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HYDRAULIC CONNECTIONS OF SHALLOW GROUNDWATER AND LAKE TANA, ETHIOPIA: A CASE OF DEMBIA FLOOD PLAIN

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A thesis submitted to the School of Research and post graduate Studies of Bahir Dar Institute of Technology, Bahir Dar University in Partial Fulfillment of the Requirements for the Degree of Masters of Science in Hydraulic Engineering in the Faculty of Civil and Water Resources Engineering

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DECLARATION

I, the undersigned, declare that the thesis comprises my own work. Where all materials has been used for this work from other sources, it has been properly acknowledged.

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February, 2018

Dedicated to

My wife Workitu Legesse and My children Tsion Gebeyehu.

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ABSTRACT

The seasonal groundwater level decline due to dry season groundwater evapotranspiration and lateral groundwater flow, and the hydraulic connections of the shallow groundwater with the Lake Tana in the Dembia flood plain, North of Ethiopia had be studied. Studies show that shallow groundwater evapotranspiration in tropical regions is huge. So, there is a need to quantify the shallow groundwater evaporation in the area during the dry season. For this, fourty seven groundwater observation wells distributed over the plain are identified. The groundwater table are observed in these wells on bi-weekly time step over a period in 2016/17. This helps us to understand the shallow groundwater table fluctuations in the seasons. Our observations showed that in the year, the groundwater level reached the surface during the rainy monsoon phase around third week of July. The hydraulic conductivity for the groundwater is needed to calculate the groundwater flux. It was determined from four disturbed soil samples taken from near four well locations using the falling head permeameter. The average hydraulic conductivity was 0.00034m/day. The slope of ground surface elevation and predicted groundwater elevations in the transect section was computed. The ground surface has a general slope of 0.00094. The steepest gradient of groundwater is approximately 0.0009 and the general hydraulic gradient is about 0.00088 from the farthest point to the Lake. This showed that the shallow groundwater is flowing to the lake about a distance of 5.6km starting from the farthest point to the Lake. The slope is less (negative) near the lake because of the intrusion of the lake water to the groundwater, which is the amount of Lake water transported to groundwater about a distance of 4.6km. There is hydraulic connection between the shallow groundwater in the plain and the Lake Tana, and has the computed specific discharge using the average hydraulic conductivity and the general hydraulic gradient is as low as $3.0*10^{-7}$m/day, which is negligible. Thus, all changes in the elevation of the water table are due to recharge or evaporation. At well locations, the actual evaporation from the linear evapotranspiration function for the groundwater table depth was computed as 928mm and the maximum cumulative evaporation at the end of the dry phase was 874mm.

Key words: Lake Tana, Dembia flood plain, Groundwater level, Ethiopia

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LIST OF ABBREVIATIONS AND SYMBOLS

ADSWE…………Amhara Design and supervision Works Enterprise

BRS…………….Bureau of Rural Science

0c…………………Degree centigrade

GPS……………..Global Position System

USGS……………United States Geographical Survey

UTM……………...Universal Transfer Mercator

DOY…………………Day of the year

ETg…………………..Groundwater evapotranspiration

Eq…………………….Equation

ET…………………… Evapotranspiration

GWT…………………Ground Water Table

HDW………………....Hand dug well

OGL…………………Original Ground Level

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1. INTRODUCTION

1.1 Background

This study is carried out in Dembia floodplain, located north of Lake Tana, Ethiopia. Megech and Dirma are the two rivers that transverse the plain. The plain is prone to flooding by the Megech and Dirma rivers, other small intermittent streams directly draining to the plain, and direct rainfall. Groundwater-surface water interactions are difficult to observe and measure, and have commonly been ignored in water management considerations and policies (Winter et. al., 1998). Some believe this is due to the separation of the fields of hydrology and hydrogeology (Sophocleous 2002), while others believe it is because the interactions are difficult to assess (winter et al.1998).

Here the seasonal groundwater level decline due to dry season groundwater evapotranspiration and lateral groundwater flow, and the hydraulic connections of the shallow groundwater with the Lake Tana in the Dembia flood plain had be studied. For this, fourty seven groundwater observation wells distributed over the plain are identified. The groundwater table are observed in these wells on bi-weekly time step for a period in 2016/17 in order to understand the shallow groundwater table fluctuations in the season.

Understanding the groundwater balance, the amount of recharge and withdrawals also important for sustainable water use and effective management of groundwater resources (Enku, 2016). This is especially important in the tropics where three crops per year can be grown and potential groundwater withdrawals can be great (such as in the Lake Tana basin) where only 3% of the potential irrigable area is irrigated with surface water (Worqlul et al., 2015). One of the most important components of the groundwater balance is groundwater evapotranspiration (ETg). This is critical especially in long dry and hot climate like the Dembia floodplain. So, accurate estimation of ETg, and groundwater recharge is important in understanding the groundwater systems for planning, developing and managing for its sustainable use. Therefore; there is a need to understand the seasonal groundwater level fluctuations and its response to the inputs and outputs in the Dembia floodplain.

The groundwater table depth in the Dembia plain is generally shallow, which has the depth up to150meter(source: Amhara Design and Supervision Works Enterprise Hydrogeology and Geotechnic core work process Hydrogeological investigation and design guideline December, 2017 Bahir Dar.

1.2 Statement of the problem

Identify the causes of the seasonal groundwater level fluctuation in the area during the dry season and identify the hydraulic connections of shallow groundwater with the Lake Tana in Dembia flood plain was my thesis statement of the problem.

1.3 Objective of the study

The general objective of the study is to assess the hydraulic connection of the shallow groundwater and the lakeTana water in the Dembia floodplain.

The specific objectives of this study are:

- To assess the groundwater level fluctuations over the seasons
- To assess the response of shallow groundwater level to evapotranspiration (ET) loss and recharge in the Dembia floodplain
- To estimate the shallow groundwater flow to the LakeTana /rivers.

1.4 Research questions

1. How much is the groundwater flow to the Lake?

2. How much is the shallow groundwater evapotranspiration will be during the dry season?

3. Is the groundwater feeds to the Lake or vice versa?

1.5 Scope of the study

The scope of the study deals with the assessment of hydraulic connections of shallow groundwater and the Lake Tana water in Dembia floodplain that is by quantifying the interactions between surface water and groundwater whether groundwater discharges into the lake water or Lake Water infiltrates into and recharges groundwater. Estimation of the quantity of water fluxes: Evaporation, discharge and recharge.

1.6 Significance of the study

To understand the seasonal shallow groundwater level fluctuations and its response in the floodplain. Accurate estimation of groundwater evapotranspiration, discharge and groundwater recharge is important in understanding the groundwater systems for planning, developing and managing for the sustainable use of the groundwater resource.

2. LITERATURE REVIEW

2.1 Introduction

Traditionally groundwater and surface water have been managed as an isolated components of the hydrologic cycle, even though they interact in a variety of physiographic settings (Sophocleous 2002). Interactions between these systems have commonly been ignored in water management considerations and policies (Winter et al. 1998). Some believe this is due to the separation of the fields of hydrology and hydrogeology (Sophocleous 2002), while others believe it is because the interactions are difficult to assess (winter et al.1998). In the last decade recognition of the importance of groundwater-surface water interaction has flourished (Langhoff et al. 2006), and today it is widely recognized that to better manage these water issues there is a need to manage groundwater and surface water together as a connected resource.

Groundwater and surface water are not isolated components of the hydrological cycle and they may interact in a range of topographic, geologic and climatic landscapes (Winter et al. 1998). In order for interaction between surface water and groundwater systems to occur, the systems need to be hydraulically connected.

The concept of groundwater interacting with surface water is not new and has been studied since the 1960's (Meyboom 1961, Toth 1962, 1963, Freeze and Witherspoon 1967). Assessing groundwater-surface water interactions is often complex and difficult (Brodie et al. 2005a). Commonly, groundwater level measurements are used to define the hydraulic gradient and the direction of groundwater flow (K. Annan, 2006). In most cases the limited number of data collection points results in a lack of detailed understanding of groundwater-surface water interactions in the field (Brodie et al. 2005a).

Hydraulic connection refers to systems where there is an opportunity for groundwater and surface water to exchange, and occurs where the stream/lake and groundwater elevations are in close proximity to each other (K. Annan, 2006). The main factor controlling connectivity is the difference between the surface water level and the groundwater level (Bureau of Rural Sciences, BRS 2006). The simplest way to assess connectivity is to compare the elevation of the stream/lake with the elevation of groundwater.

Knowledge of the hydrogeological setting is critical in understanding groundwater -surface water interactions (BRS 2006). Specific information on hydrogeological parameters, such as those listed below, provide a useful context when evaluating the extent and direction of groundwater-surface water exchanges. Useful hydrogeological parameters to evaluate groundwater-surface water exchange, include (BRS 2006):

- groundwater availability, in terms of bore yield
- potentials, in terms of depth to water table, elevation of groundwater surfaces,
- groundwater flow paths and head difference between aquifers
- aquifer hydraulic properties, typically transmissivity and storativity
- Aquifer structure, typically aquifer boundaries, aquifer thickness, and specific features such as faults.

The hydraulic conductivity depends on soil characteristics such as type, size, shape, and packing of grains (Carter and Novitzki, 1986). Porosity is the fraction of a soil volume occupied by voids, and effective porosity represents the potential area through which water can flow (Carter and Novitzki, 1986). The storativity is a measure of the amount of water released from an aquifer (per unit surface area) per unit decline in hydraulic head (Fetter, 2001). The most basic interpretation of surface water-groundwater interaction can be described by the direction of flux between a surface water body and the underlying aquifer. A connected water resource is the combination of a surface water feature, such as a lake, streams, springs and the groundwater system that can directly interact in terms of movement of water. The hydrological cycle describes the constant movement of water above, on, and below the Earth's surface (Figure 1). The water table is the expression of groundwater in the shallow aquifer. A confined aquifer is created by the presence of an impermeable barrier, known as an aquitard at the base of the shallow aquifer.

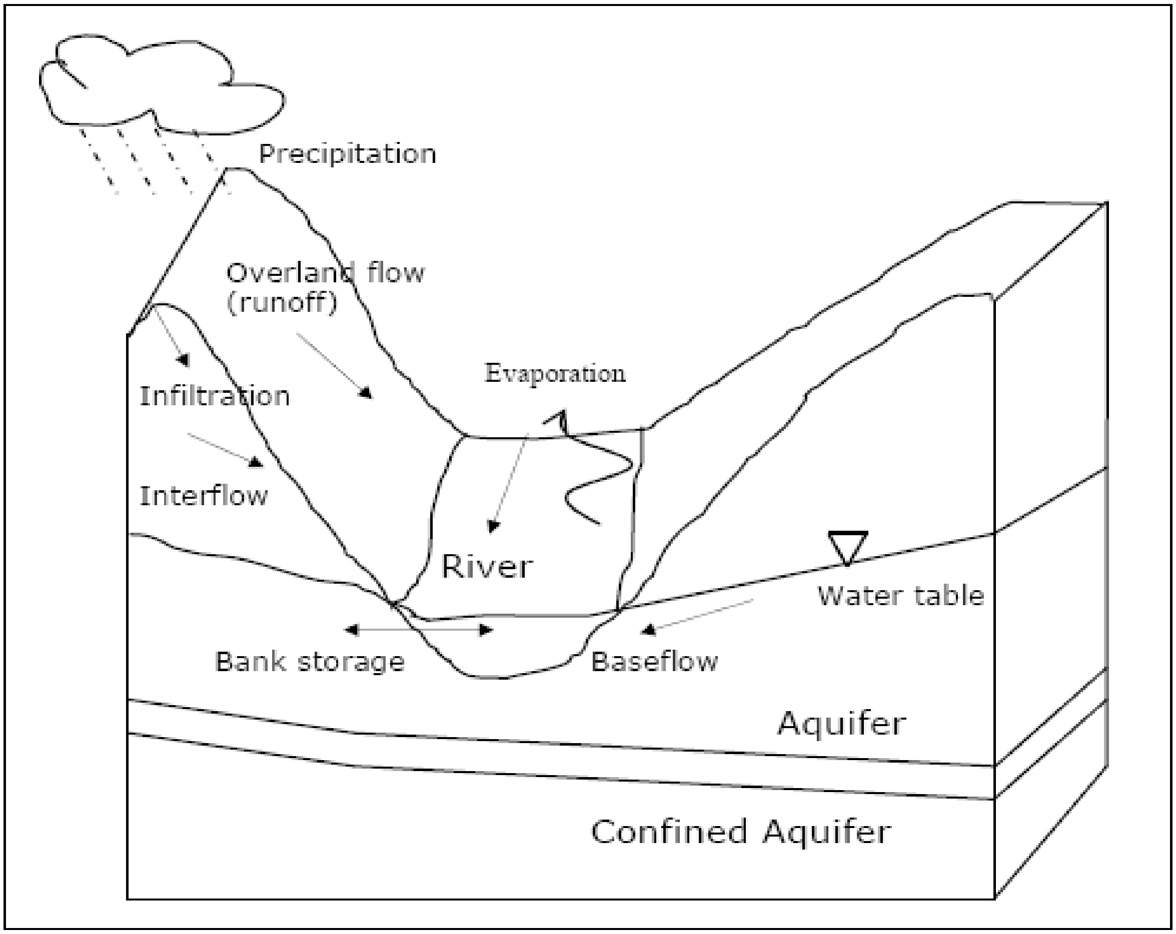


Figure 1. The hydrologic cycle and components of groundwater-surface water interaction (K. Annan 2006, adapted from (Church 1996))

Hydraulic connection is believed to exist between surface water and ground water systems when the water table is near or above the river/lake bed. Interactions between surface water and groundwater may be classified in three ways:

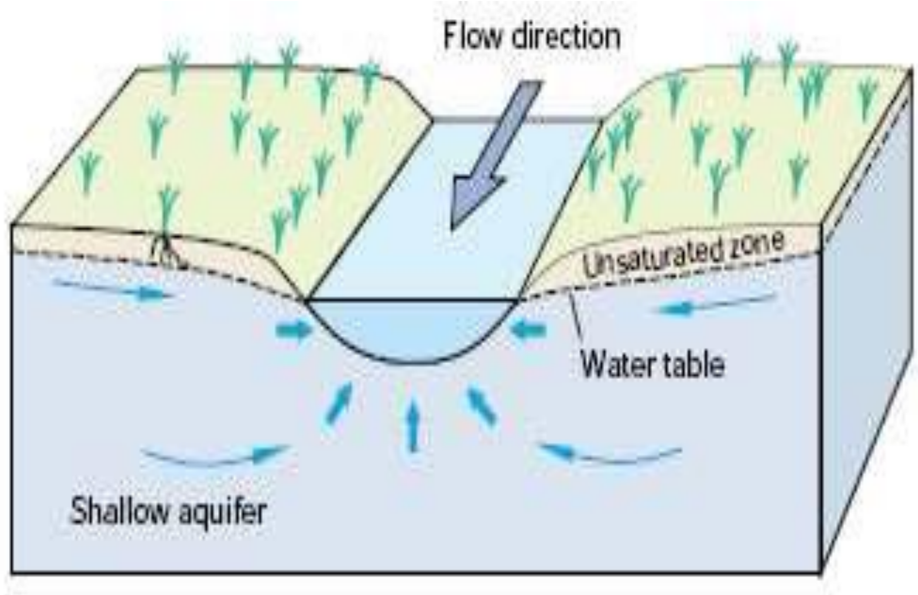
1) Gaining system: gain water from inflow of groundwater through the stream/lake bed.

2) Losing system: lose water to groundwater by outflow through the stream/lake bed.

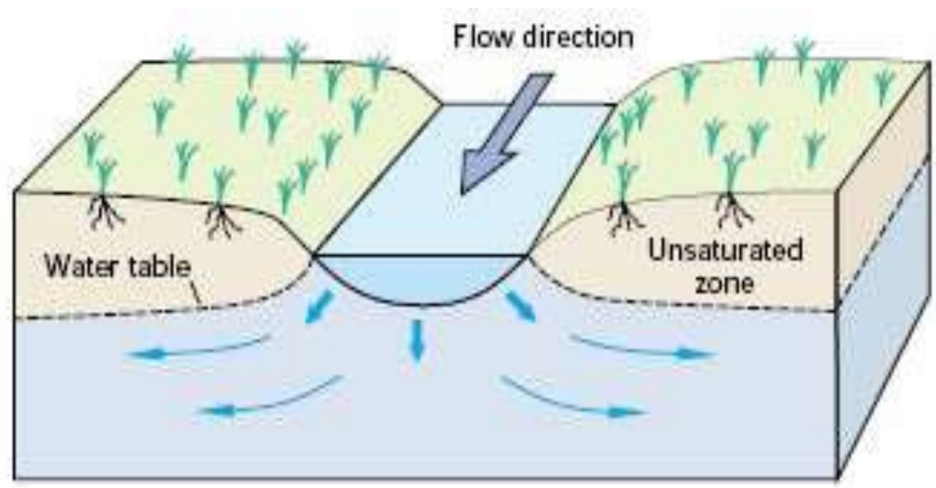
3) Neutral system: neither gaining nor losing

In order for groundwater to discharge into a stream/lake, the elevation of the water table adjacent to the stream/lake must be higher than the elevation of the stream/lake bed. This setting creates an upward hydraulic gradient, which promotes groundwater inflow to the stream and thus a gaining system (Figure 2a).

For surface water to seep into groundwater the elevation of the water table must be lower than the elevation of the stream/lake bed. This creates a downward hydraulic gradient between the stream/lake and aquifer, promoting the outflow of surface water through the stream/lake bed and thus a losing system (Figure 2b). In both cases it is assumed a permeable structure exists that allows the hydraulic head to move water across the stream/lake bed (Braaten & Gates 2001).



a)



b)

Figure 2. a) Gaining system and b) Losing system (Winter et al. 1998)

A neutral system occurs where the water table is at the same elevation as the river/lake bed and thus in hydraulic continuity with the stream/lake (Figure 3).

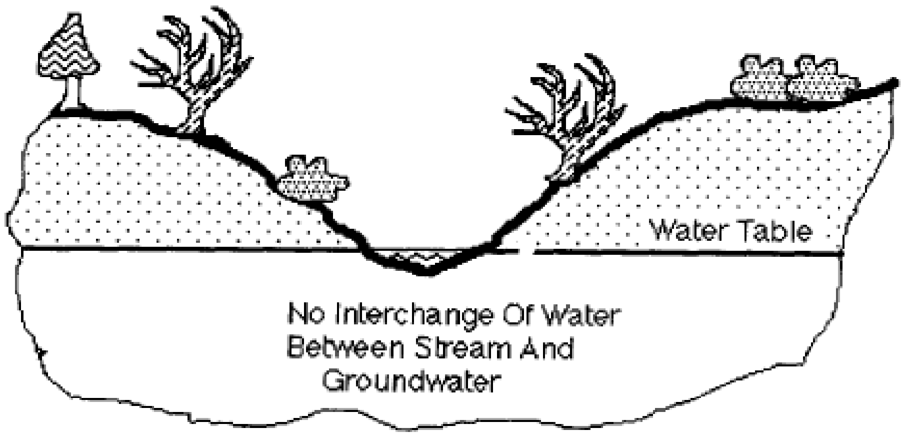


Figure 3. Hydraulically neutral system (Silliman & Booth 1993)

A neutral system may also occur where the system is hydraulically disconnected, usually due to the presence of a thick impermeable barrier (Sophocleous 2002). Although this setting has been more commonly described as a disconnected losing system (Figure 4). In this setting the stream is disconnected from the groundwater system by an unsaturated zone, the water table may have a discernible mound below the stream (Figure 4) if the rate of recharge through the streambed and unsaturated zone is greater than the rate of lateral groundwater flow away from the water table mound (Winter et al. 1998).

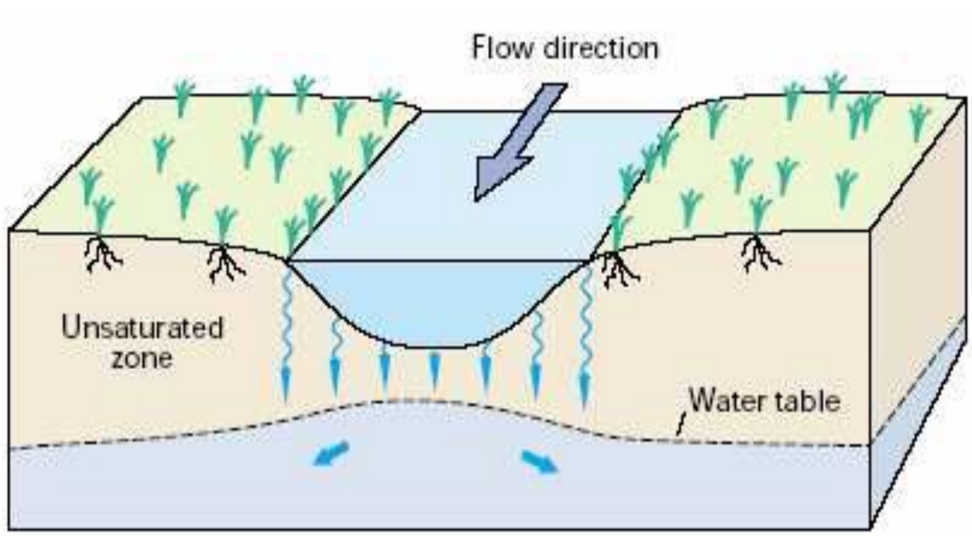


Figure 4. A disconnected system, where the stream/lake is separated from the groundwater by an unsaturated zone.

It is possible to have a variably gaining/losing situation where the stream/lake may be gaining and losing in the same reach at different times of the year. Furthermore, a stream/lake may be gaining in some reaches and losing in others. Therefore, it is important to consider spatial and temporal variations in groundwater-surface water interaction before the connectivity along a stream/lake can be classified.

2.2 Techniques used to investigate connectivity

Commonly, groundwater level measurements are used to define the hydraulic gradient and the direction of groundwater flow (K. Annan, 2006). Abandoned observation well shallow groundwater level measurement techniques are used to investigate the hydraulic connections.

2.3 Groundwater Flow

Once hydraulic connection is established, it is important to establish the predominant direction of flux between the stream/lake and groundwater system. A common challenge with assessing groundwater-surface water interactions is collecting the field data.

Groundwater is increasingly a vital resource to human populations around the world (Clark and Fritz 1997; Winter et al. 1998) especially in Africa where economic development and poverty reduction programmes drive the development of groundwater resources (Adelana and MacDonald 2008; MacDonald et al. 2012; Lapworth et al. 2013). The movement and storage of groundwater is influenced by a number of factors, including hydraulic gradients, hydraulic conductivity, porosity and storativity (Carter and Novitzki, 1986). For an unconfined aquifer, the amount of water released is mainly due to the change in the saturation of the pores (Fetter, 2001). The movement of surface water and groundwater is controlled to a large extent by topography and the geologic framework of an area (Winter, 1999). The contributions of water to and the loss of water from the earth's surface are controlled by climate (Winter, 1999). There are three main outside forces acting on groundwater. The first is gravity, which pulls groundwater downward (Fetter, 2001). The second force is external pressure, which includes atmospheric pressure and the weight of overlying water that creates pressure in the saturation zone (Fetter, 2001).

The third force is molecular attraction, which causes water to adhere or adsorb to the surface of solid particles (Fetter, 2001).

Groundwater flows from high to low hydraulic head, and the hydraulic gradient is determined by the slope of the groundwater table surface (Hailey E. Ashworth, 2012). The rate of flow is determined by the hydraulic gradient and the hydraulic conductivity of the porous media (Hailey E. Ashworth, 2012).

The configuration of the water table continuously changes in response to recharge to and discharge from the groundwater system (winter, 1999). Complex groundwater – surface water interactions can develop in the vicinity of surface water features where the groundwater table is near the surface (winter, 1999).

Darcy's Law states that the amount of water (Q) flowing through porous media depends on the energy driving the water flow, hydraulic gradient ($\Delta h/\Delta x$) and the hydraulic conductivity (K) of the porous media, and it is computed with the Darcy's equation as:

$$q_x = -K \frac{\Delta h}{\Delta x}$$

Groundwater flows from high to low hydraulic head, and the hydraulic gradient is determined by the slope of the predicted groundwater table surface and the experimental measurements of hydraulic conductivity

2.4 Groundwater recharge

The term recharge to shallow groundwater flow system is taken to be the volume of water that crosses the water table after infiltration through the vadose zone, expressed as the height of the water column that enters the groundwater zone per unit time (F. Manna, J.A. Cherry, D.B. McWhorter, B.L. Parker, 2016). Estimating groundwater recharge is an important issue in hydrogeologic studies. In most cases, recharge is estimated by using the water-balance method. Study of the water balance for any arbitrary volume and during any period of time, the difference between total input and output will be balanced by the change of water storage within the volume. In the field of hydrology the water balance budget idea is widely used.

Considering that the change in groundwater storage can be attributed to recharge, (sum of the direct recharge from the precipitation and the indirect recharge from surface bodies), and groundwater inflow to the wells minus outflow (evapotranspiration from groundwater and groundwater outflow from the wells), the groundwater budget can be expressed by the equation. $R + Q_{in} = ET + Q_{ou} + \Delta S$ Where, R is the amount of total groundwater recharge (sum of the direct recharge from the precipitation and the indirect recharge from surface bodies), Q_{in} and Q_{ou} are the input and output of groundwater flows respectively, ET is the evapotranspiration from the groundwater, ΔS represents the changes in groundwater storage. Accurate quantification of recharge rates is imperative to proper management and protection of valuable groundwater resources (Richard W. Healy, Peter G. Cook, 2002). Recharge is a basic component of the hydrological cycle, quantification is difficult because it cannot be directly measured (F. Manna, J.A. Cherry, D.B. McWhorter, B.L. Parker, 2016). Estimating recharge rates based on groundwater levels are among the most widely-applied methods due to the abundance of available groundwater-level data and the simplicity of estimating recharge rates from fluctuations of groundwater levels (Richard W. Healy, Peter G. Cook, 2002). To have a measure of groundwater recharge, it is necessary to obtain precise information on the factors governing infiltration and loss from the groundwater system (Hailey E. Ashworth, 2012).

2.5 Kriging

Kriging is an advanced geostatistical raster interpolation procedure that generates an estimated surface from a scattered set of points with z-values. To use the Kriging tool effectively involves an interactive investigation of the spatial behavior of the phenomenon represented by the z-values before we select the best estimation method for generating the output surface. Kriging assumes that the distance or direction between sample points reflects a spatial correlation that can be used to explain variation in the surface. Kriging is a multistep process; it includes exploratory statistical analysis of the data, variogram modeling, and creating the surface.

Kriging is based on the regionalized variable theory that assumes that the spatial variation in the phenomenon represented by the z-values is statistically homogeneous throughout the surface (for example, the same pattern of variation can be observed at all locations on the surface). This hypothesis of spatial homogeneity is fundamental to the regionalized variable theory. Kriging is an interpolator that can be exact or smoothed depending on the measurement error model. It is very flexible and allows to investigate graphs of spatial auto- and cross-correlation. Kriging uses statistical models that allow a variety of output surfaces including predictions, prediction standard errors, probability and quantile. The flexibility of kriging can require a lot of decision-making. Kriging is a processor-intensive process. The speed of execution is dependent on the number of points in the input dataset. Low values within the optional output variance of prediction raster indicate a high degree of confidence in the predicted value. High values may indicate a need for more data points. If the values of the points at the common location are the same, they are considered duplicates and have no effect on the output. If the values are different, they are considered coincident points. The main application of kriging is the prediction of attribute values at unsampled locations. The Kriging tool provides the following functions from which to choose for modeling the empirical semivariogram: Stable, Circular, Spherical, Exponential, Gaussian, and Linear. The selected model influences the prediction of the unknown values, particularly when the shape of the curve near the origin differs significantly. The steeper the curve near the origin, the more influence the closest neighbors will have on the prediction. As a result, the output surface will be less smooth. The two common model examples are, spherical and exponential. A spherical model: This model shows a progressive decrease of spatial autocorrelation (equivalently, an increase of semivariance) until some distance, beyond which autocorrelation is zero. The spherical model is one of the most commonly used models. An exponential model**:** This model is applied when spatial autocorrelation decreases exponentially with increasing distance. Here, the autocorrelation disappears completely only at an infinite distance. The exponential model is also a commonly used model. The choice of which model to use is based on the spatial autocorrelation of the data and on prior knowledge of the phenomenon. There are two kriging methods: ordinary and universal.

Ordinary kriging is the most general and widely used of the kriging methods and is the default. It assumes the constant mean is unknown. This is a reasonable assumption unless there is a scientific reason to reject it. Ordinary kriging assumes the model: $Z(s) = \mu + \varepsilon(s)$, where μ is an unknown constant. One of the main issues concerning ordinary kriging is whether the assumption of a constant mean is reasonable. In fact, this data was simulated from the ordinary kriging model with a constant mean μ. The true but unknown mean is given by the dashed line. Thus, ordinary kriging can be used for data that seems to have a trend. There is no way to decide, based on the data alone, whether the observed pattern is the result of autocorrelation, among the errors $\varepsilon(s)$ with μ constant, or trend, with $\mu(s)$ changing with s. Ordinary kriging can use either semivariograms or covariances (which are the mathematical forms you use to express autocorrelation), use transformations and remove trends, and allow for measurement error. Universal kriging assumes that there is an overriding trend in the data, for example, a prevailing wind, and it can be modeled by a deterministic function, a polynomial. This polynomial is subtracted from the original measured points, and the autocorrelation is modeled from the random errors. Once the model is fit to the random errors and before making a prediction, the polynomial is added back to the predictions to give meaningful results. Universal kriging should only be used when we know there is a trend in our data and we can give a scientific justification to describe it. In our thesis study I use ordinary kriging method of prediction.

2.5.1 Making a prediction

To make a prediction with the kriging interpolation method, two tasks are necessary: Uncover the dependency rules and Make the predictions. To realize these two tasks, kriging goes through a two-step process:

1. It creates the variograms and covariance functions to estimate the statistical dependence (called spatial autocorrelation) values that depend on the model of autocorrelation (fitting a model).

2. It predicts the unknown values (making a prediction).

It is because of these two distinct tasks that kriging uses the data twice: the first time to estimate the spatial autocorrelation of the data and the second to make the predictions. After you have uncovered the dependence or autocorrelation in our data and have finished with the first use of the data, using the spatial information in the data to compute distances and model the spatial autocorrelation. We can make a prediction using the fitted model. Thereafter, the empirical semivariogram is set aside.

We can now use the data to make predictions. Kriging weights come from a semivariogram that was developed by looking at the spatial nature of the data. To create a continuous surface of the phenomenon, predictions are made for each location, in the study area based on the semivariogram and the spatial arrangement of measured values that are nearby.

2.5.2 Semivariogram

The semivariogram depicts the spatial autocorrelation of the measured sample points. Because of a basic principle of geography (things that are closer are more alike), measured points that are close generally have a smaller difference squared than those farther apart. Once each pair of locations is plotted after being binned, a model is fit through them. Range, sill, and nugget are commonly used to describe the models. A default value for Lag size is initially set to the default output cell size. For Major range, Partial sill, and Nugget, a default value will be calculated internally if nothing is specified.

I. Range and sill

The distance where the model first flattens is known as the range. Sample locations separated by distances closer than the range are spatially autocorrelated, whereas locations farther apart than the range are not. The value at which the semivariogram model attains the range (the value on the y-axis) is called the sill. A partial sill is the sill minus the nugget. The nugget is described below

II. Nugget

The nugget effect can be attributed to measurement errors or spatial sources of variation at distances smaller than the sampling interval (or both). Measurement error occurs because of the error inherent in measuring devices. Natural phenomena can vary spatially over a range of scales. Variation at microscales smaller than the sampling distances will appear as part of the nugget effect. Before collecting data, it is important to gain an understanding of the scales of spatial variation in which we are interested. If the semivariogram model intercepts the y-axis at 2, then the nugget is 2.

2.5.3 Semivariogram graph

Fitting a model, or spatial modeling, is also known as structural analysis, or variography. In spatial modeling of the structure of the measured points, we begin with a graph of the empirical semivariogram. The empirical semivariogram is a graph of the averaged semivariogram values on the y-axis and the distance (or lag) on the x-axis. To fit a model to the empirical semivariogram, select a function that serves as our model, a spherical type that rises and levels off for larger distances beyond a certain range (see the spherical model example above) are used. Kriging is an interpolator that can be exact or smoothed depending on the measurement error model. Semivariogram modeling is a key step between spatial description and spatial prediction. The empirical semivariogram provides information on the spatial autocorrelation of datasets. However, it does not provide information for all possible directions and distances. For this reason, and to ensure that kriging predictions have positive kriging variances, it is necessary to fit a model, that is, a continuous function or curve to the empirical semivariogram. This is similar to regression analysis, in which a continuous line or curve is fitted to the data points. Theoretically, at zero separation distance (for example, lag = 0), the semivariogram value is 0. However, at an infinitely small separation distance, the semivariogram often exhibits a nugget effect, which is a value greater than 0.

2.6 Previous studies in Lake Tana basin

Recently, a number of studies have been conducted on the hydrology of the Lake Tana. The studies encompass stream flow modelling (Kebede et al., 2011; Wale et al., 2009), sediment dynamics and river flow (Abate et al., 2015; Kaba et al., 2014; Steenhuis et al., 2009), land use dynamics and climate change impact (Dile et al., 2013; Melesse et al., 2009), groundwater flow modeling (Kebede et al., 2005), hydrodynamics of Lake Tana (Chebud & Melesse, 2013), eco-hydrology (Enku et al., 2014; Melesse et al., 2014) water allocation and demand analysis (Belete, 2013) watershed dynamics in The headwaters of the Abay (Blue Nile) River (Enku T. (2016)), Hydrological balance of Lake Tana upper Blue Nile Sub Basin, Ethiopia (Abeyou Wale, 2008), Estimation of water balance components using remote sensing products in the upper Blue Nile, Lake Tana Sub Basin (Fasikaw Atanaw,2009).

Because of multi-purpose uses; various studies have been made to understand the functions of the lake (Belete, 2013; Chebud & Melesse, 2013; Kebede et al., 2006; Mekete et al., 2015; Minale & Rao, 2011; SMEC, 2007).

3. STUDY AREA

3.1. General Description

Dembia floodplain is found in the North Gonder Zone of the Amhara region. The Megech River originates in the North-Gondor in Gonder administrative zone and flows south to Lake-Tana through dembia floodplain. Megech River is one of the four perennial rivers (Gilgil Abbay, Megech, Ribb, and Gumera) which fed Lake Tana.

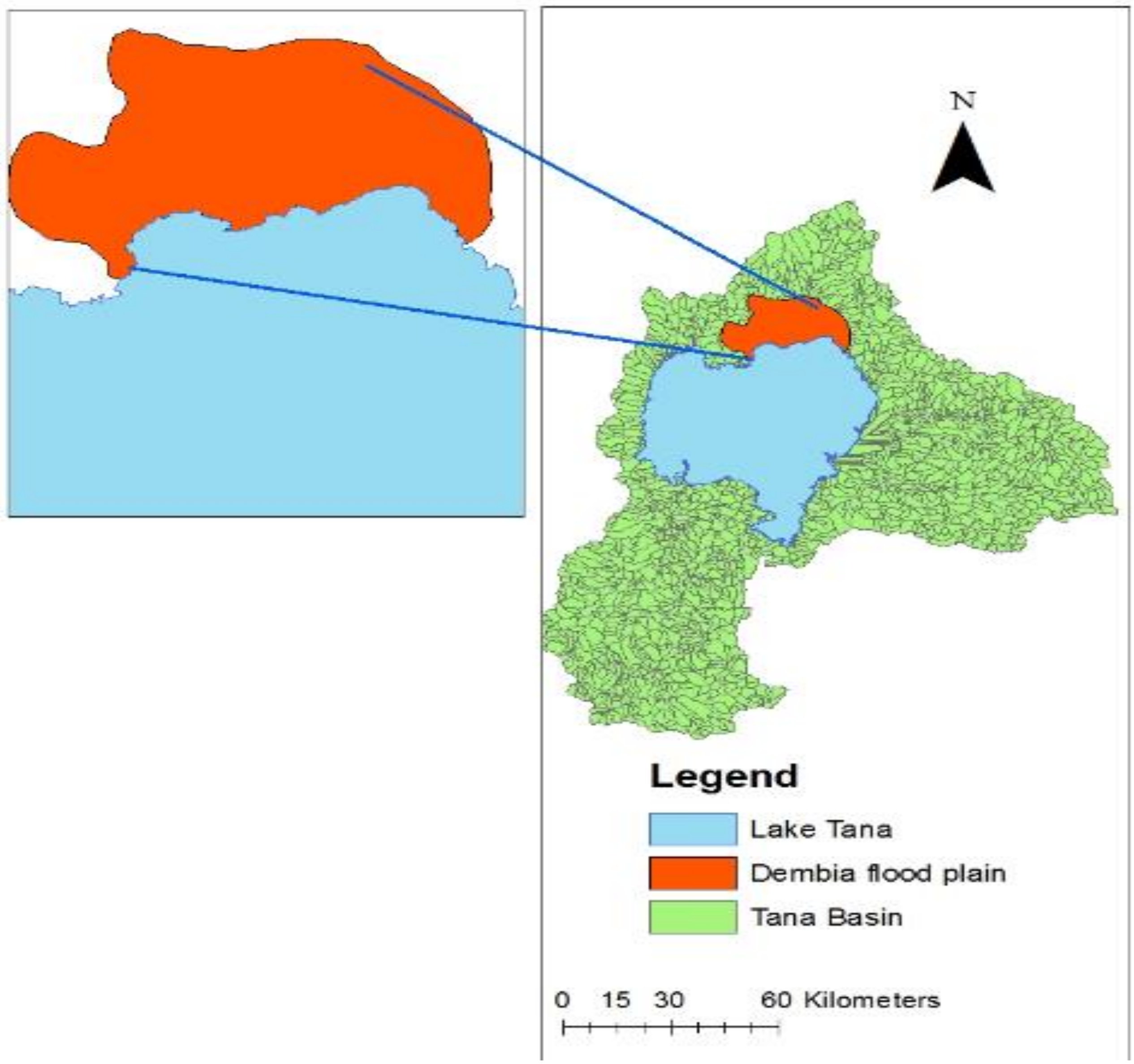


Figure 5: Location map of Dembia floodplain located in Lake Tana basin, Ethiopia.

3.2 Topography

Geographically Dembia floodplain lies with coordinates of $12^{o}19'36.29''$ N latitude and $37^{0}21'40.7''$ E longitude. Topographically the study area lies in the north of Lake Tana with altitude ranging from 1780 to 1811m above sea level.

3.3. Climate of the study area

The sources for almost all rain in Ethiopia are the Indian and Atlantic Oceans (Degefu, 1987). The amount of rainfall in Ethiopia is influenced by the location of the place relative to the source of moisture, the direction of winds and topographical relief. Based on the general classification of Agro- climate zone (on the bases of annual rainfall, temperature, length of growing period and plant types), the year is divided into two seasons: a rainy season mainly is on the months of June to September, and a dry season is from October to March.

The mean annual rainfall at azezo meteorological station is 1450mm. The mean monthly temperature minima ranges' between 5.9^{0}c and 11.8^{0}c, and that of maximum temperature between 7.2^{0}c and 27.4^{0}c. The minimum temperature is 5.9^{0}c, registered in December and the maximum temperature 27.4^{0}c, registered in February (SOCIET, October 2007).

3.4 Soils

Dembia floodplain is mainly formed from vertisols the main soil type in the plain. Fertile soils present in the plain are the basis for good harvests of barley, rice, millet, maize, teff, chickpea, nech azmud, tikur azmud and vetch, whilst there is widespread rice production by smallholders on irrigated land – a highly unusual crop for Ethiopia, introduced in the zone by schemes in recent decades. Maize, barley and millet are the main food crops, while rice, vetch and chickpea are the main cash crops. ((Fikadu, 2012). The soil map of the Lake Tana basin is shown in figure three.

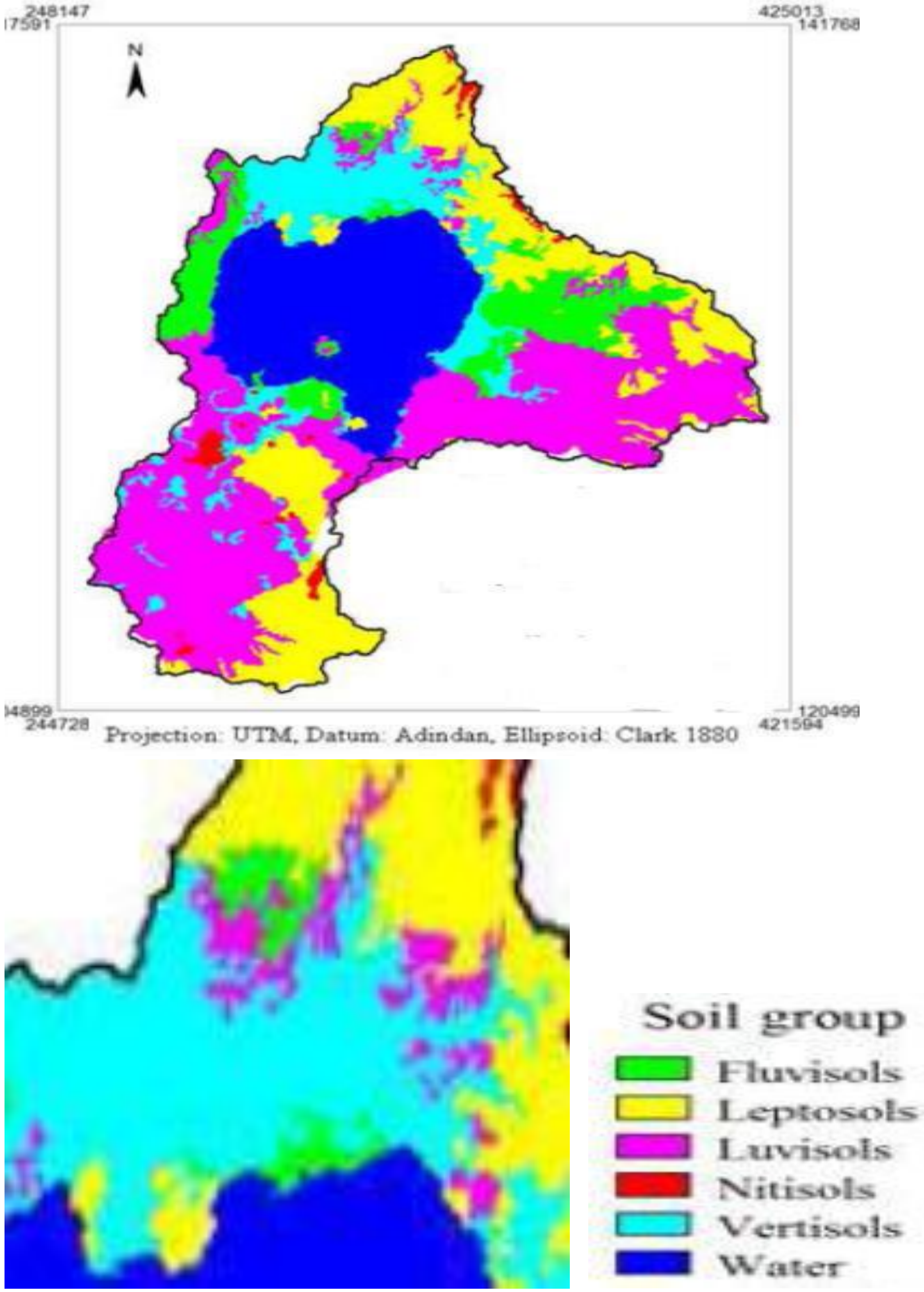


Figure 6: Soil Properties of the Area (Source: Hydrological Balance of Lake Tana Upper Blue Nile Basin, Ethiopia

3.5 Land Use

A survey of the land in Dembia woreda shows that 64% is arable or cultivable and another 25% under irrigation, 6% pasture, 4% forest or shrubland, and the remaining 1% is considered degraded or other (Fikadu, 2012). Agriculture is highly practiced in the wetland. The land cover map of Lake tana basin is shown in figure four.

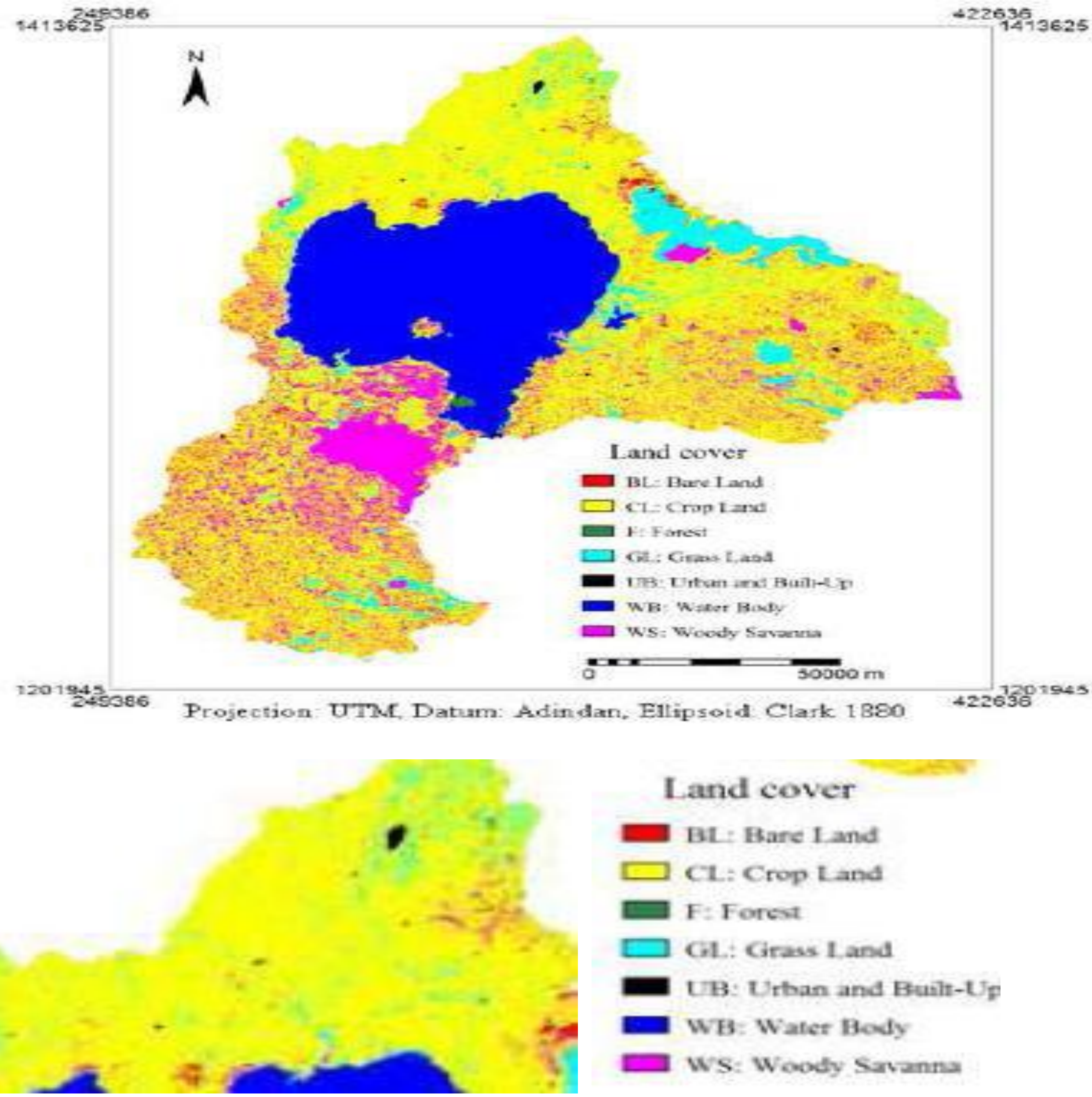


Figure 7: Land Cover of the Area (Source: Hydrological Balance of Lake Tana Upper Blue Nile Basin, Ethiopia)

4. MATERIALS AND METHODS

This section outlines the methodology used to investigate groundwater-surface water (lakeTana) hydraulic connections in Dembia floodplain.

4.1 Data

For this study the data listed below are collected. Fourty seven limited use and/or abandoned wells, distributed in the floodplain are selected and groundwater table measurements for each well bi-weekly time step observations are collected. Disturbed soil sample are also collected from randomly selected wells in the plain in order to determine hydraulic conductivity of the soil by laboratory. Daily maximum temperature data from Gonder (Azezo meteorological station) are used to calculate the potential evaporation rate. The Lake Tana level data are also be collected from Abay basin Authority.

4.2 Materials

The under listed materials are required in this study.

- ❖ Soil laboratory materials of Amhara design and supervision works enterprise are used for the determination of soil properties collected from the field by Falling head permeability method such materials are:
    - ➢ Mould,/Specimen size(four inch)
    - ➢ Compaction equipment (rammer)= used to compact the soil sample
    - ➢ Balance 2000gm
    - ➢ Graduated beaker –to measure the volume of water seeping through the specimen.
    - ➢ Stopwatch- to measure the time needed for a volume of water to seep through a soil specimen
    - ➢ Measuring tape and caliper –to measure specimen dimensions and total head changes
    - ➢ mixing pans/ moisture can- to mix the soil sample with percentage of water
    - ➢ Oven dry containers-used to dry the soil sample with in 24hours
    - ➢ soak apparatus-used to saturate the soil sample

- scopas -used to clean
- oil- used for painting of the mould before compact the sample- for easily removal of the soil sample from the mould
- jar-used to add percentage of water into the soil sample
- street edge cutter-used to cut/trim the soil sample put above the mould size
- Remover- used to remove the soil sample from the mould/ soil specimen

- Soil sample collection plastic bags are used.
- Soil sample collection core drill/pick/ -for the in-situ field soil sample excavation collection are used
- Meter and string-used for shallow groundwater measurement
- GPS Garmin 72H- used for shallow groundwater location coordinate reading
- Spade/shovle -For removal of excavated Soil and to put the Soil sample into the plastic bag

4.3 Methods

Abandoned wells due to different reasons and/or limited use wells had been selected as groundwater table observation sites. Abandoned wells are considered because; it is assumed that the decrease in groundwater level is due to the natural climatic demand for the evapotranspiration in the area and the groundwater outflow from the wells. For this, about fourty seven such wells, distributed in the floodplain having different land cover, was identified and groundwater level had been observed regularly on bi-weekly time step by trained personnel. In four observation wells, the disturbed soil sample are collected and their soil property (hydraulic conductivity) are determined in the laboratory. The groundwater table model, (which relates the groundwater table depth with time) developed by ((Enku, 2016)) are tested with the data in the Dembia flood plain. After wards, the observed groundwater level and the simulated water level are compared and the applicability and the performance of the new model in the monsoon climate of the Dembia floodplain had been evaluated. The spatial groundwater level in the plain are predicted using Ordinary Kriging geostatistical raster interpolation method using the available observed well data during the periods of the dry season.

The groundwater flow are also be determined from the Darcy equation using the saturated hydraulic conductivity and hydraulic head difference between the farthest groundwater level and the Lake level. The groundwater level and the Lake level are evaluated for understanding the connections of the shallow groundwater and the Lake.

4.3.2 Observation wells and lake level

Fourty seven abandoned or limited use hand dug wells were selected in 2016/17 as groundwater table observations. These wells were excavated originally for domestic water supply, but abandoned due to either the hand pump failure or water quality issues. These fourty seven (47) observation wells were located in ten (10) distinct kebeles (local name for lowest administrative region) found in the floodplain numbered from HDW-1 to HDW-47 accordingly which is shown in Figure nine. The kebele names in the plain are: Seraba Dablo- Central north (HDW-1 to HDW-7), Guramba Bata –north (HDW-8 to HDW-24 with different sub kebele), Guramba Mikael -north east (HDW-25 to HDW-30); Achera Mariam- south (HDW-31 and HDW-32), Chenker cherkos-West (HDW-33 to HDW-36), Kuami Mikael-North West (HDW-37 and HDW-38), Abrja (HDW-39), TachTeda (HDW-40), Tsion sewach (HDW-41) and Lenba- south east (HDW-42 to HDW-47) of the plain. The distance of the well closest to the lake was about 2.6km and the farthest near the foothills was about 10.24km from the shoreline. Forty-four (44) wells were located in grazing land and only three (3) of the observation wells were found on bare land. Figure eight shows abandoned /non-functional Groundwater table observation wells and its measurement mechanism in the floodplain area. The Location map of observation well data collected kebele in the study area are shown in Figure 8.

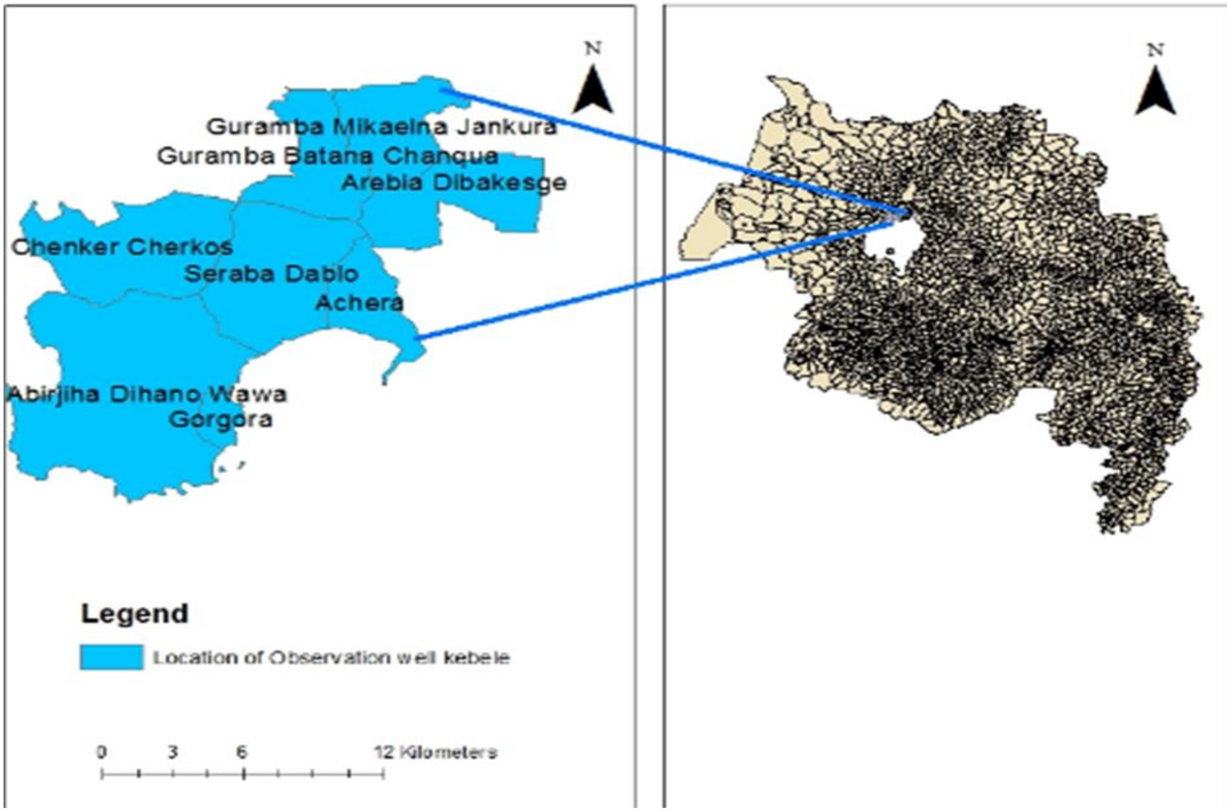


Figure 8: The Location map of observation well data collected kebele in the study area.

Figure 9: The abandoned groundwater table observation wells in the floodplain area.

Groundwater table data were collected bi-weekly time step when the groundwater table was below the land surface and fields were accessible. When the fields were inaccessible, groundwater was assumed at the surface of the land. Finally, the daily lake level data at Bahir Dar station was obtained from the Abay basin Authority of Ethiopia from 1959 to 2016. The Lake Level and groundwater table elevation was carried out to indicate the presence and character of connected reaches by comparing their elevations. Groundwater table elevation was determined from groundwater observation levels. The Locations and distributions of observation wells in the plain is shown in figure 10.

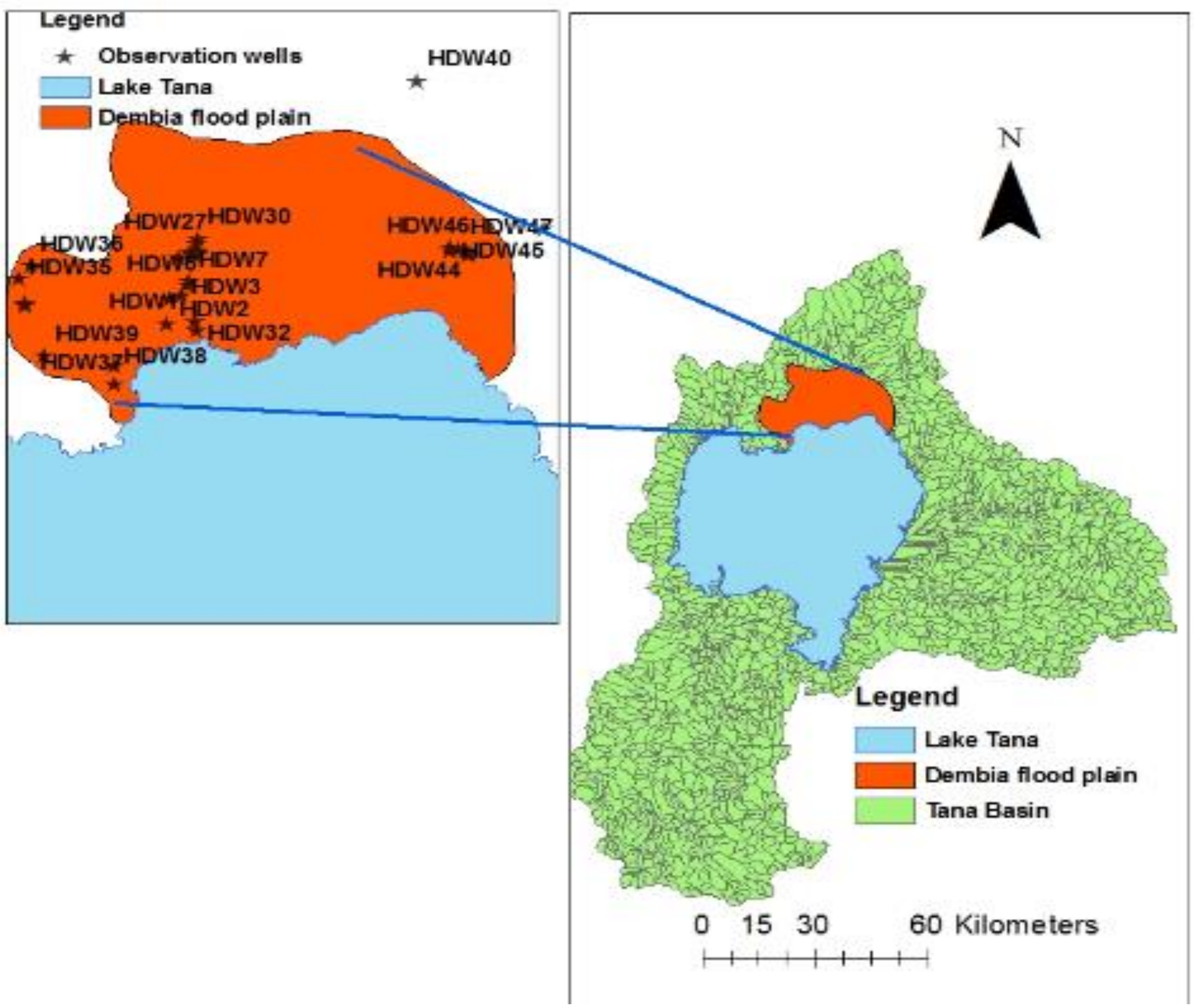


Figure 10: Locations and distributions of observation wells in the Dembia plain

4.3.3 Hydraulic conductivity

Hydraulic conductivity of soil is a measure of the ability to transmit water when submitted to a hydraulic gradient. The permeability (k) represents the soil's ability to transmit and drain water. This, in turn, indicates the ability of the soil to change matric suction as a result of environmental changes (Fredlund and Rahardjo, 1993).

American Society for Testing and Materials (ASTM) standards that describes the laboratory and field tests for the evaluation of the hydraulic conductivity: Among this D5084 "standard test methods for measurement of hydraulic conductivity of saturated porous materials using a flexible wall permeameter (falling- head permeability test)." hydraulic conductivity, K depends on: porosity, grain size distribution and shape, and degree of saturation.

The hydraulic conductivity of the soil was determined in the laboratory from the disturbed soil samples collected at four well locations with a plastic bag at a sample depth of one meter from original ground level. The soil samples were soaked in water for 24 hours, trimmed to the size and placed in the falling-head permeameter, consisting of a core sample holder, a small water tube fixed firmly to a graduated stand, and perforated plate at bottom of the sample connected to a draining tube. Water was added in the standing tube and water level and elapsed time were recorded. In falling- head permeability test of soil /the hydraulic conductivity soil test the total head changes during the test and the time it takes the total hydraulic head to drop between two predetermined points is measured. The experiment was done according to Head & Epps (1986) and Hydraulic conductivity, Ks was computed using:

$$Ks = \frac{2.3At*L}{As*t}\log\left(\frac{h1}{h2}\right) \tag{4.1}$$

Where, At is area of the tube filled by water=1.91cm^2, L is length of the sample=11.81cm, As is cross-sectional area of the sample=81.03cm^2, and t is the time elapsed to fall from a height of water h1 to h2 =3600second all the values are obtained during the experiment work see Figure 7.

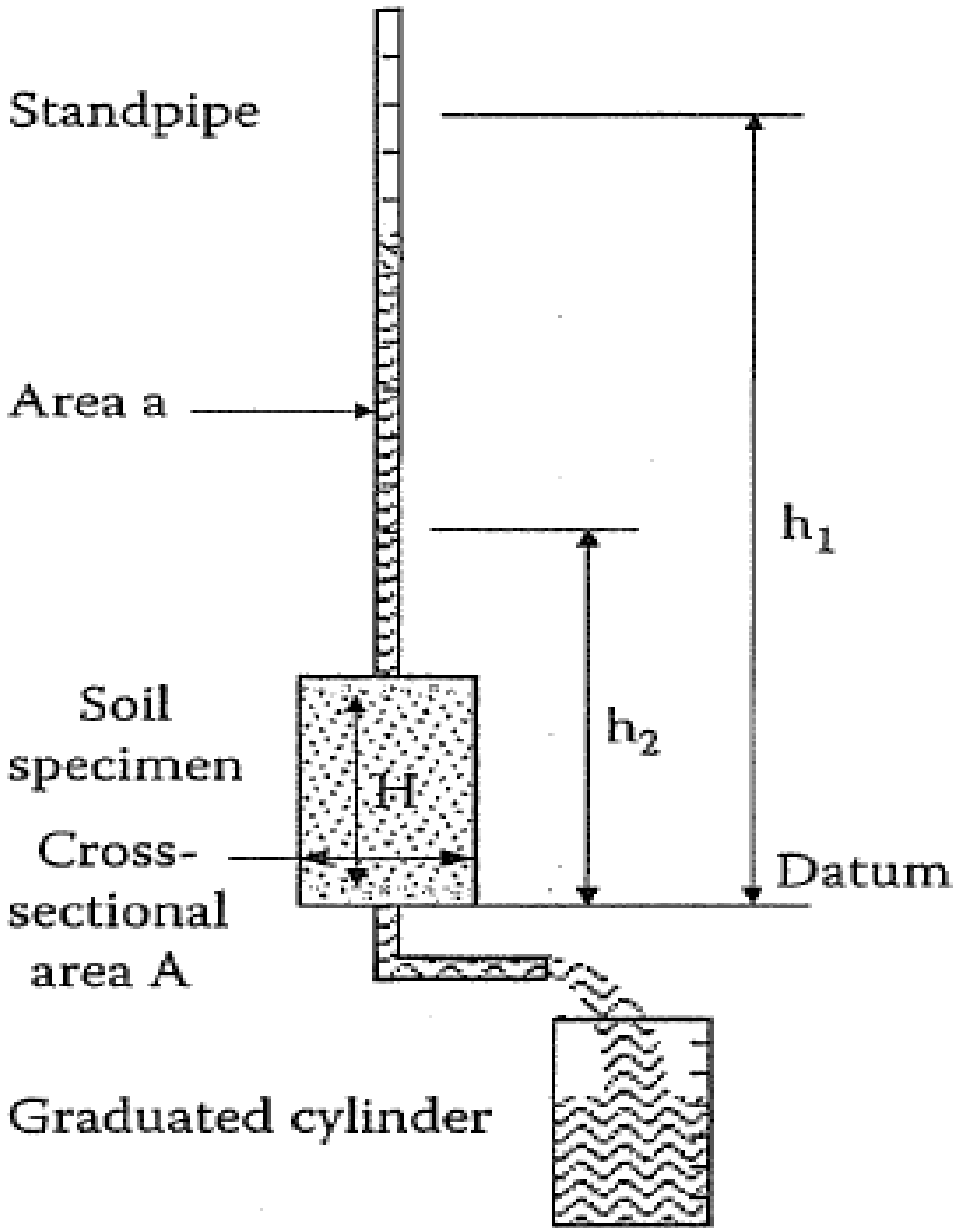


Figure 11: Falling head permeameter (source: Introduction to soil mechanics Laboratory testing manual by Taylor and Francis Group, 2007).

4.3.4 Groundwater table depth in the Dembia plain

Ordinary kriging GIS interpolation technique on ArcGIS 10.1 platform was used to predict the groundwater table elevations and variance in the Dembia plain. Observation wells data were used as input. To visualize the groundwater table in the Dembia plain, we prepared the kriged spatial water table maps, early in the dry phase on December 09, 2016 when the groundwater table was near the surface and at the end on May 8, 2017, before any significant rainfall occurred and groundwater had its lowest level. The prediction standard error spatial maps were also prepared.

4.3.5 The groundwater flow

The lateral flow in the surficial aquifer was determined along the cross sections perpendicular to the equipotential lines based on bi- weekly water table and lake level observations in 2016/17 using Darcy's law:

$$q_x = -K\frac{\Delta h}{\Delta x} \qquad (4.2)$$

Where $\mathbf{q_x}$ in the groundwater flow per unit area in (m/day), $\boldsymbol{K}$ is the laboratory determined saturated hydraulic conductivity of the soil medium (m/day), $\Delta\boldsymbol{h}/\Delta\boldsymbol{x}$ is the average hydraulic gradient along the selected transects perpendicular to the groundwater table contours in 2016/17.

4.3.6 Evapotranspiration from the groundwater storage and recharge

Evapotranspiration from the groundwater storage and recharge are the major components of the groundwater balance in flat terrain and shallow aquifer systems (Lam et al., 2011). Accurate estimation of evapotranspiration (ET) is essential in water resources management and hydrological practices. A new simple temperature method is developed, Enku T. and Melesse A. (2014) which uses only maximum temperature data to estimate ET.

Groundwater evapotranspiration during dry periods in the floodplain was calculated by the method consists of a linear function between actual evaporation and groundwater table depth that was initially used by United States Geological Survey (USGS) in their models to predict evaporation from shallow groundwater.

It requires only two soil parameters: the evapotranspiration surface and extinction depths (Harbaugh, 2005; Harbaugh & McDonald, 1996; McDonald & Harbaugh, 1988). The linear evapotranspiration function is expressed as:

$$et = \begin{cases} \boldsymbol{et_{max}};\ \boldsymbol{d_t < d_o} \\ \boldsymbol{et_{max}\left(\frac{d_e - d_t}{d_e - d_o}\right)};\ \boldsymbol{d_o \le d_t \le d_e} \\ \boldsymbol{0};\ \boldsymbol{d_t > d_e} \end{cases} \tag{4.4}$$

where et is the groundwater evaporation rate (L/T); et_{max} is the potential evaporation rate (L/T); $\boldsymbol{d_t}$ is the depth of groundwater table (L); $\boldsymbol{d_o}$ is the depth of evaporation surface (L) defined as depth where the evaporation become less than the potential rate; and $\boldsymbol{d}_e$ is the extinction depth (L) below which the evaporation is negligible. Literature values of $\boldsymbol{d_o}$ and $\boldsymbol{d}_e$ for clay soils and similar land cover types were used from (Shah et al., 2007) that reported evaporation surface depths of 0.54, 0.88, and 1.86m and extinction depths of 6.2, 7.15, and 8.2m in a bare, grass, and forested land covers, respectively. The potential evapotranspiration in the dry phase was estimated from Enku T. and Melesse A. (2014) as:

$$et_{max} = \frac{Tmax^n}{K} \tag{4.5}$$

Where, et_{max} is the potential evaporation (mm/day), T_{max} is the daily maximum temperature (^oC), n = 2.5, and k = *48Tmm - 330 where* T_{mm} is the long term daily mean maximum temperature (^oC).

4.3.7. Estimation of Groundwater Storage Change

Study of the water balance for any arbitrary volume and during any period of time, the difference between total input and output will be balanced by the change of water storage within the volume. In the field of hydrology the water balance budget idea is widely used. Considering that the change in groundwater storage can be attributed to recharge, (sum of the direct recharge from the precipitation and the indirect recharge from surface bodies), and groundwater inflow to the wells minus outflow (evapotranspiration from groundwater and groundwater outflow from the wells), the groundwater budget can be expressed by the equation. $R + Q_{in} = ET + Q_{ou} + \Delta S$ Where, R is the amount of total groundwater recharge (sum of the direct recharge from the precipitation and the indirect recharge from surface bodies), Q_{in} and Q_{ou} are the input and output of groundwater flows respectively, ET is the evapotranspiration from the groundwater, ΔS represents the changes in groundwater storage.

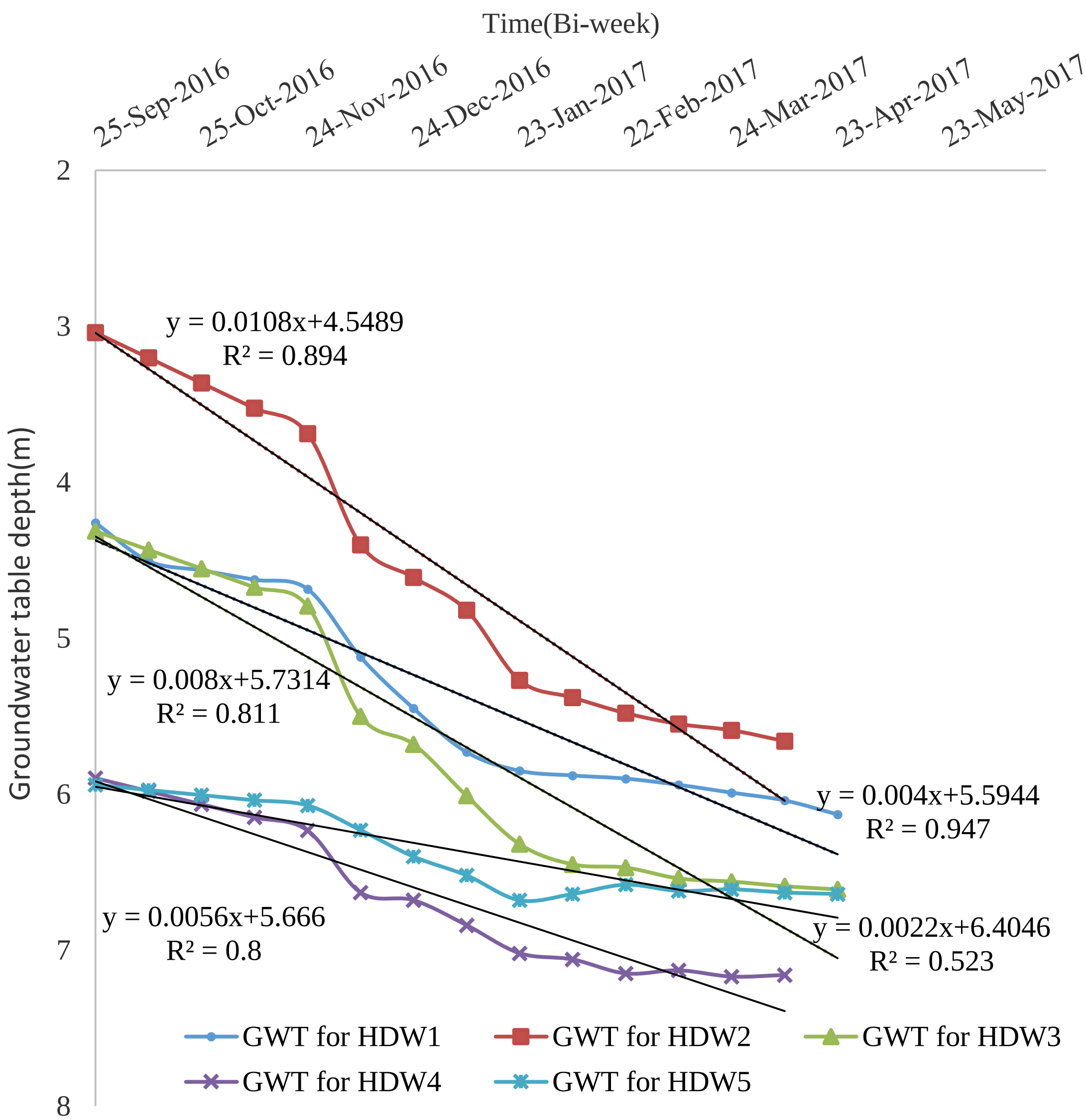
4.3.8 Estimation of Water Table Fluctuation, Δh

The water-table fluctuation (WTF) is based on the premise that rises in groundwater levels in the aquifers are due to recharge arriving at the water table. This is most applicable in areas with shallow water tables that display sharp rises and declines following rainfall events. Various phenomenon that are independent from rainfall, can induce water table rise. Δh can be estimated either in wet season corresponding to water level rise (recharge), or either in dry season corresponding to water level decline. In a relatively undisturbed system, long-term average recharge and withdrawal are balanced. The water table fluctuation estimated in wet season (Δh_{wet}) is usually used for groundwater storage change in terms of renewable groundwater resource. On the other hand, the water table estimated in dry season (Δh_{dry}) is used for quantifying the drainable groundwater resource for each observation well

5. RESULTS AND DISCUSSIONS

5.1 Groundwater table elevation in the Dembia Plain

As a result, understanding the spatial groundwater elevation in the Dembia plain, the groundwater table was plotted in the dry monsoon phase. On the dry season the observed groundwater table depth declines with time as shown in figure 12.



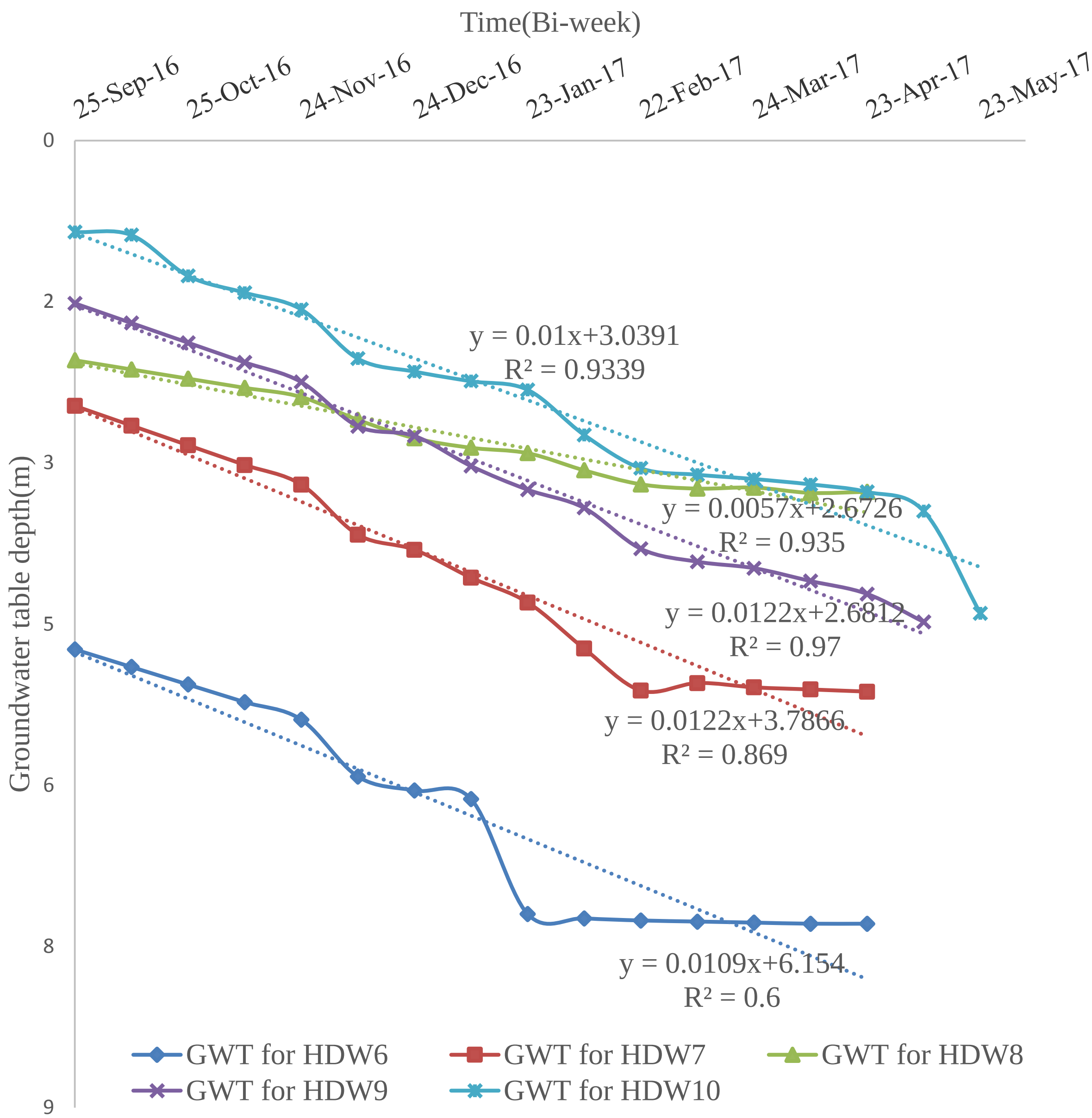


Figure 12: Groundwater table decline (shows how to decline the groundwater table with time on the dry season 2016/17)

Table 1: Groundwater decline and linear fit for selected observation wells in the Dembia floodplain For 2016/17 dry season.

Well name	Land cover type	Groundwater depth trend line Eq.	R^2	Depth at the end of dry season (m)	Draw down rate (cm/bi-week)
HDW1	Grass land	y = 0.004x + 5.594	0.9473	6.13	3.144
HDW2	Grass land	y = 0.0108x + 4.5489	0.893	5.63	2.887
HDW3	Grass land	y = 0.008x + 5.7314	0.8112	6.61	3.390
HDW4	Grass land	y = 0.0056x + 6.6662	0.8977	7.17	3.677
HDW5	Grass land	y = 0.0022x + 6.4046	0.5229	6.64	3.405
HDW6	Grass land	y = 0.0109x + 6.154	0.689	7.29	3.738
HDW7	Grass land	y = 0.0122x + 3.7866	0.8692	5.13	2.631
HDW8	Grass land	y = 0.0057x + 2.6726	0.9356	3.28	1.682
HDW9	Grass land	y = 0.0122x + 2.6812	**0.9759**	4.48	2.297
HDW10	Grass land	y = 0.01x + 3.0391	**0.9339**	4.45	2.282
HDW11	Grass land	y = 0.0141x + 2.9344	**0.9955**	5.05	2.590
HDW12	Grass land	y = 0.0136x + 2.8511	**0.995**	4.88	2.503
HDW13	Grass land	y = 0.0112x + 2.889	**0.8778**	4.99	2.559
HDW14	Grass land	y = 0.0102x + 2.4645	**0.9713**	3.97	2.036
HDW15	Grass land	y = 0.0099x + 5.6693	**0.9739**	7.04	3.610
HDW16	Grass land	y = 0.0035x + 8.3879	**0.9703**	8.83	4.528
HDW17	Grass land	y = 0.0027x + 7.9293	**0.874**	8.33	4.272
HDW18	Grass land	y = 0.0075x + 4.3379	**0.9637**	5.65	2.897
HDW19	Grass land	y = 0.0041x + 8.188	**0.8314**	8.55	4.385
HDW20	Grass land	y = 0.003x + 9.4885	**0.8303**	10.00	5.128
HDW21	Grass land	y = 0.0032x + 8.07	**0.7128**	8.54	4.379
HDW22	Bare land	y = 0.0068x + 3.3483	**0.8535**	4.24	2.174
HDW23	Grass land	y = 0.0089x + 4.0135	**0.9932**	5.38	2.759
HDW24	Grass land	y = 0.0075x + 5.3329	**0.9844**	6.57	3.369
HDW25	Grass land	y = 0.0112x + 6.5672	**0.9561**	8.21	4.210
HDW26	Grass land	y = 0.0028x + 5.6287	**0.9683**	6.01	3.082
HDW27	Grass land	y = 0.0114x + 5.8578	**0.966**	7.53	3.862
HDW28	Grass land	y = 0.0072x + 5.003	**0.8944**	5.89	3.021
HDW29	Grass land	y = 0.0128x + 3.4225	**0.9726**	5.43	2.785
HDW30	Bare land	y = 0.0087x + 3.8687	**0.9675**	5.30	2.718
HDW31	Grass land	y = 0.0102x + 7.08	**0.8603**	7.95	4.077
HDW32	Grass land	y = 0.0078x + 8.637	**0.9312**	9.93	5.092
HDW33	Grass land	y = 0.0074x + 0.7377	1.00	1.84	0.944
HDW34	Grass land	y = 0.0094x + 1.507	1.00	2.91	1.492
HDW35	Grass land	y = 0.0088x + 0.183	0.9783	10.91	5.595

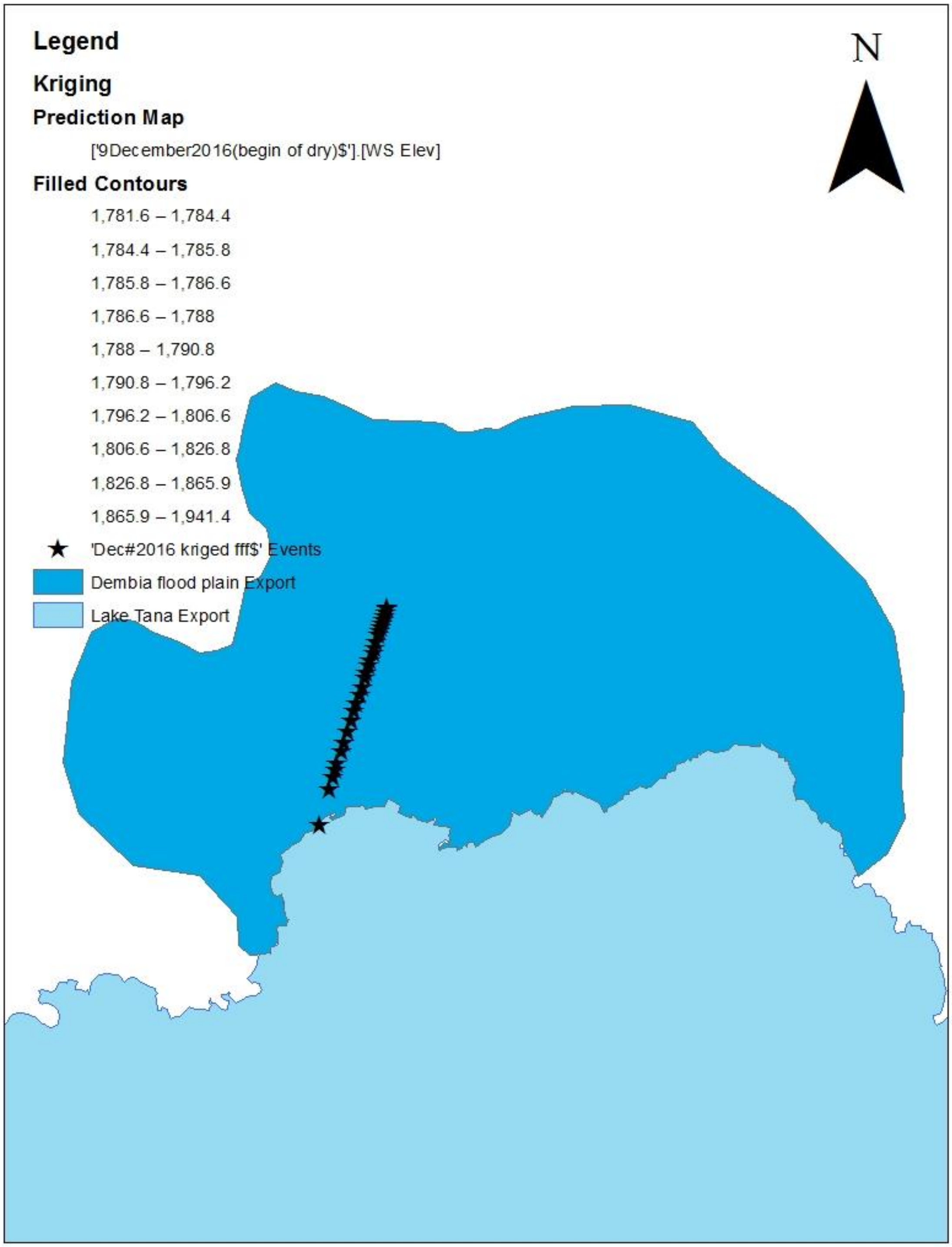
HDW36	Grass land	y = 0.0161x + 8.5045	1.00	1.67	0.856
HDW37	Grass land	y = 0.008x + 0.6972	1.00	1.78	0.913
HDW38	Bare land	y = 0.0052x + 3.9552	1.00	4.65	2.385
HDW39	Grass land	y = 0.0047x + 4.6284	1.00	0.85	0.436
HDW40	Grass land	y = 0.0047x + 0.2184	1.00	5.26	2.697
HDW41	Grass land	y = 0.0054x + 1.7882	1.00	2.51	1.287
HDW42	Grass land	y = 0.0054x + 6.6182	1.00	7.34	3.764
HDW43	Grass land	y = 0.004x + 4.1786	1.00	5.42	2.779
HDW44	Grass land	y = 0.0033x + 4.9689	1.00	4.72	2.421
HDW45	Grass land	y = 0.006x + 7.9579	1.00	8.77	4.497
HDW46	Grass land	y = 0.0054x + 6.5982	1.00	7.32	3.754
HDW47	Grass land	y = 0.0033x + 6.3689	1.00	6.82	3.497
Average				**5.912**	**3.032**

In order to understand the spatial groundwater elevation in the Dembia plain, the groundwater table was plotted at the beginning of the dry monsoon phase on December 9, 2016 when almost all surface ponding had disappeared, and at the end of dry phase on May 8, 2017 before any significant rainfall occurred. The groundwater levels between the observed points were predicted with ordinary kriging is shown in Figures 13a and 13b.

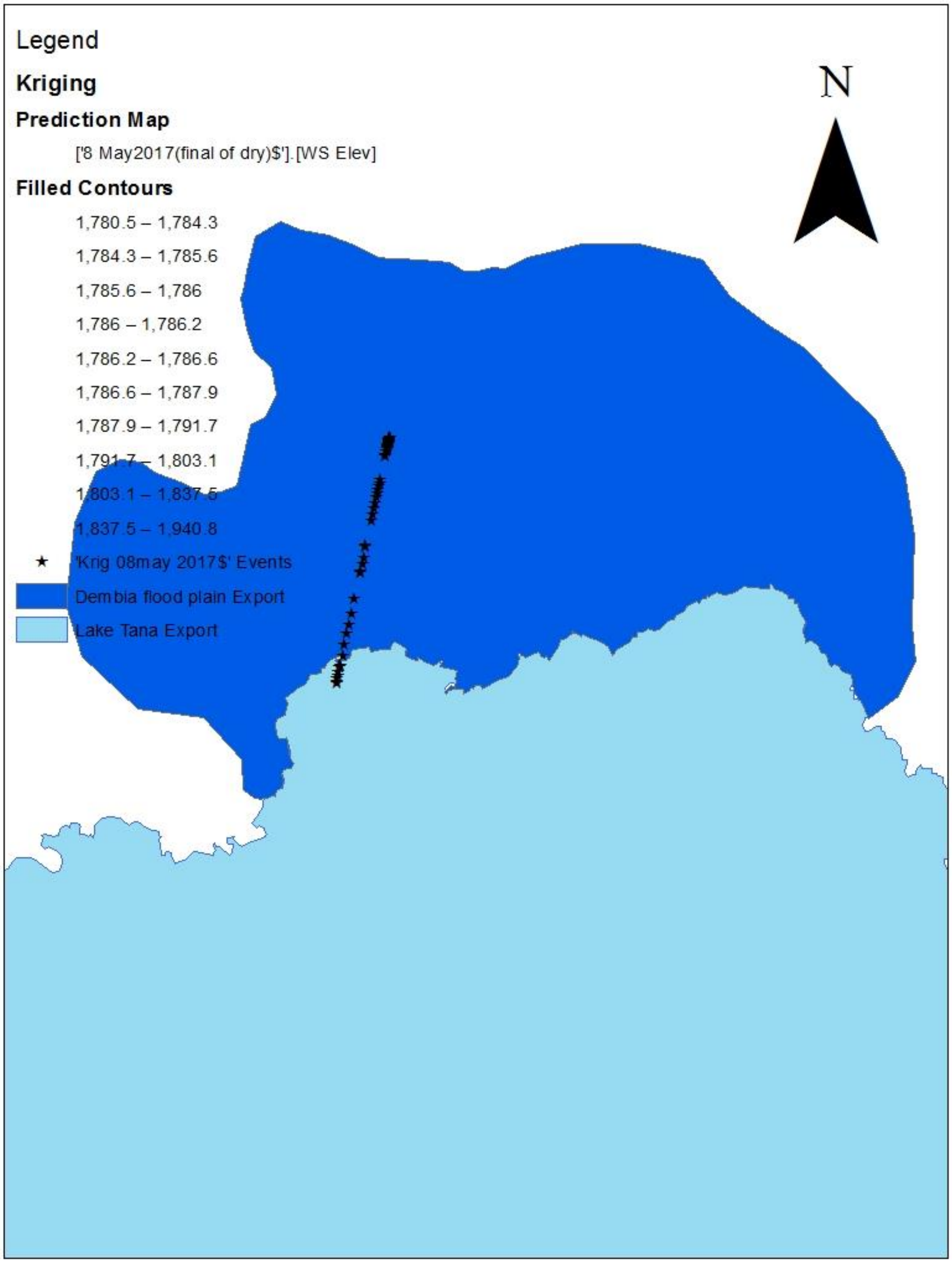
As expected, the groundwater table elevations are higher near the foothills and lower near Lake Tana but always greater than the lake level except for six observation wells (that is for Hand dug Wells 1, 2, 3, 5, 27 and 32 which has an elevation of 1784.4, 1780.5, 1782.6, 1782.4, 1781.7, and 1783.07meters above mean sea level respectively) near the lake at the end of the dry phase where farmers used/fetched the groundwater for their mud house construction and for their cattle drink.

Figure 13 shows that the largest error occurred at the outer boundaries where there are less observation wells, but the overall prediction appears reasonably good. This is confirmed by the prediction error statistics result, where the root-mean-squared standardized error is close to one, and the mean error is close to zero.

Moreover, the average standard errors are also close to the root-mean-squared prediction errors, which indicate correct assessment of the variability in the prediction. Slope of ground surface elevation and the hydraulic gradient in the flood plain is shown in Figure 14, and there Kriged line data at the Begin of dry season (09 December, 2016) and at the end of dry season (08 may, 2017) is shown in table 4 and 5 respectively. The red line in (Figure14) represents the December 9, 2016 groundwater table slope, the pink line represents the May 8, 2017 groundwater table slope and the blue line represents the original ground level slope taken from 30meter by 30meter Amhara digital elevation model map.



a) Kriged groundwater level on December 9, 2016



b) Kriged groundwater level on May 8, 2017

Figure 13: Kriged groundwater level in the Dembia plain on a) December 9, 2016. b) May 8, 2017.

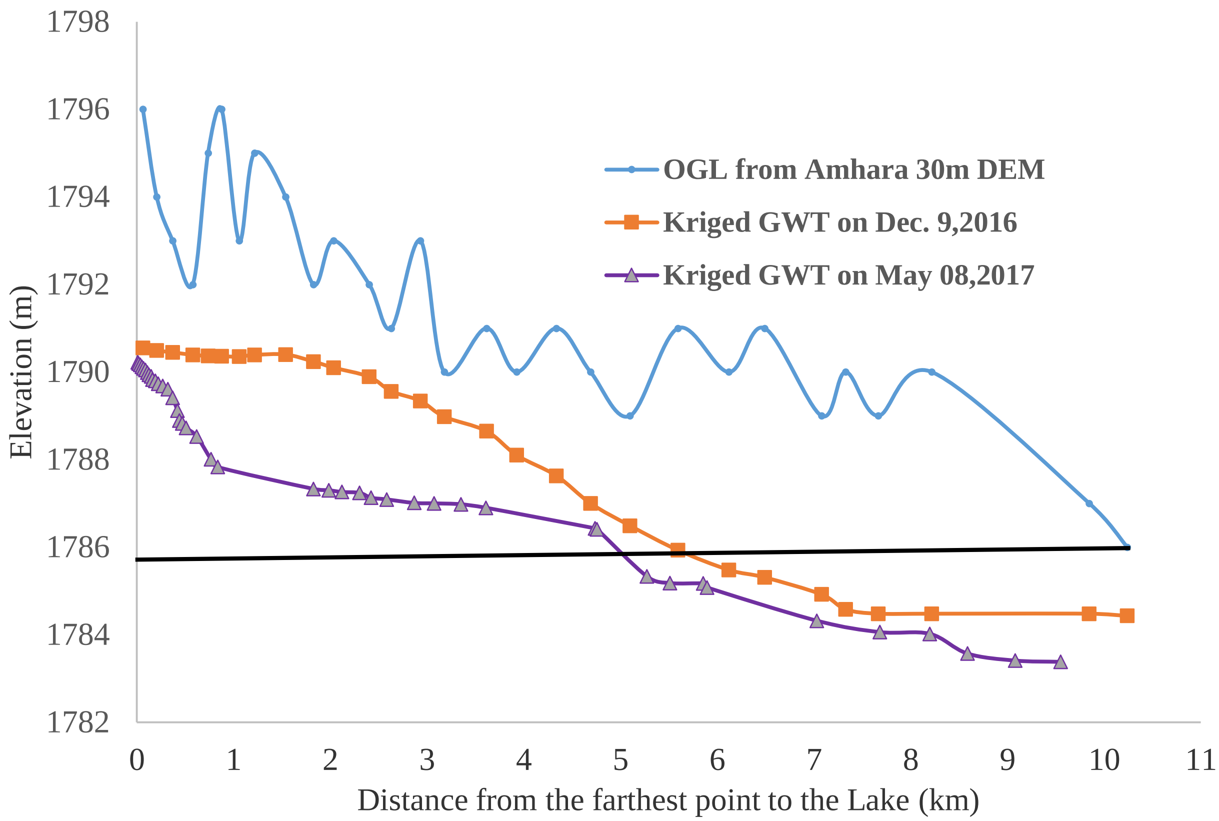


Figure 14: Slope of ground surface elevation and the hydraulic gradient in the Dembia plain

From figure 14(the slope of ground surface elevation and the hydraulic gradient) the horizontal line indicates the level of Lake Tana which is 1786 meter above sea level and From kriged prediction groundwater table data the ground surface has a general slope of 0.00094, and the steepest gradient of groundwater is approximately 0.0009 and the general hydraulic gradient is about 0.00088. This showed that the shallow groundwater is flowing to the lake about a distance of 5.6km starting from the farthest point to the Lake. The slope is negative near the lake because of the intrusion of the lake water to the groundwater, which is the amount of Lake water transported to groundwater about a distance of 4.6km. Implies that the hydraulic connection exists between the shallow groundwater and Lake Tana in the floodplain.

Table 2: Dry season Kriged line data (09 December, 2016)

X	Y	Z	dis.(km)	cumulative dis.(km)	Remark
319702.26	1366294	1790.55	0.062	0.062	farthest
319680.3	1366235	1790.49	0.143	0.205	
319632.04	1366100	1790.45	0.164	0.369	
319588.15	1365942	1790.39	0.208	0.578	
319522.3	1365745	1790.37	0.158	0.736	
319469.65	1365596	1790.36	0.14	0.876	
319421.38	1365464	1790.35	0.181	1.057	
319377.49	1365289	1790.39	0.159	1.216	
319337.99	1365135	1790.4	0.322	1.538	
319228.27	1364832	1790.24	0.286	1.824	
319153.66	1364556	1790.1	0.209	2.033	
319079	1364360	1789.89	0.369	2.402	
318964.89	1364009	1789.56	0.228	2.63	
318903.45	1363790	1789.34	0.301	2.931	
318806.89	1363504	1788.98	0.246	3.177	
318727.89	1363272	1788.65	0.438	3.615	
318609.4	1362851	1788.1	0.312	3.927	
318504	1362556	1787.63	0.411	4.338	
318376.79	1362166	1787	0.353	4.69	
318262.68	1361832	1786.49	0.408	5.099	
318144.18	1361442	1785.93	0.496	5.595	
317990.6	1360970	1785.48	0.526	6.121	
317828.24	1360470	1785.31	0.369	6.49	
317714.13	1360119	1784.92	0.588	7.078	
317534.14	1359559	1784.58	0.25	7.328	
317440.25	1359327	1784.48	0.337	7.664	Nearest

317341	1359006	1784.48	0.555	8.219	
317195.2	1358471	1784.48	1.628	9.847	
316771.5	1356899	1784.43	0.393	10.24	
316619.12	1356536	1786.47		10.24	Lake

Table 3: Dry season Kriged line data (08 may, 2017)

X	Y	Z	dis.(km)	cumulative dis.(km)	Remark
319551.90	1366758.00	1790.22	0.01	0.01	farthest
319550.00	1366748.00	1790.19	0.01	0.02	
319547.60	1366738.00	1790.16	0.02	0.04	
319544.30	1366723.00	1790.12	0.02	0.05	
319541.00	1366707.00	1790.08	0.02	0.07	
319537.80	1366692.00	1790.04	0.02	0.09	
319533.40	1366672.00	1789.99	0.02	0.11	
319529.10	1366651.00	1789.94	0.02	0.13	
319525.60	1366636.00	1789.90	0.02	0.15	
319520.60	1366612.00	1789.83	0.01	0.16	
319517.70	1366599.00	1789.80	0.03	0.19	
319511.70	1366571.00	1789.73	0.03	0.22	
319505.40	1366542.00	1789.68	0.05	0.27	
319495.90	1366498.00	1789.61	0.06	0.32	
319484.30	1366444.00	1789.41	0.05	0.37	
319474.20	1366397.00	1789.12	0.05	0.42	
319464.00	1366349.00	1788.89	0.02	0.44	
319459.90	1366330.00	1788.83	0.03	0.47	
319453.30	1366300.00	1788.72	0.04	0.51	
319444.80	1366259.00	1788.53	0.11	0.62	
319419.10	1366153.00	1788.01	0.15	0.77	

319387.30	1366010.00	1787.83	0.07	0.84	
319376.70	1365942.00	1787.33	0.99	1.83	
319165.10	1364973.00	1787.30	0.16	1.98	
319133.30	1364820.00	1787.26	0.14	2.12	
319101.60	1364688.00	1787.24	0.18	2.30	
319064.50	1364508.00	1787.13	0.12	2.42	
319043.30	1364391.00	1787.09	0.16	2.58	
319006.30	1364232.00	1787.01	0.28	2.87	
318942.80	1363957.00	1787.00	0.20	3.07	
318905.80	1363756.00	1786.98	0.28	3.35	
318837.00	1363486.00	1786.90	0.26	3.61	
318789.30	1363232.00	1786.43	1.13	4.74	
318540.60	1362132.00	1786.41	0.02	4.76	
318535.30	1362110.00	1785.33	0.52	5.27	
318440.10	1361604.00	1785.18	0.24	5.51	
318392.50	1361371.00	1785.17	0.34	5.85	
318313.10	1361037.00	1785.08	0.04	5.90	
318295.90	1361001.00	1784.32	1.14	7.03	
318063.10	1359890.00	1784.06	0.65	7.68	
317925.50	1359255.00	1784.02	0.52	8.20	Nearest
317819.60	1358747.00	1783.57	0.39	8.59	
317745.60	1358366.00	1783.41	0.49	9.08	
317618.60	1357890.00	1783.38	0.47	9.55	
317544.50	1357424.00	1786.12	0.42	9.98	Lake

To view the groundwater table depth fluctuation with time five representative wells shown in Figure15 are located within10.24 to 2.6km from the lake show that the groundwater table depth was in the range of 2.6m at the wells near the Lake, and at the wells near the foothills the groundwater table depth was in the range of 8.49m at the end of the dry phase and reached the surface back in third week of July. The groundwater depth at the end of the 2017 dry season was an average of about 5.9m (see table 2 above) deeper in the floodplain.

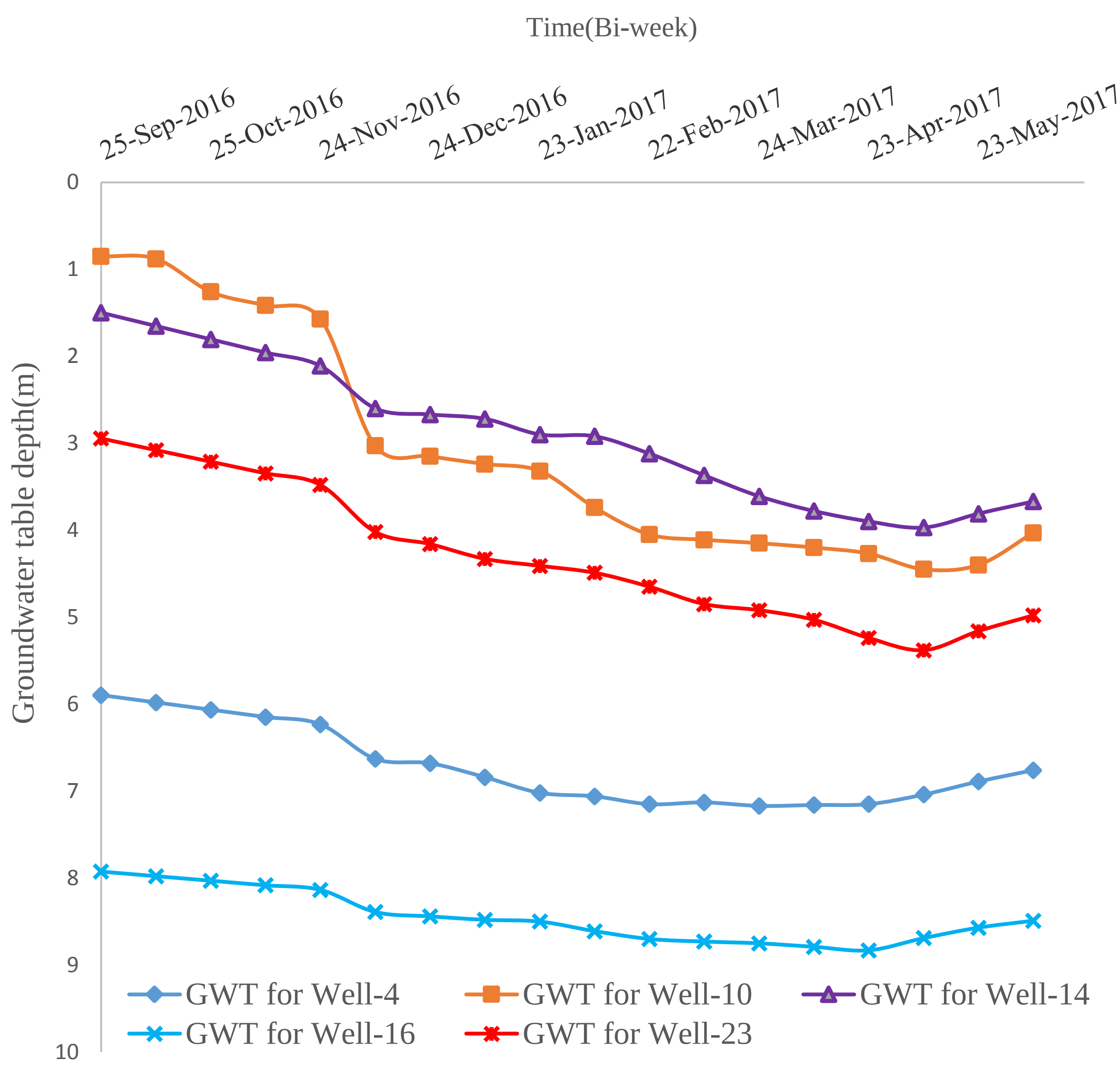


Figure 15: Groundwater table fluctuations in five selected wells in Dembia floodplain.

5.2 Hydraulic Conductivity

The hydraulic conductivity for the groundwater is needed to calculate the groundwater flux. It was determined for four soil samples taken from near four well locations using the falling head permeameter. The average hydraulic conductivity was 0.00034m/day and ranges from a minimum of zero (0) to a maximum of 0.00073m/day (see Table 5 below) from the experimental equation $K = \frac{2.3At * L}{As * t} \log(\frac{h1}{h2})$

Where, A_t= is area of the tube filled by water $A_t = \frac{\pi d^2}{4}$

Where, d is the diameter of the standing circular tube obtained by caliper measurement =1.56cm

$$At = \frac{3.14 * 1.56^2}{4} = 1.91cm^2$$

L is length of the sample specimen (mould) obtained by tape measurement =11.81cm

As= is cross-sectional area of the sample = $\frac{\pi d^2}{4}$

Where, d=diameter of the sample specimen (mould) =4inch=4*25.4mm=10.16cm

At= $\frac{3.14 * 10.16^2}{4}$ =81.03cm^2 and t is the time elapsed to fall from a height of water from h1 to h2=3600second.

Table 4: Summary of falling head permeability results

Trial	h1(cm)	h2(cm)	Time (se)	h1/h2	log(h1/h2)	K at test temp. (22oc) (cm/sec)	Kaverage (cm/sec)	Code
1	137	135.5	3600	1.01107	0.00478	$8.5034*10^{-7}$		HDW36
2	137	135.6	3600	1.01032	0.00446	$7.9335*10^{-7}$		HDW36
3	137	135.8	3600	1.00883	0.00382	$6.7952*10^{-7}$	$7.741*10^{-7}$	HDW36
1	137	135.6	3600	1.01032	0.00446	$7.93354*10^{-7}$		HDW33
2	137	135.9	3600	1.00809	0.00350	$6.2266*10^{-7}$		HDW33
3	137	136	3600	1.00735	0.003182	$5.65848*10^{-7}$	$6.606*10^{-7}$	HDW33
1	137	136.9	3600	1.0007	0.000317	$3.17119*10^{-4}$		HDW37
2	137	136.9	3600	1.0007	0.000317	$3.17119*10^{-4}$		HDW37
3	137	136.9	3600	1.0007	0.000317	$3.17119*10^{-4}$	$5.6398*10^{-7}$	HDW37
1	137	137	3600	1.00	0	0		HDW16
2	137	137	3600	1.00	0	0		HDW16
3	137	137	3600	1.00	0	0	0	HDW16

Note: Average permeability at 22oc: K22oc=3.184*10^-7 cm/s=0.00034m/day

5.3 Lateral flow in the aquifer

It was found that the lateral groundwater flow is minimum allowing us to assign all changes in water table depth from the aquifer to either recharge or evaporation. Results from continuous water level measurements within the dry season showed that lateral flow into the Lake are negligible.

The transect section shown in Figure 13 were drawn perpendicular to equipotential lines, in areas with the smallest errors and without the effect of the Megech and Dirma to draw the hydraulic gradients and compute groundwater flow. Figure14 shows the original ground surface elevation with the general slope of the plain and the predicted groundwater elevations at the transect sections from the farthest foothills to the lake. The hydraulic gradient is the change in total head divided the distance over which the change occurs. A hydraulic gradient causes water to move. Darcy's Law states that the amount of water (Q) flowing through porous media depends on the energy driving the water flow ($\Delta h/\Delta L$) and the hydraulic conductivity (K) of the porous media. Groundwater flow is impacted by a complex set of interactions of several factors. Some of those factors are hydraulic gradients, hydraulic conductivity, and soil porosity. Groundwater flows from high to low hydraulic head, and the hydraulic gradient is determined by the slope of the groundwater table surface.

The slope of hydraulic grade lines in the sections and days are less at the foothills than at the middle of the plain (Figure 14). The small hydraulic gradient near the foothills is due to small contributing area for recharge and likely greater hydraulic conductivity. The ground surface has a general slope of 0.00094. From December 09, 2016 and May 08, 2017 kriged prediction groundwater table data the steepest gradient of groundwater is approximately 0.0009 and the general hydraulic gradient is about 0.00088. This showed that the shallow groundwater is flowing to the lake starting from the farthest point to the LakeTana. The groundwater flow towards the Lake in the Dembia floodplain was calculated with equation (4-2) using the average hydraulic conductivity of 0.00034m/day (see Table 3) and the general hydraulic gradient of 0.00088. The computed specific discharge is as low as $3.0*10^{-7}$m/day, which is negligible.

The groundwater flow in flat terrain is generally low (Lam et al., 2011). Thus, all changes in the elevation of the water table are due to recharge or evaporation.

The Darcy's Law of estimated groundwater flow, based on experimental measurements of hydraulic conductivity and the average hydraulic gradient, represents the groundwater and Lake Tana water interactions of the observation wells within the floodplain. The groundwater and Lake Tana water interacts as part of a complex system and extensive data coverage is required to characterize the high degree of heterogeneity of this system.

5.4 Groundwater evapotranspiration and recharge in the floodplain

5.4.1 Evaporation

The average groundwater depth at the end of dry phase, May8, 2017 was 5.9m (see Table 2). In order to calculate the evaporation rate during the dry phase we used the linear evapotranspiration function for the groundwater table depth (Eq. 4-4) at the wells. The soil of the plots is clay and was covered with grass land and Bare land the evaporation surface and extinction depths were according to the (Shah et al., 2007). At these well locations, the cumulative actual evaporation from the linear function was computed as 928mm during the dry period of the season.

5.4.2 Groundwater evaporation for the Dembia plain

In the Dembia plain we note that the groundwater table decreases after the rain phase is a linear function of time for all wells. Based on this we can use an equation for groundwater evaporation using the relationship (Eq. 4-4) developed by United States Geological Survey (Harbaugh, 2005; Harbaugh & McDonald, 1996; McDonald & Harbaugh, 1988) to compute groundwater evaporation rate in the area.

$$et = \begin{cases} et_{max};\ d_t < d_o \\ et_{max}\left(\frac{d_e - d_t}{d_e - d_o}\right);\ d_o \le d_t \le d_e \\ 0;\ d_t > d_e \end{cases} \qquad (4\text{-}4)$$

We can now calculate the maximum cumulative evaporation at the end of the dry phase by multiplying the result of (Eq. 4-4) by the respective periods for the groundwater table to decline to d_o and d_e. The potential evaporation (mm/day) in the dry phase was estimated from Enku and Melesse (2014) as 5.028mm/day by taking the daily maximum temperature (^oC), T_{max} =30 ^oC, n = 2.5, and $k = 48Tmm - 330$ *where* the long term daily mean maximum temperature (^oC) ,T_{mm} =27.3.We used this equation to compute the cummulative evaporation at the end of the dry phase in the Dembia plain, we found the daily evaporation rate increase linearly with time and the cummulative at the end of the dry phase was 874.59mm is shown in Figure16 and see the evaporation sample calculation example for well ten are shown in table 7.

Table 5: the literature values of evaporation surface depth and extinction depth

From Shah et al.(2007)		
do(m)	de(m)	Description of the area
0.88	7.15	For Grass land cover
0.54	6.2	for bare land cover

Where $\boldsymbol{d_o}$ is the depth of evaporation surface (L) defined as depth where the evaporation become less than the potential rate; and $\boldsymbol{d}_e$ is the extinction depth (L) below which the evaporation is negligible.

Table 6: Observation well groundwater evaporation rate computation

Gorg.date	GWT depth (dt,m)	Well evapo(mm/day)	Evapo*time(mm)	Cumulative evapo.(mm)
25-09-16	0.85	5.00	5.00	5.00
10-10-16	0.88	5.00	75.00	80.00
25-10-16	1.26	4.70	72.73	152.73
09-11-16	1.42	4.57	69.53	222.25
24-11-16	1.57	4.45	67.66	289.91
09-12-16	2.03	4.08	63.99	353.90
24-12-16	2.15	3.99	60.53	414.42
08-01-17	2.24	3.92	59.27	473.69
23-01-17	2.32	3.85	58.25	531.95
07-02-17	2.74	3.52	55.26	587.21
22-02-17	3.05	3.27	50.90	638.11
09-03-17	3.11	3.22	48.68	686.79
24-03-17	3.15	3.19	48.09	734.88
08-04-17	3.20	3.15	47.55	782.43
23-04-17	3.27	3.09	46.83	829.26
08-05-17	3.45	2.95	45.33	874.59

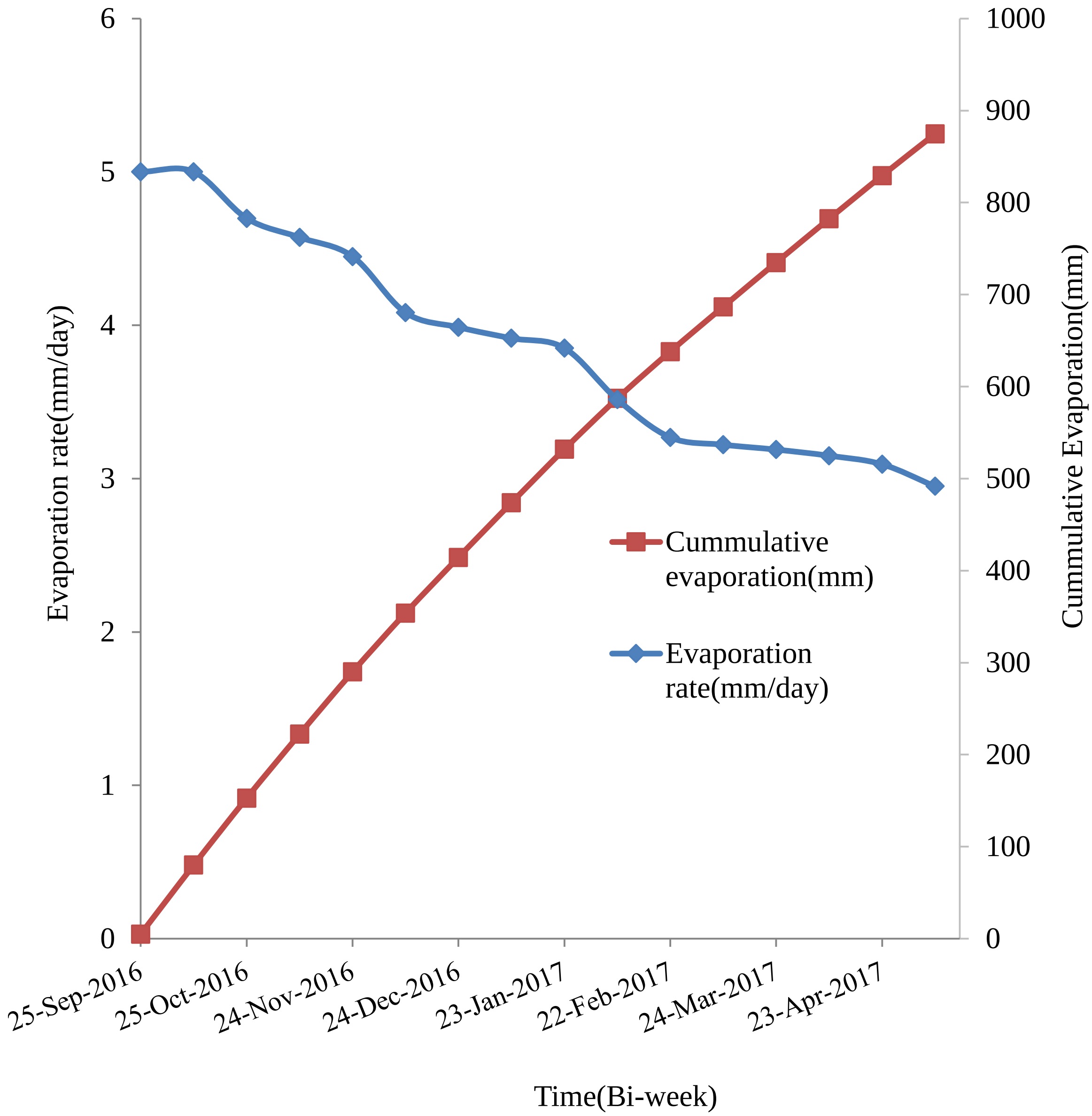


Figure 16: Daily evaporation rate and cummulative evaporation during the dry phase of 2016/17 in the Dembia plain.

5.4.3 Recharge

The water-table fluctuation are a technique for estimating recharge; it requires changes in groundwater levels over time. Recharge is one of the key hydrological parameters for assessment, budgeting, management, and modelling of groundwater resources. To estimate the groundwater recharge, it is necessary to obtain precise information on the factors governing infiltration and percolation to the groundwater system.

Considering that excess rainfall could be recharged to the groundwater in the flood plain. The result shows that the average shallow groundwater table declined in the Plain during the end of the dry season was 5.9 m. The groundwater table was rapidly recharged during the wet period by excess rainfall and flooding from rivers Dirma and Megech except for wells which are located at the highest elevation in the Plain.

In many of the observation wells, the groundwater table reached the surface as the plain starts to flood, usually third week of July.

The analysis of the water table fluctuation concerns the monitored observation wells. From rainfall dynamic during the study period rainfall to be the only source of aquifer's recharge once a year in the wet season while water level decline corresponds to in the dry season. The water level rise and decline in the aquifer are under rainfall control. It was observed that the aquifer is responding immediately to the onset of the wet season.

Over the observation period, the corresponding water table fluctuation (Δh) is 5.9m. Thus recharge to the aquifer is equal to the amount of evaporation during the dry phases. This volume is usually recharged by the rainfall that takes place between the first rains in May to the third week of July. This large quantity of recharge demonstrates the important role in shallow groundwater resources management. The groundwater table remains at the surface until the rainfall stops and evaporation becomes larger than the rainfall amounts. Groundwater recharge from rainfall are essential for effective management of groundwater resources.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

- From predicted hydraulic gradient computation we can conclude that the hydraulic connection exists between the shallow groundwater and Lake Tana.
- At observation wells, the groundwater table fluctuation in the dry season was due to evaporation, minimum groundwater lateral flow and recharge.
- The computed groundwater flow was 3.0*10-7m/day, which is negligible shows that the decline of groundwater table was due to evaporation.
- At well locations, the actual daily evaporation from evapotranspiration function for the groundwater table depth was computed as 928mm and the cumulative evaporation at the end of the dry phase was 874mm.
- It was found that groundwater recharge from excess rainfall and river flood is equivalent to evaporation rate.
- Finally we can conclude that the groundwater system in the floodplain is sustainable.

6.2 Recommendations

To visualize the interaction of groundwater and surface water flow more in the Dembia floodplain for future work I recommend that:

- Additional observation well groundwater table data collection/measurement for different year are required in order to understand the exact hydraulic connection of groundwater-surface water (Lake Tana) over time.
- Additional soil sample for different location around observation wells are required for hydraulic conductivity analysis.
- Soil property, land use and geology of the area investigation are required because they helps to understand the fluctuation of groundwater table elevations and the degree of groundwater recharge.

The groundwater system in the floodplain is sustainable but in the future, it is expected that more irrigation will take place during the dry season so, I recommend in the future that the groundwater system in the plain needs further investigation.

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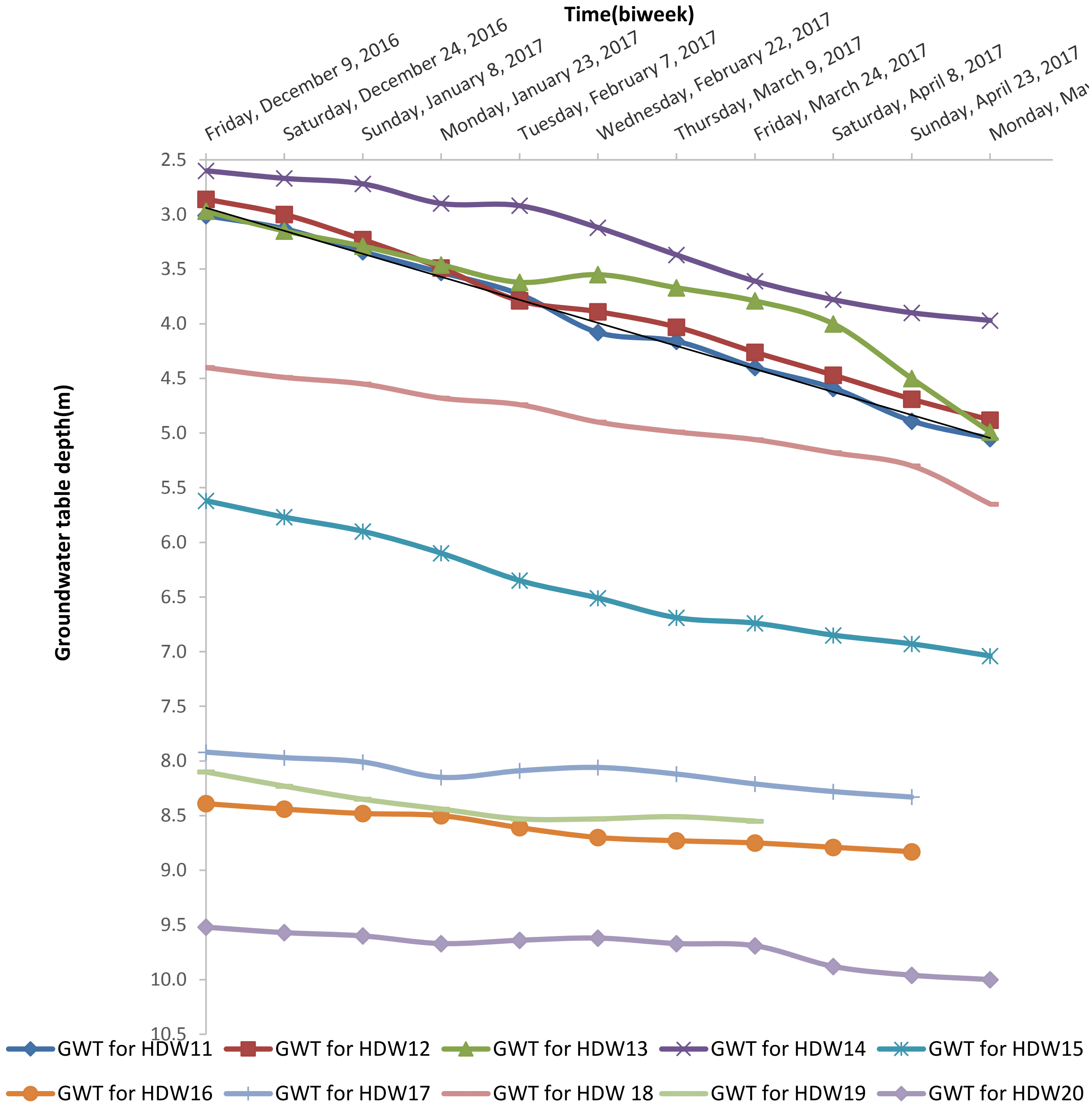
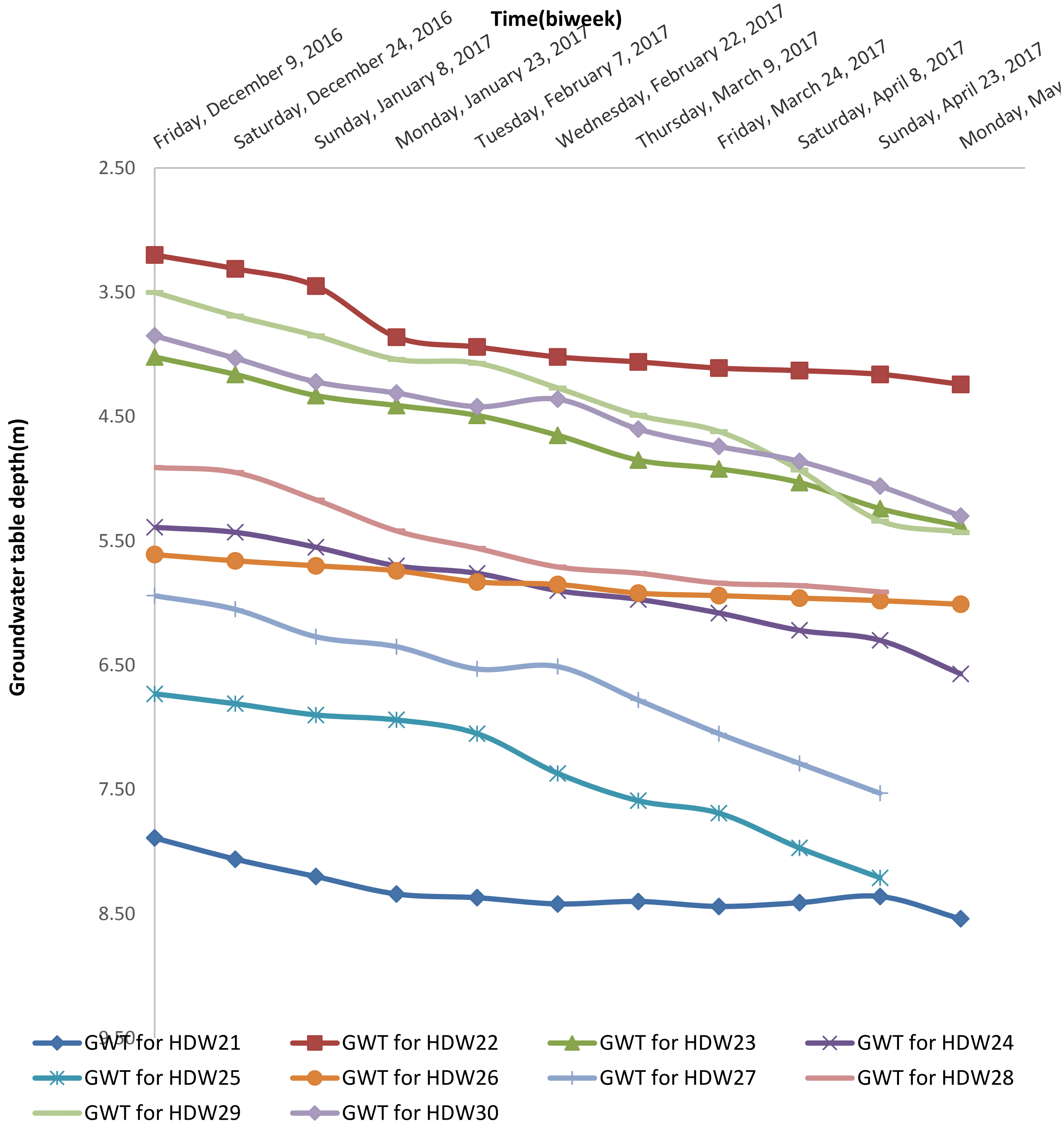
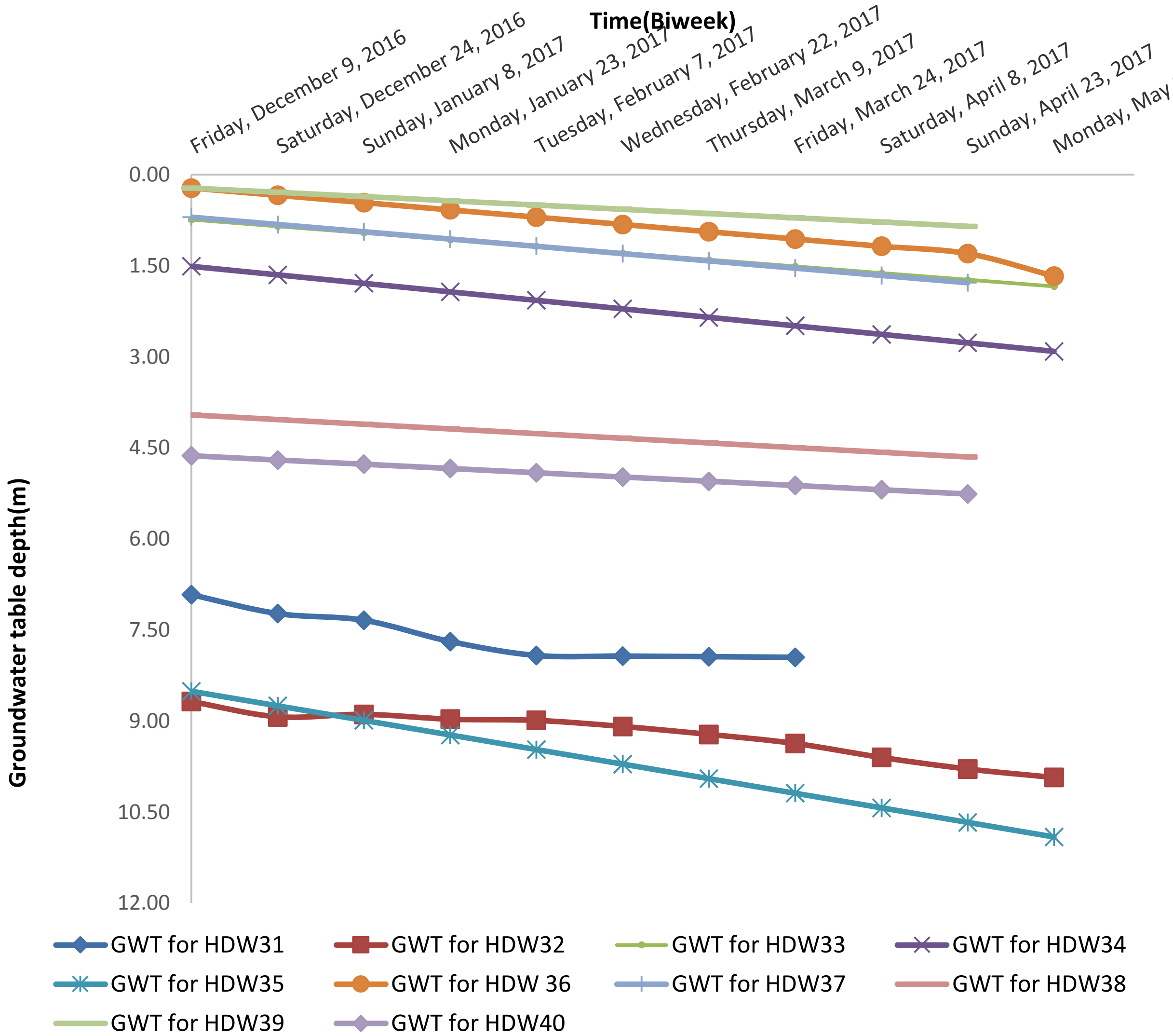
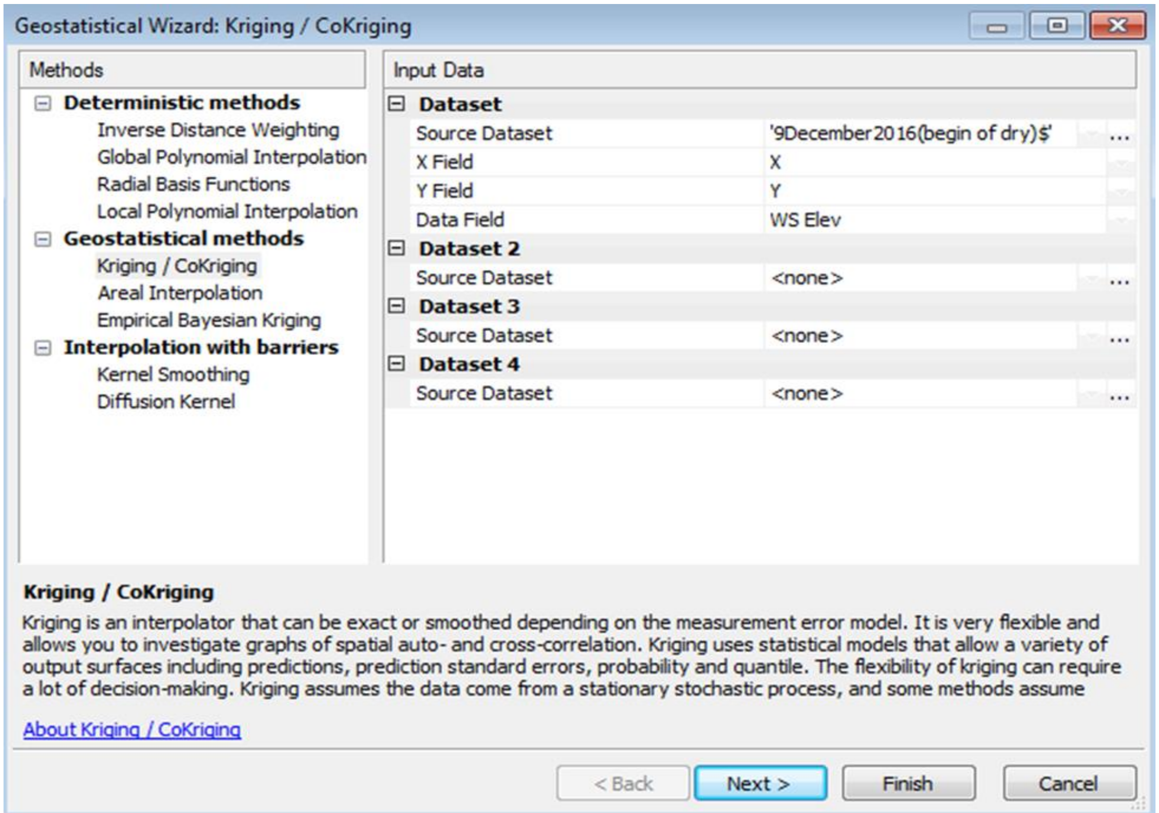
Appendix 1: Chart of dry season observed groundwater table depth declines With Time.

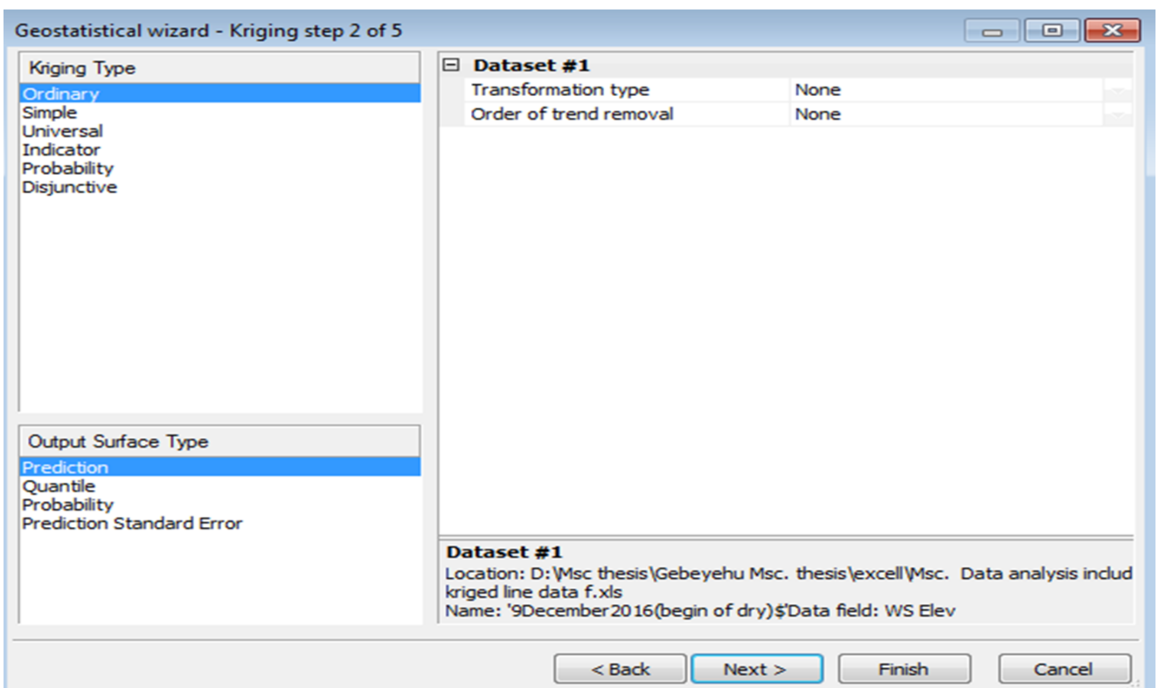


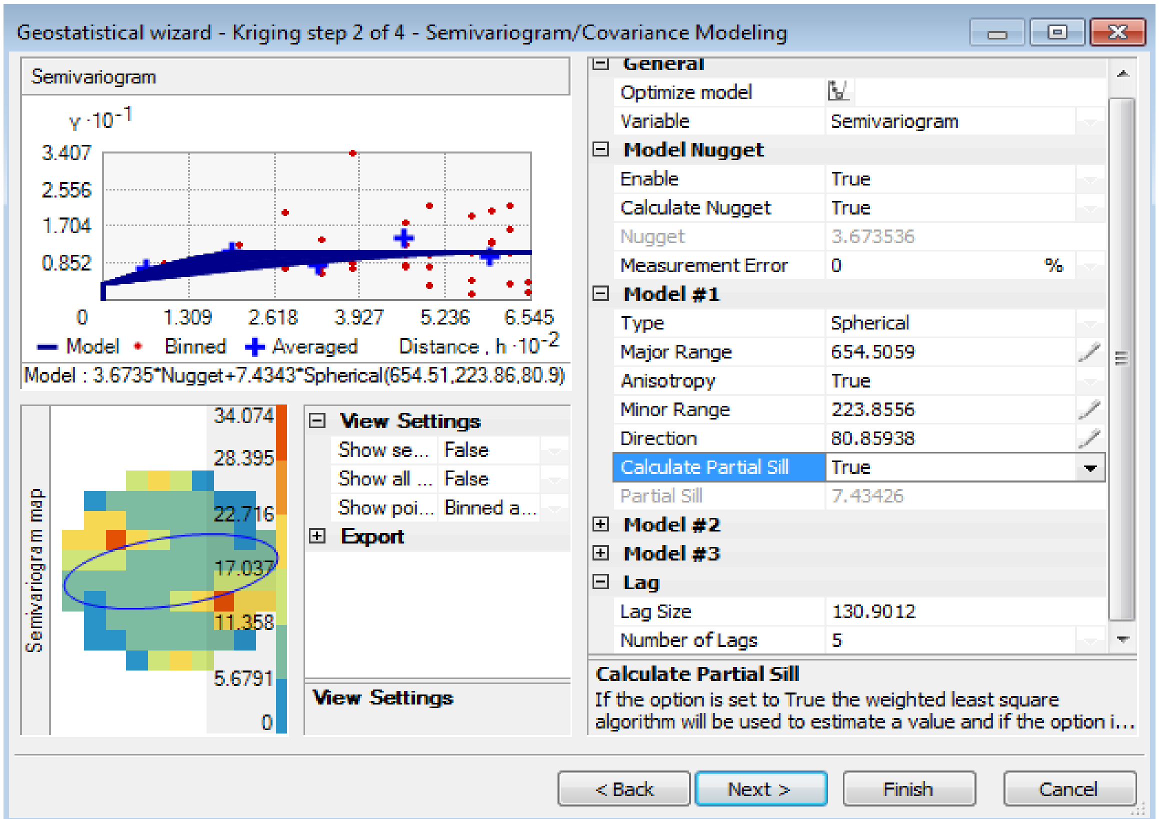

Time(biweek)
Friday, December 9, 2016
Saturday, December 24, 2016
Sunday, January 8, 2017
Monday, January 23, 2017
Tuesday, February 7, 2017
Wednesday, February 22, 2017
Thursday, March 9, 2017
Friday, March 24, 2017
Saturday, April 8, 2017
Sunday, April 23, 2017
Monday, May
Groundwater table depth(m)
2.50
3.50
4.50
5.50
6.50
7.50
8.50
9.50
GWT for HDW21
GWT for HDW22
GWT for HDW23
GWT for HDW24
GWT for HDW25
GWT for HDW26
GWT for HDW27
GWT for HDW28
GWT for HDW29
GWT for HDW30

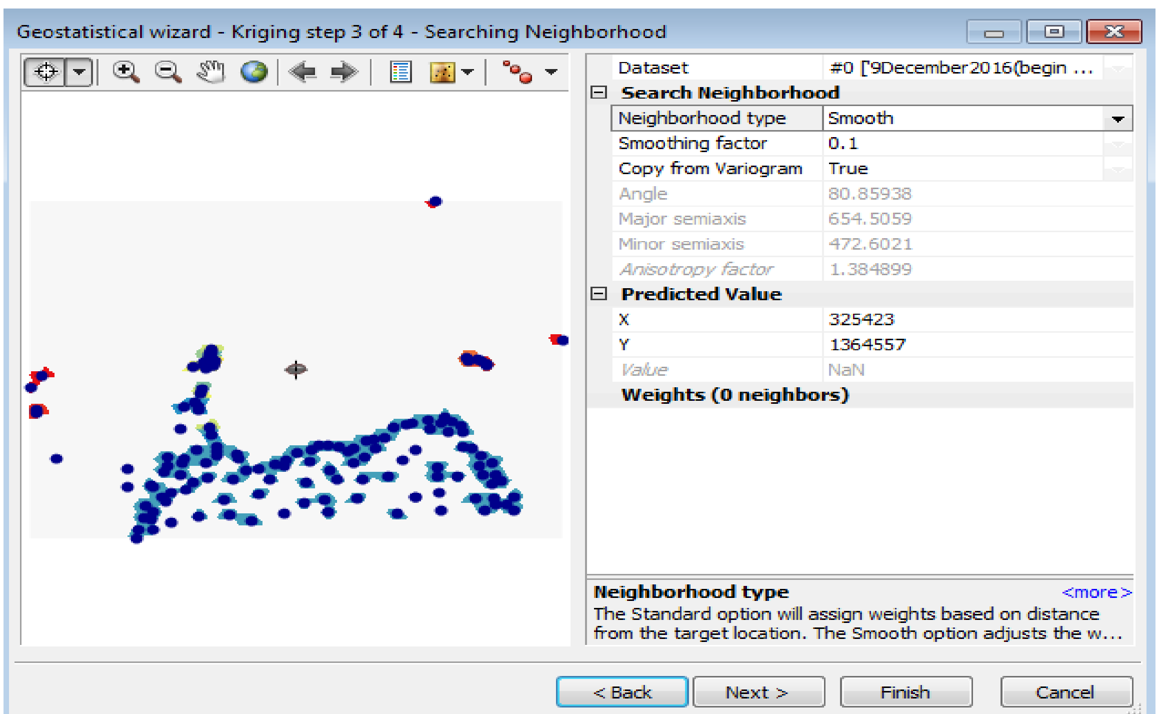

Time(Biweek)
Friday, December 9, 2016
Saturday, December 24, 2016
Sunday, January 8, 2017
Monday, January 23, 2017
Tuesday, February 7, 2017
Wednesday, February 22, 2017
Thursday, March 9, 2017
Friday, March 24, 2017
Saturday, April 8, 2017
Sunday, April 23, 2017
Monday, May
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
Groundwater table depth(m)
GWT for HDW31
GWT for HDW32
GWT for HDW33
GWT for HDW34
GWT for HDW35
GWT for HDW 36
GWT for HDW37
GWT for HDW38
GWT for HDW39
GWT for HDW40

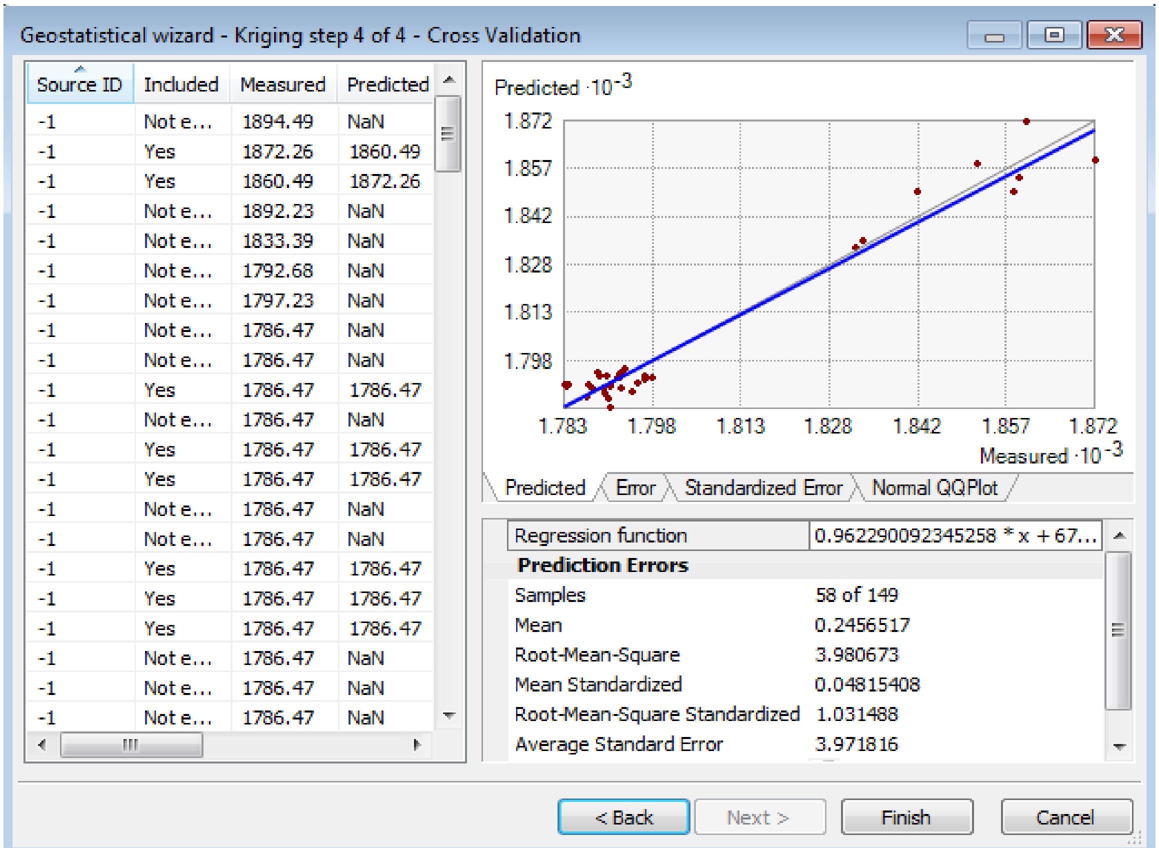
Appendix 2: Kriged input dataset and output for the dry season.






Geostatistical wizard - Kriging step 2 of 4 - Semivariogram/Covariance Modeling
Semivariogram
γ ·10^-1
3.407
2.556
1.704
0.852
0
1.309
2.618
3.927
5.236
6.545
Model
Binned
Averaged
Distance , h ·10^-2
Model : 3.6735*Nugget+7.4343*Spherical(654.51,223.86,80.9)
Semivariogram map
34.074
28.395
22.716
17.037
11.358
5.6791
0
View Settings
Show se... False
Show all ... False
Show poi... Binned a...
Export
View Settings
General
Optimize model
Variable Semivariogram
Model Nugget
Enable True
Calculate Nugget True
Nugget 3.673536
Measurement Error 0 %
Model #1
Type Spherical
Major Range 654.5059
Anisotropy True
Minor Range 223.8556
Direction 80.85938
Calculate Partial Sill True
Partial Sill 7.43426
Model #2
Model #3
Lag
Lag Size 130.9012
Number of Lags 5
Calculate Partial Sill
If the option is set to True the weighted least square algorithm will be used to estimate a value and if the option i...
< Back
Next >
Finish
Cancel


Geostatistical wizard - Kriging step 3 of 4 - Searching Neighborhood
Dataset #0 ['9December2016(begin ...
Search Neighborhood
Neighborhood type Smooth
Smoothing factor 0.1
Copy from Variogram True
Angle 80.85938
Major semiaxis 654.5059
Minor semiaxis 472.6021
Anisotropy factor 1.384899
Predicted Value
X 325423
Y 1364557
Value NaN
Weights (0 neighbors)
Neighborhood type
<more>
The Standard option will assign weights based on distance from the target location. The Smooth option adjusts the w...
< Back
Next >
Finish
Cancel



d) Normal QQ plot cross validation

Input datasets

-Dataset

D:\Msc thesis\Gebeyehu Msc. thesis\excell\Copy of Msc. Data analysis includ kriged line data f.xlsx\'9December2016 (begin of dry)$'

Type	Table
X field	X
Y field	Y
Data field 1	WS Elev
Records	149
-Method	**Kriging**
Type	Ordinary
Output type	Prediction
-Dataset #	1

Trend type	None
-**Searching neighborhood**	Smooth
Smoothing factor	0.1
Major semiaxis	654.505887324416
Minor semiaxis	472.602059360822
Angle	80.859375
-**Variogram**	Semivariogram
Number of lags	5
Lag size	130.901177464883
Nugget	3.673536380979
Measurement error %	0
-**Model type**	Spherical
Range	654.505887324416
Anisotropy	Yes
Minor range	223.855573080846
Direction	80.859375
Partial sill	7.434260477405

Appendix 3: Lake Tana Level Data, Observation Wells Data, Evaporation Rate and Cumulative Evaporation Estimation Table.

Table 1.1: Lake Tana Level data

	Lake Tana level data											
Date	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
1	1785.97	1786.92	1786.66	1786.41	1786.09	1785.7	1785.56	1785.42	1785.8	1786.35	1786.62	1786.58
2	1785.98	1786.92	1786.64	1786.41	1786.1	1785.71	1785.57	1785.42	1785.81	1786.44	1786.66	1786.54
3	1785.97	1786.92	1786.66	1786.38	1786.08	1785.69	1785.5	1785.46	1785.81	1786.44	1786.62	1786.57
4	1785.97	1786.9	1786.64	1786.4	1786.08	1785.69	1785.5	1785.44	1785.83	1786.44	1786.63	1786.55
5	1785.97	1786.9	1786.66	1786.4	1786.09	1785.67	1785.5	1785.38	1785.85	1786.48	1786.6	1786.57
6	1785.98	1786.88	1786.66	1786.42	1786.06	1785.71	1785.53	1785.43	1785.84	1786.48	1786.66	1786.61
7	1785.99	1786.88	1786.64	1786.4	1786.07	1785.77	1785.5	1785.41	1785.89	1786.51	1786.68	1786.62
8	1785.96	1786.85	1786.63	1786.34	1786.04	1785.62	1785.48	1785.49	1785.9	1786.49	1786.65	1786.56
9	1785.97	1786.89	1786.58	1786.33	1786.02	1785.68	1785.49	1785.46	1785.91	1786.57	1786.64	1786.56
10	1785.98	1786.85	1786.59	1786.32	1785.98	1785.68	1785.5	1785.49	1785.94	1786.59	1786.66	1786.6
11	1785.96	1786.84	1786.58	1786.32	1785.96	1785.69	1785.43	1785.46	1785.98	1786.53	1786.66	1786.55
12	1785.96	1786.85	1786.58	1786.3	1785.94	1785.66	1785.47	1785.53	1786	1786.54	1786.66	1786.54
13	1785.95	1786.83	1786.58	1786.31	1785.94	1785.6	1785.4	1785.49	1785.98	1786.55	1786.66	1786.54
14	1785.94	1786.81	1786.54	1786.29	1785.92	1785.65	1785.44	1785.46	1785.9	1786.6	1786.67	1786.54
15	1785.96	1786.77	1786.53	1786.29	1785.92	1785.67	1785.49	1785.56	1785.97	1786.59	1786.66	1786.53
16	1785.95	1786.8	1786.51	1786.28	1785.91	1785.6	1785.4	1785.54	1786.04	1786.6	1786.65	1786.52
17	1785.96	1786.78	1786.52	1786.28	1785.9	1785.6	1785.39	1785.6	1786.14	1786.63	1786.65	1786.52
18	1785.94	1786.76	1786.51	1786.23	1785.87	1785.54	1785.44	1785.54	1786.16	1786.59	1786.66	1786.52
19	1785.96	1786.75	1786.52	1786.19	1785.86	1785.56	1785.44	1785.63	1786.17	1786.67	1786.65	1786.52
20	1785.96	1786.76	1786.5	1786.14	1785.84	1785.6	1785.5	1785.63	1786.2	1786.64	1786.65	1786.52
21	1785.95	1786.74	1786.49	1786.15	1785.83	1785.64	1785.43	1785.6	1786.22	1786.68	1786.63	1786.52
22	1785.96	1786.73	1786.48	1786.2	1785.82	1785.57	1785.47	1785.61	1786.26	1786.7	1786.62	1786.53
23	1785.93	1786.73	1786.45	1786.18	1785.8	1785.51	1785.4	1785.62	1786.2	1786.66	1786.62	1786.49
24	1785.93	1786.72	1786.48	1786.16	1785.78	1785.53	1785.45	1785.61	1786.15	1786.69	1786.61	1786.48
25	1785.94	1786.71	1786.48	1786.14	1785.77	1785.53	1785.51	1785.65	1786.26	1786.65	1786.62	1786.48
26	1785.92	1786.7	1786.44	1786.14	1785.74	1785.49	1785.4	1785.67	1786.26	1786.65	1786.62	1786.46
27	1785.93	1786.68	1786.42	1786.14	1785.76	1785.56	1785.42	1785.7	1786.24	1786.64	1786.61	1786.46
28	1785.92	1786.69	1786.4	1786.12	1785.73	1785.54	1785.38	1785.67	1786.28	1786.66	1786.62	1786.44
29	1785.68	1786.68	-	1786.14	1785.71	1785.53	1785.44	1785.77	1786.23	1786.66	1786.6	1786.41
30	1785.67	1786.67	-	1786.11	1785.7	1785.48	1785.47	1785.7	1786.24	1786.63	1786.6	1786.4
31	1784.83	1786.67	-	1786.12	-	1785.53	-	1785.74	1786.35	-	1786.59	-

Table 1.2: Observation well measured data on Dembia floodplain

Gorg.date	DOY	X	Y	OGL_GPS	WS_depth	Masonry height	GWT depth	WS Elev
25-09-16	268	317339	1359392	1790	5.11	0.85	4.26	1785.74
10-10-16	283	317339	1359392	1790	5.35	0.85	4.50	1785.50
25-10-16	298	317339	1359392	1790	5.41	0.85	4.56	1785.44
09-11-16	313	317339	1359392	1790	5.47	0.85	4.62	1785.38
24-11-16	328	317339	1359392	1790	5.53	0.85	4.68	1785.32
09-12-16	343	317339	1359392	1790	5.97	0.85	5.12	1784.88
24-12-16	358	317339	1359392	1790	6.30	0.85	5.45	1784.55
08-01-17	8	317339	1359392	1790	6.58	0.85	5.73	1784.27
23-01-17	23	317339	1359392	1790	6.70	0.85	5.85	1784.15
07-02-17	38	317339	1359392	1790	6.73	0.85	5.88	1784.12
22-02-17	53	317339	1359392	1790	6.75	0.85	5.90	1784.10
09-03-17	68	317339	1359392	1790	6.79	0.85	5.94	1784.06
24-03-17	83	317339	1359392	1790	6.84	0.85	5.99	1784.01
08-04-17	98	317339	1359392	1790	6.89	0.85	6.04	1783.96
23-04-17	113	317339	1359392	1790	6.98	0.85	6.13	1783.87
08-05-17	128	317339	1359392	1790	6.47	0.85	5.62	1784.38
23-05-17	143	317339	1359392	1790	6.40	0.85	5.55	1784.45
07-06-17	158	317339	1359392	1790	6.23	0.85	5.38	1784.62
	HDW2							
25-09-16	268	317554	1361370	1786	3.74	0.70	3.04	1782.96
10-10-16	283	317554	1361370	1786	3.90	0.70	3.20	1782.80
25-10-16	298	317554	1361370	1786	4.06	0.70	3.36	1782.64
09-11-16	313	317554	1361370	1786	4.22	0.70	3.52	1782.48
24-11-16	328	317554	1361370	1786	4.39	0.70	3.69	1782.31
09-12-16	343	317554	1361370	1786	5.10	0.70	4.40	1781.60
24-12-16	358	317554	1361370	1786	5.31	0.70	4.61	1781.39
08-01-17	8	317554	1361370	1786	5.52	0.70	4.82	1781.18
23-01-17	23	317554	1361370	1786	5.97	0.70	5.27	1780.73
07-02-17	38	317554	1361370	1786	6.08	0.70	5.38	1780.62
22-02-17	53	317554	1361370	1786	6.18	0.70	5.48	1780.52
09-03-17	68	317554	1361370	1786	6.25	0.70	5.55	1780.45
24-03-17	83	317554	1361370	1786	6.29	0.70	5.59	1780.41
08-04-17	98	317554	1361370	1786	6.36	0.70	5.66	1780.34
23-04-17	113	317554	1361370	1786	6.33	0.70	5.63	1780.37
08-05-17	128	317554	1361370	1786	6.17	0.70	5.47	1780.53
23-05-17	143	317554	1361370	1786	6.03	0.70	5.33	1780.67

07-06-17	158	317554	1361370	1786	5.89	0.70	5.19	1780.81
	HDW3							
25-09-16	268	318371	1361708	1789	5.11	0.80	4.31	1784.69
10-10-16	283	318371	1361708	1789	5.23	0.80	4.43	1784.57
25-10-16	298	318371	1361708	1789	5.35	0.80	4.55	1784.45
09-11-16	313	318371	1361708	1789	5.47	0.80	4.67	1784.33
24-11-16	328	318371	1361708	1789	5.59	0.80	4.79	1784.21
09-12-16	343	318371	1361708	1789	6.30	0.80	5.50	1783.50
24-12-16	358	318371	1361708	1789	6.48	0.80	5.68	1783.32
08-01-17	8	318371	1361708	1789	6.81	0.80	6.01	1782.99
23-01-17	23	318371	1361708	1789	7.12	0.80	6.32	1782.68
07-02-17	38	318371	1361708	1789	7.25	0.80	6.45	1782.55
22-02-17	53	318371	1361708	1789	7.27	0.80	6.47	1782.53
09-03-17	68	318371	1361708	1789	7.34	0.80	6.54	1782.46
24-03-17	83	318371	1361708	1789	7.36	0.80	6.56	1782.44
08-04-17	98	318371	1361708	1789	7.39	0.80	6.59	1782.41
23-04-17	113	318371	1361708	1789	7.41	0.80	6.61	1782.39
08-05-17	128	318371	1361708	1789	7.20	0.80	6.40	1782.60
23-05-17	143	318371	1361708	1789	7.11	0.80	6.31	1782.69
07-06-17	158	318371	1361708	1789	7.04	0.80	6.24	1782.76
	HDW4							
25-09-16	268	318576	1361312	1797	6.25	0.35	5.90	1791.10
10-10-16	283	318576	1361312	1797	6.33	0.35	5.98	1791.02
25-10-16	298	318576	1361312	1797	6.41	0.35	6.06	1790.94
09-11-16	313	318576	1361312	1797	6.50	0.35	6.15	1790.85
24-11-16	328	318576	1361312	1797	6.58	0.35	6.23	1790.77
09-12-16	343	318576	1361312	1797	6.98	0.35	6.63	1790.37
24-12-16	358	318576	1361312	1797	7.03	0.35	6.68	1790.32
08-01-17	8	318576	1361312	1797	7.19	0.35	6.84	1790.16
23-01-17	23	318576	1361312	1797	7.37	0.35	7.02	1789.98
07-02-17	38	318576	1361312	1797	7.41	0.35	7.06	1789.94
22-02-17	53	318576	1361312	1797	7.50	0.35	7.15	1789.85
09-03-17	68	318576	1361312	1797	7.48	0.35	7.13	1789.87
24-03-17	83	318576	1361312	1797	7.52	0.35	7.17	1789.83
08-04-17	98	318576	1361312	1797	7.51	0.35	7.16	1789.84
23-04-17	113	318576	1361312	1797	7.50	0.35	7.15	1789.85
08-05-17	128	318576	1361312	1797	7.39	0.35	7.04	1789.96
23-05-17	143	318576	1361312	1797	7.24	0.35	6.89	1790.11
07-06-17	158	318576	1361312	1797	7.11	0.35	6.76	1790.24
	HDW5							
25-09-16	268	318603	1361097	1789	6.24	0.30	5.94	1783.06

10-10-16	283	318603	1361097	1789	6.27	0.30	5.97	1783.03
25-10-16	298	318603	1361097	1789	6.31	0.30	6.01	1782.99
09-11-16	313	318603	1361097	1789	6.34	0.30	6.04	1782.96
24-11-16	328	318603	1361097	1789	6.37	0.30	6.07	1782.93
09-12-16	343	318603	1361097	1789	6.53	0.30	6.23	1782.77
24-12-16	358	318603	1361097	1789	6.70	0.30	6.40	1782.60
08-01-17	8	318603	1361097	1789	6.82	0.30	6.52	1782.48
23-01-17	23	318603	1361097	1789	6.98	0.30	6.68	1782.32
07-02-17	38	318603	1361097	1789	6.94	0.30	6.64	1782.36
22-02-17	53	318603	1361097	1789	6.88	0.30	6.58	1782.42
09-03-17	68	318603	1361097	1789	6.92	0.30	6.62	1782.38
24-03-17	83	318603	1361097	1789	6.91	0.30	6.61	1782.39
08-04-17	98	318603	1361097	1789	6.93	0.30	6.63	1782.37
23-04-17	113	318603	1361097	1789	6.94	0.30	6.64	1782.36
08-05-17	128	318603	1361097	1789	6.90	0.30	6.60	1782.40
23-05-17	143	318603	1361097	1789	6.71	0.30	6.41	1782.59
07-06-17	158	318603	1361097	1789	6.56	0.30	6.26	1782.74
	HDW6							
25-09-16	268	318782	1362545	1800	5.34	0.60	4.74	1795.26
10-10-16	283	318782	1362545	1800	5.50	0.60	4.90	1795.10
25-10-16	298	318782	1362545	1800	5.66	0.60	5.06	1794.94
09-11-16	313	318782	1362545	1800	5.83	0.60	5.23	1794.77
24-11-16	328	318782	1362545	1800	5.99	0.60	5.39	1794.61
09-12-16	343	318782	1362545	1800	6.52	0.60	5.92	1794.08
24-12-16	358	318782	1362545	1800	6.65	0.60	6.05	1793.95
08-01-17	8	318782	1362545	1800	6.73	0.60	6.13	1793.87
23-01-17	23	318782	1362545	1800	7.80	0.60	7.20	1792.80
07-02-17	38	318782	1362545	1800	7.84	0.60	7.24	1792.76
22-02-17	53	318782	1362545	1800	7.86	0.60	7.26	1792.74
09-03-17	68	318782	1362545	1800	7.87	0.60	7.27	1792.73
24-03-17	83	318782	1362545	1800	7.88	0.60	7.28	1792.72
08-04-17	98	318782	1362545	1800	7.89	0.60	7.29	1792.71
23-04-17	113	318782	1362545	1800	7.89	0.60	7.29	1792.71
08-05-17	128	318782	1362545	1800	7.84	0.60	7.24	1792.76
23-05-17	143	318782	1362545	1800	7.76	0.60	7.16	1792.84
07-06-17	158	318782	1362545	1800	7.62	0.60	7.02	1792.98
	HDW7							
25-09-16	268	318861	1362878	1792	2.87	0.40	2.47	1789.53
10-10-16	283	318861	1362878	1792	3.05	0.40	2.65	1789.35
25-10-16	298	318861	1362878	1792	3.24	0.40	2.84	1789.16

09-11-16	313	318861	1362878	1792	3.42	0.40	3.02	1788.98
24-11-16	328	318861	1362878	1792	3.60	0.40	3.20	1788.80
09-12-16	343	318861	1362878	1792	4.07	0.40	3.67	1788.33
24-12-16	358	318861	1362878	1792	4.21	0.40	3.81	1788.19
08-01-17	8	318861	1362878	1792	4.47	0.40	4.07	1787.93
23-01-17	23	318861	1362878	1792	4.70	0.40	4.30	1787.70
07-02-17	38	318861	1362878	1792	5.13	0.40	4.73	1787.27
22-02-17	53	318861	1362878	1792	5.52	0.40	5.12	1786.88
09-03-17	68	318861	1362878	1792	5.45	0.40	5.05	1786.95
24-03-17	83	318861	1362878	1792	5.49	0.40	5.09	1786.91
08-04-17	98	318861	1362878	1792	5.51	0.40	5.11	1786.89
23-04-17	113	318861	1362878	1792	5.53	0.40	5.13	1786.87
08-05-17	128	318861	1362878	1792	5.50	0.40	5.10	1786.90
23-05-17	143	318861	1362878	1792	5.43	0.40	5.03	1786.97
07-06-17	158	318861	1362878	1792	5.32	0.40	4.92	1787.08
	HDW8							
25-09-16	268	319731	1365328	1799	2.25	0.20	2.05	1796.95
10-10-16	283	319731	1365328	1799	2.33	0.20	2.13	1796.87
25-10-16	298	319731	1365328	1799	2.42	0.20	2.22	1796.78
09-11-16	313	319731	1365328	1799	2.50	0.20	2.30	1796.70
24-11-16	328	319731	1365328	1799	2.59	0.20	2.39	1796.61
09-12-16	343	319731	1365328	1799	2.80	0.20	2.60	1796.40
24-12-16	358	319731	1365328	1799	2.97	0.20	2.77	1796.23
08-01-17	8	319731	1365328	1799	3.06	0.20	2.86	1796.14
23-01-17	23	319731	1365328	1799	3.11	0.20	2.91	1796.09
07-02-17	38	319731	1365328	1799	3.27	0.20	3.07	1795.93
22-02-17	53	319731	1365328	1799	3.40	0.20	3.20	1795.80
09-03-17	68	319731	1365328	1799	3.44	0.20	3.24	1795.76
24-03-17	83	319731	1365328	1799	3.43	0.20	3.23	1795.77
08-04-17	98	319731	1365328	1799	3.48	0.20	3.28	1795.72
23-04-17	113	319731	1365328	1799	3.47	0.20	3.27	1795.73
08-05-17	128	319731	1365328	1799	3.42	0.20	3.22	1795.78
23-05-17	143	319731	1365328	1799	3.37	0.20	3.17	1795.83
07-06-17	158	319731	1365328	1799	3.22	0.20	3.02	1795.98
	HDW9							
25-09-16	268	319666	1365294	1795	1.77	0.25	1.52	1793.48
10-10-16	283	319666	1365294	1795	1.95	0.25	1.70	1793.30
25-10-16	298	319666	1365294	1795	2.13	0.25	1.88	1793.12
09-11-16	313	319666	1365294	1795	2.32	0.25	2.07	1792.93
24-11-16	328	319666	1365294	1795	2.50	0.25	2.25	1792.75

09-12-16	343	319666	1365294	1795	2.91	0.25	2.66	1792.34
24-12-16	358	319666	1365294	1795	3.00	0.25	2.75	1792.25
08-01-17	8	319666	1365294	1795	3.28	0.25	3.03	1791.97
23-01-17	23	319666	1365294	1795	3.50	0.25	3.25	1791.75
07-02-17	38	319666	1365294	1795	3.67	0.25	3.42	1791.58
22-02-17	53	319666	1365294	1795	4.05	0.25	3.80	1791.20
09-03-17	68	319666	1365294	1795	4.17	0.25	3.92	1791.08
24-03-17	83	319666	1365294	1795	4.23	0.25	3.98	1791.02
08-04-17	98	319666	1365294	1795	4.35	0.25	4.10	1790.90
23-04-17	113	319666	1365294	1795	4.47	0.25	4.22	1790.78
08-05-17	128	319666	1365294	1795	4.73	0.25	4.48	1790.52
23-05-17	143	319666	1365294	1795	4.68	0.25	4.43	1790.57
07-06-17	158	319666	1365294	1795	4.39	0.25	4.14	1790.86
	HDW10							
25-09-16	268	319537	1365216	1793	2.23	1.38	0.85	1792.15
10-10-16	283	319537	1365216	1793	2.26	1.38	0.88	1792.12
25-10-16	298	319537	1365216	1793	2.64	1.38	1.26	1791.74
09-11-16	313	319537	1365216	1793	2.80	1.38	1.42	1791.58
24-11-16	328	319537	1365216	1793	2.95	1.38	1.57	1791.43
09-12-16	343	319537	1365216	1793	3.41	1.38	2.03	1790.97
24-12-16	358	319537	1365216	1793	3.53	1.38	2.15	1790.85
08-01-17	8	319537	1365216	1793	3.62	1.38	2.24	1790.76
23-01-17	23	319537	1365216	1793	3.70	1.38	2.32	1790.68
07-02-17	38	319537	1365216	1793	4.12	1.38	2.74	1790.26
22-02-17	53	319537	1365216	1793	4.43	1.38	3.05	1789.95
09-03-17	68	319537	1365216	1793	4.49	1.38	3.11	1789.89
24-03-17	83	319537	1365216	1793	4.53	1.38	3.15	1789.85
08-04-17	98	319537	1365216	1793	4.58	1.38	3.20	1789.80
23-04-17	113	319537	1365216	1793	4.65	1.38	3.27	1789.73
08-05-17	128	319537	1365216	1793	4.83	1.38	3.45	1789.55
23-05-17	143	319537	1365216	1793	5.78	1.38	4.40	1788.60
07-06-17	158	319537	1365216	1793	4.41	1.38	3.03	1789.97
	HDW11							
25-09-16	268	319550	1365122	1795	1.88	0.30	1.58	1793.42
10-10-16	283	319550	1365122	1795	2.09	0.30	1.79	1793.21
25-10-16	298	319550	1365122	1795	2.30	0.30	2.00	1793.00
09-11-16	313	319550	1365122	1795	2.51	0.30	2.21	1792.79
24-11-16	328	319550	1365122	1795	2.72	0.30	2.42	1792.58
09-12-16	343	319550	1365122	1795	3.31	0.30	3.01	1791.99

24-12-16	358	319550	1365122	1795	3.43	0.30	3.13	1791.87
08-01-17	8	319550	1365122	1795	3.64	0.30	3.34	1791.66
23-01-17	23	319550	1365122	1795	3.83	0.30	3.53	1791.47
07-02-17	38	319550	1365122	1795	4.03	0.30	3.73	1791.27
22-02-17	53	319550	1365122	1795	4.38	0.30	4.08	1790.92
09-03-17	68	319550	1365122	1795	4.46	0.30	4.16	1790.84
24-03-17	83	319550	1365122	1795	4.70	0.30	4.40	1790.60
08-04-17	98	319550	1365122	1795	4.89	0.30	4.59	1790.41
23-04-17	113	319550	1365122	1795	5.19	0.30	4.89	1790.11
08-05-17	128	319550	1365122	1795	5.35	0.30	5.05	1789.95
23-05-17	143	319550	1365122	1795	5.05	0.30	4.75	1790.25
07-06-17	158	319550	1365122	1795	4.86	0.30	4.56	1790.44
	HDW12							
25-09-16	268	319579	1365041	1799	1.83	0.25	1.58	1797.42
10-10-16	283	319579	1365041	1799	2.04	0.25	1.79	1797.21
25-10-16	298	319579	1365041	1799	2.24	0.25	1.99	1797.01
09-11-16	313	319579	1365041	1799	2.44	0.25	2.19	1796.81
24-11-16	328	319579	1365041	1799	2.65	0.25	2.40	1796.60
09-12-16	343	319579	1365041	1799	3.11	0.25	2.86	1796.14
24-12-16	358	319579	1365041	1799	3.25	0.25	3.00	1796.00
08-01-17	8	319579	1365041	1799	3.48	0.25	3.23	1795.77
23-01-17	23	319579	1365041	1799	3.74	0.25	3.49	1795.51
07-02-17	38	319579	1365041	1799	4.04	0.25	3.79	1795.21
22-02-17	53	319579	1365041	1799	4.14	0.25	3.89	1795.11
09-03-17	68	319579	1365041	1799	4.28	0.25	4.03	1794.97
24-03-17	83	319579	1365041	1799	4.51	0.25	4.26	1794.74
08-04-17	98	319579	1365041	1799	4.72	0.25	4.47	1794.53
23-04-17	113	319579	1365041	1799	4.94	0.25	4.69	1794.31
08-05-17	128	319579	1365041	1799	5.13	0.25	4.88	1794.12
23-05-17	143	319579	1365041	1799	4.86	0.25	4.61	1794.39
07-06-17	158	319579	1365041	1799	4.71	0.25	4.46	1794.54
	HDW13							
25-09-16	268	319569	1364991	1796	2.05	0.30	1.75	1794.25
10-10-16	283	319569	1364991	1796	2.22	0.30	1.92	1794.08
25-10-16	298	319569	1364991	1796	2.39	0.30	2.09	1793.92
09-11-16	313	319569	1364991	1796	2.55	0.30	2.25	1793.75
24-11-16	328	319569	1364991	1796	2.72	0.30	2.42	1793.58
09-12-16	343	319569	1364991	1796	3.27	0.30	2.97	1793.03
24-12-16	358	319569	1364991	1796	3.45	0.30	3.15	1792.85

08-01-17	8	319569	1364991	1796	3.59	0.30	3.29	1792.71
23-01-17	23	319569	1364991	1796	3.76	0.30	3.46	1792.54
07-02-17	38	319569	1364991	1796	3.92	0.30	3.62	1792.38
22-02-17	53	319569	1364991	1796	3.85	0.30	3.55	1792.45
09-03-17	68	319569	1364991	1796	3.97	0.30	3.67	1792.33
24-03-17	83	319569	1364991	1796	4.09	0.30	3.79	1792.21
08-04-17	98	319569	1364991	1796	4.30	0.30	4.00	1792.00
23-04-17	113	319569	1364991	1796	4.80	0.30	4.50	1791.50
08-05-17	128	319569	1364991	1796	5.29	0.30	4.99	1791.01
23-05-17	143	319569	1364991	1796	5.13	0.30	4.83	1791.17
07-06-17	158	319569	1364991	1796	5.02	0.30	4.72	1791.28
	HDW14							
25-09-16	268	319571	1364966	1799	1.70	0.20	1.50	1797.50
10-10-16	283	319571	1364966	1799	1.85	0.20	1.65	1797.35
25-10-16	298	319571	1364966	1799	2.01	0.20	1.81	1797.19
09-11-16	313	319571	1364966	1799	2.16	0.20	1.96	1797.04
24-11-16	328	319571	1364966	1799	2.31	0.20	2.11	1796.89
09-12-16	343	319571	1364966	1799	2.80	0.20	2.60	1796.40
24-12-16	358	319571	1364966	1799	2.87	0.20	2.67	1796.33
08-01-17	8	319571	1364966	1799	2.92	0.20	2.72	1796.28
23-01-17	23	319571	1364966	1799	3.10	0.20	2.90	1796.10
07-02-17	38	319571	1364966	1799	3.12	0.20	2.92	1796.08
22-02-17	53	319571	1364966	1799	3.32	0.20	3.12	1795.88
09-03-17	68	319571	1364966	1799	3.57	0.20	3.37	1795.63
24-03-17	83	319571	1364966	1799	3.81	0.20	3.61	1795.39
08-04-17	98	319571	1364966	1799	3.98	0.20	3.78	1795.22
23-04-17	113	319571	1364966	1799	4.10	0.20	3.90	1795.10
08-05-17	128	319571	1364966	1799	4.17	0.20	3.97	1795.03
23-05-17	143	319571	1364966	1799	4.01	0.20	3.81	1795.19
07-06-17	158	319571	1364966	1799	3.87	0.20	3.67	1795.33
	HDW15							
25-09-16	268	319238	1364989	1803	4.93	0.20	4.73	1798.27
10-10-16	283	319238	1364989	1803	5.08	0.20	4.88	1798.12
25-10-16	298	319238	1364989	1803	5.22	0.20	5.02	1797.98
09-11-16	313	319238	1364989	1803	5.37	0.20	5.17	1797.83
24-11-16	328	319238	1364989	1803	5.52	0.20	5.32	1797.68
09-12-16	343	319238	1364989	1803	5.82	0.20	5.62	1797.38
24-12-16	358	319238	1364989	1803	5.97	0.20	5.77	1797.23
08-01-17	8	319238	1364989	1803	6.10	0.20	5.90	1797.10
23-01-17	23	319238	1364989	1803	6.30	0.20	6.10	1796.90

07-02-17	38	319238	1364989	1803	6.55	0.20	6.35	1796.65
22-02-17	53	319238	1364989	1803	6.71	0.20	6.51	1796.49
09-03-17	68	319238	1364989	1803	6.89	0.20	6.69	1796.31
24-03-17	83	319238	1364989	1803	6.94	0.20	6.74	1796.26
08-04-17	98	319238	1364989	1803	7.05	0.20	6.85	1796.15
23-04-17	113	319238	1364989	1803	7.13	0.20	6.93	1796.07
08-05-17	128	319238	1364989	1803	7.24	0.20	7.04	1795.96
23-05-17	143	319238	1364989	1803	7.02	0.20	6.82	1796.18
07-06-17	158	319238	1364989	1803	6.91	0.20	6.71	1796.29
	HDW16							
25-09-16	268	319232	1365014	1801	8.13	0.20	7.93	1793.07
10-10-16	283	319232	1365014	1801	8.18	0.20	7.98	1793.02
25-10-16	298	319232	1365014	1801	8.23	0.20	8.03	1792.97
09-11-16	313	319232	1365014	1801	8.28	0.20	8.08	1792.92
24-11-16	328	319232	1365014	1801	8.34	0.20	8.14	1792.86
09-12-16	343	319232	1365014	1801	8.59	0.20	8.39	1792.61
24-12-16	358	319232	1365014	1801	8.64	0.20	8.44	1792.56
08-01-17	8	319232	1365014	1801	8.68	0.20	8.48	1792.52
23-01-17	23	319232	1365014	1801	8.70	0.20	8.50	1792.50
07-02-17	38	319232	1365014	1801	8.81	0.20	8.61	1792.39
22-02-17	53	319232	1365014	1801	8.90	0.20	8.70	1792.30
09-03-17	68	319232	1365014	1801	8.93	0.20	8.73	1792.27
24-03-17	83	319232	1365014	1801	8.95	0.20	8.75	1792.25
08-04-17	98	319232	1365014	1801	8.99	0.20	8.79	1792.21
23-04-17	113	319232	1365014	1801	9.03	0.20	8.83	1792.17
08-05-17	128	319232	1365014	1801	8.89	0.20	8.69	1792.31
23-05-17	143	319232	1365014	1801	8.77	0.20	8.57	1792.43
07-06-17	158	319232	1365014	1801	8.69	0.20	8.49	1792.51
	HDW17							
25-09-16	268	319023	1364910	1800	7.73	0.50	7.23	1792.77
10-10-16	283	319023	1364910	1800	7.77	0.50	7.27	1792.73
25-10-16	298	319023	1364910	1800	7.81	0.50	7.31	1792.69
09-11-16	313	319023	1364910	1800	7.85	0.50	7.35	1792.65
24-11-16	328	319023	1364910	1800	7.89	0.50	7.39	1792.61
09-12-16	343	319023	1364910	1800	8.42	0.50	7.92	1792.08
24-12-16	358	319023	1364910	1800	8.47	0.50	7.97	1792.03
08-01-17	8	319023	1364910	1800	8.51	0.50	8.01	1791.99
23-01-17	23	319023	1364910	1800	8.65	0.50	8.15	1791.85
07-02-17	38	319023	1364910	1800	8.59	0.50	8.09	1791.91
22-02-17	53	319023	1364910	1800	8.56	0.50	8.06	1791.94

09-03-17	68	319023	1364910	1800	8.62	0.50	8.12	1791.88
24-03-17	83	319023	1364910	1800	8.71	0.50	8.21	1791.79
08-04-17	98	319023	1364910	1800	8.78	0.50	8.28	1791.72
23-04-17	113	319023	1364910	1800	8.83	0.50	8.33	1791.67
08-05-17	128	319023	1364910	1800	8.81	0.50	8.31	1791.69
23-05-17	143	319023	1364910	1800	8.73	0.50	8.23	1791.77
07-06-17	158	319023	1364910	1800	8.65	0.50	8.15	1791.85
	HDW18							
25-09-16	268	319074	1364722	1796	3.78	0.20	3.58	1792.42
10-10-16	283	319074	1364722	1796	3.89	0.20	3.69	1792.31
25-10-16	298	319074	1364722	1796	4.00	0.20	3.80	1792.20
09-11-16	313	319074	1364722	1796	4.11	0.20	3.91	1792.09
24-11-16	328	319074	1364722	1796	4.23	0.20	4.03	1791.97
09-12-16	343	319074	1364722	1796	4.60	0.20	4.40	1791.60
24-12-16	358	319074	1364722	1796	4.69	0.20	4.49	1791.51
08-01-17	8	319074	1364722	1796	4.75	0.20	4.55	1791.45
23-01-17	23	319074	1364722	1796	4.88	0.20	4.68	1791.32
07-02-17	38	319074	1364722	1796	4.94	0.20	4.74	1791.26
22-02-17	53	319074	1364722	1796	5.10	0.20	4.90	1791.10
09-03-17	68	319074	1364722	1796	5.19	0.20	4.99	1791.01
24-03-17	83	319074	1364722	1796	5.26	0.20	5.06	1790.94
08-04-17	98	319074	1364722	1796	5.38	0.20	5.18	1790.82
23-04-17	113	319074	1364722	1796	5.50	0.20	5.30	1790.70
08-05-17	128	319074	1364722	1796	5.85	0.20	5.65	1790.35
23-05-17	143	319074	1364722	1796	5.55	0.20	5.35	1790.65
07-06-17	158	319074	1364722	1796	5.37	0.20	5.17	1790.83
	HDW19							
25-09-16	268	319043	1365179	1795	7.88	0.30	7.58	1787.42
10-10-16	283	319043	1365179	1795	7.94	0.30	7.64	1787.36
25-10-16	298	319043	1365179	1795	8.00	0.30	7.70	1787.30
09-11-16	313	319043	1365179	1795	8.07	0.30	7.77	1787.24
24-11-16	328	319043	1365179	1795	8.13	0.30	7.83	1787.17
09-12-16	343	319043	1365179	1795	8.40	0.30	8.10	1786.90
24-12-16	358	319043	1365179	1795	8.53	0.30	8.23	1786.77
08-01-17	8	319043	1365179	1795	8.65	0.30	8.35	1786.65
23-01-17	23	319043	1365179	1795	8.74	0.30	8.44	1786.56
07-02-17	38	319043	1365179	1795	8.83	0.30	8.53	1786.47
22-02-17	53	319043	1365179	1795	8.83	0.30	8.53	1786.47
09-03-17	68	319043	1365179	1795	8.81	0.30	8.51	1786.49
24-03-17	83	319043	1365179	1795	8.85	0.30	8.55	1786.45

08-04-17	98	319043	1365179	1795	8.80	0.30	8.50	1786.50
23-04-17	113	319043	1365179	1795	8.78	0.30	8.48	1786.52
08-05-17	128	319043	1365179	1795	8.81	0.30	8.51	1786.49
23-05-17	143	319043	1365179	1795	8.74	0.30	8.44	1786.56
07-06-17	158	319043	1365179	1795	8.62	0.30	8.32	1786.68
	HDW20							
25-09-16	268	319141	1365166	1800	9.26	0.20	9.06	1790.94
10-10-16	283	319141	1365166	1800	9.31	0.20	9.11	1790.89
25-10-16	298	319141	1365166	1800	9.35	0.20	9.15	1790.85
09-11-16	313	319141	1365166	1800	9.40	0.20	9.20	1790.80
24-11-16	328	319141	1365166	1800	9.44	0.20	9.24	1790.76
09-12-16	343	319141	1365166	1800	9.72	0.20	9.52	1790.48
24-12-16	358	319141	1365166	1800	9.77	0.20	9.57	1790.43
08-01-17	8	319141	1365166	1800	9.80	0.20	9.60	1790.40
23-01-17	23	319141	1365166	1800	9.87	0.20	9.67	1790.33
07-02-17	38	319141	1365166	1800	9.84	0.20	9.64	1790.36
22-02-17	53	319141	1365166	1800	9.82	0.20	9.62	1790.38
09-03-17	68	319141	1365166	1800	9.87	0.20	9.67	1790.33
24-03-17	83	319141	1365166	1800	9.89	0.20	9.69	1790.31
08-04-17	98	319141	1365166	1800	10.08	0.20	9.88	1790.12
23-04-17	113	319141	1365166	1800	10.16	0.20	9.96	1790.04
08-05-17	128	319141	1365166	1800	10.20	0.20	10.00	1790.00
23-05-17	143	319141	1365166	1800	10.02	0.20	9.82	1790.18
07-06-17	158	319141	1365166	1800	9.88	0.20	9.68	1790.32
	HDW21							
25-09-16	268	318995	1365190	1797	7.83	0.30	7.53	1789.47
10-10-16	283	318995	1365190	1797	7.88	0.30	7.58	1789.42
25-10-16	298	318995	1365190	1797	7.93	0.30	7.63	1789.37
09-11-16	313	318995	1365190	1797	7.97	0.30	7.67	1789.33
24-11-16	328	318995	1365190	1797	8.02	0.30	7.72	1789.28
09-12-16	343	318995	1365190	1797	8.19	0.30	7.89	1789.11
24-12-16	358	318995	1365190	1797	8.36	0.30	8.06	1788.94
08-01-17	8	318995	1365190	1797	8.50	0.30	8.20	1788.80
23-01-17	23	318995	1365190	1797	8.64	0.30	8.34	1788.66
07-02-17	38	318995	1365190	1797	8.67	0.30	8.37	1788.63
22-02-17	53	318995	1365190	1797	8.72	0.30	8.42	1788.58
09-03-17	68	318995	1365190	1797	8.70	0.30	8.40	1788.60
24-03-17	83	318995	1365190	1797	8.74	0.30	8.44	1788.56
08-04-17	98	318995	1365190	1797	8.71	0.30	8.41	1788.59
23-04-17	113	318995	1365190	1797	8.66	0.30	8.36	1788.64

08-05-17	128	318995	1365190	1797	8.84	0.30	8.54	1788.46
23-05-17	143	318995	1365190	1797	8.81	0.30	8.51	1788.49
07-06-17	158	318995	1365190	1797	8.61	0.30	8.31	1788.69
	HDW22							
25-09-16	268	318209	1364804	1796	2.84	1.15	1.69	1794.31
10-10-16	283	318209	1364804	1796	2.94	1.15	1.79	1794.21
25-10-16	298	318209	1364804	1796	3.04	1.15	1.89	1794.11
09-11-16	313	318209	1364804	1796	3.14	1.15	1.99	1794.01
24-11-16	328	318209	1364804	1796	3.25	1.15	2.10	1793.90
09-12-16	343	318209	1364804	1796	4.35	1.15	3.20	1792.80
24-12-16	358	318209	1364804	1796	4.46	1.15	3.31	1792.69
08-01-17	8	318209	1364804	1796	4.60	1.15	3.45	1792.55
23-01-17	23	318209	1364804	1796	5.01	1.15	3.86	1792.14
07-02-17	38	318209	1364804	1796	5.09	1.15	3.94	1792.06
22-02-17	53	318209	1364804	1796	5.17	1.15	4.02	1791.98
09-03-17	68	318209	1364804	1796	5.21	1.15	4.06	1791.94
24-03-17	83	318209	1364804	1796	5.26	1.15	4.11	1791.89
08-04-17	98	318209	1364804	1796	5.28	1.15	4.13	1791.87
23-04-17	113	318209	1364804	1796	5.31	1.15	4.16	1791.84
08-05-17	128	318209	1364804	1796	5.39	1.15	4.24	1791.76
23-05-17	143	318209	1364804	1796	5.25	1.15	4.10	1791.90
07-06-17	158	318209	1364804	1796	5.13	1.15	3.98	1792.02
	HDW23							
25-09-16	268	319463	1365261	1799	3.35	0.40	2.95	1796.05
10-10-16	283	319463	1365261	1799	3.48	0.40	3.08	1795.92
25-10-16	298	319463	1365261	1799	3.61	0.40	3.21	1795.79
09-11-16	313	319463	1365261	1799	3.75	0.40	3.35	1795.65
24-11-16	328	319463	1365261	1799	3.88	0.40	3.48	1795.52
09-12-16	343	319463	1365261	1799	4.42	0.40	4.02	1794.98
24-12-16	358	319463	1365261	1799	4.56	0.40	4.16	1794.84
08-01-17	8	319463	1365261	1799	4.73	0.40	4.33	1794.67
23-01-17	23	319463	1365261	1799	4.81	0.40	4.41	1794.59
07-02-17	38	319463	1365261	1799	4.89	0.40	4.49	1794.51
22-02-17	53	319463	1365261	1799	5.05	0.40	4.65	1794.35
09-03-17	68	319463	1365261	1799	5.25	0.40	4.85	1794.15
24-03-17	83	319463	1365261	1799	5.32	0.40	4.92	1794.08
08-04-17	98	319463	1365261	1799	5.43	0.40	5.03	1793.97
23-04-17	113	319463	1365261	1799	5.64	0.40	5.24	1793.76
08-05-17	128	319463	1365261	1799	5.78	0.40	5.38	1793.62
23-05-17	143	319463	1365261	1799	5.56	0.40	5.16	1793.84

07-06-17	158	319463	1365261	1799	5.38	0.40	4.98	1794.02
	HDW24							
25-09-16	268	319438	1365360	1794	4.77	0.45	4.32	1789.68
10-10-16	283	319438	1365360	1794	4.88	0.45	4.43	1789.57
25-10-16	298	319438	1365360	1794	5.00	0.45	4.55	1789.45
09-11-16	313	319438	1365360	1794	5.11	0.45	4.66	1789.34
24-11-16	328	319438	1365360	1794	5.22	0.45	4.77	1789.23
09-12-16	343	319438	1365360	1794	5.84	0.45	5.39	1788.61
24-12-16	358	319438	1365360	1794	5.88	0.45	5.43	1788.57
08-01-17	8	319438	1365360	1794	6.00	0.45	5.55	1788.45
23-01-17	23	319438	1365360	1794	6.15	0.45	5.70	1788.30
07-02-17	38	319438	1365360	1794	6.21	0.45	5.76	1788.24
22-02-17	53	319438	1365360	1794	6.35	0.45	5.90	1788.10
09-03-17	68	319438	1365360	1794	6.42	0.45	5.97	1788.03
24-03-17	83	319438	1365360	1794	6.53	0.45	6.08	1787.92
08-04-17	98	319438	1365360	1794	6.67	0.45	6.22	1787.78
23-04-17	113	319438	1365360	1794	6.75	0.45	6.30	1787.70
08-05-17	128	319438	1365360	1794	7.02	0.45	6.57	1787.43
23-05-17	143	319438	1365360	1794	6.93	0.45	6.48	1787.52
07-06-17	158	319438	1365360	1794	6.82	0.45	6.37	1787.63
	HDW25							
25-09-16	268	319314	1365674	1794	5.73	0.30	5.43	1788.57
10-10-16	283	319314	1365674	1794	5.90	0.30	5.60	1788.40
25-10-16	298	319314	1365674	1794	6.06	0.30	5.76	1788.24
09-11-16	313	319314	1365674	1794	6.23	0.30	5.93	1788.07
24-11-16	328	319314	1365674	1794	6.40	0.30	6.10	1787.90
09-12-16	343	319314	1365674	1794	7.03	0.30	6.73	1787.27
24-12-16	358	319314	1365674	1794	7.11	0.30	6.81	1787.19
08-01-17	8	319314	1365674	1794	7.20	0.30	6.90	1787.10
23-01-17	23	319314	1365674	1794	7.24	0.30	6.94	1787.06
07-02-17	38	319314	1365674	1794	7.35	0.30	7.05	1786.95
22-02-17	53	319314	1365674	1794	7.67	0.30	7.37	1786.63
09-03-17	68	319314	1365674	1794	7.89	0.30	7.59	1786.41
24-03-17	83	319314	1365674	1794	7.99	0.30	7.69	1786.31
08-04-17	98	319314	1365674	1794	8.27	0.30	7.97	1786.03
23-04-17	113	319314	1365674	1794	8.51	0.30	8.21	1785.79
08-05-17	128	319314	1365674	1794	8.26	0.30	7.96	1786.04
23-05-17	143	319314	1365674	1794	8.07	0.30	7.77	1786.23
07-06-17	158	319314	1365674	1794	8.01	0.30	7.71	1786.29
	HDW26							

25-09-16	268	319326	1365707	1795	5.42	0.20	5.22	1789.78
10-10-16	283	319326	1365707	1795	5.46	0.20	5.26	1789.74
25-10-16	298	319326	1365707	1795	5.50	0.20	5.30	1789.70
09-11-16	313	319326	1365707	1795	5.54	0.20	5.34	1789.66
24-11-16	328	319326	1365707	1795	5.59	0.20	5.39	1789.61
09-12-16	343	319326	1365707	1795	5.81	0.20	5.61	1789.39
24-12-16	358	319326	1365707	1795	5.86	0.20	5.66	1789.34
08-01-17	8	319326	1365707	1795	5.90	0.20	5.70	1789.30
23-01-17	23	319326	1365707	1795	5.94	0.20	5.74	1789.26
07-02-17	38	319326	1365707	1795	6.03	0.20	5.83	1789.17
22-02-17	53	319326	1365707	1795	6.05	0.20	5.85	1789.15
09-03-17	68	319326	1365707	1795	6.12	0.20	5.92	1789.08
24-03-17	83	319326	1365707	1795	6.14	0.20	5.94	1789.06
08-04-17	98	319326	1365707	1795	6.16	0.20	5.96	1789.04
23-04-17	113	319326	1365707	1795	6.18	0.20	5.98	1789.02
08-05-17	128	319326	1365707	1795	6.21	0.20	6.01	1788.99
23-05-17	143	319326	1365707	1795	6.09	0.20	5.89	1789.11
07-06-17	158	319326	1365707	1795	5.98	0.20	5.78	1789.22
	HDW27							
25-09-16	268	319429	1365909	1789	5.00	1.10	3.90	1785.10
10-10-16	283	319429	1365909	1789	5.17	1.10	4.07	1784.93
25-10-16	298	319429	1365909	1789	5.34	1.10	4.24	1784.76
09-11-16	313	319429	1365909	1789	5.52	1.10	4.42	1784.58
24-11-16	328	319429	1365909	1789	5.69	1.10	4.59	1784.41
09-12-16	343	319429	1365909	1789	7.04	1.10	5.94	1783.06
24-12-16	358	319429	1365909	1789	7.15	1.10	6.05	1782.95
08-01-17	8	319429	1365909	1789	7.37	1.10	6.27	1782.73
23-01-17	23	319429	1365909	1789	7.45	1.10	6.35	1782.65
07-02-17	38	319429	1365909	1789	7.63	1.10	6.53	1782.47
22-02-17	53	319429	1365909	1789	7.61	1.10	6.51	1782.49
09-03-17	68	319429	1365909	1789	7.88	1.10	6.78	1782.22
24-03-17	83	319429	1365909	1789	8.15	1.10	7.05	1781.95
08-04-17	98	319429	1365909	1789	8.39	1.10	7.29	1781.71
23-04-17	113	319429	1365909	1789	8.63	1.10	7.53	1781.47
08-05-17	128	319429	1365909	1789	8.43	1.10	7.33	1781.67
23-05-17	143	319429	1365909	1789	8.36	1.10	7.26	1781.74
07-06-17	158	319429	1365909	1789	8.17	1.10	7.07	1781.93
	HDW28							
25-09-16	268	319421	1365968	1795	4.46	0.25	4.21	1790.79
10-10-16	283	319421	1365968	1795	4.57	0.25	4.32	1790.68

25-10-16	298	319421	1365968	1795	4.68	0.25	4.43	1790.57
09-11-16	313	319421	1365968	1795	4.79	0.25	4.54	1790.46
24-11-16	328	319421	1365968	1795	4.90	0.25	4.65	1790.36
09-12-16	343	319421	1365968	1795	5.16	0.25	4.91	1790.09
24-12-16	358	319421	1365968	1795	5.20	0.25	4.95	1790.05
08-01-17	8	319421	1365968	1795	5.42	0.25	5.17	1789.83
23-01-17	23	319421	1365968	1795	5.67	0.25	5.42	1789.58
07-02-17	38	319421	1365968	1795	5.81	0.25	5.56	1789.44
22-02-17	53	319421	1365968	1795	5.96	0.25	5.71	1789.29
09-03-17	68	319421	1365968	1795	6.01	0.25	5.76	1789.24
24-03-17	83	319421	1365968	1795	6.09	0.25	5.84	1789.16
08-04-17	98	319421	1365968	1795	6.11	0.25	5.86	1789.14
23-04-17	113	319421	1365968	1795	6.16	0.25	5.91	1789.09
08-05-17	128	319421	1365968	1795	6.14	0.25	5.89	1789.11
23-05-17	143	319421	1365968	1795	5.97	0.25	5.72	1789.28
07-06-17	158	319421	1365968	1795	5.83	0.25	5.58	1789.42
	HDW29							
25-09-16	268	319495	1366248	1794	2.46	0.30	2.16	1791.84
10-10-16	283	319495	1366248	1794	2.65	0.30	2.35	1791.65
25-10-16	298	319495	1366248	1794	2.85	0.30	2.55	1791.45
09-11-16	313	319495	1366248	1794	3.04	0.30	2.74	1791.26
24-11-16	328	319495	1366248	1794	3.23	0.30	2.93	1791.07
09-12-16	343	319495	1366248	1794	3.80	0.30	3.50	1790.50
24-12-16	358	319495	1366248	1794	3.99	0.30	3.69	1790.31
08-01-17	8	319495	1366248	1794	4.15	0.30	3.85	1790.15
23-01-17	23	319495	1366248	1794	4.34	0.30	4.04	1789.96
07-02-17	38	319495	1366248	1794	4.37	0.30	4.07	1789.93
22-02-17	53	319495	1366248	1794	4.57	0.30	4.27	1789.73
09-03-17	68	319495	1366248	1794	4.79	0.30	4.49	1789.51
24-03-17	83	319495	1366248	1794	4.92	0.30	4.62	1789.38
08-04-17	98	319495	1366248	1794	5.23	0.30	4.93	1789.07
23-04-17	113	319495	1366248	1794	5.64	0.30	5.34	1788.66
08-05-17	128	319495	1366248	1794	5.73	0.30	5.43	1788.57
23-05-17	143	319495	1366248	1794	5.58	0.30	5.28	1788.72
07-06-17	158	319495	1366248	1794	5.41	0.30	5.11	1788.89
	HDW30							
25-09-16	268	319542	1366311	1796	3.22	0.20	3.02	1792.98
10-10-16	283	319542	1366311	1796	3.35	0.20	3.15	1792.85
25-10-16	298	319542	1366311	1796	3.48	0.20	3.28	1792.72
09-11-16	313	319542	1366311	1796	3.61	0.20	3.41	1792.59

24-11-16	328	319542	1366311	1796	3.74	0.20	3.54	1792.46
09-12-16	343	319542	1366311	1796	4.05	0.20	3.85	1792.15
24-12-16	358	319542	1366311	1796	4.23	0.20	4.03	1791.97
08-01-17	8	319542	1366311	1796	4.42	0.20	4.22	1791.78
23-01-17	23	319542	1366311	1796	4.51	0.20	4.31	1791.69
07-02-17	38	319542	1366311	1796	4.62	0.20	4.42	1791.58
22-02-17	53	319542	1366311	1796	4.56	0.20	4.36	1791.64
09-03-17	68	319542	1366311	1796	4.80	0.20	4.60	1791.40
24-03-17	83	319542	1366311	1796	4.94	0.20	4.74	1791.26
08-04-17	98	319542	1366311	1796	5.06	0.20	4.86	1791.14
23-04-17	113	319542	1366311	1796	5.26	0.20	5.06	1790.94
08-05-17	128	319542	1366311	1796	5.50	0.20	5.30	1790.70
23-05-17	143	319542	1366311	1796	5.35	0.20	5.15	1790.85
07-06-17	158	319542	1366311	1796	5.22	0.20	5.02	1790.98
	HDW31							
25-09-16	268	319339	1359550	1799	6.32	0.66	5.66	1793.35
10-10-16	283	319339	1359550	1799	6.47	0.66	5.81	1793.19
25-10-16	298	319339	1359550	1799	6.62	0.66	5.96	1793.04
09-11-16	313	319339	1359550	1799	6.77	0.66	6.11	1792.89
24-11-16	328	319339	1359550	1799	6.93	0.66	6.27	1792.73
09-12-16	343	319339	1359550	1799	7.58	0.66	6.92	1792.08
24-12-16	358	319339	1359550	1799	7.89	0.66	7.23	1791.77
08-01-17	8	319339	1359550	1799	8.00	0.66	7.34	1791.66
23-01-17	23	319339	1359550	1799	8.35	0.66	7.69	1791.31
07-02-17	38	319339	1359550	1799	8.58	0.66	7.92	1791.08
22-02-17	53	319339	1359550	1799	8.59	0.66	7.93	1791.07
09-03-17	68	319339	1359550	1799	8.60	0.66	7.94	1791.06
24-03-17	83	319339	1359550	1799	8.61	0.66	7.95	1791.05
08-04-17	98	319339	1359550	1799	8.58	0.66	7.92	1791.08
23-04-17	113	319339	1359550	1799	8.55	0.66	7.89	1791.11
08-05-17	128	319339	1359550	1799	8.45	0.66	7.79	1791.21
23-05-17	143	319339	1359550	1799	8.32	0.66	7.66	1791.34
07-06-17	158	319339	1359550	1799	8.19	0.66	7.53	1791.47
	HDW32							
25-09-16	268	319446	1358907	1793	8.05	0.60	7.45	1785.55
10-10-16	283	319446	1358907	1793	8.17	0.60	7.57	1785.43
25-10-16	298	319446	1358907	1793	8.29	0.60	7.69	1785.31
09-11-16	313	319446	1358907	1793	8.40	0.60	7.80	1785.20
24-11-16	328	319446	1358907	1793	8.52	0.60	7.92	1785.08
09-12-16	343	319446	1358907	1793	9.28	0.60	8.68	1784.32

24-12-16	358	319446	1358907	1793	9.53	0.60	8.93	1784.07
08-01-17	8	319446	1358907	1793	9.49	0.60	8.89	1784.11
23-01-17	23	319446	1358907	1793	9.57	0.60	8.97	1784.03
07-02-17	38	319446	1358907	1793	9.59	0.60	8.99	1784.01
22-02-17	53	319446	1358907	1793	9.69	0.60	9.09	1783.91
09-03-17	68	319446	1358907	1793	9.82	0.60	9.22	1783.78
24-03-17	83	319446	1358907	1793	9.97	0.60	9.37	1783.63
08-04-17	98	319446	1358907	1793	10.20	0.60	9.60	1783.40
23-04-17	113	319446	1358907	1793	10.39	0.60	9.79	1783.21
08-05-17	128	319446	1358907	1793	10.53	0.60	9.93	1783.07
23-05-17	143	319446	1358907	1793	10.38	0.60	9.78	1783.22
07-06-17	158	319446	1358907	1793	10.21	0.60	9.61	1783.39
	HDW35							
25-09-16	268	306798	1363061	1903	7.92	0.61	7.31	1895.69
10-10-16	283	306798	1363061	1903	8.16	0.61	7.55	1895.45
25-10-16	298	306798	1363061	1903	8.40	0.61	7.79	1895.21
09-11-16	313	306798	1363061	1903	8.64	0.61	8.03	1894.97
24-11-16	328	306798	1363061	1903	8.88	0.61	8.27	1894.73
09-12-16	343	306798	1363061	1903	9.12	0.61	8.51	1894.49
24-12-16	358	306798	1363061	1903	9.36	0.61	8.75	1894.25
08-01-17	8	306798	1363061	1903	9.60	0.61	8.99	1894.01
23-01-17	23	306798	1363061	1903	9.84	0.61	9.23	1893.77
07-02-17	38	306798	1363061	1903	10.08	0.61	9.47	1893.53
22-02-17	53	306798	1363061	1903	10.32	0.61	9.71	1893.29
09-03-17	68	306798	1363061	1903	10.56	0.61	9.95	1893.05
24-03-17	83	306798	1363061	1903	10.80	0.61	10.19	1892.81
08-04-17	98	306798	1363061	1903	11.04	0.61	10.43	1892.57
23-04-17	113	306798	1363061	1903	11.28	0.61	10.67	1892.33
08-05-17	128	306798	1363061	1903	11.52	0.61	10.91	1892.09
23-05-17	143	306798	1363061	1903	11.48	0.61	10.87	1892.13
07-06-17	158	306798	1363061	1903	11.39	0.61	10.78	1892.22
	HDW38							
25-09-16	268	313609	1355976	1797	3.84	0.27	3.57	1793.43
10-10-16	283	313609	1355976	1797	3.92	0.27	3.65	1793.35
25-10-16	298	313609	1355976	1797	4.00	0.27	3.73	1793.27
09-11-16	313	313609	1355976	1797	4.07	0.27	3.80	1793.20
24-11-16	328	313609	1355976	1797	4.15	0.27	3.88	1793.12
09-12-16	343	313609	1355976	1797	4.23	0.27	3.96	1793.04
24-12-16	358	313609	1355976	1797	4.30	0.27	4.03	1792.97

08-01-17	8	313609	1355976	1797	4.38	0.27	4.11	1792.89
23-01-17	23	313609	1355976	1797	4.46	0.27	4.19	1792.81
07-02-17	38	313609	1355976	1797	4.54	0.27	4.27	1792.74
22-02-17	53	313609	1355976	1797	4.61	0.27	4.34	1792.66
09-03-17	68	313609	1355976	1797	4.69	0.27	4.42	1792.58
24-03-17	83	313609	1355976	1797	4.77	0.27	4.50	1792.50
08-04-17	98	313609	1355976	1797	4.84	0.27	4.57	1792.43
23-04-17	113	313609	1355976	1797	4.92	0.27	4.65	1792.35
08-05-17	128	313609	1355976	1797	4.87	0.27	4.60	1792.40
23-05-17	143	313609	1355976	1797	4.83	0.27	4.56	1792.44
07-06-17	158	313609	1355976	1797	4.69	0.27	4.42	1792.58
	HDW40							
25-09-16	268	335123	1379100	1946	4.95	0.67	4.28	1941.72
10-10-16	283	335123	1379100	1946	5.02	0.67	4.35	1941.65
25-10-16	298	335123	1379100	1946	5.09	0.67	4.42	1941.58
09-11-16	313	335123	1379100	1946	5.16	0.67	4.49	1941.51
24-11-16	328	335123	1379100	1946	5.23	0.67	4.56	1941.44
09-12-16	343	335123	1379100	1946	5.30	0.67	4.63	1941.37
24-12-16	358	335123	1379100	1946	5.37	0.67	4.70	1941.30
08-01-17	8	335123	1379100	1946	5.44	0.67	4.77	1941.23
23-01-17	23	335123	1379100	1946	5.51	0.67	4.84	1941.16
07-02-17	38	335123	1379100	1946	5.58	0.67	4.91	1941.09
22-02-17	53	335123	1379100	1946	5.65	0.67	4.98	1941.02
09-03-17	68	335123	1379100	1946	5.72	0.67	5.05	1940.95
24-03-17	83	335123	1379100	1946	5.79	0.67	5.12	1940.88
08-04-17	98	335123	1379100	1946	5.86	0.67	5.19	1940.81
23-04-17	113	335123	1379100	1946	5.93	0.67	5.26	1940.74
08-05-17	128	335123	1379100	1946	5.87	0.67	5.20	1940.80
23-05-17	143	335123	1379100	1946	5.78	0.67	5.11	1940.89
07-06-17	158	335123	1379100	1946	5.72	0.67	5.05	1940.95
	HDW42							
25-09-16	268	338755	1365102	1859	6.52	0.30	6.22	1852.78
10-10-16	283	338755	1365102	1859	6.60	0.30	6.30	1852.70
25-10-16	298	338755	1365102	1859	6.68	0.30	6.38	1852.62
09-11-16	313	338755	1365102	1859	6.76	0.30	6.46	1852.54
24-11-16	328	338755	1365102	1859	6.84	0.30	6.54	1852.46
09-12-16	343	338755	1365102	1859	6.92	0.30	6.62	1852.38
24-12-16	358	338755	1365102	1859	7.00	0.30	6.70	1852.30

08-01-17	8	338755	1365102	1859	7.08	0.30	6.78	1852.22
23-01-17	23	338755	1365102	1859	7.16	0.30	6.86	1852.14
07-02-17	38	338755	1365102	1859	7.24	0.30	6.94	1852.06
22-02-17	53	338755	1365102	1859	7.32	0.30	7.02	1851.98
09-03-17	68	338755	1365102	1859	7.40	0.30	7.10	1851.90
24-03-17	83	338755	1365102	1859	7.48	0.30	7.18	1851.82
08-04-17	98	338755	1365102	1859	7.56	0.30	7.26	1851.74
23-04-17	113	338755	1365102	1859	7.64	0.30	7.34	1851.66
08-05-17	128	338755	1365102	1859	7.56	0.30	7.26	1851.74
23-05-17	143	338755	1365102	1859	7.50	0.30	7.20	1851.80
07-06-17	158	338755	1365102	1859	7.41	0.30	7.11	1851.89
	HDW43							
25-09-16	268	338695	1364985	1852	5.12	0.40	4.72	1847.28
10-10-16	283	338695	1364985	1852	5.17	0.40	4.77	1847.23
25-10-16	298	338695	1364985	1852	5.22	0.40	4.82	1847.18
09-11-16	313	338695	1364985	1852	5.27	0.40	4.87	1847.13
24-11-16	328	338695	1364985	1852	5.32	0.40	4.92	1847.08
09-12-16	343	338695	1364985	1852	5.37	0.40	4.97	1847.03
24-12-16	358	338695	1364985	1852	5.42	0.40	5.02	1846.98
08-01-17	8	338695	1364985	1852	5.47	0.40	5.07	1846.93
23-01-17	23	338695	1364985	1852	5.52	0.40	5.12	1846.88
07-02-17	38	338695	1364985	1852	5.57	0.40	5.17	1846.83
22-02-17	53	338695	1364985	1852	5.62	0.40	5.22	1846.78
09-03-17	68	338695	1364985	1852	5.67	0.40	5.27	1846.73
24-03-17	83	338695	1364985	1852	5.72	0.40	5.32	1846.68
08-04-17	98	338695	1364985	1852	5.77	0.40	5.37	1846.63
23-04-17	113	338695	1364985	1852	5.82	0.40	5.42	1846.58
08-05-17	128	338695	1364985	1852	5.75	0.40	5.35	1846.65
23-05-17	143	338695	1364985	1852	5.73	0.40	5.33	1846.67
07-06-17	158	338695	1364985	1852	5.66	0.40	5.26	1846.74
	HDW44							
25-09-16	268	338427	1365279	1858	4.33	0.45	3.88	1854.12
10-10-16	283	338427	1365279	1858	4.39	0.45	3.94	1854.06
25-10-16	298	338427	1365279	1858	4.45	0.45	4.00	1854.00
09-11-16	313	338427	1365279	1858	4.51	0.45	4.06	1853.94
24-11-16	328	338427	1365279	1858	4.57	0.45	4.12	1853.88
09-12-16	343	338427	1365279	1858	4.63	0.45	4.18	1853.82
24-12-16	358	338427	1365279	1858	4.69	0.45	4.24	1853.76
08-01-17	8	338427	1365279	1858	4.75	0.45	4.30	1853.70

23-01-17	23	338427	1365279	1858	4.81	0.45	4.36	1853.64
07-02-17	38	338427	1365279	1858	4.87	0.45	4.42	1853.58
22-02-17	53	338427	1365279	1858	4.93	0.45	4.48	1853.52
09-03-17	68	338427	1365279	1858	4.99	0.45	4.54	1853.46
24-03-17	83	338427	1365279	1858	5.05	0.45	4.60	1853.40
08-04-17	98	338427	1365279	1858	5.11	0.45	4.66	1853.34
23-04-17	113	338427	1365279	1858	5.17	0.45	4.72	1853.28
08-05-17	128	338427	1365279	1858	5.14	0.45	4.69	1853.31
23-05-17	143	338427	1365279	1858	5.08	0.45	4.63	1853.37
07-06-17	158	338427	1365279	1858	4.99	0.45	4.54	1853.46
	HDW45							
25-09-16	268	337429	1365347	1832	8.61	1.10	7.51	1824.49
10-10-16	283	337429	1365347	1832	8.70	1.10	7.60	1824.40
25-10-16	298	337429	1365347	1832	8.79	1.10	7.69	1824.31
09-11-16	313	337429	1365347	1832	8.88	1.10	7.78	1824.22
24-11-16	328	337429	1365347	1832	8.97	1.10	7.87	1824.13
09-12-16	343	337429	1365347	1832	9.06	1.10	7.96	1824.04
24-12-16	358	337429	1365347	1832	9.15	1.10	8.05	1823.95
08-01-17	8	337429	1365347	1832	9.24	1.10	8.14	1823.86
23-01-17	23	337429	1365347	1832	9.33	1.10	8.23	1823.77
07-02-17	38	337429	1365347	1832	9.42	1.10	8.32	1823.68
22-02-17	53	337429	1365347	1832	9.51	1.10	8.41	1823.59
09-03-17	68	337429	1365347	1832	9.60	1.10	8.50	1823.50
24-03-17	83	337429	1365347	1832	9.69	1.10	8.59	1823.41
08-04-17	98	337429	1365347	1832	9.78	1.10	8.68	1823.32
23-04-17	113	337429	1365347	1832	9.87	1.10	8.77	1823.23
08-05-17	128	337429	1365347	1832	9.79	1.10	8.69	1823.31
23-05-17	143	337429	1365347	1832	9.70	1.10	8.60	1823.40
07-06-17	158	337429	1365347	1832	9.61	1.10	8.51	1823.49
	HDW46							
25-09-16	268	337385	1365583	1831	7.20	1.00	6.20	1824.80
10-10-16	283	337385	1365583	1831	7.28	1.00	6.28	1824.72
25-10-16	298	337385	1365583	1831	7.36	1.00	6.36	1824.64
09-11-16	313	337385	1365583	1831	7.44	1.00	6.44	1824.56
24-11-16	328	337385	1365583	1831	7.52	1.00	6.52	1824.48
09-12-16	343	337385	1365583	1831	7.60	1.00	6.60	1824.40
24-12-16	358	337385	1365583	1831	7.68	1.00	6.68	1824.32
08-01-17	8	337385	1365583	1831	7.76	1.00	6.76	1824.24
23-01-17	23	337385	1365583	1831	7.84	1.00	6.84	1824.16

07-02-17	38	337385	1365583	1831	7.92	1.00	6.92	1824.08
22-02-17	53	337385	1365583	1831	8.00	1.00	7.00	1824.00
09-03-17	68	337385	1365583	1831	8.08	1.00	7.08	1823.92
24-03-17	83	337385	1365583	1831	8.16	1.00	7.16	1823.84
08-04-17	98	337385	1365583	1831	8.24	1.00	7.24	1823.76
23-04-17	113	337385	1365583	1831	8.32	1.00	7.32	1823.68
08-05-17	128	337385	1365583	1831	8.23	1.00	7.23	1823.77
23-05-17	143	337385	1365583	1831	8.15	1.00	7.15	1823.85
07-06-17	158	337385	1365583	1831	8.09	1.00	7.09	1823.91
	HDW47							
25-09-16	268	338065	1365433	1842	6.32	0.20	6.12	1835.88
10-10-16	283	338065	1365433	1842	6.37	0.20	6.17	1835.83
25-10-16	298	338065	1365433	1842	6.42	0.20	6.22	1835.78
09-11-16	313	338065	1365433	1842	6.47	0.20	6.27	1835.73
24-11-16	328	338065	1365433	1842	6.52	0.20	6.32	1835.68
09-12-16	343	338065	1365433	1842	6.57	0.20	6.37	1835.63
24-12-16	358	338065	1365433	1842	6.62	0.20	6.42	1835.58
08-01-17	8	338065	1365433	1842	6.67	0.20	6.47	1835.53
23-01-17	23	338065	1365433	1842	6.72	0.20	6.52	1835.48
07-02-17	38	338065	1365433	1842	6.77	0.20	6.57	1835.43
22-02-17	53	338065	1365433	1842	6.82	0.20	6.62	1835.38
09-03-17	68	338065	1365433	1842	6.87	0.20	6.67	1835.33
24-03-17	83	338065	1365433	1842	6.92	0.20	6.72	1835.28
08-04-17	98	338065	1365433	1842	6.97	0.20	6.77	1835.23
23-04-17	113	338065	1365433	1842	7.02	0.20	6.82	1835.18
08-05-17	128	338065	1365433	1842	6.99	0.20	6.79	1835.21
23-05-17	143	338065	1365433	1842	6.96	0.20	6.76	1835.24
07-06-17	158	338065	1365433	1842	6.87	0.20	6.67	1835.33

Table 1.3: Observation wells estimated evaporation rate and cumulative evaporation on the floodplain (for Grass and bare land cover)

From Shah et al.(2007)		
do(m)	de(m)	
0.88	7.15	for Grass land cover
0.54	6.2	for bare land cover

$$et = \begin{cases} et_{max};\ d_t < d_o \\ et_{max}\left(\frac{d_e - d_t}{d_e - d_o}\right);\ d_o \le d_t \le d_e \\ 0;\ d_t > d_e \end{cases}$$

		HDW1		
time(day)	GWT depth (dt, m)	Evaporation rate for wells(mm/day)	Evaporation rate* time(mm)	Cummulative(mm)
1	4.26	2.30	2.30	2.30
15	4.50	2.11	33.11	35.41
30	4.56	2.06	31.29	66.70
45	4.62	2.01	30.57	97.27
60	4.68	1.97	29.85	127.12
75	5.12	1.62	26.89	154.01
90	5.45	1.36	22.31	176.32
105	5.73	1.13	18.66	194.98
120	5.85	1.04	16.27	211.25
135	5.88	1.01	15.37	226.62
150	5.90	1.00	15.07	241.69
165	5.94	0.96	14.71	256.40
180	5.99	0.93	14.17	270.58
195	6.04	0.89	13.58	284.15
210	6.13	0.81	12.74	296.89
225	5.62	1.22	15.25	312.14

		HDW2		
1	3.04	3.28	3.28	3.28
15	3.20	3.15	48.21	51.49
30	3.36	3.02	46.27	97.75
45	3.52	2.89	44.33	142.09
60	3.69	2.76	42.39	184.48
75	4.40	2.19	37.16	221.64
90	4.61	2.03	31.64	253.28
105	4.82	1.86	29.13	282.40
120	5.27	1.50	25.18	307.58
135	5.38	1.41	21.83	329.41
150	5.48	1.33	20.57	349.99
165	5.55	1.28	19.56	369.55
180	5.59	1.24	18.90	388.45
195	5.66	1.19	18.24	406.69
210	5.63	1.21	18.00	424.69
225	5.47	1.34	19.14	443.83
		HDW3		
1	4.31	2.26	2.26	2.26
15	4.43	2.17	33.21	35.47
30	4.55	2.07	31.78	67.25
45	4.67	1.97	30.34	97.59
60	4.79	1.88	28.91	126.50
75	5.50	1.32	23.96	150.46
90	5.68	1.17	18.66	169.12
105	6.01	0.91	15.61	184.73
120	6.32	0.66	11.78	196.52
135	6.45	0.56	9.15	205.67
150	6.47	0.54	8.25	213.92
165	6.54	0.49	7.72	221.64
180	6.56	0.47	7.18	228.81
195	6.59	0.45	6.88	235.69
210	6.61	0.43	6.58	242.27
225	6.40	0.60	7.72	249.99
		HDW4		
1	5.90	1.00	1.00	1.00
15	5.98	0.93	14.50	15.50
30	6.06	0.87	13.49	28.99
45	6.15	0.80	12.49	41.47
60	6.23	0.73	11.48	52.95

75	6.63	0.41	8.60	61.55
90	6.68	0.37	5.92	67.47
105	6.84	0.25	4.67	72.14
120	7.02	0.10	2.63	74.77
135	7.06	0.07	1.32	76.08
150	7.15	0.00	0.54	76.62
165	7.13	0.02	0.12	76.74
180	7.17	0.00	0.12	76.86
195	7.16	0.00	0.00	76.86
210	7.15	0.00	0.00	76.86
225	7.04	0.09	0.66	77.52
		HDW5		
1	5.94	0.97	0.97	0.97
15	5.97	0.94	14.28	15.25
30	6.01	0.91	13.89	29.13
45	6.04	0.89	13.49	42.62
60	6.07	0.86	13.10	55.72
75	6.23	0.73	11.95	67.67
90	6.40	0.60	9.99	77.66
105	6.52	0.50	8.25	85.91
120	6.68	0.37	6.58	92.49
135	6.64	0.41	5.86	98.36
150	6.58	0.45	6.46	104.81
165	6.62	0.42	6.58	111.39
180	6.61	0.43	6.40	117.79
195	6.63	0.41	6.34	124.13
210	6.64	0.41	6.16	130.29
225	6.60	0.44	6.34	136.63
		HDW6		
1	4.74	1.92	1.92	1.92
15	4.90	1.79	27.89	29.82
30	5.06	1.66	25.94	55.75
45	5.23	1.53	23.98	79.73
60	5.39	1.40	22.02	101.76
75	5.92	0.98	17.88	119.64
90	6.05	0.88	13.94	133.57
105	6.13	0.81	12.68	146.25
120	7.20	0.00	6.10	152.35
135	7.24	0.00	0.00	152.35
150	7.26	0.00	0.00	152.35

165	7.27	0.00	0.00	152.35
180	7.28	0.00	0.00	152.35
195	7.29	0.00	0.00	152.35
210	7.29	0.00	0.00	152.35
225	7.24	0.00	0.00	152.35
		HDW7		
1	2.47	3.73	3.73	3.73
15	2.65	3.58	54.87	58.60
30	2.84	3.44	52.68	111.28
45	3.02	3.29	50.49	161.77
60	3.20	3.15	48.30	210.07
75	3.67	2.78	44.42	254.48
90	3.81	2.66	40.79	295.27
105	4.07	2.46	38.40	333.67
120	4.30	2.27	35.47	369.14
135	4.73	1.93	31.52	400.65
150	5.12	1.62	26.61	427.27
165	5.05	1.67	24.70	451.97
180	5.09	1.64	24.88	476.85
195	5.11	1.63	24.52	501.37
210	5.13	1.61	24.28	525.65
225	5.10	1.63	24.34	550.00
		HDW8		
1	2.05	4.07	4.07	4.07
15	2.13	4.00	60.55	64.62
30	2.22	3.93	59.53	124.15
45	2.30	3.87	58.51	182.66
60	2.39	3.80	57.48	240.14
75	2.60	3.63	55.70	295.84
90	2.77	3.49	53.41	349.25
105	2.86	3.42	51.85	401.10
120	2.91	3.38	51.02	452.12
135	3.07	3.25	49.76	501.88
150	3.20	3.15	48.03	549.91
165	3.24	3.12	47.01	596.92
180	3.23	3.13	46.83	643.75
195	3.28	3.09	46.59	690.34
210	3.27	3.09	46.35	736.69

		HDW9		
1	1.52	4.49	4.49	4.49
15	1.70	4.35	66.30	70.79
30	1.88	4.20	64.11	134.89
45	2.07	4.05	61.92	196.81
60	2.25	3.91	59.73	256.54
75	2.66	3.58	56.17	312.71
90	2.75	3.51	53.17	365.88
105	3.03	3.29	50.96	416.84
120	3.25	3.11	47.97	464.80
135	3.42	2.97	45.63	510.44
150	3.80	2.67	42.34	552.78
165	3.92	2.58	39.35	592.14
180	3.98	2.53	38.28	630.41
195	4.10	2.43	37.20	667.62
210	4.22	2.34	35.77	703.38
225	4.48	2.13	33.49	736.87
		HDW10		
1	0.85	5.00	5.00	5.00
15	0.88	5.00	75.00	80.00
30	1.26	4.70	72.73	152.73
45	1.42	4.57	69.53	222.25
60	1.57	4.45	67.66	289.91
75	2.03	4.08	63.99	353.90
90	2.15	3.99	60.53	414.42
105	2.24	3.92	59.27	473.69
120	2.32	3.85	58.25	531.95
135	2.74	3.52	55.26	587.21
150	3.05	3.27	50.90	638.11
165	3.11	3.22	48.68	686.79
180	3.15	3.19	48.09	734.88
195	3.20	3.15	47.55	782.43
210	3.27	3.09	46.83	829.26
225	3.45	2.95	45.33	874.59
		HDW11		
1	1.58	4.44	4.44	4.44
15	1.79	4.28	65.40	69.84
30	2.00	4.11	62.87	132.71
45	2.21	3.94	60.34	193.05
60	2.42	3.77	57.81	250.86

75	3.01	3.30	53.03	303.89
90	3.13	3.21	48.80	352.70
105	3.34	3.04	46.83	399.53
120	3.53	2.89	44.44	443.97
135	3.73	2.73	42.11	486.07
150	4.08	2.45	38.82	524.89
165	4.16	2.38	36.24	561.13
180	4.40	2.19	34.33	595.46
195	4.59	2.04	31.76	627.22
210	4.89	1.80	28.83	656.05
225	5.05	1.67	26.08	682.12
		HDW12		
1	1.58	4.44	4.44	4.44
15	1.79	4.28	65.39	69.83
30	1.99	4.12	62.95	132.79
45	2.19	3.95	60.51	193.30
60	2.40	3.79	58.07	251.37
75	2.86	3.42	54.08	305.46
90	3.00	3.31	50.48	355.94
105	3.23	3.13	48.27	404.20
120	3.49	2.92	45.33	449.54
135	3.79	2.68	41.99	491.52
150	3.89	2.60	39.59	531.12
165	4.03	2.49	38.16	569.27
180	4.26	2.30	35.94	605.22
195	4.47	2.14	33.31	638.53
210	4.69	1.96	30.74	669.27
225	4.88	1.81	28.29	697.56
		HDW13		
1	1.75	4.31	4.31	4.31
15	1.92	4.17	63.60	67.91
30	2.09	4.04	61.59	129.50
45	2.25	3.91	59.58	189.08
60	2.42	3.77	57.57	246.65
75	2.97	3.33	53.28	299.94
90	3.15	3.19	48.92	348.86
105	3.29	3.08	47.01	395.87
120	3.46	2.94	45.16	441.02
135	3.62	2.81	43.18	484.21

150	3.55	2.87	42.64	526.85
165	3.67	2.78	42.34	569.19
180	3.79	2.68	40.91	610.10
195	4.00	2.51	38.94	649.04
210	4.50	2.11	34.69	683.73
225	4.99	1.72	28.77	712.49
		HDW14		
1	1.50	4.51	4.51	4.51
15	1.65	4.38	66.67	71.18
30	1.81	4.26	64.84	136.03
45	1.96	4.14	63.01	199.04
60	2.11	4.02	61.18	260.22
75	2.60	3.63	57.35	317.57
90	2.67	3.57	54.01	371.58
105	2.72	3.53	53.29	424.87
120	2.90	3.39	51.91	476.78
135	2.92	3.37	50.72	527.50
150	3.12	3.21	49.40	576.90
165	3.37	3.01	46.71	623.61
180	3.61	2.82	43.78	667.39
195	3.78	2.69	41.33	708.72
210	3.90	2.59	39.59	748.31
225	3.97	2.54	38.46	786.77
		HDW15		
1	4.73	1.93	1.93	1.93
15	4.88	1.81	28.10	30.03
30	5.02	1.70	26.32	56.35
45	5.17	1.58	24.54	80.90
60	5.32	1.46	22.77	103.66
75	5.62	1.22	20.09	123.76
90	5.77	1.10	17.40	141.16
105	5.90	1.00	15.73	156.89
120	6.10	0.84	13.76	170.65
135	6.35	0.64	11.06	181.71
150	6.51	0.51	8.61	190.32
165	6.69	0.37	6.58	196.90
180	6.74	0.33	5.20	202.10
195	6.85	0.24	4.25	206.35
210	6.93	0.18	3.11	209.46
225	7.04	0.09	1.97	211.43

		HDW16		
1	7.93	0.00	0.00	0.00
15	7.98	0.00	0.00	0.00
30	8.03	0.00	0.00	0.00
45	8.08	0.00	0.00	0.00
60	8.14	0.00	0.00	0.00
75	8.39	0.00	0.00	0.00
90	8.44	0.00	0.00	0.00
105	8.48	0.00	0.00	0.00
120	8.50	0.00	0.00	0.00
135	8.61	0.00	0.00	0.00
150	8.70	0.00	0.00	0.00
165	8.73	0.00	0.00	0.00
180	8.75	0.00	0.00	0.00
195	8.79	0.00	0.00	0.00
210	8.83	0.00	0.00	0.00
225	8.69	0.00	0.00	0.00
		HDW17		
1	7.23	0.00	0.00	0.00
15	7.27	0.00	0.00	0.00
30	7.31	0.00	0.00	0.00
45	7.35	0.00	0.00	0.00
60	7.39	0.00	0.00	0.00
75	7.92	0.00	0.00	0.00
90	7.97	0.00	0.00	0.00
105	8.01	0.00	0.00	0.00
120	8.15	0.00	0.00	0.00
135	8.09	0.00	0.00	0.00
150	8.06	0.00	0.00	0.00
165	8.12	0.00	0.00	0.00
180	8.21	0.00	0.00	0.00
195	8.28	0.00	0.00	0.00
210	8.33	0.00	0.00	0.00
225	8.31	0.00	0.00	0.00
		HDW18		
1	3.58	2.85	2.85	2.85
15	3.69	2.76	42.09	44.94
30	3.80	2.67	40.74	85.68
45	3.91	2.58	39.39	125.07
60	4.03	2.49	38.05	163.12

75	4.40	2.19	35.14	198.25
90	4.49	2.12	32.36	230.61
105	4.55	2.07	31.46	262.07
120	4.68	1.97	30.32	292.39
135	4.74	1.92	29.19	321.58
150	4.90	1.79	27.87	349.45
165	4.99	1.72	26.38	375.83
180	5.06	1.67	25.42	401.24
195	5.18	1.57	24.28	425.53
210	5.30	1.48	22.85	448.37
225	5.65	1.20	20.04	468.41
		HDW19		
1	7.58	0.00	0.00	0.00
15	7.64	0.00	0.00	0.00
30	7.70	0.00	0.00	0.00
45	7.77	0.00	0.00	0.00
60	7.83	0.00	0.00	0.00
75	8.10	0.00	0.00	0.00
90	8.23	0.00	0.00	0.00
105	8.35	0.00	0.00	0.00
120	8.44	0.00	0.00	0.00
135	8.53	0.00	0.00	0.00
150	8.53	0.00	0.00	0.00
165	8.51	0.00	0.00	0.00
180	8.55	0.00	0.00	0.00
195	8.50	0.00	0.00	0.00
210	8.48	0.00	0.00	0.00
225	8.51	0.00	0.00	0.00
		HDW20		
1	9.06	0.00	0.00	0.00
15	9.11	0.00	0.00	0.00
30	9.15	0.00	0.00	0.00
45	9.20	0.00	0.00	0.00
60	9.24	0.00	0.00	0.00
75	9.52	0.00	0.00	0.00
90	9.57	0.00	0.00	0.00
105	9.60	0.00	0.00	0.00
120	9.67	0.00	0.00	0.00
135	9.64	0.00	0.00	0.00
150	9.62	0.00	0.00	0.00

165	9.67	0.00	0.00	0.00
180	9.69	0.00	0.00	0.00
195	9.88	0.00	0.00	0.00
210	9.96	0.00	0.00	0.00
225	10.00	0.00	0.00	0.00
		HDW21		
1	7.53	0.00	0.00	0.00
15	7.58	0.00	0.00	0.00
30	7.63	0.00	0.00	0.00
45	7.67	0.00	0.00	0.00
60	7.72	0.00	0.00	0.00
75	7.89	0.00	0.00	0.00
90	8.06	0.00	0.00	0.00
105	8.20	0.00	0.00	0.00
120	8.34	0.00	0.00	0.00
135	8.37	0.00	0.00	0.00
150	8.42	0.00	0.00	0.00
165	8.40	0.00	0.00	0.00
180	8.44	0.00	0.00	0.00
195	8.41	0.00	0.00	0.00
210	8.36	0.00	0.00	0.00
225	8.54	0.00	0.00	0.00
		HDW22		
1	1.69	3.99	3.99	3.99
15	1.79	3.90	59.11	63.09
30	1.89	3.81	57.76	120.85
45	1.99	3.72	56.41	177.26
60	2.10	3.63	55.05	232.31
75	3.20	2.65	47.07	279.37
90	3.31	2.55	39.02	318.40
105	3.45	2.43	37.37	355.77
120	3.86	2.07	33.72	389.49
135	3.94	2.00	30.48	419.97
150	4.02	1.93	29.42	449.38
165	4.06	1.89	28.62	478.00
180	4.11	1.85	28.03	506.03
195	4.13	1.83	27.56	533.59
210	4.16	1.80	27.23	560.82
225	4.24	1.73	26.50	587.32

		HDW23		
1	2.95	3.35	3.35	3.35
15	3.08	3.25	49.49	52.84
30	3.21	3.14	47.89	100.73
45	3.35	3.03	46.29	147.03
60	3.48	2.93	44.70	191.73
75	4.02	2.50	40.67	232.40
90	4.16	2.38	36.60	269.00
105	4.33	2.25	34.75	303.75
120	4.41	2.19	33.25	337.00
135	4.49	2.12	32.30	369.30
150	4.65	1.99	30.86	400.16
165	4.85	1.83	28.71	428.87
180	4.92	1.78	27.09	455.96
195	5.03	1.69	26.02	481.98
210	5.24	1.52	24.10	506.08
225	5.38	1.41	22.01	528.09
		HDW24		
1	4.32	2.26	2.26	2.26
15	4.43	2.17	33.17	35.43
30	4.55	2.08	31.83	67.26
45	4.66	1.99	30.48	97.74
60	4.77	1.90	29.14	126.88
75	5.39	1.40	24.76	151.64
90	5.43	1.37	20.81	172.45
105	5.55	1.28	19.86	192.31
120	5.70	1.16	18.24	210.55
135	5.76	1.11	16.99	227.53
150	5.90	1.00	15.79	243.32
165	5.97	0.94	14.53	257.86
180	6.08	0.85	13.46	271.31
195	6.22	0.74	11.96	283.28
210	6.30	0.68	10.65	293.92
225	6.57	0.46	8.55	302.47
		HDW25		
1	5.43	1.37	1.37	1.37
15	5.60	1.24	19.60	20.98
30	5.76	1.11	17.59	38.57
45	5.93	0.97	15.58	54.15
60	6.10	0.84	13.57	67.73

75	6.73	0.33	8.80	76.52
90	6.81	0.27	4.55	81.07
105	6.90	0.20	3.53	84.60
120	6.94	0.17	2.75	87.35
135	7.05	0.08	1.85	89.20
150	7.37	0.00	0.60	89.80
165	7.59	0.00	0.00	89.80
180	7.69	0.00	0.00	89.80
195	7.97	0.00	0.00	89.80
210	8.21	0.00	0.00	89.80
225	7.96	0.00	0.00	89.80
		HDW26		
1	5.22	1.54	1.54	1.54
15	5.26	1.51	22.85	24.39
30	5.30	1.47	22.35	46.74
45	5.34	1.44	21.85	68.58
60	5.39	1.41	21.34	89.93
75	5.61	1.23	19.76	109.68
90	5.66	1.19	18.12	127.81
105	5.70	1.16	17.58	145.39
120	5.74	1.12	17.11	162.50
135	5.83	1.05	16.33	178.82
150	5.85	1.04	15.67	194.49
165	5.92	0.98	15.13	209.62
180	5.94	0.96	14.59	224.22
195	5.96	0.95	14.35	238.57
210	5.98	0.93	14.11	252.69
225	6.01	0.91	13.82	266.50
		HDW27		
1	3.90	2.59	2.59	2.59
15	4.07	2.45	37.82	40.41
30	4.24	2.32	35.77	76.18
45	4.42	2.18	33.73	109.91
60	4.59	2.04	31.68	141.59
75	5.94	0.96	22.57	164.16
90	6.05	0.88	13.82	177.98
105	6.27	0.70	11.84	189.82
120	6.35	0.64	10.05	199.87
135	6.53	0.49	8.49	208.36
150	6.51	0.51	7.54	215.90

165	6.78	0.30	6.04	221.94
180	7.05	0.08	2.81	224.75
195	7.29	0.00	0.60	225.35
210	7.53	0.00	0.00	225.35
225	7.33	0.00	0.00	225.35
		HDW28		
1	4.21	2.34	2.34	2.34
15	4.32	2.26	34.49	36.83
30	4.43	2.17	33.19	70.02
45	4.54	2.08	31.90	101.92
60	4.65	2.00	30.61	132.53
75	4.91	1.79	28.38	160.91
90	4.95	1.75	26.56	187.47
105	5.17	1.58	25.00	212.47
120	5.42	1.38	22.19	234.66
135	5.56	1.27	19.86	254.51
150	5.71	1.15	18.12	272.64
165	5.76	1.11	16.93	289.56
180	5.84	1.04	16.15	305.71
195	5.86	1.03	15.55	321.26
210	5.91	0.99	15.13	336.39
225	5.89	1.00	14.95	351.34
		HDW29		
1	2.16	3.98	3.98	3.98
15	2.35	3.82	58.51	62.49
30	2.55	3.67	56.21	118.70
45	2.74	3.52	53.92	172.62
60	2.93	3.36	51.62	224.24
75	3.50	2.91	47.07	271.31
90	3.69	2.76	42.52	313.83
105	3.85	2.63	40.43	354.26
120	4.04	2.48	38.34	392.60
135	4.07	2.46	37.02	429.62
150	4.27	2.30	35.65	465.27
165	4.49	2.12	33.13	498.40
180	4.62	2.02	31.04	529.44
195	4.93	1.77	28.41	557.85
210	5.34	1.44	24.10	581.95
225	5.43	1.37	21.11	603.07

		HDW30		
1	3.02	2.81	2.81	2.81
15	3.15	2.70	41.32	44.14
30	3.28	2.58	39.59	83.73
45	3.41	2.47	37.87	121.60
60	3.54	2.35	36.14	157.73
75	3.85	2.08	33.21	190.94
90	4.03	1.92	29.95	220.88
105	4.22	1.75	27.50	248.38
120	4.31	1.67	25.64	274.02
135	4.42	1.57	24.32	298.34
150	4.36	1.63	23.98	322.32
165	4.60	1.41	22.79	345.11
180	4.74	1.29	20.27	365.38
195	4.86	1.18	18.55	383.94
210	5.06	1.01	16.43	400.37
225	5.30	0.80	13.52	413.88
		HDW31		
1	5.66	1.19	1.19	1.19
15	5.81	1.07	16.97	18.16
30	5.96	0.95	15.14	33.30
45	6.11	0.83	13.31	46.60
60	6.27	0.70	11.48	58.08
75	6.92	0.18	6.66	64.74
90	7.23	0.00	1.38	66.11
105	7.34	0.00	0.00	66.11
120	7.69	0.00	0.00	66.11
135	7.92	0.00	0.00	66.11
150	7.93	0.00	0.00	66.11
165	7.94	0.00	0.00	66.11
180	7.95	0.00	0.00	66.11
195	7.92	0.00	0.00	66.11
210	7.89	0.00	0.00	66.11
225	7.79	0.00	0.00	66.11
		HDW32		
1	7.45	0.00	0.00	0.00
15	7.57	0.00	0.00	0.00
30	7.69	0.00	0.00	0.00
45	7.80	0.00	0.00	0.00
60	7.92	0.00	0.00	0.00

75	8.68	0.00	0.00	0.00
90	8.93	0.00	0.00	0.00
105	8.89	0.00	0.00	0.00
120	8.97	0.00	0.00	0.00
135	8.99	0.00	0.00	0.00
150	9.09	0.00	0.00	0.00
165	9.22	0.00	0.00	0.00
180	9.37	0.00	0.00	0.00
195	9.60	0.00	0.00	0.00
210	9.79	0.00	0.00	0.00
225	9.93	0.00	0.00	0.00
		HDW35		
1	7.31	0.00	0.00	0.00
15	7.55	0.00	0.00	0.00
30	7.79	0.00	0.00	0.00
45	8.03	0.00	0.00	0.00
60	8.27	0.00	0.00	0.00
75	8.51	0.00	0.00	0.00
90	8.75	0.00	0.00	0.00
105	8.99	0.00	0.00	0.00
120	9.23	0.00	0.00	0.00
135	9.47	0.00	0.00	0.00
150	9.71	0.00	0.00	0.00
165	9.95	0.00	0.00	0.00
180	10.19	0.00	0.00	0.00
195	10.43	0.00	0.00	0.00
210	10.67	0.00	0.00	0.00
225	10.91	0.00	0.00	0.00
		HDW38		
1	3.57	2.32	2.32	2.32
15	3.65	2.25	34.31	36.63
30	3.73	2.19	33.29	69.93
45	3.80	2.12	32.27	102.20
60	3.88	2.05	31.25	133.45
75	3.96	1.98	30.23	163.68
90	4.03	1.91	29.21	192.90
105	4.11	1.85	28.19	221.09
120	4.19	1.78	27.17	248.26
135	4.27	1.71	26.15	274.41

150	4.34	1.64	25.13	299.54
165	4.42	1.57	24.11	323.65
180	4.50	1.51	23.09	346.74
195	4.57	1.44	22.07	368.81
210	4.65	1.37	21.05	389.86
225	4.60	1.41	20.87	410.73
		HDW40		
1	4.28	2.29	2.29	2.29
15	4.35	2.23	33.91	36.20
30	4.42	2.18	33.07	69.27
45	4.49	2.12	32.24	101.51
60	4.56	2.07	31.40	132.91
75	4.63	2.01	30.56	163.47
90	4.70	1.95	29.72	193.20
105	4.77	1.90	28.89	222.09
120	4.84	1.84	28.05	250.14
135	4.91	1.79	27.21	277.35
150	4.98	1.73	26.38	303.72
165	5.05	1.67	25.54	329.26
180	5.12	1.62	24.70	353.96
195	5.19	1.56	23.86	377.83
210	5.26	1.51	23.03	400.85
225	5.20	1.56	22.97	423.82
		HDW42		
1	6.22	0.74	0.74	0.74
15	6.30	0.68	10.65	11.39
30	6.38	0.61	9.69	21.08
45	6.46	0.55	8.73	29.81
60	6.54	0.49	7.78	37.58
75	6.62	0.42	6.82	44.40
90	6.70	0.36	5.86	50.26
105	6.78	0.30	4.90	55.17
120	6.86	0.23	3.95	59.11
135	6.94	0.17	2.99	62.11
150	7.02	0.10	2.03	64.14
165	7.10	0.04	1.08	65.22
180	7.18	0.00	0.30	65.51
195	7.26	0.00	0.00	65.51
210	7.34	0.00	0.00	65.51

225	7.26	0.00	0.00	65.51
		HDW43		
1	4.72	1.94	1.94	1.94
15	4.77	1.90	28.77	30.71
30	4.82	1.86	28.17	58.88
45	4.87	1.82	27.57	86.45
60	4.92	1.78	26.97	113.42
75	4.97	1.74	26.38	139.80
90	5.02	1.70	25.78	165.57
105	5.07	1.66	25.18	190.75
120	5.12	1.62	24.58	215.33
135	5.17	1.58	23.98	239.32
150	5.22	1.54	23.39	262.70
165	5.27	1.50	22.79	285.49
180	5.32	1.46	22.19	307.68
195	5.37	1.42	21.59	329.27
210	5.42	1.38	20.99	350.26
225	5.35	1.44	21.11	371.38
		HDW44		
1	3.88	2.61	2.61	2.61
15	3.94	2.56	38.76	41.36
30	4.00	2.51	38.04	79.40
45	4.06	2.46	37.32	116.72
60	4.12	2.42	36.60	153.33
75	4.18	2.37	35.89	189.21
90	4.24	2.32	35.17	224.38
105	4.30	2.27	34.45	258.83
120	4.36	2.22	33.73	292.56
135	4.42	2.18	33.01	325.57
150	4.48	2.13	32.30	357.87
165	4.54	2.08	31.58	389.45
180	4.60	2.03	30.86	420.31
195	4.66	1.99	30.14	450.45
210	4.72	1.94	29.43	479.88
225	4.69	1.96	29.25	509.13
		HDW45		
1	7.51	0.00	0.00	0.00
15	7.60	0.00	0.00	0.00
30	7.69	0.00	0.00	0.00

45	7.78	0.00	0.00	0.00
60	7.87	0.00	0.00	0.00
75	7.96	0.00	0.00	0.00
90	8.05	0.00	0.00	0.00
105	8.14	0.00	0.00	0.00
120	8.23	0.00	0.00	0.00
135	8.32	0.00	0.00	0.00
150	8.41	0.00	0.00	0.00
165	8.50	0.00	0.00	0.00
180	8.59	0.00	0.00	0.00
195	8.68	0.00	0.00	0.00
210	8.77	0.00	0.00	0.00
225	8.69	0.00	0.00	0.00
		HDW46		
1	6.20	0.76	0.76	0.76
15	6.28	0.69	10.89	11.64
30	6.36	0.63	9.93	21.57
45	6.44	0.57	8.97	30.54
60	6.52	0.50	8.01	38.56
75	6.60	0.44	7.06	45.61
90	6.68	0.37	6.10	51.71
105	6.76	0.31	5.14	56.86
120	6.84	0.25	4.19	61.04
135	6.92	0.18	3.23	64.27
150	7.00	0.12	2.27	66.55
165	7.08	0.06	1.32	67.86
180	7.16	0.00	0.42	68.28
195	7.24	0.00	0.00	68.28
210	7.32	0.00	0.00	68.28
225	7.23	0.00	0.00	68.28
		HDW47		
1	6.12	0.82	0.82	0.82
15	6.17	0.78	12.02	12.84
30	6.22	0.74	11.42	24.27
45	6.27	0.70	10.83	35.09
60	6.32	0.66	10.23	45.32
75	6.37	0.62	9.63	54.95
90	6.42	0.58	9.03	63.98
105	6.47	0.54	8.43	72.41

120	6.52	0.50	7.83	80.25
135	6.57	0.46	7.24	87.48
150	6.62	0.42	6.64	94.12
165	6.67	0.38	6.04	100.16
180	6.72	0.34	5.44	105.61
195	6.77	0.30	4.84	110.45
210	6.82	0.26	4.25	114.70
225	6.79	0.29	4.13	118.82
Sum		928		