JIMMA UNIVERSITY

SCHOOL OF GRADUAT STUDY

JIMMA INSTITUTE OF TECHNOLOGY

FACULTYOF CIVIL AND ENVIRONMENTAL ENGINEERING

HYDRAULIC ENGINEERING STREAM

M.Sc Thesis

Groundwater Flow Modeling of WejaRiver Catchment By Using MODFLOW

By: HabibJemal Eriko

A ThesisSubmittedto the School of Graduate Studies ofJimma University Institute of Technology in Partial Fulfillment of the Requirements for the Degree of Master of Science in Hydraulics Engineering

Jimma Ethiopia

October, 2021

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Main; Advisor:Dr.Eng.-FekaduFuffa(PhD)

Co-Advisor; Mr. BerihanTekuam (MSc)

Jimma Ethiopia

October, 2021

CERTIFICATION

The undersigned certify that I read and hereby recommend for the acceptance by the JimmaUniversity Institute of Technology a Thesis entitled: “Groundwater Flow Modeling of the Weja River Catchment by Using MODFLOW” in partial fulfilment of a degree of Masters of Science in Engineering.

Advisor; Dr.Eng.-FekaduFuffa(PhD)

Co-Advisor, Mr. BerihanTekuam(MSc)

DECLARATION

I under signed, declare that this thesis entitled " Ground Water Flow Modeling of Weja River Catchment By Using MODFLOW" is my original work, and has not been presented by any others person for an award of a degree in Jimma University or other University.

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ABSTRACT

The Weja River Catchment Study Area Located in the Central Ethiopia Rifty Valley to West of Lake Ziway and Total Catchment Study Area 967S.km Was Simulated Study Area Ground Water Flow Modeling by Using MODFLOW USGS-2005(MODFLOW USGS-2005 Version, 3.1).

The aims of the Modeling Ground Water Flow MODFLOW Quantify Hydraulics and Aquifer Parameters of Study Area by Existed Data Collections from Desk of Office and Minster Sector and giving Emphasis Well and Fields Data that Inputs for Raw Data for MODFLOW Modeling and The approaches to achieve the objective of the research involve data collection, analysis and synthesis with understanding the flow system of the Study Area.

Sensitivity analysed for Ground Water Flow System and Aquifer Parameters Were Time Steps Response for Natural and Man Mad Influence of Study Area Stream Flow,

The Scenarios Analysed the Study Area System of Flow for Ground Water Extraction and Natural Drain System (spring) Simulated time Steps Response that Due to Over Extraction of Discharge the Ground Water Flow System Were Time Steps Transited Flow From Steady State to Unsteady State Ground Water Flow System and Drawn Dawn Was Increased Time Steps.

MODFLOW USGS-2005 Analysed the Hydraulics Conductivity of Ground Water Flow System Were Increased Time Steps and Porosity and Other Most Aquifer Parameters Were Decreased Due to Increased Ground Water Outflow and Over Extraction of Ground Water Storage Reservoir.

The Study Area Source of Stream Flow Were from Ground Water Storage Reservoir Outflow to Surface Flow System in the Form of Stream Flow or springs.

Therefore Scenarios Simulated that Due to Over Extraction of Ground Water Level of Ground Water Decline and Drown Dawn Were Increased Time Steps Due to that Ground Water Outflow System by Spring Outflow Were Decreased and the Study Area Surface Stream Flow Were Time Steps Dries Stream Were Formed on Weja River Catchment.

Keywords: Weja River Catchment,Modeling, MODFLOW, Protect Nature of Groundwater Inflowand Outflow.

LIST OF ACRONYMS

°C	Degree Celsius
D.D	Draw down
DEM	Digital elevation model
GIS	Geographical information system
GUI	Graphical user interference
ITCZ	Inter Tropical Convergence Zone
JICA	Japan International Cooperation Agency
K	Hydraulic conductivity
MAE	Mean Absolute Error
M.a.s.l	Meter above mean sea level
MCM	Million cubic meters
ME	Mean Error
MER	Main Ethiopian Rift
MODFLOW	Modular 3 dimensional finite difference groundwater flow models
MoWE	Ministry of Water & Energy
NMA	National Meteorological Agency
NE	North East
Q	Well yield
RMS	Root Mean Squared Error
SKM	Square Kilometer
SWWCE	South Water Work Construction and Enterprise
SWL	Static Water Level
T	Transmissivity
USGS	United states geological survey
UTM	Universal Transverse Mercator
WWDSE	Water Works Design and Supervision Enterprise

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1.0 Chapter One

1.1 Introduction

1.1.1 Background of the Study Area

Groundwater flow model calibration is the process one of the most popular and comprehensive deterministic groundwater models available today is the (USGS MODFLOW USGS-2005).

The model was coded in a modular style to allow and encourage the development of additional packages or modules that can be added on or linked to the original code. MODFLOW is organized by “Processes,” which currently include the Ground-Water Flow, Observation, Sensitivity, Parameter-Estimation, Ground-Water Management, and Ground-Water Transport Processes.

Flow can be steady or transient. Layers can be simulated as confined or convertible between confined and unconfined. Flow associated with external stresses, such as wells, a really distributed recharge, drains, lakes, and streams, can also be simulated through the use of specified head, specified flux, or head-dependent flux boundary conditions.

The implicit finite-difference equations can be solved using one of several available solver packages. Although the input and output systems of the program were designed to permit maximum flexibility, usability and ease of interpretation of model results can be enhanced by using one of several commercially available pre-processing and post processing packages; some of these packages operate independently of MODFLOW, where as others are directly integrated into reprogrammed and recompiled versions of the MODFLOW code(Ayenew, 2003).

Weja-Sub-Catchment of Mikeriver catchment has an abundance surface and groundwater resources ;(Alemu D., 2008)however, due to climatic change, industrialization, high population growth, the amount of water available is decreasing and its quality is degrading. In a country like Ethiopia, where rain fed agriculture is the main source of economy and ensures the wellbeing of many people, water resources are essential. Nevertheless, if the water resources are not utilized properly in an integrated planning manner, its sustainability and its support to food security to the country will become endanger. Therefore proper planning of water resources development as well as utilization is very essential.

The Weja River Catchments Ground Water Flow Modelling By Using MODFLOW USGS-2005 Analyses Ground Water Fluctuation and Simulate Stress Responses for Hydraulics and Aquifer Parametersis quite recent and little experience has been accrued in this context for the area. Groundwater modelling is a result of careful understanding of hydrology, hydrogeology and dynamics of groundwater flow in and around the study area. The final model can be used as a tool to help understand the flow system, to confirm that estimates of aquifer properties are reasonable, and also to see the response of the system for different scenarios which help us to better understand the system.

1.2 Statement of the Problem

There were Different Problems in Developing Countries like Ethiopia which Might Occurred Due to Natural and Man Made Activities. the Central Ethiopia Rivity Valley has been Interested for Many Researchers and Organization, Thus A Number of Essential Works Carried out Over the Hydrology, Hydrogeology, Climate Change, Water Resources Potential and land use of Basin But In this Study Conducted on Analysed Weja River Catchment Ground Water flow system and Response for Hydraulic and Aquifer Parameters Stress with Balance Inflow and Outflows of Ground Water Storage Reservoirs Budget By Using MODFLOWModelling.

The Central Ethiopia Rivity Valley Community was Exposed for Number of Problems; like Surface and Sub Surface Water Scarcity, lack of Clean Drinking Water, Proper Facilitates in Educational Centre, Electricity, Improper Drainage System, lack of Clean Public Toilet and Improper Solid waste Disposal.

Those Mentioned Problems were the Major problems that Existed on Weja River Catchment Study Area. These Problems were all Major Adverse programs that Required Mitigation Measures as much as possible. Hence Based on Different Criteria; like Most Essential and Adverse Impact on Community has been priorities those problems and has selected to Reduced Existed Society problems.
Therefore this Research was aimed to Solve Water Scarcity problem on Study Area to Cause Influenced on Hydraulic and Aquifer Parameters Stress and Evaluate Ground Water Storage Reservoirs Inflow Recharge and Outflow Discharge Balance By Using MODFLOWModelling and Analysis Future Ground Water Sustainable Management Systems Developing with Details Predictions of Parameters Stress Distribution and Identify Solutions for Ground Water Storage Reservoirs Problems with Management Practice on Study Area Catchment Community.

1.3 Scope of the Study

The scope of the proposed study is to Analysis the existing groundwater balance using the simulation model in water quantity with Predictions of Future Ground Distribution, Parameters Stress and Identify Problems with Solution to ensure sustainable water resource development of the Study Area.

1.4 Significance of the Study

The major significant of this study is it allows the planners, decision makers and any Concerned persons to understand the opportunities to develop Prevent Nature Related to ground water and to Balance Recharge and Discharge of the Catchment Ground Water Reservoir and its impact on water availability, demand, reservoirs and water resource planning management. Investment in water is a long-term pay-off for human development and economic growth, with immediate visible short-term gains.

1.5 General Objective

The General Objective of Proposed Study Was to Analysis Weja River Catchment Ground Water flow system and Stress Response for Hydraulics and Aquifer Parameters By Using MODFLOW through Simulation Model of Regional Ground Water flow in Aquifer.

1.5.1 Specific Objective

1, To Identify Regional Ground Water Flow System and Simulated Ground Water Flow of the Study Area,

2, To Indicate Stress Responses for Most Aquifer Parameters of Study Areas.

3, To Analyzed Weja River Catchment Stream Flow Response for Stress to Evaluate Ground Water Fluctuation.

1.6 Research Questions

1, How Ground Water Parameters Stress Change Directions of flow Systems?

2, Why Hydraulics Conductivity, Was the Root Cause of Others Ground Water Parameters Stress?

3, What is the Relationships of Stream Flow and Ground Water Fluctuations?

1.8Limitation of Study

The Groundwater flow model of Weja river catchment provides a Regional groundwater flow in the aquifer system of the study area. the groundwater model results depends on the accuracy of the input data and has corresponding limitations in model precision, because the database management of the hydrogeology of the country is so poor and with limited vital parameter. Therefore the user of the model should consider the deficiency of the data that encountered the modeler.

Weja River Catchment Ground Water Flow Modeling Were Achieved aim of Study Objectives by Limited Data of Measured Recorded Surfaces Water Body of Hydraulics Parameters and Ground Water Aquifer Parameters of Study Catchment and Modeling MODFLOW USGS-2005 Packages was the Recently and 21 Century Ground Water Computer Programming Best Method of Modeling Approaches for Complicated Geological Conditional Area and Irregulars Shapes of Ground Water Flow System But To Analyses of Result Required Periodic Measured and Recorded Data of Surfaces and Ground Water Parameters But Most Developing Country and Ethiopia Weren't Adopted Such Surfaces and Ground Databases Management System.

Due to these Basics Surfaces and Ground Water Unknown Variables were Assumed and Calibration Based on Global Standard for Increasing Result of out Put Modeling MODFLOW of Study Area.

2.0 Chapter Two

2.1Reviewof Literature

2.1.1 Review of previous study

Groundwater models describe the groundwater flow and transport processes using mathematical Equation based on certain Simplify Assumptions. These assum^p^tions typically involve the direction of flow, geometry of the aquifer, the heterogeneity or anisotropy of sediments or bedrock within the aquifer, the contaminant transport mechanisms and chemical reactions. Because of the simplifying assumptions embedded in the mathematical equations and the many uncertainties in the values of data required by the model, a model must be viewed as an approximation and not an exact duplication of field conditions. Groundwater models, however, even as approximations are a useful investigation tool that groundwater hydrologists may use for a number of applications (Ayenew, 2003).

Applications of existing groundwater models include water balance (in terms of water quantity), gaining knowledge about the quantitative aspects of the unsaturated zone, simulating of water flow and chemical migration in the saturated zone including river groundwater relations, assessing the impact of changes of the groundwater regime on the environment, setting up/optimizing, monitoring networks, and setting up groundwater protection zones(TenalemAyenew, 2001.

Ph.D. thesis analyzed general hydrology and hydrogeology of Ziway–Shalla basin ,the study includes evaluation of groundwater and surface water interaction, water balance and recharge estimation of sub catchments , (TenalemAyenew, 2001) done numerical groundwater flow modeling of the central main Ethiopian rift lake basin, Tenalem (Ayenew, 2003) also done evapo transpiration estimation using thematic mapper spectral satellite data in the Ethiopian rift and adjacent highlands and Alemu Drib ,2006 in his MSc thesis study groundwater–surface water interaction and analysis of recent changes in hydrologic environment of Lake Ziway catchment.

Research Papers One of the researches conducted in the area was the assessment of Lake Ziway water balance (Amare, 2008). The objectives of this research paper were;

1,to estimate the various water balance components of the Lake Ziway which includes, Surface runoff (Inflow and Out flow estimation for gauged and Un-gauged catchment tothe Lake Ziway), Evaporation and precipitation over the surface of Lake Ziway.

2. Assess the water abstraction and future scenario.
3. Assess the impact of Lake Ziway on Lake Abiyata.

The model was developed using the values from each water balance component and the main components of Lake Ziway water balance quantified are Katar, Meki&Bulbula River runoff, runoff from un-gauged sub-catchment of the lake, precipitation on the lake surfaces, Evaporation from the Lake Surface and abstractions from the lake. The simulation of lake level variations (1980-2005) has been conducted through modelling at monthly time steps. The total annual inflow to the lake is equals 1106.91MMC and the total annual outflow from the lake equals 1,050.35MMC. Final result of the water balance simulation for the Lake has shown that 77.5% of the inflow is lost as evaporation.

The Other Research study was the impact of climate change on Lake Ziway, Numerical Ground Water Flow Modelling (Dereji,B.2011),watershed water availability (Zeray., 2006).

The Objectives of this Research were: to Analysis Weja River Catchment Ground Water flow Modelling, Stress Response for Hydraulics and Aquifer Parameters through Simulation Model of Regional Ground Water flow System.

2.2 Types of Groundwater Models

Basically there are Different types of groundwater models; physical and mathematical groundwater models.

2.3 Physical groundwater models

A physical model is a scaled representation of a hydraulic flow situation. Both the boundary conditions (e.g. channel bed, sidewalls), the upstream flow conditions and the flow field must be scaled in an appropriate manner.

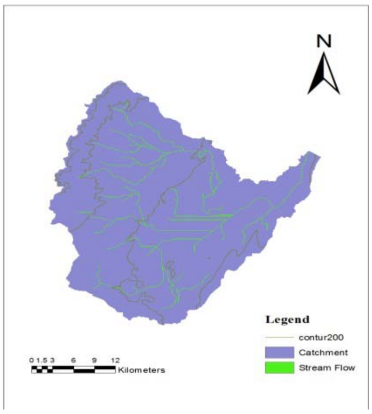

Figure :2.1Weja river catchment study area Topographic Condition.

2.4 Mathematical groundwater models

These are indirect models and use governing equations of groundwater flow and transport equations that describe boundary conditions. Mathematical groundwater models can be classified as analytical and numerical groundwater model.

2.4.1 Analytical groundwater models

Analytical models are an exact solution of a specific, often greatly simplified groundwater flow or transport equation. The equation is a simplification of more complex three dimensional groundwater flow or solute transport equations. Prior to the development and wide spread use of computers, there was a need to simplify the three dimensional equations because it was not possible to easily solve these equations. Specifically these simplifications resulted in reducing the groundwater flow to one dim

2.4 Ground Water Modeling

2.4.1Conceptual model

A conceptual model is pictorial representation of the groundwater flow system, frequently in the form of a block diagram or a cross-section (Anderson and Woessner, 1992).

The development of a conceptual model depends on the amount of data available, the model scale, the purpose of the model and the simplicity or complexity of the area under study.

The concept of numerical modeling is built on the fact that every field situation can be represented with governing physical laws and these laws can be explained in equations to represent the material mathematically. The conceptual model is intend to maintain the mathematical representation by identifying the available major system, the possible boundaries and aquifer characteristic which results an input data base , cross section and simplified map for the modeling.

2.5 Groundwater Flow System

Groundwater flows from areas of recharge to areas of discharge. The balance between groundwater recharge and discharge controls groundwater levels and storage. The common practice in the country for borehole construction, use to position the screen in various depth of the borehole and difficult to identify the water level for particular aquifer system in a multi-aquifer geological profile. Groundwater flow directions have been estimated based on the available data. The groundwater flow within the study area is mainly from the western escarpment towards MekkiRivrt and Lake Ziway, which indicates that it is the main recharge source. (Deraji B. 2001).

Table :2.1 Common typical value of storage coefficient Based on Geological Formation

Materials	Specific Yield
Slit	0.00-0.05
Fine Sand	0.03-0.19
Medium Sand	0.15-0.32
Coarse Sand	0.20-0.35
Gravel	0.14-0.35

Source ;(Johnson, 1979)

2.6 Recharge

Groundwater recharge to the aquifer may occurs naturally from precipitation, rivers, canals, lakes, as man induced phenomena (irrigation, urban recharge). Recharge could also be direct, indirect or localized based on the source and mechanism by which water reaches the water table. The quantity and type of recharge depends on topography, geology, climate, soil zone, land use and cover, drainage, geographic location, vegetation, structure and other.

Recharge is a specific flux boundary which is independent of the head of the cell but MODFLOW consider it as a property for spatially distributed all over the model area. Recharge to the model consisted of infiltration from direct precipitation, stream infiltration draining the eastern escarpment and artificial recharge of irrigation-return flow. Recharge was applied to the active model area as a spatially varying, specified flux to the highest active cell. In general, precipitation recharge varies spatially with land surface permeability, which is a function of soil characteristics and land use, and spatial distribution and intensity of rainfall. The recharge stated used on the conceptual model is also used as an input to model parameter (Mc Donald and Harbaugh, 2008).

2.7 Discharge

Discharge to streams were modeled using the river package and was used to simulate the hydraulic connection between groundwater and surface water by allowing streams to gain or lose water, based on the difference between the surrounding hydraulic head and stream stage, through riverbed material of a specified hydraulic conductance (McDonald and Harbaugh, 2008). Estimated riverbed conductance was based on model calibration. Model cells were designated as river cells along major streams and tributaries where the groundwater table intersected the land surface.

2.8 Topography and drainage

The upper riches of the basin are steep and mountainous while the lower basin is flat with a broad valley.The area can be divided into three physiographic areas: the high plateaux on the western summit of the area with elevation range of (2295 – 3611m), the transitional escarpment (1856 – 2294m) and the rift floor (1636 – 1855m) (Hawi Abate, 2007).

The western plateau of the Gurage highlands with elevation ranging from 3500 to 3600m.a.s.l. is the perennial sources of the Weja River while the tributaries in the escarpment and rift floor are almost intermittent sources.

The highland is characterized by higher drainage density than the escarpment and flat areas of lacustrine deposits in the southern part of the study area, which lack drainage due to differences in rock permeability, climate and slope (TesfayeChernet, 1992). Rift faults have affected the drainage of the area both by determining the river courses and by impounding river water and causing some marshy areas, in the southern part of the study area (TesfayeChernet, 1992)

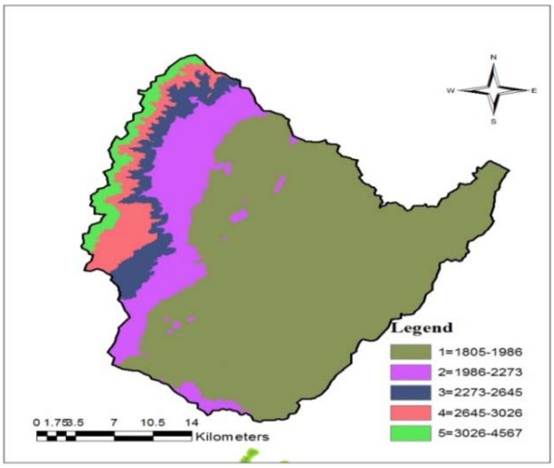

Figure :2.2Weja river catchment study area Elevation Classification.

2.12 Surface Water Hydrology

2.12.1 Lakes

The area between Local Lake Abaya (Tuffa), Areshetan and Ziway Lake Near to Catchment Boundary area and have very flat plain fed by flood and seasonal streams from west of Butajira area. Mostly this part of the plain gets flooded during the summer and develops temporary lake, which shrinks during the dry season. It is mostly water logged during the rainy season. This is because of the flat topography surface runoff from the west and east and the input of the springs, shallow groundwater and overflow from the lake.

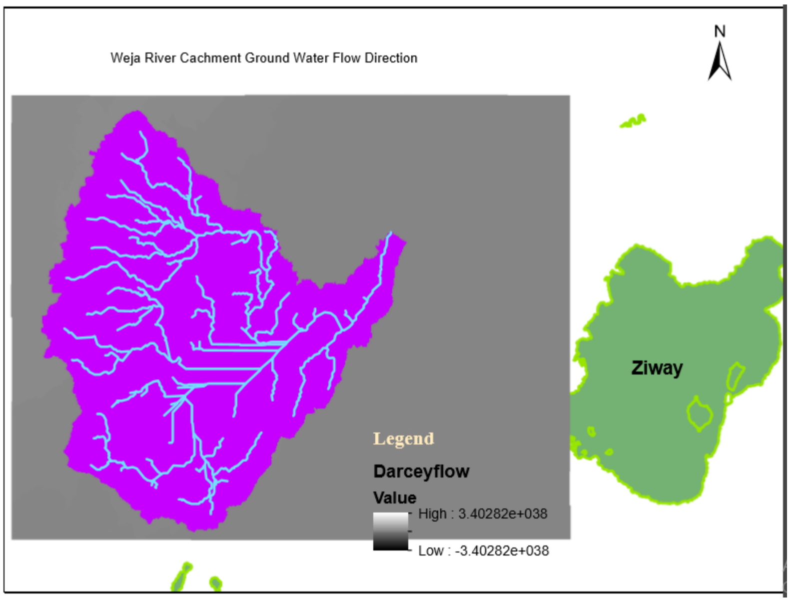

Figure :2.4Weja river catchment study area Surface Water Hydrology.

2.12.2 Rivers

In the study area groundwater level is affected by fluctuation of perennial river stages originating from highlands of Gurage and travels from the highlands at altitude of 3,472 m to 1, 805 m before draining into Mekki and Lake Ziway. Water flows from the river into the aquifer and the groundwater becomes elevated when there is an increase in river stage with respect to the altitude of the groundwater level. A decrease in river stage with respect to the groundwater level causes water to flow from the aquifer into the river and result in the decrease of groundwater level. The extent of the change in the groundwater level elevation in response to river stage fluctuations depends on the magnitude of the change in the river stage, the length of time the river remains at the current river stage, the hydraulic properties of the aquifer material, and the distance from the river to the point of interest.

2.13 Aquifer Parameters

2.13.1 Aquifer hydraulic properties

The hydraulic properties of the aquifer used in the conceptual model and for the first run of the numerical model were obtained from the existing data, fieldwork, indirect and direct, qualitative and quantitative approach. Characterization of hydraulic properties of the aquifer involves use of existing pumping test data, geologic map, hydro geological map, soil map, lithology obtained from well logs, aquifer thickness, water table depth, structures and surface water features, etc. so as to see the lateral Distribution and nature of the aquifer.

2.13.2 Hydraulic Conductivity

Hydraulic conductivity is the most essential aquifer parameter that determines the flow system of a model. It is a measure of the ability of fluid to move through aquifer media. It is dependent on the properties of both porous media and the fluid.

The spatial distribution of the hydraulic conductivity of the area is highly variable due to the presence of different geologic structures and it is demonstrated on the results of the analysis of pumping test data.

The initial hydraulic conductivity map used as an input for the first simulation process and The hydraulic conductivity of an aquifer has a directional value and in this model as the model area is conceptualized as isotropic and single layer unconfined aquifer.

2.14 Geology Situation of Study Area

2.14.1 General overview

The rift system is one of the largest structural features of the Earth's crust, extending for a distance of 6000km from Mozambique to Syria, equivalent to1/6 of the earth's circumference (Mohr, 1992). In, Ethiopia the rift system extends over 1000km in a general NE direction. It covers 150,000km and it can be divided into two broad units: The Main Ethiopian Rift (MER $5^0$9'N and37 30'-40 E) and the Afar depression.

The pyroclastic formation includes typical ignimbrites, sellers and layered pumice. In the MER, these are the most ancient formation out cropping on the floor of the rift valley. Its age is upper Pliocene, according to (Mohr, 1992)that assumed the same age for the rift ignimbrites andthe last ignimbrite cover of the plateau. Several layers constitute the pyroclastic formation with variable thickness, from 0.9 to 1.5 m up to 24m or more in a single unit. In many cases, paleosolsare observed between ignimbrite sequences.

Lacustrine sediments are quite important formation, which cover an area of 4,000km in the Main Ethiopian Rift. The thickness of sediments on the floor of lakes basin is not accurately known. Sediments are probably thickest in tectonic trough, which correspond in part to the topographic lows occupied by lakes (Llyod, E.F., 1995).

2.14.2 Local geology

The geology of the study area except for Paleozoic deposits comprises rocks from Precambrian age up to recent. The geological formation in the study area starting from the oldest formations to the recent ones is described as follows.

2.14.3 Precambrian rocks

In the Rift Valley of the study area, East of Guraghe Mountains a metamorphic rock(Biotitic gneiss) is exposed due to uplifting (Dipola, 1992). A high grade metamorphic rock biotitle gneiss cut by quartz field spathic pegmatite veins and minor migmatites is overlain by 150m – 200m thick typical Adigrat sandstone, cross-bedded quartz sandstone with coarse, medium and fine grained.

2.14.4 Mesozoic sediments

Dipola ,1992 reported his observation of out crops of Mesozoic sediments in the rift valley. These Mesozoic sediments crop out at western rift margin, east of Guraghe Mountains. About 30 m thick limestone overlies about 240m thick sandstone. It is underlain by Biotitic Gneiss, which is also exposed at the same locality.

2.14.5 Tertiary upper Miocene to Pliocene volcanic rocks

Northeast of the study area is exposed to rhyolites and ignimbrites formation, basaltic rock is exposed in the plateau north and northwest of Butajira Town. Volcanic rock occupies the western escarpment and the plateau and considered as upper Miocene in age (Kazmin and Seifemichael, 1980) which includes ash flow tuffs, pantellritic ignimbrites and un-welded tuffs while the Dino formation is made up of Dino ignimbrites. These rocks outcrop at the NW part of the plateau part in the study area.Alkaline and peralkalinestratoidsilicics; ignimbrites, un-welded tuffs, ash flows, rhyolites and trachyte s formation occupies the main part of the escarpment west, northeast and north of Butajira. The rocks of this formation are at places highly weathered and some sections show series of weathered layers.

2.14.6 Quaternary volcanic and sedimentary rocks

Dino formation includes peralkalinesilicis of ignimbrites, tuffs; water lain pyroclastic and occasional lacustrine beds which are overlain by coarse, un-welded pumiceous pyroclastic .This formation covers mainly the Tora-Koshe-Dugda ridge and are made up of lithic and pumiceous tuff. Recent basalts in the Butajira-Siltie area consist of a lot of scoria and their texture varies from aphyric to porphyritic.

Lacustrine sediments cover quite a vast area in the study area. It consists of layers of alternating silt and clay with volcanoclastic sediments, sands, ashes, transported pumice slit, clay and diatomite.

Lacustrine deposits in the study area occur in two areas. The major part is the Ziway plain deposit and the second one, which is composed, of lacustrine, alluvial, and pyroclastic deposits, forms the Kuntane-Inseno-Kela plain fan and talus deposits occur in the Butajira crescent and along the pediment plains of the escarpment.

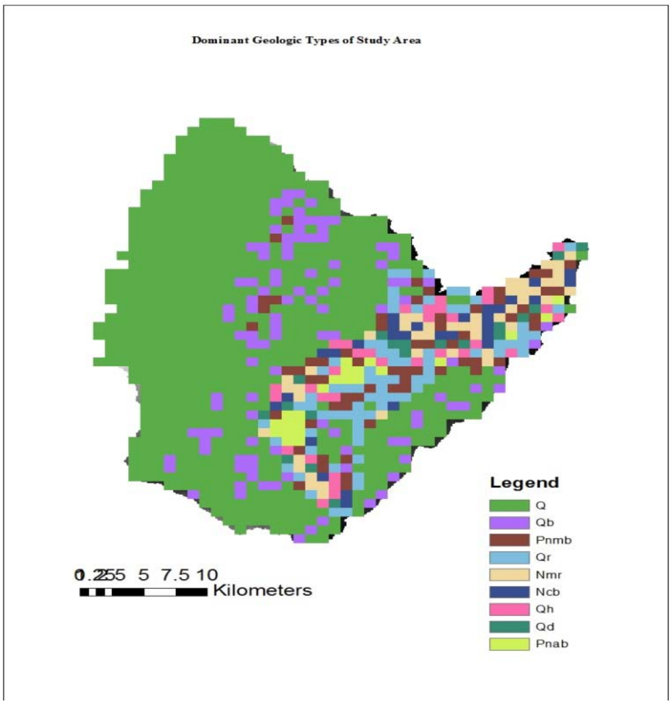

Figure :2.5 Weja Rivercatchments Dominant Geologic Classification.

3.0 Chapter Three

3.1 MethodologyOf Study

3.1.1 Research Design

Weja River Catchment Research Design Approaches Were Used Both Qualitative and Quantitative Data Collection Methodological Approaches Because Required Essential Data Taken Sampling (Quantitative) and Collection and Analysis Textual Data (Qualitative) Done to Achieved of Objective of Study.

3.2 Weja River Catchment Study Area

3.2.1 Location of Study Area

Weja river catchment was located in the central main Ethiopian rift valley. Kosheand Ensenotown is located about 185 km from the capital city of the country, Addis Ababa. The area stretches from the edges of the western escarpment of the rift valley in the west and to Lake Ziway in the east. Geographically, it is $7^{0}51^{'}$E and $8^{0}27'$ E Longitude 38015' N and 38051 N latitude (UTM: located approximately between 414717-454629E and 865384-910060 N, Zone 37, Northern Hemisphere) respectively.

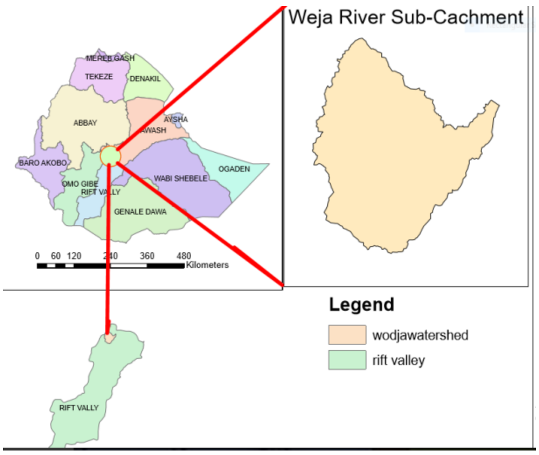

Figure :3.1 Weja river catchment study area By Using GIS.

The total area of Weja river catchment is about 967SKmTopography of the area is primarily determined by the rift system of faulting. The study area lies within altitudes ranging from 3472m in the west to 1805m.a.s.l toMekki and Lake Ziway.

3.2.2 Climate Situation of Study Area

Climate of the study area consists of three ecological zones: humid to dry humid, dry sub-humid or semi-arid and semiarid or arid lands (Makin et al., 1996). Accordingly, highland areas west of Butajira are categorized under humid to dry sub-humid land. The areas east of Butajira around Lake Abaya are dry sub-humid lands. The rest of the area which is around the lake is in semiarid or arid zone. Rainfall and temperature in the area show strong altitudinal variations. The average annual rainfall varies spatially and ranges from around 815 mm/year in the rift floor to more than 1100 mm/year at extreme highland areas.The average annual prevailing mean temperature ranges from the highlands toLow Land of Study Area Were Described on Appendix.

3.2.3 Dominant Soil of Study Area

The land use/ cover and soil map of the study area is obtained from rift valley lakes master plan study report by Halcrow Consulting Group report in the form of shape file having a scale of 1:250 000 . Soil in the study area is closely related to parent material and degree of weathering. Basalt, ignimbrite, acidic lava, volcanic ash and pumice, and riverine and lacustrine alluvium are the main parent materials. Generally the dominate soil types of the study area are Chromic Cambisol, EutricCambisol, EutricVertisol, HaplicLuvisol, Leptosol, and Vitric Andosol.

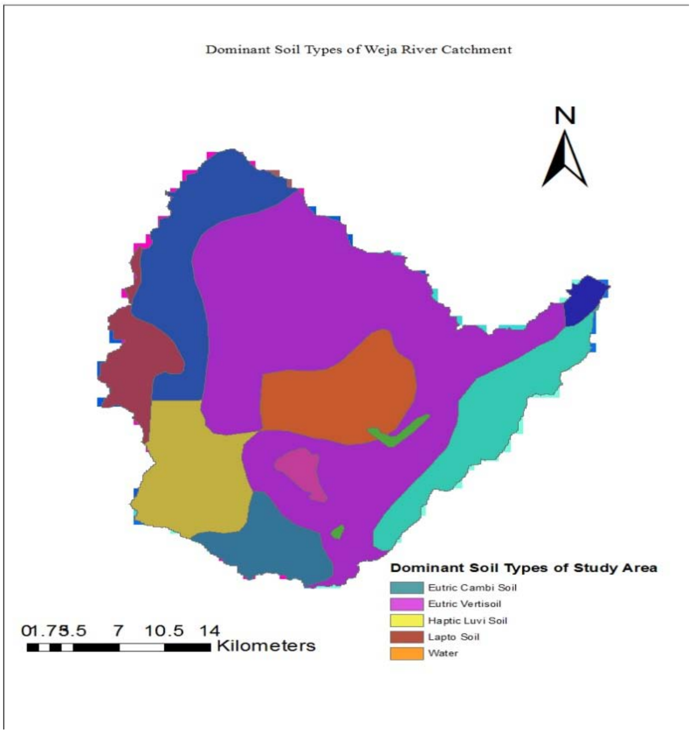

Figure :3.2 Weja river catchment Dominant Soil Types By Using GIS.

3.2.4 Land used and cover

The land cover of the catchment is controlled with topographical, climatic and ecological conditions. The land cover has made dramatic change with the past years in association with the population growth of the rift valley basin. The major land use and cover is categorized as forest, grassland, intensively cultivated, marshland, moderately cultivated, shrub land, and water body that covers 9%, 1%, 51%, 3%,29%,6% and 1% of the study area respectively.

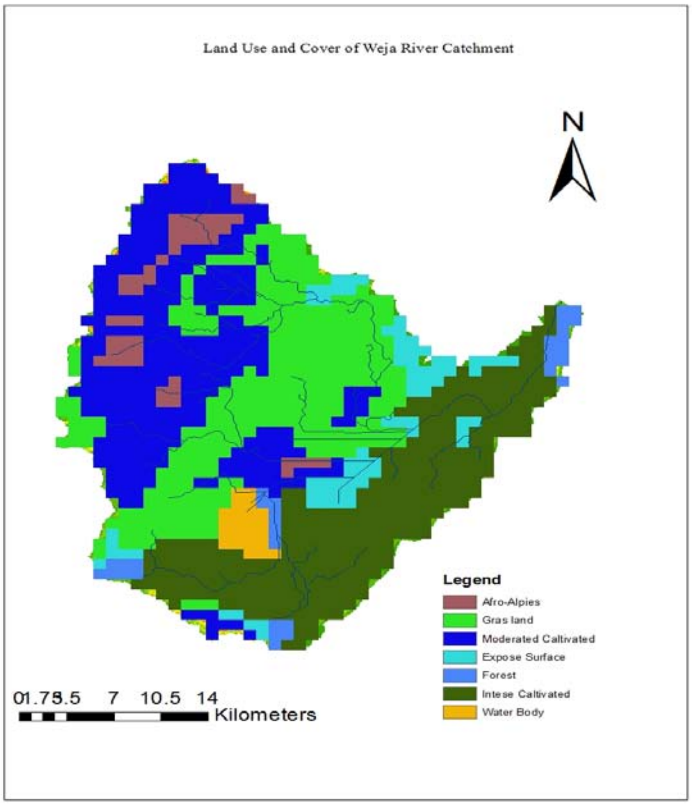

Figure :3.3Land Use and Cover of Weja river catchment study area.

Table :3.1 Land Use and Cover of Study Area Extracted By GIS

Rowid	VALUE	COUNT	MIN_M	DESCRIPTION
0	6	49	0.02	Mosaic Forest / Croplands
1	9	315	0.04	Deciduous woodland
2	10	319	0.04	Deciduous shrub land with sparse tree
3	12	74	0.04	Closed grassland
4	17	32	0.02	Croplands (>50%)
5	18	308	0.02	Croplands with open woody vegetated
6	23	23	0.09	Water bodies

Table :3.2 Land Use and Cover of Study Area(Source: Rift Valley Lakes Basin Integrated Resources Development Master Plan Study Project MoWR, 2008)

Land Use/Cover	Coverage (%)
Intensively Cultivated	49.3
Moderately Cultivated	28.6
Grass land	2.2
Exposed surface	0.4
Afro-Alpie	7.2
Forest	0.2
Marsh land	0.2
Water Body	7.7
Shrub land	4.1

3.2.5 Spatial distribution of rainfall

Precipitation of the study area was analyzed based on the 4 stations found in and around the catchment and the average aerial depth of precipitation over the catchment has been determined using Thiesen polygon.

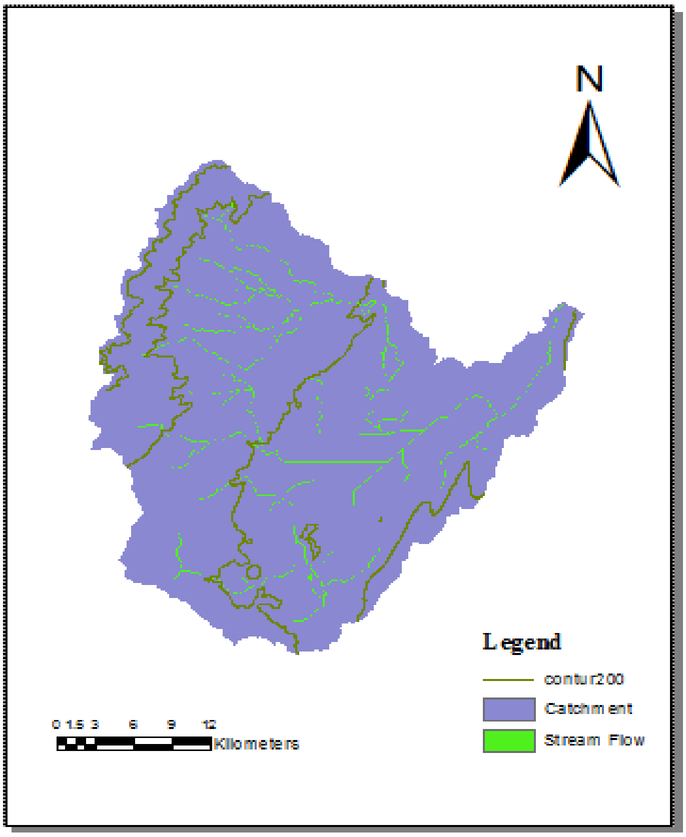

Figure :3.2 Weja River catchments Study Area Adjustment for Rainfall Station Data.

The Number of Station Used for Study Were Depends on Area of Study Catchment Based on Area Four Station Were Sufficient for Weja River Catchment Modeling Ground Water Flow System, The contours have been constructed on Study Area by using 4 stations and Approximated Divided Stream Flow Catchment by Four Sub-Catchment Area and Calculated Approximated Recharge Zone for Each Catchment Area.

Table 3.2 Mean Annual Precipitations of Study Area

Station	UTM E(m)	UTM E(m)	Mean(mm)
Koshe	432000	882000	924.72
Butajira	422000	894000	1021.84
Mitto	421000	863000	815.94
Toraa	412000	861000	874.62

3.2.6 Recharge Input in MODFLOW USGS-2005

This Boundary condition is the major category in the model of Weja river catchment that relates hydrologic processes including recharge, groundwater flow to and from streams, well withdrawal and groundwater outflow to the Mekki River

Recharge from precipitation is represented as specified-flux boundary condition. Recharge to the groundwater system was given by considering sources of groundwater from infiltration of precipitation and deep percolation of applied irrigation water. It is simulated as a specified flux to the uppermost layer of the model using seven different zones based on the previously developed conceptual model.

MODFLOW USGS-2005 Require Time Steps Recorded Data Within Per Year from Half Year to Year to Year Recharge, Hydraulics Parameters and Aquifer Parameters Data to Simulate Accurate Time Steps Stress Response of Hydraulics and Aquifer Parameters But Such Data Recorded Measurements Didn't Adopted by Study Area and Our Country and To Analyzed Result and Minimize Input Data By Calibration and Adjust Input Raw Data for Tools of Measured Data Scarcity of Study Area By Using Metrological Gauged Rainfall Precipitation Data and Considering Surface Water Route With Many Tri- and Error Approach Percolations of Ground Water Recharge Were Estimated for MODFLOW.

3.6.1 Applied MODFLOW Input Numerical Data

Thiessen Polygons Approach Method Were Used for Estimation of Average Rainfall of Weja River Catchment Due to Adjacent Location of Station of Study Area.

Average Rainfall of Study Area Were Estimated By Numerical Modelling of Thiessen Polygon of Appendex-11, Were As,

$$\mathrm{P} = \frac{924.7 * 386.4 + 1021.8 * 214 + 815.9 * 194 + 874.6 * 175 +}{976.685} = \frac{908.76mm}{Year}$$

Average Precipitation of Stud Area 0.9087676meter/31536000s was $2.88165906*10^{-6}$m/sor $2.88165906*10^{-3}$mm/s.

Therefor the Average Rainfall of Weja River Catchment Were 908.76mm per Year.

The Average Rainfall Intensity of Study Area Would be 908.76mm/8760hr were 0.10374mm/hr or 10.374cm/hr.

Table 3.3; Amount of Recharge Input in MODFLOW of Study Area

S.No	Amount of Recharge Input in MODFLOW of Study Area					
Name of Sub. Catchments of Study Area		Area S.Km	MCM	M	m/s	M3/s
Koshe, Enseno&Gerebebare	A1	386.729	5.035	0.127	$3.615*10^{-9}$	1.716
Worabe to Butsjira Crest	A2	214.326	23.673	0.158	$4.576*10^{-9}$	0.826
Wetland & Conic Area	A3	191.426	4.784	0.036	$6.875*10^{-9}$	0.164
Western Escapement	A4	174.867	4.279	0.021	$5.246*10^{-10}$	0.142
Weja River	Total A.	976.685	2.146	0.097	$2.882*10^{-6}$	1.2

The Area of Weja River Catchment has been Adjusted Based on Soil and Geologic Classification by Considering Adjacent Location of Station and on Study Area by using 4 stations and Approximated Divided Stream Flow Catchment by Four Sub-Catchment Area and Calculated Approximated Recharge Zone for Each Catchment Area.

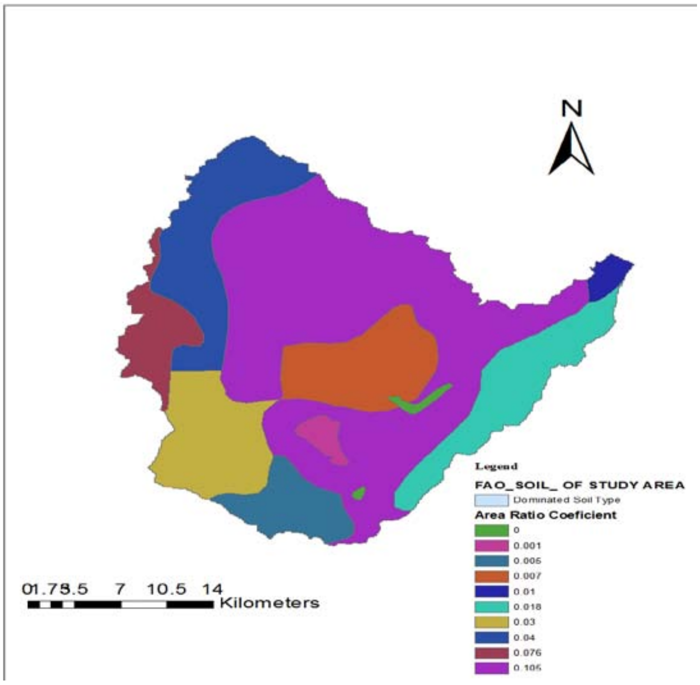

Figure :3.3 Weja River Catchments Study Area Classification for Recharge Input of MODFLOW.

3.2.7Weja River Catchment Stream Flow Input in MODFLOW USGS-2005

Weja River Catchment Stream Flow Input By Scenarios for Simulate Stream Feature and Other Parameters and Due to the time required for the change to propagate into and through the aquifer the groundwater level increase or decrease in response to increase or decrease in river stage is more obvious in areas closer to the river. Therefore, the area of the aquifer that is affected by an increase or decrease in river stage depends on the length of time that the river stage remains at the new altitude. Changes in the groundwater level at distant locations from the river are the result of long term river-stage changes typically caused by seasonal high and low flows or long-term river-stage management.

MODFLOW USGS-2005, Required Additional Data of Measured and Recorded Stream Flow to Increase Accuracies for Output Result of Simulation to Aquifer and Hydraulics Parameter During Adjustments and Calibration of Analyses of Result, Due to These Applied MODFLOW Steam Flow Input Data of Previous Study of Measured Stream Flow By Using Hydrometer With Modified Elevation Position for Stream Flow Input Data.

Table;3;4 Weja River Catchment Stream Input in MODFLOW USGS-2005 Applied By Modified (Deraj B,2011)

No	Major Stream	Conductivity(m/d)	Thickness Bed(m)	Head of River (m)	Width(m)
1	Weja river	0.09-0.12	1.05-1.5	1805-2215	6.25-12.5
2	Lebu river	0.12	0.8-1.1	1979.66-2364.54	3.8-7
3	Akamuja river	0.12-0.27	0.7-1.2	2000.43-2371.59	5-8.5
4	Irinzaf river	0.076-0.27	0.5-0.9	2225.54-2896.69	4-7.5

3.2.8 Boundary Condition

Boundary conditions are mathematical statements specifying the dependent variable (head) or the derivative of the dependent variable (flux) at the boundaries of the problem domain MODFLOW USGS-2005. In Ground Water flow state simulation, the boundaries largely determine the flow pattern. Setting the boundary is the critical step on the modeling and controls the water entrance and exit point of the model system.

3.3 Data Sampling Techniques

The Study Area Techniques of Data Sampling was Based on Systematic Databases Approaches Because Simulations of Hydraulics and Aquifer Parameters Responses Depending on Ground Water Consumers and Water Demands for Differences Purposes, Therefore Study Ground Water Extraction and Demand were Increased at Eastern Part of Low Land Due Highest Populations Density, Soil Fertility and Agricultural Production, Temperature and Dry Land Increasing From Western High Land to Eastern Parts of towards Lakes Ziway Specially Between Butajira Town and Battu (Ziway) Town, Due to These Most Observations to Bore Hole Head of Static and Dynamic Water Levels Selected from Tora to Koshe and Butajira to Battu Site and Field Investigation and Physical Ground Water Modeling was Addressed Most Required Study Area Catchment.

3.4 Methods of Data Collections and Materials

Weja River Catchment Basic Required Data for Ground Water Modeling of MODFLOW Input Raw Data was incurred for Processing by Using Were Primarily and Secondary Data Collections Methodological Approaches and Tools.

3.4.1 Primarily Data Collections of Study Area

The Basic Essential Databases of Modeling MODFLOW of Observations to Ground Water Static and Dynamic Water Levels, Physical Ground Water Modeling, Rehabilitation of Some Bore Hole, Stream Flow Condition, Elevation of Stream

Linked, Detail Filed Visited, Weja River Catchment Outlet Point Coordination With Separated Works of Mekki River Catchment Done By Using these Approach.

3.4.2 Secondary Data Collections of Study Area

The Secondary Data Collections Works to Achieved the Research Objectives Were Taken from Reviewed of Literatures, Desk Works, Topographic Maps, Geological Maps, Digital Elevation Modeling, Meteorological Recorded Station Data, Hydro geological Maps, Hydrological Data, with Visited Specific Site for Confidential Conceptual Modeling Development of Study Area.

The Data Sources Were from Minister of Water and Energy, Ethiopia Mapping Agency, National Meteorological Agency, Geological Survey of Ethiopia, South Water Work Construction and Enterprise, Consulting Hydro Geological Agency , Water Work Construction Agencies and Privacy Works of Study Area Data Were Used for Processing of Modeling MODFLOW and Calibration for Unknown Variables.

3.4.3 Materials Used for Ground Water Modeling

The Hydraulics Parameters and Ground Water Aquifer Parameters and Stress Responses Were Evaluated by Many Methodological Approaches and Ground Water Computers Programming Cods and Modeling MODFLOW Was the Recently and 21 Century Ground Water Programming Method of Complicated Geological Condition and Irregulars Shapes of Ground Water Flow Systematic Simulations With Accuracy of Outputs of Result.

The Study Researcher Used Tools of ArcGIS (10.1) and MOFLOW (3.1) Packages of Software Ground Water Computer Programming Cods Were Applied to Modeling MODFLOW USGS-2005.

3.5 Variables of Ground Water Modeling

The Hydraulics Parameters of Recharge(q), Discharge(Q) and Ground Water Aquifer Parameters, Conductivity (K), Porosity(e), Storage(Ss) and Others Ground Water Parameters of Were Evaluated by Existed Data Collection Processed, Numerical Modeling, Physical Modeling, Conceptual Modeling and Calibration Processed for

Unknown Variables to Achieved Ground Modeling Processed for Increased Accuracy of Results.

3.6 Modeling Data Processing and Analysis

3.6.1 MODFLOW Modelling Processed Approach for Study

The paper approaches the problem of understanding the flow system of the Weja river catchment with the very deterministic and numerical model which approximates physical law with finite difference. It is a method developed by United State Geological Survey (McDonald and Harbaugh, 2005). The paper used the power of the GIS and Surfer for all spatial data and conceptual models that has been done in the research.

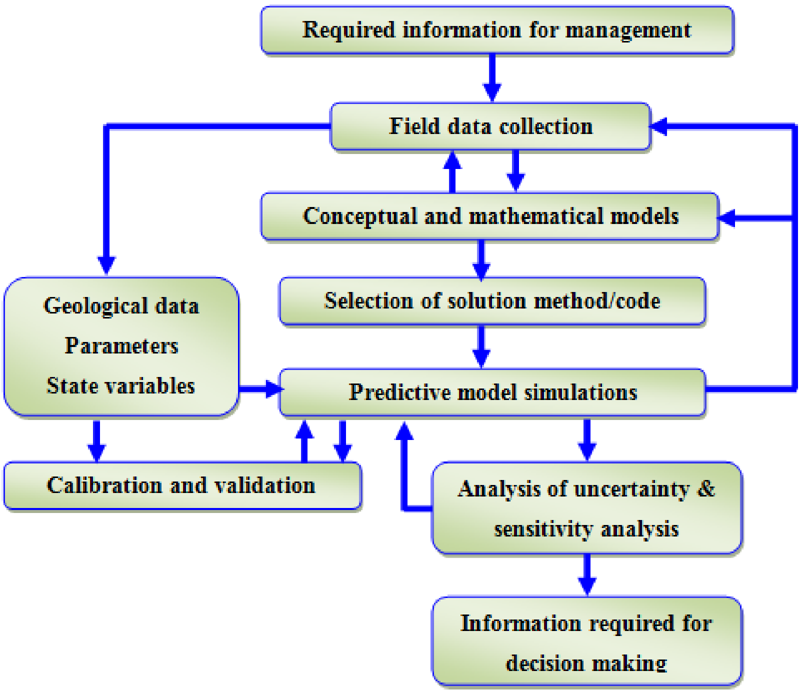

Figure :3.3 The modelling process.

3.6.2 Input Data Processing for the Model

The information gathered from different sources and field have different format. In order to construct the model using the information gathered from different sources a process of checking, selection, format conversion and organization had to be carried out to prepare the appropriate data for the model input. Most of the investigations carried out around the Weja river catchment and Lake Hydrological, Ground Water Boundary have been spread among adifferent organizations

The important procedures in data processing are removing wells where water levels might be measured inappropriately because of problems with the datum, organizing all necessary information in tables using excel, and converting maps in a format that is acceptable by the modeling software.

Geographic Information System (GIS) was used to get a better general picture of the study area and assist in making some important decisions, like boundary condition.

The digital elevation model used for the study area is the RASTER DEM of the Main Ethiopian Rift with resolution of 30 meter by 30 meter. The original DEM covered a large area than the desired region so a sub catchment has been selected to increasing the computing and processing speed of the computer. by specifying the mesh size used in MODFLOW in the x and y direction then the working environment of the study area is assigned as input by specifying the projection UTM, Zone 37 (Northern Hemisphere), and datum WGS84 is used in this study, and the working environment lies within (UTM 4147000-450000 E and 860000-910060N).Now the file is ready to import to MODFLOW.

Finally using GIS different maps of segment, polygon and point were overlaid for differentiating zonation of hydro geological parameters, location and distribution of observation wells, model boundaries, water point alignment with respect to structures, model boundaries and for other analysis using as background during the construction of the numerical model and in different variations of the conceptual model for the period of calibration process by importing it to MODFLOW.

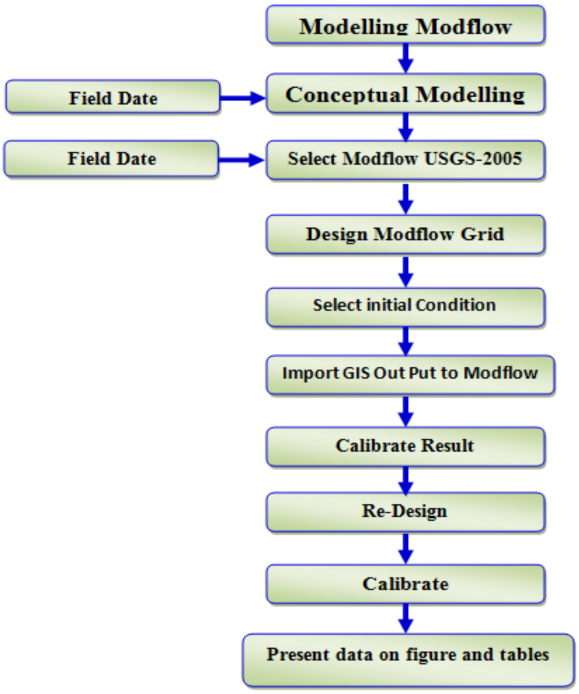

Figure :3.4 the Modelling Input process.

3.6.3 MODFLOW USGS-2005

MODFLOW USGS-2005 the Recent Tools of Ground Water that Response for Stress of Hydraulics and Aquifer Parameters to Indicate Unbalance of Inflow and Outflow to Ground Water Reservoirs Route.

The Study area Ground Water Flow System Response for Time Steps Stress for Hydraulics and Aquifer Parameters Methodological Approach of Stage for Analysed Scenarios Result was as Shawn;

3.6.3.1 MODFLOW USGS-2005 Starting Stage

In this Stage Starting Stage Starting MODFLOW USGS -2005 Computer Programing Cod Identifications, Geographic Coordination System, Project Naming, Initial Time Steps, Number of Column, Number of Raw, Layer Number, Grid Size Adjustments Stage to Simulate Hydraulics and Aquifer Parameters Stress Response on Study Stream Flow Catchment.

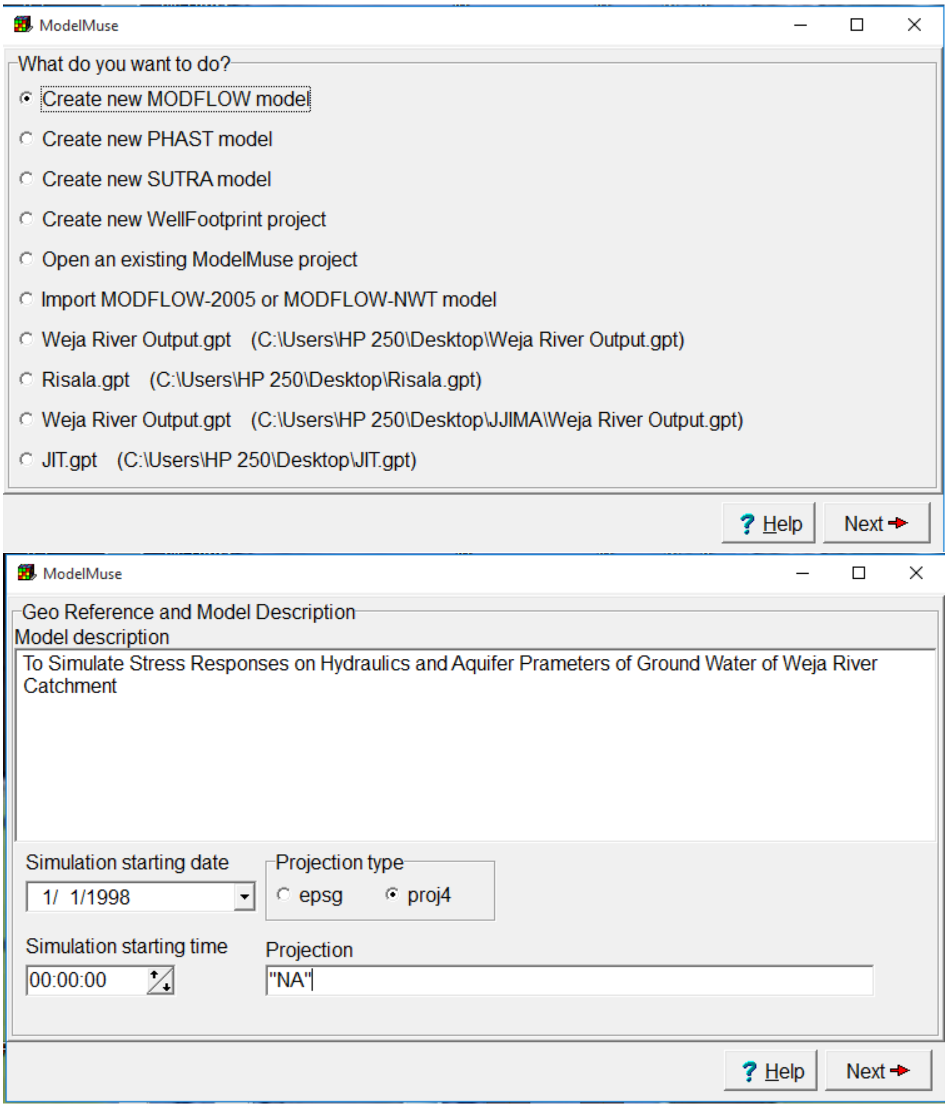

Figure :3.5 The Modelling process.

3.6.3.2 MODFLOW USGS-2005 Data Imported Stage

In this Stage Import Analysed Data from GIS to MODFLOW After Translating USGS Ground Water Computer Programing Cod on GIS Analysed System.

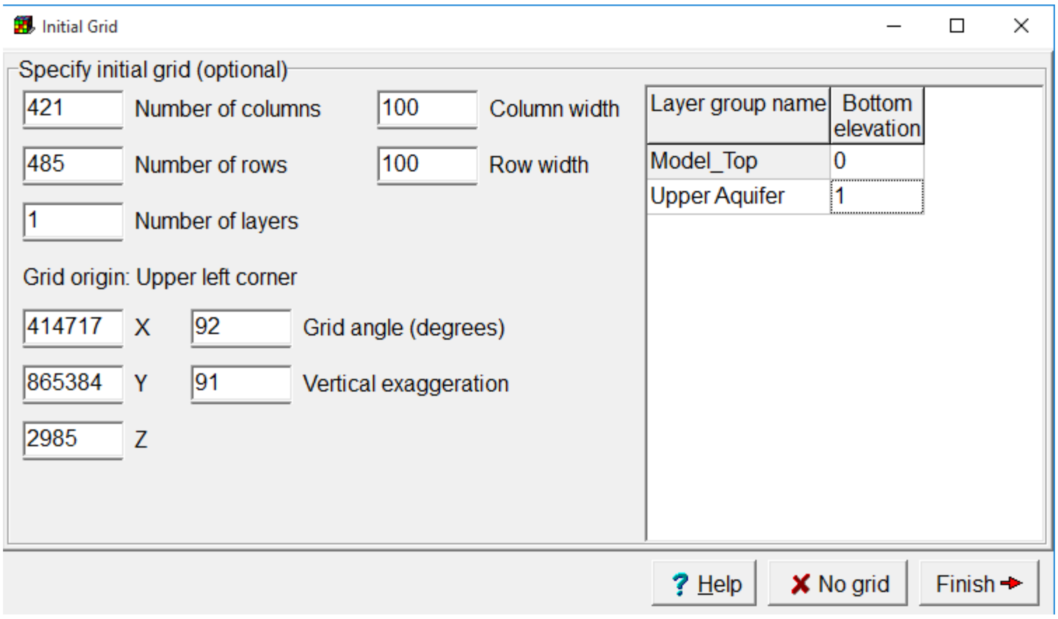

Figure :3.6 The Modelling process.

3.6.3.3 MODFLOW USGS-2005 USGS Imported Data Adjustment Stage

In this Stage Data Communication Stage of GIS Data in MODFLOW to Accept Raw Input Ground Water Data for MODFLOW.

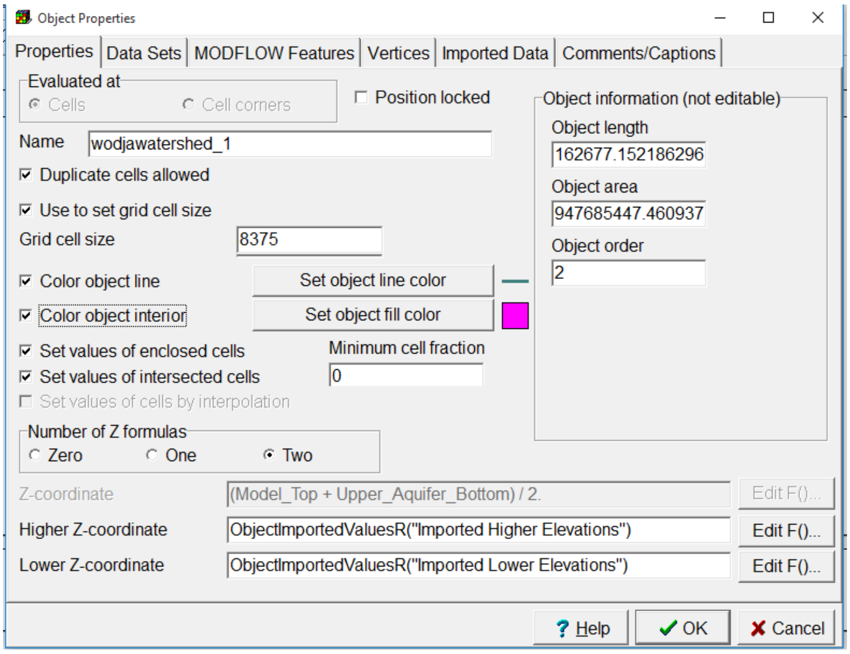

Figure :3.7 The Modelling process.

3.6.3.4 MODFLOW USGS-2005 Ground Water Data Adjustment Stage

In This Stage Necessary Hydraulics and Aquifer Parameters Data Were Organized, Fill MODFLOW Data Packages Arranged to Analysed Ground Water Flow System.

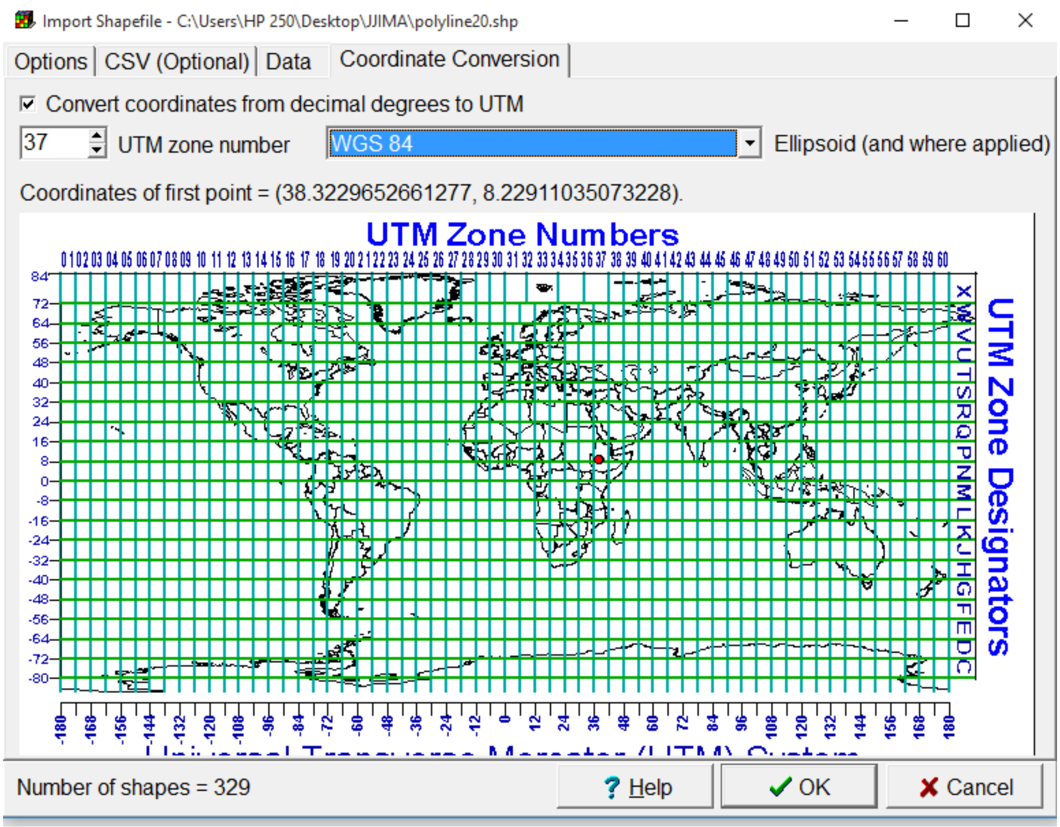

Figure :3.8 The Modelling process of Import GIS Data to MODFLOW.

3.6.3.5 MODFLOW USGS-2005 Analysed and Simulation Stage

In This Stage By Data Organization, Arranged, Re-Arranged and Calibrated Imported and Ground Water Data on MODFLOW to Simulate Time Steps Stress on Ground Water Flow System.

3.6.4. Model validation

Once a model has been selected for a particular problem at a particular site of Weja River Catchment. Model validation is the process of making sure that the model correctly describes all the relevant processes that affect the excitation-response relations of interest to an acceptable degree of accuracy. The only way to validate a model is an experiment. Although it is desirable to perform the model validation for the actual site of interest, we often validate the model in principle, i.e., ensuring that it represents the phenomena, by conducting controlled field. Unlike laboratory experiments, many features encountered in field experiments, such as heterogeneity and anisotropy, cannot be controlled or identified. Unfortunately, in many cases they dominate the system’s behaviour. If model validation cannot be implemented, it is sometimes combined with model calibration

3.6.4.1 Model calibration

Model calibration consists of changing values of model input parameters in an attempt to match field conditions within some acceptable criteria. This requires that field conditions at a site be properly characterized. Lack of proper characterization may result in a model that is calibrated to a set of conditions which are not representative of actual field conditions. The calibration process typically involves calibrating to steady state and transient conditions.

3.6.4.2 Code Verification

When a new numerical model and a code are developed for solving a mathematical model, the code is not considered ready for use unless it undergoes a proper verification procedure. Here, verification means checking that the code does what it proclaims to do, namely, to solve the mathematical model. Verification involves comparing solutions obtained by using the code with those obtained by analytical methods, whenever such solutions are possible. This is usually done for some simplified domain geometry, homogeneous materials, etc. In many cases, analytical solutions cannot be derived. The only procedure, then, is to compare code Good codes, especially commercial ones, should have documented code verification.

3.6.4.3 Model Verification

Model verification is a process to determine if the errors between the historical observed and simulated values are significant and there by establishing a level of confidence in the model verification should be objective subject to formal and rigorous statistician tests. When verifying model output it is assumed that the model is valid including model design the governing equations and computer coding. General aim of model is that simulated values should correspond to observed values as closely as possible.

3.6.4.4 Calibration Sensitivity

Sensitivity analysis is the process of varying model input parameters over a reasonable range (range of uncertainty in values of model parameters) and observing the relative change in model response. Typically, the observed changes in hydraulic head, flow rate or contaminant transport are noted. The purpose of the sensitivity analysis is to demonstrate the sensitivity of the model simulations to uncertainty in values of model input data. The sensitivity of one model parameter relative to other parameters is also demonstrated. Sensitivity analysis is also beneficial in determining the direction of future data collection activities.

3.6.4.5 Data analysis and synthesis

It involves the analysis and synthesis of the available data with a help of modeling code of MODFLOW interfaced by Processing MODFLOW (Version3.1) that consider the physical condition of the study area which can be represented with governing equation. This part of the work embarks the modeling protocol like conceptual model development, defining model geometry and boundary, assigning the hydro geological parameter, running the model and calibration.

3.7 Data Quality and Management of Study Area

The Weja River Catchment Study Area Data Basic Essential Data Were Incurred By Data Collections Processing, Assumed Based on Global Standard, Calibration Processed of Unknown Parameters to Increased Accuracy of Modeling Resulted and MODFLOW USGS-2005 Computer Programming Package was Better Modeling Cods of Privacy Ground Water Modeling Programming Because of Major Errors Were Automatically Rejected by Calibration Processed of Analyses of Result Research Objective.

4.0 Chapter Four

4.1 Result And Discussion

4.1.1 General Overview

The model is calibrated to Ground Water flow condition with observed head measured at the available production well. In addition the water balance is checked every time with regards to input values of recharge and outputs from wells and springs. The groundwater level measurement is taken during the construction and inventory time of the borehole. Because, there is no practice of monitoring the existing well standing water level and no accessing means like an observation pipe installation to easily measure the water level.

MODFLOW calculates the hydraulic heads distribution of the groundwater surface. The simulated head distribution shows the groundwater surface flow from western escarpment to east directions finally join to Mike River and Lake Ziway. The groundwater level is generally flat to gentle slope and In these areas the groundwater contour shows steep slope probably due to the nature of the rocks or the fault systems separating these zones and The Maximum and Minimum Elevation Classification of Weja River Catchment Shown On Figure Below.

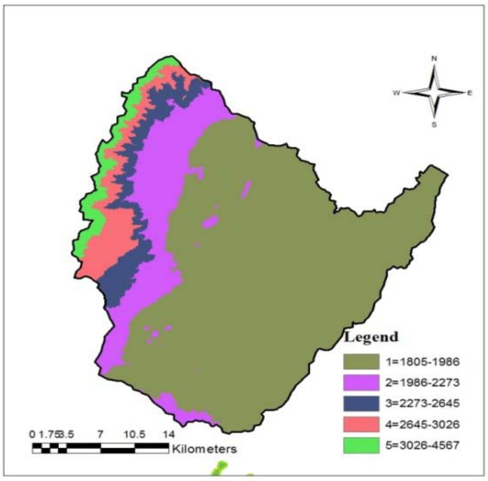

Figure :4.1 Model Elevation Boundary conditions

4.2 Ground Water Flow Calibrations of Study Area

Groundwater flow model calibration is the process of adjusting selected model parameters within an expected range until the difference between models predicated heads and the field observed heads are within selected criteria for best performance of the model (Mercer and Faust, 1993). In order to provide some assurance that the model reflects the behavior or appearance of the flow system, it must be calibrated prior to use as a predictive tool. Model calibration is accomplished by finding a set of model parameters, boundary conditions that produce simulated heads and fluxes that match measurement values within an acceptable range of Data Sets.

4.2.1Calibration Method

Ground Water Parameters Adjustments and Inverse Modeling Approaches, Modeling Ground Water Flow MODFLOW USGS-2005 Was Used Methodological Approaches of Ground Water Adjustment Method Because MODFLOW Ground Water Computer Programmed Was Adjusted all Required Missed Data Settings Were Adjustable During Modeling Processed and An Acceptable Data Were Rejected and Shown on Modeling Procedures and Re-targeted Required Data Sets and Continue Processed of Modeling Untitled Simulations of Required Targeted of Research Objectives of Study.

4.2.2Aquifer Parameters Calibration of Study Area

Weja River Catchment Ground Water Flow Modeling Was Calibrated Base on Outcomes Guidance Data of GIS to MODFLOW USGS-2005 with Adjustments of Import Shapes as Objective of Set Values of Enclosed Element, Set Values of Intersected Element and Set Values of Elements By Interpolation at Evaluated of Elements and Nodes With Modeling Observations of 84 Well Head CSV Data Adjustments With GIS Import Shapes, ACIIS and Binary Data Based on Boundary Limitation of Coordination With Settings Required Data Sets and Converted Coordination Conversion System UTM-37 With WGS-84 and Finally Arranged Import Criteria With Edited Ground Water Modeling MODFLOW Aquifer Parameters and Adjustments MODFLOW Modeling Cods and Continue Calibration Processes Untitled Satisfaction of Targeted of Objective Study.

4.2.3 Calibration Technique of Study Area

Calibration Techniques was MODFLOW Inputs Data Sets Communication of Unknown Ground Water Parameters of Study Area With GIS Imported, Physical, Numerical Modeling Known Aquifer Parameters of Study Area.

MODFLOW Flow Guided Unknown Required Ground Water Flow Parameters Simulations During Procedures of Data Settings With Showing Symbol of Warning Errors and Blocking of Next Steps Data Sets and Backed to Errors Data Sets and Continue Calibration of Required Parameters of Hydraulics and Aquifer Parameters of Modeling MODFLOW Untitled Satisfy Data Sets Criteria to Processed of Result of Objective Study.

4.2.3.1 Modeling Boundary Condition

Weja River Catchment Study Area Modeling Were Limitation Based on Simulations of Starting of Streams Flow System and Highest Elevation Pointed Coordination of Catchment of Study Area and Modeling of Ground Water Flow MODFLOW Simulated Local Ground Water Flow Boundary of Weja River Catchment of Stagnation Point to Others River Sub-Catchment of Basin With Respect to Study Area and Detailed Limited Boundary Coordination Simulation Was Analyses on MODFLOW-2005, Shown on Appendix

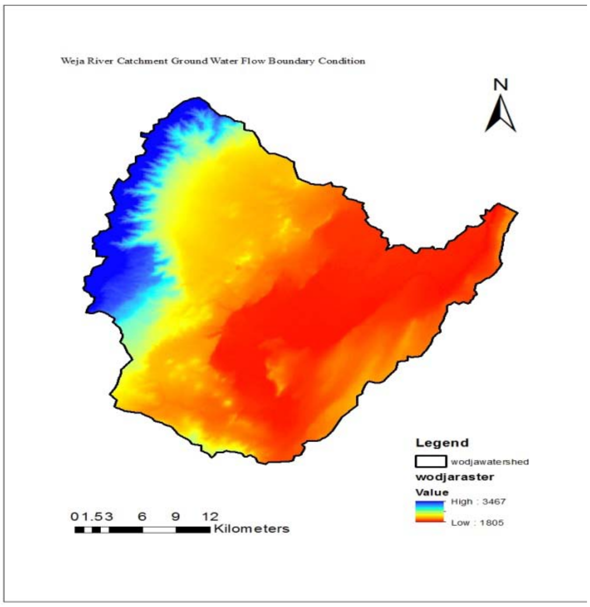

Figure :4.2 Model Ground Water Flow Boundary conditions

4.3.2Spatial Discretization

The MODFLOW Model difference grid representing the Weja river catchment covers approximately 967Sq Km .Illustrates the model grid in plain view. Additionally it shows that the model domain in MODFLOW exceeds the study area defined in the conceptual model.

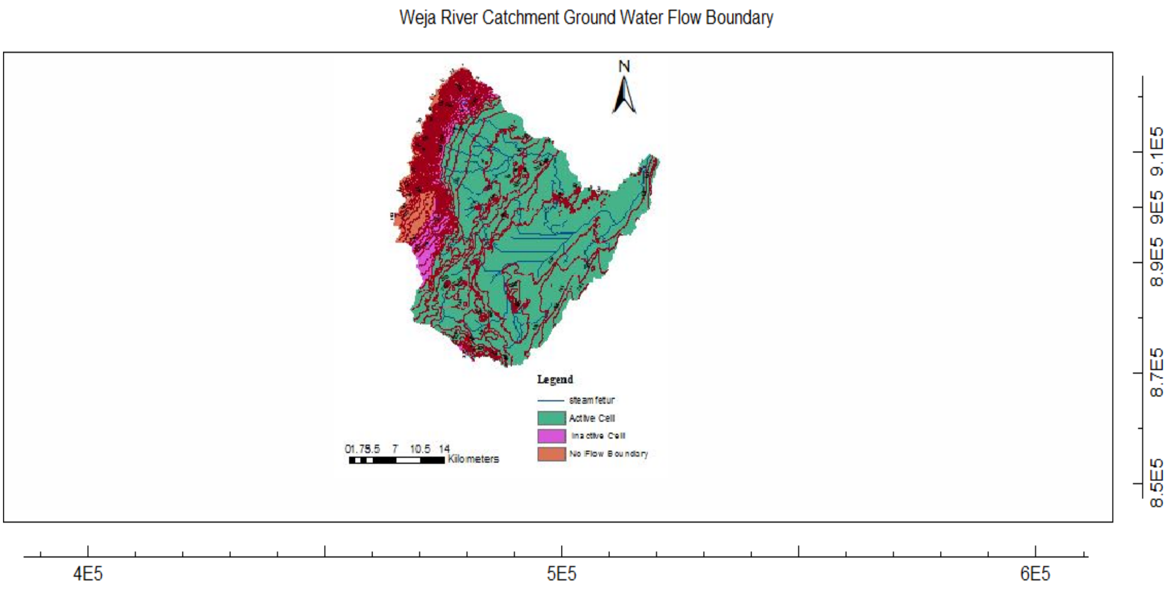

Figure :4.3 Model Stream FlowBoundary conditions

So, we defined the bound by first establishing the lateral extent of the formations in each layer using the catchment boundary map and assigned a cell as active if the formation covered on cell area.

Meshes Spaces and Length of times Steps was Estimated, when numerical model was used in Spacing and time Increments must defined.The model domain spans of finite difference grid has 421 columns, 485 rows, and one vertical layer for a total of 8375 cells.

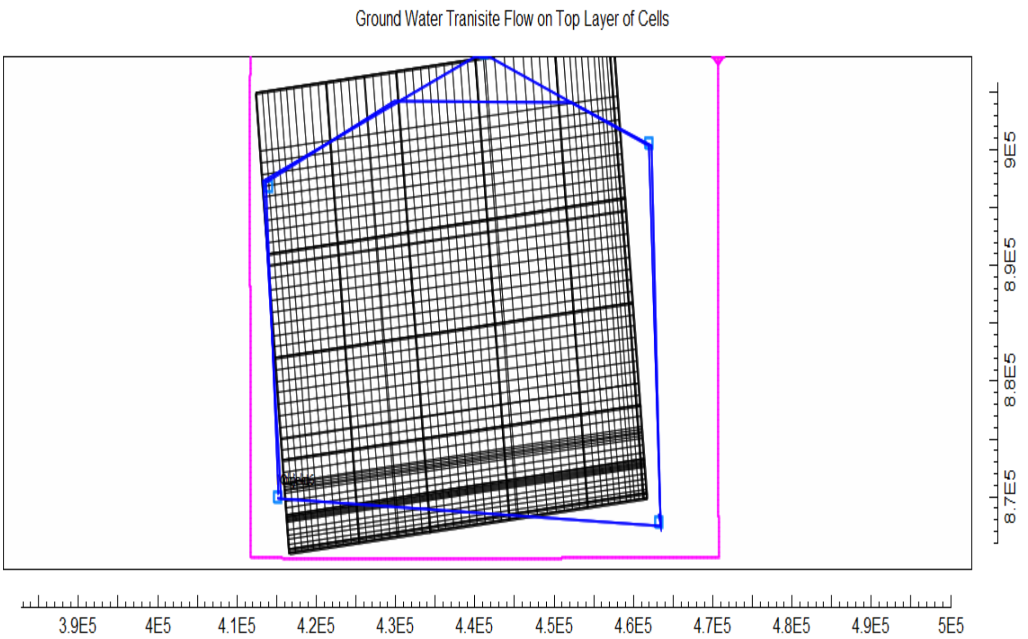

Figure :4.4 Model Sub grid design and Child Cell.

4.3Starting Conditions

Initial conditions refer to the head distribution everywhere in the system at the beginning of the simulation (MODFLOW USGS-2005). If the field measured head values were used as initial conditions, the model response in the early time steps would reflect not only the model stress under study but also the adjustment of model head values to offset the lack of correspondence between model hydrologic inputs and parameters and the initial head values (Franke et al., 1991).

Therefore, in the model, user specified initial head distribution obtained from the first steady state simulation was used as initial and prescribed hydraulic head for the model, where the first steady state simulation uses initial and prescribed hydraulic head by Measuring from top of layer of the model obtained from a 30 m by 30 m resolution RASTER DEM of the catchment.

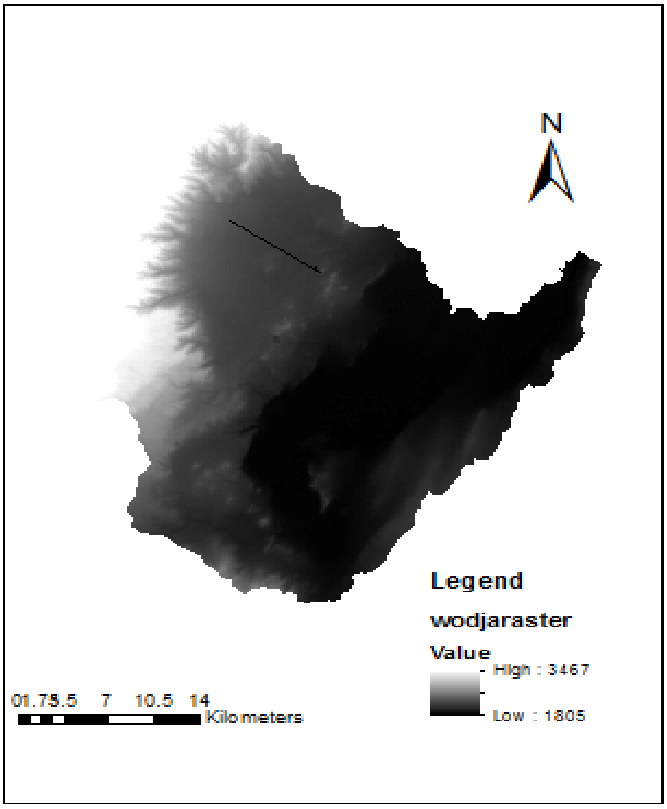

Figure :4.5 Model Raster DEM Design and lateral Boundary Conditions

4.4Analysis of Ground Water Flow

The Ground water flow system and Directions of flow on Catchment were analyzed by Scenario by Considering the Elevation Difference of Observed well, Stagnation point of Rivet Valley and GibbeCatchment to Outlet of Study Catchment.

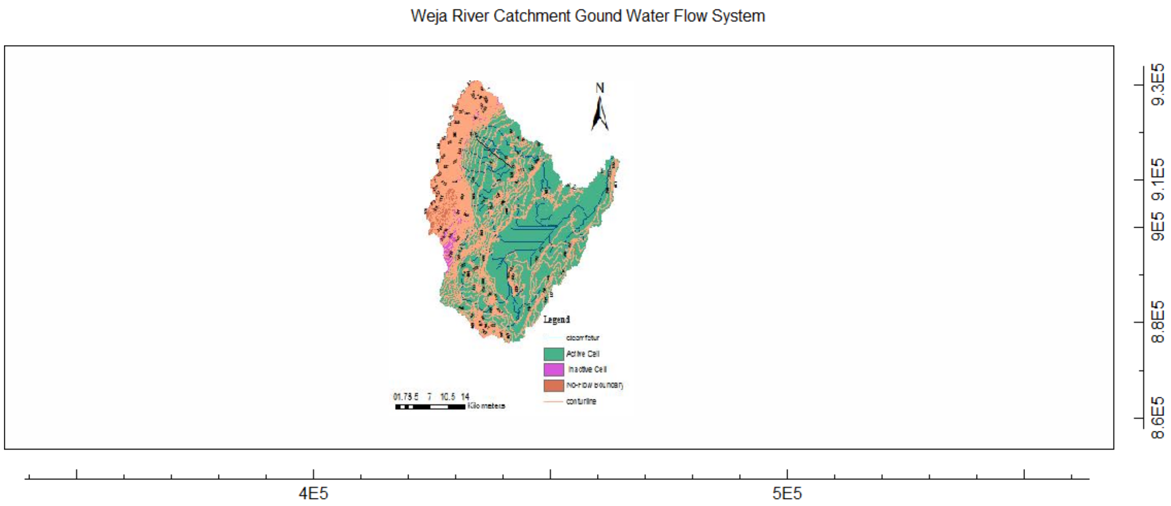

Figure :4.6Weja River Catchment Ground Water Flow Systems.

4.4.1 Ground Water Flow on Measured Water Level and Simulated Head

Ground Water Flow System Study Area Were Analyzed on Indirect Method by Using Observed and Simulated Head of Numerical Modeling Approach; Based on basic Equation (Appendex-11),

The three Dimensional equations for unsteady flow of Ground Water with Change of Head and times travel of Ground Water flow Rate; Ground Flow System of Study Area Change of Local Observations Head Witn Simulation Head Numerical Modeling of Cell Sized Spaces of Nodes Were Estimated by 3D Ground Water Finite Numerical Modeling Equations of L^2=10*7*9125/0.25,638750/0.25L was 1598.4367 m, and Approximate to 2000m,

These Numerical Modeling of Simulations Shawn that Ground Water Flow System with Length of Time Travel to Change of Between Head of Changed of Ground Flow System of Study Area. and Length of Ground Water flow change in head used for Initial Conditions of Diminution Cell's.

The Ground Water Flow System of Study Catchment Were Evaluated by from Specific Single Cell to Overall Study Catchment Simulation Approach:

1, The Magnitude of the Head Difference of each Cell was given by as;

The Observed Head Maximum of Stream Flow Catchment, hs was 38m, and the Simulated Head of MODFLOW Modeling, hm was 46 m. and Number of Cell on Study Catchment, Simulated by GIS and Ground Water Computer Programming as Column Were 421 and Rows Were 485.

The Minimum Observations Head, hs was 8m and the Minimum Simulated ByModeling Tool, hm was 11m.

Due to these Ground Water Aquifer Parameters Was Evaluated as charge of total Difference head/number of Cell of Rows,hs was 38-8/485,hs was 0.647m

The total Charge of simulated head across study's Catchment,

∆hm was 46-11/485,∆hm was 0.75m

2,Change of Ground Water Level Head across Catchment of Study Area,

∆H=Average of Observed and Simulated Head,

∆H was evaluated as 0.647 + 0.75m/2 was 0.68m,

The Maximum Change of Head through Study Area of Ground Water Decline were BH Evaluated total Head Difference Were 46m-38m was 8m.

Therefore the Minimum Change of Head through Study Area of Ground Water Decline Were BH was 11.5-8 was 2.5m.

Based on (Hurbbert,1940) Appendix-11 Ground Water Analysis Method Ground Water flow Analysis of Weja River Catchment as;

The Scenario Analyzed Observed and Simulated Head Difference from Zero on Catchment of Study, The Systems of flow on Catchment were Unsteady State flow System of Ground Water on Areas of Weja River Catchment and Directions of flow from Higher Elevation to Lower Elevation with Approximately Parallels with Weja River Catchment Stream Flow.

Numerical Ground Flow Modeling of the Meki River Catchment of Ground Water Level was Generally Falt to Gentle Slope Except at Tora, Koshe and Dugda Ridge and Weja and Mekki River Catchment Contour Shows Steep Slope Due to Nature of Rock and Ground Water Flow from Western Escarpments to East Directions Finally Joins Lakes Ziway (DerejeBerihanu, 2011).

4.4.2 Analyzed Ground Water Flow Simulation on MODFLOW USGS-2005

Ground Water Flow System of Study Area and Stress Response for Aquifer Parameters Were Simulated By MODFLOW-2005 Ground Water Computer Program of Direct Approach of Automatic Displayed on Tools.

Weja River Catchment Ground Water Flow System Were Simulated By Modeling of MODFLOW USGS-2005 Based on Observations Head, Analyses of Computer Programming Simulated Head, Elevation Boundary Condition of Local Ground Water

Flow System of Stagnation Coordination and Ground Water Extraction for Community Modeling Predicted System of Ground Water Flow Were from Steady State System to Transient and Un Steady State Flow System on Study Area and Mostly Highest Ground Extraction Were Simulated By Modeling MODFLOW on Eastern Part of Refit Valley of Weja River Catchment Sampled BH Coordinated Study Area.

Therefore Scenario Analyzed Ground Water Flow System, Stress Period, Drown Dawn, Time Steps of Study Area Were Automatic Calculation of Output Result and OutputTime Control Were Simulated Analyses Detail Result on Appendix.

Table :4.1 Ground Water Flow System, Stress Period, Drown Dawn, Time Steps of Study Area

Length	Max first time step length	Multiplier	Steady State/ Transient
0	0	0	

Stress period	Starting time	Ending time	Length	Max first time step length	Multiplier	Steady State/ Transient	Drawdown reference	Number of steps (calculated)
2	31557600	63115200	31557600	1	1	Steady state	☑	31557600
3	63115200	94672800	31557600	1	1	Steady state	☑	31557600
4	94672800	126230400	31557600	1	1	Steady state	☑	31557600
5	126230400	157788000	31557600	1	1	Steady state	☑	31557600
6	157788000	189345600	31557600	1	1	Steady state	☑	31557600
7	189345600	220903200	31557600	1	1	Steady state	☑	31557600
8	220903200	252460800	31557600	1	1	Transient	☑	31557600
9	252460800	284018400	31557600	1	1	Transient	☑	31557600
10	284018400	315576000	31557600	1	1	Transient	☑	31557600
11	315576000	347133600	31557600	1	1	Transient	☑	31557600
12	347133600	378691200	31557600	1	1	Transient	☑	31557600
13	378691200	410248800	31557600	1	1	Transient	☑	31557600
14	410248800	441806400	31557600	1	1	Transient	☑	31557600
15	441806400	473364000	31557600	1	1	Transient	☑	31557600
16	473364000	504921600	31557600	1	1	Transient	☑	31557600
17	504921600	536479200	31557600	1	1	Transient	☑	31557600
18	536479200	568036800	31557600	1	1	Transient	☑	31557600
19	568036800	599594400	31557600	1	1	Transient	☑	31557600
20	599594400	631152000	31557600	1	1	Transient	☑	31557600

The Regional Ground Water Flow System of Study Area Were Simulated Depends and Controlled By Elevation Difference Topography of Western Highland Escapement to Rift Valley Lowest Elevation of Mekki and Lake Ziway, Community Water Depends Was Influenced by Environmental Condition Due to From Highland of Worabe and Butajira Area of Low Consumers to Highest Consumers of Eastern Parts of Koshe and Dugeda Area, and Wet lands of Geribebar and AshuttieBuraqo to Dry Lands of Mekki and Lake Ziway of Highest Ground Water Extraction for Differences Purposes Area of Meki and Battu Town.

The Local Ground Water Flow System of Study Area Simulated By Modeling MODFLOW of Influenced by Over Extraction of Ground Water for Differences Purposes to Increase of Demands, Due to these Ground Water Flow System from Steady State to Transient to Un Steady State Flow System, and Ground Water Levels of Study Area Declined and Drown Dawn of Were Increased with Time Series, Direction of Flow Under Controlled to Specific Area of Radial flow for Balanced System of Flow and to Reduces Stress of Aquifer Parameters.

4.4.3 Observed and Simulated Head

Model Calculated Head Result on diagram showing between the observed and simulated heads for Stress Response for Ground Water Parameters and a plot show deviation from the straight line in adistribution of Parameters in the Form of Points on Study Area.

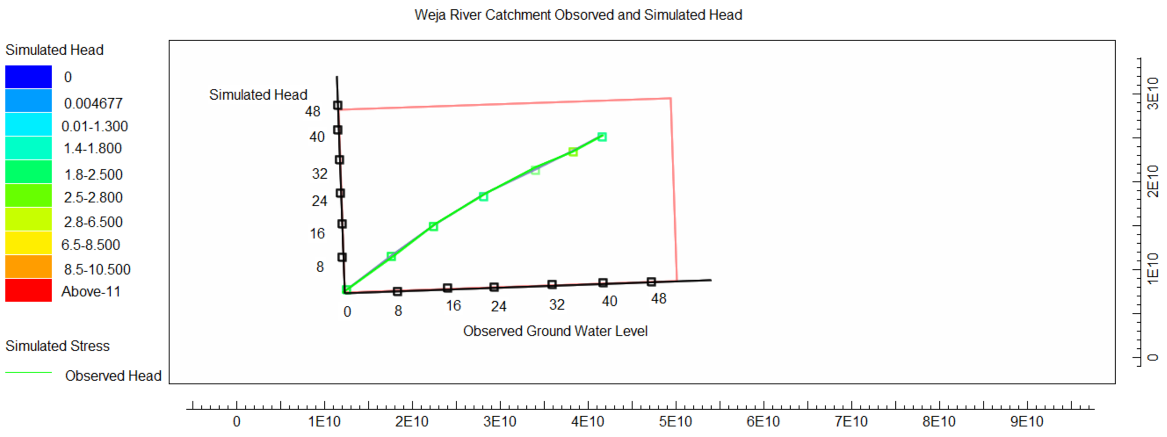

Figure :4.7 Calibrated Observed and Simulated Head Result

2.5 Ground Water Aquifer parameters of Study Area

4.5.1 Hydraulic properties

In this model groundwater flow within the layer was assumed to be horizontal. Hydraulic conductivity can be defined as the volume of water that will move through a porous medium in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow. Hydraulic conductivity is a function of both the medium and the fluid. Transmissivity which is the product of hydraulic conductivity and saturated thickness is the rate at which water flows through a vertical strip of the aquifer one meter wide and extending through the full saturated thickness, under the hydraulic gradient to indicate how much water will move through the formation.

TheGeneral Guide Common Range of Hydraulic Conductivity and Transmissiviety at Normal Temperature (10^0 to 25^0).

Table :4.2 Common Range of Hydraulic Conductivity and Transmissiviety at Normal Temperature (10^0 to 25^0), Source; (Anderson, 1982)

Materials	Hydraulics Conductivity(m/d)	Transmissiviety (m2/d)	Comment
Basalt flow	0.00001-100	200-100	Dense Un fractured
Basaltic formation	0.01-20	20-200	Pyroclastic
Resent Basaltic	1-1000	100-100000	Unaltered
Loose Pyroclasts	0.1-50	10-500	Younger
Phoneslitics	0.1-20	20-1500	Effective of major fusser
Alluvium	1-10	2-200	Poorly Storage

By usingSimulated model calibration, sub zone delineation and estimated values were determined within reasonable limits estimated during the conceptual model. Since it is unconfined aquifer, the model was allowed to calculate changes in theTransmissivity as the saturated thickness changes in the aquifer. The effective porosity was Automatic Calculated on Tools was 0.25,and each Cell of Study Area Aquifer Parameters Detail Described on Appendix-10.

4.5.2 Hydraulics Conductivity of Study Area

The very essential parameter in the aquifer system is the hydraulic conductivity that defines the flow rate of the groundwater in the aquifer system. The model uses the spatial distribution of the hydraulic map described in the conceptual model to begin the model simulation.

Hydraulics Conductivity and Stress Response of Ground Water Were Simulated by Different Methodological Approach;

The Hydraulics Conductivity of Study Area WereSimulationBy Using Tools As;

By Delineation Weja River Catchment Raster DEM, Hydrological and Ground Water Boundary with Input Necessary Input Data for Tools and Analyzed Hydraulics Conductivity of Study Area With Stress Response for Simulation.

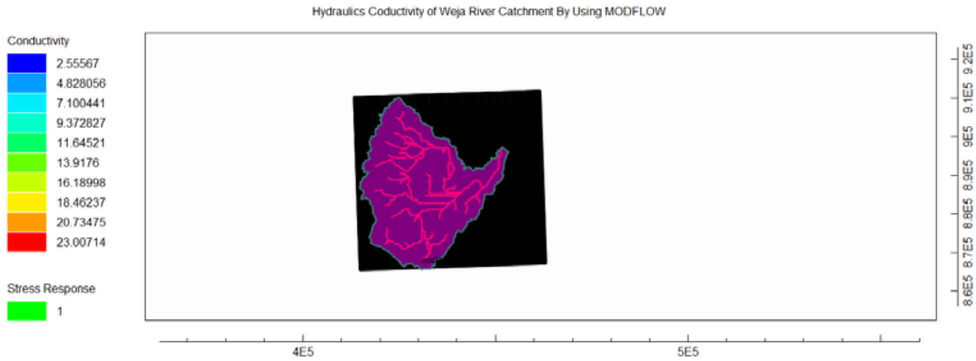

Figure :4.8 Calibrated hydraulic conductivity map of Weja river catchment

Based on Modeling Tools Simulated Magnitudes of Hydraulics Conductivity of Eastern Part of Study Area Were 2.5m/day to 23m/day and Average Catchment of Study Area Each Cell of 3D An Horizontal an Isotropic Hydraulic Conductivity, Porosity, Specific Storage of Study Area Were Detail Described on Appendix-10.

TenalemAyenew Analyzed Hydraulic conductivity of all Weja and Mekki River Catchment on PHD Study Program, The western escarpment or highlands of Gurage Mountain have permeability ranging from 0.1 m/day to 1m/day (TenalemAyenew, 1998).

Modeling MODFLOW of Study the Ground Water Modeling of Hydraulics Parameters and Aquifer Parameters Were Dependent of Each Other’s But Hydraulics Conductivity was Most Essential Ground Water Aquifer Parameters of Modeling MODFLOW Because Increased or Decreased of Conductivity Automatically Influenced and Affected Others Ground Water Aquifer Parameters.

Due Increasing of Hydraulics Conductivity Study Area was Increased of Drawn Dawn, Storage Coefficients Going to Decreased, Regional Ground Water Stagnation Area and Boundary Increased and Ground Water Flow Boundary Decreased, Ground Water Out Flow Increased, Porosity and Void Spaces on Ground Surfaces and Decreased With Increasing of Shrinkages of Ground Water Saturation Zone of Study Area and Eastern Catchment of Some Specific Area of Tora, Koshe and Dugeda Study Area Magnitudes of Hydraulics Conductivity More than 15m/day Simulated Stress and Warned than Others Area of Boundary of Weja River Catchment Study Area.

4.5.3 Hydraulics Conductivity of Sub-Catchment of Study Area

MODFLOW Analyzed Aquifer Parameters Stress Response for Ground Water flow System of GIS Analyzed Data With Translated USGS Ground Water Flow System Computer Programing Cod and Converting Data in the Form of ASCII, Binary and Text File Forms.

MODFLOW Simulated Hydraulics Conductivity of Weja River Catchment by Using ASCII,Binary, Text and Input Other Necessary Ground Water Raw Data. Finally Magnitudes of Hydraulics Conductivity of Eastern Part of Study Area Were 2.5m/day to 23m/day and Average Catchment of Study Area Each Cell of 3D An Horizontal an Isotropic Hydraulic Conductivity, Porosity, Specific Storage of Study Area Were Detail Described on Appendix-10.

TenalemAyenew Analyzed Hydraulic conductivity of all Weja and Mekki River Catchment on PHD Study Program, The western escarpment or highlands of Gurage Mountain have permeability ranging from 0.1 m/day to 1m/day (TenalemAyenew, 1998). The rocks comprising this zone are highly welded ignimbrites, tuff, rhyolite and trachyte without visible large faults. The upper weathered rock and soils are permeable; however, the underlying volcanic sequences are massive.

Butajira Pediment, Kuntane-Inseno-Kela plain, Tora-Koshe-Dugda ridge and North

Eastern area based on the characteristics of ignimbrite, fracturing and weathering grade, the units possess 4m/day to 12m/day permeability value (TenalemAyenew, 1998) and 1.5m/day to 20m/day (TenalemAyenew, 2008)

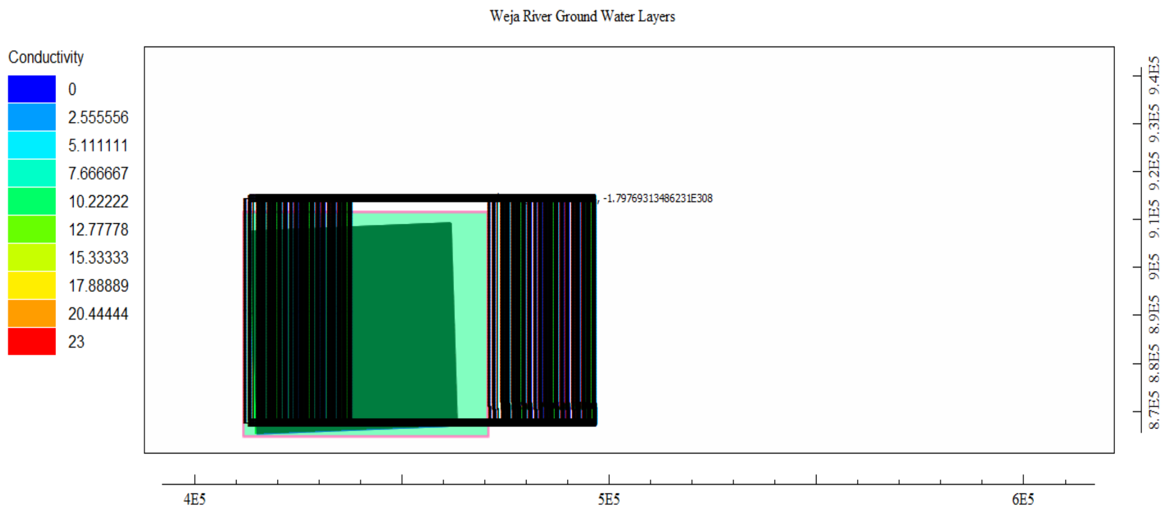

Figure :4.9 Calibrated hydraulic conductivity map of Weja river catchment

4.5.2 Hydraulics Parameters

4.5.2.1 Recharge (q)

Recharge is a specific flux boundary which is independent of the head of the cell but MODFLOW consider it as a property for spatially distributed all over the model area. Recharge to the model consisted of infiltration from direct precipitation, stream infiltration draining the eastern escarpment and artificial recharge of irrigation-return flow. Recharge was applied to the active model area as a spatially varying, specified flux to the highest active cell. In general, precipitation recharge varies spatially with land surface permeability, which is a function of soil characteristics and land use, and spatial distribution and intensity of rainfall. The recharge stated used on the conceptual model is also used as an input to model parameter (McDonald and Harbaugh, 2008)..

The recharge is the most essential parameter of the aquifer system that governs the water budget system and MODFLOW USGS-2005 Require Time Steps Recorded Data Within Per Year from Half Year to Year to Year Recharge, Hydraulics Parameters and Aquifer Parameters Data to Simulate Accurate Time Steps Stress Response of Hydraulics and Aquifer Parameters But Such Data Recorded Measurements Didn't Adopted by Study Area and Our Country and To Analyzed Result and Minimize Input Data Error Adjust Input Raw Data for Tools of Measured Data Scarcity of Study Area

By Using Metrological Gauged Rainfall Precipitation Data and Considering Surface Water Route With Guide Helps Modeling Approach Percolations of Ground Water Recharge Were Estimated for MODFLOW.

Recharge is the volume of the water that joins the saturated zone of the aquifer. It is a term used to describe many of the processes involved in the addition of water to the saturated zone (Wilson and Miller, 1998). Groundwater recharge to the aquifer may occurs naturally from precipitation, rivers, canals, lakes, as man induced phenomena (irrigation, urban recharge). Recharge could also be direct, indirect or localized based on the source and mechanism by which water reaches the water table. The quantity and type of recharge depends on topography, geology, climate, soil zone, land use and cover, drainage, geographic location, vegetation, structure and other.

The calibrated recharge rate for each hydrogeological zone and the estimated Recharge of the Study Area were analyzed by MODFLOW assuming geological limitations and overall study's area of average rate ratio with Soil Types Classification by Considering Variation of shape of Stagnation of Ground Water to Outlet of Catchment and the total Recharge for Initial Conditions Adjusting of MODFLOW were taken from the Cell Square was given by (Hubat, 1940);

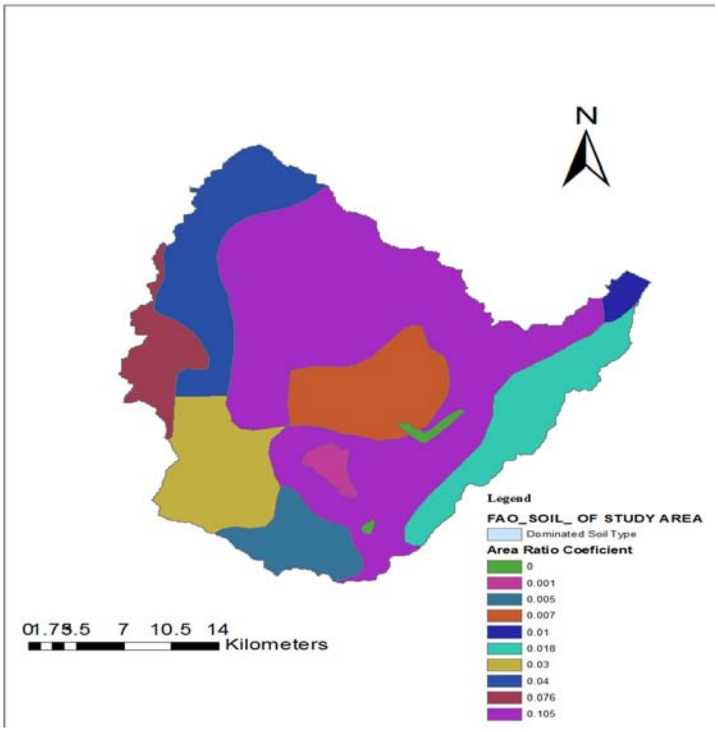

Figure :4.10Weja river catchment AreaMODFLOW Input Recharge Zone

The Average Rainfall of Weja River Catchment Were 908.76mm per Year and The Average Rainfall Intensity of Study Area Would be 908.76mm/8760hr were 0.10374mm/hr or 10.374cm/hr.

4.5.2.2Groundwater discharge (Q)

In the study area, discharge from groundwater systems includes groundwater withdrawal, groundwater outflow to the adjacent Lake Mekki River Catchment and discharge to stream and springs. In themodel, different MODFLOW packages were used to simulate these discharge components.

Aquifer system is not only with an input of a recharge but also releases its resource out of the system. The major removal of groundwater from aquifer system of the study area is possibly occurred through abstraction of water wells, springs, base flow to surface water body, inter basin or aquifer system transfer and evapotranspiration. In the study area discharge to streams occurs as Springs seeps and Were Detail Described on Appendix for Each Well Head Drawn Dawn.

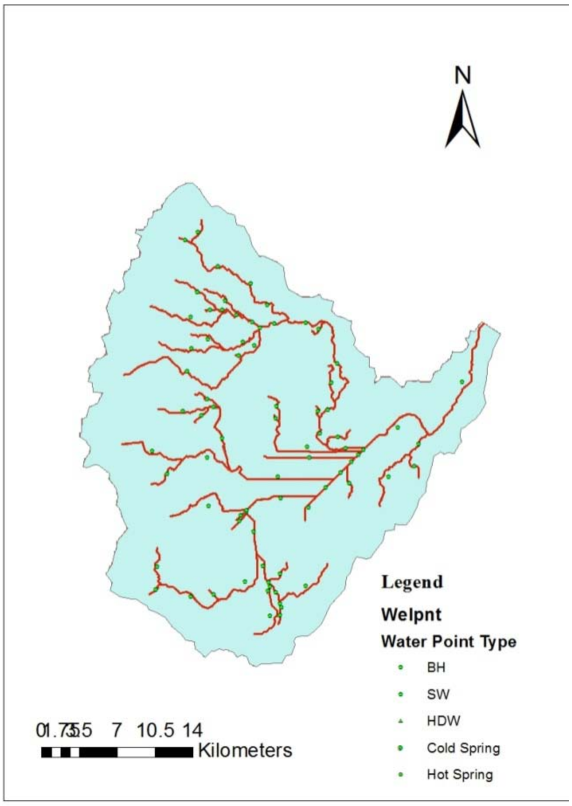

Figure :4.11 Calibrated hydraulic conductivity map of Weja river catchment

The Estimated Discharge of Study Area Analyzed by MODFLOW by Considering the Rate of flow through Square Cell of each flow net by assuming the Size of Cell through the Study Area Approximately Square.

The Magnitude Calibrated of Discharge for Initial Conditions Adjusting ofMODFLOW were taken from the Cell Square was given by Darcy laws as and (Hubat,1940);
The Analyzed Discharge,fromCross-sections Area of flow Q goes through, The Magnitude of Head Difference between Adjacent Constant Head.The magnitudes of Outflows Discharge from Aquifer of Study Area.

4.6Estimate Weja River Catchment Stream Flow

Weja River Catchment Stream Flow Was Sub-Catchment of Mekki River Catchment Stream Flow in Main Ethiopia Rift Valley System, and The Study Area Steam Flow Was Don't Recorded on Minster of Water and Energy, Due to Sub-Catchment of Mekki River Stream Flow, Weja River Catchment Covered Area Was Less than 1000 S.Km Because Steam Flow More than 1000 S.Km Have Recoded Data at Data Center, and To Solve Challenges Data Scarcity on Study Area Estimated Approach as;

1, Area Ratio 2, Regionalization Data Approach,

Area Ratio Method Were Simplest and Better than Others Because During Estimating Unknown Parameters These Method Had Less Unknown Value.

Therefore Weja River Catchment Stream Flow Data Was Calculated By Using Area Ratio Numerical Modeling Tri- and Error Approach Mekki River Catchment Recorded Data Center, and Area Covered of Weja River Catchment Was 967S.Km and Mekki River Was 2018S.Km By Using Area Ratio Approach of(A1/A2, 967Skm/2018SKm) was 0.47919.

The Estimated River Leakage boundaries were Used to Represent Discharge from resistant river bed to Under laying Aquifers, Discharge from resistant drains and other similar features, not in direct contact with aquifers. The Leakage was Represent by Discharge(Q) that added to Qs and Detail Simulation Were Described on Appendix.

4.6.1 Weja River Catchment Stream and Ground Water Flow Stress Responses for Simulation

4.6.1.1 Weja River Catchment Stream Flow

Weja River Catchment Was one of Sub-Catchment of Mikke River on Ethiopian Main Ethiopian Rift Valley and Area Was Expose to Valley System, Due to Ground Water Level Western Part of Highland Mountain Gurage Zone and Silite Zone Ground Water Level Intersect With Low Land of Rift Valley Ground Level of Original Land Surface, Due to Ground Water Outflow in the Form of Many Stream Flow System, Like Irinzafe,Lebu,Moritute, Merache and Form Weja River Catchment and join With Mekki River Finally Join on Lake Ziway.

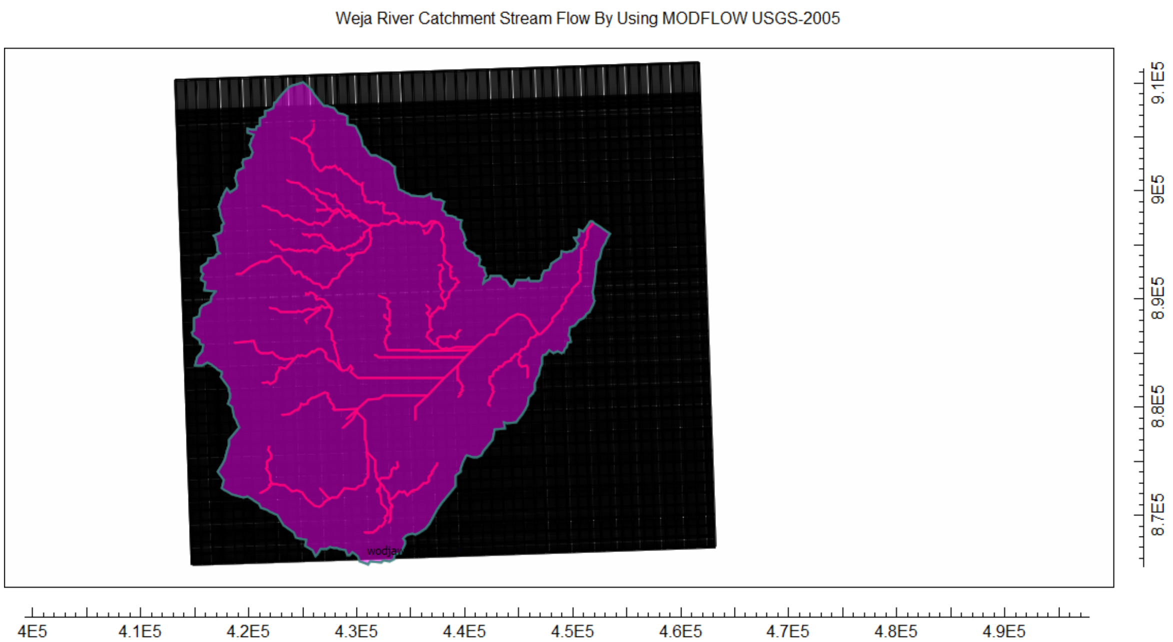

Figure :4.12 Stream Flow Future Simulation the Mirror Image of Ground Water Level Change

4.6.1.2 Weja River Catchment Stream Flow Stress Responses By Using GIS

Stream Flow Feature Simulation Were One of Method of Prediction Stress On Ground Water Flow Parameters and Ground Water Level Fluctuations, Ground Water Flow Parallel With Stream Flow(MODFLOW USGS-2005) Stress Response on Stream Flow Similar With Ground Water Flow Parameters.

The Stress Response of Weja River Catchment Would the Mirror Image of Stress Prediction on Ground Water Flow Parameters.

Therefore Extraction of Ground Water Outflow Continue By Man Mad and Natural System ArcGIS Analyzed Stream Feature Shown on Figure Many Streams Flow of Weja River Catchment Would Going to Dry and Ground Water Level and Drown Dawn Increase time to time.

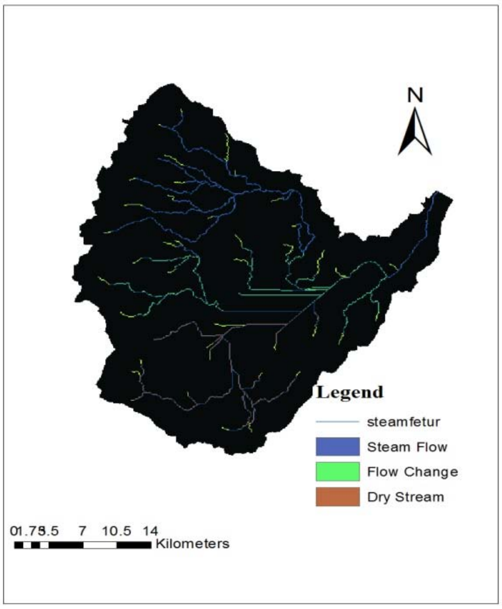

Figure :4.13 Stream Flow Future Simulation the Mirror Image of Ground Water Level Change

4.6.1.3 Weja River Catchment Stream Flow Stress ResponsesBy Using MODFLOW

One of Method to Analyzed Stress Response of Hydraulics and Aquifer Parameters Would By Using MODFLOW.

The Study Area Stream Flow System from Higher Elevation Stagnation Point of Regional Ground Water Flow System Boundary of Gibe River Catchment to Rift Valley of Study Area Boundary Outlet Was Shawn on Figure Below

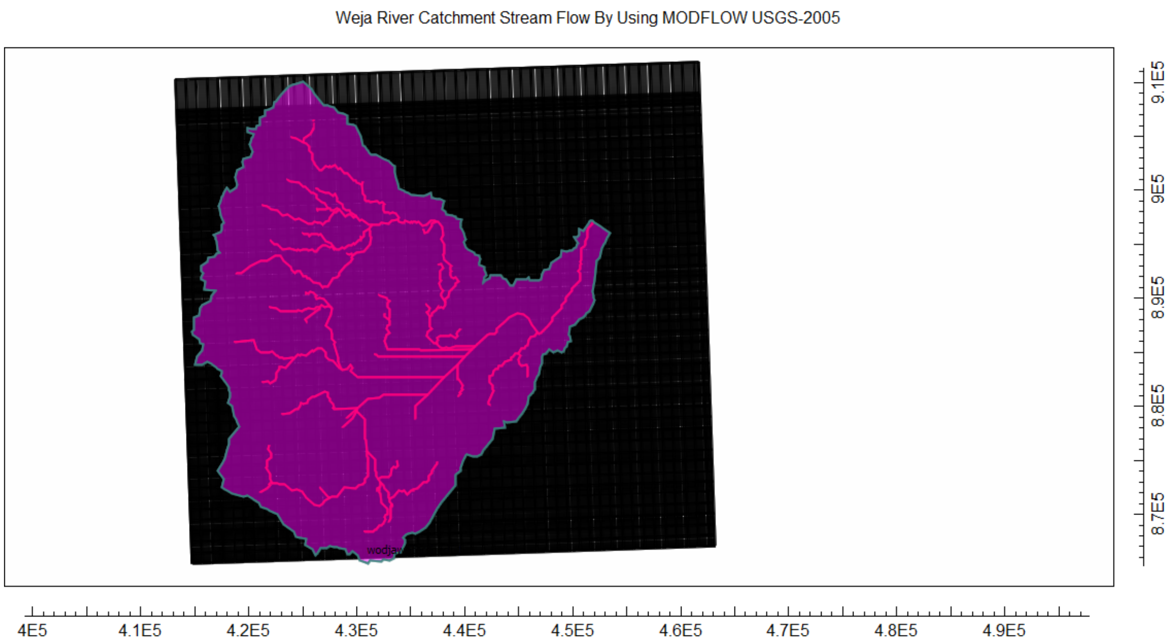

Figure :4.13 Stream Flow Future Simulation the Mirror Image of Ground Water Level Change

MODFLOW Analyzed Simulation of Stress on Weja River Catchment by Two Major Approach;

1, By Using ArcGIS DelineationWeja River Catchment Raster Data and Input Necessary Raw Data on Tool and By Analyzed Stream Flow System and Evaluate Stream Feature of Catchment,

2, MODFLOW Analyzed Stress Response of Stream Flow and Ground Water Flow Parameters By Using Output Data of Stream Feature By Translating GIS Data to USGS of Ground Water MODFLOW Computer Programing COD and Simulation Stress on Ground Water Flow Parameters and Stream Flow.

Mekki River Catchment Numerical Ground Water Flow of second scenario simulated by the model is a decrease in recharge by 25 percent which could be the case if mild drought conditions were imposed on the aquifer system while water extraction is maintained at current rates. The decrease in recharge caused more inflow from constant-head boundaries and Decrease stream flow but decrease drains. Simulated drought condition showed a reduction of water level (Deraj B. 2011).

Therefore MODFLOW Analyzed Stream Flow of Weja River Catchment Would Going to Completely Dray and Ground Water Level and Drown Dawn Increase time to time.

In this discretization process, the model domain is represented by a network of grid cells or elements and the time of the simulation is represented by time steps.

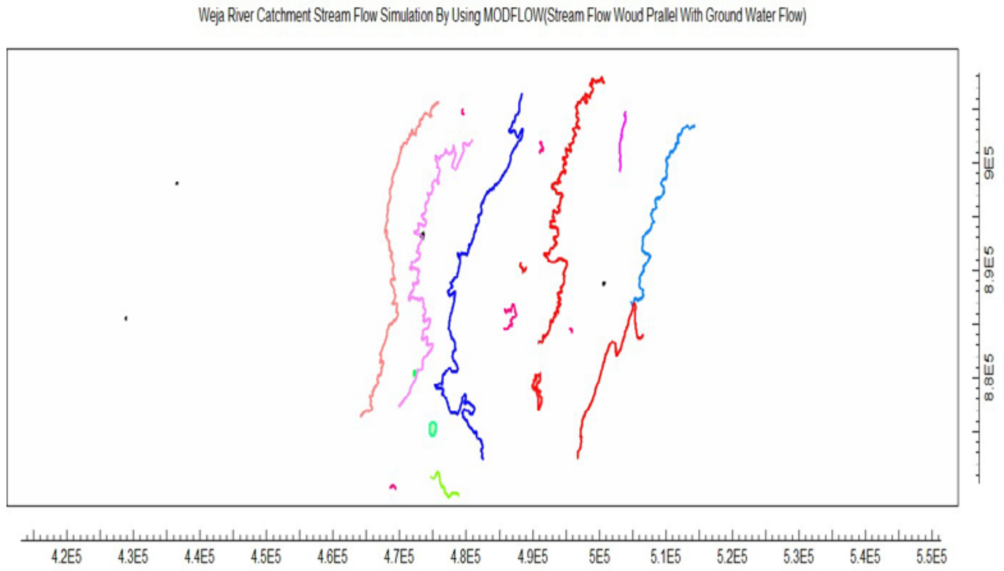

Figure :4.14 Stream Flow Future Simulation the Mirror Image of Ground Water Level Change

The Weja River Catchment Based on Physical Modeling, Numerical Modeling and MODFLOW Modeling of Regional Ground Water Flow System and Surface Water Body Were Linked and Mirrors Images of Each Other's Because Within Regional Ground Water Flow System Sources of Ground Water and Stream Flow Were Inter Changeable on Up Stream of Catchment Sources of Stream Flow Were Ground Water, and Included Specific Flow Boundary on Catchment Dawn Stream Sources of Ground Were Stream Flow and Others Surfaces Water Body.

Modeling MODFLOW Analyses of Study Area Ground Water Flow System in Aquifer of Saturation Zone Was Parallel With Stream Flow Systems on Ground Surfaces of Water Body Under Flow System, But Geological Condition of Specific Area Were Controlled 1% to 5% of Direction of Ground Water Flow System in Aquifer of Saturation Zone, Due Stress Simulations of Streams Flow of Study Area Was Mirrors Images of Ground Water Aquifer Parameters of Study Area.

4.7 Sensitivity Simulated for Study Area

Model sensitivity analysis is performed to quantify the uncertainties in the calibrated model caused by uncertainty in the estimates of aquifer parameters, stresses and boundary conditions (MODFLOW USGS-2005).

Sensitivity analysed for Weja River Catchment Ground Water Flow System and Aquifer Parameters Were Time Steps Response for Natural and Man Mad Influence of Study

Area Stream Flow, Ground Water Flow System and Aquifer Parameters Were Predicted By Using MODFLOW USGS-2005 to Stress Response for Parameters Were As;

1, Scenarios Analysed the Study Area System of Flow for Ground Water Extraction and Natural Drain System (spring) Simulated time Steps Response that Due to Over Extraction of Discharge the Ground Water Flow System Were Time Steps Transited Flow From Steady State to Unsteady State Ground Water Flow System and Drawn Dawn Was Increased Increased Time Steps.

2, MODFLOW USGS-2005 Analysed the Hydraulics Conductivity of Ground Water Flow System Were Increased Time Steps and Porosity and Other Most Aquifer Parameters Were Decreased Due to Increased Ground Water Outflow and Over Extraction of Ground Water Storage Reservoir.

3, The Weja River Catchment Study Area Source of Stream Flow Were From Ground Water Storage Reservoir Outflow to Surface Flow System in the Form of Stream Flow or springs.

Therefore Scenarios Simulated that Due to Over Extraction of Ground Water Level of Ground Water Decline and Drown Dawn Were Increased Time Steps Due to that Ground Water Outflow System by Spring Outflow Were Decreased and the Study Area Surface Stream Flow Were Time Steps Dries Stream Were Formed on Weja River Catchment.

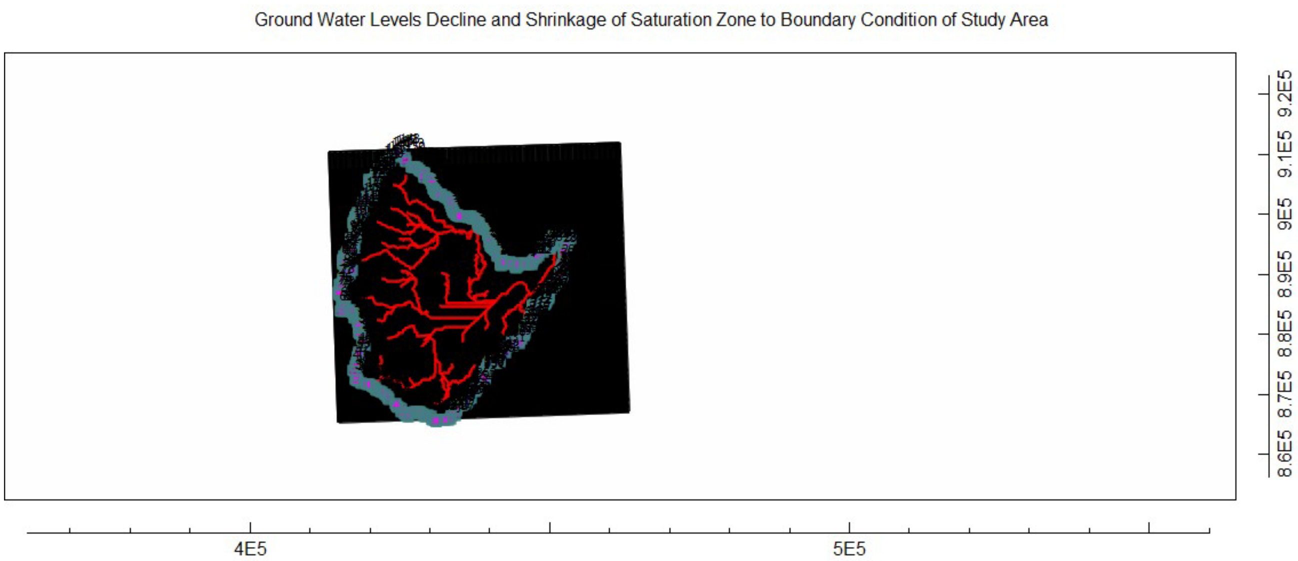

Figure   :4.15 Ground Water Decline and Shrinkages on Boundary of Saturation Zone

5.0 CONCULUSION ANDRECOMMENDATION

5.1 CONCULUSION

This research Analysis of Using a conceptual model of groundwater flow in the aquifer and documents the development and calibration of a numerical model to simulate groundwater flow by Using MODFLOW USGS-2005. The approaches to achieve the objective of the research involve data collection, analysis and synthesis with understanding the flow system of the Study Area.

Model calibration was completed by varying the model parameters within acceptable ranges to produce the best fit between simulated and observed hydraulic heads in the modeled area.

Sensitivity analysed for Weja River Catchment Ground Water Flow System and Aquifer Parameters Were Time Steps Response for Natural and Man Mad Influence of Study Area Stream Flow, Ground Water Flow System and Aquifer Parameters Were Predicted By Using MODFLOW USGS-2005 to Stress Response for Parameters Were As;

The Scenarios Analysed the Study Area System of Flow for Ground Water Extraction and Natural Drain System (spring) Simulated time Steps Response that Due to Over Extraction of Discharge the Ground Water Flow System Were Time Steps Transited Flow From Steady State to Unsteady State Ground Water Flow System and Drawn Dawn Was Increased Time Steps.

MODFLOW USGS-2005 Analysed the Hydraulics Conductivity of Ground Water Flow System Were Increased Time Steps and Porosity and Other Most Aquifer Parameters Were Decreased Due to Increased Ground Water Outflow and Over Extraction of Ground Water Storage Reservoir.

The Study Area Source of Stream Flow Were from Ground Water Storage Reservoir Outflow to Surface Flow System in the Form of Stream Flow or springs.

Therefore Scenarios Simulated that Due to Over Extraction of Ground Water Level of Ground Water Decline and Drown Dawn Were Increased Time Steps Due to that Ground Water Outflow System by Spring Outflow Were Decreased and the Study Area Surface Stream Flow Were Time Steps Dries Stream Were Formed on Weja River Catchment.

5.2 RECOMMENDATION

The Study Area Ground Water Flow Model Could be Enhanced With Further Modeler Flow Option, Simulate Stress Response for Hydraulics and Aquifer Parameters, Research Works, Data Collection and Interpretation Use Addition Data Packages MODFLOW Option.

Therefore as soon as a new data is available, the model could be updated and recalibrated. After all further research work, data collection, and MODFLOW options that could enable refinements, and in turn increase the utility of the groundwater flow model. Within the study area

Weja River Catchment Area Community, Stakeholders, Governmental, Non-Governmental and Other Concerned Body Better to Prevent Natural Environment Degradation By Reducing Effects of Man Mad Action on Natural Ecosystem, Hydrological System, Surface Water Ground Water Would Reduce to Stress on Hydraulics Parameters Aquifer Parameters Would Protected Nature of Ground Water Inflow and Outflow System.

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7. Appendix

Appendix table1: Mean monthly precipitation (1999_2021)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean of Yearly
Butajira	34.05	66.36	133.67	126.08	110.94	124.12	169.01	159.34	115.06	44.24	12.59	14.6	1019
Koshe	21.76	50.08	76.59	97.09	92.95	95.39	174.43	168.06	108.12	49.70	5.24	4.94	927
Tora	25.41	43.69	79.57	120.38	92.13	85.25	132.54	123.32	119.40	50.60	8.36	6.03	815
Mitio	10.6	75.443	74.254	126.343	109.168	77.844	112.965	116.53	124.19	54.373	26.74	24.7	988

Appendix table2: Mean maximum temperature Co)

	Mean maximum temperature (c^0)											
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	DEC
Koshe	27.42	28.89	29.77	30.05	30.56	29.46	25.89	26.18	27.19	27.70	27.36	26.94
Tora	23.11	24.16	24.86	24.69	24.62	23.37	21.29	20.98	21.41	22.75	22.79	22.57
Butajira	26.09	26.68	26.75	26.36	26.52	25.56	24.16	24.32	25.55	25.98	26.37	26.03
Mito	25.49	26.54	26.98	26.77	27.49	26.00	23.62	23.50	24.76	25.31	25.40	25.35

Appendix table3: Mean Monthly temperature (C^o)

	Mean Monthly temperature (c^0)											
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Koshe	19.83	21.06	22.14	22.27	22.67	21.63	20.17	20.27	20.60	20.38	19.45	19.12
Tora	19.49	21.03	21.95	22.29	22.56	22.09	20.15	20.37	20.82	20.09	18.68	18.18
Mito	15.67	16.73	17.69	18.18	18.07	17.14	16.09	15.85	15.86	16.57	15.82	15.22
Butajira	18.93	19.23	19.69	19.75	19.55	19.06	18.37	18.36	19.05	19.07	18.98	18.75

Appendix table4: Mean minimum temperature (c)

	Mean minimum temperature (c)											
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	NOV	DEC
Koshe	12.70	13.79	15.06	15.56	15.77	15.39	14.98	14.94	14.37	13.07	11.62	11.42
Tora	11.56	13.17	14.14	14.53	14.57	14.72	14.41	14.56	14.44	12.48	10.00	9.42
Butaji	11.76	11.78	12.63	13.13	12.58	12.56	12.59	12.39	12.55	12.15	11.58	11.47
Mito	7.99	8.66	10.40	10.66	10.81	9.67	9.55	9.81	9.54	8.24	6.73	6.41

Appendix table5: Observed Groundwater level

X	Y	MWD	Top Aquifer	Bottom Aquifer
445605	9037771	11	1	1
439579	889744	13	1	1
444850	903004	12	1	1
444726	898403	14	1	1
440765	900279	29	1	1
442210	897728	21	1	1
426651	893194	11	1	1
442856	895335	17	1	1
440452	892845	15	1	1
445262	898450	9.2	1	1
440327	885936	11	1	1
439431	884108	8	1	1
440430	886660	13	1	1
440865	887742	15	1	1
440241	888283	17	1	1
439963	882790	19	1	1
438656	887471	15	1	1
439035	888021	17	1	1
440041	888116	15	1	1
439913	889759	15	1	1
444072	880922	25	1	1
441593	889370	18	1	1
442270	889009	14	1	1
440437	888732	15	1	1
441018	887621	16	1	1
441661	887058	15	1	1
441296	886640	13	1	1
442092	888168	18	1	1

442134	888657	14	1	1
445700	890279	12	1	1
443851	889674	14	1	1
440437	888732	13	1	1
446774	891229	21	1	1
445976	892197	23	1	1
445730	891579	27	1	1
445737	890889	26	1	1
445602	889475	28	1	1
445505	888578	19	1	1
447497	891229	38	1	1
447287	892225	35	1	1
446763	892243	23	1	1
447330	889247	21	1	1
447568	886855	11	1	1
447568	887237	12	1	1
446419	886964	9	1	1
447197	887281	12.5	1	1
447205	887242	13	1	1
445939	887679	8	1	1
446503	886514	8	1	1
447047	887062	11.5	1	1
446290	887100	9	1	1
440786	895644	18	1	1
440644	895417	20	1	1
440545	895745	21	1	1
440978	894736	17	1	1
440814	895042	18	1	1
441446	893007	18	1	1
441496	892883	12	1	1
441743	892827	15	1	1
442297	892554	12	1	1
442950	892620	15	1	1
443206	893775	11	1	1
440492	891968	14	1	1
441440	891587	16	1	1
440170	891553	18	1	1
440469	891312	17	1	1
440711	890956	17	1	1
441403	890633	18	1	1
441114	890068	18	1	1
440884	889612	9	1	1
439533	889018	24	1	1
439531	889394	24	1	1

438215	887057	9	1	1
440041	888116	25	1	1
439035	888021	6	1	1
440770	896395	8	1	1
439871	886531	22	1	1
439529	886696	19	1	1
440177	883924	11	1	1
442456	890843	39	1	1
446577	882700	28	1	1
440987	888242	18	1	1
441848	888155	13	1	1
447320	888853	35	1	1

Appendix table6:Simulated Ground Water Head

Higher-Z	Lower-Z	ARCID	ARCID-COD	From NOD	To Noad	hm
8.186043	8.181877	1	1	2	3	12.4
8.20146	8.181877	2	1	1	3	13.7
8.181877	8.146877	3	2	3	6	12.5
8.14896	8.146877	4	1	5	6	15.2
8.151044	8.126877	5	1	4	9	31.5
8.126877	8.125211	6	1	10	9	23.8
8.126877	8.125211	7	2	9	11	12.5
8.143544	8.121044	8	1	7	12	19
8.126044	8.119377	9	2	11	12	17
8.146877	8.117711	10	2	6	13	11.6
8.129377	8.112711	11	1	8	11	14.5
8.121044	8.112711	12	2	12	16	9.7
8.117711	8.112711	13	3	16	13	14.6
8.117711	8.112711	14	3	13	14	18.3
8.112711	8.109377	15	3	17	16	16.8
8.116044	8.106044	16	1	18	14	22.9
8.106461	8.093544	17	1	19	21	16.9
8.109377	8.092711	18	2	21	17	19.7
8.099794	8.091044	19	1	20	21	16.4
8.088544	8.086878	20	1	22	23	17.2
8.109377	8.086878	21	2	23	17	28.7
8.086878	8.060211	22	1	25	23	22.6
8.080211	8.048545	23	1	24	28	13.7
8.116044	8.048545	24	3	14	28	16.8
8.046045	8.044378	25	2	30	31	19.5
8.056878	8.044378	26	1	26	31	17
8.044378	8.040211	27	1	32	30	14.6
8.046461	8.036045	28	1	29	34	21

8.048545	8.036045	29	3	28	34	17.4
8.038961	8.033545	30	1	33	35	13.6
8.054795	8.033545	31	1	27	35	13.7
8.044378	8.031461	32	1	36	30	14.5
8.115627	8.021878	33	4	38	15	25
8.036045	8.012712	34	3	34	40	24.3
8.026461	8.012712	35	1	37	40	29.4
8.039378	8.011045	36	4	41	38	28.7
8.012712	8.009378	37	3	40	41	31
8.011045	8.008545	38	4	42	41	23.2
8.033545	8.007712	39	2	35	42	46.8
8.022711	8.005212	40	2	43	38	39
8.004378	8.002712	41	1	44	45	26.4
8.008545	8.002712	42	4	45	42	21.2
8.016045	8.001045	43	1	39	46	13
8.002712	7.996045	44	4	47	45	15
8.009378	7.992712	45	2	46	48	12
8.044378	7.992712	46	2	31	48	14
8.005212	7.985629	47	1	49	43	12.7
7.996045	7.985212	48	3	48	50	9.5
7.996045	7.985212	49	4	50	47	10.4
8.001045	7.980212	50	1	51	46	12.3
7.985212	7.971045	51	3	52	50	11
7.996045	7.968962	52	1	53	47	20.6
8.005212	7.962295	53	1	54	43	24.8
7.971045	7.959379	54	3	55	52	20.5
7.959379	7.958545	55	3	56	55	18.3
7.958545	7.956879	56	3	57	56	19
7.973545	7.954379	57	1	58	55	20.4
7.958545	7.950629	58	1	59	56	11.3
7.971045	7.949796	59	1	60	52	16
7.956879	7.943129	60	1	61	57	12.8
7.956879	7.923546	61	3	63	57	17.6
7.923546	7.900213	62	3	66	63	13.4
7.915629	7.900213	63	1	64	66	17
7.900213	7.897713	64	3	67	66	18.9
7.928129	7.896879	65	1	62	68	19.8
7.897713	7.893546	66	2	69	67	20.6
7.893546	7.889796	67	1	71	69	19
7.896879	7.888963	68	1	72	68	21.7
7.893129	7.884379	69	1	70	73	19.3
7.923546	7.884379	70	2	73	63	11.4
7.897713	7.883546	71	2	74	67	27.5
7.914796	7.883546	72	1	65	74	26

7.883546	7.87938	73	2	75	74	10.6
7.896879	7.877713	74	2	68	73	29.3
7.87938	7.876463	75	1	76	75	7.8
7.87938	7.863963	76	1	77	75	12.5
7.893546	7.856046	77	1	78	69	21.9

Appendix table7: Measured and Simulated Ground Water Level.

X	Y	H	hm	(H-hm)	$q=(H-hm)^2$
445605	9037771	11	12.4	1.4	1.96
439579	889744	13	13.7	-0.7	0.49
444850	903004	12	12.5	-0.5	0.25
444726	898403	14	15.2	-1.2	1.44
440765	900279	29	31.5	-2.5	6.25
442210	897728	21	23.8	-2.8	7.84
426651	893194	11	12.5	-1.5	2.25
442856	895335	17	19	-2	4
440452	892845	15.5	17	-1.5	2.25
445262	898450	9.2	11.6	-2.4	5.76
440327	885936	11	14.5	-3.5	12.25
439431	884108	8	9.7	-1.7	2.89
440430	886660	13	14.6	-1.6	2.56
440865	887742	15	18.3	-3.3	10.89
440241	888283	17	16.8	0.2	0.04
439963	882790	19	22.9	-3.9	15.21
438656	887471	15	16.9	-1.9	3.61
439035	888021	17	19.7	-2.7	7.29
440041	888116	15	16.4	-1.4	1.96
439913	889759	15	17.2	-2.2	4.84
444072	880922	25	28.7	-3.7	13.69
441593	889370	18	22.6	-4.6	21.16
442270	889009	14	13.7	0.3	0.09
440437	888732	15	16.8	-1.8	3.24
441018	887621	16	19.5	-3.5	12.25
441661	887058	15	17	-2	4
441296	886640	13	14.6	-1.6	2.56
442092	888168	18	21	-3	9
442134	888657	14	17.4	-3.4	11.56
445700	890279	12	13.6	-1.6	2.56
443851	889674	14	13.7	0.3	0.09
440437	888732	13	14.5	-1.5	2.25
446774	891229	21	25	-4	16
445976	892197	23	24.3	-1.3	1.69
445730	891579	27	29.4	-2.4	5.76

445737	890889	26	28.7	-2.7	7.29
445602	889475	28	31	-3	9
445505	888578	21	23.2	-2.2	4.84
447497	891229	42	46.8	-4.8	23.04
447287	892225	35	39	-4	16
446763	892243	23	26.4	-3.4	11.56
447330	889247	21	21.2	-0.2	0.04
447568	886855	11	13	-2	4
447568	887237	12	15	-3	9
446419	886964	10.5	12	-1.5	2.25
447197	887281	12.5	14	-1.5	2.25
447205	887242	13	12.7	0.3	0.09
445939	887679	8	9.5	-1.5	2.25
446503	886514	8	10.4	-2.4	5.76
447047	887062	11.5	12.3	-0.8	0.64
446290	887100	9	11	-2	4
440786	895644	18	20.6	-2.6	6.76
440644	895417	20	24.8	-4.8	23.04
440545	895745	21	20.5	0.5	0.25
440978	894736	17	18.3	-1.3	1.69
440814	895042	18	19	-1	1
441446	893007	18	20.4	-2.4	5.76
441496	892883	12	11.3	0.7	0.49
441743	892827	15	16	-1	1
442297	892554	12	12.8	-0.8	0.64
442950	892620	15	17.6	-2.6	6.76
443206	893775	11	13.4	-2.4	5.76
440492	891968	14	17	-3	9
441440	891587	16	18.9	-2.9	8.41
440170	891553	18	19.8	-1.8	3.24
440469	891312	17	20.6	-3.6	12.96
440711	890956	17	19	-2	4
441403	890633	18	21.7	-3.7	13.69
441114	890068	18	19.3	-1.3	1.69
440884	889612	9	11.4	-2.4	5.76
439533	889018	24	27.5	-3.5	12.25
439531	889394	24	26	-2	4
438215	887057	9	10.6	-1.6	2.56
440041	888116	27.5	29.3	-1.8	3.24
439035	888021	6	7.8	-1.8	3.24
440770	896395	8	12.5	-4.5	20.25
439871	886531	22	21.9	0.1	0.01
439529	886696	19	20.4	-1.4	1.96
440177	883924	11	10.5	0.5	0.25

443384	890843	36	38	2	4
446577	882700	28	32	-4	16
440987	888242	18	21.4	-3.4	11.56
441848	888155	13	12.8	0.2	0.04
447320	888853	38.5	41.5	-3	9

Appendix table8: Weja River Catchment Ground Water Flow Boundary Coordination.

Modelling Boundary Coordination of Weja River Catchment		
X	Y	Location Status
431024.1	865440.9	TRUE
430884.6	865485.4	TRUE
430292.4	865694.5	TRUE
430128.3	866217	TRUE
429641.8	866533.1	TRUE
429322.3	866313.3	TRUE
429133.2	866321.1	TRUE
428935.1	866743.9	TRUE
428406.1	866871.1	TRUE
428225.8	866967.2	TRUE
427883.4	866954.1	TRUE
427519.9	867082.5	TRUE
427210.1	866869.4	TRUE
426983.8	866878.7	TRUE
426680.8	866867.2	TRUE
426353.7	866361	TRUE
426165.3	866233.2	TRUE
425856.7	866714.2	TRUE
425269.5	867095.8	TRUE
425294.6	867707.5	TRUE
424732.7	867798.2	TRUE
424390.3	867919.2	TRUE
424185.9	868355.4	TRUE
423208.7	869076.7	TRUE
422901.7	869555.3	TRUE
422611	869980.4	TRUE
422028.4	870257.4	TRUE
421696.6	870487.2	TRUE
421097.6	870678.5	TRUE
420913	871072.5	TRUE
420420.8	871306.5	TRUE
420332.6	871402.3	TRUE
419858.8	871682.7	TRUE
419535.6	871670.4	TRUE

418472.5	871870.6	TRUE
417945.5	872235.7	TRUE
417758.5	872324.6	TRUE
417533.1	872444.7	TRUE
417741.1	873235.1	TRUE
417146.8	873970.1	TRUE
417610.3	874768.2	TRUE
417807.1	875184.4	TRUE
417948.6	875921	TRUE
418044.5	876193.7	TRUE
418143	876503.8	TRUE
418127.1	876925.5	TRUE
419142	878155.8	TRUE
418963.6	878495.4	TRUE
418875.8	878775.4	TRUE
418663.8	879085.6	TRUE
418416.1	879983.1	TRUE
418079.9	880296.7	TRUE
418236.7	880892.6	TRUE
418233.2	880986	TRUE
418244.1	881251.1	TRUE
418142.1	881445.3	TRUE
418153.1	881711.9	TRUE
417996	882011	TRUE
417409	882737.3	TRUE
417509.1	883022.2	TRUE
417501	883236.2	TRUE
417135.6	883473.8	TRUE
416972.6	883651	TRUE
416677.1	883843.2	TRUE
416588.9	883939	TRUE
416133.7	884084.5	TRUE
415647.5	883827.6	TRUE
415044.4	883852.7	TRUE
415243	884607.2	TRUE
415672.8	885134.9	TRUE
415823.5	885764.8	TRUE
415487	885872.4	TRUE
415373.4	886234.5	TRUE
414857.8	886569.9	TRUE
414757.7	886900.7	TRUE
414955.9	887084.3	TRUE
414911.5	888263.3	TRUE
415396.5	888416.3	TRUE

415523.4	889076.2	TRUE
415688	889386.9	TRUE
416451.8	889746.8	TRUE
416597	890204.1	TRUE
416944.4	890656.9	TRUE
415930.1	890767.1	TRUE
415964	891586.1	TRUE
415587.1	891706.6	TRUE
415598.5	891982.4	TRUE
415781.7	892328.1	TRUE
415591.1	892505.9	TRUE
415611.9	893009	TRUE
416137.2	893394.1	TRUE
416261.4	893785.1	TRUE
416807.4	893888.7	TRUE
417063.4	894165	TRUE
417350.8	894255.7	TRUE
417155.8	894437.7	TRUE
417069	895270.6	TRUE
416974	895451.5	TRUE
416886	895639.5	TRUE
416767	895866.3	TRUE
417429.5	896178.6	TRUE
417533.3	896290.6	TRUE
417513	896829.4	TRUE
417716	897017.4	TRUE
417437.2	897661.9	TRUE
417349.9	898218.3	TRUE
417202.9	898498.3	TRUE
417443.1	898951.7	TRUE
417532.2	899415.7	TRUE
417627.7	899504.2	TRUE
417716.5	899783.9	TRUE
417947.3	900219.7	TRUE
418307	899828.6	TRUE
418811.2	900215.2	TRUE
418968.8	900548.6	TRUE
418751.4	901174.8	TRUE
418934.9	901872.5	TRUE
419477.8	902128.4	TRUE
419458.7	902635.1	TRUE
419471.3	902940.7	TRUE
420190.6	903111.3	TRUE
420385.8	903583.5	TRUE

420062	904200.3	TRUE
420207.3	904474.7	TRUE
420296.2	904846.6	TRUE
420391.7	904935.1	TRUE
420480.4	905186.7	TRUE
419917.7	905366.7	TRUE
419935.7	905800.4	TRUE
420307.4	905668.9	TRUE

Appendix table9: Ground Water Aquifer Parameters Simulation of Study Area.

	Appendix-9, Weja River Catchment Ground Water Auifer Parameters of Each Cell of Study Area Simulated Result By Using MODFLOW USGS-2005															
X	**Y**	**Z**	**X-P**	**Y-P**	**C**	**R**	**L**	**H.Anis**	**Kx**	**Ky**	**Kz**	**S.S**	**n**	**M**	**MT**	**SS1**
4.15E+05	8.65E+05	5.00E-01	8.51E+05	-4.44E+05	1	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.66E+05	5.00E-01	8.51E+05	-4.44E+05	2	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.66E+05	5.00E-01	8.51E+05	-4.44E+05	3	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.66E+05	5.00E-01	8.51E+05	-4.44E+05	4	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.66E+05	5.00E-01	8.51E+05	-4.44E+05	5	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.66E+05	5.00E-01	8.51E+05	-4.44E+05	6	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.66E+05	5.00E-01	8.51E+05	-4.44E+05	7	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.66E+05	5.00E-01	8.51E+05	-4.44E+05	8	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.66E+05	5.00E-01	8.52E+05	-4.44E+05	9	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.66E+05	5.00E-01	8.52E+05	-4.44E+05	10	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.66E+05	5.00E-01	8.52E+05	-4.44E+05	11	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.67E+05	5.00E-01	8.52E+05	-4.44E+05	12	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.67E+05	5.00E-01	8.52E+05	-4.44E+05	13	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.67E+05	5.00E-01	8.52E+05	-4.44E+05	14	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.67E+05	5.00E-01	8.52E+05	-4.44E+05	15	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.67E+05	5.00E-01	8.52E+05	-4.44E+05	16	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.67E+05	5.00E-01	8.52E+05	-4.44E+05	17	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.67E+05	5.00E-01	8.52E+05	-4.44E+05	18	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.67E+05	5.00E-01	8.53E+05	-4.44E+05	19	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.67E+05	5.00E-01	8.53E+05	-4.44E+05	20	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.67E+05	5.00E-01	8.53E+05	-4.44E+05	21	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.68E+05	5.00E-01	8.53E+05	-4.44E+05	22	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.68E+05	5.00E-01	8.53E+05	-4.44E+05	23	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.68E+05	5.00E-01	8.53E+05	-4.44E+05	24	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.68E+05	5.00E-01	8.53E+05	-4.44E+05	25	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00

4.15E+05	8.68E+05	5.00E-01	8.53E+05	-4.44E+05	26	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.68E+05	5.00E-01	8.53E+05	-4.44E+05	27	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.68E+05	5.00E-01	8.53E+05	-4.44E+05	28	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.68E+05	5.00E-01	8.54E+05	-4.44E+05	29	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.68E+05	5.00E-01	8.54E+05	-4.44E+05	30	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.68E+05	5.00E-01	8.54E+05	-4.44E+05	31	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.69E+05	5.00E-01	8.54E+05	-4.44E+05	32	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.69E+05	5.00E-01	8.54E+05	-4.44E+05	33	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.69E+05	5.00E-01	8.54E+05	-4.44E+05	34	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.69E+05	5.00E-01	8.54E+05	-4.44E+05	35	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.69E+05	5.00E-01	8.54E+05	-4.44E+05	36	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.69E+05	5.00E-01	8.54E+05	-4.44E+05	37	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.69E+05	5.00E-01	8.54E+05	-4.44E+05	38	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.69E+05	5.00E-01	8.55E+05	-4.44E+05	39	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.69E+05	5.00E-01	8.55E+05	-4.44E+05	40	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.69E+05	5.00E-01	8.55E+05	-4.44E+05	41	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.70E+05	5.00E-01	8.55E+05	-4.44E+05	42	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.70E+05	5.00E-01	8.55E+05	-4.44E+05	43	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.70E+05	5.00E-01	8.55E+05	-4.44E+05	44	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.70E+05	5.00E-01	8.55E+05	-4.44E+05	45	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.70E+05	5.00E-01	8.55E+05	-4.44E+05	46	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.70E+05	5.00E-01	8.55E+05	-4.44E+05	47	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.70E+05	5.00E-01	8.55E+05	-4.44E+05	48	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.70E+05	5.00E-01	8.56E+05	-4.44E+05	49	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.70E+05	5.00E-01	8.56E+05	-4.44E+05	50	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.70E+05	5.00E-01	8.56E+05	-4.44E+05	51	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.71E+05	5.00E-01	8.56E+05	-4.44E+05	52	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.71E+05	5.00E-01	8.56E+05	-4.44E+05	53	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.71E+05	5.00E-01	8.56E+05	-4.44E+05	54	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.71E+05	5.00E-01	8.56E+05	-4.44E+05	55	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.71E+05	5.00E-01	8.56E+05	-4.44E+05	56	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.71E+05	5.00E-01	8.56E+05	-4.44E+05	57	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.71E+05	5.00E-01	8.56E+05	-4.44E+05	58	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.71E+05	5.00E-01	8.57E+05	-4.44E+05	59	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.71E+05	5.00E-01	8.57E+05	-4.44E+05	60	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.71E+05	5.00E-01	8.57E+05	-4.44E+05	61	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.72E+05	5.00E-	8.57E+05	-4.44E+05	62	1	1	1.00E+00	1.00E-	1.00E-	1.00E-	1.00E-	2.50E-	1	-	1.00E+00

		01							04	04	05	05	01		1.00E+00	
4.15E+05	8.72E+05	5.00E-01	8.57E+05	-4.44E+05	63	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.72E+05	5.00E-01	8.57E+05	-4.44E+05	64	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.72E+05	5.00E-01	8.57E+05	-4.44E+05	65	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.72E+05	5.00E-01	8.57E+05	-4.44E+05	66	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.72E+05	5.00E-01	8.57E+05	-4.44E+05	67	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.72E+05	5.00E-01	8.57E+05	-4.44E+05	68	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.72E+05	5.00E-01	8.58E+05	-4.44E+05	69	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.72E+05	5.00E-01	8.58E+05	-4.44E+05	70	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.72E+05	5.00E-01	8.58E+05	-4.44E+05	71	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.73E+05	5.00E-01	8.58E+05	-4.44E+05	72	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.73E+05	5.00E-01	8.58E+05	-4.44E+05	73	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.15E+05	8.73E+05	5.00E-01	8.58E+05	-4.44E+05	74	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.73E+05	5.00E-01	8.58E+05	-4.44E+05	75	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.73E+05	5.00E-01	8.58E+05	-4.44E+05	76	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.73E+05	5.00E-01	8.58E+05	-4.44E+05	77	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.73E+05	5.00E-01	8.58E+05	-4.44E+05	78	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.73E+05	5.00E-01	8.59E+05	-4.44E+05	79	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.73E+05	5.00E-01	8.59E+05	-4.44E+05	80	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.73E+05	5.00E-01	8.59E+05	-4.44E+05	81	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.74E+05	5.00E-01	8.59E+05	-4.44E+05	82	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.74E+05	5.00E-01	8.59E+05	-4.44E+05	83	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.74E+05	5.00E-01	8.59E+05	-4.44E+05	84	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.74E+05	5.00E-01	8.59E+05	-4.44E+05	85	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.74E+05	5.00E-01	8.59E+05	-4.44E+05	86	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.74E+05	5.00E-01	8.59E+05	-4.44E+05	87	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.74E+05	5.00E-01	8.59E+05	-4.44E+05	88	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.74E+05	5.00E-01	8.60E+05	-4.44E+05	89	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.74E+05	5.00E-01	8.60E+05	-4.44E+05	90	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.74E+05	5.00E-01	8.60E+05	-4.44E+05	91	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.75E+05	5.00E-01	8.60E+05	-4.44E+05	92	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.75E+05	5.00E-01	8.60E+05	-4.44E+05	93	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.75E+05	5.00E-01	8.60E+05	-4.44E+05	94	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.75E+05	5.00E-01	8.60E+05	-4.44E+05	95	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.75E+05	5.00E-01	8.60E+05	-4.44E+05	96	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.75E+05	5.00E-01	8.60E+05	-4.44E+05	97	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.75E+05	5.00E-01	8.60E+05	-4.44E+05	98	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00

4.14E+05	8.75E+05	5.00E-01	8.61E+05	-4.44E+05	99	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.75E+05	5.00E-01	8.61E+05	-4.44E+05	100	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.75E+05	5.00E-01	8.61E+05	-4.44E+05	101	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.76E+05	5.00E-01	8.61E+05	-4.44E+05	102	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.76E+05	5.00E-01	8.61E+05	-4.44E+05	103	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.76E+05	5.00E-01	8.61E+05	-4.44E+05	104	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.76E+05	5.00E-01	8.61E+05	-4.44E+05	105	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.76E+05	5.00E-01	8.61E+05	-4.44E+05	106	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.76E+05	5.00E-01	8.61E+05	-4.44E+05	107	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.76E+05	5.00E-01	8.61E+05	-4.44E+05	108	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.76E+05	5.00E-01	8.62E+05	-4.44E+05	109	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.76E+05	5.00E-01	8.62E+05	-4.44E+05	110	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.76E+05	5.00E-01	8.62E+05	-4.44E+05	111	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.77E+05	5.00E-01	8.62E+05	-4.44E+05	112	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.77E+05	5.00E-01	8.62E+05	-4.44E+05	113	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.77E+05	5.00E-01	8.62E+05	-4.44E+05	114	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.77E+05	5.00E-01	8.62E+05	-4.44E+05	115	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.77E+05	5.00E-01	8.62E+05	-4.44E+05	116	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.77E+05	5.00E-01	8.62E+05	-4.44E+05	117	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.77E+05	5.00E-01	8.62E+05	-4.44E+05	118	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.77E+05	5.00E-01	8.63E+05	-4.44E+05	119	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.77E+05	5.00E-01	8.63E+05	-4.44E+05	120	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.77E+05	5.00E-01	8.63E+05	-4.44E+05	121	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.78E+05	5.00E-01	8.63E+05	-4.44E+05	122	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.78E+05	5.00E-01	8.63E+05	-4.44E+05	123	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.78E+05	5.00E-01	8.63E+05	-4.44E+05	124	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.78E+05	5.00E-01	8.63E+05	-4.44E+05	125	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.78E+05	5.00E-01	8.63E+05	-4.44E+05	126	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.78E+05	5.00E-01	8.63E+05	-4.44E+05	127	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.78E+05	5.00E-01	8.63E+05	-4.44E+05	128	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.78E+05	5.00E-01	8.64E+05	-4.44E+05	129	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.78E+05	5.00E-01	8.64E+05	-4.44E+05	130	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.78E+05	5.00E-01	8.64E+05	-4.44E+05	131	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.79E+05	5.00E-01	8.64E+05	-4.44E+05	132	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.79E+05	5.00E-01	8.64E+05	-4.44E+05	133	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.79E+05	5.00E-01	8.64E+05	-4.44E+05	134	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.79E+05	5.00E-	8.64E+05	-4.44E+05	135	1	1	1.00E+00	1.00E-	1.00E-	1.00E-	1.00E-	2.50E-	1	-	1.00E+00

		01							04	04	05	05	01		1.00E+00	
4.14E+05	8.79E+05	5.00E-01	8.64E+05	-4.44E+05	136	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.79E+05	5.00E-01	8.64E+05	-4.44E+05	137	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.79E+05	5.00E-01	8.64E+05	-4.44E+05	138	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.79E+05	5.00E-01	8.65E+05	-4.44E+05	139	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.79E+05	5.00E-01	8.65E+05	-4.44E+05	140	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.79E+05	5.00E-01	8.65E+05	-4.44E+05	141	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.80E+05	5.00E-01	8.65E+05	-4.44E+05	142	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.80E+05	5.00E-01	8.65E+05	-4.44E+05	143	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.80E+05	5.00E-01	8.65E+05	-4.44E+05	144	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.80E+05	5.00E-01	8.65E+05	-4.44E+05	145	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00
4.14E+05	8.80E+05	5.00E-01	8.65E+05	-4.44E+05	146	1	1	1.00E+00	1.00E-04	1.00E-04	1.00E-05	1.00E-05	2.50E-01	1	-1.00E+00	1.00E+00

Appendix table11: Numerical Modelling Ground Water Governing equations.

I, ∂x(Kxx*h x) + ∂ y(Kyy*hy) + ∂z(Kzz*hz) – W=Ss∂h/t

Where: h is hydraulic head (L);

W is a volumetric flux per unit volume and represents sinks and/or sources (T^{-1}), S is the specific storage of the porous material (L^{-1}), and St is time (T).

II,∂x(Kxx*h x) + ∂ y(Kyy*hy) + ∂z(Kzz*hz) – W=Ss∂h/t

Assuming the Transmissivity as Tx =Kxhand = Ty=Kyh,

The Saturated Thickness of Aquifers Transmissivity given by Darcy law as,

III, The Magnitude of the Head Difference of each Cell was given by Darcy as;

$\mathrm{Hs} = \frac{ht}{nh}$,

Where;ht, the total charge in head across the flow net of Catchment, nh,

V, L^2=K$\frac{*(ho-hm*t)}{ne}$

Where; L, The Length of times Steps to change Ground Water Head,

K, The Average Hydraulic Conductivity of Study areas, ho, The Observed Head of Study Area, hm, Simulated Head of Study Catchment,

t, The times Interval of study years, née, porous of Study Area,

IV, |Q|=K*b*|Δh|

The Leakage factor was defined by Darcy law for vertical flow through the river bed as;

VI, L=Kz*A/b and A=Δ X*Y,

Where;Kz, The Vertical Hydraulic Conductivity of the resisting river bed material

, X, the change of distance of bed of River, Y, The change of Head to River,

b, The Vertical thickness of material , A , Areas of River bed within the limit of the block cell, when The enter Surface areas of block cell underlies the River.

The two parameters were proportional Related as flow (Hubbent, 1940).

VII k=K*µ/w*g

Where; µ and w, were dynamic viscosity and density of water,

g, gravitational acceleration,

VIX, $\mathrm{P} = \frac{P1A1+P2A2+P3A3+P4A4+}{A} + \cdots \frac{Pn\mathrm{An}}{An}\ldots$