660	53.9	4.45	2.459916
720	53.94	4.49	2.482027
780	54	4.55	2.515195
840	54.03	4.58	2.531778
900	54.09	4.64	2.564946
960	54.16	4.71	2.603641
1020	54.24	4.79	2.647864
1080	54.31	4.86	2.686559

1140	54.36	4.91	2.714199
1200	54.42	4.97	2.747366
1260	54.45	5	2.76395
1320	54.49	5.04	2.786062
1380	54.54	5.09	2.813701
1440	54.57	5.12	2.830285
1500	54.6	5.15	2.846869
1560	54.63	5.18	2.863452
1620	54.66	5.21	2.880036
1680	54.68	5.23	2.891092
1740	54.72	5.27	2.913203
1800	54.76	5.31	2.935315
1860	54.79	5.34	2.951899
1920	54.85	5.4	2.985066
1980	54.9	5.45	3.012706
2040	54.94	5.49	3.034817
2100	54.97	5.52	3.051401
2160	55	5.55	3.067985
2220	55.04	5.59	3.090096
2280	55.08	5.63	3.112208
2340	55.1	5.65	3.123264
2400	55.13	5.68	3.139847
2460	55.15	5.7	3.150903
2520	55.17	5.72	3.161959
2580	55.19	5.74	3.173015
2640	55.23	5.78	3.195126
2700	55.27	5.82	3.217238
2760	55.31	5.86	3.239349

2820	55.34	5.89	3.255933
2880	55.36	5.91	3.266989
2940	55.38	5.93	3.278045
3000	55.4	5.95	3.289101
3060	55.42	5.97	3.300156
3120	55.44	5.99	3.311212
3180	55.46	6.01	3.322268
3240	55.48	6.03	3.333324
3300	55.51	6.06	3.349907
3360	55.53	6.08	3.360963
3420	55.55	6.1	3.372019
3480	55.58	6.13	3.388603
3540	55.61	6.16	3.405186
3600	55.63	6.18	3.416242
3660	55.65	6.2	3.427298
3720	55.67	6.22	3.438354
3780	55.7	6.25	3.454938
3840	55.72	6.27	3.465993
3900	55.75	6.3	3.482577
3960	55.77	6.32	3.493633
4020	55.8	6.35	3.510217
4080	55.82	6.37	3.521272
4140	55.85	6.4	3.537856
4200	55.9	6.45	3.565496
4260	55.93	6.48	3.582079
4320	55.95	6.5	3.593135

Table 38 Recovery Test for well SL-PW-12

Time (min)	Water level,(m)	RRD. Drawdown,(m)	Sc (pp)	t/t''
0	53.08	3.76	2.07849	#DIV/0!
1	50.06	0.74	0.409065	120
2	50.03	0.71	0.392481	60
3	49.96	0.64	0.353786	40
4	49.9	0.58	0.320618	30
5	49.89	0.57	0.31509	24
6	49.88	0.56	0.309562	20
7	49.85	0.53	0.292979	17.14
8	49.82	0.5	0.276395	15
9	49.8	0.48	0.265339	13.33
10	49.8	0.48	0.265339	12
12	49.78	0.46	0.254283	10
14	49.78	0.46	0.254283	8.571
16	49.78	0.46	0.254283	7.5
18	49.77	0.45	0.248756	6.66
20	49.75	0.43	0.2377	6
25	49.74	0.42	0.232172	4.8
30	49.72	0.4	0.221116	4
35	49.7	0.38	0.21006	3.42
40	49.69	0.37	0.204532	3
45	49.68	0.36	0.199004	2.66
50	49.66	0.34	0.187949	2.4
55	49.65	0.33	0.182421	2.18
60	49.64	0.32	0.176893	2
70	49.62	0.3	0.165837	1.714
80	49.6	0.28	0.154781	1.5
90	49.58	0.26	0.143725	1.33
100	49.57	0.25	0.138198	1.2
120	49.55	0.23	0.127142	1

Table 39 Constant Pumping Test for well SL-PW-24

Time (min)	Water level,(m)	Drawdown, (m)	PP sc
0	65	0	0
1	67.9	2.9	2.429849
2	68.21	3.21	2.689592
3	68.35	3.35	2.806895
4	68.47	3.47	2.90744
5	68.56	3.56	2.982849
6	68.65	3.65	3.058258
7	68.73	3.73	3.125289
8	68.81	3.81	3.192319
9	68.89	3.89	3.259349
10	68.95	3.95	3.309622
12	69.08	4.08	3.418546
14	69.17	4.17	3.493955
16	69.27	4.27	3.577743
18	69.39	4.39	3.678289
20	69.46	4.46	3.73694
25	69.67	4.67	3.912895
30	69.8	4.8	4.021819
35	69.91	4.91	4.113986
40	70.13	5.13	4.298319
45	70.24	5.24	4.390486
50	70.35	5.35	4.482653
55	70.45	5.45	4.566441
60	70.5	5.5	4.608335
70	70.62	5.62	4.70888
80	70.71	5.71	4.784289
90	70.8	5.8	4.859698
100	70.88	5.88	4.926729
120	71	6	5.027274
140	71.06	6.06	5.077547
160	71.11	6.11	5.119441
180	71.14	6.14	5.144577
210	71.17	6.17	5.169713
240	71.21	6.21	5.203229
270	71.25	6.25	5.236744
300	71.27	6.27	5.253501
360	71.32	6.32	5.295395
420	71.35	6.35	5.320532
480	71.38	6.38	5.345668
540	71.43	6.43	5.387562
600	71.44	6.44	5.395941
660	71.46	6.46	5.412698
720	71.48	6.48	5.429456
780	71.5	6.5	5.446214
840	71.52	6.52	5.462971
900	71.54	6.54	5.479729
960	71.54	6.54	5.479729
1020	71.55	6.55	5.488107
1080	71.55	6.55	5.488107
1140	71.56	6.56	5.496486
1200	71.59	6.59	5.521623
1260	71.56	6.56	5.496486
1320	71.56	6.56	5.496486
1380	71.57	6.57	5.504865
1440	71.57	6.57	5.504865
1500	71.58	6.58	5.513244
1560	71.59	6.59	5.521623
1620	71.59	6.59	5.521623
1680	71.59	6.59	5.521623
1740	71.58	6.58	5.513244

1800	71.58	6.58	5.513244
1860	71.58	6.58	5.513244
1920	71.59	6.59	5.521623
1980	71.59	6.59	5.521623
2040	71.6	6.6	5.530001
2100	71.61	6.61	5.53838
2160	71.61	6.61	5.53838
2220	71.62	6.62	5.546759
2280	71.62	6.62	5.546759
2340	71.62	6.62	5.546759
2400	71.63	6.63	5.555138
2460	71.63	6.63	5.555138
2520	71.63	6.63	5.555138
2580	71.63	6.63	5.555138
2640	71.63	6.63	5.555138
2700	71.64	6.64	5.563517
2760	71.64	6.64	5.563517
2820	71.64	6.64	5.563517
2880	71.64	6.64	5.563517
2940	71.64	6.64	5.563517
3000	71.64	6.64	5.563517
3060	71.64	6.64	5.563517

3120	71.64	6.64	5.563517
3180	71.64	6.64	5.563517
3240	71.64	6.64	5.563517
3300	71.64	6.64	5.563517
3360	71.64	6.64	5.563517
3420	71.64	6.64	5.563517
3480	71.65	6.65	5.571895
3540	71.65	6.65	5.571895
3600	71.65	6.65	5.571895
3660	71.65	6.65	5.571895
3720	71.65	6.65	5.571895
3780	71.65	6.65	5.571895
3840	71.65	6.65	5.571895
3900	71.65	6.65	5.571895
3960	71.65	6.65	5.571895
4020	71.65	6.65	5.571895
4080	71.66	6.66	5.580274
4140	71.66	6.66	5.580274
4200	71.66	6.66	5.580274
4260	71.66	6.66	5.580274
4320	71.67	6.67	5.588653

Table 40 Recovery Test for Well SL-PW-24

Time (min)	Water level(m)	RDD	sc partial pp	t/t''
0	65	0	0	#DIV/0!
1	67.9	2.9	2.4298491	4320.00
2	68.21	3.21	2.68959159	2160.00
3	68.35	3.35	2.80689465	1440.00
4	68.47	3.47	2.90744013	1080.00
5	68.56	3.56	2.98284924	864.00
6	68.65	3.65	3.05825835	720.00
7	68.73	3.73	3.12528867	617.14
8	68.81	3.81	3.19231899	540.00
9	68.89	3.89	3.25934931	480.00
10	68.95	3.95	3.30962205	432.00
12	69.08	4.08	3.41854632	360.00
14	69.17	4.17	3.49395543	308.57
16	69.27	4.27	3.57774333	270.00
18	69.39	4.39	3.67828881	240.00
20	69.46	4.46	3.73694034	216.00
25	69.67	4.67	3.91289493	172.80
30	69.8	4.8	4.0218192	144.00
35	69.91	4.91	4.11398589	123.43
40	70.13	5.13	4.29831927	108.00
45	70.24	5.24	4.39048596	96.00
50	70.35	5.35	4.48265265	86.40
55	70.45	5.45	4.56644055	78.55
60	70.5	5.5	4.6083345	72.00
70	70.62	5.62	4.70887998	61.71
80	70.71	5.71	4.78428909	54.00
90	70.8	5.8	4.8596982	48.00
100	70.88	5.88	4.92672852	43.20
120	71	6	5.027274	36.00
140	71.06	6.06	5.07754674	30.86
160	71.11	6.11	5.11944069	27.00
180	71.14	6.14	5.14457706	24.00
210	71.17	6.17	5.16971343	20.57
240	71.21	6.21	5.20322859	18.00
270	71.25	6.25	5.23674375	16.00
300	71.27	6.27	5.25350133	14.40
360	71.32	6.32	5.29539528	12.00
420	71.35	6.35	5.32053165	10.29
480	71.38	6.38	5.34566802	9.00
540	71.43	6.43	5.38756197	8.00
600	71.44	6.44	5.39594076	7.20
660	71.46	6.46	5.41269834	6.55
720	71.48	6.48	5.42945592	6.00
780	71.5	6.5	5.4462135	5.54
840	71.52	6.52	5.46297108	5.14
900	71.54	6.54	5.47972866	4.80
960	71.54	6.54	5.47972866	4.50
1020	71.55	6.55	5.48810745	4.24
1080	71.55	6.55	5.48810745	4.00
1140	71.56	6.56	5.49648624	3.79
1200	71.59	6.59	5.52162261	3.60
1260	71.56	6.56	5.49648624	3.43
1320	71.56	6.56	5.49648624	3.27
1380	71.57	6.57	5.50486503	3.13
1440	71.57	6.57	5.50486503	3.00
1500	71.58	6.58	5.51324382	2.88
1560	71.59	6.59	5.52162261	2.77
1620	71.59	6.59	5.52162261	2.67
1680	71.59	6.59	5.52162261	2.57

1740	71.58	6.58	5.51324382	2.48
1800	71.58	6.58	5.51324382	2.40
1860	71.58	6.58	5.51324382	2.32
1920	71.59	6.59	5.52162261	2.25
1980	71.59	6.59	5.52162261	2.18
2040	71.6	6.6	5.5300014	2.12
2100	71.61	6.61	5.53838019	2.06
2160	71.61	6.61	5.53838019	2.00
2220	71.62	6.62	5.54675898	1.95
2280	71.62	6.62	5.54675898	1.89
2340	71.62	6.62	5.54675898	1.85
2400	71.63	6.63	5.55513777	1.80
2460	71.63	6.63	5.55513777	1.76
2520	71.63	6.63	5.55513777	1.71
2580	71.63	6.63	5.55513777	1.67
2640	71.63	6.63	5.55513777	1.64
2700	71.64	6.64	5.56351656	1.60
2760	71.64	6.64	5.56351656	1.57
2820	71.64	6.64	5.56351656	1.53
2880	71.64	6.64	5.56351656	1.50
2940	71.64	6.64	5.56351656	1.47
3000	71.64	6.64	5.56351656	1.44

3060	71.64	6.64	5.56351656	1.41
3120	71.64	6.64	5.56351656	1.38
3180	71.64	6.64	5.56351656	1.36
3240	71.64	6.64	5.56351656	1.33
3300	71.64	6.64	5.56351656	1.31
3360	71.64	6.64	5.56351656	1.29
3420	71.64	6.64	5.56351656	1.26
3480	71.65	6.65	5.57189535	1.24
3540	71.65	6.65	5.57189535	1.22
3600	71.65	6.65	5.57189535	1.20
3660	71.65	6.65	5.57189535	1.18
3720	71.65	6.65	5.57189535	1.16
3780	71.65	6.65	5.57189535	1.14
3840	71.65	6.65	5.57189535	1.13
3900	71.65	6.65	5.57189535	1.11
3960	71.65	6.65	5.57189535	1.09
4020	71.65	6.65	5.57189535	1.07
4080	71.66	6.66	5.58027414	1.06
4140	71.66	6.66	5.58027414	1.04
4200	71.66	6.66	5.58027414	1.03
4260	71.66	6.66	5.58027414	1.01
4320	71.67	6.67	5.58865293	1.00

Table 41 Constant Pumping Test for Well SL-PW-25

Time (min)	Water level (m)	Drawdown (m)	SC
0	56.04	0	0
1	58.43	2.39	1.549485
2	58.53	2.49	1.614317
3	58.6	2.56	1.659699
4	58.7	2.66	1.724531
5	58.76	2.72	1.76343
6	58.82	2.78	1.80233
7	58.86	2.82	1.828262
8	58.92	2.88	1.867162
9	59	2.96	1.919027
10	59.03	2.99	1.938477
12	59.13	3.09	2.003309
14	59.23	3.19	2.068141
16	59.3	3.26	2.113523
18	59.4	3.36	2.178355
20	59.49	3.45	2.236704
25	59.7	3.66	2.372851
30	59.94	3.9	2.528448
35	60.05	4.01	2.599763
40	60.19	4.15	2.690528
45	60.3	4.26	2.761843
50	60.45	4.41	2.859091
55	60.53	4.49	2.910957
60	60.66	4.62	2.995238
70	60.82	4.78	3.09897
80	61.04	5	3.2416
90	61.21	5.17	3.351814
100	61.4	5.36	3.474995
120	61.61	5.57	3.611142
140	61.8	5.76	3.734323
160	61.99	5.95	3.857504
180	62.16	6.12	3.967718
210	62.37	6.33	4.103866
240	62.5	6.46	4.188147
270	62.65	6.61	4.285395
300	62.74	6.7	4.343744
360	62.92	6.88	4.460442
420	63.06	7.02	4.551206
480	63.21	7.17	4.648454
540	63.27	7.23	4.687354
600	63.36	7.32	4.745702
660	63.4	7.36	4.771635
720	63.48	7.44	4.823501
780	63.56	7.52	4.875366
840	63.6	7.56	4.901299
900	63.64	7.6	4.927232
960	63.68	7.64	4.953165
1020	63.7	7.66	4.966131
1080	63.74	7.7	4.992064
1140	63.76	7.72	5.00503
1200	63.81	7.77	5.037446
1260	63.83	7.79	5.050413
1320	63.84	7.8	5.056896
1380	63.86	7.82	5.069862
1440	63.89	7.85	5.089312
1500	63.9	7.86	5.095795
1560	63.91	7.87	5.102278
1620	63.92	7.88	5.108762
1680	63.95	7.91	5.128211
1740	63.96	7.92	5.134694

1800	63.99	7.95	5.154144
1860	64	7.96	5.160627
1920	64.02	7.98	5.173594
1980	64.05	8.01	5.193043
2040	64.09	8.05	5.218976
2100	64.1	8.06	5.225459
2160	64.12	8.08	5.238426
2220	64.14	8.1	5.251392
2280	64.16	8.12	5.264358
2340	64.18	8.14	5.277325
2400	64.18	8.14	5.277325
2460	64.19	8.15	5.283808
2520	64.2	8.16	5.290291
2580	64.2	8.16	5.290291
2640	64.21	8.17	5.296774
2700	64.21	8.17	5.296774
2760	64.23	8.19	5.309741
2820	64.24	8.2	5.316224
2880	64.26	8.22	5.32919
2940	64.28	8.24	5.342157
3000	64.28	8.24	5.342157
3060	64.28	8.24	5.342157

3120	64.28	8.24	5.342157
3180	64.29	8.25	5.34864
3240	64.3	8.26	5.355123
3300	64.36	8.32	5.394022
3360	64.38	8.34	5.406989
3420	64.4	8.36	5.419955
3480	64.41	8.37	5.426438
3540	64.43	8.39	5.439405
3600	64.45	8.41	5.452371
3660	64.45	8.41	5.452371
3720	64.45	8.41	5.452371
3780	64.45	8.41	5.452371
3840	64.46	8.42	5.458854
3900	64.47	8.43	5.465338
3960	64.47	8.43	5.465338
4020	64.47	8.43	5.465338
4080	64.48	8.44	5.471821
4140	64.48	8.44	5.471821
4200	64.48	8.44	5.471821
4260	64.49	8.45	5.478304
4320	64.5	8.46	5.484787

Table 42 Recovery Test for well SL-PW-25

Time (min)	Water level, m	Drawdown (m)	sc	t/t"
0	64.5	8.46	5.4847957	#DIV/0!
1	62.1	6.06	3.9288253	140
2	62.01	5.97	3.8704764	70
3	61.93	5.89	3.8186107	46.66667
4	61.85	5.81	3.766745	35
5	61.79	5.75	3.7278458	28
6	61.73	5.69	3.6889465	23.33333
7	61.68	5.64	3.6565304	20
8	61.6	5.56	3.6046648	17.5
9	61.55	5.51	3.5722487	15.55556
10	61.5	5.46	3.5398327	14
12	61.39	5.35	3.4685174	11.66667
14	61.28	5.24	3.397202	10
16	61.19	5.15	3.3388532	8.75
18	61.09	5.05	3.2740211	7.777778
20	61.01	4.97	3.2221554	7
25	60.82	4.78	3.0989744	5.6
30	60.6	4.56	2.9563438	4.666667
35	60.45	4.41	2.8590956	4
40	60.3	4.26	2.7618475	3.5
45	60.12	4.08	2.6451497	3.111111
50	59.97	3.93	2.5479015	2.8
55	59.9	3.86	2.5025191	2.545455
60	59.77	3.73	2.4182373	2.333333
70	59.6	3.56	2.3080228	2
80	59.41	3.37	2.1848418	1.75
90	59.19	3.15	2.0422112	1.555556
100	58.92	2.88	1.8671645	1.4

120	58.8	2.76	1.789366	1.166667
140	58.59	2.55	1.6532186	1

Table 43 Constant Pumping Test for well SL-PW-30

Time(min)	Water level,(m)	Drawdown,(m)	correction for (pp)
0	132.4	0	0
1	133.1	0.7	0.378
2	133.45	1.05	0.567
3	133.55	1.15	0.621
4	133.6	1.2	0.648
5	133.61	1.21	0.6534
6	133.62	1.22	0.6588
7	133.65	1.25	0.675
8	133.67	1.27	0.6858
9	133.69	1.29	0.6966
10	133.69	1.29	0.6966
12	133.69	1.29	0.6966
14	133.69	1.29	0.6966
16	133.69	1.29	0.6966
18	133.7	1.3	0.702
20	133.7	1.3	0.702
25	133.7	1.3	0.702
30	133.7	1.3	0.702
35	133.7	1.3	0.702
40	133.71	1.31	0.7074
45	133.72	1.32	0.7128
50	133.72	1.32	0.7128
55	133.72	1.32	0.7128
60	133.72	1.32	0.7128
70	133.7	1.3	0.702
80	133.71	1.31	0.7074
90	133.72	1.32	0.7128
100	133.72	1.32	0.7128
120	133.72	1.32	0.7128
140	133.72	1.32	0.7128
160	133.72	1.32	0.7128
180	133.72	1.32	0.7128
210	133.72	1.32	0.7128
240	133.72	1.32	0.7128
270	133.72	1.32	0.7128
300	133.72	1.32	0.7128
360	133.72	1.32	0.7128
420	133.72	1.32	0.7128
480	133.73	1.33	0.7182
540	133.73	1.33	0.7182
600	133.74	1.34	0.7236
660	133.75	1.35	0.729
720	133.75	1.35	0.729
780	133.75	1.35	0.729
840	133.76	1.36	0.7344
900	133.77	1.37	0.7398
960	133.77	1.37	0.7398
1020	133.77	1.37	0.7398
1080	133.77	1.37	0.7398
1140	133.77	1.37	0.7398
1200	133.78	1.38	0.7452

1260	133.78	1.38	0.7452
1320	133.78	1.38	0.7452
1380	133.78	1.38	0.7452
1440	133.76	1.36	0.7344
1500	133.75	1.35	0.729
1560	133.73	1.33	0.7182
1620	133.72	1.32	0.7128
1680	133.7	1.3	0.702
1740	133.7	1.3	0.702
1800	133.7	1.3	0.702
1860	133.7	1.3	0.702
1920	133.7	1.3	0.702
1980	133.72	1.32	0.7128
2040	133.73	1.33	0.7182
2100	133.73	1.33	0.7182
2160	133.73	1.33	0.7182
2220	133.73	1.33	0.7182
2280	133.73	1.33	0.7182
2340	133.73	1.33	0.7182
2400	133.73	1.33	0.7182
2460	133.73	1.33	0.7182

2520	133.73	1.33	0.7182
2580	133.73	1.33	0.7182
2640	133.74	1.34	0.7236
2700	133.74	1.34	0.7236
2760	133.74	1.34	0.7236
2820	133.75	1.35	0.729
2880	133.75	1.35	0.729
2940	133.73	1.33	0.7182
3000	133.72	1.32	0.7128
3060	133.72	1.32	0.7128
3120	133.72	1.32	0.7128
3180	133.71	1.31	0.7074
3240	133.71	1.31	0.7074
3300	133.7	1.3	0.702
3360	133.7	1.3	0.702
3420	133.69	1.29	0.6966
3480	133.7	1.3	0.702
3540	133.71	1.31	0.7074
3600	133.71	1.31	0.7074
3660	133.71	1.31	0.7074
3720	133.71	1.31	0.7074

Table 44 Recovery Test for Well SL-PW-30

Time (min)	Water level,(m)	Water level,(m)	sc (pp)	t/t"
0	133.71	1.31	0.7074	#DIV/0!
1	132.9	0.5	0.27	1020
2	132.84	0.44	0.2376	510
3	132.78	0.38	0.2052	340
4	132.71	0.31	0.1674	255
5	132.68	0.28	0.1512	204
6	132.62	0.22	0.1188	170
7	132.58	0.18	0.0972	145.71
8	132.56	0.16	0.0864	127.5
9	132.54	0.14	0.0756	113.3
10	132.52	0.12	0.0648	102
60	132.46	0.06	0.0324	17
70	132.46	0.06	0.0324	14.571
80	132.46	0.06	0.0324	12.75
90	132.46	0.06	0.0324	11.33333
100	132.46	0.06	0.0324	10.2
120	132.46	0.06	0.0324	8.5
140	132.46	0.06	0.0324	7.285714
160	132.46	0.06	0.0324	6.375
180	132.46	0.06	0.0324	5.666667
210	132.46	0.06	0.0324	4.857143
240	132.45	0.05	0.027	4.25
270	132.45	0.05	0.027	3.777778
300	132.45	0.05	0.027	3.4
360	132.45	0.05	0.027	2.833333
420	132.45	0.05	0.027	2.428571
480	132.44	0.04	0.0216	2.125
540	132.44	0.04	0.0216	1.888889

600	132.44	0.04	0.0216	1.7
660	132.43	0.03	0.0162	1.545455
720	132.43	0.03	0.0162	1.416667
780	132.43	0.03	0.0162	1.307692
840	132.42	0.02	0.0108	1.214286
900	132.41	0.01	0.0054	1.133333
960	132.41	0.01	0.0054	1.0625
1020	132.4	0	0	1

Table 45 Constant Pumping Test for SL-PW-14

Time (min)	Water level (m)	Drawdown (m)	unconfined sc	sc
`0	70.25	0	0	0
1	93.17	22.92	21.74805	13.04883
2	93.54	23.29	22.07991	13.24794
3	93.95	23.7	22.44693	13.46816
4	94.12	23.87	22.59889	13.55933
5	94.32	24.07	22.7775	13.6665
6	94.38	24.13	22.83104	13.69863
7	94.46	24.21	22.90242	13.74145
8	94.55	24.3	22.98268	13.78961
9	94.67	24.42	23.08963	13.85378
10	64.86	-5.39	-5.45481	-3.27289
12	95.09	24.84	23.46348	14.07809
14	95.17	24.92	23.5346	14.12076
16	95.32	25.07	23.66787	14.20072
18	95.45	25.2	23.78329	14.26997
20	95.48	25.23	23.80992	14.28595
25	95.69	25.44	23.99618	14.39771
30	95.77	25.52	24.06708	14.44025
35	95.87	25.62	24.15567	14.4934
40	95.92	25.67	24.19995	14.51997
45	95.99	25.74	24.26192	14.55715
50	96.05	25.8	24.31503	14.58902
55	96.13	25.88	24.3858	14.63148
60	96.21	25.96		14.67393
70	96.3	26.05	24.53611	14.72166
80	96.35	26.1	24.58029	14.74817
90	96.43	26.18	24.65096	14.79058
100	96.54	26.29	24.74808	14.84885
120	96.62	26.37	24.81869	14.89121
140	96.64	26.39	24.83633	14.9018
160	96.67	26.42	24.8628	14.91768
180	96.81	26.56	24.98625	14.99175
210	96.84	26.59	25.01269	15.00762
240	96.9	26.65	25.06557	15.03934
270	96.96	26.71	25.11842	15.07105
300	96.99	26.74	25.14485	15.08691
360	97.08	26.83	25.22409	15.13445
420	97.15	26.9	25.2857	15.17142

480	97.22	26.97	25.34729	15.20837
540	97.28	27.03	25.40006	15.24004
600	97.35	27.1	25.46161	15.27696
660	97.38	27.13	25.48798	15.29279
720	97.39	27.14	25.49677	15.29806
780	97.42	27.17	25.52313	15.31388
840	97.44	27.19	25.54071	15.32442
900	97.46	27.21	25.55828	15.33497
960	97.48	27.23	25.57585	15.34551
1020	97.49	27.24	25.58463	15.35078
1080	97.51	27.26	25.6022	15.36132
1140	97.52	27.27	25.61099	15.36659
1200	97.52	27.27	25.61099	15.36659
1260	97.53	27.28	25.61977	15.37186
1320	97.55	27.3	25.63733	15.3824
1380	97.58	27.33	25.66368	15.39821
1440	97.6	27.35	25.68124	15.40874
1500	97.6	27.35	25.68124	15.40874
1560	97.62	27.37	25.6988	15.41928

1620	97.64	27.39	25.71635	15.42981
1680	97.65	27.4	25.72513	15.43508
1740	97.69	27.44	25.76024	15.45614
1800	97.7	27.45	25.76901	15.46141
1860	97.71	27.46	25.77779	15.46667
1920	97.72	27.47	25.78656	15.47194
1980	97.74	27.49	25.80411	15.48247
2040	97.77	27.52	25.83043	15.49826
2100	97.78	27.53	25.8392	15.50352
2160	97.79	27.54	25.84797	15.50878
2220	97.82	27.57	25.87428	15.52457
2280	97.82	27.57	25.87428	15.52457
2340	97.85	27.6	25.90059	15.54035
2400	97.93	27.68	25.97073	15.58244
2460	97.93	27.68	25.97073	15.58244
2520	97.96	27.71	25.99702	15.59821
2580	97.96	27.71	25.99702	15.59821
2640	97.97	27.72	26.00578	15.60347
2700	97.98	27.73	26.01454	15.60873

2760	97.98	27.73	26.01454	15.60873
2820	97.99	27.74	26.02331	15.61398
2880	98.01	27.76	26.04083	15.6245
2940	98.04	27.79	26.06711	15.64027
3000	98.04	27.79	26.06711	15.64027
3060	98.06	27.81	26.08463	15.65078
3120	98.07	27.82	26.09339	15.65603
3180	98.1	27.85	26.11967	15.6718
3240	98.13	27.88	26.14594	15.68756
3300	98.15	27.9	26.16345	15.69807
3360	98.17	27.92	26.18096	15.70857
3420	98.18	27.93	26.18971	15.71383
3480	98.2	27.95	26.20722	15.72433
3540	98.22	27.97	26.22472	15.73483
3600	98.22	27.97	26.22472	15.73483
3660	98.25	28	26.25098	15.75059
3720	98.27	28.02	26.26848	15.76109
3780	98.28	28.03	26.27723	15.76634
3840	98.3	28.05	26.29472	15.77683
3900	98.31	28.06	26.30347	15.78208
3960	98.32	28.07	26.31222	15.78733
4020	98.32	28.07	26.31222	15.78733
4080	98.32	28.07	26.31222	15.78733
4140	98.32	28.07	26.31222	15.78733
4200	98.32	28.07	26.31222	15.78733
4260	98.33	28.08	26.32097	15.79258
4320	98.33	28.08	26.32097	15.79258

Table 46 Recovery Test for SL-PW-14

Time (min)	Water level,(m)	Residual DD(m)	t/t'	Unconfined sc	sc
0	98.3	28.1	#DIV/0!	26.320967	15.79258
1	74	3.73	1500	3.6989617	2.219377
2	74	3.71	750	3.6792937	2.207576
3	73.9	3.69	500	3.6596239	2.195774
4	73.9	3.69	375	3.6596239	2.195774
5	73.9	3.63	300	3.6006037	2.160362
6	73.7	3.47	250	3.443138	2.065883
7	73.6	3.37	214.286	3.3446639	2.006798
8	73.5	3.27	187.5	3.2461452	1.947687
9	73.4	3.18	166.667	3.1574403	1.894464
10	73.4	3.1	150	3.0785611	1.847137
12	73.2	2.97	125	2.9503215	1.770193
14	73.1	2.85	107.143	2.8318795	1.699128
16	73	2.76	93.75	2.7430059	1.645804
18	72.9	2.69	83.3333	2.673857	1.604314
20	72.9	2.65	75	2.6343335	1.5806
25	72.8	2.5	60	2.4860569	1.491634
30	72.6	2.38	50	2.3673633	1.420418
35	72.6	2.31	42.8571	2.2980957	1.378857
40	72.5	2.27	37.5	2.2585044	1.355103
45	72.5	2.24	33.3333	2.2288062	1.337284
50	72.5	2.22	30	2.2090052	1.325403
55	72.4	2.19	27.2727	2.1793004	1.30758
60	72.4	2.16	25	2.1495915	1.289755
70	72.4	2.13	21.4286	2.1198786	1.271927
80	72.4	2.11	18.75	2.1000678	1.260041
90	72.3	2.08	16.6667	2.0703482	1.242209
100	72.31	2.06	15	2.050533	1.23032
120	72.3	2.04	12.5	2.0307159	1.21843

140	72.3	2.01	10.7143	2.0009869	1.200592
160	72.2	1.99	9.375	1.9811654	1.188699
180	72.2	1.97	8.33333	1.9613421	1.176805
210	72.2	1.95	7.14286	1.941517	1.16491
240	72.2	1.93	6.25	1.9216901	1.153014
270	72.2	1.92	5.55556	1.911776	1.147066
300	72.2	1.9	5	1.8919465	1.135168
360	72.1	1.84	4.16667	1.8324471	1.099468
420	72	1.79	3.57143	1.782852	1.069711
480	72	1.73	3.125	1.7233231	1.033994
540	71.9	1.69	2.77778	1.6836283	1.010177
600	71.9	1.65	2.5	1.6439264	0.986356
660	71.9	1.6	2.27273	1.5942889	0.956573
720	71.8	1.56	2.08333	1.5545709	0.932743
780	71.8	1.53	1.92308	1.5247777	0.914867
840	71.7	1.47	1.78571	1.4651793	0.879108
900	71.7	1.45	1.66667	1.4453095	0.867186
960	71.7	1.44	1.5625	1.435374	0.861224
1020	71.7	1.42	1.47059	1.4155016	0.849301
1080	71.6	1.39	1.38889	1.3856897	0.831414
1140	71.6	1.37	1.31579	1.3658128	0.819488
1200	71.6	1.35	1.25	1.3459342	0.807561
1260	71.6	1.33	1.19048	1.3260538	0.795632
1320	71.6	1.3	1.13636	1.2962298	0.777738
1380	71.5	1.27	1.08696	1.2664018	0.759841
1440	71.5	1.25	1.04167	1.2465142	0.747909
1500	71.5	1.23	1	1.2266249	0.735975

Table 47 Constant Pumping Test for SL-PW-16

Constant Test			
Time(min)	Water level (m)	Drawdown (m)	sc
0	69.98	0	0
1	86.45	16.47	11.1996
2	89.65	19.67	13.3756
3	91.05	21.07	14.3276
4	91.47	21.49	14.6132
5	91.71	21.73	14.7764
6	91.83	21.85	14.858
7	91.95	21.97	14.9396
8	92.04	22.06	15.0008
9	92.12	22.14	15.0552
10	92.18	22.2	15.096
12	92.28	22.3	15.164
14	92.37	22.39	15.2252
16	92.41	22.43	15.2524
18	92.45	22.47	15.2796
20	92.49	22.51	15.3068
25	92.65	22.67	15.4156
30	92.71	22.73	15.4564
35	92.81	22.83	15.5244
40	92.88	22.9	15.572
45	92.91	22.93	15.5924
50	92.96	22.98	15.6264
55	92.98	23	15.64
60	93.01	23.03	15.6604
70	93.06	23.08	15.6944
80	93.12	23.14	15.7352
90	93.18	23.2	15.776
100	93.25	23.27	15.8236
120	93.38	23.4	15.912
140	93.44	23.46	15.9528
160	93.48	23.5	15.98
180	93.53	23.55	16.014
210	93.56	23.58	16.0344
240	93.65	23.67	16.0956
270	93.75	23.77	16.1636
300	93.82	23.84	16.2112
360	94.04	24.06	16.3608
420	94.12	24.14	16.4152
480	94.28	24.3	16.524
540	94.37	24.39	16.5852
600	94.45	24.47	16.6396
660	94.54	24.56	16.7008
720	94.55	24.57	16.7076
780	94.67	24.69	16.7892
840	94.77	24.79	16.8572
900	94.87	24.89	16.9252
960	94.95	24.97	16.9796
1020	94.99	25.01	17.0068
1080	95.08	25.1	17.068
1140	95.12	25.14	17.0952
1200	95.18	25.2	17.136
1260	95.25	25.27	17.1836
1320	95.33	25.35	17.238
1380	95.38	25.4	17.272
1440	95.43	25.45	17.306
1500	95.5	25.52	17.3536
1560	95.55	25.57	17.3876
1620	95.58	25.6	17.408
1680	95.63	25.65	17.442

1740	95.68	25.7	17.476
1800	95.73	25.75	17.51
1860	95.78	25.8	17.544
1920	95.83	25.85	17.578
1980	95.87	25.89	17.6052
2040	95.92	25.94	17.6392
2100	95.96	25.98	17.6664
2160	95.98	26	17.68
2220	96.03	26.05	17.714
2280	96.06	26.08	17.7344
2340	96.1	26.12	17.7616
2400	96.13	26.15	17.782
2460	96.15	26.17	17.7956
2520	96.17	26.19	17.8092
2580	96.2	26.22	17.8296
2640	96.23	26.25	17.85
2700	96.24	26.26	17.8568
2760	96.27	26.29	17.8772
2820	96.3	26.32	17.8976
2880	96.34	26.36	17.9248
2940	96.37	26.39	17.9452
3000	96.39	26.41	17.9588

3060	96.42	26.44	17.9792
3120	96.45	26.47	17.9996
3180	96.49	26.51	18.0268
3240	96.51	26.53	18.0404
3300	96.54	26.56	18.0608
3360	96.57	26.59	18.0812
3420	96.6	26.62	18.1016
3480	96.65	26.67	18.1356
3540	96.66	26.68	18.1424
3600	96.7	26.72	18.1696
3660	96.73	26.75	18.19
3720	96.74	26.76	18.1968
3780	96.75	26.77	18.2036
3840	96.79	26.81	18.2308
3900	96.8	26.82	18.2376
3960	96.82	26.84	18.2512
4020	96.85	26.87	18.2716
4080	96.88	26.9	18.292
4140	96.9	26.92	18.3056
4200	96.93	26.95	18.326
4260	96.95	26.97	18.3396
4320	96.98	27	18.36

Table 48 Recovery Test for SL-PW-16

Time (min)	Water level(m)	Drawdown (m)	sc	t/t"
0	96.98	27	18.36	#DIV/0!
1	74.89	4.91	3.3388	1440
2	74.6	4.62	3.1416	720
3	74.5	4.52	3.0736	480
4	74.38	4.4	2.992	360
5	74.29	4.31	2.9308	288
6	74.23	4.25	2.89	240
7	74.18	4.2	2.856	205.7
8	74.13	4.15	2.822	180
9	74.07	4.09	2.7812	160
10	74.02	4.04	2.7472	144
12	73.98	4	2.72	120
14	73.94	3.96	2.6928	102.8
16	73.9	3.92	2.6656	90
18	73.85	3.87	2.6316	80
20	73.82	3.84	2.6112	72
25	73.75	3.77	2.5636	57.6
30	73.7	3.72	2.5296	48
35	73.64	3.66	2.4888	41.14
40	73.57	3.59	2.4412	36
45	73.55	3.57	2.4276	32
50	73.53	3.55	2.414	28.8
55	73.46	3.48	2.3664	26.18
60	73.35	3.37	2.2916	24
70	73.29	3.31	2.2508	20.5
80	73.25	3.27	2.2236	18
90	73.2	3.22	2.1896	16
100	73.16	3.18	2.1624	14.4
120	73.11	3.13	2.1284	12
140	73.03	3.05	2.074	10.2
160	72.98	3	2.04	9
180	72.92	2.94	1.9992	8
210	72.84	2.86	1.9448	6.8
240	72.79	2.81	1.9108	6
270	72.75	2.77	1.8836	5.3
300	72.7	2.72	1.8496	4.8
360	72.56	2.58	1.7544	4
420	72.48	2.5	1.7	3.4
480	72.37	2.39	1.6252	3
540	72.3	2.32	1.5776	2.6
600	72.23	2.25	1.53	2.4
660	72.19	2.21	1.5028	2.18
720	72.13	2.15	1.462	2
780	72.05	2.07	1.4076	1.84
840	71.93	1.95	1.326	1.71
900	71.88	1.9	1.292	1.6
960	71.84	1.86	1.2648	1.5
1020	71.79	1.81	1.2308	1.41
1080	71.74	1.76	1.1968	1.33
1140	71.7	1.72	1.1696	1.26
1200	71.64	1.66	1.1288	1.2
1260	71.59	1.61	1.0948	1.14
1320	71.54	1.56	1.0608	1.09
1380	71.52	1.54	1.0472	1.04
1440	71.52	1.54	1.0472	1

APPINDIX-07 Summery of the well completion report

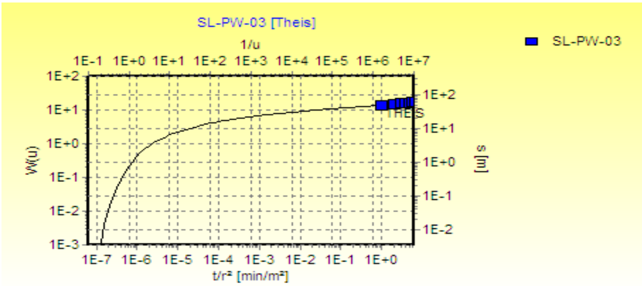
No	Prospective site/well field	well field	Well Index	Well type	Coordinate UTM Zone 37 Adindan		Elev, m	Contractor	Depth, m	Static water level, m	Dynamic water level, m	Draw down, m	Q, test, (l/S)	Transmis. (m2/day)	Specific well yield, l/s/m	Status
					UTM east	UTM north										
1	Akaki	Well field 02	SL-PW-03	production well	475276	976930	2052	CGCOC	582	54.32	128.99	74.67	75.44	448	1.01	Completed
2	Akaki	Well field 02	SL-PW04	production well	476037	976861	2068	CGCOC	595	55.18	91.25	36.07	88	150	2.44	Completed
3	Akaki	Well field 02	SL-PW-05	production well	475058	976100	2062	CGCOC	502	48.79	68.99	20.2	91	822	4.5	Completed
4	Akaki	Well field 02	SL-PW-06	production well	475528	975870	2059	CGCOC	600	52.02	86.4	34.38	86.5	747	2.51	Completed
5	Akaki	Well field 02	SL-PW-07	production well	476098	976183	2076	CGCOC	550	53.52	131.03	77.51	46.7	309	0.6	Completed
6	Akaki	Well field 02	SL-PW-08	production well	474528	975585	2057	CGCOC	569	49.06	73.5	24.44	95	138	3.88	Completed
7	Akaki	Well field 02	SL-PW-09	production well	473954	975244	2068	CGCOC	600	64.54	78.72	14.18	70.43	1000	4.966	Completed
8	Akaki	Well field 02	SL-PW-10	production well	473954	975244	2053	CGCOC	591	49.28	133.39	84.11	55	255	0.65	Completed
9	Akaki	Well field 02	SL-PW-11	production well	471453	974241	2048	CGCOC	335	50.04	63.35	13.31	112.7	635	8.467	Completed
10	Akaki	Well field 02	SL-PW-12	production well	475507	974697	2046	CGCOC	320	49.45	55.95	6.5	113.48	140	17.458	Completed

No	Prospective site/well field	well field	Well Index	Well type	Coordinate UTM Zone 37 Adindan		Elev, m	Contractor	Depth, m	Static water level, m	Dynamic water level, m	Draw down, m	Q, test, (l/S)	Transmis. (m2/day)	Specific well yield, l/s/m	Status
					UTM east	UTM north										
11	Akaki	Well field 02	SL-PW-13	Production well	472078	974359	2050	CGCOC	319	51.65	57.57	5.92	106	1020	17.9	Completed
12	Akaki	Well field 02	SL-PW-14	Production well	472640	973882	2072	CGCOC	518.5	70.25	98.33	28.08	84.9	1010	3.02	Completed
13	Akaki	Well field 02	SL-PW-15	Production well	473428	973584	2078	CGCOC	623	70.55	134.5	63.95	32.35	85.6	0.51	Completed
14	Akaki	Well field 02	SL-PW-16	production well	474702	974792	2069	CGCOC	59.5	69.98	97	27.02	98	761	3.62	Completed
15	Akaki	Well field 02	SL-PW-17	Production well	474733	973382	2072	CGCOC	501	78.54	124.67	124.67	34.55	90.7	0.8	Completed
16	Akaki	Well field 02	SL-PW-18	production well	477023	973986	2090	CGCOC	503	84.85	114.61	29.76	66.17	1020	2	Completed
17	Akaki	Well field 02	SL-PW-19	production well	476375	974046	2091	CGCOC	568	90.5	147.06	56.56	27	32.5	0.477	Completed
18	Akaki	Well field 02	SL-PW-21	production well	477959	974168	2103	CGCOC	501	98.47	108.3	9.83	90.23	4040	9.179	Completed
19	Akaki	Well field 02	SL-PW-22	Production well	475507	974679	2070	CGCOC	51.5	76.65	120.13	43.48	72.34	1020	1.66	Completed
20	Akaki	Well field 02	SL-PW-24	Production well	475941	975137	2063	CGCOC	551	65	71.67	6.67	102	2450	15.3	Completed
21	Akaki	Well field 02	SL-PW-25	Production well	473071	974284	2060	CGCOC	552	56.08	61.61	5.53	109	792	19.7	Completed

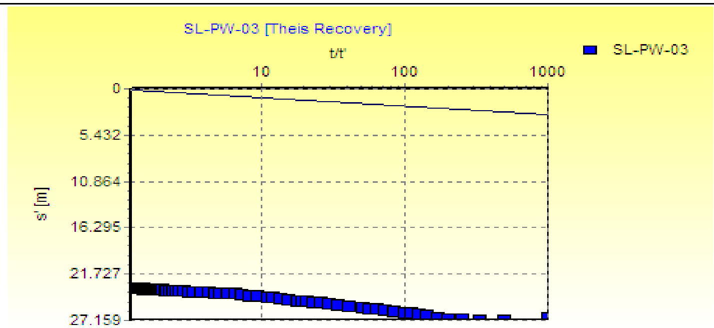
No	Prospective site/well field	well field	Well Index	Well type	Coordinate UTM Zone 37 Adindan		Elev, m	Contractor	Depth, m	Static water level, m	Dynamic water level, m	Draw down, m	Q, test, (l/S)	Transmis. (m2/day)	Specific well yield, l/s/m	Status
					UTM east	UTM north										
22	Akaki	Well field 02	SL-PW-30	Production well	478528	973384	2113	CGCOC	518	132.4	133.72	1.32	46	18700	34.848	Completed
23	Akaki	Well field 02	SL-PW-32	Production well	476725	973381	2111	CGCOC	170	110	149.74	39.74	47.67	438	1.2	Completed
24	Akaki	Well field 02	SL-PW-33	Production well	477415	973284	2112	CGCOC	453	116.38	139.69	23.31	37.34	242	1.6	Completed

APPINDIX-08 Aquifer test 3.5 software Graph

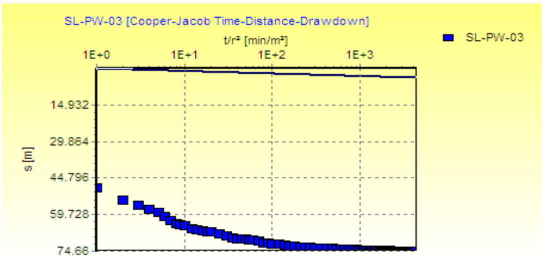
a) SL-PW-03



Transmissivity: 1.37E+2 m²/d
Conductivity: 2.52E+0 m/d
Storativity: 2.40E-7



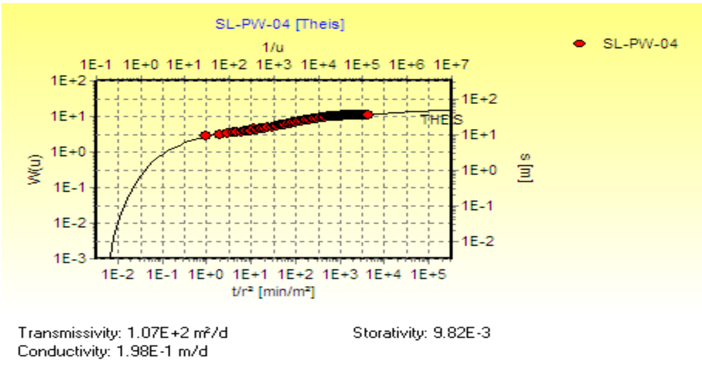
Transmissivity: 1.12E+3 m²/d
Conductivity: 2.05E+1 m/d



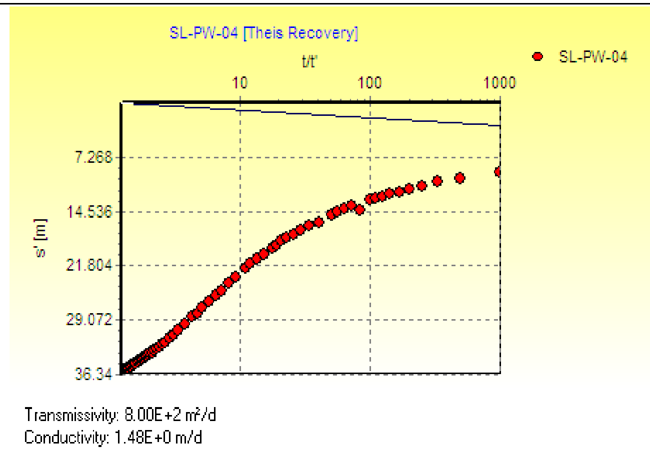
Transmissivity: 1.12E+3 m²/d
Conductivity: 2.05E+1 m/d
Storativity: 1.74E+0

Figure 68 a Aquifer test 3.5 software graphs for SL-PW-03

b)SL-PW-04



c



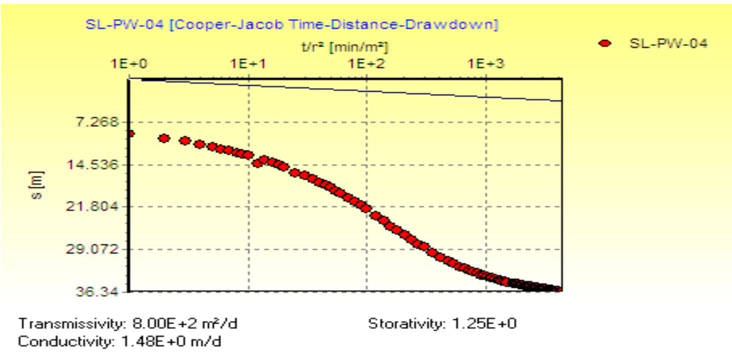


Figure 69 b Aquifer test 3.5 software graphs for SL-PW-04

C) SL-PW-06

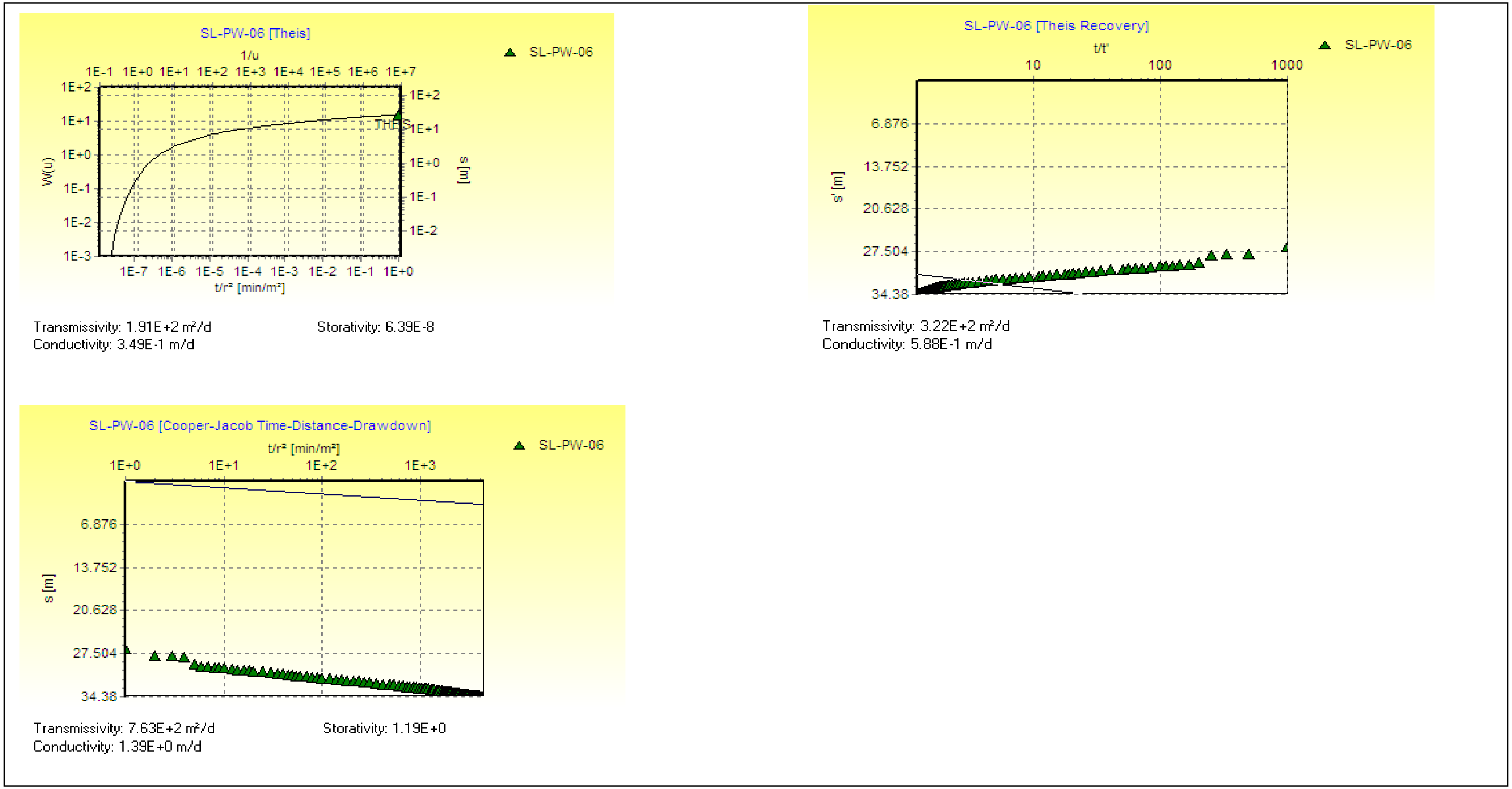


Figure 70 c Aquifer test 3.5 software graphs for SL-PW-06

D) SL-PW-07

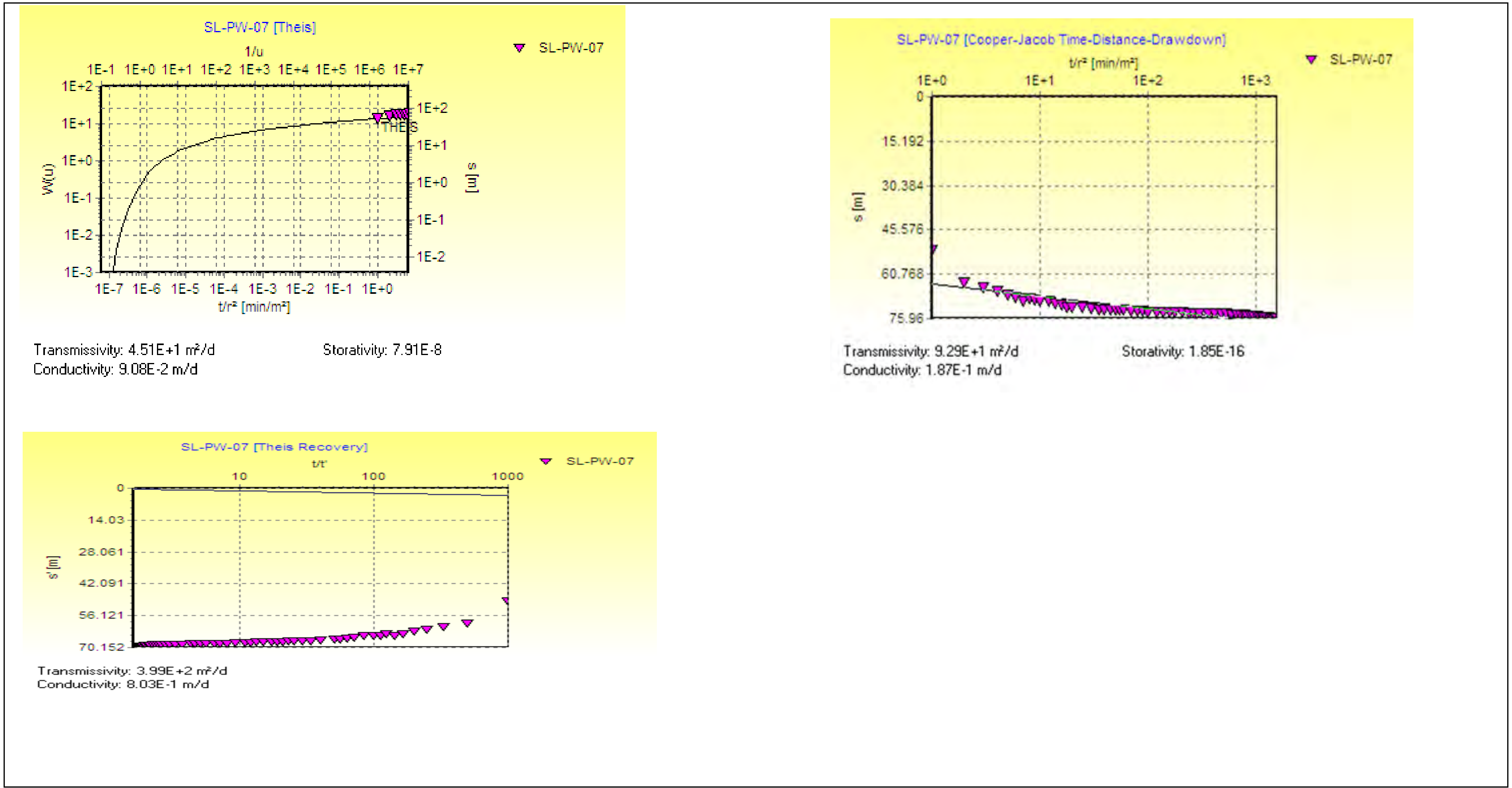


Figure 71 d Aquifer test 3.5 software graph for SL-PW-07

E) SL-PW-08

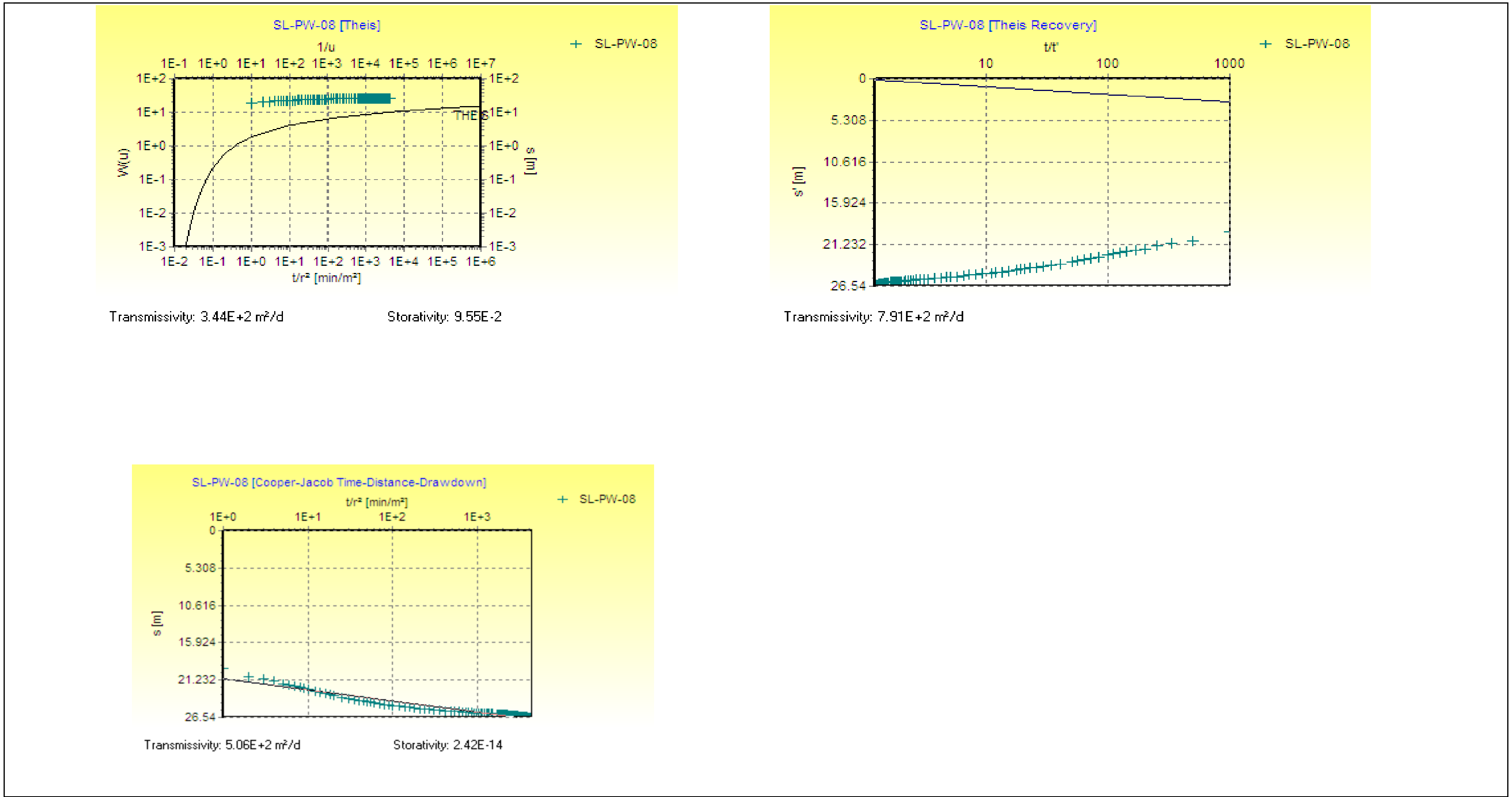


Figure 72 e Aquifer test 3.5 software graph for SL-PW-08

F) SL-PW-11

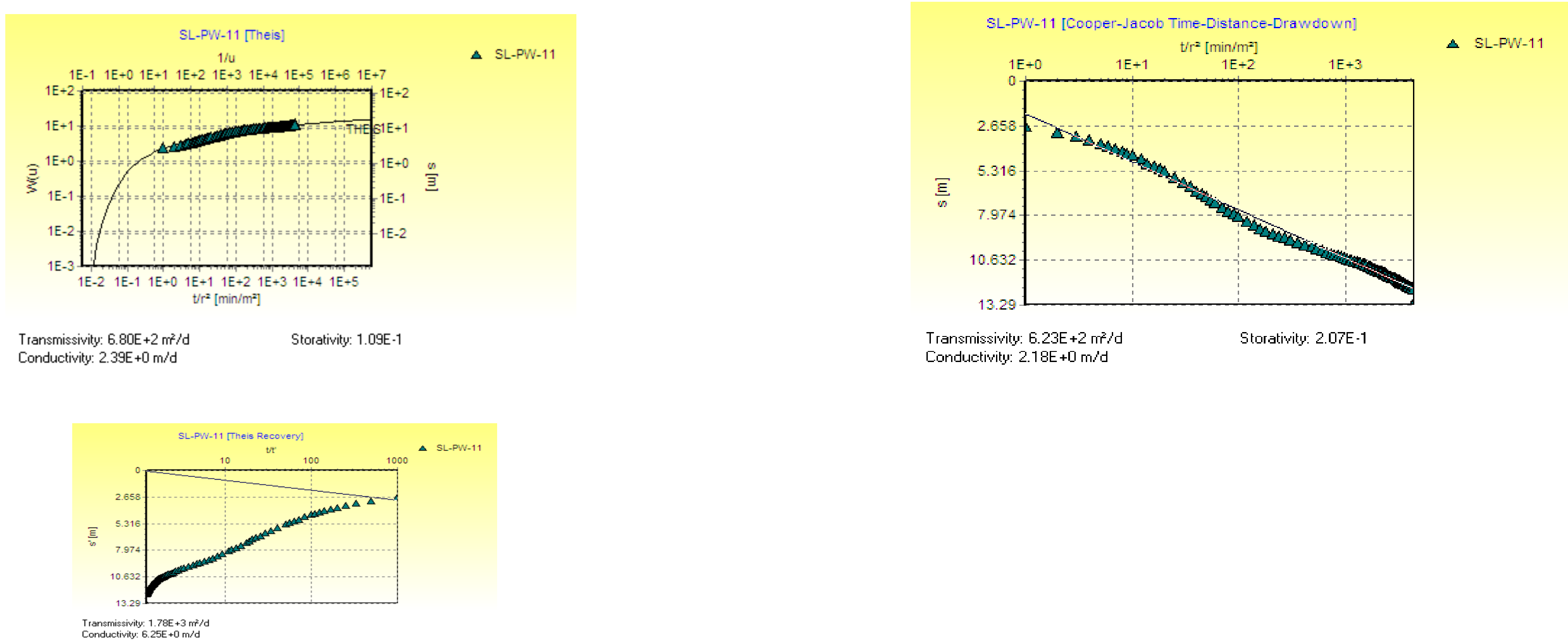
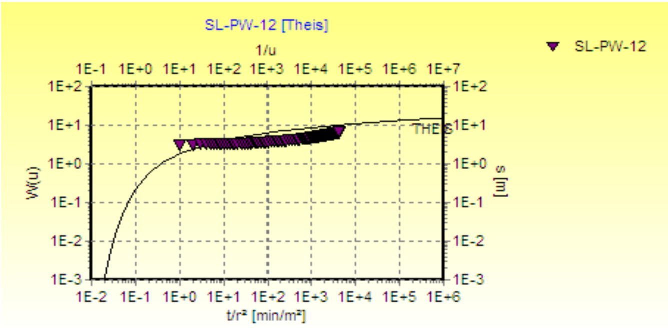
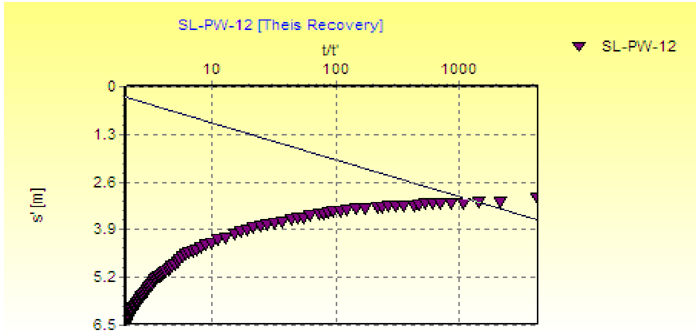


Figure 73 f Aquifer test 3.5 software graphs for SL-PW-11

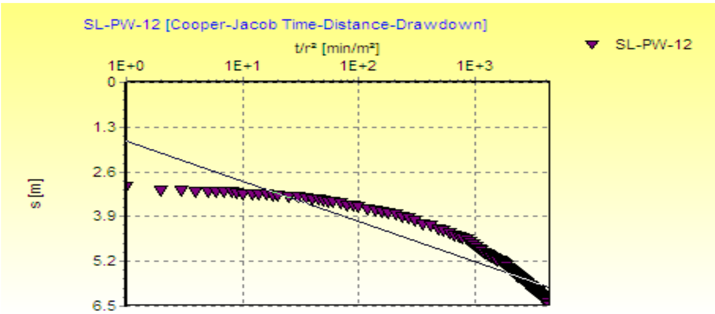
G) SL-PW-12



Transmissivity: 7.80E+2 m²/d
Conductivity: 2.88E+0 m/d
Storativity: 2.17E-1



Transmissivity: 1.79E+3 m²/d
Conductivity: 6.63E+0 m/d



Transmissivity: 1.54E+3 m²/d
Conductivity: 5.70E+0 m/d
Storativity: 8.19E-2

Figure 74 g Aquifer test 3.5 software graphs for SL-PW-12

H) SL-PW-14

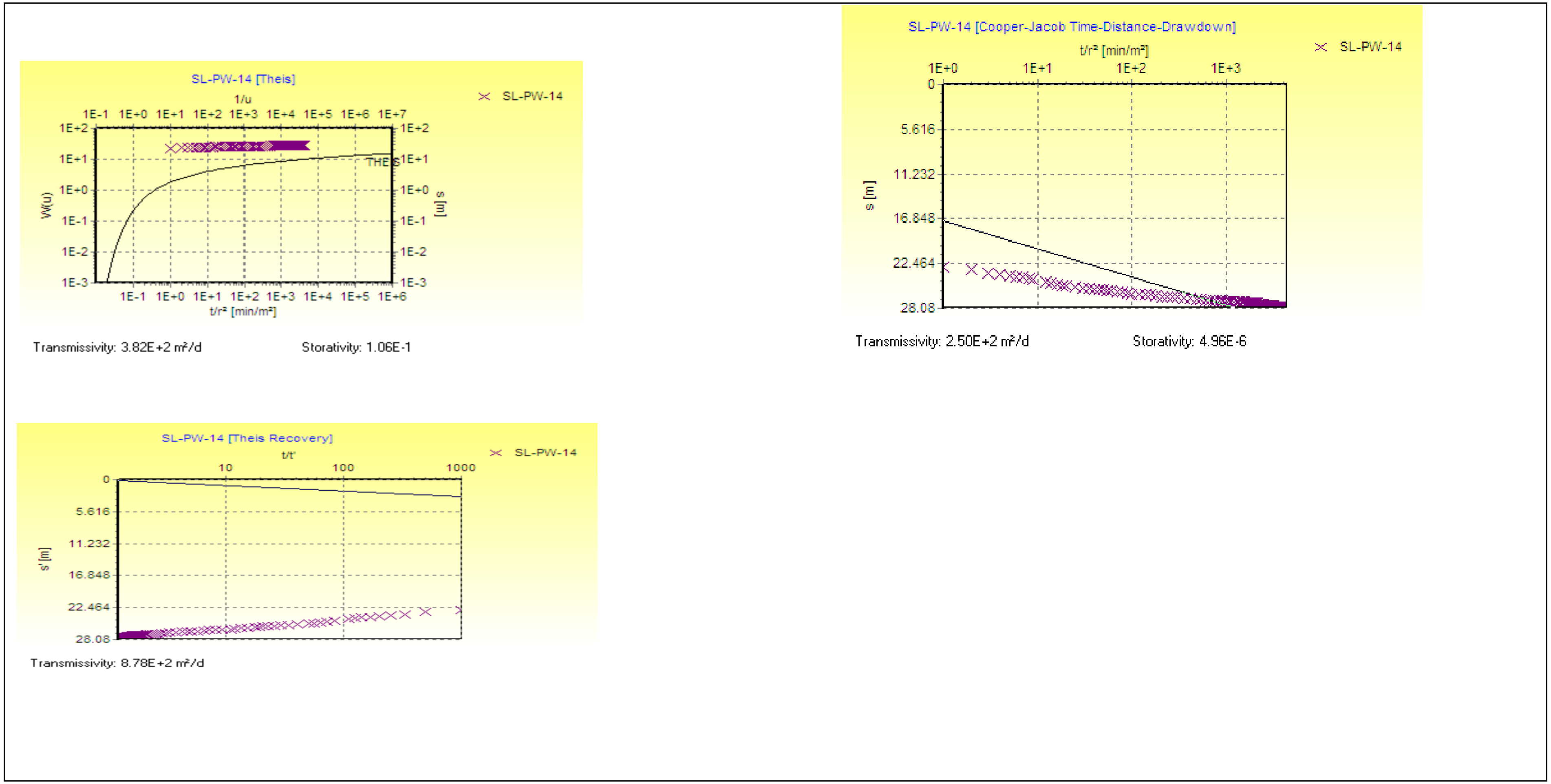


Figure 75 h Aquifer test 3.5 software graph for SL-PW-14

I) SL-PW-16

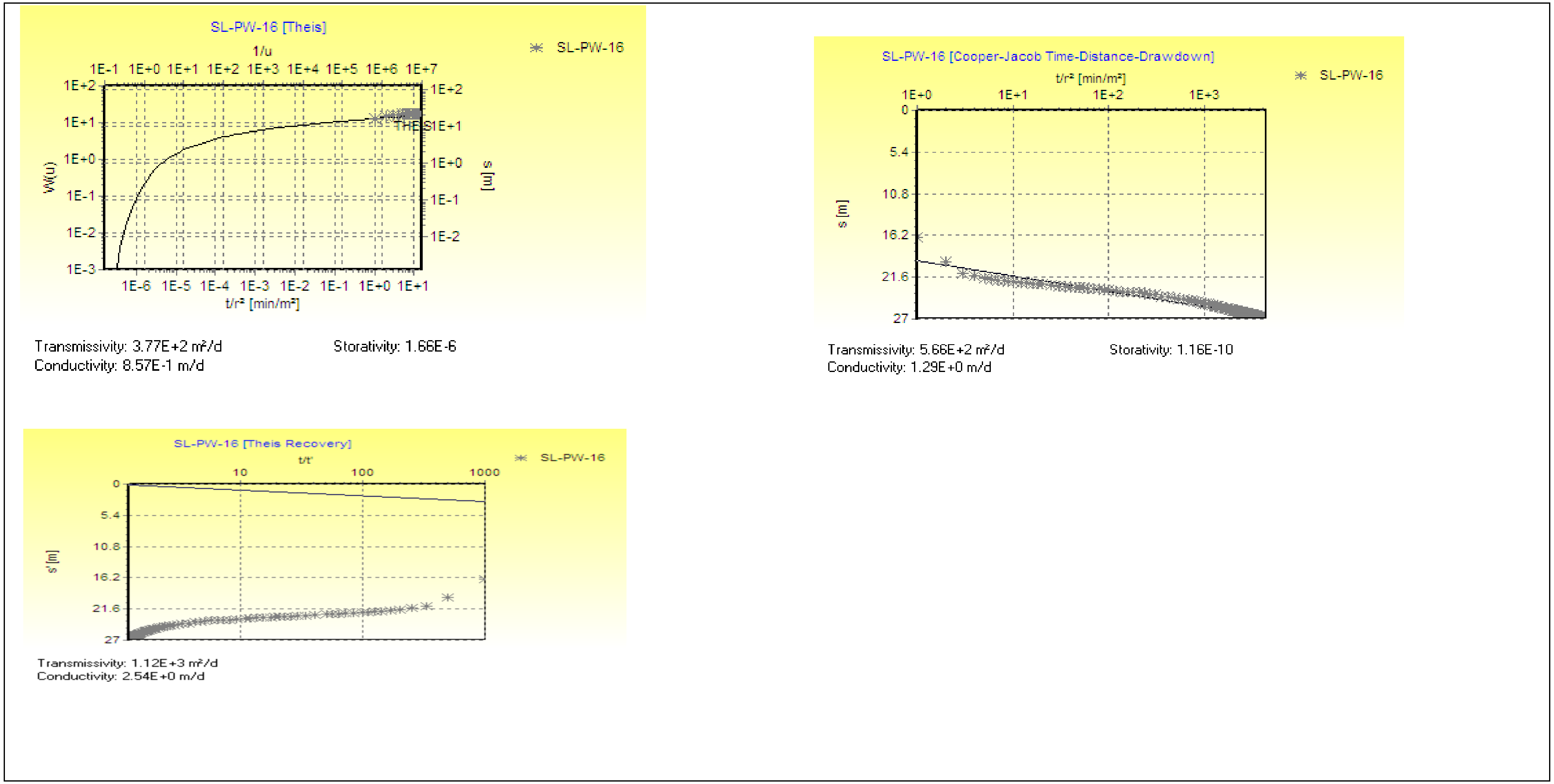


Figure 76 i Aquifer test 3.5 software graph for SL-PW-16

J) SL-PW-17

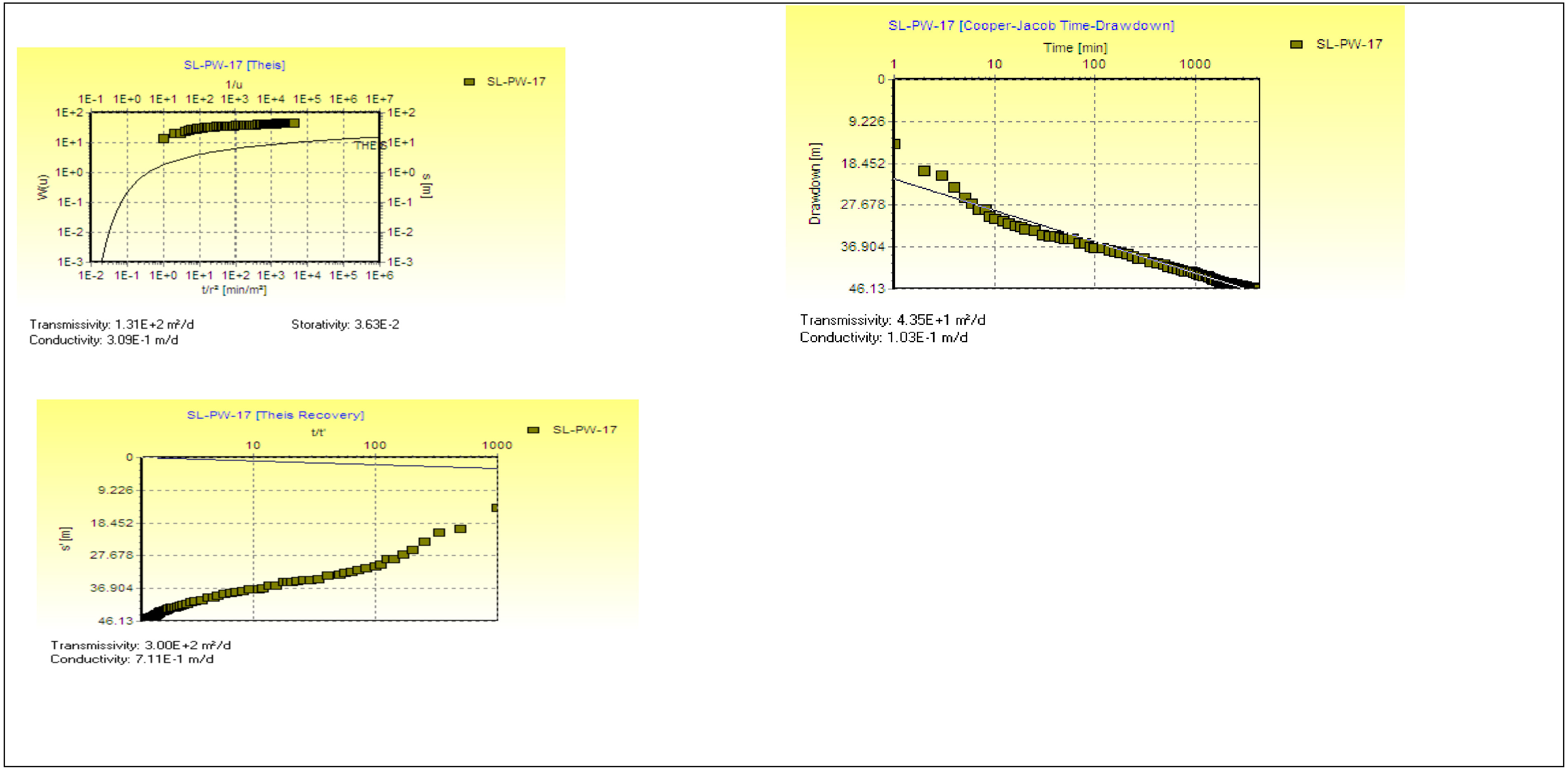


Figure 77 J Aquifer test 3.5 software graph for SL-PW-17

K) SL-PW-19

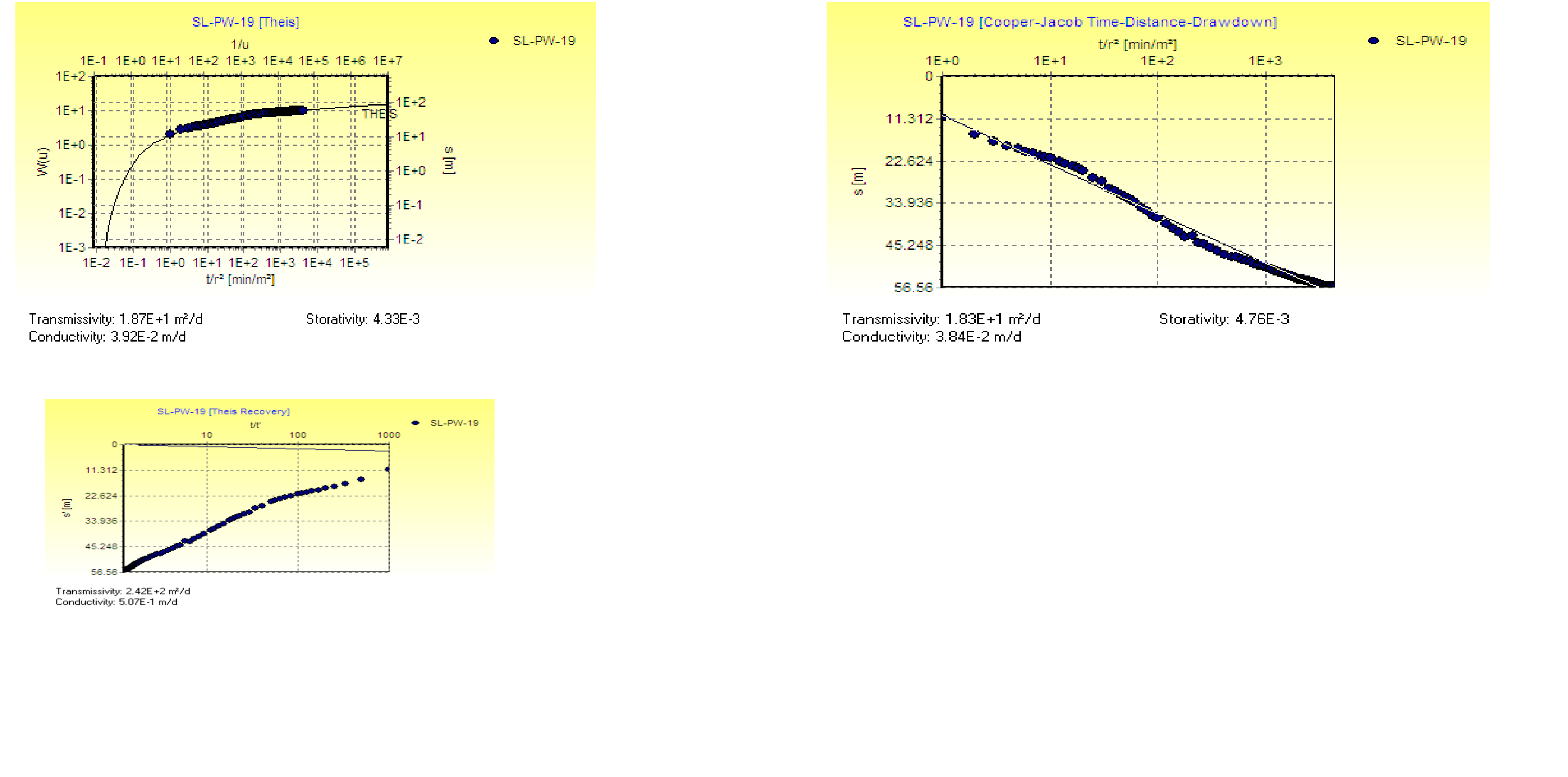


Figure 78 k Aquifer test 3.5 software graphs for SL-PW-19

L) SL-PW-21

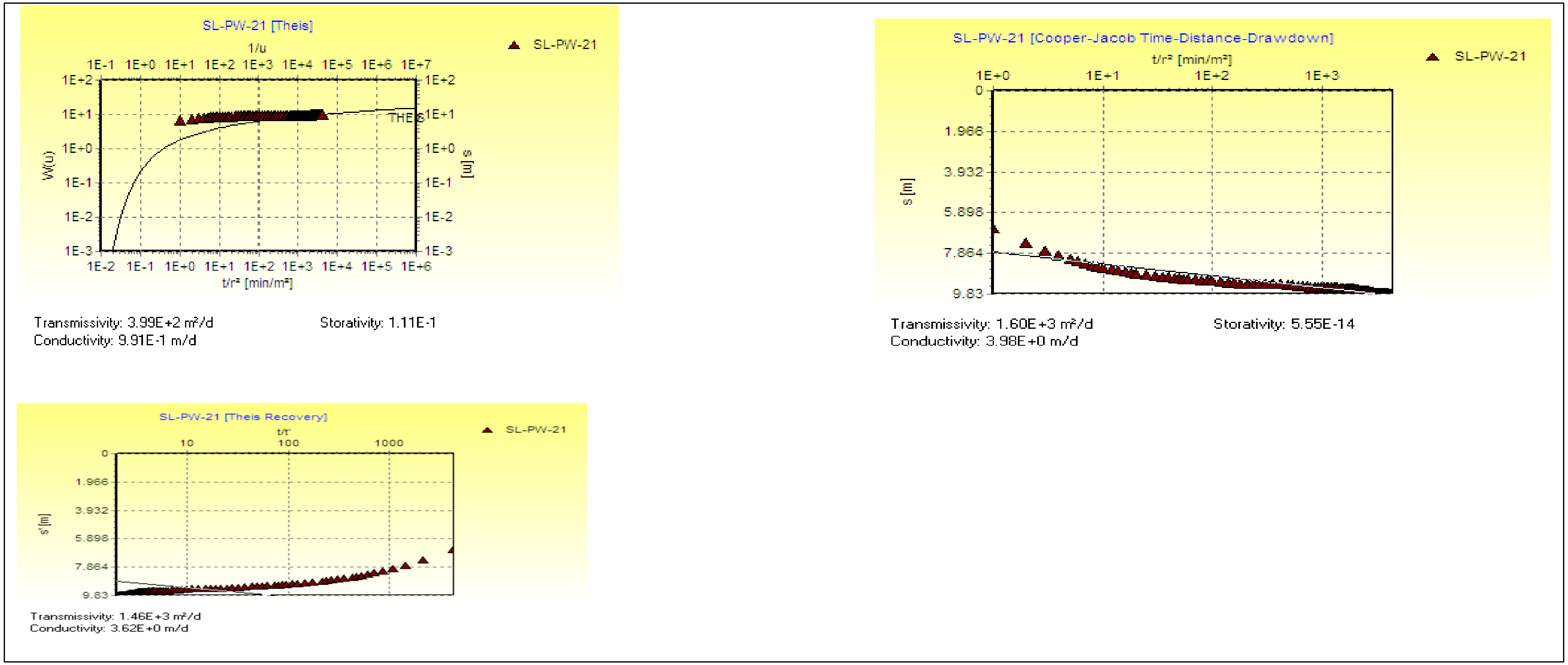


Figure 79 l Aquifer test 3.5 software graph for SL-PW-21

M) SL-PW-22

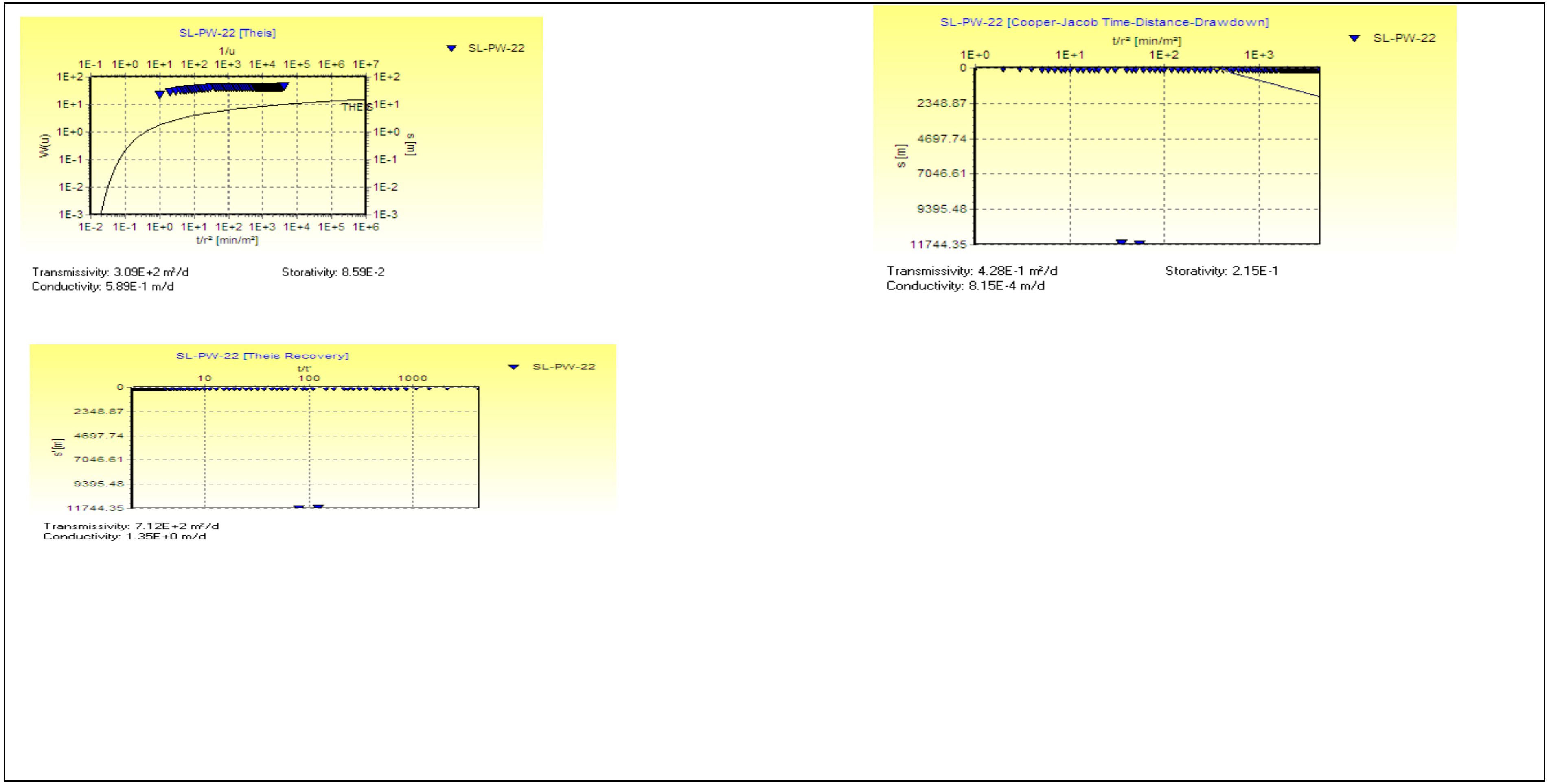


Figure 80 m Aquifer test 3.5 software graph for SL-PW-22

N) SL-PW-24

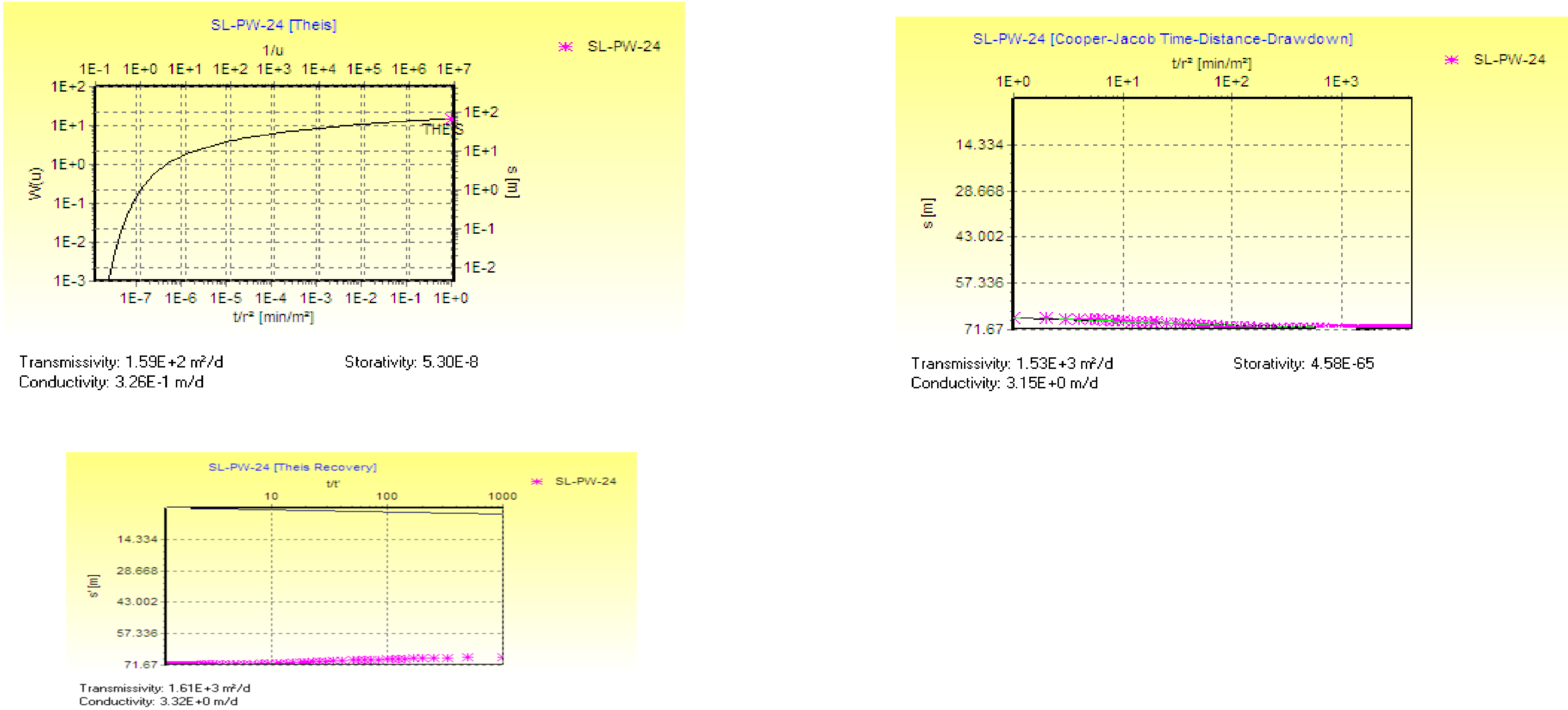


Figure 81 n Aquifer test 3.5 software graphs for SL-PW-24

O) SL-PW-25

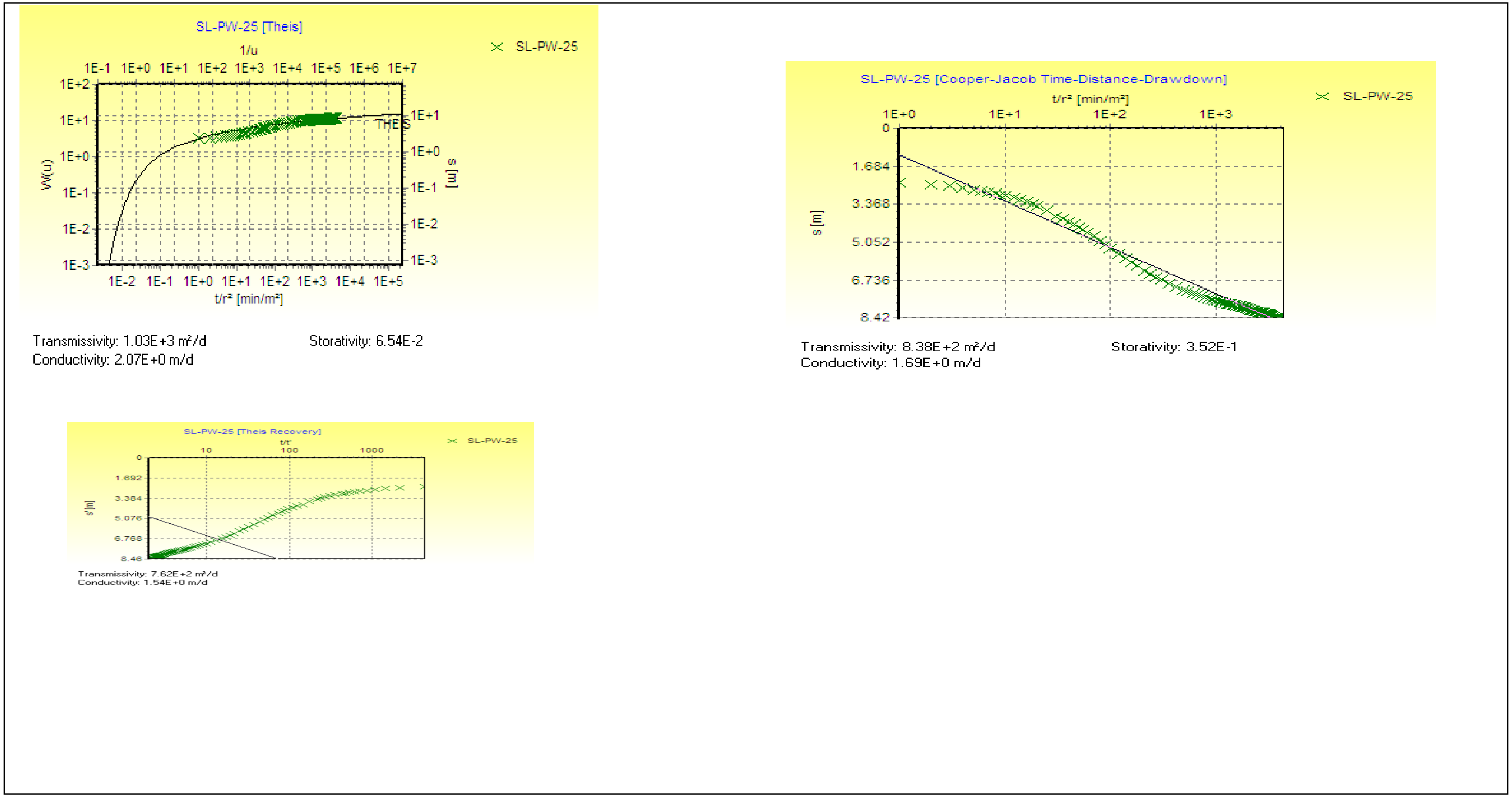


Figure 82 o Aquifer test 3.5 software graph for SL-PW-25

P) SL-PW-30

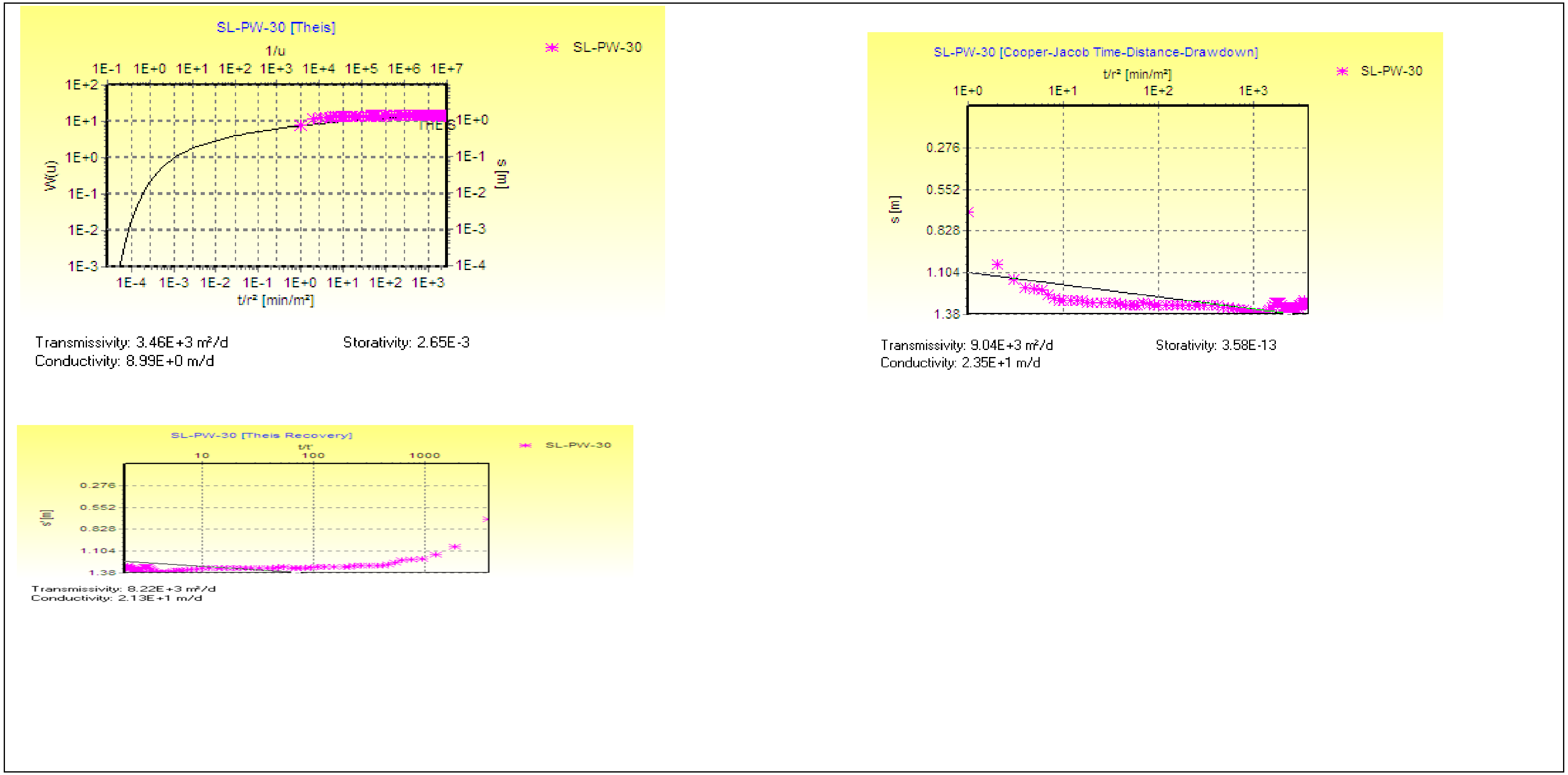


Figure 83 p Aquifer test 3.5 software graph for SL-PW-30