ASSESSMENT OF EXPLOITATION LEVEL OF LOCAL WATER BODIES BY ALL WATER CONSUMER IN A RADIUS OF 10 KM AROUND NESTLE KABIRWALA FACTORY, SOUTH PUNJAB, PAKISTAN

CLIENT: NESTLE KABIRWALA FACTORY

CONSULTANT: GREEN CRESCENT ENVIRONMENTAL CONSULTANTS

TITLE: ASSESSMENT OF EXPLOITATION LEVEL OF LOCAL WATER BODIES BY ALL WATER CONSUMER IN A RADIUS OF 10 KM AROUND NESTLE KABIRWALA FACTORY, SOUTH PUNJAB, PAKISTAN.

STATUS	NAME	DESIGNATION	SIGN
Compiled by	Rameesha Ishtiaq	Geologist	
	Farheen Asghar	Senior Geologist	
Supervised by	Asrar Hussain	Senior Hydrogeologist	
Reviewed by	Hamza Bilal	Senior Hydrologist	
Consult By	Faizan Ahmed	Principal Hydrogeologist	

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CASES

GLOSSARY

EXECUTIVE SUMMARY

Nestlé Pakistan is Public Interest Company (PIC) with four production facilities across the country. Nestle Kabirwala is a multi-product manufacturing facility, mainly related to dairy products. Nestle is always concern to its locality and climate change impact, they design and practice several studies to forecast the impact and implement the remedies if needed. Water resource study is one of the global practices of Nestle and this was initially conducted in 2015 at Nestle Kabirwala Pakistan and re-verified on 2020 covering the reconnaissance surveys, pump testing and water budgeting to understand the subsurface water regime of regional aquifer.

To carried out the study, nestle engage the Green Crescent Environment Consultant to assist the total inflows and outflows of the basin, including qualitative and quantitative figures of all industries, municipalities, domestic and agriculture users of water with respect to different sources like surface water and ground water.

The study is carried out with meeting the local community, farmers, cattle farmers and industrial representatives of regional area for collection of water usage and demarcation of resources, collection of water samples and soil samples, which was later tested in GCEC lab. The pump test also practices on tubewell of Nestle Kabirwala to confirm the aquifer properties and characteristics and determination of recharge time of aquifer from dynamic level to static level. Seasonal rainfall data, WAPA Irrigation Canal System, National Policy for water exploitation, Census data for population per capita usage and metrological data is also obtained from different government department which help to orient the study.

The study area is covered by quaternary alluvium which presumably over lies semi-consolidated Tertiary rocks or metamorphic and igneous basement rocks of Precambrian age. The Lower bari doab canal (LBDC) is marked as a major source of groundwater recharge in the study area. The groundwater level of the study area is varying from 16 meters to 30 meters from existing groundwater level as per seasonal variation.

On data modeling obtained during desktop study and field visit, the total groundwater inflow in the subsurface is found to be 136.736 MCM/Yr. (0.109 MAF/Yr.) in our 10 km2 study area and outflow is found to be 149.42 MCM/Yr. (0.1195 MAF/Yr.). The delta between inflow and outflow is calculated to be 12.69 MCM/Yr. (0.01014 MAF/Yr.). Major usage is found to be agriculture of total water consumption up to 76%, 17% for Industry and 7% consume by domestic and livestock. Average water consumption of Nestle is 1506 m3/day of the total industrial usage of an area and 0.37 % of groundwater withdrawal of that area annually. As the recharge of aquifer is found to be good and delta between the discharge and recharge is negligible. The studies conclude that, the Nestle ground water extraction lies in safe zone and Nestle production shall sustain with current available resources.

CHAPTER-1

INTRODUCTION

1.1 INTRODUCTION

To understand the behavior and transport of contamination in the groundwater of the regional area around Nestle Factory Kabirwala, numerical flow and transport modeling of the area is considered to be the best option and it is therefore carried out.

The hydrogeological monitoring studies were started in the area in 1962 by WAPDA. Water and Power Development Authority (WAPDA) had executed substantial work on groundwater exploration in pursuit of improvements in agrarian economy of the country. In the period of 1961 to 1963 extensive work was done in Bari Doab, and basic data on the subsurface lithology, and quality of groundwater was collected. Data on aquifer tests and their analysis was also collected. This data was published in 1980 and 1982.

Nestle Kabirwala factory lies on Khanewal Road, Kabirwala, District Khanewal, Punjab, Pakistan. They had introduced a largest milk reception factory at Kabirwala in March, 2007. Nestle is using a considerable amount of groundwater along their neighboring factories. If the difference of water inflow and out flow increases it will cause difficulties for local small industry like farming, cattle farms etc. as well as it will effect on other industries like Nestle, Jadeed Feeds etc. For minimizing the threat of water depletion in aquifers or water logging and salinity, there were conduct many studies or lead the projects in past few years. Here, Nestle allocate a project of “assessment of exploitation level of local water bodies by all consumers in a radius of 10KM around Nestle Factory” to Green Crescent. This study also includes groundwater quality assessment.

For achieving this purpose Green crescent is doing qualitative and quantitative evaluation of industries, domestic and agriculture users in the context of surface and ground water. This project needs accurate and valid hydrogeological information, groundwater elevation maps and profiles and their hydraulic characteristics. Hence, this information will be used for locating groundwater recharge source, surface water catchment area and water availability in aquifers for water supply, annual replenishment of aquifers, and depletion in levels. Such information will lead towards identifying successful hydrological priorities for Nestle Kabirwala Factory as that it can be operated with more environmentally safe yield limits.

Figure 1: Satellite image of Study area

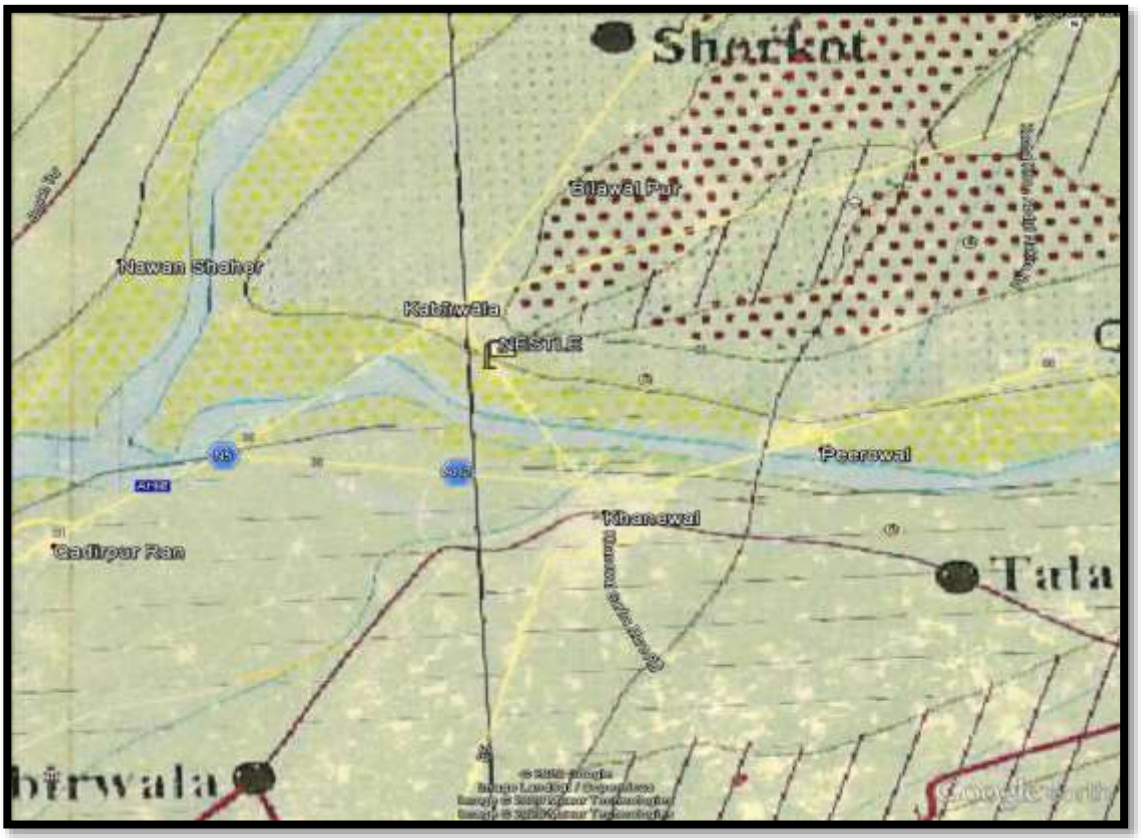


Figure 2: Geological map of the study area

1.2 SCOPE OF WORK

The assessment should include qualitative and quantitative figures of all industries, municipalities, domestic and agriculture users of water with respect to different sources like surface water and ground water.

1. Total recharge to study area and overall water sustainability analysis based on recharge and discharge. Information should cover recharge sources and potential contribution by each source in the study area.
2. A conceptual model of the groundwater flow system should be developed.
3. Official legislation related to surface and groundwater abstraction/use shall be part of the key information.
4. Rainfall, temperature/flood level/drought evolution over the last 10 years (monthly data for 10km radius)
5. Topographic map of the study area (1:25,000 is recommended)
6. Geology: Geological description includes but not limited to:
    a. Information related to the geometry of each layer,
    b. Surficial materials,
    c. lithology and intrinsic properties,
7. A clear geological map (scale: 1/50000) should be included.
8. Description of groundwater system with respect to:
    a. Lithology,
    b. Type of aquifer,
    c. hydrodynamic properties,
    d. Recharge area,
    e. Direction of groundwater inflow should be assessed,
    f. Quantitative aspects.
9. Information on water levels should be collected and consolidated for: Piezometric and potentiometric maps for the aquifer materials as applicable,
10. Water level trend over previous 5 years (national, regional and study area) Quality data should be consolidated with major elements at least. Data should be evaluated in comparison to regional and local official legislation and/or regulations (compliance, non-compliance, issue-specific, etc.).
11. Some sampling should be organized to support additional analyses.
12. The list of potential pollution sources and/or risk analysis (farming, industries, roads and increasing of cities…) should be identified and discussed. A hazards map should be included.
13. Impact to downstream surface water bodies

14. The use of water at internally operated water resources might potentially have a detrimental impact to downstream water bodies (river/stream/pound/wet zones) which are recharged by these groundwater sources, insofar their natural flows might be reduced by Nestlé's abstraction. These impacts/risks (if any) should be assessed (impact on natural ecosystems, biodiversity, other water uses) and reported in the Water Resource study (WRS).
15. Evaluation and updating of an upstream / downstream analysis vis-à-vis our water abstraction points is critical element in order to check what real impact might derive from the water use by the manufacturing facility and what from other local stakeholders.
16. Historical evolution of surface water, ground water and hydrogeology in the study area and surrounding areas.
17. Any reliable reference quoted in the report shall be fully produced as annexure (the complete reference report). International rules of referencing should be used wherever applicable.
18. Conclusions should include
19. A brief summary on surface and groundwater characteristics of the study area
20. A clear description of the sustainability level of water resources used by the manufacturing facility and recommendations on how to address potential risks (including roll out of possible collective action towards water conservation, aimed at transforming any potential threats into win-win opportunities).
21. The study must be written in English and should be available in soft and hard copies.

1.3 TOOLS USED FOR STUDIES

When the term suggests of Field work in Field geology, the directed rehearsed perception of outcrop, exposures, landscapes, and drill cores. Those engaged in field geology investigate landforms, rocks and rock type, basin, landforms in their natural environment. Field geologists in this way endeavor to portray and clarify surface highlights, underground structures, and their interrelationships by using field equipment and tools. Although field geology is based on observation, many conclusions are predicated on inferences. The ability to infer and infer correctly is the goal of training in field geology. Proficiency as a geologist is greatly measured by one's ability to sketch reasonable conclusions from observed phenomena and to predict the occurrence of features, conditions or processes using field experience.

With respect to scope of work to our client Nestle Kabirwala Factory, GCEC team used following tools to obtain maximum result of total recharge of water in the study area, conceptual model of the groundwater flow system, Rainfall, temperature/flood level/drought evolution over the last 10 years (monthly data for 10km radius) and geological description of the study area.

1.3.1 GPS (GLOBAL POSITIONING SYSTEM)

GPS (Global Positioning System), a system that changed navigation forever. GPS is the only system today that is able to show you your exact position on the Earth anytime, in any weather, anywhere on or above the earth surface. It is a worldwide radio-navigation system formed from a constellation of 24 satellites and their ground stations. GPS satellites orbit at 11,000 nautical miles (1 nautical mile = 1852 m) above the Earth. Ground stations located worldwide continuously monitor them. The satellites transmit signals that can be detected by anyone with a GPS receiver. Using the receiver, you can determine your position accurate to a matter of meters.

Figure 3: GPS TOOL

1.3.2 BRINTON COMPASS

To initiate your location different compasses can be used but in terms of geology the, specialized magnetic compasses such as Brinton and Saliva compasses be used measure orientation of geological structures. This Brinton Compass are practically use in combination of two functions, direction finding and navigation (especially in remote areas), and the ability to measure strike and dip of bedding surfaces or metamorphic foliation planes of the strata. Structural geologists concerned with geometry to measure the plunge and plunge direction of lineation.

Figure 4: Brinton Compass

1.3.3 ACID-HCL (HYDROCHLORIC ACID)

Every field work required small bottle of 10% Hydrochloric Acid to disguised the most common carbonate rocks, dolomite, and limestone (or marble, which may be composed of either mineral). A few drop of HCL on the rock, the carbonate rocks will give effervescences. This 10% of HCL also helps geologist to identify the cementing agents of Sandstone. They place a drop of dilute HCL on the sandstone and closely observe. If calcite is the cementing agent, an effervescence will occur and some of the sand grains might be liberated. All of above observation helps geologist to optimize the exact lithology of the study area.

Figure 5: 10% Conc. Hydrochloric acid

1.3.4 WTM (WETTED TAPE METHOD)

An old-fashioned way to measure depth to water is the wetted tape method. It is typically used for depths up to 80 or 90 feet. In order to use this method, you must already know the depth to water within a few feet. To use the wetted tape method, you will need a steel measuring tape, a weight and a carpenter's chalk. To measure the depth of water, attach the weight to the end of the measuring tape. Coat the lower 3 to 4 ft. of the tape with carpenter's chalk. Lower the tape into the well until the lower part of the tape is under water, then lower the tape a little more until the next foot marker is at the surface level. Record the number of feet indicated. Remove the tape from the well and record the length of tape that was under water. (The chalk which was under water will be wet or washed away.) The difference in these two measurements is the depth to water.

Figure 6: Groundwater measurement from Wetted Tape

1.3.5 WLI (WATER LEVEL INDICATOR)

The static groundwater level was noted by inserting an electric probe in the well. When the circuit has been completed the buzzer was responded and then note the length of the probe that shows the depth of ground water level from existing ground level.

Figure 7: Measurement of groundwater from WLI

1.3.6 TDS METER (TOTAL DISSOLVE SOLIDS)

TDS (Total dissolve solids) is the combination of all ion particles that exist in nature less than 2 microns including inorganic salts and organic matter which dissolved in a given volume of water. This includes all disassociated electrolytes such as calcium, magnesium, potassium and sodium, which are all cations, and carbonates, nitrates, bicarbonates, chlorides and sulphates, which are all anions.

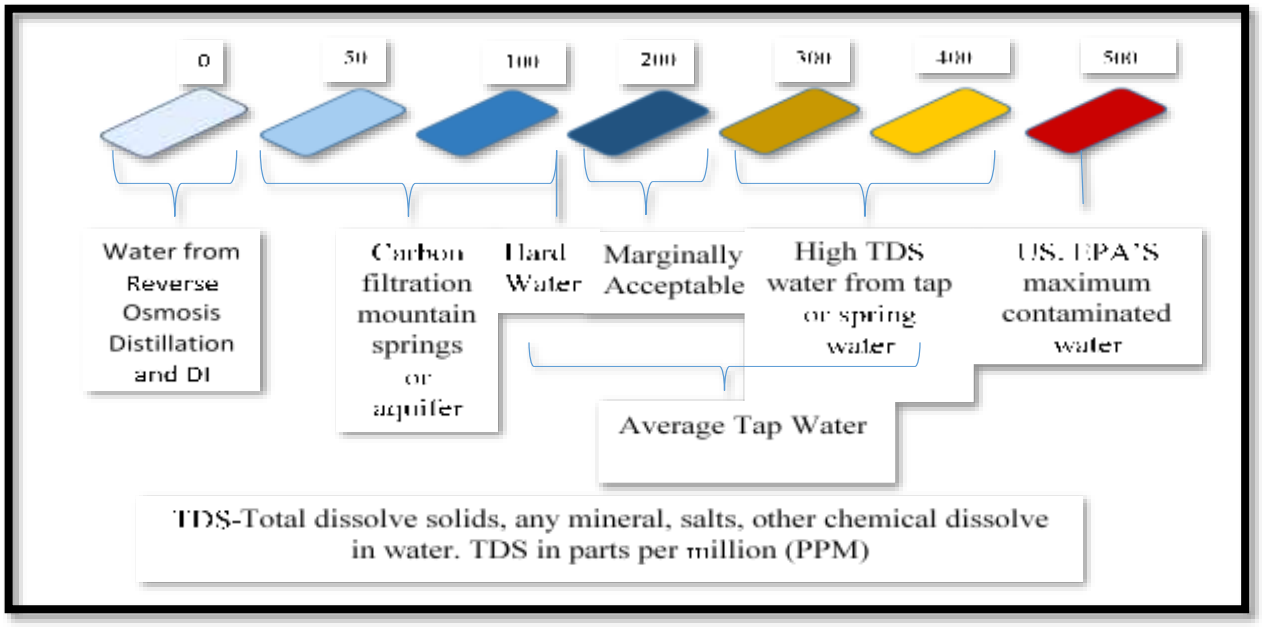


Figure 8: Actual TDS level

The concentration and composition of TDS in natural waters is determined by the geology of the drainage basin, atmospheric precipitation and the water balance. Alterations in the concentration of total dissolved solids in natural waters is often the result of industrial effluent, changes to the water balance.

Figure 9: Calculation of TDS at wells

1.4 SOFTWARE

1.4.1 GIS (GEOGRAPHIC INFORMATION SYSTEM)

A geographic information system (GIS) is a framework for gathering, managing, and analyzing data. Rooted in the science of geography, GIS integrates many types of data. It analyzes spatial location and organizes layers of information into visualizations using maps and 3D scenes. With this unique capability, GIS reveals deeper insights into data, such as patterns, relationships, and situations—helping users make smarter decisions.

GIS help geologist to study the structure, composition and changes over time. Geologists map out features of the earth's surface and offer guidance for natural resources management. The user use these methods to gather, analyze, manipulate and visualize geographic data can reveal fascinating details regarding your study area.

Mapping and modeling weather and climate with GIS yields valuable insights for expert as they study the processes at work in the atmosphere. Geologist pinpoint locations of weather events and analyze how systems move over time. Identifying meaningful patterns and trends in GIS weather data leads to more accurate predictions.

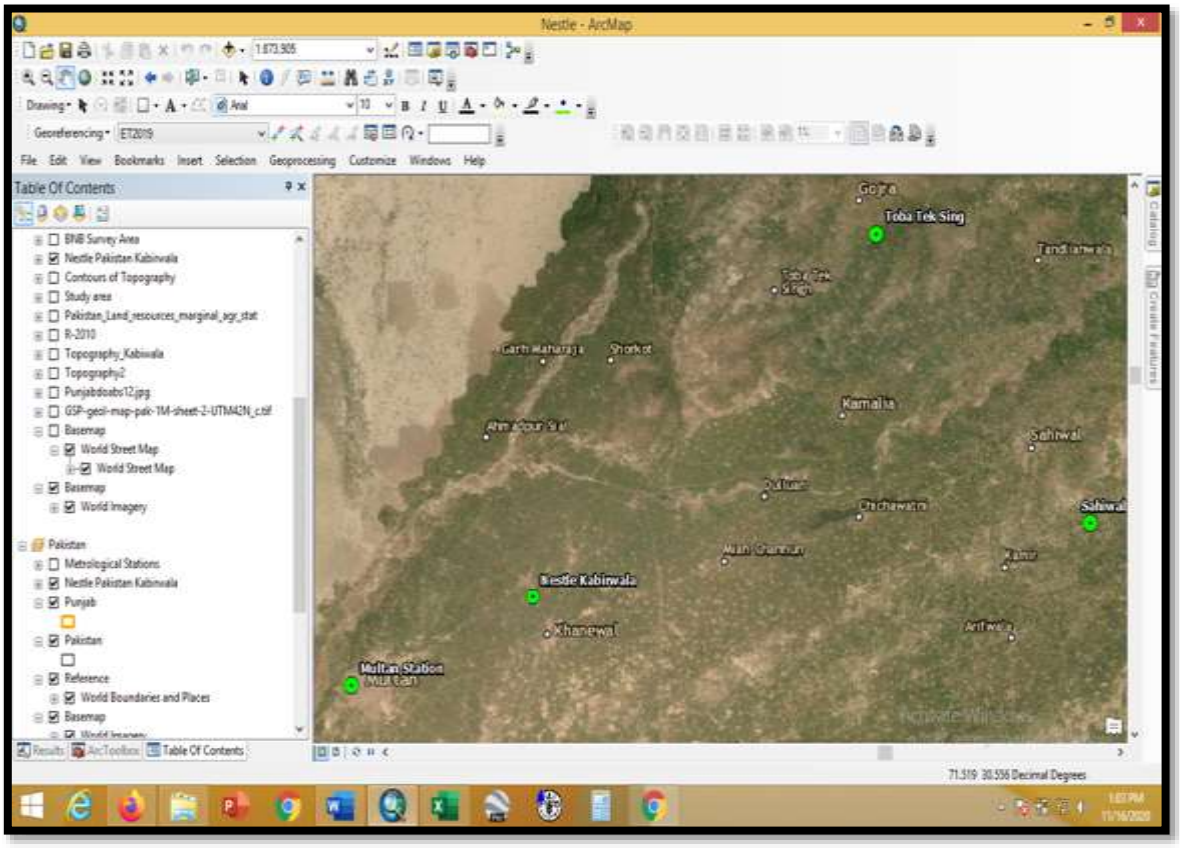


Figure 10: GIS Software

1.4.2 RS (REMOTE SENSING)

The term remote sensing variously defined the art or science of telling something about an object without touching it. This platform has established the Artificial Intelligence (AI) for earth initiative to facilitate the use of its AI tools for addressing environmental challenges in four main areas of climate, agriculture, biodiversity, and water. In Recent years, there has been a significant increase in the number of remote sensing (RS) datasets acquired by various space borne and airborne sensors with different characteristics e.g. spectral, spatial, temporal, and radiometric resolutions.

Remote sensing is a phenomenon that has numerous applications including, surveying, geology, forestry, photography and many more. But it is in the field of water quality, agriculture in collect massive database for decade's process, production, identification, subsurface moisture, monitoring and management.

In the next decade other operational applications are likely using remote measurements of land cover, water resources groundwater, and areal inputs to hydrological models. Many research challenges remain, and significant progress is expected in areas like albedo measurements, energy budgets, and evapotranspiration estimation. The research in remote sensing and water resources also has much relevance for related studies of climate change and global habitability.

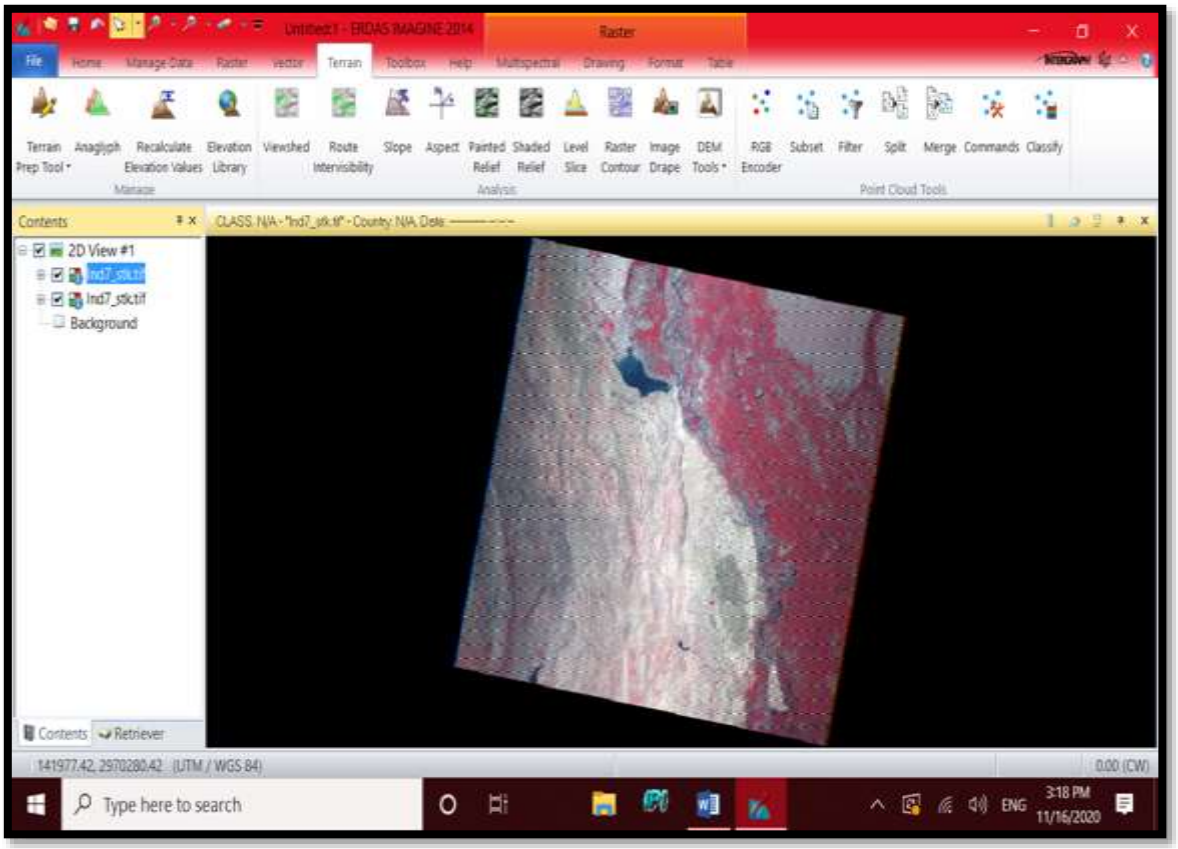


Figure 11: Remote sensing Software

1.4.3 CROPWAT

Computer program for the calculation of crop water requirements and irrigation requirements based on soil, climate and crop data. In addition, the program allows the development of irrigation schedules for different management conditions and the calculation of scheme water supply for varying crop patterns. Although a host of updated and new features, including daily soil water balance output tables, possibility to estimate climatic data in the absence of measured value and decade and daily calculation of crop water requirements based on updated calculation algorithms including adjustment of crop-coefficient values.

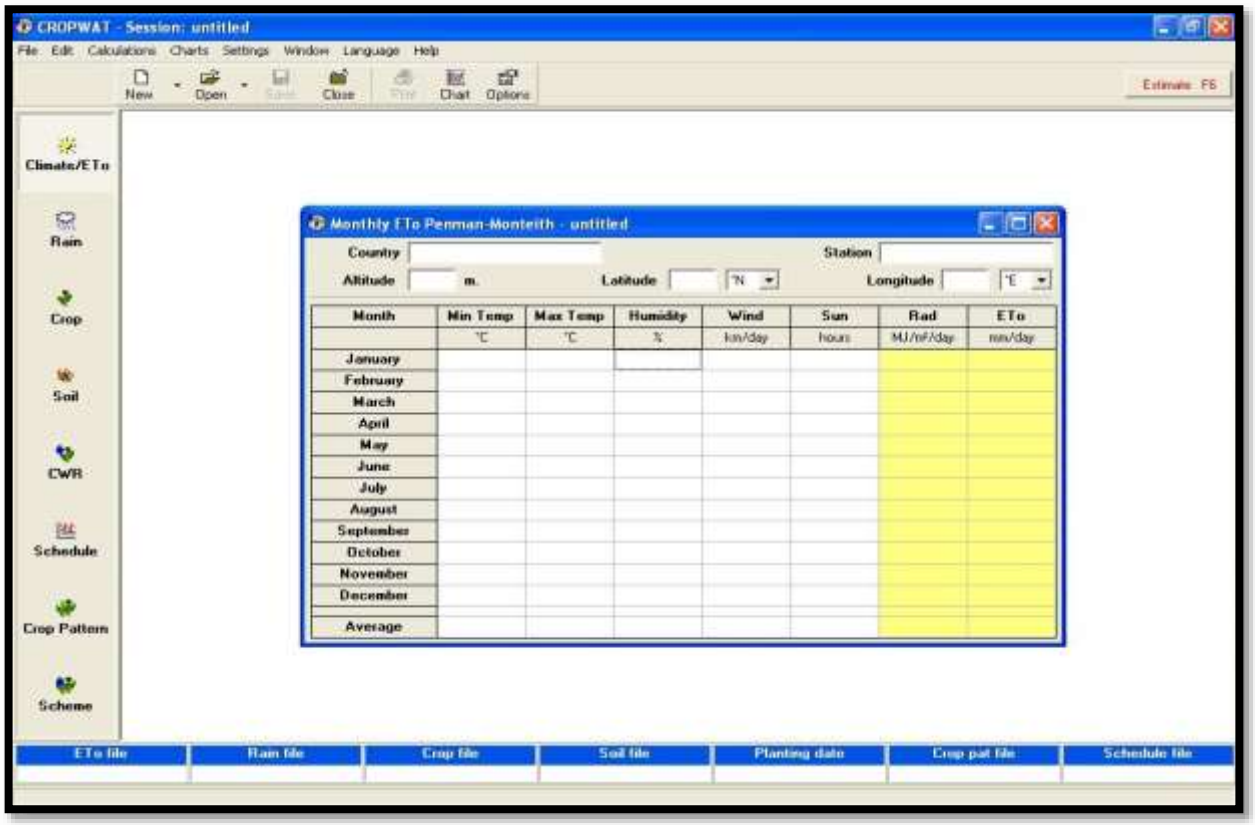


Figure 12: CROPWAT Software

1.4.4 AQUIFER TEST PRO

Aquifer Test pro is a software which is design to analyzing, interpreting visualizing pump test data of the well. This software provides all the tools needed to accurately interpret data from all types of aquifers in all types of test conditions.

Aquifer test pro software used to calculate hydraulic characteristics would be relatively easy if the aquifer system (i.e. aquifer plus well) were precisely known. This is generally not the case, so interpreting a pumping test is primarily a matter of identifying an unknown system. System identification relies on models, the characteristics of which are assumed to represent the characteristics of the real aquifer system.

The model main plot curve will contain two data series:

1. The time-drawdown data

2. The drawdown derivative data (time vs. change in drawdown).

The drawdown derivative data series will be represented by a standard symbol with the addition of an X through the middle of the symbol.

On the right side of the window, you will see five time-drawdown graph templates, each one representing different aquifer conditions, and/or scenarios encountered during a pumping test. These include:

- **Confined**
- **Leaky or Recharge Boundary**
- **Barrier Boundary**
- **Double Porosity (Fractured Flow) and Unconfined**
- **Well Effects**

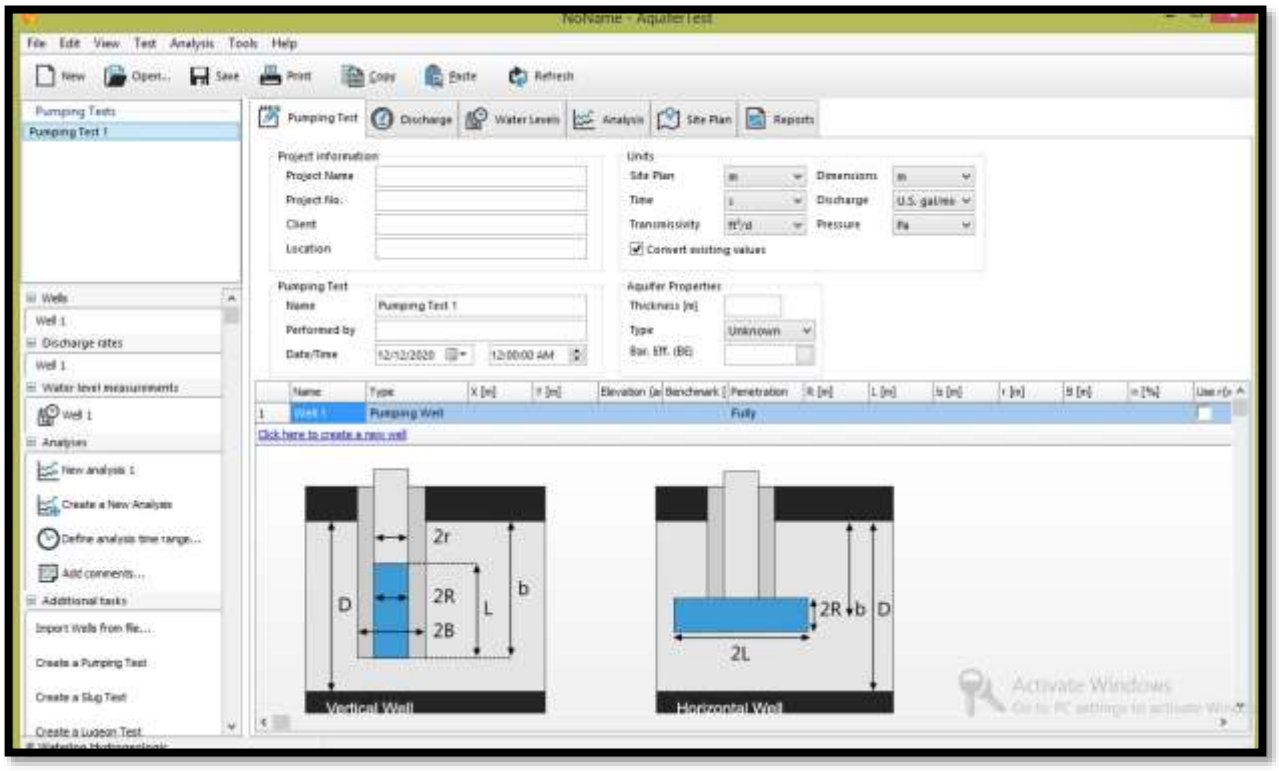


Figure 13: Aquifer Test pro Software

1.5 PREVIOUS STUDY OF NESTLE

1.5.1 SUMMARY

The previous study entitled “Assessment of the exploitation level water bodies by all water consumers in a radius of water consumers in a radius of 10 km (315 square kilometers area) around Nestle Kabirwala Factory (6.5km Kabirwala Khanewal Road) South Pakistan” covers a wide range of range of studies including hydrology and hydrogeology, temperature, rainfall, relative humidity, and spatial distribution of

rainfall and temperature in Multan, Khanewal, Toba Tek Singh, Jhang, Faisalabad, onsite data collection about fifty three (53) sites for water table, hydraulic heads, construction methodology, year of installation of wells, tentative well discharges and drawdown. Based on these information, contour maps of the water tables, hydraulic heads with vector lines (groundwater elevation map), and direction of groundwater flows 2015 are constructed by a best contouring routine SURFER Version 11. Numerical groundwater modeling study on a regional scale has also been carried out using 3-D Numerical groundwater flow and transport model (Visual MOD Flow Software 2013) to develop steady-state and transient (non-steady state) flow models of the historic past in 1962 and most recent version in 2015. Directions of flows are in the southwest and southeast directions on the regional trend. Particle tracking (Contaminants) are also added as a point source and their direction of dispersion have been simulated with MOD Path transport utility of the Visual MOD flow, which tend to move towards the Ravi River, and in the middle of the area southwest of the Nestle Kabirwala Factory. Different Scenarios of dispersion paths are simulated.

1.5.2 CONCLUSION

Interpretative results of the entire studies including hydrology and hydrogeology, temperature, rainfall, relative humidity, and spatial distribution of rainfall and temperature in Multan, Khanewal, Toba Tek Singh, Jhang, Faisalabad, onsite data collection about fifty three (53) sites for water table, hydraulic heads, construction methodology, year of installation of wells, tentative well discharges and drawdown have led to the following conclusions.

1. Aquifers underlain in the subsurface formation are composed of sand of various grain sizes that contain good potentially enriched groundwater with lesser amount of drawdown in response to abstraction of groundwater. Nestle Kabirwala Factory is operating only two water wells with low yielding capabilities of 0.50 to 0.75 cusecs, although higher rating submersible pumps could be installed as well to abstract larger quantity of groundwater within safe yield phenomena (without degrading the environmental issues and or creating trough in the water levels).

2. Numerical groundwater modeling study on a regional scale has also been carried out using 3-D Numerical groundwater flow and transport model (Visual ModFlow Software 2013) to develop steady-state and transient (non-steady state) flow models of the historic past in 1962 and most recent version in 2015. Model has indicated the groundwater flows are in the southwest and southeast directions on the regional trend.

3. Water Budget 2015 of the Bari Doab based on the recharge (rainfall, irrigation system, and return flow from groundwater abstraction) and discharge (groundwater abstraction from public and private tube-wells, and evaporation loss) have shown a close balance between the recharging component 35.08 MAF and discharging components 35.54 MAF. Results are valid over a decade with ± change of 1%.Particle tracking (Contaminants) as a part of modeling study based on artificially generated point source and

their direction of dispersion have been simulated with MODPath transport utility of the Visual Modflow, which tend to move towards the Ravi River, and in the middle of the area southwest of the Nestle Kabirwala Factory (figures 33, 34, and 35). However, as such no apparent contamination appears to exist within the Nestle Factory and also in its surroundings.

4. Electrical Resistivity Sounding Survey (ERSS) carried out within the Nestle Factory Kabirwala over seventeen (17) different locations have shown mostly aquifers of unconfined in nature and they represent large quantity of groundwater with negligible drawdown of about 2~4 meters in response to pumping of 0.5 to 0.75 cusecs. Water wells up to 1.5 cusecs can also be installed within the premises of Nestle factory.

5. To study the distribution of chemical concentrations in and around the Nestle Kabirwala Factory, five (5) samples each of different quantities were collected to determine the trace elements, Volatile organic compounds (VOCs), THMs, Pesticides, and radioactivity. The samples are taken from the existing water wells that are listed in the following Table-01 with reference to their latitude and longitude.

Table 1: Locations of water sample collection sites for Chemical Analyses

Locations of Water Samples Collection Sites		
Latitude (degree-min-sec)	Longitude (degree-min-sec)	Remarks
1) 30-18-12 N	71-55-26 E	TMA Khanewal Well 1 that is 350 feet deep, year of installation 1987
2) 30-22-22 N	71-52-99 E	Nestle Well 2 (in actual well 1) 350 feet deep, year of installation 1989
3) 30-22-24 N	71-52-56 E	Nestle Well 3 (in actual well 2) 350 feet deep
4) 30-24-29 N	71-52-06 E	TMA Kabirwala Well 4, 450 feet deep, year of installation 1998
5) 30-23-07 N	71-52-16 E	Kabirwala Agricultural Well 5 200 feet deep

6. The results of the trace elements, Volatile organic compounds (VOCs), THMs, Pesticides, and radioactivity fall within the permissible limits for the Nestle Water Wells 1 and 2, but for the TMA Khanewal well results of total dissolved solids (TDS), total hardness, Nitrate are relatively high.

7. Field data acquisition of water table depth within 10 Km radius varies between 35 to 55 feet depth and it is recharged by the annual rate of rainfall, and runoff that spills over the Ravi River, tributaries and the Indus Plain.

8. No undesirable results and environmentally degradation have shown by this study. X. The Nestle Kabirwala Factory is meeting all requirements of safe yield operation.

1.5.3 RECOMMENDATIONS

Electrical Resistivity Sounding Survey (ERSS) is carried out within the Nestle Factory Kabirwala over seventeen (17) different locations to study the subsurface lithology and potential of underlying groundwater aquifer regimes. Mostly the aquifers are unconfined in nature and they represent large quantity of groundwater with negligible drawdown of about 2~4 meters in response to pumping of 0.5 to 0.75 cusecs. Suitable probes recommended for future drilling for tube-wells are provided in the following Table 2. The locations of ERSS sites are provided in figure 36. Sites ERSS-1 or ERSS-8 can be used for drilling a new tube-well up to 390 feet depth.

Table 2: Recommendations of ERSS Points for future drilling

Nestle Kabirwala Factory	Recommendation Depth
ERSS-1, ERSS-8	Water Well of 390 feet depth
ERS-2, ERSS-4, ERSS10, ERSS-15	Water Well of 370 feet depth
ERSS-5	Water Well of 380 feet depth
ERSS-13	Water Well of 365 feet depth

CHAPTER-2

STUDY AREA INSIGHT

2.1 STUDY AREA

The study area lies between the two main river bodies of River Ravi and River Sutlaj. The main access is from Multan highway leading to Karachi and a bypass to Kabirwala that would lead to Nestle Factory. Many other factories are located in this area and a great hustle and bustle due to trucks including local transports can be seen. The area lies within longitudes 71º 12´ to 72º E and latitudes 29° 24´ to 30° 48´ N covering an area of about 3,721 sq km. It comprises of four Tehsils namely Multan Cantonment, Multan Sadar, Shujabad and Jalalpur Pirwala. It is well connected via railways, road and air links with other parts of the country.

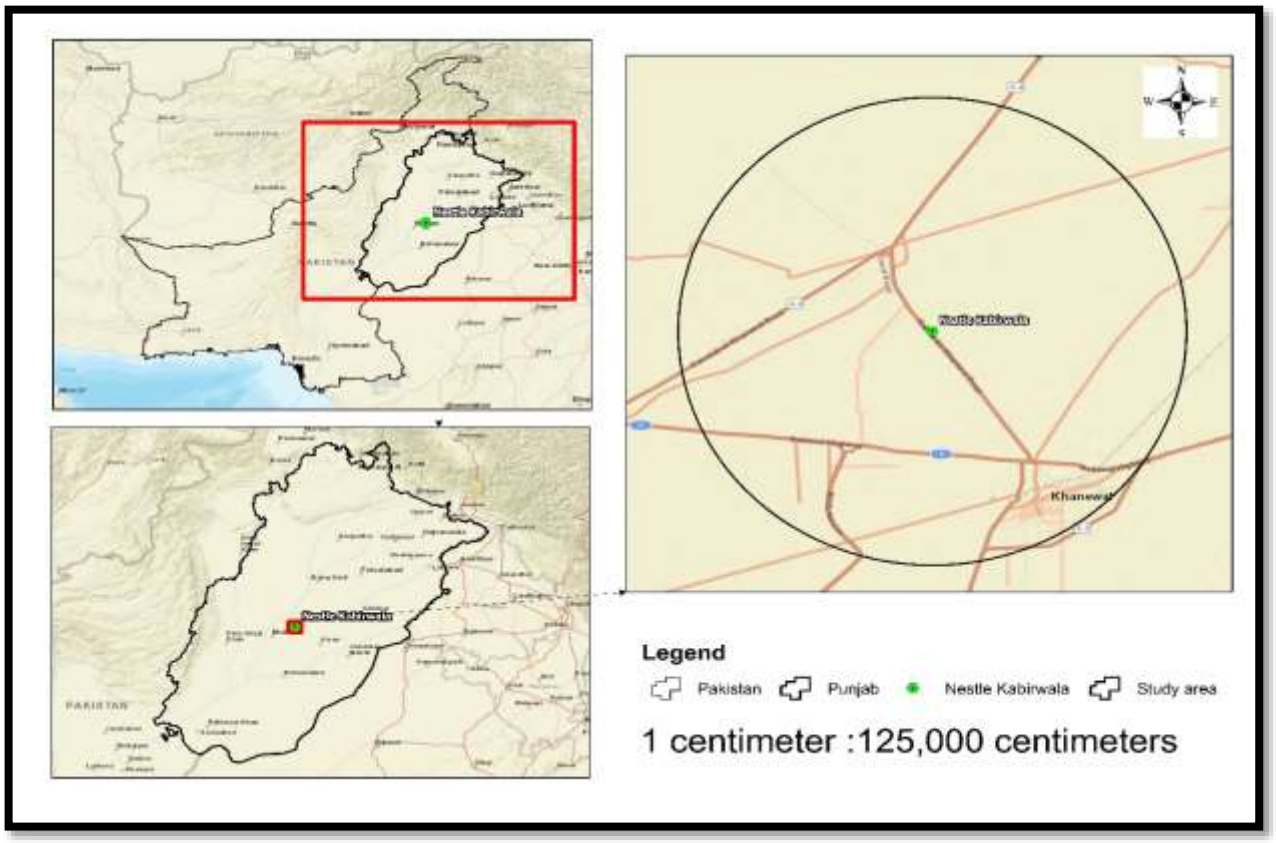


Figure 14: Location map of Study area

2.2 ACCESSIBILITY

The main access is from Multan highway leading to Karachi and a bypass to Kabirwala that would lead to Nestle Factory. Many other factories are located in this area and a great hustle and bustle due to trucks including local transports can be seen. Boundary of study area is the 10km around the Nestle Pakistan Facility. This boundary is covers Khanewal City in south and Kabirwala City on North and it covers about 628 sq.km area.

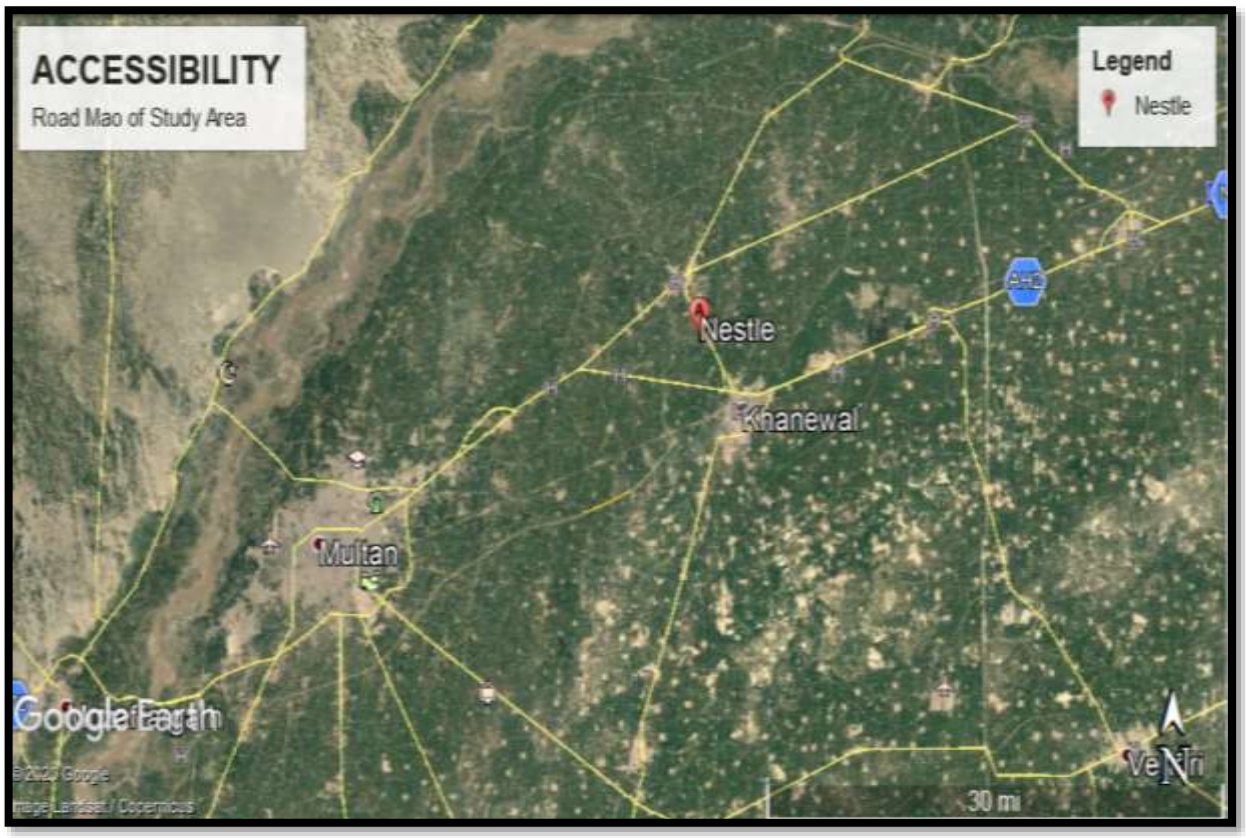


Figure 15: Accessibility Map

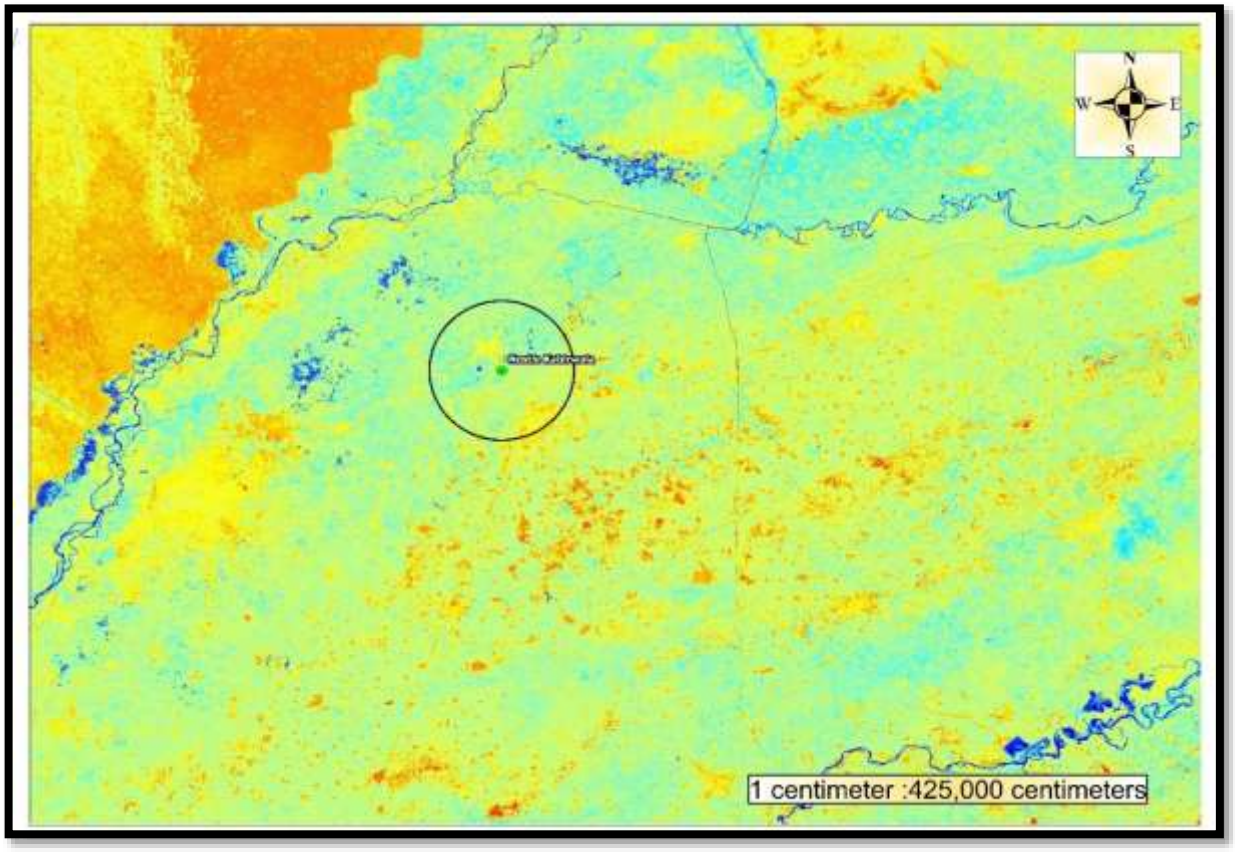


Figure 16: Location of the study area in the Landsat 8 image of 2019

Figure 17: Location of the study area over Google Earth image

2.3 CLIMATE

The climate of the study area is considered on the basis of precipitation and rainfall. As well as some related literature was reviewed.

2.3.1 TEMPERATURE OF THE STUDY AREA

It feels maximum 30 ^{O}C to 35 ^{O}C temperature in summer season while in winter season it is drops till 8 ^{O}C to 3 ^{O}C. In the study area the summer season is moderately long as per winter season. While the winter is very cold as per summer is very hot. The autumn and spring are very short seasons. The increase in maximum annual temperature is due to global warming. The researchers say that annually 2.5 to 10 ^{O}F or 2 to 3 ^{O}C temperature is rising as an impact of climate change.

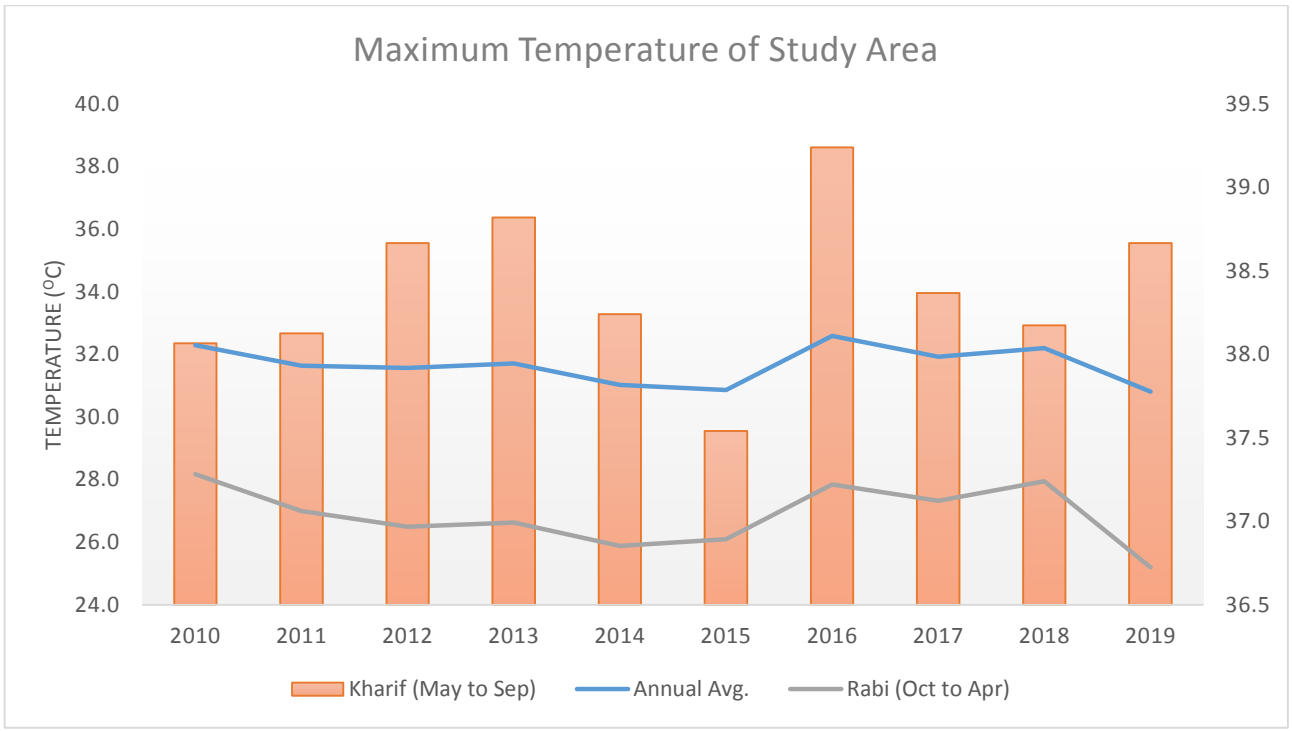


Figure 18: The Maximum Temperature (^{0}C) of study area (period 2010 – 2019)

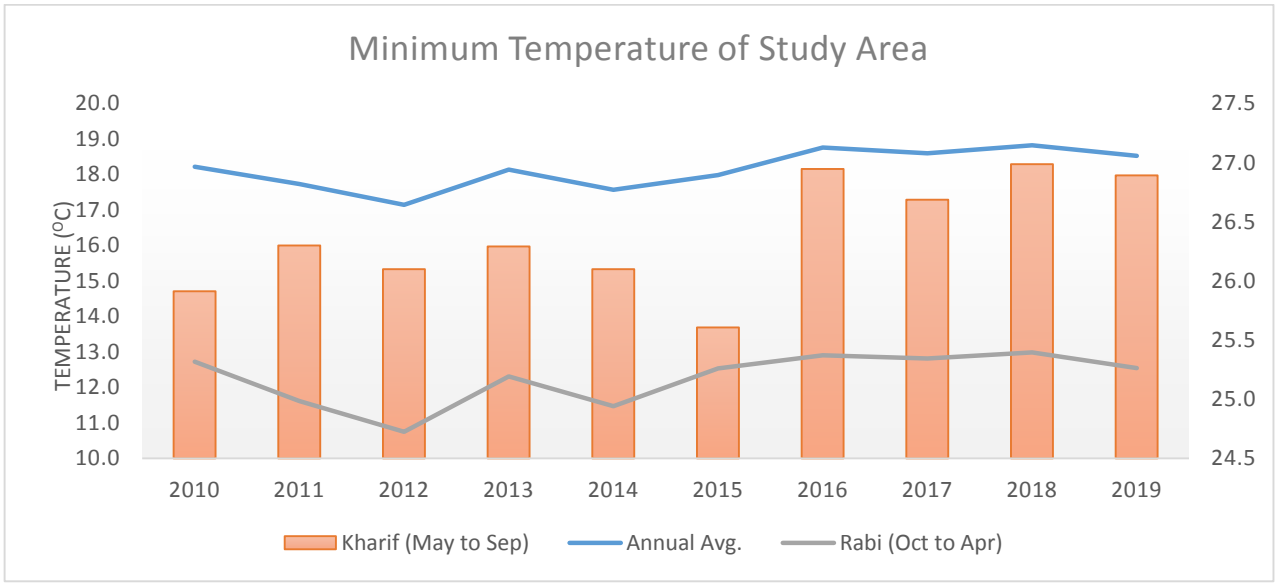


Figure 19: The Minimum Temperature (^{0}C) of study area (period 2010 – 2019)

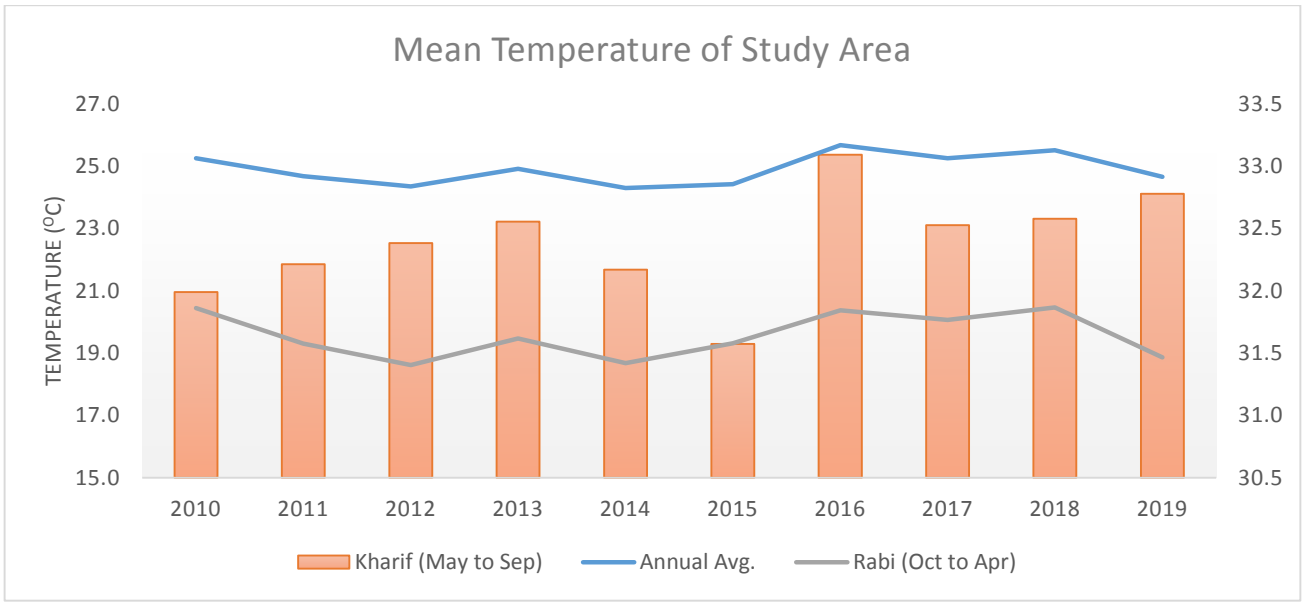


Figure 20: Temperature (^{0}C) of study area (period 2010 – 2019)

As well as the rain fall is ranging in between 385 mm to 442.1 mm in last 10 years (2010 to 2019). On the basis of precipitation data many spells were estimates and marked. While due to climate change and aquifer melting heavy rainfall and floods were demarcate in 2010, 2011 and 2015. Due to increase in temperature as a result of global warming in the land form areas due to low air pressure the rate of precipitation is increases day by day.

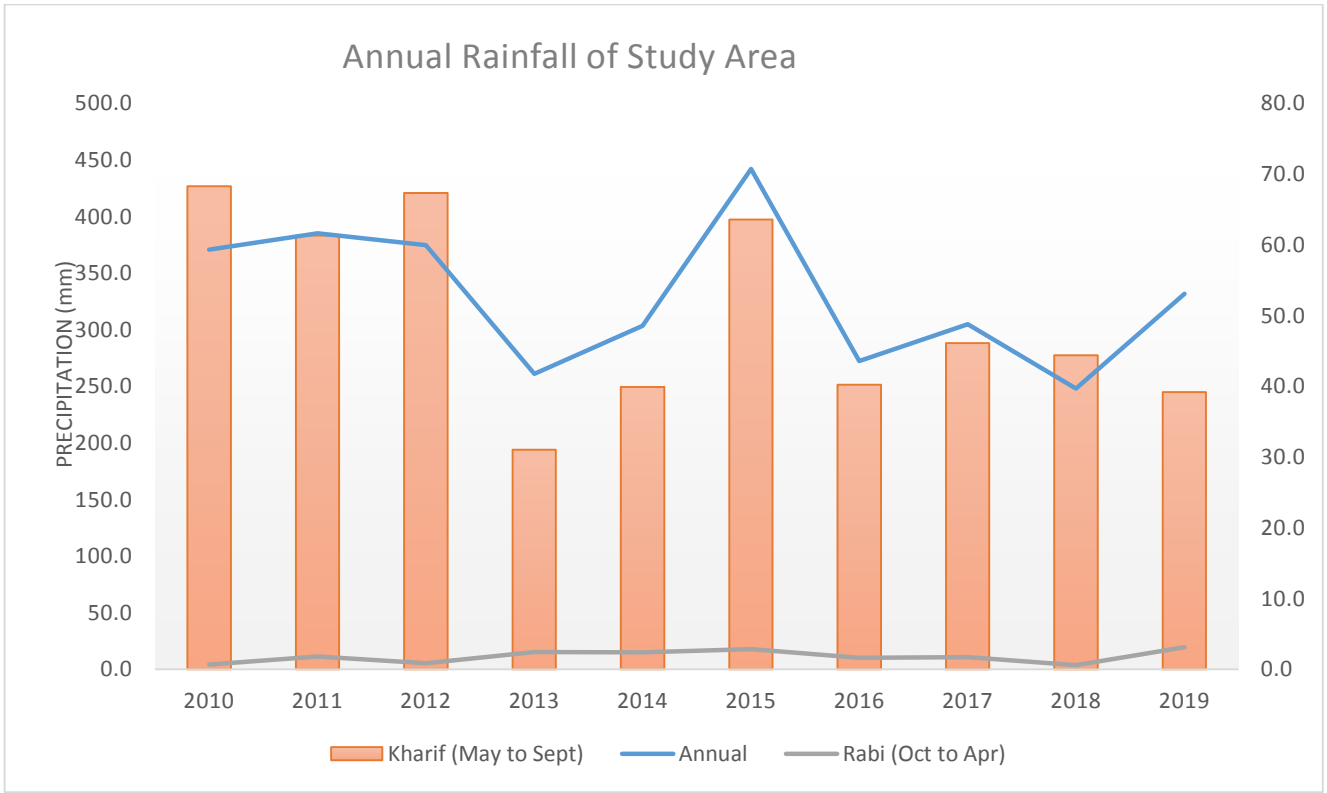


Figure 21: Annual precipitation (mm) at study area (period 2010 – 2019)

2.3.2 CLIMATE TREND INDEX

For analysis of the drought period, Standard Precipitation Index (SPI) is the most powerful and flexible method. The SPI was intended to quantify the deficit of precipitation for different timescales according to the water resource subtleties.

SPI was written as:

SPI= (Monthly amount of rainfall – Arithmetic Mean of Rainfall) /Standard Deviation

SPI values show many mild drought and mild wet seasons. Like in 2016 and 2012 shows mild wet climate in them. And the change in trend is due to change in climate or global warming. Because the SPI is trigger with annual rate of rainfall and the precipitation rate is increasing due to climate change.

Table 3: Climatic trend analysis Table

S. No	Classification	SPI Value
1	Extremely wet	2.0 <
2	Very wet	1.46 < 2.0
3	Moderately Wet	1 < 1.46
4	Mild Wet	0 < 1
5	Mild Drought	0 > -1
6	Moderately Drought	-1 > -1.5
7	Severely Drought	-1.5 > -2
8	Extremely Drought	-2 >

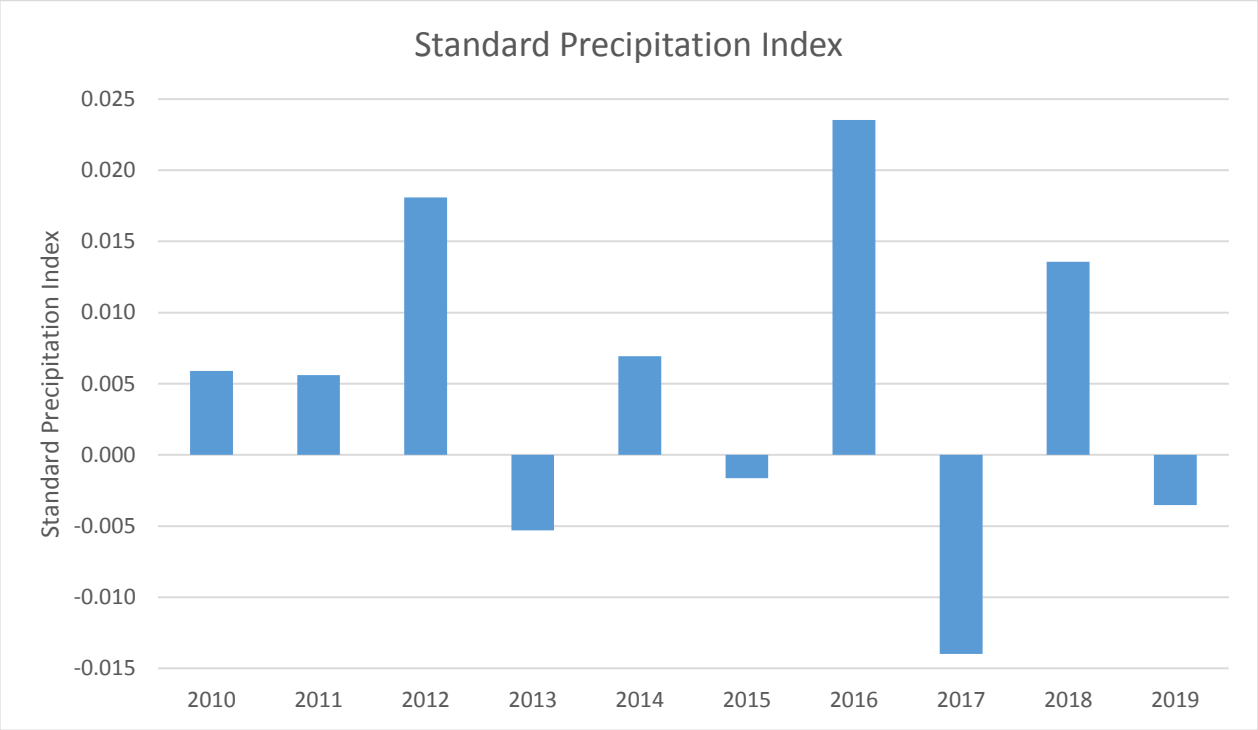


Figure 22: SPI Values

Pakistan is situated in Arid, Semi-Arid and highland climate zone. While Punjab is marked in arid and semi-arid climate zone. Arid zones of Punjab are Thal desert while the land form areas are semi-arid climates. The study area is the part of Punjab land form. So, it is the part of semi-arid climate but it is nearer to Thal desert which is the part of arid climate that's why it feels high temperature and long summer and low temperature with short winter.

2.4 TOPOGRAPHY

The Kabirwala is the part of Bari Doab lies in the south of River Ravi, South east of River Jhelum and North of River Sutlej. The relief of the area lies between 127m to 143m (Figure-23). In average elevation of the study area is 131m while the maximum elevation is 143.8m in south towards Khanewal district and the minimum value of 127.2m is encountered on the south western portion of study area. The Northern side of study area has 132m to 138m elevation.

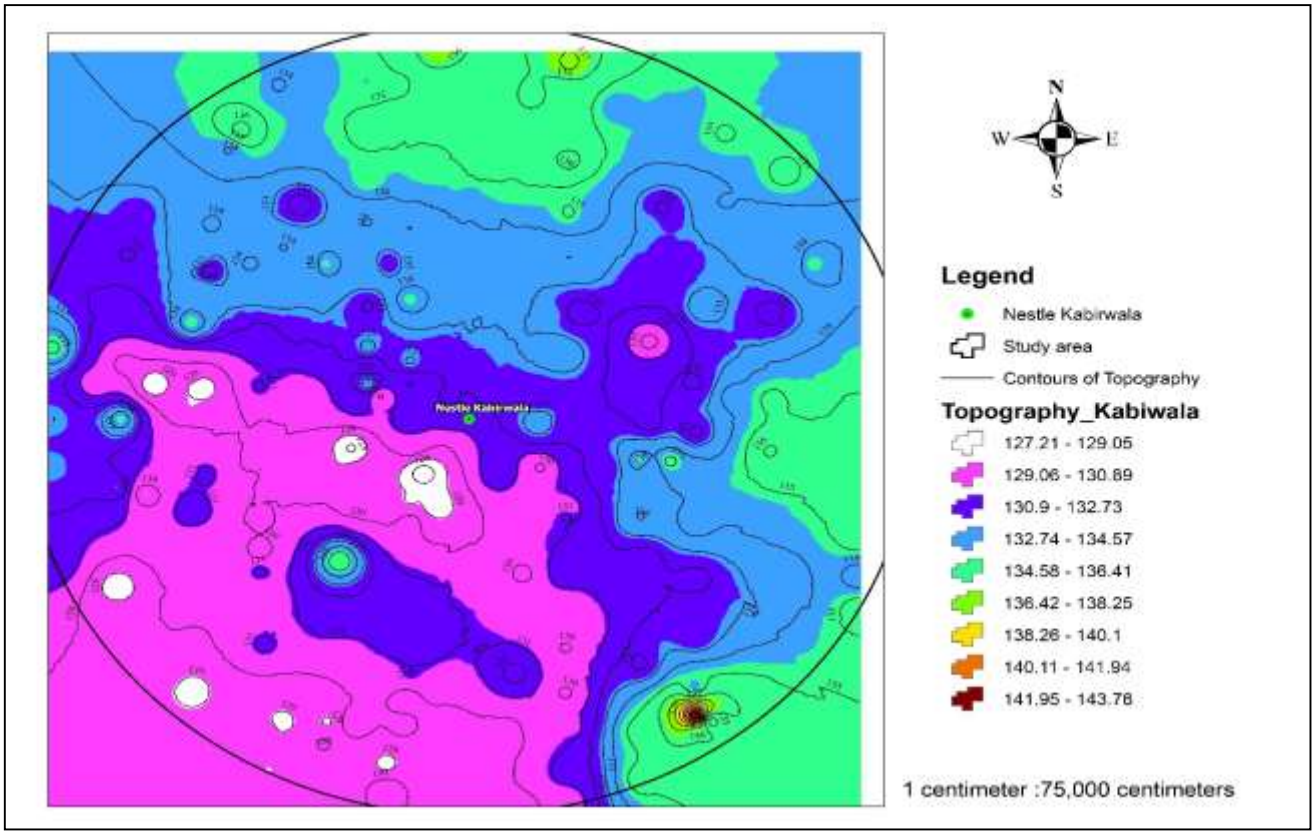


Figure 23: Topography map of study area

2.5 GEOMORPHOLOGY

As per previous study Nestle Factory and Surroundings Doab is composed of three geomorphic units which are as follows:

1. Present Flood Plains

2. Abandoned Flood Plains

3. Bar Uplands

2.5.1 PRESENT FLOOD PLAINS

This area is locally known as Sailaba. Silaba means the river bank or flood plain areas and these areas are only used for irrigation in dry seasons. While during flooding they are the part of river. During the active season of the present rivers, a narrow strip of 2 to 8 miles in width because of the floods and meandering making thereby characteristics topographic features like natural levees, swales and sand bars.

2.5.2 ABANDONED FLOOD PLAINS

It covers about two thirds of the Doab area. It has general low relief shaped by meandering courses of former streams. The area around Ox-bow lakes, segments of stream channelsand natural levees which show to the presence of streams, nullahs up to comparatively recent time. The area was occupied by old

channels of the Ravi, the Sutlej and the Chenab Rivers and also by the Beas River whose former channel can be traced throughout most of the Doab. This area is generally 5 to 15 feet above the present flood plains. However, the low-lying portions may be flooded during high flood seasons.

2.5.3 BAR UPLAND

The Bar upland is an almost uniformly level plain with very little relief, however, photo mosaics and topographic maps show traces of some channels that crossed it in the distant part. The most important channel, whose course is very prominent on the photo mosaics, is the Hudaira Rohi, which occupies a two to four miles wide depression of land some 13 miles South of Lahore. It parallels the Ravi from Hudaira village to Pattoki and drains a major part of the area north of upper Bari Doab Canal into the Ravi. Another depression in the area between Sahiwal and Harappa suggests that a channel from the Ravi extended across the bar upland southward towards the flood plain of the Beas.

2.6 GEOLOGY OF MIDDLE INDUS PLAIN

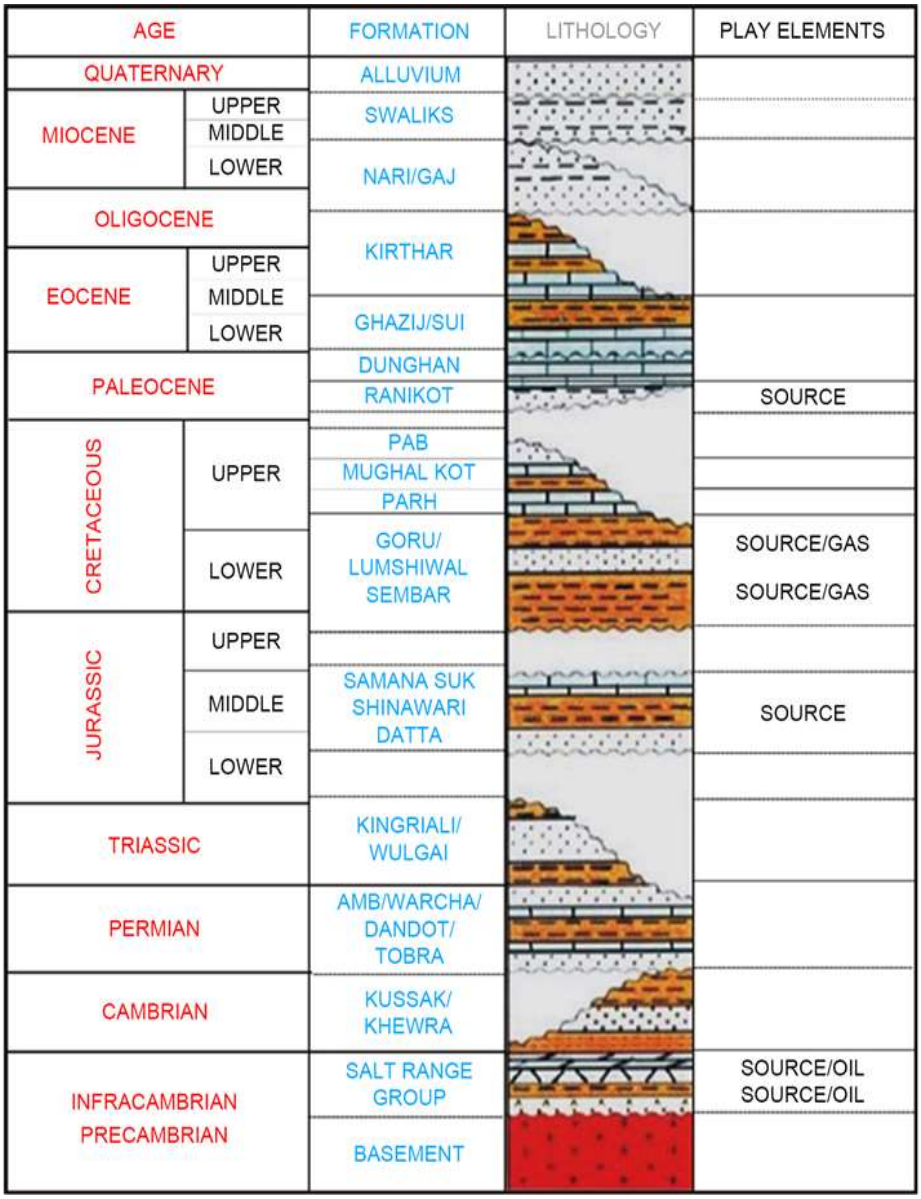
Indus plan is the part of Indian shield and starts from Himalayan range and ends at start of Arabian Sea plate. Furthermore, Indus plan is divided into three parts:

1. Lower Indus
2. Middle Indus &
3. Upper Indus

These divisions were occurred on the basis of their depositional environments and tectonic regimes. The middle Indus and Lower Indus is separates from Jacobabad high and from while the Northern boundary of middle Indus is separating form Upper Indus at Kirana Hills.

The Indus plain is covered by thick alluvial complex deposited. These deposits were related to the ancestral Indus River and its tributaries. These tributaries had been formed due to the subsiding tectonic depression lying between Himalaya's contiguous mountain ranges and plateaus. Alluvium of the Indus basin has been deposited on the basement of Tertiary shale's and limestones. The stratigraphy chart is shown in Table-04. The unconsolidated valley-fill deposits of Quaternary age cover the valley floor.

Table 4: Stratigraphy of Middle Indus Plan (Punjab Plan)



The bulk of the alluvium consists chiefly on fine to medium sand, silt and clay. Coarse sand and gravel however are uncommon. Hence, they are found near the mountainous areas of the plain. Concretions of silt and sand are commonly found in the clay deposits. The alluvial complex contains a vast regional porous aquifer system which extends to a depth of few hundred meters or more virtually throughout the Indus plain. The alluvial deposits occur chiefly in irregularly shaped tabular bodies of sand, interbedded with lenticular layers of silt and clay.

2.6.1 GEOLOGY OF THE STUDY AREA AND SURROUNDINGS

Nestle Factory falls with the Lower Bari Doab area is a part of the Indo-Gangetic Plain and as per Kidwai, 1963 this area has a geologic history similar to Reachna and Chaj Doabs. According to the survey conducted by WAPDA in 1980 Bari Doab is covered by Quaternary alluvium which presumably over lies semi-consolidated Tertiary rocks or metamorphic and igneous rocks of Precambrian age. Except for a

small area in the northeastern part of the doab, where the basement rock was encountered by deep test holes, no information is available at present regarding the distribution of Tertiary and Precambrian rocks (bedrock) in the doab.

A. Precambrian Basement Rock

The oldest rocks, the well-known Kiranas of Precambrian age, have been mapped in Chaj and Rachna. They are completely hidden by Quaternary alluvial deposits that cover the Bari Doab. There are many comparatively deep test holes were drilled in Bari Doab to determine the thickness of the alluvium, the depth to bedrock and its nature, and the quality of water at deeper zones.

B. Quaternary Alluvial Complex

The Quaternary alluvial complex within the Doab consists of unconsolidated sand, silt and silty clay with variable amounts of kankers. The sands are mainly grey or grayish-brown, fine to medium grained and sub-angular to sub-round. Very fine sand is common. Finer grained deposits generally include sandy silt; silt and silty clay are rare in the area. This has been confirmed to some extent by the study of a small number of core samples.

Gravels of hard rock are not found within the alluvium and coarse or very coarse sands are uncommon. Gravels have been reported by the geologists in the drilling logs, but a closer examination of samples has shown that these are mudstones, siltstones and cankers of concretionary origin.

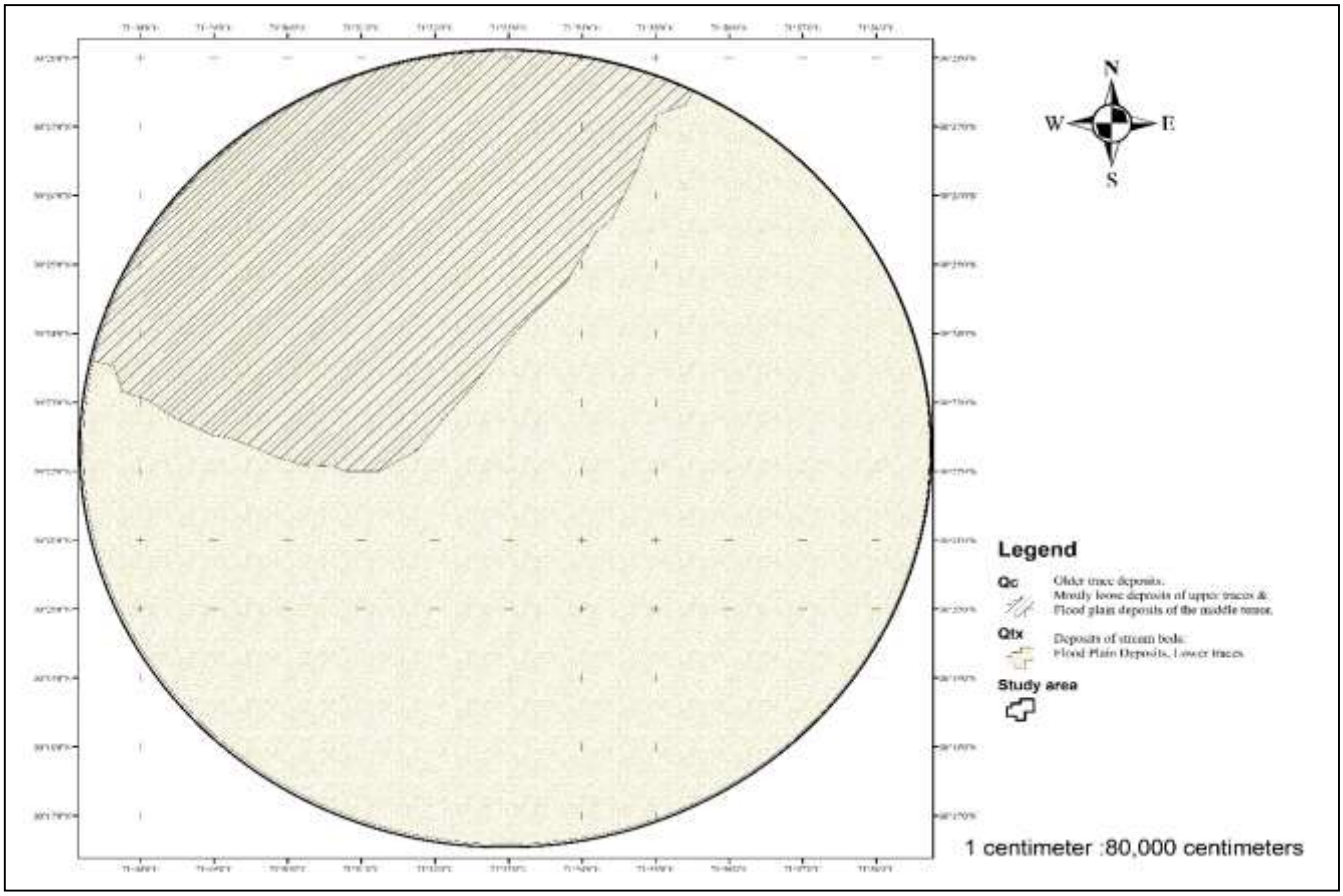


Figure 24: Geological Map of Study area

2.7 HYDROLOGAL SETTING

The natural topography of the Kabirwala Basin offers to form a boundary of the catchment where the runoff-runoff flows in NE to SW direction. Bounded by Sutlej River and Ravi River the study area is part of Lower Bari Doab and falls in command area of Lower Bari Doab Canal (LBDC). Drainage pattern of Kabirwala Basin is shown in figure-25, 26 and 27:

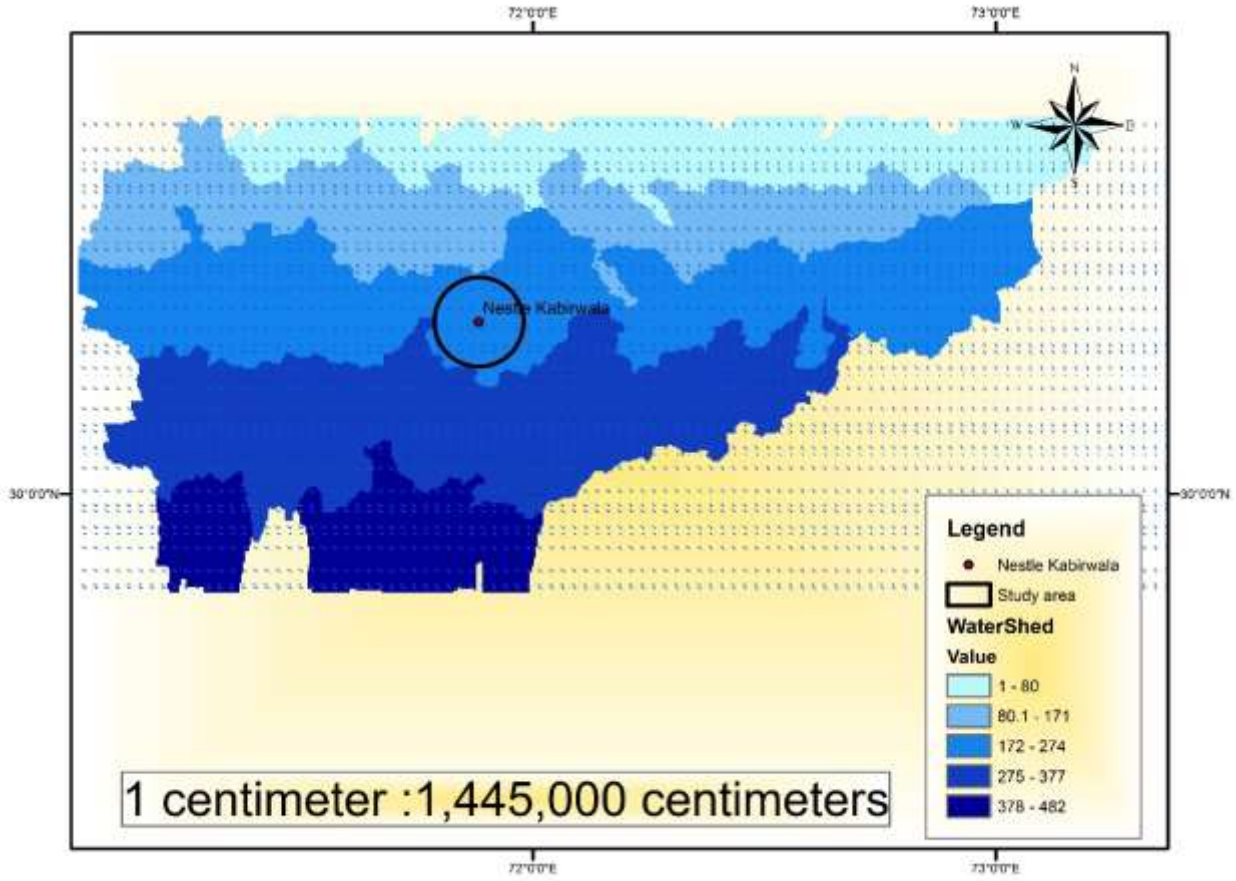


Figure 25: Regional Surface Water Basins and Drainage Pattern

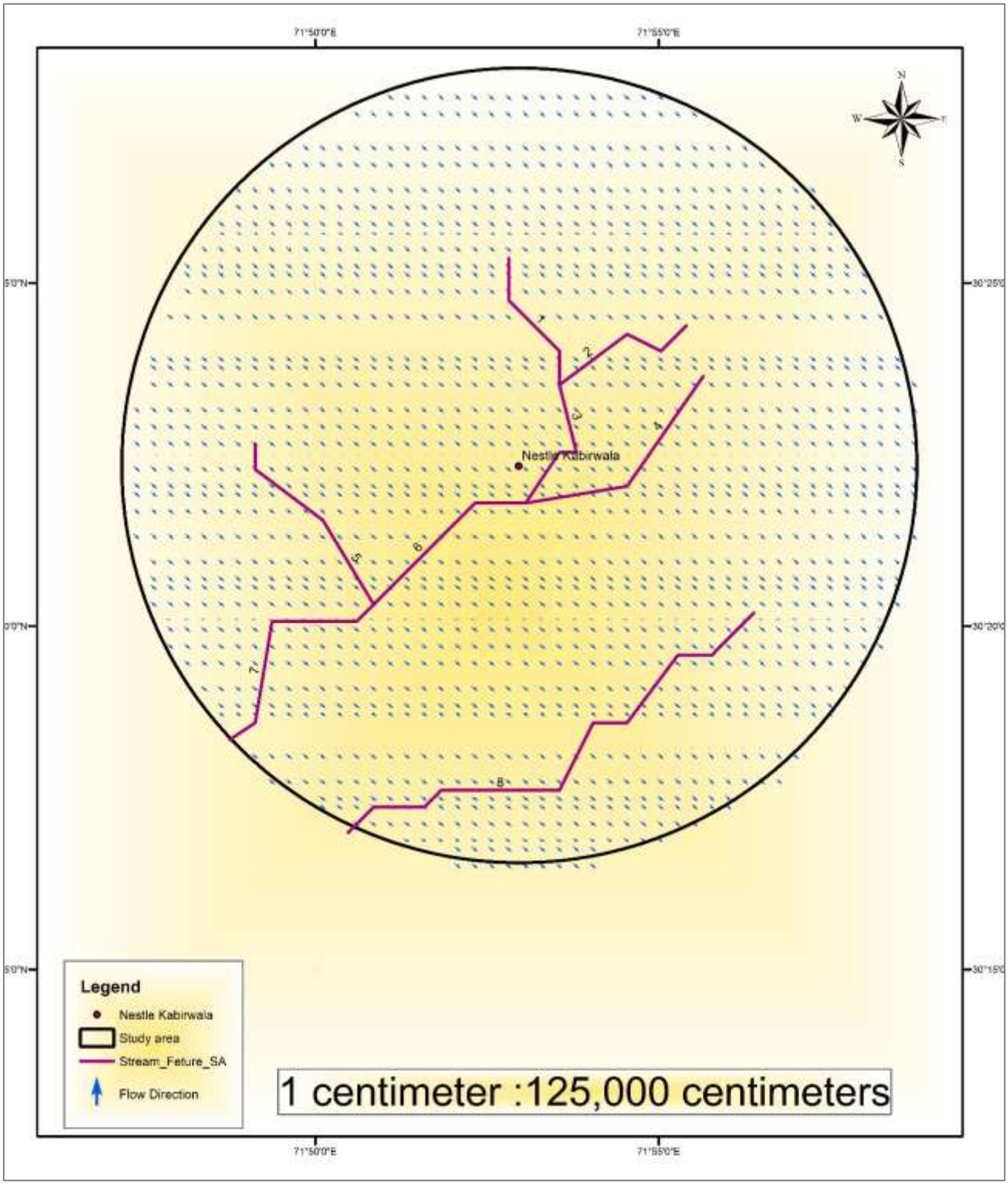


Figure 26: Surface Water Direction and Streams in Study Area

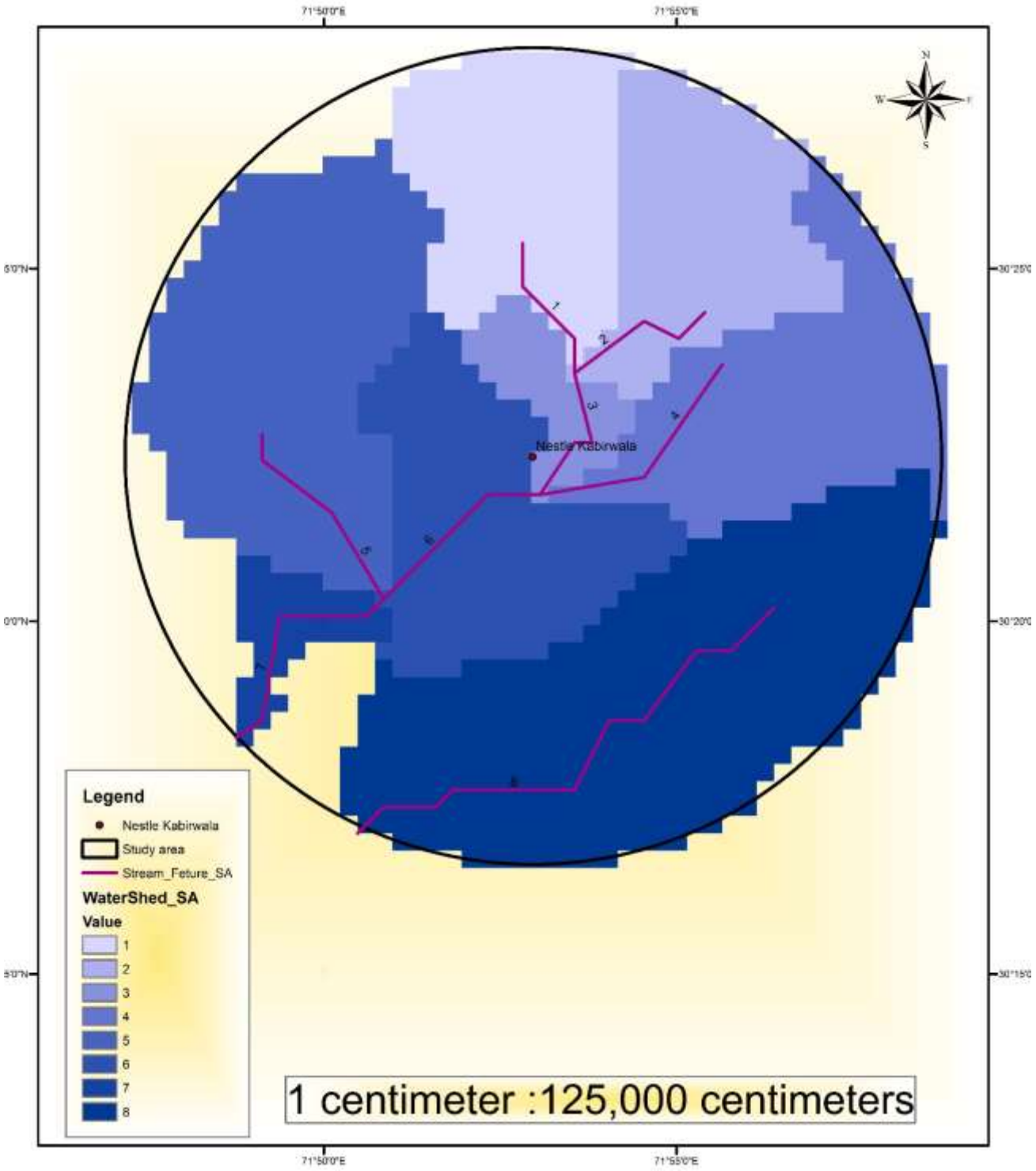


Figure 27: Sub Basins in Study Area

2.7.1 HYDROGEOLOGAL BRIEF

The porous type aquifer is found in the unconsolidated sediments in the vast alluvial deposits of the Indus plain. Groundwater occurs in the interstices or pore spaces between the granular sedimentary particles of unconsolidated deposits constituting the groundwater reservoirs. The porous aquifer on the basis of grain size could be distinguished in sandy and gravelly type aquifers. The sandy aquifer covers almost the

entire Indus plain where the aquifer is encountered at shallow depth having large vertical and lateral extent. It is not uncommon to strike over thick saturated 300 meters sand formation in the large parts plain. The sand formation constituting the aquifer generally grade from fine to medium size well assorted having porosity up to 30 percent. The average value of specific yield of these aquifers is 17 percent. The sand formation in the Indus plain is found to have high transmissivity. The tube- wells installed with screen section of 10 to 15 meters in length facing the aquifer yield of one cusec (102 m3/hr.) with a drawdown of 1 to 1.5m of water level.

2.7.2 AVAILABLE WATER SOURCES

The main supply of water in project area vicinity is based on surface water and ground water. For agricultural purpose, rainfall also plays a vital role by relieving load from other sources. Use of any source depends mainly on the availability; and partially on the intended use including agricultural, industrial and domestic needs.

Overall, the availability of each water source holds entirely different phenomena within a boundary established by hydrological patterns, climate, geology, manmade infrastructure and mode of use. Rainfall is independent of human influence and has been quantified on basis of available met data. Surface water availability is dependent on provision and maintenance of required infrastructure and is estimated using allocated flows, available studies and local sources. Groundwater is dependent on geological parameters, quantum of usage and rate of withdrawal. In terms of availability, these sources are further elaborated in the following;

A. RAINFALL

Rainfall is considered as major source of water as a feeding part of water availability in any form. Relevant meteorological records of Multan, Sahiwal and Toba Tek Singh shows that the project area receives average annual rainfall of 300 mm with 70% (225mm) contribution during wet season i.e. Kharif Period ranging from May to September. Whereas, the dry season experiences 25% (75mm) of average annual rainfall. During last 10 Years, maximum annual rainfall was recorded at all three stations in 2015, with 395 mm at Multan, 453mm at Toba Tek Singh and 478mm at Sahiwal.

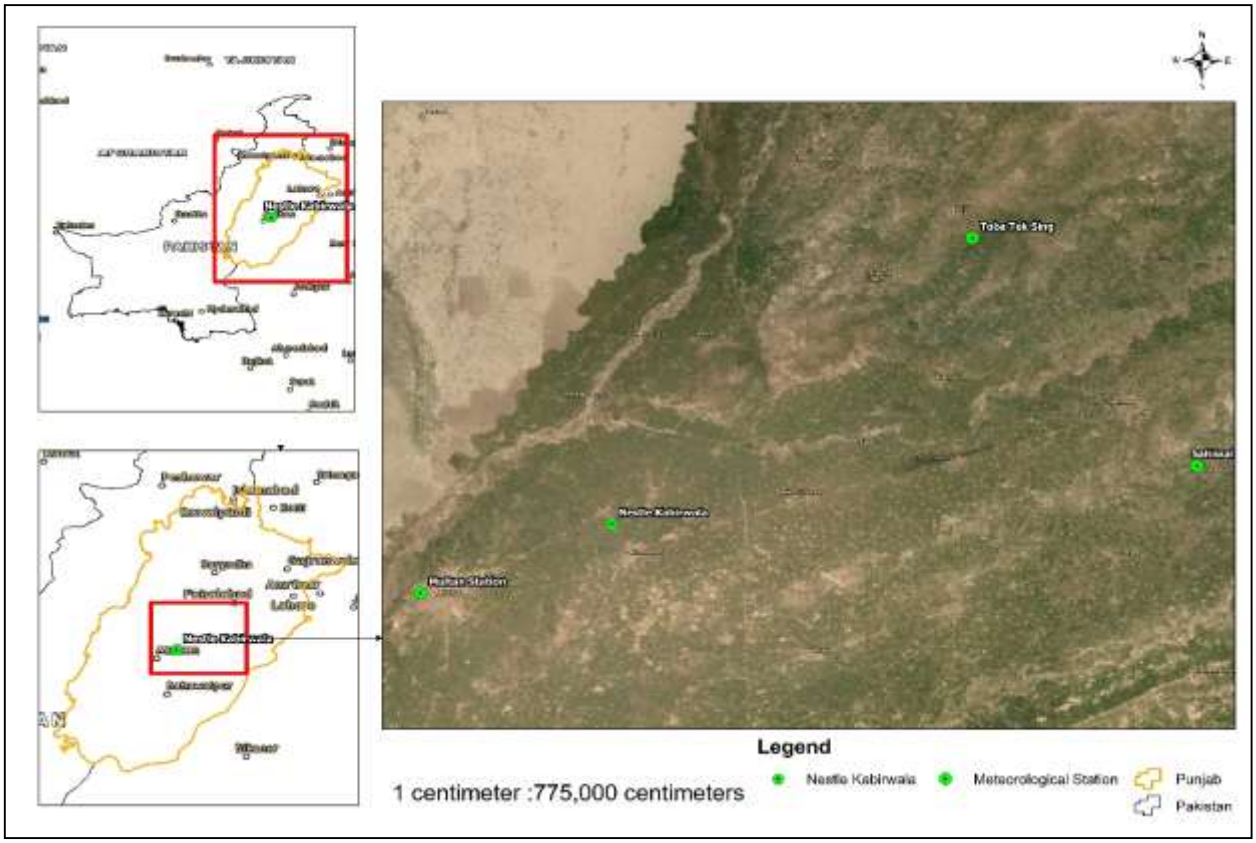


Figure 28: Locations of neighboring meteorological stations

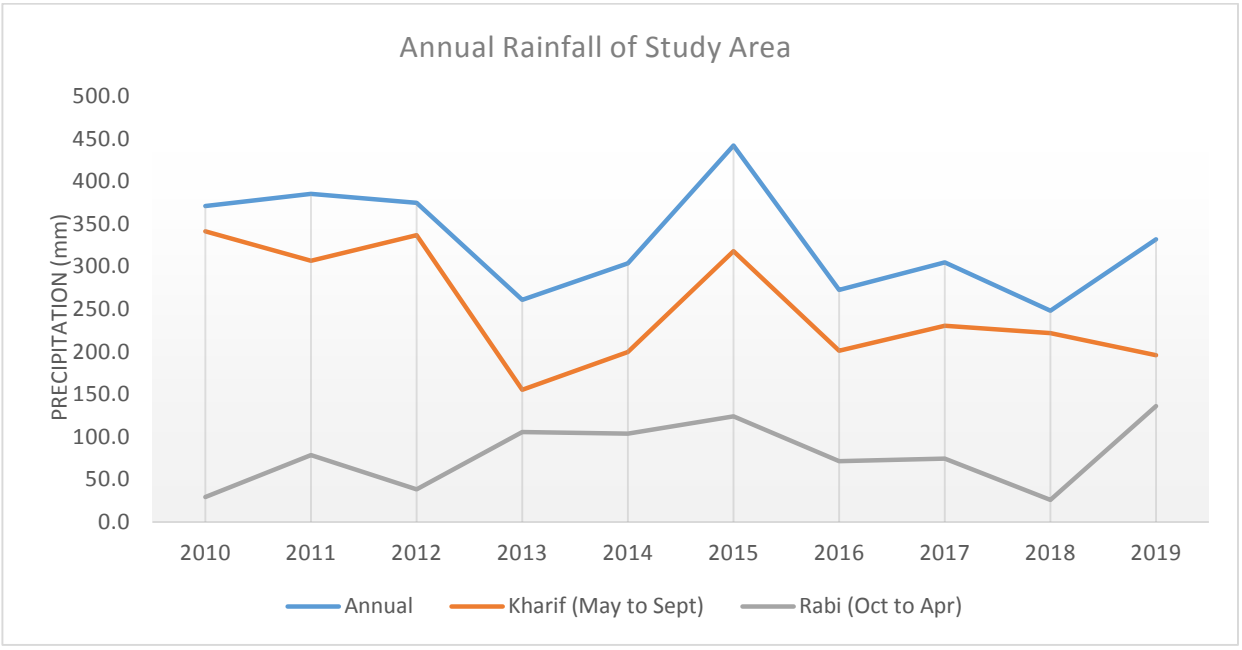


Figure 29: Annual precipitation (mm) at study area (period 2010 – 2019)

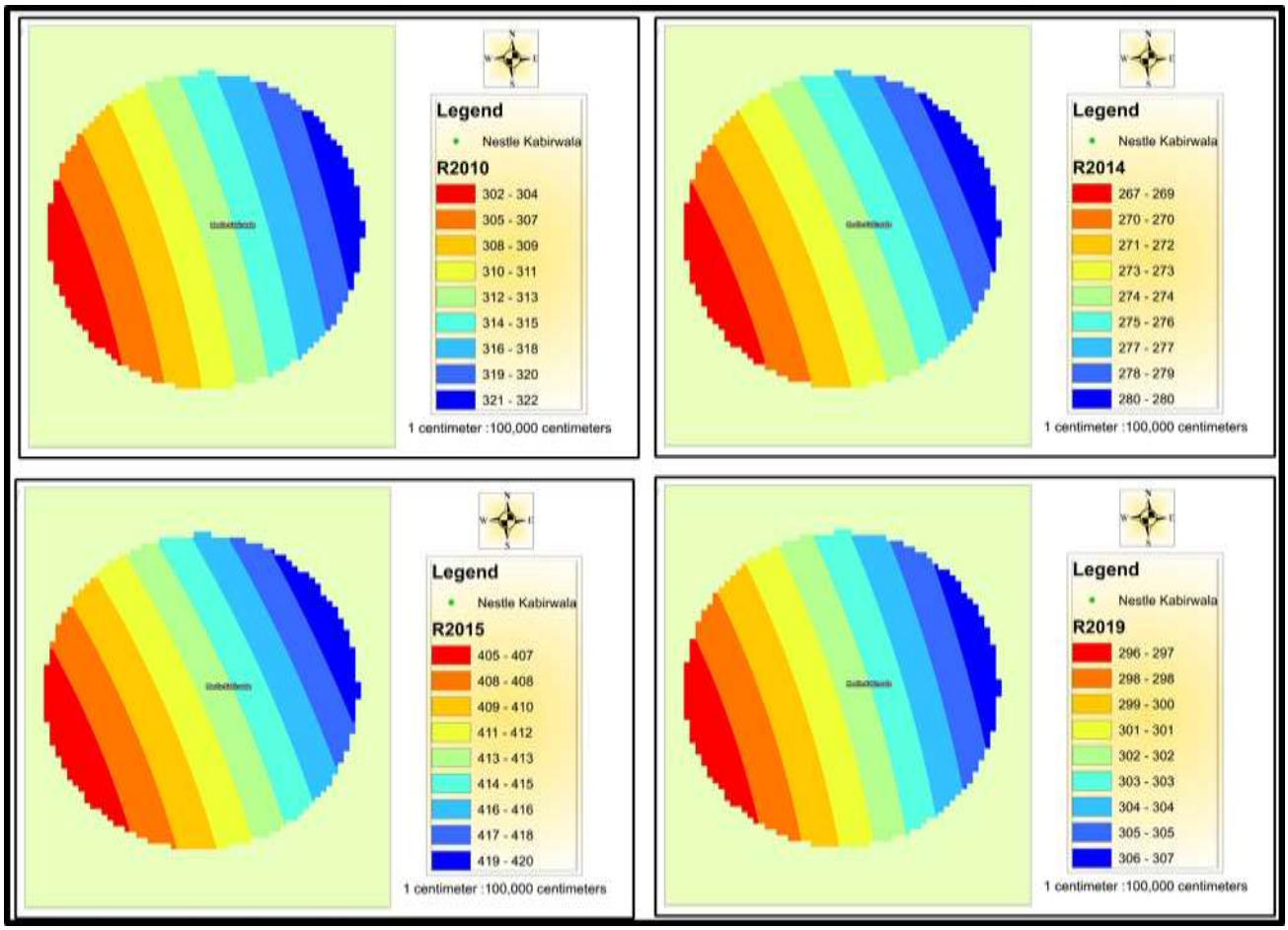


Figure 30: Annual Rainfall Trend in Study area

The available water from rainfall is calculated by subtracting factors including evapotranspiration and runoff. The evapotranspiration is calculated by Penman method by using CROPWAT 8.0 software leading to estimation of crop water requirement (CWR). The analysis is based on maximum and minimum temperature with humidity, wind and sunshine.

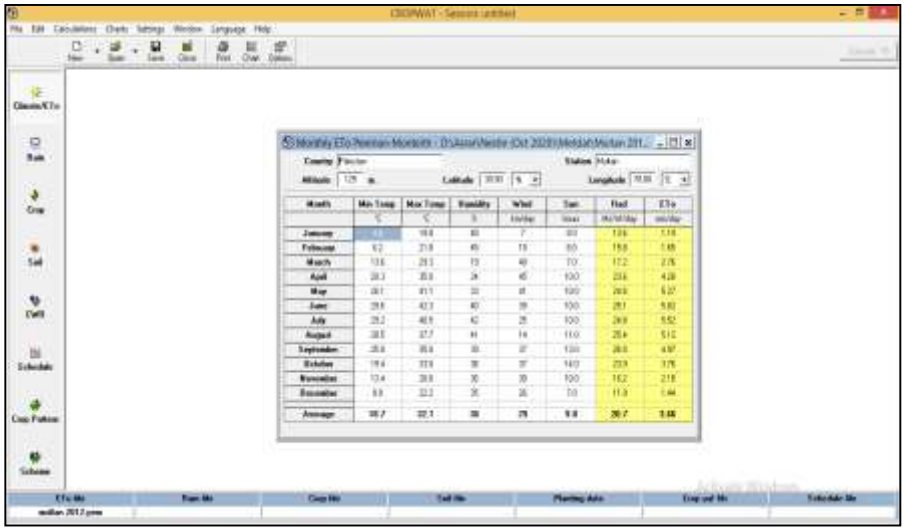


Figure 31: Estimation of ETo by CROPWAT 8.0

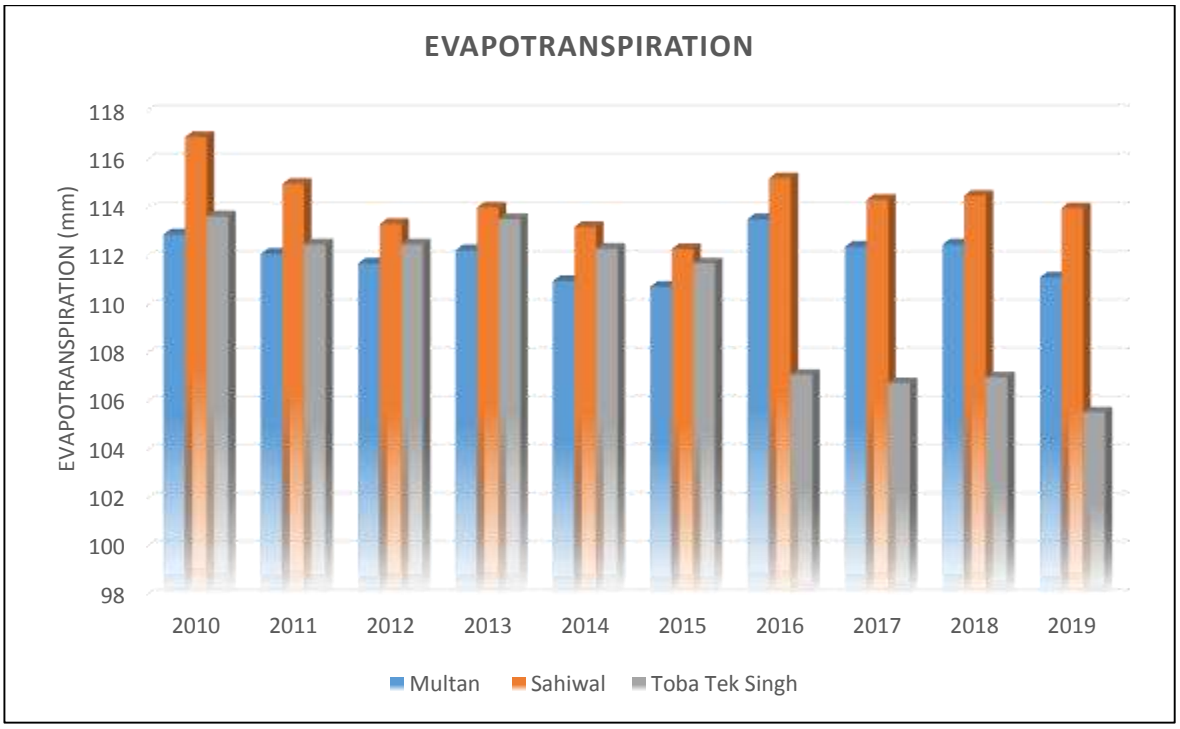


Figure 32: Actual Evapotranspiration form adjacent meteorological stations

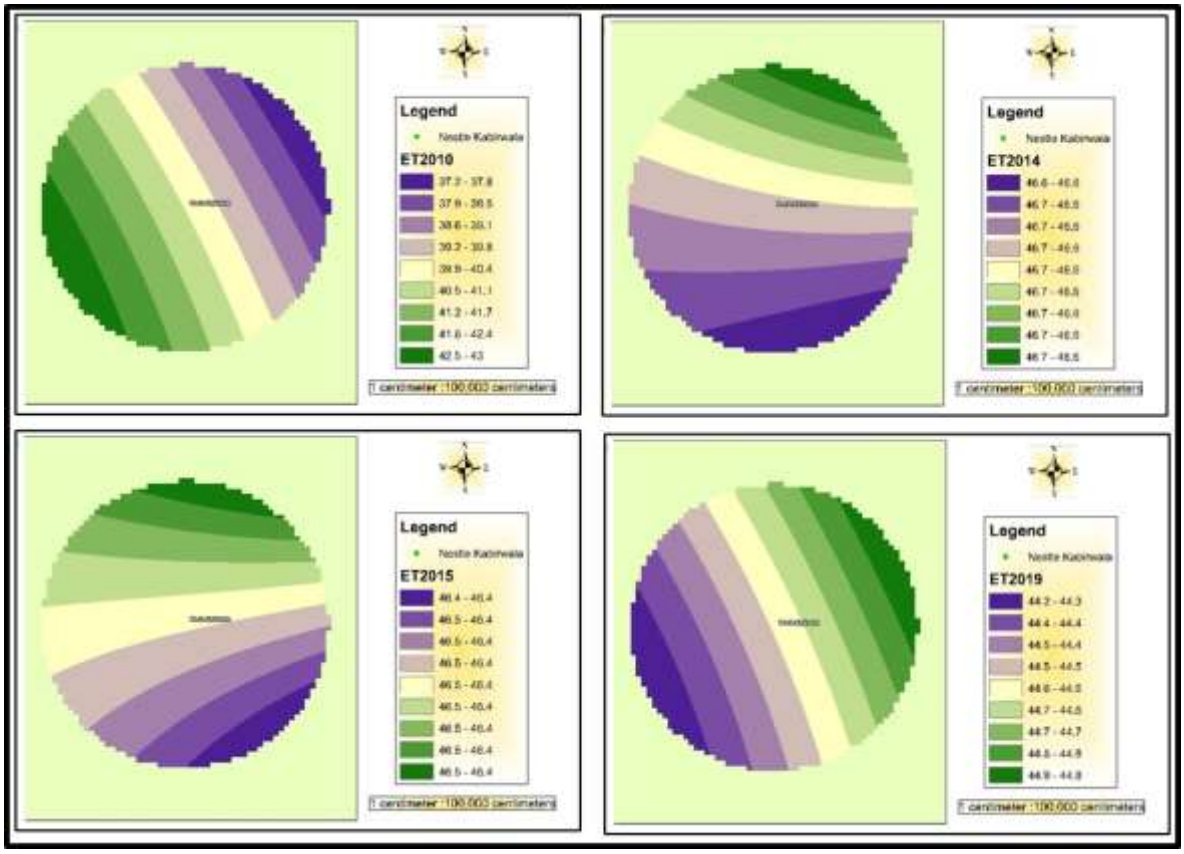


Figure 33: Annual Evapotranspiration format in Study Area

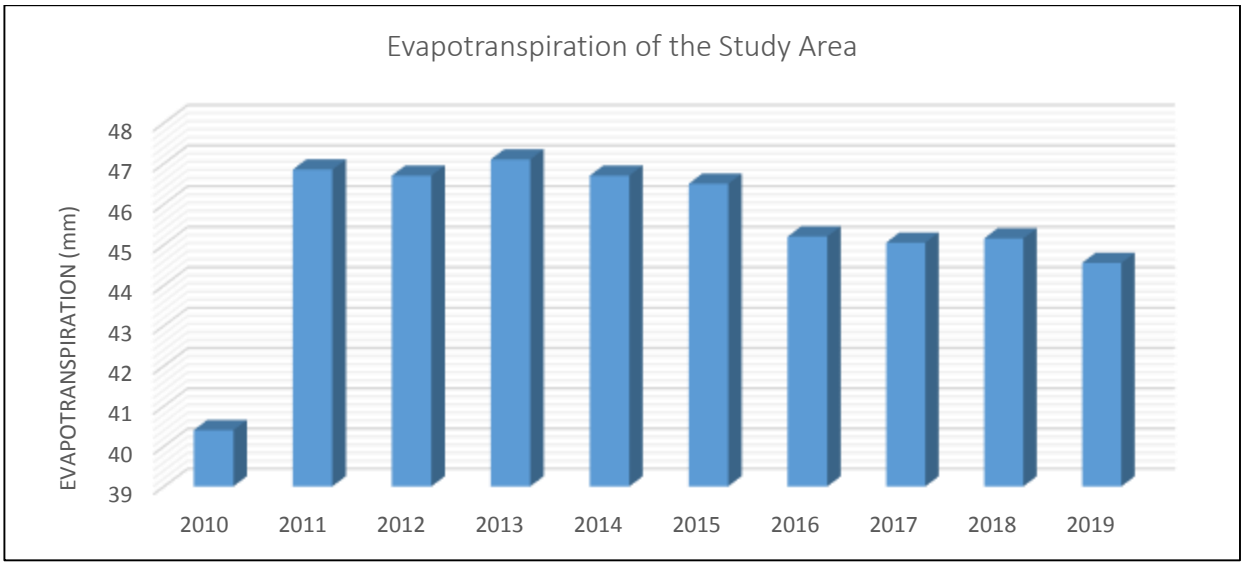


Figure 34: Actual Evapotranspiration form study area

The surface runoff is calculated by using SCS curve method as given in the following;

$Q= (P-0.2S)^2/(P+0.8S)$

Here,

Q= Runoff (mm)

P=Precipitation (mm)

S=Potential Maximum retention = (25400/CN)-254

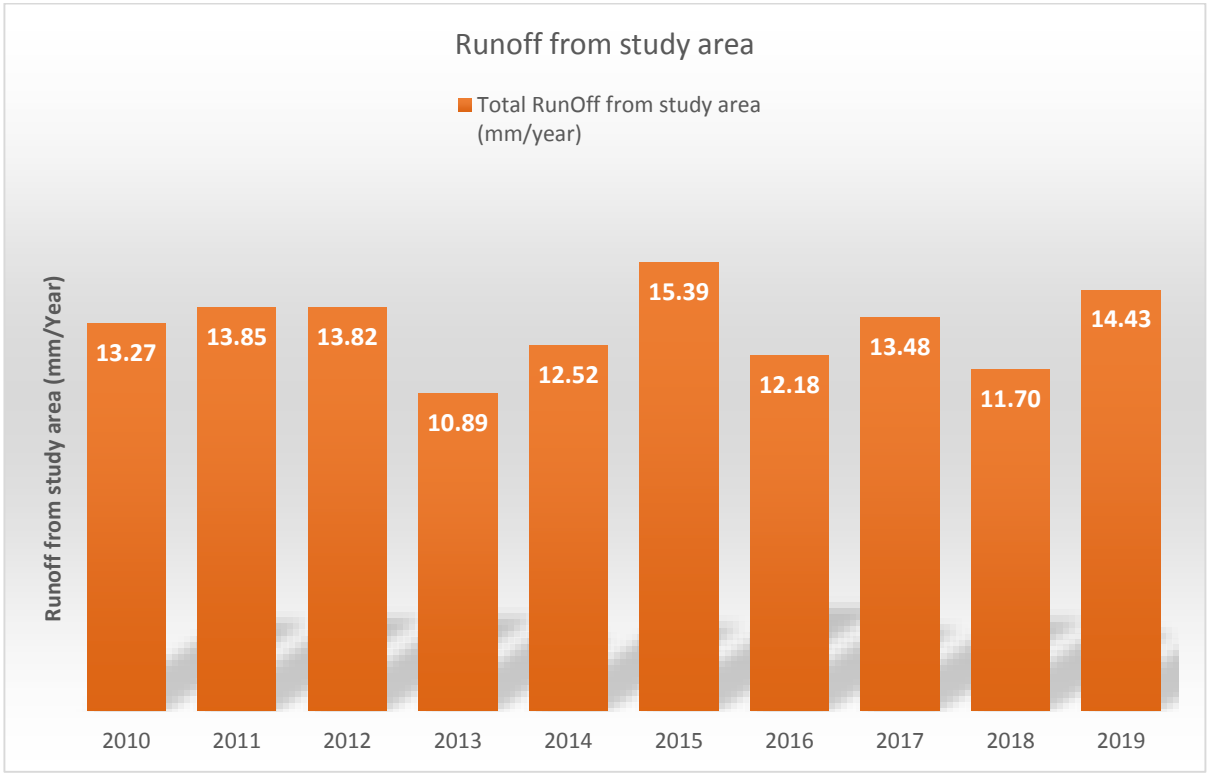


Figure 35: Total Runoff from study area

Table 5: Total useable water from Rainfall (i.e. Groundwater Recharge)

YEAR	Annual Rainfall (mm/Yr.)	Evapotranspiration Losses (mm/Yr.)	Runoff Losses (mm/Yr.)	Ground Water Recharge	
				(mm/Yr.)	(MCM/Yr.)
2010	370.40	46.15	310.98	13.27	4.17
2011	384.50	45.81	324.84	13.85	4.35
2012	374.20	45.66	314.72	13.82	4.34
2013	260.87	45.84	204.14	10.89	3.42
2014	302.90	45.44	244.94	12.52	3.93
2015	441.40	45.12	380.89	15.39	4.83
2016	272.23	44.91	215.14	12.18	3.83
2017	304.53	44.52	246.53	13.48	4.23
2018	246.73	44.54	190.50	11.70	3.68
2019	331.87	44.22	273.22	14.43	4.53

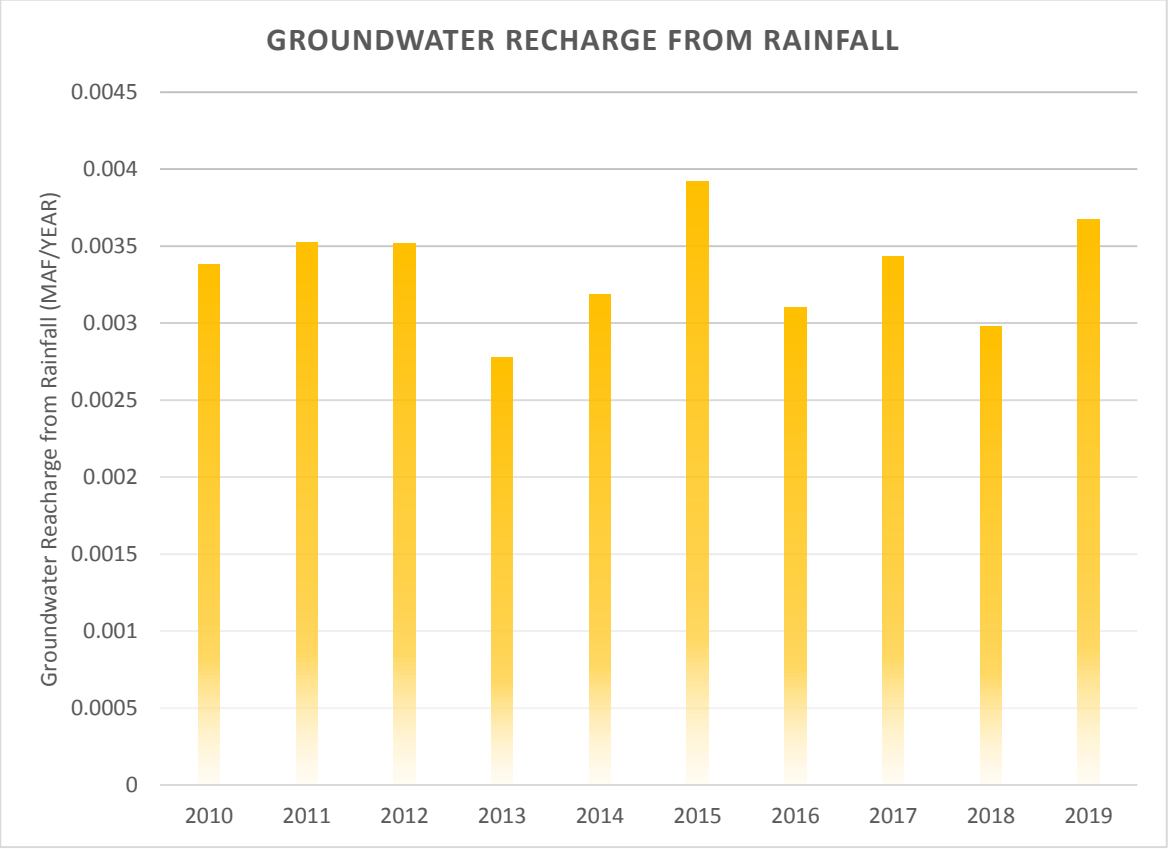


Figure 36: Total Groundwater Recharge from Rainfall

The rain water in study area for groundwater recharge is found to be 4.12 MCM/Yr. (i.e., 0.0033 MAF/Yr.). In the study area rainfall is used for agriculture purpose, while it is not sufficiently fulfilling the needs of agriculture.

B. SURFACE WATER

Bounded by Ravi River in North, Sutlej River in South and Chenab River in West, the study area lies in Lower Bari Doab. It receives its surface water share through gravity from Lower Bari Doab Canal (LBDC) originating from Head Balloki that is situated on Ravi River. The canal irrigates the command area of 7,000 Sq.Km (700,000 Hectare or 1,729,740 Acres) and terminates in Khanewal division near Jahanian Tehsil with total length of 201 Km and design discharge capacity of 278 cumecs i.e 25 Sq.Km/cumecs (175 acres/cusecs). Current capacity of canal is reduced to 243 cumecs due to old canal infrastructure i.e. 28 Sq.Km/cumecs (195 acres/cusec). On basis of reduced flow, the agriculture land of 236 Sq.Km in study area (i.e. 75% of 316.6 Sq. Km) is receiving around 8.42 cumecs (298 cusecs) flow for limited time, total flow from the study area passed away about to 278.18 MCM/yr, in which approx. 66.38328 MCM/Yr. (i.e., 0.053106624 MAF /Yr.) utilized as a surface resource to agriculture and remain passed to further supply to adjacent south tehsil and districts. Hence, according to local sources, the dependency on ground water is increasing due shortage of surface water.

2.7.3 WATER TABLE DEPTH AND POTENTIAL

In study area groundwater as a source is dependent on recharge from rainfall and surface water. Ground water potential is shown in the accompanying maps (Figures 28, 29 and 30). In broader sight, the depth of ground water table in the Indus Basin canal commands exhibits an annual cycle of rise and fall. The water table is measured twice a year during pre-monsoon (April/June) and post monsoon (October) period. It is at its lowest point in the period prior to the monsoon (April/June). Recharged through Kharif season (summer) irrigation and rains, it rises to its highest point in October, when it is closest to the land surface before declining again. High water table conditions after the monsoon, although transitory, interfere with the cultivation of Rabi (winter) crops. The water table position in April/June is, particularly, critical as it persists throughout the year and is used as an index of waterlogged area. Zone wise point data of depth to water table below national standard limit (NSL) for the periods June and October 2002, for all the irrigation canal commands were digitized, analyzed and the contour maps were generated through interpolation technique. The criteria for classification of water table depth categories adopted for this study are according to Soil Survey Manual Agricultural Handbook No.18 and are shown in Figures 37 & 38 and given in the Table-6.

Table 6: Classification of Water table Depth by Drainage NSL indicates National Standard Limit

Drainage Class	Water table Depth (cm below NSL)
Very poorly drained (Waterlogged)	< 100
Poorly drained (Waterlogged)	100 < 150
Moderately drained	150 < 300
Well drained	>300

The zone wise depths to water table results for June and October 2002 are shown in Figures 28 and 29.

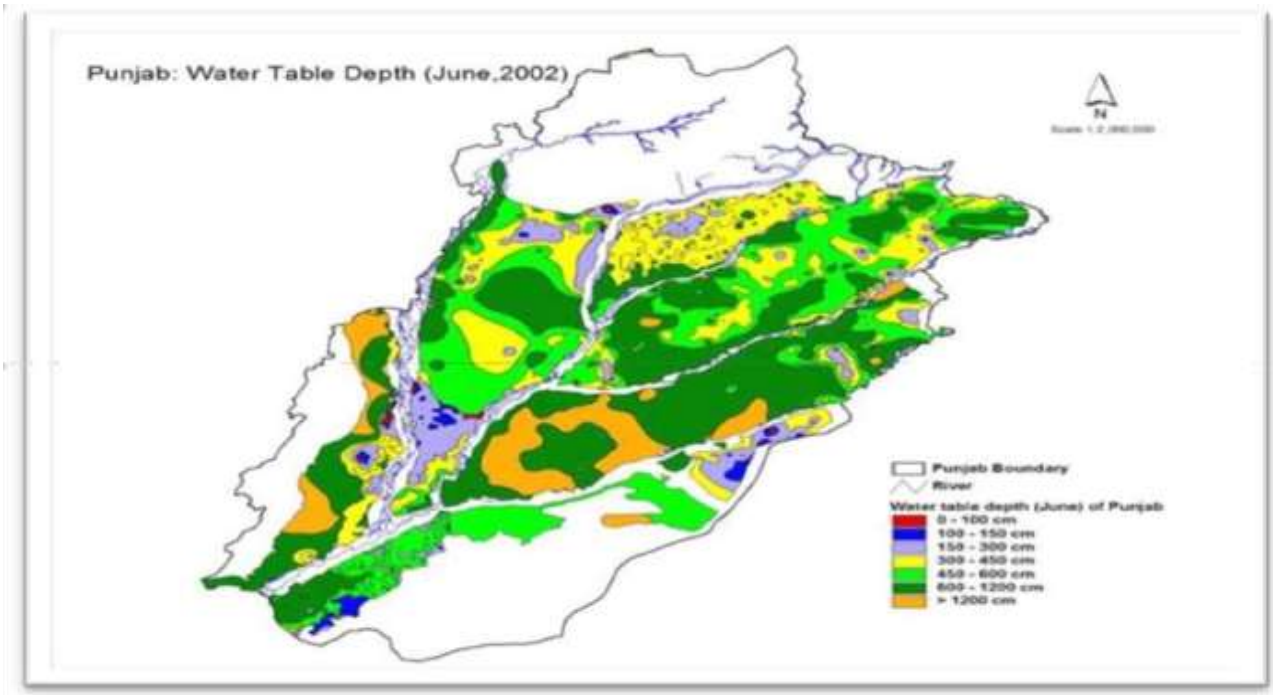


Figure 37: Water Table depth during June 2002 in Punjab (LUAP, 2009)

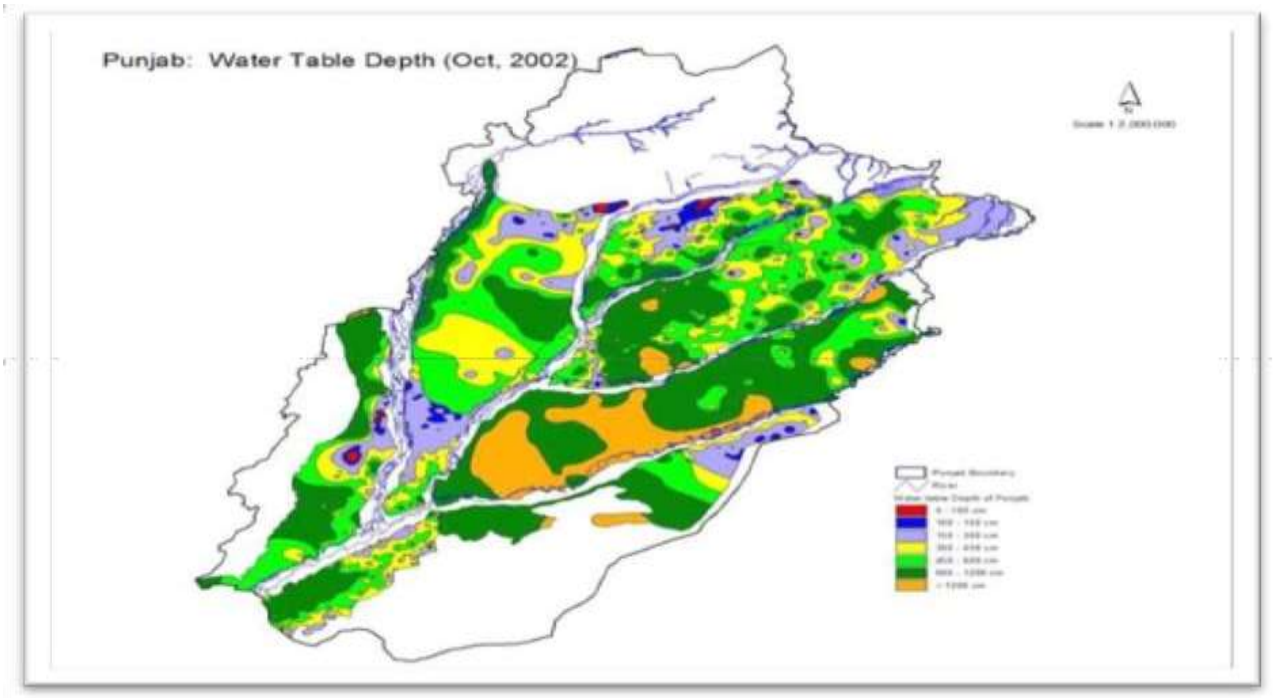


Figure 38: Water Table depth during October 2002 in Punjab (LUAP, 2009)

The zone wise water quality based on TDS results for the survey during 2001 2003 are shown in Figure-28 and Table 3. The study area lies in Bari doab where about 65% area possesses usable groundwater quality.

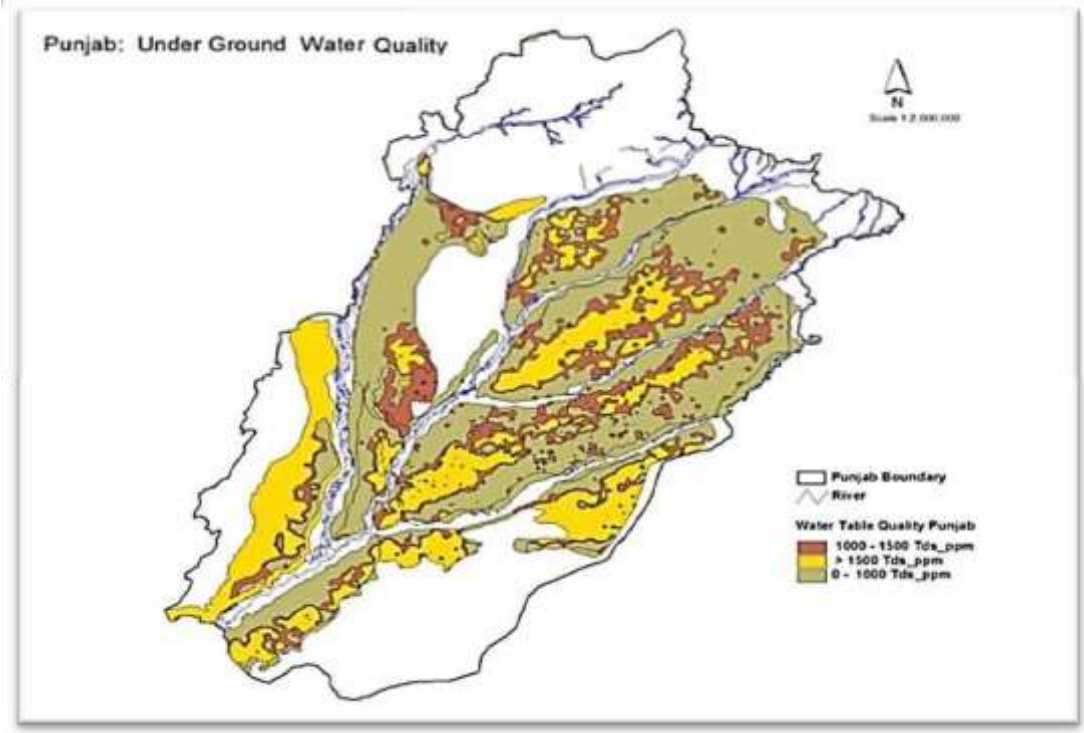


Figure 39: Groundwater quality in Punjab area

Table 7: Shallow water quality based on TDS in Punjab area

Zone Name	Area Surveyed	Shallow Water Quality Based on of TDS(ppm)					
		Usable (<1000)		Marginal (1000-1500)		Hazardous (>1500)	
		Area	%	Area	%	Area	%
PUNJAB							
Thal Doab	3.977	2.627	66.05	0.567	14.26	0.783	19.69
Chaj Doab	2.474	1.624	65.64	0.49	19.81	0.36	14.55
Rechna Doab	5.729	3.245	56.64	1.095	19.11	1.389	24.25
Bari Doab	4.288	2.77	64.60	0.76	17.72	0.758	17.68
Fordwah Zone	2.534	0.718	28.33	0.336	13.26	1.48	58.41
Punjnad Zone	1.644	0.986	59.98	0.161	9.79	0.497	30.23
D.G.Khan Zone	0.957	0.37	38.66	0.214	22.36	0.373	38.98
Total	**21.603**	**12.34**	**57.12**	**3.623**	**16.77**	**5.64**	**26.11**

The hydrogeological maps prepared by WAPDA at scales of 1:500,000 and 1:250,000 were used to extract information related to surface and groundwater resource of the Punjab area. There are five potential zones of groundwater defined for Rod-kohi region i.e. High, Medium, Low, Poor and N.A (No potential aquifer) as modified from WAPDA (1989 & 2001). The zones are based on the following characteristics of groundwater aquifer:

High	Yield 100 to 300 m^3/hr. or more, down to 150m, Fairly thick and extensive aquifer.
Medium	Yield between 50 to 100 m^3/hr. down to 150m. Moderately thick and extensive aquifer.
Low	Yield between 10 to 50 m^3/hr. down to 150m. Aquifer of limited thickness and extension.
Poor	Yield less than 10 m^3/hr. down to 150m. poor and patchy, hard rock, discontinuous aquifer
N.A	No potential Aquifer

The extent of these zones in central Punjab is shown in Figure-40 including The Kabirwala and Khanewal areas around Nestle Factory Kabirwala.

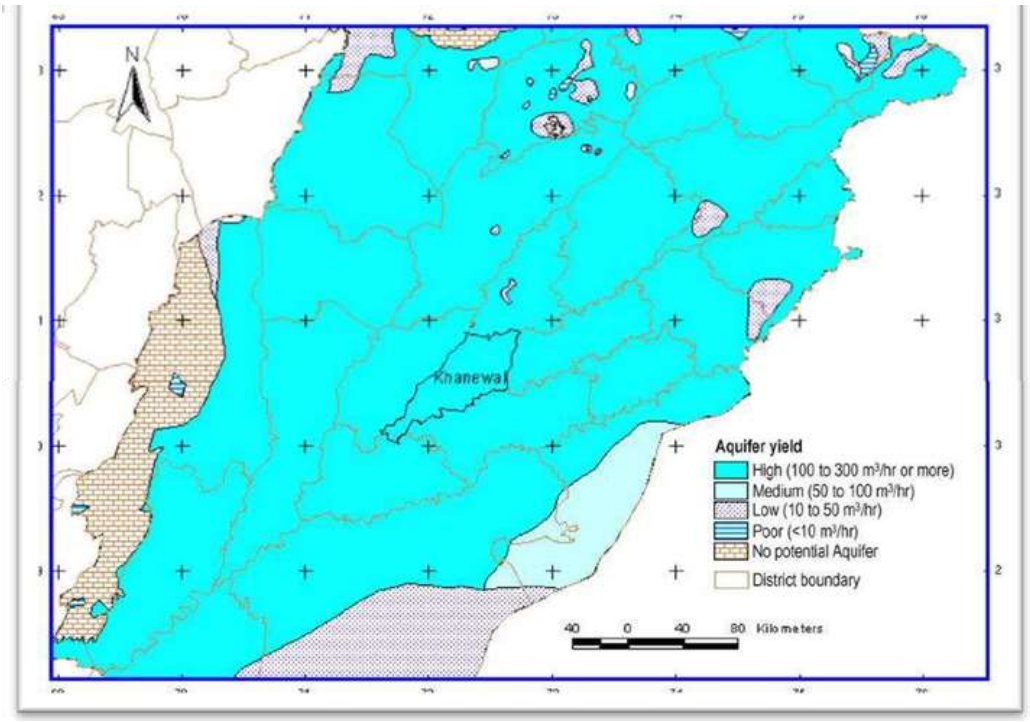


Figure 40: Aquifer yield map of Study area

As a matter of fact, the River bank areas of Punjab foreland is divided into 5 parts. This division was doing on the basis of rivers present around the areas and known as "Doab". Doab is a Persian word means the land area bounded with two rivers. As per division the areas are known as:

1. Sindh Sagar Doab (Bounded with Indus River and Jhelum River)
2. Jech Doab (Bounded with Jhelum and Chenab River)
3. Rechna Doab (Bounded with Chenab and Ravi River)
4. Bari Doab (Ravi River and Bias)
5. Bisat Doab (Bias River and Sutlej River)

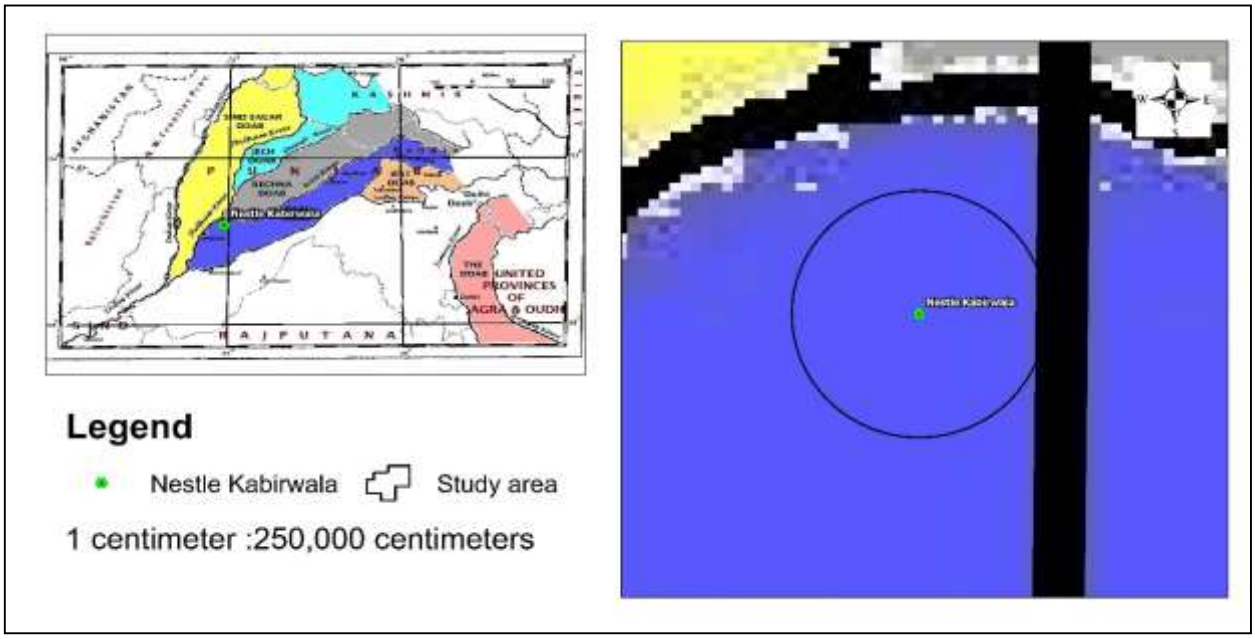


Figure 41: Location of Nestle Pakistan on Doab Map

CHAPTER-3

FIELD ACTIVITIES

3.1 PUMP TEST

In order to determine some of the aquifer characteristics including permeability, Transmissivity, Storage etc. in a groundwater producing area it is essential to perform a long term pumping test on a completed and properly developed Tube well. For this purpose the completed tube well is pumped at a constant rate to its maximum designed capacity for minimum of 24 hours to a maximum of 72 hours. The discharge and the drawdown parameters in the pumping well.

The Dynamic Water Level (DWL) in the pumped well is regularly recorded at a definite interval of time as provided in the enclosed form. The required levels in the tube well are measured through a dip tube provided in the tube well during its construction.

3.1.1 PUMPING DATA RECORDING

Dynamic Water Level (DWL) in the pumped well is measured and recorded at a particular time with flow and recheck after an interval of timings as provided in the recording form. This process is to be continued till the completion of 24 hours or as required. The Original Static Water Level (OSWL) in the pumped well has been taken after finishing of the activity. The required levels in the tube well are measured through a sounder to measure the water level fluctuations (drawdown) in the well.

According to the same interval of timings as provided in the recording Form, This process is to be continued till the completion of 24 hours or as required. During recording following measure would be taken care.

- PH
- TDS
- Discharge
- Draw down

3.1.2 RECOVERY TEST

At the completion of 24 hours or as required pumping the further pumping is discontinued. The water level in the pumped well starts rising. This stage is known as the “Recovery” of water level in the pumped well. A continuous record of rising of water level in the pumped well is maintained on the similar Form with observations recorded at the similar interval of time as was done during the start of the pumping test. This recording may be continued till the 20 hours.

Table 8 Table of Pumping Data:

PROJECT: Assessment of the exploitation level of local water bodies by all water.			
CLIENT: Nestle Kabirwala Factory		**Static Water Level:** 16.17 ft.	**Well Location:** T-1
Conducted By: Mr. Taha Ismail		**Date started:**	17-September-2020
Supervised By: Mr. Waleed Ur Rehman		**Date end:**	17-September-2020
S.No.	Time (min)	Recovery (ft)	
1	01:10 PM	16.20m	
2	01:12 PM	16.19m	
3	01:12 PM	16.18m	
4	01:13 PM	16.17m	

3.1.3 GROUNDWATER MODELING

In a pumping test the type of aquifer, the well effects (well losses and well bore storage, and partial penetration), and the boundary conditions (barrier or recharge boundaries) dominate at different times during the test. They affect the drawdown behavior of the system in their own individual ways. So, to identify an aquifer system, one must compare its drawdown behavior with that of the various theoretical models. The model that compares best with the real system is then selected for the calculation of the hydraulic parameters.

Calculating hydraulic characteristics would be relatively easy if the aquifer system (i.e. aquifer plus well) were precisely known. This is generally not the case, so interpreting a pumping test is primarily a matter of identifying an unknown system. System identification relies on models, the characteristics of which are assumed to represent the characteristics of the real aquifer system.

The model main plot curve will contain two data series:

1. The time-drawdown data
2. The drawdown derivative data (time vs. change in drawdown).

The drawdown derivative data series will be represented by a standard symbol with the addition of an X through the middle of the symbol.

On the right side of the window, you will see five time-drawdown graph templates, each one representing different aquifer conditions, and/or scenarios encountered during a pumping test. These include:

- Confined
- Leaky or Recharge Boundary
- Barrier Boundary

- Double Porosity (Fractured Flow) and Unconfined
- Well Effects

In the Diagnostic plots, the time (t) is plotted on the X axis, and the drawdown (s) is plotted on the y axis. There are two different representations are available:

1. Log-Log scale
2. Semi-log, whereby the drawdown (s) is plotted on a linear axis.

The scale type may be selected directly above the time-drawdown graph templates. Changing the plot type will display a new set of the graph templates, and also plot the observed drawdown data in the new scale.

Each diagnostic graph contains three lines:

- Theis type curve (dashed black line)
- Theoretical drawdown curve under the expected conditions (solid black line)
- Drawdown derivative curve (solid green line).

3.1.4 MODEL ASSUMPTIONS

The model assumptions control which solution method will be chosen for your data, and what superposition factors will be applied.

The following model assumptions are available for the pumping test solutions:

- Type: Confined, Unconfined, Leaky, Fractured
- Extent: Infinite, Recharge Boundary, Barrier Boundary
- Isotropy: Isotropic, Anisotropic
- Discharge: Constant, Variable
- Well Penetration: Fully, Partially

Each time a model assumption is modified, modeling software will attempt to recalculate the theoretical drawdown curve, and a new automatic fit must be applied by the user. If the automatic fit fails, then a manual curve fit can be done using the parameter controls.

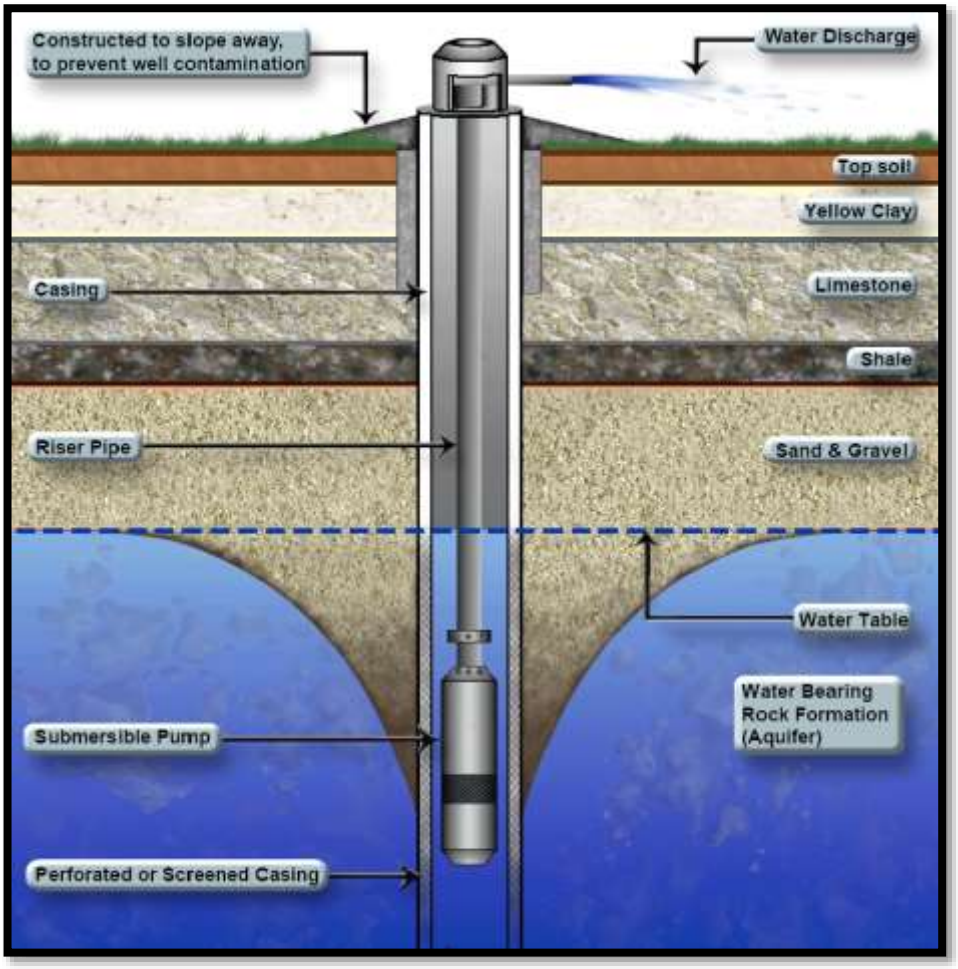


Figure 42: Illustration diagram of tubewell

3.1.5 STEP DOWN

A step-drawdown test (or step test) is a single-well pumping test designed to investigate the performance of a pumping well under controlled variable discharge conditions. In a step-drawdown test, the discharge rate in the pumping well is increased from an initially low constant rate through a sequence of pumping intervals (steps) of progressively higher constant rates. Each step is typically of equal duration, lasting from approximately 30 minutes to 2 hours. Each step should be of sufficient duration to allow dissipation of wellbore storage effects.

In addition to estimating hydraulic properties of an aquifer system such as transmissivity and hydraulic conductivity, the goal of a step-drawdown test is to evaluate well performance criteria such as well loss and well efficiency.

Table 9: Table of Step down Test

STEP DRAW DOWN

Sheet 01 of 01

PROJECT: Assessment of the exploitation level of	Well Location: Turbine-01
CLIENT: Nestle Kabir wala	Static Water Level : 16.17m
Conducted By: Taha Shakeel	Date started: 17-09-2020
Supervised By: Waleed ur Rehman	Date end: 17-09-2020

S.No	Rate Q.Max	Flow Rate (Cubic m/hr)	Date	Start Time (12 hours)	End Time (12 hours)	Water Level (m)	Draw Down (m)
1	0.25	75	17-Sep-20	10:15 AM	10:17 AM	16.18	0.01
2	0.25	75	17-Sep-20	10:17 AM	10:19 AM	16.31	0.14
3	0.25	75	17-Sep-20	10:19 AM	10:21 AM	16.43	0.26
4	0.25	75	17-Sep-20	10:21 AM	10:23 AM	16.55	0.38
5	0.25	75	17-Sep-20	10:23 AM	10:25 AM	16.61	0.44
6	0.25	75	17-Sep-20	10:25 AM	10:30 AM	16.74	0.57
7	0.25	75	17-Sep-20	10:30 AM	10:35 AM	16.86	0.69
8	0.25	75	17-Sep-20	10:35 AM	10:40 AM	17.01	0.84
9	0.25	75	17-Sep-20	10:40 AM	10:45 AM	17.17	1
10	0.25	75	17-Sep-20	10:45 AM	10:55 AM	17.36	1.19
11	0.25	75	17-Sep-20	10:55 AM	11:05 AM	17.52	1.35
12	0.25	75	17-Sep-20	11:05 AM	11:07 AM	17.93	1.76
PUMP STOPPED AT 11:07 AM							
PUMP STARTED AT 11:55 AM							
13	0.25	75	17-Sep-20	11:55 AM	12:15 PM	17.89	1.72
14	0.25	75	17-Sep-20	12:15 PM	12:00 PM	17.87	1.7
15	0.25	75	17-Sep-20	12:00 PM	12:05 PM	17.88	1.71
16	0.25	75	17-Sep-20	12:05 PM	12:10 PM	17.88	1.71
17	0.25	75	17-Sep-20	12:10 PM	12:15 PM	17.88	1.71
18	0.25	75	17-Sep-20	12:15 PM	12:20 PM	17.88	1.71
19	0.25	75	17-Sep-20	12:20 PM	12:30 PM	17.89	1.72
20	0.25	75	17-Sep-20	12:30 PM	12:45 PM	17.9	1.73
21	0.25	75	17-Sep-20	12:45 PM	1:00 PM	17.93	1.76
22	0.25	75	17-Sep-20	1:00 PM	1:08 PM	17.93	1.76
PUMP STOPPED AT 01:08 PM							
PUMP STARTED AT 10:49 AM							
23	0.5	233.17	18-Sep-20	10:49 AM	10:50 AM	22	5.83
24	0.5	233.17	18-Sep-20	10:50 AM	10:51 AM	22.16	5.99
25	0.5	233.17	18-Sep-20	10:51 AM	10:52 AM	22.17	6
26	0.5	233.17	18-Sep-20	10:52 AM	10:53 AM	22.2	6.03
27	0.5	233.17	18-Sep-20	10:53 AM	10:54 AM	22.24	6.07
28	0.5	233.17	18-Sep-20	10:54 AM	10:56 AM	22.26	6.09
29	0.5	233.17	18-Sep-20	10:56 AM	11:00 AM	22.28	6.11
30	0.5	233.17	18-Sep-20	11:00 AM	11:07 AM	22.28	6.11
PUMP STOPPED AT 11:02 AM							
PUMP STARTED AT 11:15 AM							

31	0.5	233.17	18-Sep-20	11:15 AM	11:16 AM	22.1	5.93
32	0.5	233.17	18-Sep-20	11:16 AM	11:18 AM	22.13	5.96
33	0.5	233.17	18-Sep-20	11:18 AM	11:19 AM	22.17	6
34	0.5	233.17	18-Sep-20	11:19 AM	11:20 AM	22.21	6.04
35	0.5	233.17	18-Sep-20	11:20 AM	11:21 AM	22.23	6.06
36	0.5	233.17	18-Sep-20	11:21 AM	11:22 AM	22.23	6.06
37	0.5	233.17	18-Sep-20	11:22 AM	11:23 AM	22.25	6.08
38	0.5	233.17	18-Sep-20	11:23 AM	11:24 AM	22.26	6.09
39	0.5	233.17	18-Sep-20	11:24 AM	11:25 AM	22.26	6.09
40	0.5	233.17	18-Sep-20	11:25 AM	11:26 AM	22.26	6.09
41	0.5	233.17	18-Sep-20	11:26 AM	11:27 AM	22.27	6.1
42	0.5	233.17	18-Sep-20	11:27 AM	11:28 AM	22.28	6.11
43	0.5	233.17	18-Sep-20	11:28 AM	11:29 AM	22.28	6.11
44	0.5	233.17	18-Sep-20	11:29 AM	11:30 AM	22.28	6.11
PUMP STOPPED AT 11:30 AM							
PUMP STARTED AT 11:45 AM							
45	0.5	233.17	18-Sep-20	11:45 AM	11:46 AM	21.28	5.11
46	0.5	233.17	18-Sep-20	11:46 AM	11:47 AM	21.88	5.71
47	0.5	233.17	18-Sep-20	11:47 AM	11:48 AM	22.17	6
48	0.5	233.17	18-Sep-20	11:48 AM	11:49 AM	22.22	6.05
49	0.5	233.17	18-Sep-20	11:49 AM	11:50 AM	22.24	6.07
50	0.5	233.17	18-Sep-20	11:50 AM	11:51 AM	22.25	6.08
51	0.5	233.17	18-Sep-20	11:51 AM	11:52 AM	22.25	6.08
52	0.5	233.17	18-Sep-20	11:52 AM	11:53 AM	22.25	6.08
53	0.5	233.17	18-Sep-20	11:53 AM	11:54 AM	22.26	6.09
54	0.5	233.17	18-Sep-20	11:54 AM	11:55 AM	22.27	6.1
55	0.5	233.17	18-Sep-20	11:55 AM	11:56 AM	22.27	6.1
56	0.5	233.17	18-Sep-20	11:56 AM	11:57 AM	22.27	6.1
57	0.5	233.17	18-Sep-20	11:57 AM	11:58 AM	22.27	6.1
58	0.5	233.17	18-Sep-20	11:58 AM	11:59 AM	22.27	6.1
59	0.5	233.17	18-Sep-20	11:59 AM	12:00 PM	22.27	6.1
60	0.5	233.17	18-Sep-20	12:00 PM	12:01 PM	22.27	6.1
61	0.5	233.17	18-Sep-20	12:01 PM	12:02 PM	22.28	6.11

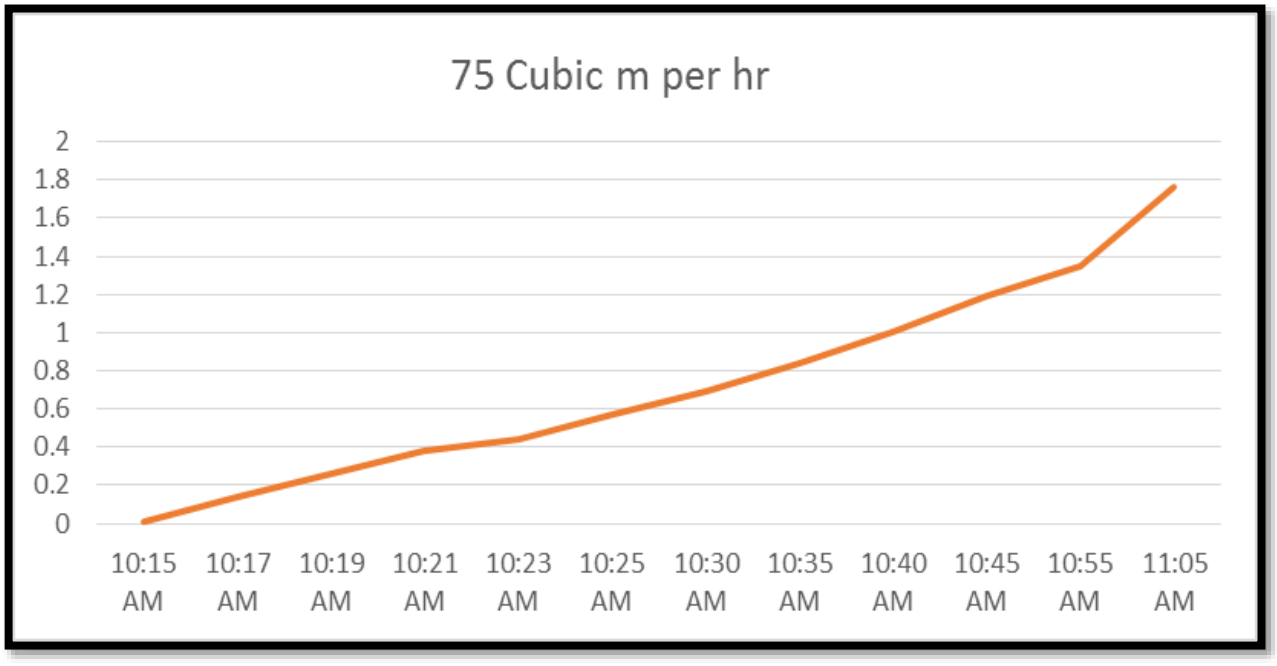
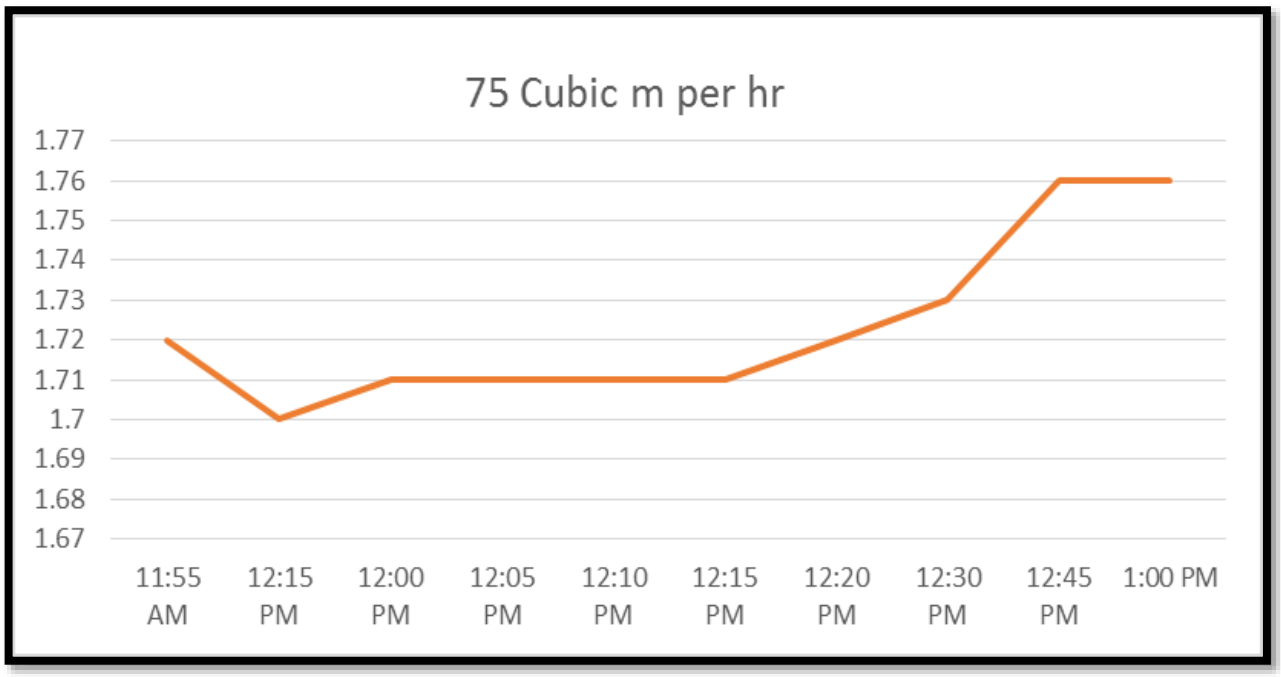
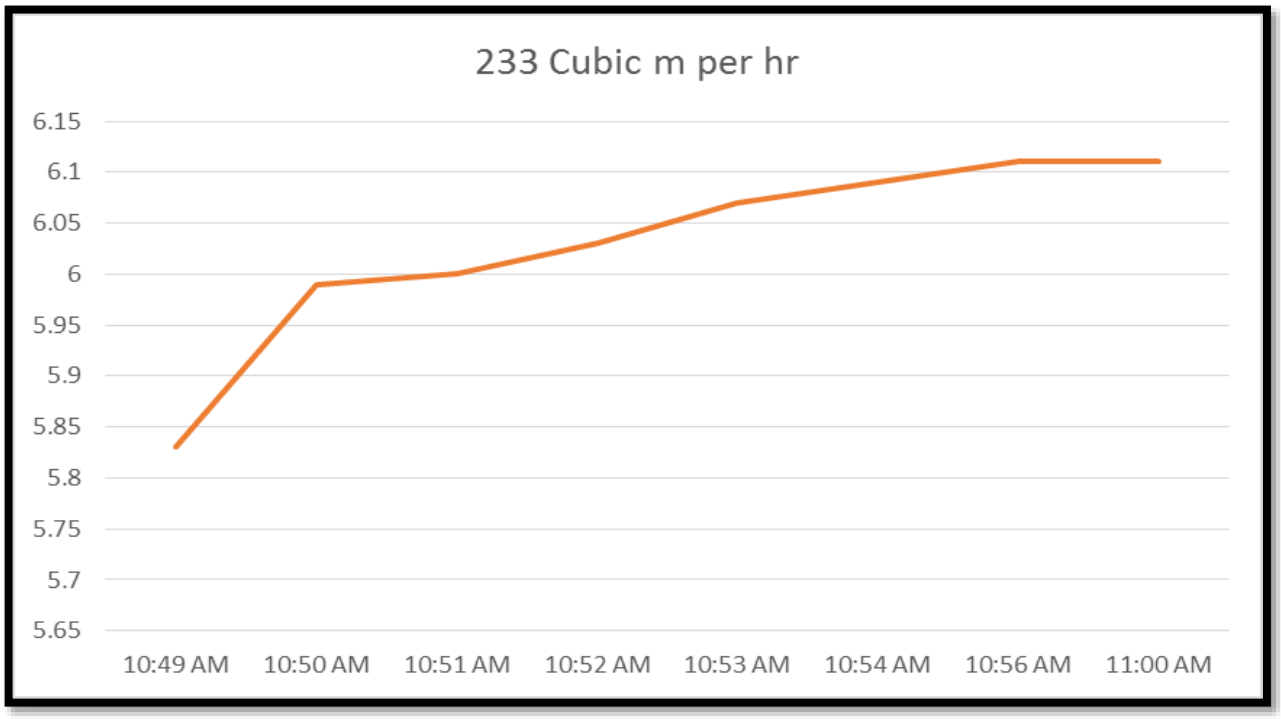
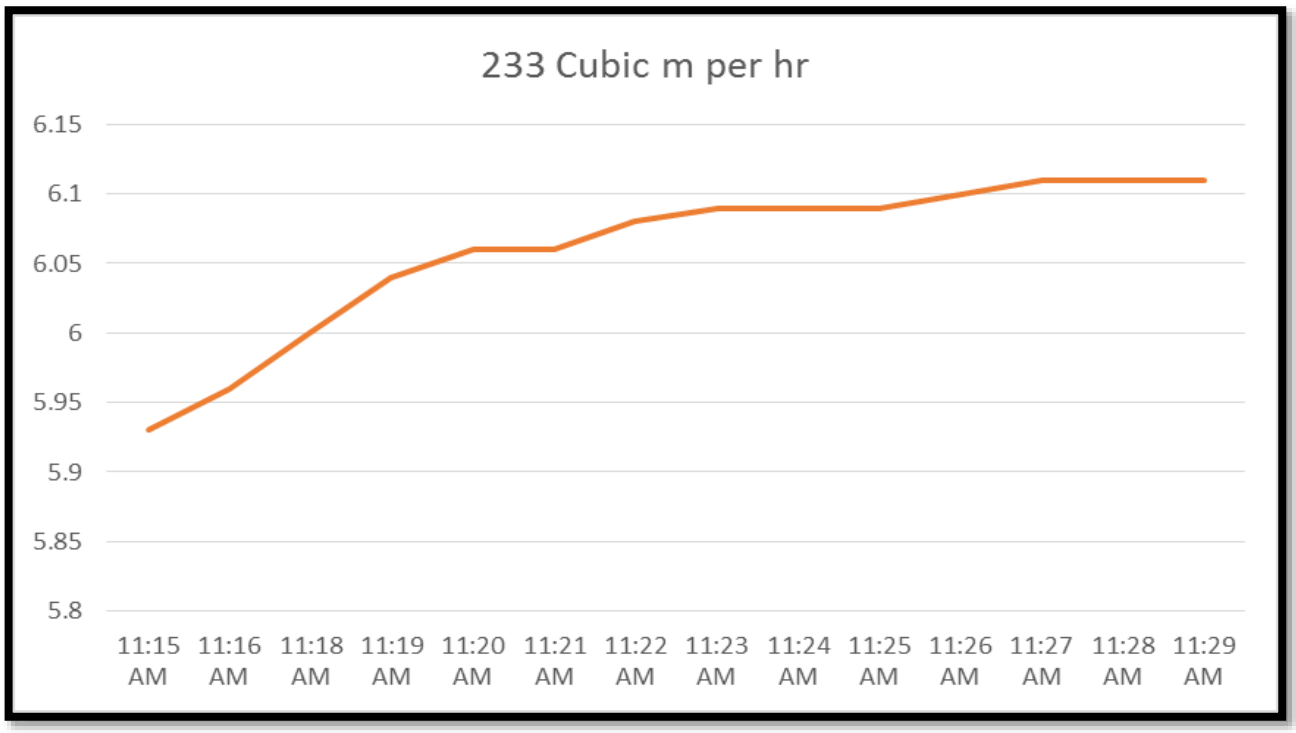
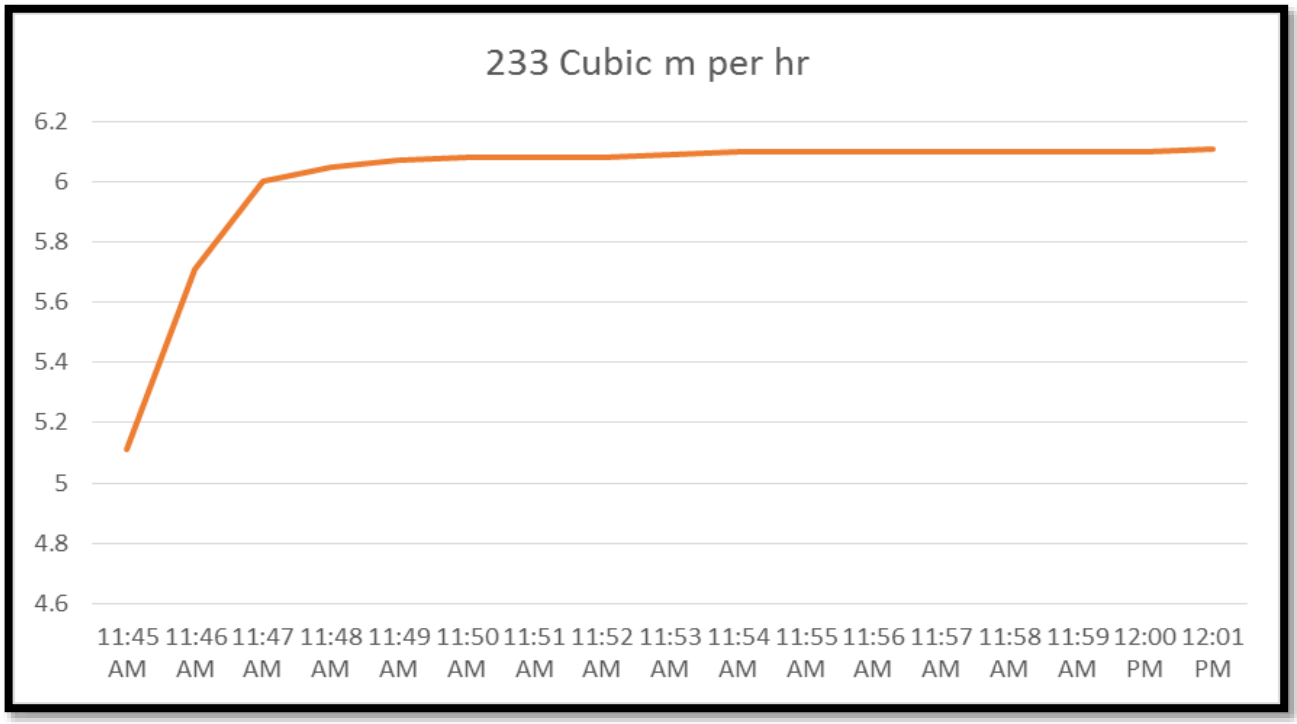


Figure 43: Step Down Curve


75 Cubic m per hr
1.77
1.76
1.75
1.74
1.73
1.72
1.71
1.7
1.69
1.68
1.67
11:55 AM
12:15 PM
12:00 PM
12:05 PM
12:10 PM
12:15 PM
12:20 PM
12:30 PM
12:45 PM
1:00 PM


233 Cubic m per hr
6.15
6.1
6.05
6
5.95
5.9
5.85
5.8
5.75
5.7
5.65
10:49 AM
10:50 AM
10:51 AM
10:52 AM
10:53 AM
10:54 AM
10:56 AM
11:00 AM


233 Cubic m per hr
6.15
6.1
6.05
6
5.95
5.9
5.85
5.8
11:15 AM
11:16 AM
11:18 AM
11:19 AM
11:20 AM
11:21 AM
11:22 AM
11:23 AM
11:24 AM
11:25 AM
11:26 AM
11:27 AM
11:28 AM
11:29 AM


233 Cubic m per hr
6.2
6
5.8
5.6
5.4
5.2
5
4.8
4.6
11:45 AM
11:46 AM
11:47 AM
11:48 AM
11:49 AM
11:50 AM
11:51 AM
11:52 AM
11:53 AM
11:54 AM
11:55 AM
11:56 AM
11:57 AM
11:58 AM
11:59 AM
12:00 PM
12:01 PM

3.1.6 AQUIFER TEST

Aquifer Test pro is a software which is design to analyzing, interpreting visualizing pump test data of the well. This software provides all the tools needed to accurately interpret data from all types of aquifers in all types of test conditions.

A. Model Curve on 233.17 m3/hr

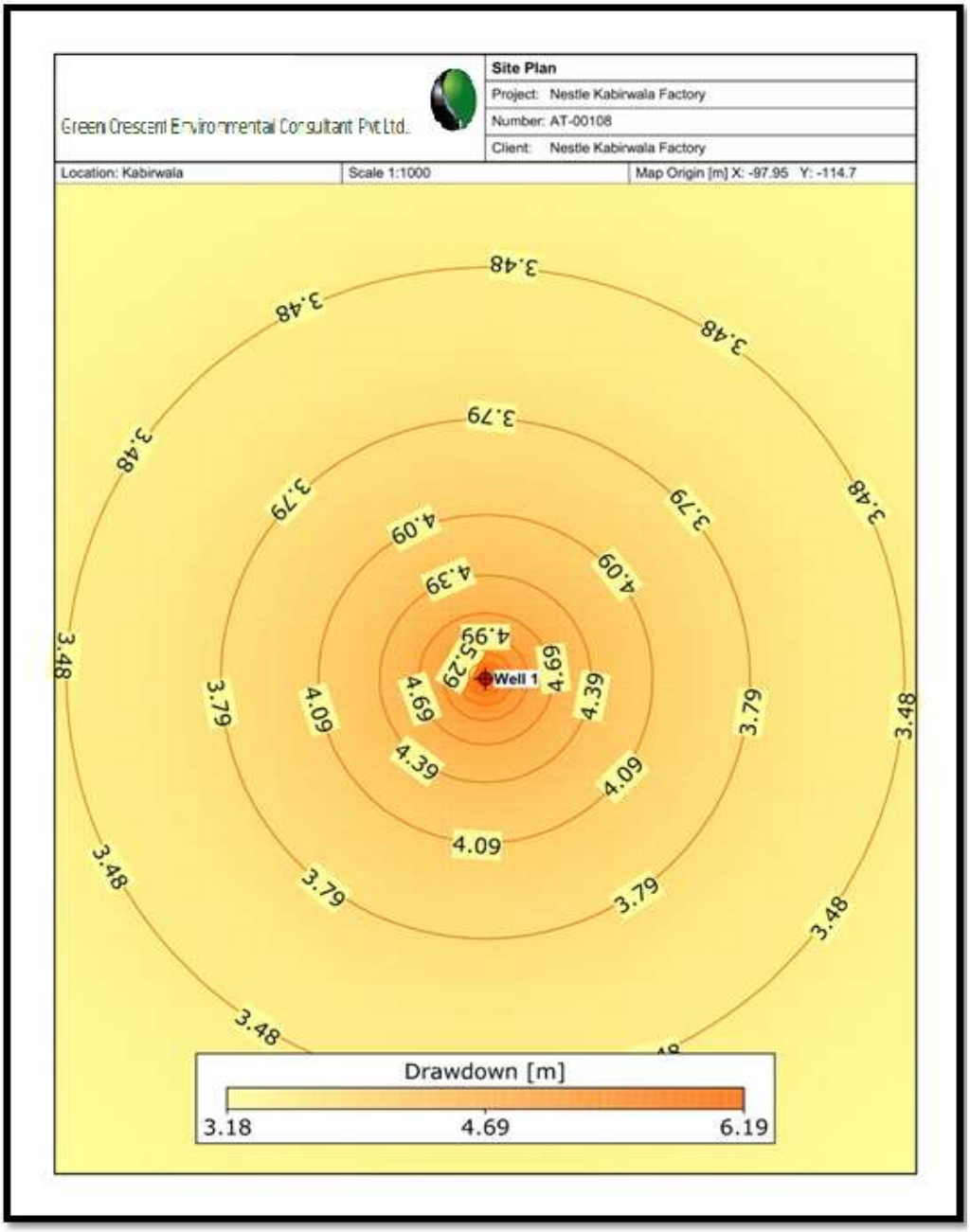


Figure 44: Contour Show the drawdown at 233.7 m³/hr

B. Model Curve

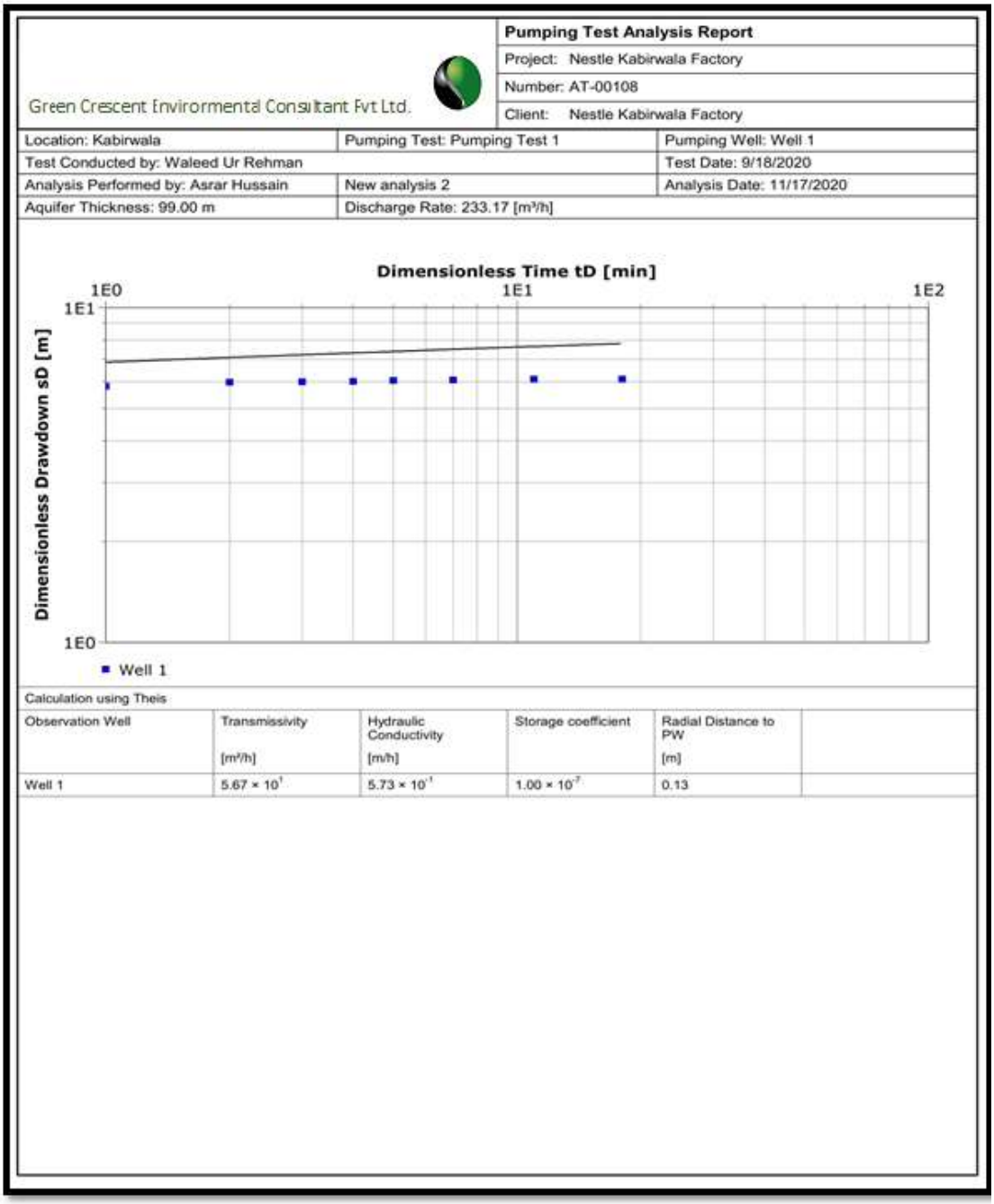


Figure 45: Dimensionless drawdown model curve

C. Drawdown Curve

Green Crescent Environmental Consultant Pvt Ltd.	**Pumping Test Analysis Report**	
	Project: Nestle Kabirwala Factory	
	Number: AT-00108	
	Client: Nestle Kabirwala Factory	
Location: Kabirwala	Pumping Test: Pumping Test 1	Pumping Well: Well 1
Test Conducted by: Waleed Ur Rehman		Test Date: 9/18/2020
Analysis Performed by: Asrar Hussain	New analysis 2	Analysis Date: 11/17/2020
Aquifer Thickness: 99.00 m	Discharge Rate: 233.17 [m³/h]	

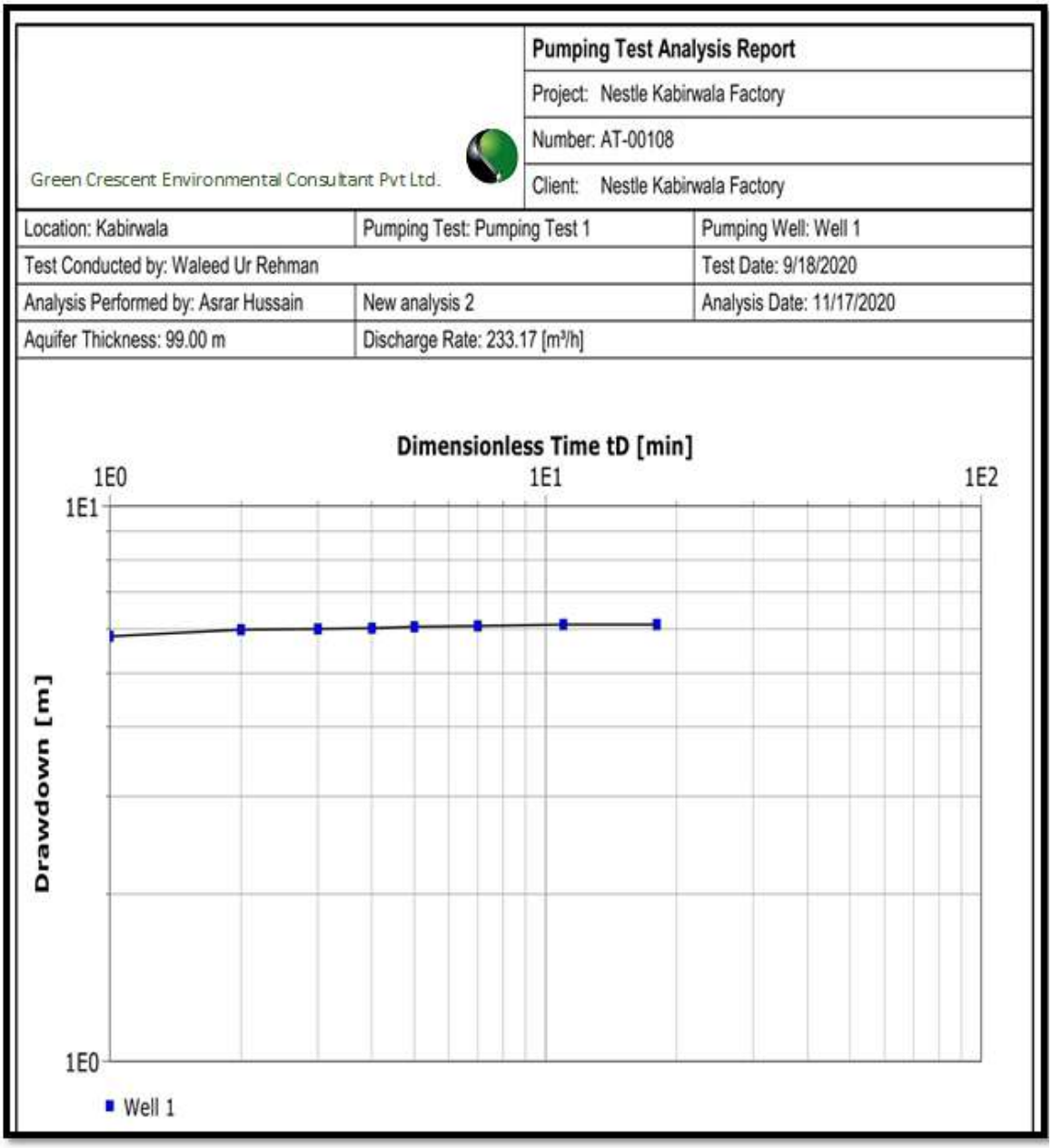


Figure 46: Drawdown curve

D. Model Report

Green Crescent Environmental Consultant Pvt Ltd.				**Pumping Test Analysis Report**				
				Project: Nestle Kabirwala Factory				
				Number: AT-00108				
				Client: Nestle Kabirwala Factory				
Location: Kabirwala			Pumping Test: Pumping Test 1			Pumping Well: Well 1		
Test Conducted by: Waleed Ur Rehman						Test Date: 9/18/2020		
Aquifer Thickness: 99.00 m			Discharge Rate: 233.17 [m³/h]					
	Analysis Name	Analysis Performed by	Analysis Date	Method name	Well	T [m²/h]	K [m/h]	S
1	New analysis 2	Asrar Hussain	11/17/2020	Theis	Well 1	5.67×10^{1}	5.73×10^{-1}	1.00×10^{-7}

3.2 RECONNAISSANCE SURVEY

Reconnaissance surveys represent a type of field survey that is often used to gather initial information regarding the potential of surface water, ground water and geology in the study area and surrounding areas.

In hydrogeology Reconnaissance survey is associated with the study of topography of the area, drainage pattern, geomorphology, geological structures and possible ground water recharge source present within the area.

Figure 47: Team during reconnaissance survey

3.2.1 SURFACE LITHOLOGICAL IDENTIFICATION

In reconnaissance survey GCEC technical team will analyze the geology of project area and surrounding area with the help of surface lithology, pre-existing geological maps and basin analysis. The lithological data helps to demarcate the subsurface condition of the area.

The study area is situated in Punjab Landform. The upper most layer is deposits in recent age of geological time scale. They were deposits due to meandering of Ravi and Jhelum River as well as on some locations soil of flood deposits are present.

3.2.2 GROUNDWATER RECHARGE

Rate of precipitation of the area help to identify the rate of the ground water recharge. As well as demarcate the surface water sources to estimate recharge from them. The ground water is recharging from rainfall as well as from command areas of canals and back recharge from cultivation lands. The LBDC is marked as a major source of groundwater recharge in the study area.

3.2.3 EXISTING TUBE WELLS

GCEC technical team will gather the information of existing water wells surrounding the project area i.e. depth of water well, water level indicator, wetted tape method, pH and TDS while marking the coordinates of each sample point to receiver maximum output.

Figure 48: Existing Tubewells in surrounding area

3.2.4 SAMPLE COLLECTION

The team will collect the water samples and soil samples to gather the maximum amount of details of the surrounding areas. All the samples were collected randomly from study area. The samples were taken in water cans and different bottles before sampling the bottle were rinse 3-4 times. All the methods and quality-assurance measures taken to ensure that the samples collected accurately represent the environment intended for study and can fulfill data-quality objectives.

3.2.5 SAMPLING METHODS

All the samples were collected systematically with regular and even intervals. The samples were taken in cans and different bottles after the bottle were rinse 3-4 times. All the methods and quality-assurance measures to ensure that the samples collected accurately represent the environment intended for study and can fulfill data-quality objectives.

Good quality soil and rock samples from subsurface strata has also be collected with assigned a reference number to each soil sample taken from different sites of Nestle Kabirwala. The number was unique for each site and in order of reference from the surrounding.

Figure 49: Water Sampling Techniques

3.2.6 SAMPLING TECHNIQUES

Water and soil samples both are taken by different location of Nestle Kabirwala Factory that are representative of the water source, treatment plant, storage facilities and distribution network. The most important test in water quality and those for microbiological qualities turbidity, for free chlorine residual

and pH where chlorination is used. These tests should be carried out whenever a sample is taken, regardless of how many other physical or chemical variables are to be measured.

3.2.7 LABELLING OF SAMPLES

All disturbed samples taken from surrounding and each sample were clearly labeled. Each label included the following information: -

- Name of Contract
- Reference number of samples
- Reference from the surrounding
- Date of sampling

3.2.8 METHODS OF RADIOACTIVE ELEMENTS

The gross alpha and beta counting equipment used in this work is MPC-2000, a Low Background alpha and beta counter. The equipment is a gasless proportional counter with ultra-thin window. The sample was placed in a planet and later placed in a sample carrier. The carrier was then placed on the sample drawer and closed for the purpose of gross alpha and beta counting. The counting was done automatically according to the selected count mode when the appropriate sample parameters were entered. The second equipment used for determination of some trace heavy metals is Atomic Absorption spectroscopy (AAS).

3.3 SAMPLE COLLECTION

3.3.1 SATELLITE IMAGE OF LOCATIONS (WATER SAMPLES)

All the samples have taken from existing wells and surrounding areas which are attached on following maps.

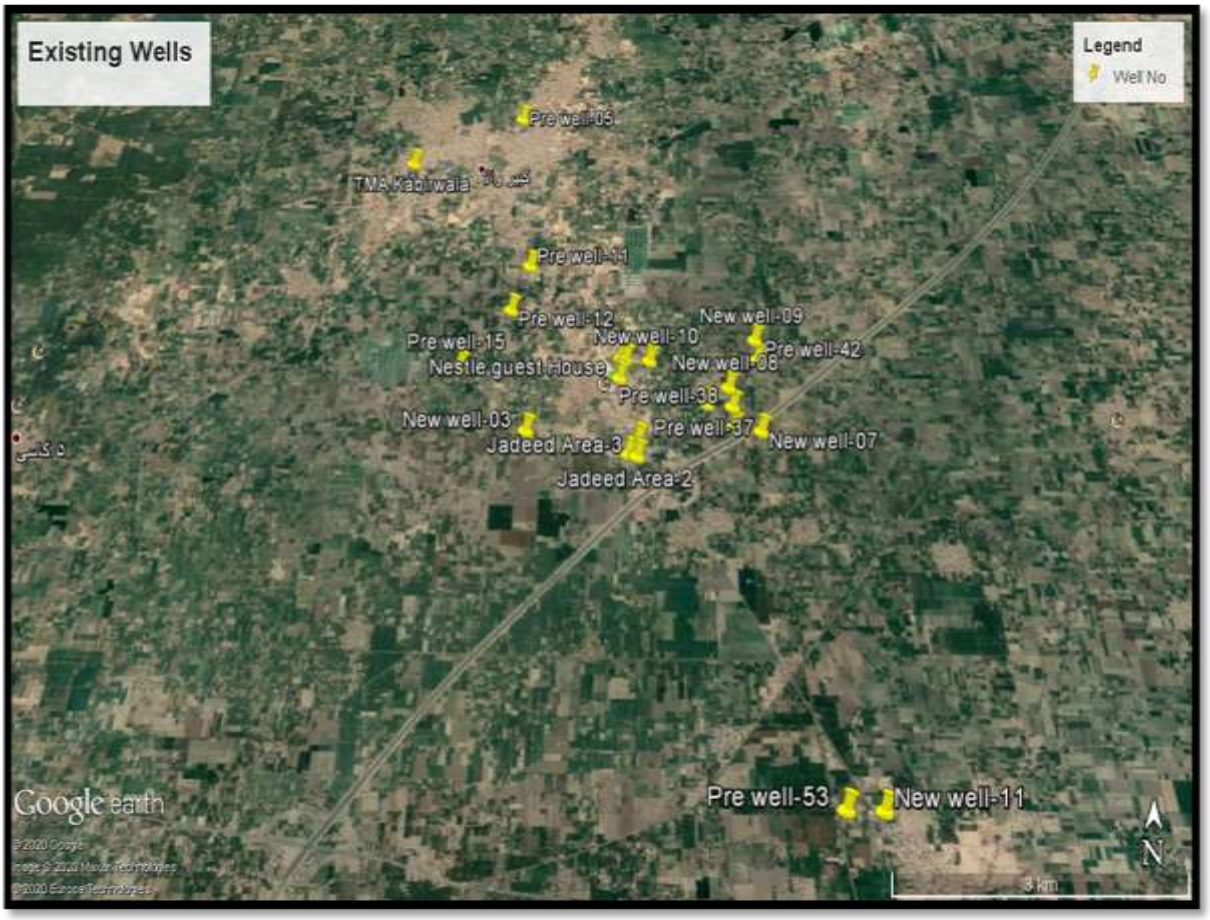


Figure 50: Water Sample Locations

3.3.2 SATELLITE IMAGE OF LOCATION (SOIL SAMPLE)

Figure 51: Soil Sample Location:

3.3.3 FIELD DATA CHART

Table 10: Details of Water Samples

WATER SAMPLE								
PROJECT:	ASSESSMENT OF EXPLOITATION LEVEL OF LOCAL WATER BODIES BY ALL WATER CONSUMER IN A RADIUS OF 10 KM AROUND NESTLE KABIRWALA FACTORY, SOUTH PUNJAB, PAKISTAN							
CLIENT:		NESTLE KABIRWALA FACTORY			**DATE:**		24-Sep-20	
GEOLOGIST:		Waleed-Ur-Rehman			**SUPERVISED BY:**			
S NO.	**SAMPLE#**	**LOCATION**		**DEPTH (ft)**	**Water Level (ft)**	**TDS (ppm)**	**PH**	**REMARKS**
		LATITUDE	**LONGITUDE**					
1	1	30°27'27.40"N	71°49'15.60"E	140	50	410	7.6	New well
2	2	30°22'45.00"N	71°52'8.00"E	100	100	377	7.36	well-12 (pre)
3	3	30°23'7.00"N	71°52'16.00"E	-	-	404	7.55	well-11 (pre)
4	4	30°22'18.00"N	71°52'45.00"E	-	-	390	7.62	well-15 (pre)
5	5	30°22'4.00"N	71°53'45.00"E	180	55	460	7.54	well-37 (pre)
6	6	30°21'32.80"N	71°53'1.90"E	230	60	780	7.31	New well
7	7	30°21'51.70"N	71°52'19.30"E	-	-	471	7.38	New well

8	8	30°21'48.00"N	71°53'12.00"E	-	-	502	7.71	Jadeed feeds
9	9	30°21'42.00"N	71°53'12.00"E	-	65	640	7.33	Jadeed feeds back area
10	10	30°22'41.20"N	71°53'11.70"E	-	-	625	7.32	Jadeed feeds back area
11	11	30°22'23.50"N	71°53'0.30"E	-	-	525	7.68	Turbine-01
12	12	30°22'22.90"N	71°53'0.30"E	-	-	200	8.27	Discharge point
13	13	30°22'24.00"N	71°54'10.00"E	150	55	403	7.58	well-42 (pre)
14	14	30°22'3.00"N	71°53'57.00"E	180	-	624	7.34	well-38 (pre)
15	15	30°21'54.00"N	71°54'10.00"E	160	-	782	7.16	well-40 (pre)
16	16	30°21'52.80"N	71°54'7.00"E	160	-	712	7.32	New well
17	17	30°22'11.30"N	71°53'55.60"E	200	-	494	7.4	New well
18	18	30°22'33.20"N	71°54'9.50"E		-	445	7.43	New well
19	19	30°22'22.60"N	71°53'17.40"E	170	-	541	7.43	New well (Nestle back side)
20	20	30◦ 19'41.0'' N	71◦ 54'48.8'' E	-	-	680	7.48	New well
21	21	30◦ 19'33'' N	71◦ 54'34'' E	150	-	659	7.36	well-52 (pre)
22	22	30◦ 18'12'' N	71◦ 55'26'' E	400	-	826	7.87	well-06 (Pre, tma Khanewal)
23	23	30◦ 24'01.3'' N	71◦ 51'02.1'' E	220	-	109	7.77	TMA Kabirwala
24	24	30◦ 22'29'' N	71◦ 52'06'' E	450	-	185	8.02	well-5 (pre) TMA Kabirwala
25	25	30◦ 22'14.6'' N	71◦ 53'03.0'' E	-	-	414	7.83	Nestle guest house

Table 11: Details of Soil Samples

SOIL SAMPLE					
PROJECT:	ASSESSMENT OF EXPLOITATION LEVEL OF LOCAL WATER BODIES BY ALL WATER CONSUMER IN A RADIUS OF 10 KM AROUND NESTLE KABIRWALA FACTORY, SOUTH PUNJAB, PAKISTAN				
CLIENT:		NESTLE KABIRWALA FACTORY		**DATE:**	24-Sep-20
GEOLOGIST:		Waleed-Ur-Rehman		**SUPERVISED BY:**	
S NO.	**SAMPLE#**	**LOCATION**		**LITHOLOGY**	**REMARKS**
		LATITUDE	**LONGITUDE**		
1	1	30°20'34.4"N	71°54'24.9"E	Silty Clay	Discharge channel sample
2	2	30°27'27.4"N	71°49'15.6"E	Silty Clay	

A. Physical Parameters

The physical parameters were checked during reconnaissance survey by the help of field-testing equipment of TDS and pH. While the static or dynamic water level was not measure in field due to Pump or casing etc. Hence, the ground water level of Nestle facility were check during survey.

B. Total Dissolve Solids (TDS) of Existing Wells

TDS was measured on field by TDS meter during reconnaissance survey from collected water samples. In the study area the TDS is ranging in between 109.02 ppm to 825.98 ppm. The highest value was encountered at NESTLE discharge point is 825.98 while lowest value is towards north at TMA Kabirwala 109 ppm.

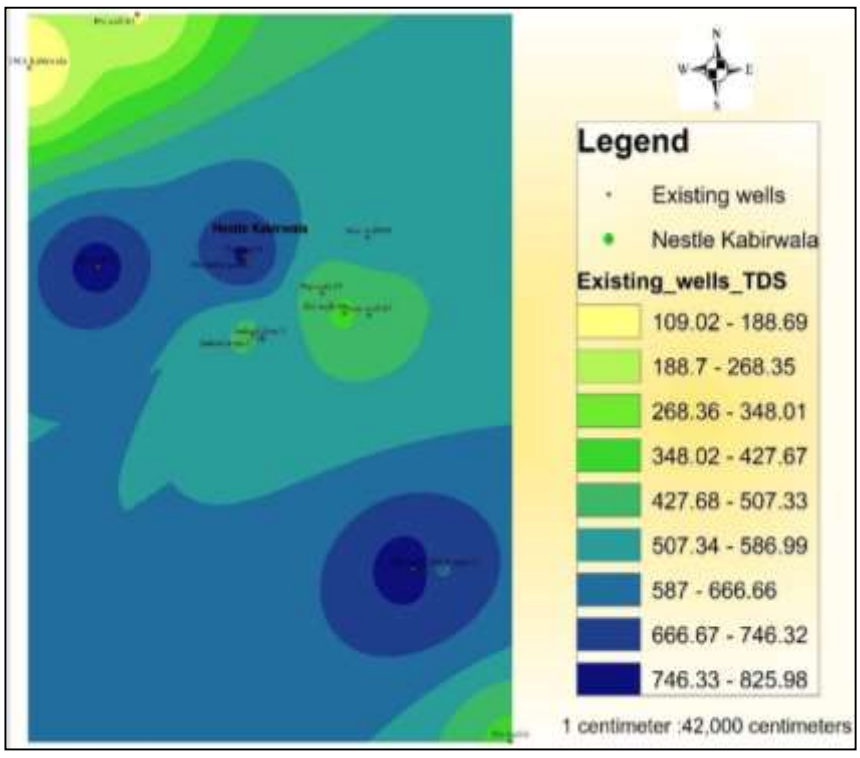


Figure 52: TDS MAP of Existing Tubewells

C. PH of Existing Wells

pH was also measured on field by pH meter during reconnaissance survey from collected water samples. In the study area the pH is ranging in between 7.17 to 8.02. The highest value was encountered at TMA Kabirwala old well while lowest value is towards north at NESTLE discharge point.

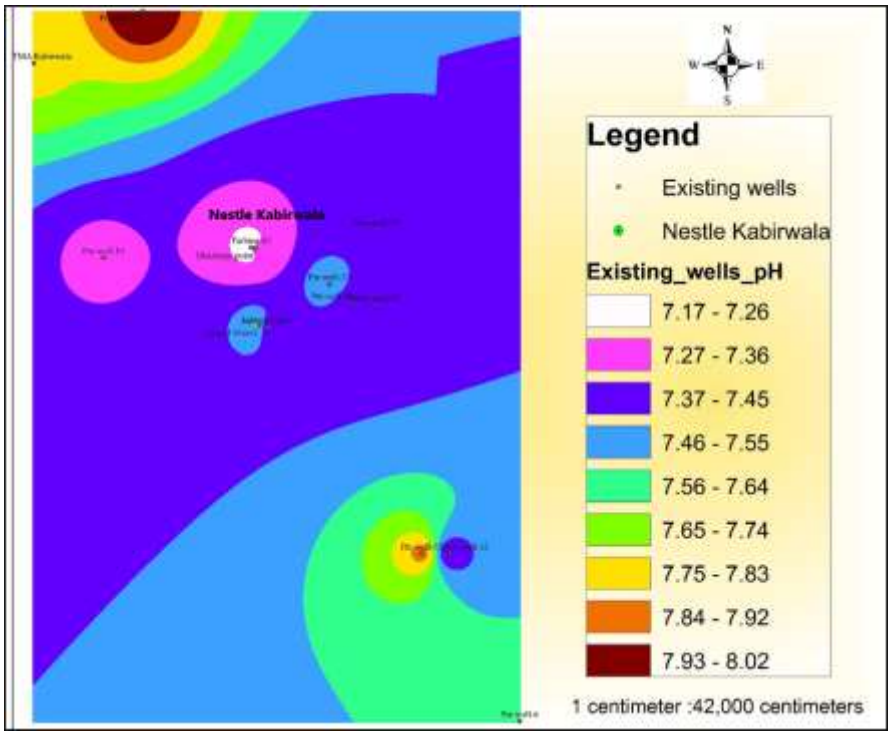


Figure 53: pH Map of Existing Tubewells

3.3.4 SHORT INTERVIEWS

In this reconnaissance survey the team took short interviews from locals to collect further data of the wells that exist in surrounding. The locals give much information of the pre-existing wells such as drilling date of the bore well, bore depth, water level, pumping rate, discharge rate etc.

According to locals the depth of wells is different in different fields. The depth variation is on the basis of their needs. The depth of water wells in the agriculture fields are varies from 43 to 70 meters. The wells of Nestle facility and TMA having depth of 100 to 121 meters. And groundwater level of the study area is varying from 16 meters to 30 meters from existing groundwater level.

Figure 54: Interview with locals

3.3.5 NATURAL EXISTING ELEVATION

The team demarked the surface elevation points at different well and sample collection points. Although, the area mostly exists at lower Indus Basin (plain area). First the team ascertain the elevations of many surrounding points and then they relate these points to one another.

3.4 PREVIOUS DATA

The water level data from all the 53 wells or open wells for a certain date is converted to water levels below land surface (the reference point from which the readings were taken needs not necessarily to be the land surface). The transformed data is subtracted from the land surface elevation of all the wells which generally refers to elevation above mean sea level (EMSL). The resulting data will now represent the groundwater elevation and will have no significant influence of the surface topographic ups and downs. The data points thus evaluated are plotted on the digitized topographical base map at observation points and lines of equal elevations are drawn by joining the equal values. A suitable contour interval is selected on the basis of changes in groundwater elevation per kilometer.

Surfer 11 software and surface mapping system are used to construct the hydrogeological water table and groundwater elevation (hydraulic head) maps. Data points entered as inputs are simply he X and Y co-ordinates and groundwater elevations. From the data points provided, more data points are interpolated by the Surfer 11software using a recognized gridding method. This version comprises 7 gridding methods namely:

1. Inverse distance
2. Kriging,
3. Minimum curvature,
4. Polynomial regression,
5. Radial basis functions,
6. Shepherd's method,
7. Triangle with lines interpolation.

Any one of the methods can be used by the user. A grid file is created with an extension containing a large number of interpolated data points and the original data points. This grid file is then further utilized to construct the groundwater elevation maps with a suitable contour interval.

A hydrogeological map of Nestle Kabirwal Factory is indicating water table range of 9 to 19 meters. The water table decreases towards northeast and southeast.

CHAPTER-4

GROUNDWATER BUDGETING

The purpose of ground water budgeting is to ascertain the impact of withdrawal by Nestle in conjunction with other available sources and their intended usage within 10 Km radius of study area. In order to figure out the water balance it is essential to analyze the water consumption to ensure the availability for incremental demand.

4.1 WATER CONSUMPTION

The water sources available in study area are utilized sector-wise where rainfall and surface water are partially fulfilling the agricultural needs. Groundwater is found to be utilized by all sectors including agriculture, industry and domestic/livestock, as the demand is majorly dependent on it. Therefore, the water balance in the report is emphasized around the groundwater in terms of recharge and discharge.

4.1.1 GROUND WATER

The groundwater outflow from a hydrogeological system can be divided into a natural discharge and anthropogenic withdrawal. Natural discharge is the groundwater flow from high altitude to low altitude. In the case of study area, the groundwater is moving towards south west direction but the rate of groundwater is negligible because of depletion of groundwater level continually. Anthropogenic discharge of groundwater is caused by withdrawal for irrigation, domestic and industrial purposes.

The quantification of the agricultural withdrawals is one of the most essential components of the water budget. Mostly, the study area is agricultural with a portion of settlements. Approximately, 30 industries are present in Khanewal district out of which 6 industries are situated in study area.

A. Agriculture

As the study area is the part of Punjab land form and command area of LBDC. The LBDC just fulfill 40.36% of their total agriculture requirement the remaining 59.63% agriculture water need was fulfil by groundwater.

Table 12: Available water quantity for Agriculture

Water Source	Consumption Area	Availability		
		MCM/YR	MAF/YR	%
Surface Water	Agriculture	66.38	0.053	40.36
Groundwater	Agriculture	98.09	0.078	59.63

B. Industry

There are only 30 industries in the Khanewal district while 6 major industries are found in study area. These are belonging to feeds, oil processing and flour industries while Nestle is belongs to dairy industry. Approx. total water consumption of industries is 36.71 MCM/yr. (0.0297 MAF/yr.).

C. Domestic Use

For domestic purposes the population density of Kabirwala is 582.4 persons per Km2 and the study area is 316.6 Km2. So, the population in the study area is 184387.84 persons. The design criteria for water and sanitation agency and PHED Punjab were caried out a survey in 2017 and they calculate the water consumption per person per day, as per their estimation 40 Gallons per person water were used. So, the total consumption is found to be 12.24 MCM/yr. (0.0097 MAF/yr.).

D. Livestock

As per University of NEBRASKA-LINCOLN (institute of agriculture and Natural Resources) publishment the different animals need different amount of water intake. The list of animals and their needs are mentioned below. For this project the number of animals and their quantity is taken from and water need for livestock is 2.38MCM/yr (0.0019 MAF/yr). The number of livestock were taken from Punjab livestock census 2006.

Table 13: Water needs of Livestock

Animals	Quantity	Water needs per day	Water needs MCM/Year
Cattles	31378.39	62	0.710092926
Buffalo	48699.70	77.5	1.377592825
Sheep	5563.52	50	0.101534317
Goat	49752.02	9.25	0.167975244
Camel	182.46	200	0.013319429
Hoarse	275.59	27.5	0.002766245
Mule	128.92	43	0.002023444
Chickens	53302.29	0.3	0.005836601

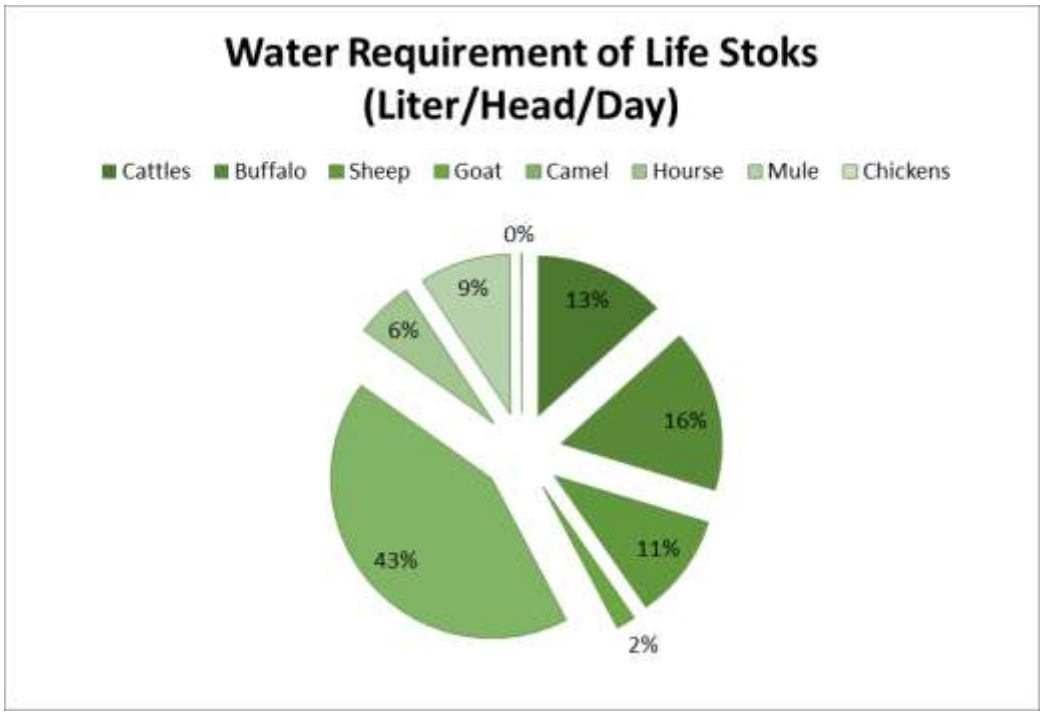


Figure 55: Pie Chart of water requirement for life stocks

4.1.2 OVERALL WATER CONSUMPTION

The approximated water consumption of the study area provided in the following table:

Table 14: Overall water consumption

Water Source	Consumption Area	Availability (Average)		
		MCM/YR	MAF/YR	%
Surface area + Ground Water	Agriculture	164.47	0.131	76%
Ground Water	Industry	36.71	0.029	17%
Ground Water	Domestic	12.24	0.009	6%
Ground Water	Livestock	2.38	0.0019	1%

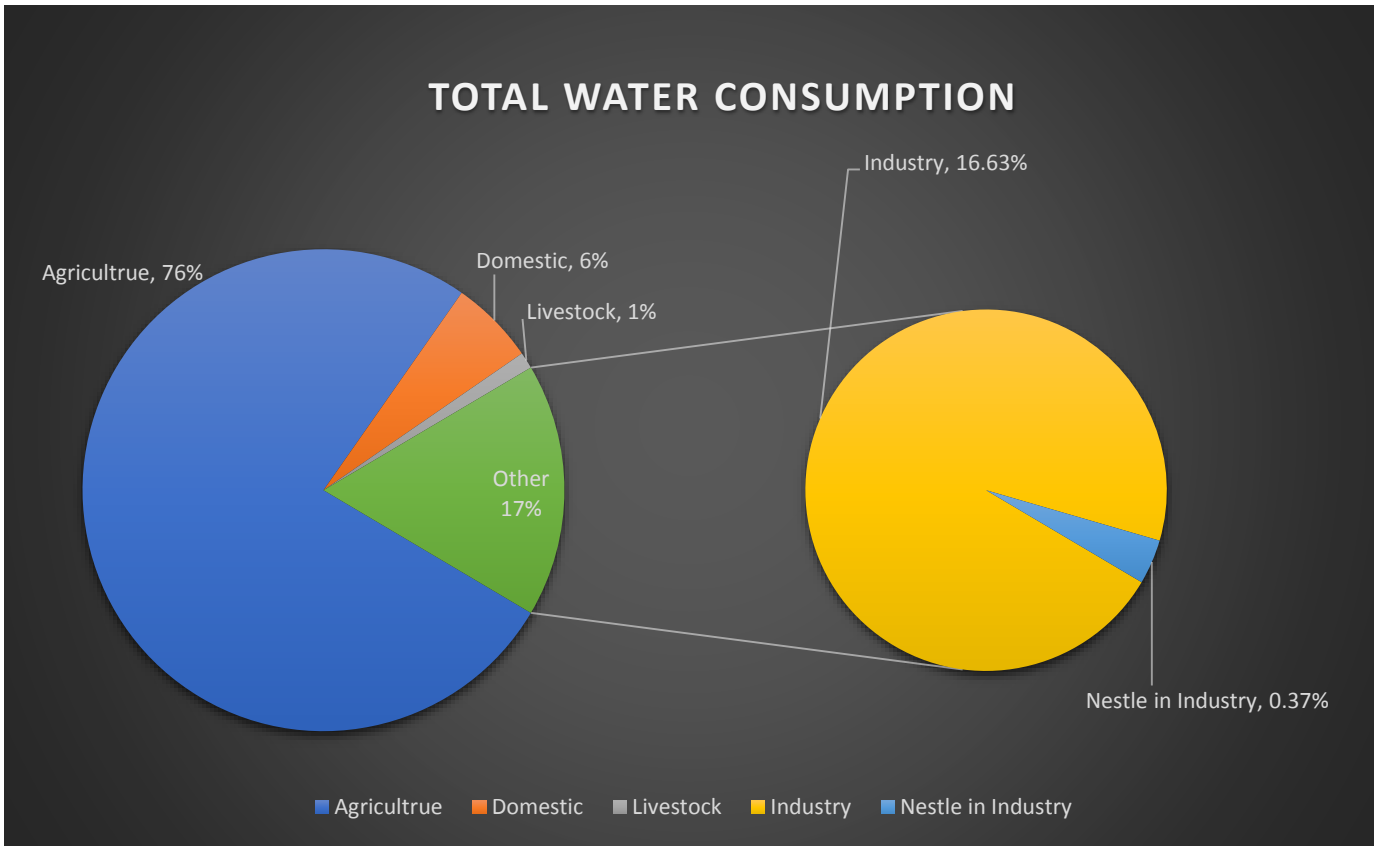


Figure 56: Pie Chart showing the water consumption of Nestle Kabirwala, compression with other industrial use

4.2 GROUNDWATER RECHARGE

4.2.1 Rainfall

As per last 10 years data provided by meteorological department the average annual rainfall is total 328.9 mm/year. Hence, the total annual groundwater recharge after subtracting evapotranspiration and runoff is 4.13 MCM/Yr. (0.0033 MAF/Yr).

4.2.2 Surface Water

The LBDC is the source of surface water recharge in the study area and it is providing approx. 278.18 MCM/Yr. (0.222 MAF/Yr) water as a surface resource. The 38% of total water supply is percolating from surface water resource. This recharge was calculated to be 105.71 MCM/Yr. (0.0845 MAF/Yr).

4.2.3 Ground water backflow

The usage and users of groundwater in the study area is mentioned above, while the maximum outflow is 149.42 MCM /Yr. (0.119 MF/Yr.). Hence, the 18% of total groundwater abstraction is going back into the sub-surface and it is 26.896 MCM /Yr. (0.0215 MF/Yr.)

4.3 WATER BALANCE

As per water usage and recharge stated above the water balance is:

Table 15: Water balance chart

Ground water Recharge and Discharge	MCM/YR	MAF/YR
Recharge from Rain fall	4.13	0.0033
Backflow flow from Irrigation system (38% of total water supply)	105.71	0.0845
Return flow from total water abstraction 18%	26.89	0.0215
Total Recharge	**136.73**	**0.1093**
Total groundwater discharge from tube wells	**149.42**	**0.1195**
Balance	**12.69**	**0.0101**

4.4 FUTURE PROJECTION

For next five year, it is assumed that the agricultural will be lesser on ratio of -0.001% per anum as per Urbanization growth or remain nearly same; for industrial water needs, it will increase 6.3% per anum as per growth rate studies of Punjab Government Planning and Development department in 2018 published on title, "Accelerating Economic Growth and Improving Social Outcomes", while demand for population and livestock will increase with rate of 2.41% as per below given formula. The population would increase, considering the variation, current and projected water demands are provided in the following:

Population growth formula

Pf = Pp(1+i)^n

Pf Future Population

Pp Present Population

i growth rate in decimal, i.e., %age/100

n years

Table 16: Future projection for next five years

DESCRIPTION	Yr.2020 (MCM/ Yr.)	Yr.2020 MAF/Yr	Yr. 2025 (MCM/ Yr.)	Yr. 2025 MAF/Yr
Agriculture	164.47	0.1315	163.65	0.1309
Industry	36.71	0.0293	48.27	0.0386
Domestic & Livestock	14.62	0.0116	16.38	0.0131
Total	215.80	0.1726	228.30	0.1826
ADDITIONAL REQUIRMENT			**12.50**	**0.0100**

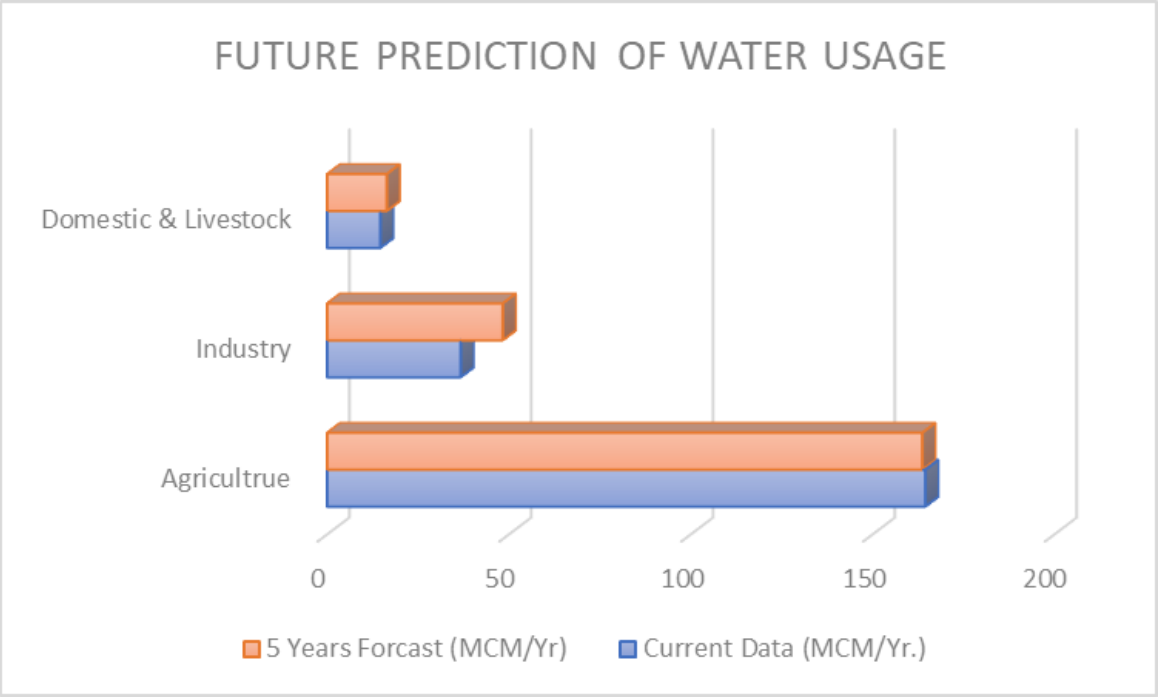


Figure 57: Future prediction of water usage

4.5 COMPARISON WITH PREVIOUS REPORT

In order to make comparison between the two resultants, it is significant to assess the scenario that works in backdrop of estimations made in previous and present reports. The previous report was prepared for Bari Doab area of 48,124,270 Acres on the basis of met data for years 2005 to 2010 and current report has been considered to be 58,222 Acres of study area. The difference in area extent, timeframe, meteorological records, demand/supply; and infrastructural setting as well as land use in terms of settlements, agricultural and industrial configuration carry their impact on the water availability and demand.

Considering abovementioned parameters in view of their weightage, comparative statement has been developed and provided in the following:

Table 17: Data Deflection in 2015 and 2020

Groundwater Recharge and Discharge	Data Deflection in 2020 MAF/Yr.	Data Deflection in 2015 MAF/Yr.
Recharge from Rain fall (48,124,270 Acre) considering previous and current rainfall data	5.708	6.970
Backflow flow from Irrigation system (38% of total water supply)	21.802	21.810
Return flow from total water abstraction 18%	6.712	6.300
Total Recharge	34.232	35.080
Total groundwater discharge	37.49	35.540
Total Discharge	37.49	35.540
Balance	3.23	0.460

CHAPTER-5

CHEMICAL ANALYSIS

Chemical testing and analysis are vital for regulatory compliance and to understand the quality and composition of chemical substances and materials that are used in products, industrial processes and manufacturing. Specialist industry knowledge, and expertise in applying the most relevant methodology are the keys to successful chemical testing. Advanced analytical instrumentation or a combination of techniques is necessary to solve problems or determine composition.

Chemical composition analysis utilizes a combination of techniques that can cover a wide range of applications, and which determine chemical quality, identity, composition and impurities of Volatile organic compounds (VOCs), Trihalomethane (THMs), Radioactivity and Biological parameter.

5.1 VOCS (VOLATILE ORGANIC COMPOUNDS)

Volatile organic compounds (VOCs) are chemicals that both vaporize into air and dissolve in water. VOCs are pervasive in daily life, because they're used in industry, agriculture, transportation, and day-to-day activities around the home. Once released into groundwater, many VOCs are persistent and can migrate to drinking-water supply wells.

VOCs tend to escape from surface water through volatilization (evaporation) into the air, once dissolved in groundwater they are more persistent. They can be transported through the unsaturated zone in recharge, in soil vapor, or as a non-aqueous-phase liquid. VOCs have high vapor pressures, low-to-medium water solubilities, and low molecular weights. Some VOCs may occur naturally in the environment, other compounds occur only as a result of manmade activities, and some compounds have both origins.

5.2 THMS (TRIHALOMETHANE)

THM, are generally higher in chlorinated water originating from surface water than in groundwater, because of higher organic matter in the former. The extent of formation of chloroform varies with different water treatment processes. Concentrations of chloroform in chlorinated water in treatment plants and distribution systems are approximately twice as high during warmer months as during colder months. This is a consequence of the higher concentrations of precursor organic materials and especially of the higher rates of formation of disinfection by-products in the raw water during the warmer period.

Concentrations of THMs have been determined in drinking-water supplies at a considerable number of locations across Canada. Eight provinces provided 1994–2000 THM data for just over 1200 water systems serving a sampled population of over 15 million Canadians. The methods of sampling and analysis varied and were often not well described, but generally samples were taken from the midpoints and/or end-points of the water systems, and the typical methods of analysis were either liquid–liquid extraction or purge-and-trap gas chromatography (GC).

5.3 RADIOACTIVE

Radioactive decay is the emission of energy in the form of ionizing radiation. The ionizing radiation that is emitted can include alpha particles, beta particles and/or gamma rays. Radioactive decay occurs in unbalanced atoms. When it decays, a radionuclide transforms into a different atom - a decay product. The atoms keep transforming to new decay products until they reach a stable state and are no longer radioactive. The majority of radionuclides only decay once before becoming stable. Those that decay in more than one step are called series radionuclides. The series of decay products created to reach this balance is called the decay chain. The series of decays or transformations that radionuclides go through before reaching a stable form. For example, the decay chain that begins with Uranium-238 culminates in Lead-206, after forming intermediates such as Uranium-234, Thorium-230, Radium-226, and Radon-222. Also called the "decay series.

Each series has its own unique decay chain. The decay products within the chain are always radioactive. Only the final, stable atom in the chain is not radioactive. Some decay products are a different chemical element. Radioactive half-life is the time required for half of the radioactive atoms present to decay. Some radionuclides have half-lives of mere seconds, but others have half-lives of hundreds of millions or billions of years.

5.4 PESTICIDES

The term "pesticide" is a composite term that includes all chemicals that are used to kill or control pests. Pesticides are used to protect crops against insects, weeds, fungi, and other pests. They also play a significant role in food production. They protect or increase yields, and the number of times per year a crop can be grown on the same land. In agriculture, this includes herbicides (weeds), insecticides (insects), fungicides (fungi), nematocides (nematodes), and rodenticides (vertebrate poisons).

The health effects of pesticides depend on the type of pesticide. Some, such as the organophosphates and carbamates, affect the nervous system. Others may irritate the skin or eyes. Some pesticides may be carcinogens (cancer causing). Others may affect the hormone or endocrine system in the body. Pesticide mixtures may be derived from common sources (such as point sources) or from multiple nonpoint sources, and may include several different types of pesticide compounds with different mechanisms of toxicity.

The toxicity of a pesticide depends on its function and other factors. For example, insecticides tend to be more toxic to humans than herbicides.

5.5 PERMISSIBLE LIMITS OF DRINKING WATER BY WHO AND NEQS

Table 18: Permissible limits of drinking water by WHO and NEQS

S.NO.	PARAMETERS	ELEMENTS	METHODS	WHO'S LIMITS	NEQS LIMITS
1	ALKALI/ ALKALINE METALS	pH @ 25	[APHA 4500 H+ B 22nd Edition]	6.5-8.5	6.5-8.5
2		Turbidity	[APHA 2130 B 22nd Edition]	10	5
3		Total Dissolved Solids (TDS)	[APHA 2540 C 22nd Edition]	1000	1000
4		Total Suspended Solids (TSS)	[APHA 2540 D 22nd Edition]	-	-
5		Chloride Cl-	[APHA 4500 CL B 22nd Edition]	200	250
6		Fluoride	[APHA 4500 F C 22nd Edition	1.5	1.5
7		Cyanide	[APHA 4500 CN E 22nd Edition]	0.07	0.05
8		Sulphate SO4-2	[APHA 4500 SO4 C 22nd Edition]	500	-
9		Total Hardness		500	-
10		Cadmium, Cd	[APHA 3120 B 22nd Edition]	-	-
11		Total Chromium		0.05	0.05
12		Copper, Cu		1	2
13		Lead, Pb		0.05	0.01
14		Nickel, Ni		50	0.02
15		Zinc, Zn		0.05	3
16		Total Iron (Fe+2 + Fe+3)		0.3	-
17		Manganese, Mn		20	0.5
18		Selenium, Se		0.01	0.01
19		Silver, Ag		-	-
20		Arsenic, As		0.05	0.01
21		Phosphate PO4		-	-
22		Barium, Ba		-	-
23		Boron, B		-	-

24		Calcium, Ca		75	-
25		Magnesium, Mg		0.5	0.5
26		Sodium Na		-	-
27		Potassium, K	[APHA 3120 B 22nd Edition]	-	-
28		Mercury, Hg	[APHA 3112B]	0.001	0.001
29		Sulfide	[0005 + APHA 4500 S F]	-	-
30		Total Organic carbon	[HACH 10129]	-	-
31		Bicarbonate Alkalinity as CaCO3	[APHA 2320 B 22nd Edition]	-	-
32		Carbonate	[APHA 2320 B 22nd Edition]	-	-
33		Total Coliforms	[0005 + APHA 9222 B 22nd Edition]	-	-
34		Total Colony Count	[0005 + APHA 9215 B 22nd Edition]	-	-
35		THMs	GC/MS	-	-
36		Pesticides	APHA-6630 B	0.5	-
37	VOC'S	Benzene	GC/MS	0.01	-
38		Bromodchloromethane	GC/MS	0.3	-
39		Chloroform	GC/MS	0.06	-
40		Ethybenzene	GC/MS	0.3	-
41		MethyBenzene	GC/MS	-	-
42		Methyl Tertbutyl Ether	GC/MS	-	-
43		Tetra Chloro Ethane	GC/MS	-	-
44		Total Xylenes	GC/MS	-	-
45		Trichloroethane	GC/MS	-	-
46	Radioactive Elements	Cesium Cs134		10	-
		Cesium Cs135		10	-
47		Radium Ra226		1	-
		Radium Ra228		0.1	-
		Potassium, K100		100	-
48		Strontium Sr		-	-

CHAPTER-6

LEGAL LEGISLATION

6.1 NATIONAL WATER POLICY

6.1.1 NATIONAL WATER POLICY 2004

The national water policy draft in Pakistan in 2004, envisaged the following elements for water reform.

- Institutional: Strengthen institutions and agencies responsible for development planning and design water resources and services delivery structures across the water sector. It is also aiming to improve the ability of water agencies to carry out their functions, including environment protection, effectively and efficiently.
- Public-Private partnership: It aims to provide opportunity and encourage private sector participation and community involvement at all feasible levels in the water sector. Also, it aims at reducing public spending on irrigation through cost sharing and irrigation management transfer.
- Promote public education programmers, equity of use and water management: It aims to improve public understanding of water issues and promote and adopt principles of Integrated Water Resources Management (IWRM). It also aims to improve levels of equity in relation to irrigation water and urban and rural domestic water.
- Promote run of the river project in Pock and ensure regular dredging: The policy aims to promote the development of hydropower, with special focus on the northern run-of-river schemes and reduce water logging, soil and water salinity agriculture drainage.

6.1.2 NATIONAL WATER POLICY 2018

A. Preamble

The objective of the National water policy is to cognizance of the emerging water crisis and provide an overall policy framework and guideline for a comprehensive plan of action. Pakistan has a federal system of government and the provinces enjoy a considerable degree of autonomy under the 18th Amendment to the Constitution. But now on the water crises is descending like a thunderbolt. While the continuing of population at an annual rate of over 2%. The phenomenon of climate change is causing faster melting of the high-altitude glacier, on which the Indus basin system is dependent and seal level rises. Pakistan is located is one of the regions which are affected by climate change. This policy provides the provinces can develop and management of water resources. This major response to the emerging water crisis is:

1. It provides a set of agreed national targets for water conservation, water storage, water treatment and clean drinking water.
2. Bulk of drinking water requirement is met by groundwater which is depleting and due to water scarcity.

3. Concentrated efforts are needed tore-use treated sewage water in order to reduce sweet water demand.
4. There is lack of awareness amongst the general public about the impending threat of water scarcity and the huge wastage of sweet water.
5. Irrigation agriculture is indispensable for Pakistan's agriculture and low irrigation efficiency vis-à-vis water productivity is a major factor leading to lower growth of the sector.

B. Policy Objective

The National water policy is based on the concept of integrated water resources management primarily aimed at the following policy objective:

1. Promoting sustainable consumption and production pattern throughout the water sector from exploitation to utilization.
2. Improving availability, reliability and quality of fresh water resources to meet critical municipal, agriculture, energy, security and environment needs.
3. Improving urban water management by increasing system efficiency and reducing non-revenue water through adequate investment to address drinking water demand, sewage, disposal, handling of wastewater and industrial effluents.
4. Treatment and possible reuse of water- domestic, agriculture and industrial.
5. Improving watershed management through extensive soil conservation, catchment area treatment, and preservation of forest and increasing forest cover.
6. Secure Katcha areas and economy thereof;
7. Drinking and sanitation
8. Irrigation including land reclamation
9. Industry and mining
10. Forestry including social forestry

C. Basin Level Planning for Developing of Water Resources

The Principal of integrated and unified planning, development and management shall be adopted. The process of holistic approached to planning shall aim at accommodating a fair and stable economic and social development within integrated drainage basin management.

1. Water resources planning for developing shall be done with the policies and projects of another sector.
2. Irrigation project must include a drainage component right from the planning stage.
3. Groundwater management planning and regulatory zones.
4. Watershed management zones in upland areas.

D. Environmental Integrity of Basin

1. The environmental integrity of basin shall be sustained and upgraded.
2. Re-afforestation, soil conservation and improvement in land use in the watershed shall be promoted.
3. Environmental flows shall be ensuring in the rivers to mountain a sound environment for the conservation of river ecology, morphology, delta, costal ecosystem and fisheries.
4. Development of water bodies shall be promoted.
5. Encroachment on natural streams, river beds, and drains will be discouraging.

E. Impact of Climate Change

The impact of climate change like intensification of flood, erotic rain and frequent drought are major concerns for the Pakistan. Other impacts are:

1. Rising temperature resulting in enhanced temperature and water-stress in arid and semi-arid regions, leading to reduce agriculture activity.
2. Due to increase in temperature crop will require more water due to Evapo-transpiration, cattle and human consumption will increases.
3. Precipitation pattern will complex as experienced.
4. Aquifer could affect by agriculture and industrial outputs.

F. Drinking Water and Sanitation

1. Plans and initiative shall be undertaken to progressively provide access to clean and safe drinking water and sanitation facilities to the urban and rural population of the country.
2. Under no circumstances shall be quality of drinking water, urban or rural be allowed to fall below the specified standards. Each agency responsible for delivery of such services shall prepare Quality monitoring plans and shall be responsible for their rigorous enforcement.
3. The sources of water, surface as well as underground, shall be diligently protected him contamination and always maintain in a healthy state, through enforcement of legislation for controlling water pollution in coordinate with provinces.
4. The groundwater levels have dropped to alarming depth and are falling further- potentially reaching the high saline ancient sea water level in the coming few years. Alternative sources of surface water need to be urgently developed and adequate groundwater re-charges ensured.

G. Hydropower

1. The accelerated development of hydropower shall be treated as a high priority objective. Water projects with power generation potential, shall be given preferences. A matter of highest consideration for ranking of hydropower projects shall be additional electricity cost in lieu of transmission from the source to the National Power Grid System.

2. Development of low head hydropower projects on canals will be encourage for distribution by power companies at local level. Such projects shall be undertaken by public or private sectors.

H. Industry

1. Industry is recognized as an important instrument of economic growth and provide of employment opportunities on large scale. The water policy accordingly classifies industry as an important user of water and the provision of its water needs shall be facilitated. A study shall be undertaken for enhancement of legislation for formally allows and define the use of water abstraction licenses and water rates for industrial use.
2. Industrial expansion shall be promoted on large industrial estates to facilities waste water treatment and monitoring of effluent disposal. However due to water storage recycling arrangement are essential. Siting of industrial estate shall take into account the constraints imposed by water availability and priority accorded for municipal and irrigation uses.

I. Stakeholder

1. An enabling environment shall be created for stakeholder constitution and participation at all levels and in all aspects of the water resources including irrigation, drainage, domestic water supply, flood protection, drought mitigation, waste water treatment and pollution control.
2. Full support will be provided build and strength water user's institution for distribution, periodic maintenance assessment and collection of water charges and resolution of local dispute amongst users.
3. Participating programmers shall be effectively coordinate with policies and programmers of all other public and private bodies to encourage partnership and to avoid conflict. Women participation will be promoted in domestic water supply and promoted of water hygiene.

J. Sustainable Water Infrastructure

1. The water related infrastructure must physical and functional sustainability for its design life and this equipment shall supersede all other consideration. All project proposals must clarify that the applicable professional standards have been followed in the field of investigation, desk studies, designs, construction specification and product quality operational procedure and maintenance provision.
2. The infrastructure shall be so engineered, constructed and operated that each component serves its designed purpose without undue wastage of water.
3. Equal priority shall be given to repair and maintenance, remodeling and rehabilitation and up gradation alongside new construction while allocating periods.
4. It would be ensured that all barrages and bridges on major rivers would have sufficient capacity to safely pass floods of at least 100year return period.

K. Irrigation Agriculture

Strategies and action plans shall be prepared to ensure food security for the people of Pakistan and these shall be vigorously and diligently pursed. More crop per drop concept will observed by peruse the following concept:

1. A national plan for implementation of improved irrigation methods and practices.
2. Steps will be taken to promulgate a law banning flood irrigation throughout the country as early as possible.
3. Modernize the irrigation network
4. The concept of participatory management of irrigation system shall be promoted and monitored with reference to its outcomes, to enable the irrigation stake holder to participate effectively in the decision-making processes.
5. Groundwater table shall be so managed that it does not impede crop growth or causes land salinity or underground saltwater intrusion.
6. Introduction of bi-fertilizer and bio-pesticides shall be encouraging to minimize ground water pollution.
7. Equity of water distribution between head and tail reached shall be ensured and water allocations between various canal commands shall be rationalized.
8. Irrigation facilities shall be extended to new cultured command areas for growing low delta high value crops through improved irrigation methods/technologies.

L. Groundwater

1. The Indus aquifer, underlying the vast Indus plains, and other aquifer in valleys and in the hard formation are recognize as important national resources and deserve protection from pollution and unsustainable abstraction.
2. Monitoring effort shall be strengthened to determine sustainable groundwater potential and prepare groundwater budgets for sub-basins and canals commands. All measure to prevent lateral/vertical movement of saline water interface shall be introducing.
3. All source of recharge/ discharge and their interaction on groundwater reservoir shall be evaluated. Groundwater recharge including arterial shall be promoted whenever technically and economically feasible. Abstraction from the aquifer shall be managed to the sustainable level that balance the recharge and boundary flows.
4. The provinces shall be encouraging to prepare a groundwater Atlas for each canal command and sub-basin delineating.
5. Groundwater development potential.
6. Water quality zones.
    a. Water table depth zones.

b. Recommendations for installation of different types of tube well.

M. Water Rights/Obligations

1. All citizen of Pakistan has the right of equal and affordable access to clean drinking water.
2. According to the constitution the provinces have jurisdiction over the river and are responsible for the maintenance of flood protection dykes, flood control and drainage. However, due to the inter provincial irrigation network and distribution of river water amongst provinces through IRSA.
3. The provincial government shall be responsible for the management of groundwater as per provincial government rules and regulation.

N. Trans-boundary Water Sharing

After the division of sub-continent into Pak and Indo, there is 3 rivers on sharing basis known as Ravi, Sutlej and Bias. On other hand Indus and Jhelum river is flowing in Pakistan from start point to end. While, Ganga, Brahmaputra and Aravalli rivers are flowing in India. In 1967 a Sindh-tas commitment was signed between Pakistan and India and decided that India will use Bias and Sutlej River for their needs while Pakistan will use Ravi River. Eventually India is continually disobey that commitment. So, World Bank and United Nation start a project on IWT. This project is use full for developing terms and conditions between both countries.

1. A substantial part of Pakistan's fresh water resources is generated from outside the country. Indus Water Treaty provides a mechanism for sharing of water of Indus System of rivers with India.
2. A mechanism shall be worked out for sharing of Tran's boundary aquifer and joint watershed management including sharing of composite real-time flow information especially relating to hydro-metrological disaster like situation enduring Pakistan's important infrastructure, communication network and economy.
3. A study shall be carried out to evaluate the impact of development in the upper catchment Western Rivers on the environment, agriculture and hydropower projects, planned and existing in the lower catchment besides the risk of damages and vulnerability to national infrastructure at large. It shall also recommend measure how to minimize these impacts within the framework of the Indus Water Treaty.
4. Options shall be explored to preserve the environment integrity of the system to reduce hazards faced by the population of areas of Western River on the Pakistan side keeping in view the right of lower riparian.

6.2 INTERNATIONAL WATER POLICY

EPA issued the Ground Water Rule (GWR) to improve drinking water quality and provide protection from disease-causing microorganisms. Water systems that have ground water sources may be susceptible to fecal contamination. In many cases, fecal contamination can contain disease causing pathogens. The purpose of the Ground Water Rule (GWR) is to reduce disease incidence associated with harmful microorganisms in drinking water.

The GWR applies to public water systems that use ground water as a source of drinking water. The rule also applies to any system that delivers surface and ground water to consumers where the ground water is added to the distribution system without treatment. The GWR was published in the Federal Register on November 8, 2006.

The GWR establishes a risk-based approach to target ground water systems vulnerable to fecal contamination. Ground water systems that are at risk of fecal contamination must take corrective action. Corrective action reduces potential illness from exposure to microbial pathogens. The rule applies to public water systems that use ground water as a source of drinking water.

6.2.1 FINAL REQUIREMENTS

The GWR's targeted, risk-based strategy addresses risks through an approach that relies on four major components:

1. Routine sanitary surveys of systems that require the evaluation of eight critical elements of a public water system and the identification of significant deficiencies (e.g., a well located near a leaking septic system);
2. Triggered source water monitoring for a system that (not treating drinking water to remove 99.99 percent (4-log) of viruses) identifies a positive sample during regular Total Coliform monitoring or assessment monitoring (at the option of the state) targeted at high-risk systems;
3. Corrective action is required for any system with a significant deficiency or source water fecal contamination; and
4. Compliance monitoring to ensure that treatment technology installed to treat drinking water reliably achieves 99.99 percent (4-log) inactivation or removal of viruses.

CHAPTER-7

CONCLUSIONS

Interpretative results of the entire studies including hydrology and hydrogeology, temperature, rainfall, relative humidity, and spatial distribution of rainfall and temperature in Multan, Khanewal, TobaTek Singh, Jhang, Faisalabad, onsite data collection about Twenty-Five (25) sites for water table, hydraulic heads, construction methodology, year of installation of wells, tentative well discharges and drawdown. Eleven (11) sample use for major and minor water quality parameters have led to the following conclusions.

1. The maximum temperature of study area is 30 ^{O}C to 35 ^{O}C.
2. The minimum temperature of study area is 8 ^{O}C to 3 ^{O}C.
3. The rain fall is ranging in between 385 mm to 442.1 mm.
4. The SPI values show many mild drought and mild wet seasons.
5. The average elevation of the study area is 131m while the maximum elevation is 143.8m in south towards Khanewal district and the minimum value is 127.2m.
6. The study area is covered by Quaternary alluvium which presumably over lies semi-consolidated Tertiary rocks or metamorphic and igneous basement rocks of Precambrian age.
7. The study area lies the high groundwater potential zone the yield 100 to 300m^3/hr or more, down to 150m.
8. The Lower bari doab canal (LBDC) is marked as a major source of groundwater recharge in the study area.
9. Fairly thick and extensive types of aquifers.
10. The static water level of Nestle existing tubewell is 16.18m.
11. The dynamic water level is 22.28m.
12. The discharge rate is 233.7 m^3/hr at 50% opening valve.
13. The aquifer thickness is 99.0m.
14. The transmissivity is 5.67x$10^1$$m^2$/h.
15. The hydraulic conductivity is 5.73x10^{-1}m/h.
16. The following model assumptions are available for the pumping test solutions:

Type	Unconfined
Extent	Infinite
Isotropy	Isotropic
Discharge	Content
Well Penetration	Fully

17. The depth of water wells in the agriculture fields are varies from 43 to 70 meters.
18. The wells of Nestle facility and TMA having depth of 100 to 121 meters.

19. The groundwater level of the study area is varying from 16 meters to 30 meters from existing groundwater level.
20. Total groundwater recharge in the subsurface is 136.736 MCM/yr (0.109 MAF/yr) in our 10 km^2 study area and discharge is 149.42 MCM/yr (0.1195 MAF/yr). The delta between inflow and outflow is 12.69 MCM/yr. (0.01014 MAF/Yr.).
21. Major usage is found to be agriculture of total water consumption up to 76%, 17% for Industry and 7% consume by domestic and livestock.
22. The water production of NESTLE is almost 2.78 % of the total industrial usage of an area and 0.37% of groundwater withdrawal of that area annually. Nestle is producing 1506m^3 per day by their two turbine and it is not marking any major impact as compare to other ground water extraction done for agriculture and other purposes.
23. The pH is found circum-neutral range and varies from 7.17 to 8.02, the TDS ranges from 109.02 ppm to 825.98 ppm, as per chemical analysis of representative ground and surface water samples depicts that the water quality of study area is found suitable for human consumption and industrial use. Around 45% of samples contain negligible quantity of T.C and TCC. While other samples contain slightly higher TCC and TC range recommended by WHO. In major analysis Pesticides are not detected in all samples. VOCs and Trihalomethanes THMS is also falls in permissible limits.
24. The water analysis of Nestle Turbine water samples is found to be satisfactory; the ions presence demarcates it to be fresh and arsenic and other hazardous ions are also within range of PEQS.
25. As the recharge of aquifer is found to be good and delta between the discharge and recharge is negligible, it can be concluded the ground water extraction for further 5 years lies in safe zone and Nestle production shall sustain with current available resources.

REFERENCE

1. Allison, G. B., Gee, G. W., & Tyler, S. W. (1994). Vadose-zone techniques for estimating groundwater rechare in arid and semiarid regions. *Soil Science Society of America Journal*, *58*(1), 6-14.
2. Viaroli, S., Mastrorillo, L., Lotti, F., Paolucci, V., & Mazza, R. (2018). The groundwater budget: a tool for preliminary estimation of the hydraulic connection between neighboring aquifers. *Journal of Hydrology*, *556*, 72-86.
3. Ashraf, A., & Ahmad, Z. (2008). Regional groundwater flow modelling of Upper Chaj Doab of Indus Basin, Pakistan using finite element model (Feflow) and geoinformatics. *Geophysical Journal International*, *173*(1), 17-24.
4. Arora, V. K., & Boer, G. J. (2003). An analysis of simulated runoff and surface moisture fluxes in the CCCma coupled atmosphere land surface hydrological model. In *Proc. of International Congress on Modelling and Simulation, MODSIM* (Vol. 1, pp. 166-171).
5. Lahee, F. H. (1961). Field geology. New York: McGraw-Hill Book Co.
6. Amani, M., Mahdavi, S., Afshar, M., Brisco, B., Huang, W., Mohammad Javad Mirzadeh, S., ... & Hopkinson, C. (2019). Canadian wetland inventory using Google Earth engine: the first map and preliminary results. *Remote Sensing*, *11*(7), 842.
7. Fischer, W. A., Hemphill, W. R., & Kover, A. (1976). Progress in remote sensing (1972–1976). *Photogrammetria*, *32*(2), 33-72.
8. He, Y., Ye, J., & Yang, X. (2015). Analysis of the spatio-temporal patterns of dry and wet conditions in the Huai River Basin using the standardized precipitation index. *Atmospheric Research*, *166*, 120-128.
9. Tigkas, D., & Tsakiris, G. (2015). Early estimation of drought impacts on rainfed wheat yield in Mediterranean climate. *Environmental Processes*, *2*(1), 97-114.
10. Kidwai, J. R. (1964). *Microbial Metabolism with Special Reference to Biosynthesis of Purine in Vibrio Cholerae* (Doctoral dissertation, Aligarh Muslim University).
11. Hütter, M., Luap, C., & Öttinger, H. C. (2009). Energy elastic effects and the concept of temperature in flowing polymeric liquids. *Rheologica acta*, *48*(3), 301-316.
12. Kruseman, G. P., De Ridder, N. A., & Verweij, J. M. (1970). *Analysis and evaluation of pumping test data* (Vol. 11). The Netherlands: International institute for land reclamation and improvement.

13. Viaroli, P., Soana, E., Pecora, S., Laini, A., Naldi, M., Fano, E. A., & Nizzoli, D. (2018). Space and time variations of watershed N and P budgets and their relationships with reactive N and P loadings in a heavily impacted river basin (Po river, Northern Italy). *Science of the Total Environment*, *639*, 1574-1587.
14. Liu, B. (2010). Uncertain risk analysis and uncertain reliability analysis. *Journal of Uncertain Systems*, *4*(3), 163-170.
15. Kresic, N. (2006). *Hydrogeology and groundwater modeling*. CRC press.
16. Tsanis, I.K., Koutroulis, A.G., Daliakopoulos, I.N. *et al.* Severe climate-induced water shortage and extremes in Crete. *Climatic Change* 106, 667–677 (2011).
17. Tzikas, A., Shakir, S., Gafoor, S., Omran, H., Berti, S., Santoro, G., & Sievert, H. (2016). Left atrial appendage occlusion for stroke prevention in atrial fibrillation: multicentre experience with the AMPLATZER Cardiac Plug. *EuroIntervention*, *11*(10), 1170-1179.
18. Zogorski, J. S. (2006). *The quality of our nation's waters: Volatile organic compounds in the nation's ground water and drinking-water supply wells* (Vol. 1292). Geological Survey (USGS).
19. LeBel, G. L., Benoit, F. M., & Williams, D. T. (1997). A one-year survey of halogenated disinfection by-products in the distribution system of treatment plants using three different disinfection processes. *Chemosphere*, *34*(11), 2301-2317.
20. National Water Policy & Water Charter 2018 (24-04-2018).
21. Pakistan Metrological Department
22. Assessment of the exploitation level of local water bodies by all water consumers in a radius of 10 km (315 square kilometers area) around Nestle Kabirwala Factory (6.5km Kabirwala Khanewal Road), South Pakistan by Hydrogeophysical & Environmental Sciences Consultants (HESC), 2015.
23. http://www.pbs.gov.pk/content/pakistan-livestock-census-2006.
24. https://www.pmd.gov.pk/en/
25. https://www.who.int/peh-emf/standards/en/
26. National Environmental Quality standards, 2010
27. https://earthexplorer.usgs.gov/
28. https://www.apha.org/

5.6 SOIL ANALYSIS

Client Detail:	
Name of Contact Person:	Mr. Bilal Sial
Designation:	-
Contact Number:	+92-333-6729939
Telephone:	-
Fax:	-
Email:	bilalahmed.sial@pk.nestle.com
Address:	Khanewal-Kabirwala Rd, Nestle Colony, Allahabad, Kabirwala

GCEC Details:	
Country Manager:	Mr. Rashid Maqbool.
Telephone:	+92-42-35761300
Fax:	+92-42-35761301
Email:	country.manager@gcee.pk
Address	112 C/E-1, Hali Road, Gulberg III, Lahore

Signatories:

Country Manager
Green Crescent Environmental Consultants (Pvt) Ltd.

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified Federal-EPA Certified

Serial # 20B / 18311

Sample Details			
Job Ref. No:	GCEC-PK-317/2020	**Sample Matrix:**	Soil Sample
Company Name:	**Nestlé Pakistan Kabirwala Factory**		
Sample Date:	25-09-2020	**Sampling Method:**	-
Sample Receipt Date:	25-09-2020	**Sampled By:**	Received
Sample Identification			
01	Discharge Channel		

Parameters	Analysis Method	Unit	LOR	Result 01
PHYSICAL & CHEMICAL ANALYSIS				
pH	APHA-4500H+ B	-	0.01	6.92
Chloride	APHA-4500Cl- B	mg/l	0.24	75.43
Sulphate	APHA-4500-SO4C	mg/l	0.41	502.0
Arsenic	APHA-3500As B	mg/l	0.01	0.08
Phosphate	APHA-4500P B	mg/l	0.1	0.56

Abbreviations:

ND: Not Detected
LOR: Limit of Reporting

Note:

**Uncertainty of all the parameters and laboratory conditions at the time of analysis will be provided as per client's requirement. The lab environmental conditions are maintained at 25±5C° and humidity at 50±15%. **Standards for Soil assessment are not available.*

Lab Manager
Green Crescent Environmental Consultants (Pvt) Ltd.

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified

Federal-EPA Certified

Serial # 20B / 18312

Sample Details			
Job Ref. No:	GCEC-PK-317/2020	Sample Matrix:	Soil Sample
Company Name:	Nestlé Pakistan Kabirwala Factory		
Sample Date:	25-09-2020	Sampling Method:	-
Sample Receipt Date:	25-09-2020	Sampled By:	Received
Sample Identification			
02	Katli Bhutto Canal		

Parameters	Analysis Method	Unit	LOR	Result
				02
PHYSICAL & CHEMICAL ANALYSIS				
pH	APHA-4500H+ B	-	0.01	6.63
Chloride	APHA-4500Cl- B	mg/l	0.24	65.50
Sulphate	APHA-4500-SO4C	mg/l	0.41	450.0
Arsenic	APHA-3500As B	mg/l	0.01	0.05
Phosphate	APHA-4500P B	mg/l	0.1	0.47

Abbreviations:

ND: Not Detected

LOR: Limit of Reporting

Note:

**Uncertainty of all the parameters and laboratory conditions at the time of analysis will be provided as per client's requirement. The lab environmental conditions are maintained at 25±5C° and humidity at 50±15%. **Standards for Soil assessment are not available.*

Lab Manager
Green Crescent Environmental Consultants (Pvt) Ltd.

5.7 GROUNDWATER MAJOR ANALYSIS

Client Detail:	
Name of Contact Person:	Mr. Bilal Sial
Designation:	-
Contact Number:	+92-333-6729939
Telephone:	-
Fax:	-
Email:	bilalahmed.sial@pk.nestle.com
Address:	Khanewal-Kabirwala Rd, Nestle Colony, Allahabad, Kabirwala

GCEC Details:	
Country Manager:	Mr. Rashid Maqbool.
Telephone:	+92-42-35761300
Fax:	+92-42-35761301
Email:	country.manager@gcee.pk
Address	112 C/E-1, Hali Road, Gulberg III, Lahore

Signatories:

Country Manager
Green Crescent Environmental Consultants (Pvt) Ltd.

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified

Federal-EPA Certified

Serial # 20B / 18314

Sample Details			
Job Ref. No:	GCEC-PK-317/2020	Sample Matrix:	Ground Water Sample
Company Name:	Nestle Kabirwala		
Sample Date:	25-09-2020	Sampling Method:	-
Sample Receipt Date:	25-09-2020	Sampled By:	Received Sample
Sample Identification			
01	New well (Near Katli Bhutto Canal)		

Parameters	Analysis Method	Unit	LOR	Result 01	PEQS
PHYSICAL & CHEMICAL ANALYSIS					
pH	APHA-4500H+ B	-	0.01	7.42	6.5-8.5
Turbidity	APHA-2130 B	NTU	-	ND	<5 NTU
Total Hardness	APHA-2340 C	mg/l	0.5	180.00	< 500 mg/l
Total Dissolved Solid (TDS)	APHA-2540 C	mg/l	1.0	605	< 1000
Chloride	APHA-4500Cl- B	mg/l	0.24	37.98	< 250
Cyanide (Cn)	APHA-4500CN E	mg/l	0.01	<0.01	≤ 0.05
Fluoride (F)	APHA-4500F- C	mg/l	0.01	<0.01	≤ 1.5
Cadmium	APHA-3500Cd B	mg/l	0.0028	<0.0028	0.01
Copper	APHA-3500Cu B	mg/l	0.0045	<0.0045	2
Chromium	APHA-3500Cr B	mg/l	0.0054	<0.0054	≤ 0.05 (P)
Mercury	APHA-3500-Hg B	mg/l	0.001	<0.001	≤ 0.001
Nickel	APHA-3500-Ni B	mg/l	0.008	<0.008	≤ 0.02
Zinc	APHA-3500-Zn B	mg/l	0.0033	<0.0033	5.0
Arsenic	APHA-3500As B	mg/l	0.01	<0.01	≤ 0.05 (P)
Barium	APHA-3500Ba B	mg/l	0.031	<0.031	0.7
Manganese	APHA-3500-Mn B	mg/l	0.0016	<0.0016	≤ 0.5
Iron	APHA-3500-Fe-B	mg/l	0.1	3.14	-
Boron	APHA-4500B-C	mg/l	0.1	<0.1	0.3
Lead	APHA-3500-Pb B	mg/l	0.013	<0.013	≤ 0.05
Selenium	APHA-3500Se C	mg/l	-	ND	0.01 (P)
Total Suspended Solid (TSS)	APHA-2540-D	mg/l	1.0	4.0	-
Sulphate	APHA-4500-SO4C	mg/l	0.41	130.06	-
Sodium	APHA-3500-Na-B	mg/l	0.0037	18.91	-
Phosphate	APHA-4500P B	mg/l	0.1	<0.1	-
Sulfide	APHA-4500-S2-E	mg/l	0.2	<0.2	-
Magnesium	APHA-2340 B & C	mg/l	1.0	19.52	-

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified

Federal-EPA Certified

Serial # 20B / 18315

Parameters	Analysis Method	Unit	LOR	Result 01	PEQS
Calcium	APHA-2340 B & C	mg/l	1.0	40.00	-
Potassium	APHA-3500-K-B	mg/l	0.0009	0.21	-
Total Organic Carbon	USEPA 415.3	mg/l	0.06	0.132	-
Bicarbonates	APHA-2320 B	mg/l	0.1	369.60	-
Carbonates	APHA-2320 B	mg/l	0.1	<0.1	-
PESTICIDES					
Pesticides	APHA-6630 B	mg/l	-	ND	0.15
VOCs					
Benzene	GC/MS	µg/l	0.020	0.026	-
Bromodichloromethane	GC/MS	µg/l	0.080	0.082	-
Chloroform	GC/MS	µg/l	0.079	0.083	-
MethylBenzene	GC/MS	µg/l	0.05	<0.05	-
Methyl Tert-butyl Ether	GC/MS	µg/l	0.20	0.22	-
Tetra Chloro Ethane	GC/MS	µg/l	0.15	0.54	-
Total Xylenes	GC/MS	µg/l	0.022	0.024	-
Trichloroethane	GC/MS	µg/l	0.043	0.047	-
THMS					
Trihalomethanes	GC/MS	µg/l	0.090	0.095	-
MICROBIOLOGICAL ANALYSIS					
Total Colony Count	APHA 9215 B	CFU/ml		112	-
Total Coliforms	APHA:9222 B	CFU/100ml		10	0/100ml
RADIOACTIVE CHEMICAL ANALYSIS					
^{226}Ra	APHA 7500 Ra B	Bq/Kg		1.22	
^{228}Ra	APHA 7500 Ra B	Bq/Kg		<0.5	
^{137}Cs	APHA 7500 Cs B	Bq/Kg		<0.03	
^{134}Cs	APHA 7500 Cs B	Bq/Kg		<0.03	
^{40}K	--	Bq/Kg		20	

Abbreviations:
ND: Not Detected
LOR: Limit of Reporting
PEQS: Punjab Environmental Quality Standard

Note:
**Uncertainty of all the parameters and laboratory conditions at the time of analysis will be provided as per client requirement. The lab environmental conditions are maintained at 25±5C° and humidity at 50±15%. The results of radioactive elements are sub-contracted.*

Lab Manager
Green Crescent Environmental Consultants (Pvt) Ltd.

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified

Federal-EPA Certified

Serial # 20B / 18316

Sample Details			
Job Ref. No:	GCEC-PK-317/2020	Sample Matrix:	Ground Water Sample
Company Name:	Nestle Kabirwala		
Sample Date:	25-09-2020	Sampling Method:	-
Sample Receipt Date:	25-09-2020	Sampled By:	Received Sample
Sample Identification			
02	Well-11 (Old Report Number)		

Parameters	Analysis Method	Unit	LOR	Result 02	PEQS
PHYSICAL & CHEMICAL ANALYSIS					
pH	APHA-4500H+ B	-	0.01	7.27	6.5-8.5
Turbidity	APHA-2130 B	NTU	-	ND	<5 NTU
Total Hardness	APHA-2340 C	mg/l	0.5	212.00	< 500 mg/l
Total Dissolved Solid (TDS)	APHA-2540 C	mg/l	1.0	631	< 1000
Chloride	APHA-4500Cl- B	mg/l	0.24	41.98	< 250
Cyanide (Cn)	APHA-4500CN E	mg/l	0.01	<0.01	≤ 0.05
Fluoride (F)	APHA-4500F- C	mg/l	0.01	<0.01	≤ 1.5
Cadmium	APHA-3500Cd B	mg/l	0.0028	<0.0028	0.01
Copper	APHA-3500Cu B	mg/l	0.0045	<0.0045	2
Chromium	APHA-3500Cr B	mg/l	0.0054	<0.0054	≤ 0.05 (P)
Mercury	APHA-3500-Hg B	mg/l	0.001	<0.001	≤ 0.001
Nickel	APHA-3500-Ni B	mg/l	0.008	<0.008	≤ 0.02
Zinc	APHA-3500-Zn B	mg/l	0.0033	<0.0033	5.0
Arsenic	APHA-3500As B	mg/l	0.01	<0.01	≤ 0.05 (P)
Barium	APHA-3500Ba B	mg/l	0.031	<0.031	0.7
Manganese	APHA-3500-Mn B	mg/l	0.0016	<0.0016	≤ 0.5
Iron	APHA-3500-Fe-B	mg/l	0.1	4.01	-
Boron	APHA-4500B-C	mg/l	0.1	<0.1	0.3
Lead	APHA-3500-Pb B	mg/l	0.013	<0.013	≤ 0.05
Selenium	APHA-3500Se C	mg/l	-	ND	0.01 (P)
Total Suspended Solid (TSS)	APHA-2540-D	mg/l	1.0	<1.0	-
Sulphate	APHA-4500-SO4C	mg/l	0.41	117.30	-
Sodium	APHA-3500-Na-B	mg/l	0.0037	19.52	-
Phosphate	APHA-4500P B	mg/l	0.1	<0.1	-
Sulfide	APHA-4500-S2-E	mg/l	0.2	<0.2	-
Magnesium	APHA-2340 B & C	mg/l	1.0	11.71	-

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified

Federal-EPA Certified

Serial # 20B / 18317

Parameters	Analysis Method	Unit	LOR	Result 02	PEQS
Calcium	APHA-2340 B & C	mg/l	1.0	65.6	-
Potassium	APHA-3500-K-B	mg/l	0.0009	0.46	-
Total Organic Carbon	USEPA 415.3	mg/l	0.06	1.254	-
Bicarbonates	APHA-2320 B	mg/l	0.1	513.6	-
Carbonates	APHA-2320 B	mg/l	0.1	<0.1	-
PESTICIDES					
Pesticides	APHA-6630 B	mg/l	-	ND	0.15
VOCs					
Benzene	GC/MS	µg/l	0.020	0.023	-
Bromodchloromethane	GC/MS	µg/l	0.080	0.085	-
Chloroform	GC/MS	µg/l	0.079	0.080	-
MethyBenzene	GC/MS	µg/l	0.05	<0.05	-
Methyl Tertbutyl Ether	GC/MS	µg/l	0.20	0.24	-
Tetra Chloro Ethane	GC/MS	µg/l	0.15	0.98	-
Total Xylenes	GC/MS	µg/l	0.022	0.025	-
Trichloroethane	GC/MS	µg/l	0.043	0.046	-
THMS					
Trihalomethanes	GC/MS	mg/l	0.090	0.091	-
MICROBIOLOGICAL ANALYSIS					
Total Colony Count	APHA 9215 B	CFU/ml		90	-
Total Coliforms	APHA:9222 B	CFU/100ml		2	0/100ml

Abbreviations:

ND: Not Detected **LOR:** Limit of Reporting **PEQS:** Punjab Environmental Quality Standard

Note:

*****_Uncertainty of all the parameters and laboratory conditions at the time of analysis will be provided as per client requirement. The lab environmental conditions are maintained at 25±5C° and humidity at 50±15%._

Lab Manager
Green Crescent Environmental Consultants (Pvt) Ltd.

GCEC

PNAC Pakistan National Accreditation Council | LAB 121 17025

Punjab-EPA Certified | Federal-EPA Certified

Serial # 20B / 18318

Sample Details			
Job Ref. No:	GCEC-PK-317/2020	Sample Matrix:	Ground Water Sample
Company Name:	Nestle Kabirwala		
Sample Date:	25-09-2020	Sampling Method:	-
Sample Receipt Date:	25-09-2020	Sampled By:	Received Sample
Sample Identification			
05	Turbine-01		

Parameters	Analysis Method	Unit	LOR	Result 05	PEQS
PHYSICAL & CHEMICAL ANALYSIS					
pH	APHA-4500H+ B	-	0.01	7.53	6.5-8.5
Turbidity	APHA-2130 B	NTU	-	ND	<5 NTU
Total Hardness	APHA-2340 C	mg/l	0.5	168.00	< 500 mg/l
Total Dissolved Solid (TDS)	APHA-2540 C	mg/l	1.0	543	< 1000
Chloride	APHA-4500Cl- B	mg/l	0.24	19.99	< 250
Cyanide (Cn)	APHA-4500CN E	mg/l	0.01	<0.01	≤ 0.05
Fluoride (F)	APHA-4500F- C	mg/l	0.01	<0.01	≤ 1.5
Cadmium	APHA-3500Cd B	mg/l	0.0028	<0.0028	0.01
Copper	APHA-3500Cu B	mg/l	0.0045	<0.0045	2
Chromium	APHA-3500Cr B	mg/l	0.0054	<0.0054	≤ 0.05 (P)
Mercury	APHA-3500-Hg B	mg/l	0.001	<0.001	≤ 0.001
Nickel	APHA-3500-Ni B	mg/l	0.008	<0.008	≤ 0.02
Zinc	APHA-3500-Zn B	mg/l	0.0033	<0.0033	5.0
Arsenic	APHA-3500As B	mg/l	0.01	<0.01	≤ 0.05 (P)
Barium	APHA-3500Ba B	mg/l	0.031	<0.031	0.7
Manganese	APHA-3500-Mn B	mg/l	0.0016	<0.0016	≤ 0.5
Iron	APHA-3500-Fe-B	mg/l	0.1	2.78	-
Boron	APHA-4500B-C	mg/l	0.1	<0.1	0.3
Lead	APHA-3500-Pb B	mg/l	0.013	<0.013	≤ 0.05
Selenium	APHA-3500Se C	mg/l	-	ND	0.01 (P)
Total Suspended Solid (TSS)	APHA-2540-D	mg/l	1.0	9.0	-
Sulphate	APHA-4500-SO4C	mg/l	0.41	121.01	-
Sodium	APHA-3500-Na-B	mg/l	0.0037	18.91	-
Phosphate	APHA-4500P B	mg/l	0.1	0.019	-
Sulfide	APHA-4500-S2-E	mg/l	0.2	<0.2	-
Magnesium	APHA-2340 B & C	mg/l	1.0	17.25	-

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified

Federal-EPA Certified

Serial # 20B / 18319

Parameters	Analysis Method	Unit	LOR	Result 05	PEQS
Calcium	APHA-2340 B & C	mg/l	1.0	38.40	-
Potassium	APHA-3500-K-B	mg/l	0.0009	0.08	-
Total Organic Carbon	USEPA 415.3	mg/l	0.06	0.594	-
Bicarbonates	APHA-2320 B	mg/l	0.1	480.0	-
Carbonates	APHA-2320 B	mg/l	0.1	<0.1	-
PESTICIDES					
Pesticides	APHA-6630 B	mg/l	-	ND	0.15
VOCs					
Benzene	GC/MS	µg/l	0.020	0.025	-
Bromodchloromethane	GC/MS	µg/l	0.080	0.083	-
Chloroform	GC/MS	µg/l	0.079	0.084	-
MethyBenzene	GC/MS	µg/l	0.05	<0.05	-
Methyl Tertbutyl Ether	GC/MS	µg/l	0.20	0.25	-
Tetra Chloro Ethane	GC/MS	µg/l	0.15	<0.15	-
Total Xylenes	GC/MS	µg/l	0.022	0.023	-
Trichloroethane	GC/MS	µg/l	0.043	0.044	-
THMS					
Trihalomethanes	GC/MS	µg/l	0.090	0.093	-
MICROBIOLOGICAL ANALYSIS					
Total Colony Count	APHA 9215 B	CFU/ml		-	-
Total Coliforms	APHA:9222 B	CFU/100ml		-	0/100ml
RADIOACTIVE CHEMICAL ANALYSIS					
^{226}Ra	APHA 7500 Ra B	Bq/Kg		<0.4	
^{228}Ra	APHA 7500 Ra B	Bq/Kg		<0.5	
^{137}Cs	APHA 7500 Cs B	Bq/Kg		<0.03	
^{134}Cs	APHA 7500 Cs B	Bq/Kg		<0.03	
^{40}K	--	Bq/Kg		12	

Abbreviations:
ND: Not Detected
LOR: Limit of Reporting
PEQS: Punjab Environmental Quality Standard

Note:
**Uncertainty of all the parameters and laboratory conditions at the time of analysis will be provided as per clients requirement. The lab environmental conditions are maintained at 25±5C° and humidity at 50±15%. The results of radioactive elements are sub-contracted.*

Lab Manager
Green Crescent Environmental Consultants (Pvt) Ltd.

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified

Federal-EPA Certified

Serial # 20B / 18320

Sample Details			
Job Ref. No:	GCEC-PK-317/2020	Sample Matrix:	Waste Water Sample
Company Name:	Nestle Kabirwala		
Sample Date:	25-09-2020	Sampling Method:	-
Sample Receipt Date:	25-09-2020	Sampled By:	Received Sample
Sample Identification			
06	Discharge point		

Parameters	Analysis Method	Unit	LOR	Result 06	PEQS
PHYSICAL & CHEMICAL ANALYSIS					
pH	APHA-4500H+ B	-	0.01	8.05	6-9
Turbidity	APHA-2130 B	NTU	-	ND	-
Total Hardness	APHA-2340 C	mg/l	0.5	136.00	-
Total Dissolved Solid (TDS)	APHA-2540 C	mg/l	1.0	2942	3500
Chloride	APHA-4500Cl- B	mg/l	0.24	143.95	1000
Cyanide (Cn)	APHA-4500CN E	mg/l	0.01	<0.01	1.0
Fluoride (F)	APHA-4500F- C	mg/l	0.01	<0.01	10
Cadmium	APHA-3500Cd B	mg/l	0.0028	<0.0028	0.1
Copper	APHA-3500Cu B	mg/l	0.0045	<0.0045	1.0
Chromium	APHA-3500Cr B	mg/l	0.0054	<0.0054	1.0
Mercury	APHA-3500-Hg B	mg/l	0.001	<0.001	0.01
Nickel	APHA-3500-Ni B	mg/l	0.008	<0.008	1.0
Zinc	APHA-3500-Zn B	mg/l	0.0033	<0.0033	5.0
Arsenic	APHA-3500As B	mg/l	0.01	<0.01	1.0
Barium	APHA-3500Ba B	mg/l	0.031	<0.031	1.5
Manganese	APHA-3500-Mn B	mg/l	0.0016	<0.0016	1.5
Iron	APHA-3500-Fe-B	mg/l	0.1	7.58	8.0
Boron	APHA-4500B-C	mg/l	0.1	<0.1	6.0
Lead	APHA-3500-Pb B	mg/l	0.013	<0.013	0.5
Selenium	APHA-3500Se C	mg/l	-	ND	0.5
Total Suspended Solid (TSS)	APHA-2540-D	mg/l	1.0	35.0	200
Sulphate	APHA-4500-SO4C	mg/l	0.41	380.73	600
Sodium	APHA-3500-Na-B	mg/l	0.0037	72.60	-
Phosphate	APHA-4500P B	mg/l	0.1	0.366	-
Sulfide	APHA-4500-S2-E	mg/l	0.2	<0.2	1.0
Magnesium	APHA-2340 B & C	mg/l	1.0	12.68	-

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified

Federal-EPA Certified

Serial # 20B / 18321

Parameters	Analysis Method	Unit	LOR	Result 06	PEQS
Calcium	APHA-2340 B & C	mg/l	1.0	33.60	-
Potassium	APHA-3500-K-B	mg/l	0.0009	2.61	-
Total Organic Carbon	USEPA 415.3	mg/l	0.06	9.174	-
Bicarbonates	APHA-2320 B	mg/l	0.1	2160	-
Carbonates	APHA-2320 B	mg/l	0.1	<0.1	-
PESTICIDES					
Pesticides	APHA-6630 B	mg/l	-	ND	0.15
VOCs					
Benzene	GC/MS	µg/l	0.020	0.029	-
Bromodchloromethane	GC/MS	µg/l	0.080	0.088	-
Chloroform	GC/MS	µg/l	0.079	0.086	-
MethyBenzene	GC/MS	µg/l	0.05	<0.05	-
Methyl Tertbutyl Ether	GC/MS	µg/l	0.20	0.26	-
Tetra Chloro Ethane	GC/MS	µg/l	0.15	<0.15	-
Total Xylenes	GC/MS	µg/l	0.022	0.028	-
Trichloroethane	GC/MS	µg/l	0.043	0.045	-
THMS					
Trihalomethanes	GC/MS	µg/l	0.090	0.097	-
MICROBIOLOGICAL ANALYSIS					
Total Colony Count	APHA 9215 B	CFU/ml		-	-
Total Coliforms	APHA:9222 B	CFU/100ml		-	-

Abbreviations:
ND: Not Detected
Standard
LOR: Limit of Reporting
PEQS: Punjab Environmental Quality

Note:
*****_Uncertainty of all the parameters and laboratory conditions at the time of analysis will be provided as per clients requirement. The lab environmental conditions are maintained at 25±5C° and humidity at 50±15%._

Lab Manager
Green Crescent Environmental Consultants (Pvt) Ltd.

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified

Federal-EPA Certified

Serial # 20B / 18322

Sample Details			
Job Ref. No:	GCEC-PK-317/2020	Sample Matrix:	Ground Water Sample
Company Name:	Nestle Kabirwala		
Sample Date:	25-09-2020	Sampling Method:	-
Sample Receipt Date:	25-09-2020	Sampled By:	Received Sample
Sample Identification			
08	Well-06 (Pre-TMA Khanewal)		

Parameters	Analysis Method	Unit	LOR	Result 08	PEQS
PHYSICAL & CHEMICAL ANALYSIS					
pH	APHA-4500H+ B	-	0.01	7.34	6.5-8.5
Turbidity	APHA-2130 B	NTU	-	ND	<5 NTU
Total Hardness	APHA-2340 C	mg/l	0.5	456.00	< 500 mg/l
Total Dissolved Solid (TDS)	APHA-2540 C	mg/l	1.0	1400	< 1000
Chloride	APHA-4500Cl- B	mg/l	0.24	137.95	< 250
Cyanide (Cn)	APHA-4500CN E	mg/l	0.01	<0.01	≤ 0.05
Fluoride (F)	APHA-4500F- C	mg/l	0.01	<0.01	≤ 1.5
Cadmium	APHA-3500Cd B	mg/l	0.0028	<0.0028	0.01
Copper	APHA-3500Cu B	mg/l	0.0045	<0.0045	2
Chromium	APHA-3500Cr B	mg/l	0.0054	<0.0054	≤ 0.05 (P)
Mercury	APHA-3500-Hg B	mg/l	0.001	<0.001	≤ 0.001
Nickel	APHA-3500-Ni B	mg/l	0.008	<0.008	≤ 0.02
Zinc	APHA-3500-Zn B	mg/l	0.0033	<0.0033	5.0
Arsenic	APHA-3500As B	mg/l	0.01	<0.01	≤ 0.05 (P)
Barium	APHA-3500Ba B	mg/l	0.031	<0.031	0.7
Manganese	APHA-3500-Mn B	mg/l	0.0016	<0.0016	≤ 0.5
Iron	APHA-3500-Fe-B	mg/l	0.1	6.62	-
Boron	APHA-4500B-C	mg/l	0.1	<0.1	0.3
Lead	APHA-3500-Pb B	mg/l	0.013	<0.013	≤ 0.05
Selenium	APHA-3500Se C	mg/l	-	ND	0.01 (P)
Total Suspended Solid (TSS)	APHA-2540-D	mg/l	1.0	<1.0	-
Sulphate	APHA-4500-SO4C	mg/l	0.41	165.46	-
Sodium	APHA-3500-Na-B	mg/l	0.0037	18.91	-
Phosphate	APHA-4500P B	mg/l	0.1	<0.1	-
Sulfide	APHA-4500-S2-E	mg/l	0.2	<0.2	-
Magnesium	APHA-2340 B & C	mg/l	1.0	36.11	-

Parameters	Analysis Method	Unit	LOR	Result 08	PEQS
Calcium	APHA-2340 B & C	mg/l	1.0	123.20	-
Potassium	APHA-3500-K-B	mg/l	0.0009	2.72	-
Total Organic Carbon	USEPA 415.3	mg/l	0.06	1.848	-
Bicarbonates	APHA-2320 B	mg/l	0.1	523.20	-
Carbonates	APHA-2320 B	mg/l	0.1	<0.1	-
PESTICIDES					
Pesticides	APHA-6630 B	mg/l	-	ND	0.15
VOCs					
Parameters	Analysis Method	Unit	LOR	Result 08	PEQS
Benzene	GC/MS	µg/l	0.020	0.027	-
Bromodchloromethane	GC/MS	µg/l	0.080	0.085	-
Chloroform	GC/MS	µg/l	0.079	0.083	-
MethyBenzene	GC/MS	µg/l	0.05	<0.05	-
Methyl Tertbutyl Ether	GC/MS	µg/l	0.20	0.24	-
Tetra Chloro Ethane	GC/MS	µg/l	0.15	<0.15	-
Total Xylenes	GC/MS	µg/l	0.022	0.026	-
Trichloroethane	GC/MS	µg/l	0.043	0.048	-
THMS					
Trihalomethanes	GC/MS	µg/l	0.090	0.094	-
MICROBIOLOGICAL ANALYSIS					
Total Colony Count	APHA 9215 B	CFU/ml		62	-
Total Coliforms	APHA:9222 B	CFU/100ml		5	0/100ml
RADIOACTIVE CHEMICAL ANALYSIS					
^{226}Ra	APHA 7500 Ra B	Bq/Kg		1.54	
^{228}Ra	APHA 7500 Ra B	Bq/Kg		1.75	
^{137}Cs	APHA 7500 Cs B	Bq/Kg		<0.03	
^{134}Cs	APHA 7500 Cs B	Bq/Kg		<0.03	
^{40}K	--	Bq/Kg		22	

Abbreviations:

ND: Not Detected Standard

LOR: Limit of Reporting

PEQS: Punjab Environmental Quality

Note:

**Uncertainty of all the parameters and laboratory conditions at the time of analysis will be provided as per clients requirement. The lab environmental conditions are maintained at 25±5C° and humidity at 50±15%. The results of radioactive elements are sub-contracted.*

Lab Manager
Green Crescent Environmental Consultants (Pvt) Ltd.

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified

Federal-EPA Certified

Serial # 20B / 18325

Sample Details			
Job Ref. No:	GCEC-PK-317/2020	Sample Matrix:	Ground Water Sample
Company Name:	Nestle Kabirwala		
Sample Date:	25-09-2020	Sampling Method:	-
Sample Receipt Date:	25-09-2020	Sampled By:	Received Sample
Sample Identification			
09	TMA Kabirwala		

Parameters	Analysis Method	Unit	LOR	Result 09	PEQS
PHYSICAL & CHEMICAL ANALYSIS					
pH	APHA-4500H+ B	-	0.01	7.52	6.5-8.5
Turbidity	APHA-2130 B	NTU	-	ND	<5 NTU
Total Hardness	APHA-2340 C	mg/l	0.5	100.00	< 500 mg/l
Total Dissolved Solid (TDS)	APHA-2540 C	mg/l	1.0	172	< 1000
Chloride	APHA-4500Cl- B	mg/l	0.24	7.99	< 250
Cyanide (Cn)	APHA-4500CN E	mg/l	0.01	<0.01	≤ 0.05
Fluoride (F)	APHA-4500F- C	mg/l	0.01	<0.01	≤ 1.5
Cadmium	APHA-3500Cd B	mg/l	0.0028	<0.0028	0.01
Copper	APHA-3500Cu B	mg/l	0.0045	<0.0045	2
Chromium	APHA-3500Cr B	mg/l	0.0054	<0.0054	≤ 0.05 (P)
Mercury	APHA-3500-Hg B	mg/l	0.001	<0.001	≤ 0.001
Nickel	APHA-3500-Ni B	mg/l	0.008	<0.008	≤ 0.02
Zinc	APHA-3500-Zn B	mg/l	0.0033	<0.0033	5.0
Arsenic	APHA-3500As B	mg/l	0.01	<0.01	≤ 0.05 (P)
Barium	APHA-3500Ba B	mg/l	0.031	<0.031	0.7
Manganese	APHA-3500-Mn B	mg/l	0.0016	<0.0016	≤ 0.5
Iron	APHA-3500-Fe-B	mg/l	0.1	1.3	-
Boron	APHA-4500B-C	mg/l	0.1	<0.1	0.3
Lead	APHA-3500-Pb B	mg/l	0.013	<0.013	≤ 0.05
Selenium	APHA-3500Se C	mg/l	-	ND	0.01 (P)
Total Suspended Solid (TSS)	APHA-2540-D	mg/l	1.0	<1.0	-
Sulphate	APHA-4500-SO4C	mg/l	0.41	47.33	-
Sodium	APHA-3500-Na-B	mg/l	0.0037	18.91	-
Phosphate	APHA-4500P B	mg/l	0.1	<1.0	-
Sulfide	APHA-4500-S2-E	mg/l	0.2	<0.2	-
Magnesium	APHA-2340 B & C	mg/l	1.0	8.78	-

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified

Federal-EPA Certified

Serial # 20B / 18281

Parameters	Analysis Method	Unit	LOR	Result 09	PEQS
Calcium	APHA-2340 B & C	mg/l	1.0	25.6	-
Potassium	APHA-3500-K-B	mg/l	0.0009	0.02	-
Total Organic Carbon	USEPA 415.3	mg/l	0.06	<0.06	-
Bicarbonates	APHA-2320 B	mg/l	0.1	172.80	-
Carbonates	APHA-2320 B	mg/l	0.1	<0.1	-
PESTICIDES					
Pesticides	APHA-6630 B	mg/l	-	ND	0.15
VOCs					
Parameters	**Analysis Method**	**Unit**	**LOR**	**Result 09**	**PEQS**
Benzene	GC/MS	µg/l	0.020	0.021	-
Bromodchloromethane	GC/MS	µg/l	0.080	0.081	-
Chloroform	GC/MS	µg/l	0.079	0.079	-
MethyBenzene	GC/MS	µg/l	0.05	<0.05	-
Methyl Tertbutyl Ether	GC/MS	µg/l	0.20	0.23	-
Tetra Chloro Ethane	GC/MS	µg/l	0.15	1.08	-
Total Xylenes	GC/MS	µg/l	0.022	0.023	-
Trichloroethane	GC/MS	µg/l	0.043	0.043	-
THMS					
Trihalomethanes	GC/MS	µg/l	0.090	0.092	-
MICROBIOLOGICAL ANALYSIS					
Total Colony Count	APHA 9215 B	CFU/ml		40	-
Total Coliforms	APHA:9222 B	CFU/100ml		5	0/100ml

Abbreviations:
ND: Not Detected
Standard
LOR: Limit of Reporting
PEQS: Punjab Environmental Quality

Note:

**Uncertainty of all the parameters and laboratory conditions at the time of analysis will be provided as per clients requirement. The lab environmental conditions are maintained at 25±5C° and humidity at 50±15%.*

Lab Manager
Green Crescent Environmental Consultants (Pvt) Ltd.

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified

Federal-EPA Certified

Serial # 20B / 18282

Sample Details			
Job Ref. No:	GCEC-PK-317/2020	Sample Matrix:	Ground Water Sample
Company Name:	Nestle Kabirwala		
Sample Date:	25-09-2020	Sampling Method:	-
Sample Receipt Date:	25-09-2020	Sampled By:	Received Sample
Sample Identification			
10	Nestle Guest House		

Parameters	Analysis Method	Unit	LOR	Result	PEQS
				10	
PHYSICAL & CHEMICAL ANALYSIS					
pH	APHA-4500H+ B	-	0.01	7.19	6.5-8.5
Turbidity	APHA-2130 B	NTU	-	ND	<5 NTU
Total Hardness	APHA-2340 C	mg/l	0.5	160.00	< 500 mg/l
Total Dissolved Solid (TDS)	APHA-2540 C	mg/l	1.0	571	< 1000
Chloride	APHA-4500Cl- B	mg/l	0.24	19.99	< 250
Cyanide (Cn)	APHA-4500CN E	mg/l	0.01	<0.01	≤ 0.05
Fluoride (F)	APHA-4500F- C	mg/l	0.01	<0.01	≤ 1.5
Cadmium	APHA-3500Cd B	mg/l	0.0028	<0.0028	0.01
Copper	APHA-3500Cu B	mg/l	0.0045	<0.0045	2
Chromium	APHA-3500Cr B	mg/l	0.0054	<0.0054	≤ 0.05 (P)
Mercury	APHA-3500-Hg B	mg/l	0.001	<0.001	≤ 0.001
Nickel	APHA-3500-Ni B	mg/l	0.008	<0.008	≤ 0.02
Zinc	APHA-3500-Zn B	mg/l	0.0033	<0.0033	5.0
Arsenic	APHA-3500As B	mg/l	0.01	<0.01	≤ 0.05 (P)
Barium	APHA-3500Ba B	mg/l	0.031	<0.031	0.7
Manganese	APHA-3500-Mn B	mg/l	0.0016	<0.0016	≤ 0.5
Iron	APHA-3500-Fe-B	mg/l	0.1	3.20	-
Boron	APHA-4500B-C	mg/l	0.1	<0.1	0.3
Lead	APHA-3500-Pb B	mg/l	0.013	<0.013	≤ 0.05
Selenium	APHA-3500Se C	mg/l	-	ND	0.01 (P)
Total Suspended Solid (TSS)	APHA-2540-D	mg/l	1.0	<1.0	-
Sulphate	APHA-4500-SO4C	mg/l	0.41	137.88	-
Sodium	APHA-3500-Na-B	mg/l	0.0037	18.91	-
Phosphate	APHA-4500P B	mg/l	0.1	<0.1	-
Sulfide	APHA-4500-S2-E	mg/l	0.2	<0.2	-
Magnesium	APHA-2340 B & C	mg/l	1.0	15.61	-

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified

Federal-EPA Certified

Serial # 20B / 18283

Parameters	Analysis Method	Unit	LOR	Result 10	PEQS
Calcium	APHA-2340 B & C	mg/l	1.0	38.40	-
Potassium	APHA-3500-K-B	mg/l	0.0009	0.22	-
Total Organic Carbon	USEPA 415.3	mg/l	0.06	0.462	-
Bicarbonates	APHA-2320 B	mg/l	0.1	518.40	-
Carbonates	APHA-2320 B	mg/l	0.1	<0.1	-
PESTICIDES					
Pesticides	APHA-6630 B	mg/l	-	ND	0.15
VOCs					
Parameters	**Analysis Method**	**Unit**	**LOR**	**Result 10**	**PEQS**
Benzene	GC/MS	µg/l	0.020	0.025	-
Bromodchloromethane	GC/MS	µg/l	0.080	0.086	-
Chloroform	GC/MS	µg/l	0.079	0.085	-
MethyBenzene	GC/MS	µg/l	0.05	<0.05	-
Methyl Tertbutyl Ether	GC/MS	µg/l	0.20	0.24	-
Tetra Chloro Ethane	GC/MS	µg/l	0.15	<0.15	-
Total Xylenes	GC/MS	µg/l	0.022	0.027	-
Trichloroethane	GC/MS	µg/l	0.043	0.045	-
THMS					
Trihalomethanes	GC/MS	µg/l	0.090	0.096	-
MICROBIOLOGICAL ANALYSIS					
Total Colony Count	APHA 9215 B	CFU/ml		10	-
Total Coliforms	APHA:9222 B	CFU/100ml		-	0/100ml

Abbreviations:
ND: Not Detected **LOR:** Limit of Reporting **PEQS:** Punjab Environmental Quality Standard

Note:

**Uncertainty of all the parameters and laboratory conditions at the time of analysis will be provided as per clients requirement. The lab environmental conditions are maintained at 25±5C° and humidity at 50±15%.*

Lab Manager
Green Crescent Environmental Consultants (Pvt) Ltd.

5.8 GROUNDWATER MINOR ANALYSIS

Client Detail:	
Name of Contact Person:	Mr. Bilal Sial
Designation:	-
Contact Number:	+92-333-6729939
Telephone:	-
Fax:	-
Email:	bilalahmed.sial@pk.nestle.com
Address:	Khanewal-Kabirwala Rd, Nestle Colony, Allahabad, Kabirwala

GCEC Details:	
Country Manager:	Mr. Rashid Maqbool.
Telephone:	+92-42-35761300
Fax:	+92-42-35761301
Email:	country.manager@gcee.pk
Address	112 C/E-1, Hali Road, Gulberg III, Lahore

Signatories:

Country Manager
Green Crescent Environmental Consultants (Pvt) Ltd.

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified

Federal-EPA Certified

Serial # 20B / 18285

Sample Details			
Job Ref. No:	GCEC-PK-317/2020	Sample Matrix:	Ground Water Sample
Company Name:	Nestle Kabirwala		
Sample Date:	25-09-2020	Sampling Method:	-
Sample Receipt Date:	25-09-2020	Sampled By:	Received Sample
Sample Identification			
03	Well-37 (Old Report Number)		

Parameters	Analysis Method	Unit	LOR	Result 03	PEQS
PHYSICAL & CHEMICAL ANALYSIS					
Total Hardness	APHA-2340 C	mg/l	0.5	196.00	< 500 mg/l
Chloride	APHA-4500Cl- B	mg/l	0.24	101.96	< 250
Ammonical Nitrogen	APHA-4500-NH3 B	mg/l	0.002	<0.002	≤ 0.05
Fluoride (F)	APHA-4500F- C	mg/l	0.01	<0.01	≤ 1.5
Arsenic	APHA-3500As B	mg/l	0.01	<0.01	≤ 0.05 (P)
Manganese	APHA-3500-Mn B	mg/l	0.0016	<0.0016	≤ 0.5
Iron	APHA-3500-Fe-B	mg/l	0.1	6.27	-
Sulphate	APHA-4500-SO4C	mg/l	0.41	133.77	-
Sodium	APHA-3500-Na-B	mg/l	0.0037	53.12	-
Phosphate	APHA-4500P B	mg/l	0.1	<0.1	-
Sulfide	APHA-4500-S2-E	mg/l	0.2	<0.2	-
Magnesium	APHA-2340 B & C	mg/l	1.0	18.54	-
Calcium	APHA-2340 B & C	mg/l	1.0	30.40	-
Potassium	APHA-3500-K-B	mg/l	0.0009	2.47	-
Total Organic Carbon	USEPA 415.3	mg/l	0.06	<0.06	-
Bicarbonates	APHA-2320 B	mg/l	0.1	696.00	-
Carbonates	APHA-2320 B	mg/l	0.1	<0.1	-

Abbreviations:
ND: Not Detected
Standard

LOR: Limit of Reporting

PEQS: Punjab Environmental Quality

Note:

**Uncertainty of all the parameters and laboratory conditions at the time of analysis will be provided as per clients requirement. The lab environmental conditions are maintained at 25±5C° and humidity at 50±15%.*

Lab Manager
Green Crescent Environmental Consultants (Pvt) Ltd.

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified

Federal-EPA Certified

Serial # 20B / 18286

Sample Details			
Job Ref. No:	GCEC-PK-317/2020	Sample Matrix:	Ground Water Sample
Company Name:	Nestle Kabirwala		
Sample Date:	25-09-2020	Sampling Method:	-
Sample Receipt Date:	25-09-2020	Sampled By:	Received Sample
Sample Identification			
04	Jadeed Feeds		

Parameters	Analysis Method	Unit	LOR	Result 04	PEQS
PHYSICAL & CHEMICAL ANALYSIS					
Total Hardness	APHA-2340 C	mg/l	0.5	192.00	< 500 mg/l
Chloride	APHA-4500Cl- B	mg/l	0.24	55.98	< 250
Ammonical Nitrogen	APHA-4500-NH3 B	mg/l	0.002	<0.002	≤ 0.05
Fluoride (F)	APHA-4500F- C	mg/l	0.01	<0.01	≤ 1.5
Arsenic	APHA-3500As B	mg/l	0.01	<0.01	≤ 0.05 (P)
Manganese	APHA-3500-Mn B	mg/l	0.0016	<0.0016	≤ 0.5
Iron	APHA-3500-Fe-B	mg/l	0.1	5.66	-
Sulphate	APHA-4500-SO4C	mg/l	0.41	141.59	-
Sodium	APHA-3500-Na-B	mg/l	0.0037	26.51	-
Phosphate	APHA-4500P B	mg/l	0.1	<0.1	-
Sulfide	APHA-4500-S2-E	mg/l	0.2	<0.2	-
Magnesium	APHA-2340 B & C	mg/l	1.0	19.52	-
Calcium	APHA-2340 B & C	mg/l	1.0	32.00	-
Potassium	APHA-3500-K-B	mg/l	0.0009	1.11	-
Total Organic Carbon	USEPA 415.3	mg/l	0.06	<0.06	-
Bicarbonates	APHA-2320 B	mg/l	0.1	528.00	-
Carbonates	APHA-2320 B	mg/l	0.1	<0.1	-

Abbreviations:
ND: Not Detected
Standard

LOR: Limit of Reporting

PEQS: Punjab Environmental Quality

Note:
*****Uncertainty of all the parameters and laboratory conditions at the time of analysis will be provided as per clients requirement. The lab environmental conditions are maintained at 25±5C° and humidity at 50±15%.*

Lab Manager
Green Crescent Environmental Consultants (Pvt) Ltd.

GCEC

PNAC Pakistan National Accreditation Council LAB 121 17025

Punjab-EPA Certified

Federal-EPA Certified

Serial # 20B / 18287

Sample Details			
Job Ref. No:	GCEC-PK-317/2020	Sample Matrix:	Ground Water Sample
Company Name:	Nestle Kabirwala		
Sample Date:	25-09-2020	Sampling Method:	-
Sample Receipt Date:	25-09-2020	Sampled By:	Received Sample

Sample Identification	
07	New well (Nestle Back Side)

Parameters	Analysis Method	Unit	LOR	Result 07	PEQS
PHYSICAL & CHEMICAL ANALYSIS					
Total Hardness	APHA-2340 C	mg/l	0.5	244.00	< 500 mg/l
Chloride	APHA-4500Cl- B	mg/l	0.24	47.98	< 250
Ammonical Nitrogen	APHA-4500-NH3 B	mg/l	0.002	<0.002	≤ 0.05
Fluoride (F)	APHA-4500F- C	mg/l	0.01	<0.01	≤ 1.5
Arsenic	APHA-3500As B	mg/l	0.01	<0.01	≤ 0.05 (P)
Manganese	APHA-3500-Mn B	mg/l	0.0016	<0.0016	≤ 0.5
Iron	APHA-3500-Fe-B	mg/l	0.1	6.89	-
Sulphate	APHA-4500-SO4C	mg/l	0.41	118.95	-
Sodium	APHA-3500-Na-B	mg/l	0.0037	25.33	-
Phosphate	APHA-4500P B	mg/l	0.1	<0.1	-
Sulfide	APHA-4500-S2-E	mg/l	0.2	<0.2	-
Magnesium	APHA-2340 B & C	mg/l	1.0	20.49	-
Calcium	APHA-2340 B & C	mg/l	1.0	33.60	-
Potassium	APHA-3500-K-B	mg/l	0.0009	1.12	-
Total Organic Carbon	USEPA 415.3	mg/l	0.06	<0.06	-
Bicarbonates	APHA-2320 B	mg/l	0.1	576.00	-
Carbonates	APHA-2320 B	mg/l	0.1	<0.1	-

Abbreviations:
ND: Not Detected
LOR: Limit of Reporting
PEQS: Punjab Environmental Quality Standard

Note:
**Uncertainty of all the parameters and laboratory conditions at the time of analysis will be provided as per clients requirement. The lab environmental conditions are maintained at 25±5C° and humidity at 50±15%.*

Lab Manager
Green Crescent Environmental Consultants (Pvt) Ltd.