

## Study on Groundwater Potential using MODFLOW for Kalipat Village

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### ABSTRACT

*Excessive withdrawal of groundwater leads to a diminution of the water stored underground. A groundwater flow modeling helps to understand groundwater systems, and explore or predict changes and build a better understanding of the relationship between natural resources and human activities. The groundwater flow model was developed for Kalipat village in Rajkot district using MODFLOW. Evaluation of Groundwater level and direction is done with the help of base map and well inventory. MODFLOW shows that the head varies from 132m on southern side to 141m on northern side. The direction of groundwater flow is north east to south-west in study area.*

**Keywords:** MODFLOW, Groundwater flow, Flow Direction, Water balance

### INTRODUCTION

Day by day, water demand is increasing and groundwater level decreasing. Groundwater is one of the most valuable natural resources, which supports human health, economic development and ecological diversity. More than 90% of our rural population is primarily dependent on groundwater (Chandrasekhar et al., 1999). The quality of groundwater is as important as that of quantity because it is the only source of drinking water in most of urban areas of India. Due to overexploitation, the groundwater systems are affected and require management to maintain the conditions of groundwater resources within acceptable

limits. With the development of computers and advances in information technology, Groundwater modeling has become a standard tool for effective groundwater management (Kumar & Kumar). Groundwater models are the backbones of water resource planning and management in semi-arid areas (Uddameri et al., 2017). Generally, in groundwater models, a simplified mathematical representation of a groundwater system is solved by a computer program (Reilly et al., 2004). A GWM help us to understand groundwater systems, and explore or predict changes and to build a better understanding of the relationship between natural resources and human activities.

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The study was planned to determine the groundwater flow directions, hydraulic gradient and estimation of groundwater potential with MODFLOW. It will help to manage and develop natural water resources.

### MATERIALS AND METHODS

In the present study Kalipat village in Rajkot district was selected as study area for estimation of groundwater potential. The study area is having typically subtropical and semi-arid climate, characterized by fairly cold and dry winter, hot and dry summer and warm and moderately humid during monsoon. The average annual rainfall of Rajkot 592 mm. The soil types are sandy, loamy sand, clay sand silt. The map of study area was prepared using GPS Google earth and AutoCAD. The location of well and boundary points recorded by GPS and located on Google earth and digitalized with AUTOCAD and imported in MODFLOW as a base map. The digital map of study area was prepared, and open wells were located as per their geo-reference positions on the map of study area. Digital elevation model of 30 \* 30 grid size covered study area. The groundwater level recorded with water level indicator, hydraulic gradient and direction of flow are determined using this data.

### RESULT AND DISCUSSION

The base of study area was imported in to visual MODFLOW. The x and y coordinate (x, y) of the system of study area (0, 0) and (1674, 2459) at south-west and North- east corner respectively. The no of rows 27 and no of columns 26 fixed based on trials. The observation on the depth of water table during the simulation period (June 2018 to May 2019) was collected from the around 21well in Kalipat village. It was observed that water table depth from groundwater surface in open wells increases as monsoon season progresses and decreases from post monsoon to pre monsoon.

#### Head

MODFLOW solution for input data of study area obtained and the contours maps of head/equipotential lines were obtained as shown in Fig 1. The head varies from 132m on southern side to 141m on northern side. The head fluctuation during the simulation period was less in Zone-II (area surrounding the Aji river) reasons might be continues recharging throughout the year from Aji river than the zone-I (agricultural area on southern part) reasons might be withdrawal of groundwater is more because of agricultural area.

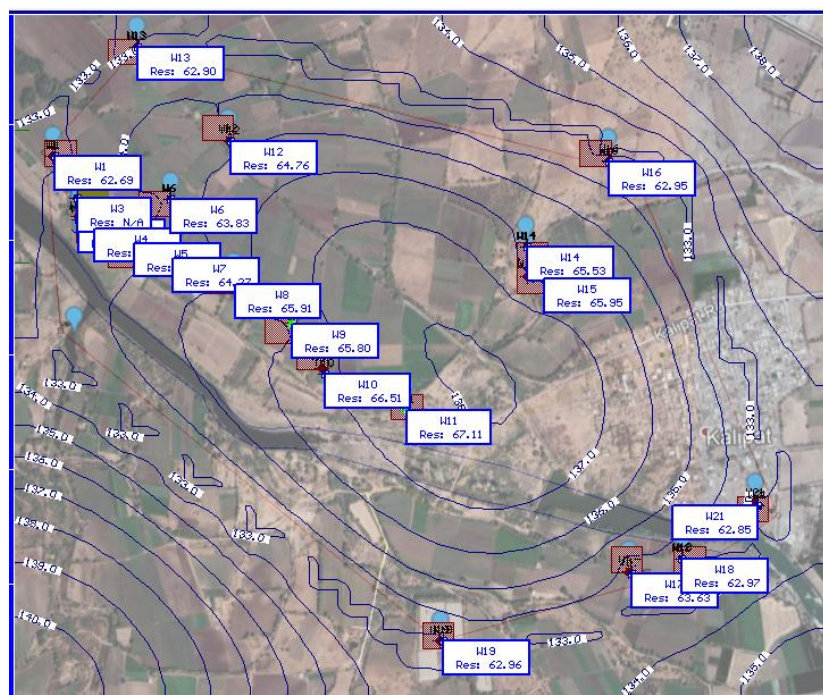
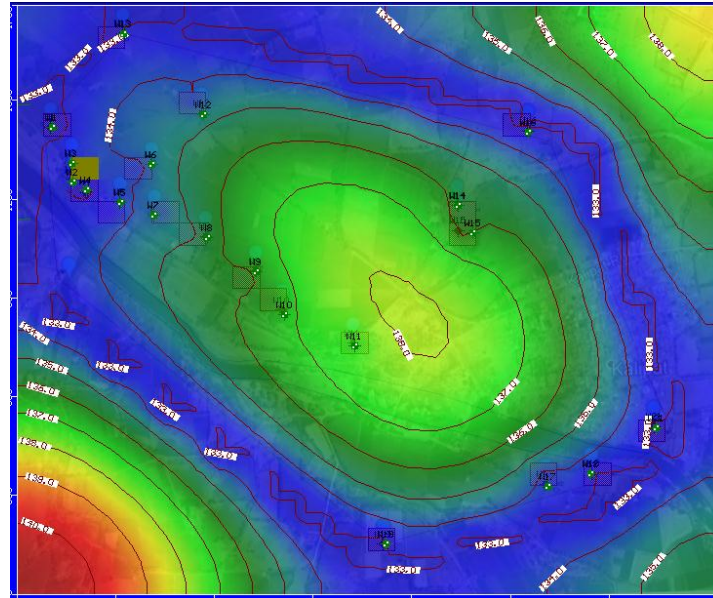


Fig. 1: The contours map of head on end of simulation period in study area

**Water table depth**

Fig 2 depicts the contours maps of water table depth of the study area. It was found that the water table depth from the groundwater surface varied from 12m at start of monsoon

and 0 m at end of monsoon. The depth of water table from groundwater surface was least on northern side and increases as we moved towards the southern side.

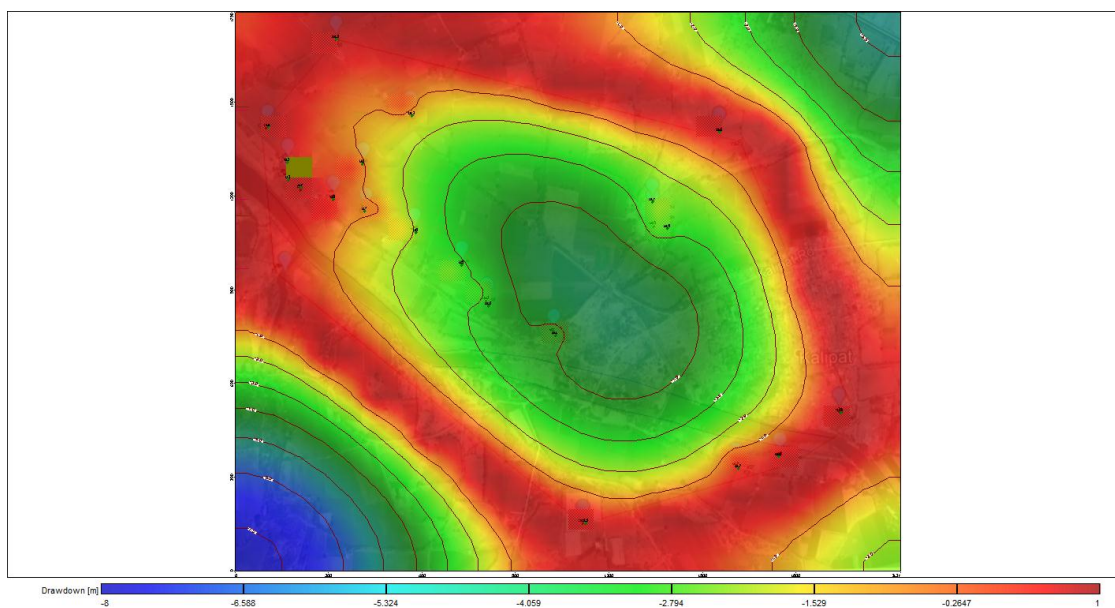


**Fig. 2: The contours maps of water table depth**

**Drawdown**

The contours of the drawdown in the study area are depicted in Fig 3. It was found that the drawdown varied from highest of 8 m surrounding. The results indicated that the

water table depth from ground surface was less on end of May 2019 (end of simulation period) as compared to that of June 2018 (start of simulation period). The reason behind this was the groundwater recharge during the monsoon.



**Fig. 3: Contours map of drawdown**

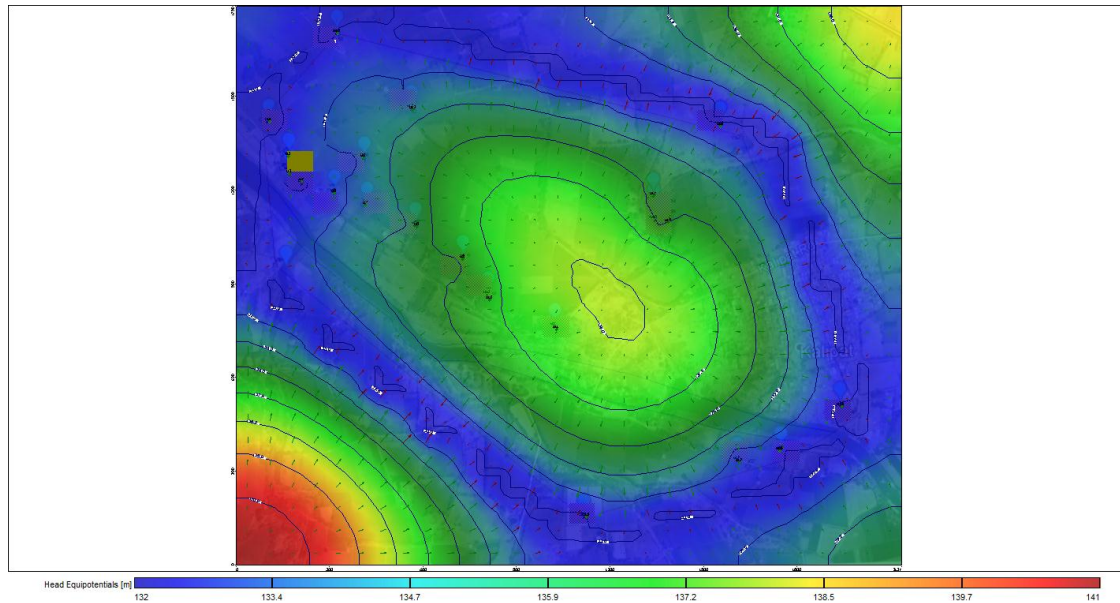
**Head Difference**

Fig 4 shows the contours maps of head difference. It was found that it varied from lowest of on southern-west boundary to highest of in the area besides to Aji River.

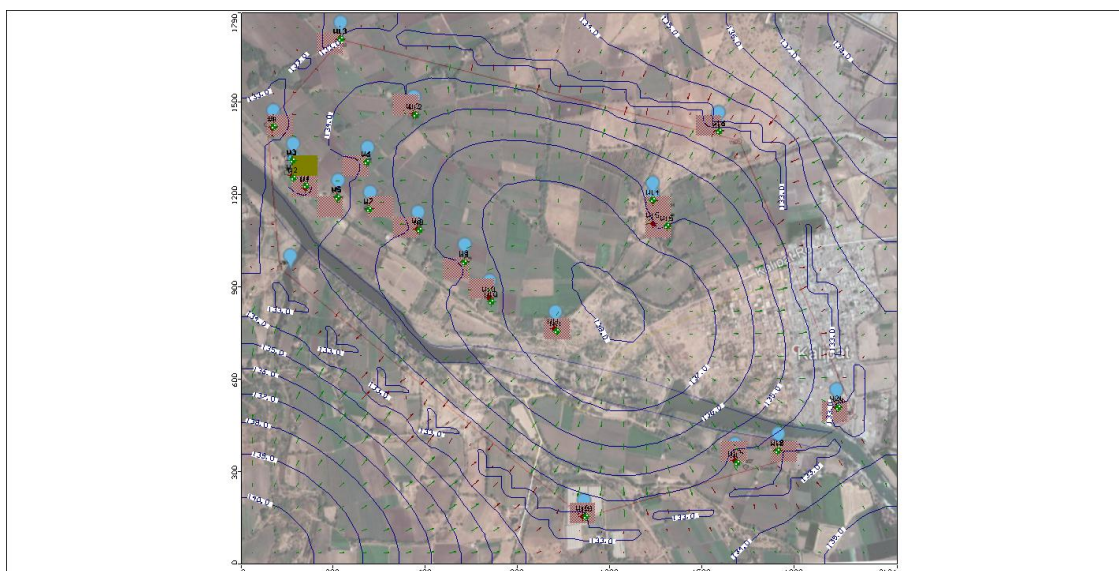
**Velocity and path line**

Fig 5 shows the direction of groundwater path line or velocity and path line. It was found that the direction of groundwater flow is north-east

to south-west in the KALIPAT. The most interesting observation was that the groundwater flow streamlines flows on both sides from Aji river line while streamlines cross the line of stream on eastern boundary lines. It indicated that the Aji had higher contribution of groundwater recharge as compared the stream passing on eastern boundary of the area.



**Fig. 4: contours map of Head difference**

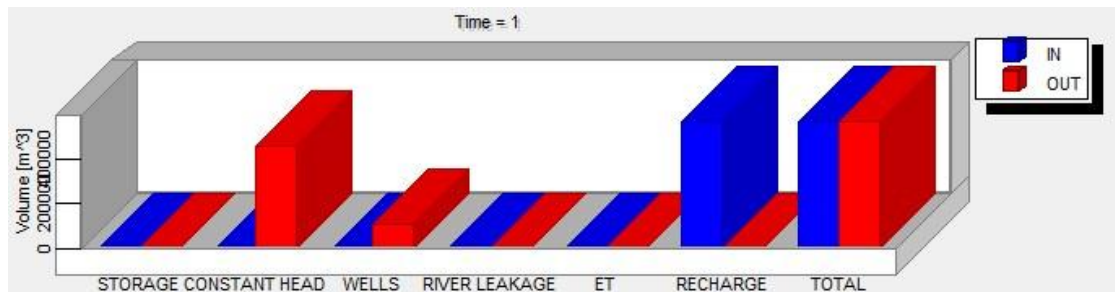


**Fig. 5: contours map Velocity**

**Water balance**

The water balance of whole area obtained through MODFLOW output is given in Fig 6 .The water balance of the study area showed that the outflow from the study area is higher

than that of inflow into the area. The reasons are net recharge in the area is 1568 cum. And the river leakage into the aquifer is higher that outgoing.



**Fig. 6: Water balance of study area**

<p><b>INFLOW</b>                  Storage = 0 [m<sup>3</sup>/day]                  Constant Head = 4.5645 [m<sup>3</sup>/day]                  Wells = 0 [m<sup>3</sup>/day]                  Drains = 0 [m<sup>3</sup>/day]                  MNW = 0 [m<sup>3</sup>/day]                  LAKE SEEPAGE = 0 [m<sup>3</sup>/day]                  Recharge = 1568 [m<sup>3</sup>/day]                  ET = 0 [m<sup>3</sup>/day]                  River Leakage = 0 [m<sup>3</sup>/day]                  Stream Leakage = 0 [m<sup>3</sup>/day]                  Surface Leakage = 0.00 m<sup>3</sup>/day                  General-Head = 0 [m<sup>3</sup>/day]                    Total IN = 1572.5 m<sup>3</sup>/day</p>	<p><b>OUTFLOW</b>                  Storage = 0 [m<sup>3</sup>/day]                  Constant Head = 1277.5 [m<sup>3</sup>/day]                  Wells = 294.84 [m<sup>3</sup>/day]                  Drains = 0 [m<sup>3</sup>/day]                  MNW = 0 [m<sup>3</sup>/day]                  LAKE SEEPAGE = 0 [m<sup>3</sup>/day]                  Recharge = 0 [m<sup>3</sup>/day]                  ET = 0 [m<sup>3</sup>/day]                  River Leakage = 0 [m<sup>3</sup>/day]                  Stream Leakage = 0 [m<sup>3</sup>/day]                  Surface Leakage = 0.00 m<sup>3</sup>/day                  General-Head = 0 [m<sup>3</sup>/day]                    Total OUT = 1572.3 m<sup>3</sup>/day</p>
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**CONCLUSION**

Estimation of water resources is helpful for planning and management. MODFLOW model is developed for estimation of water balance in kalipat village by field observations data and identify boundary condition. The direction of groundwater flow and water balance was estimated. MODFLOW shows that the head varies from 132m on southern side to 141m on northern side. The direction of groundwater flow is north east to south-west in study area.

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