

AN ANALYSIS OF GROUNDWATER LEVELS AND GROUNDWATER FLOW DISTRIBUTIONS IN LOWER NAMKAM RIVER, THAILAND

*Waradet SANGBUN¹, Songvoot SANGCHAN¹

¹*Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok 10520, Thailand*

Corresponding author: Waradet SANGBUN. E-mail: waradeathsanboom@hotmail.com

ABSTRACT

The objectives of this study were to solve flooding problem in Namkam agricultural area during rainy season and to manage water supply to the local people along the river in dry season. Since 1993, Namkam Irrigation project has been studied on the integrated surface water and groundwater uses. Research team have been studying on the water level, flow and distribution of shallow groundwater. The results shown that, groundwater level have changed when the floodgate was operated. The farmers and villagers are not only uses water from the Namkam River but also from shallow groundwater.

An automatically groundwater level observation systems in 5 points (DM6, NK2, NK3, NK8, NKOW14) were used in the Namkam river. The data were analyzed using Surfer program. From analyzed data, research team found that when floodgate was operate, shallow groundwater level and the distribution of groundwater at DM6, NK2, NK3, NK8, and NKOW14 was increased to 1.115, 0.15, 1.918, 0.5, and 0.6 metre, respectively. From results of this study, research team can cooperate with public and private organizations in the management of watersheds with higher benefits to the public in the future.

Keywords: Namkam; Groundwater; Surfer

INTRODUCTION

The lower Namkam river basin of Nakhonpanom province has the problem in lack of water due to sandy loam soil. Besides, farmers, there have to rely on groundwater for agricultural proposes, particularly during the dry season. Most of the farmers face the problem in soil salinity and salt deposit problem which is found during the dry season. Thus, the Royal Irrigation Department (RID) makes a decision to propose the Namkam basin development project in Sakonnakorn and Nakhonpanom provinces.

This study focused on the shallow groundwater level and the distribution of shallow groundwater level before and after the floodgate construction. This aimed to find shallow groundwater have changed for comparing it before and after the regulating gate construction. Shallow groundwater level data were collected after after Namkam regulating gate operated. This could be a model and data reference in surface water use in the area having soil salinity in the future. Meanwhile, it could be supporting data for

water management of the regulating gate in the lower Namkam River.

STUDY AREA

The Namkam basin is located in tropical monsoon area having an average amount of rainfall for 1,500-2,000 mm. per year. At Na Kae meteorology station, an average amount of rainfall is 1,500 mm. per year and 80 percent is found during April-September. However, lack of water occurs due to the uncertainty of the amount of rainfall. An average temperature is 31.1°C with the highest is 33.4°C in April and the lowest was 14.4°C in June. An annual amount of evapo-ration is about 1,740 mm. which is higher than the amount of rainfall for about 16 percent. Main surface water source in this area is Namkam river [1]. The highest amount of water usually occurs in September (393.7 million cubic meters) and the lowest is found in February (9.93 million cubic meters). There is a limitation of groundwater use in this area because only

shallow groundwater can be consumed where as deep groundwater contains a high

proportion of minerals which can be used for agricultural purposes [2].



Fig. 1 The Lower Namkam River Basin

Most area of the lower Namkam basin has rock salt with 5-10 slope to the north and it is about 90-200 meters below the top soil. It is usually found that there is salty water infiltrating in sand layer, sand sediment, clay, and sandstone. The surface water level of fresh water, brackish water, and salt water is found at 30-40 meters below the top soil.

DATA BASE

In this research, the behavior of groundwater in this area were analyzed. The data were collected for 8 years from 2005 to 2013. The author collected data in the area for eight years from 2005 to 2013. Methods of data collection by the field area are the surveys with questionnaire for people and farmers in the area and gathered statistics from various government agencies to obtain the information need to complete the analysis as shown in Table 1.

Table 1 Data Collection and attribute data for the study

Data Collection	Database Attribute data	Result map	Database analysis
Climate	Rainfall	Rainfall map	Thiessen polygon method
Infiltration observation	Infiltration capacity Seepage coefficient	Infiltration capacity map Seepage coefficient map	Horton method Observation field
Land use	land use classification Evapotranspiration	land use classification map Evapotranspiration map	Observation field, questionnaire, statistics Thailand's database statistics Thailand's database
Surface water	Surface water level	Surface water elevation map	Observations field
Groundwater	Groundwater level	Ground water level distribution map	Observations well
Ground surface	Ground surface elevation	Ground surface elevation map	Statistics Thailand's database, Observations field

An amount of rainfall

Data were collected from 3 out of 5 meteorology stations in the study area: station 24022-(Thatpanom district), station 24032 (Na Kae district), and station 24182 (Renukhon district) as shown in Fig. 2.

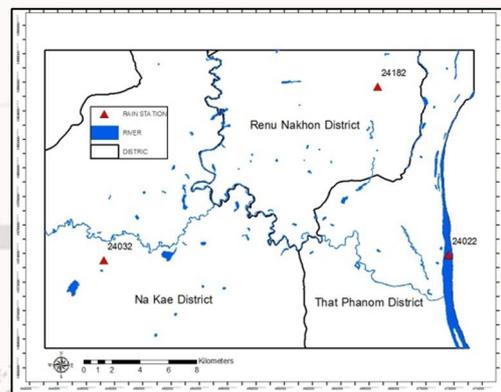


Fig.2. Rainfall station map

Amount of water

Water level and flow rate data were collected as shown in Fig.3. However, it was found that the current condition of water amount and level measuring has been changing from the past due to the construction of water level gates in the Namkam river (Na Khoo gate) and the Nam Bang river (Na Bua gate). It aimed to keep and elevate water level supplying to agricultural areas along the rivers. This made amount of water discharging to these areas was not in nature because it depended on water flow control by the regulating gates. Besides, there was the construction of the lower Namkam water level gates making most water amount and level measuring stations close. Based on the investigation, it was found that the following stations were left: Kh69A [3] (Namkam river), Kh68 (the Nam Bang and Namkam river were constructed, amount of water discharge from lower water level gates could be computed based on the Calibrate – width of opened leaf of the gate and level of water in the front and the back of water level gates. However, the water level gates still had no calibrate making the computation cannot be done; only the water level in the front and at the back of the water level gates could be recorded

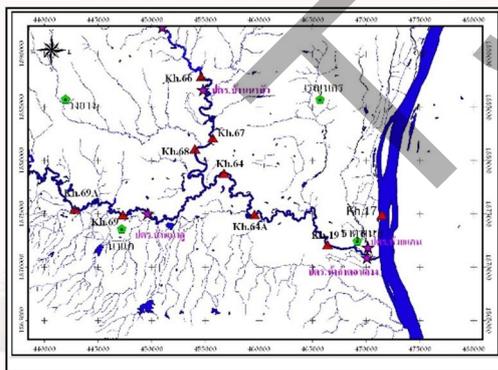


Fig.3. Water level gates station map

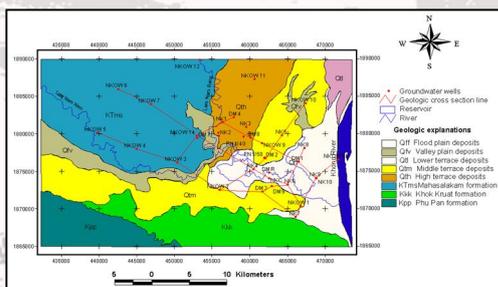


Fig. 4 Geology in the Lower Nam Kam River Basin

Geological condition characteristics of soil layer

The groundwater study area is divided into two aquifers. Shallow groundwater (until depth of 40 m) was distribution covers and supports the Lower Namkam River Basin area. Composed of sediments have not solidified of Quaternary Period. A layer of fresh water and good quality is shallow layer, and deep groundwater is located in the Maha Sarakham formation rock salt. Geological study found that the clay paste cover rock salt. The upper section of the Maha Sarakham formation has the ability to block the flow of saline water from the rock salt on top is shown in Table 1 and Fig. 4. From these soil information the author made 3-D soil construction in upper aquifer as shown in Fig. 5.

Table 2 Characteristics of soil and stone layer

Depth (m)	Description
0-2	clay and mud
2-5	coarse to very coarse sand
5-20	very fine sand
25-30	Silt, clayey sand, fine to very fine sand, silt or silty mud
31-40	silt or silty mud
41-44	Silt, clayey sand, fine to very fine sand
44 – 72	Clay stone
78-110	rock salt

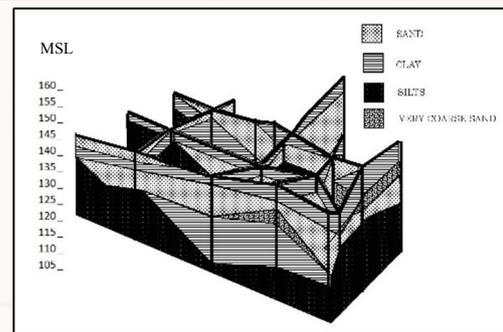


Fig. 5 3-D soil structure

Land use and agriculture

According to the 2004 land use map of the Land Development Department, it was found that cultivation in the study area was mostly under rainfed condition (547,200 m² or 60%). This was followed by forest area (18%) and 7 percent could access to irrigation. For other types of land use, the area expected to be flooded due to water storage of regulating gates in the lower Nam Kam basin was mostly eucalyptus plantation area Fig. 6.

Based on the field survey, it was found that farmers in the study area grow rice as a the main plant and the the remaining are orchard (mango and orange) and perennials (rubber and eucaly-ptus). Besides, very few crop plants were found there. After rice harvesting, most part of the study area was abandoned due to lack of water source. Farmers were used less ground-water for agriculture.

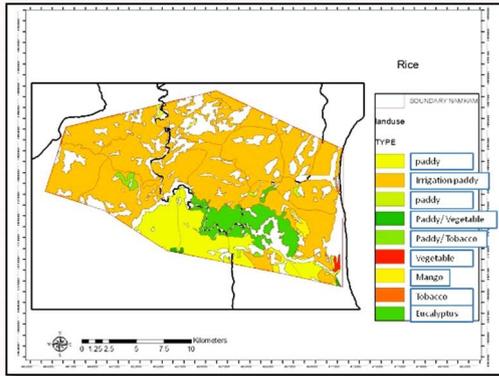


Fig. 6. Land use map

METHODOLOGY AND METHODS

Crop water requirement

$$ET_c = K_c \times ET_p \quad \dots(1)$$

Where

ET_c = crop water requirement(mm./day)

K_c = coefficient value of water use by the plants

ET_p = amount of water used by the plants (mm./day)

Rainfall

Thiessen Method was employed based on an amount of rainfall obtained from each rainfall measuring station. The determination of area around the rainfall measuring station was done based on Thiessen Polygon.

$$\bar{P} = \frac{P_1A_1 + P_2A_2 + \dots + P_nA_n}{A_1 + A_2 + \dots + A_n} \quad \dots(2)$$

Where

P_1 = average amount of rainfall at sub-basin 1

P_n = average amount of rainfall at sub-basin n

A_n = area of sub-basin n

Infiltration

The movement process of infiltration would increase moisture in the soil which was

beneficial to plants for water uptake. Besides, it was beneficial to groundwater accumulation during the rainy season and groundwater use in the dry season.

Infiltration capacity properties by using Double Ring Method

This method was employed for finding filtration. Two metal cylinders with at least 0.08 inch in thickness, and open ended were used. The diameter of the outer cylinder must be greater than that of the inner cylinder for at least 8 inches. The inner cylinder had at least 12 inches in diameter and 12-14 inches in length. The outer cylinder was hammered into the soil for 2 inches and then the inner cylinder was hammered into the soil for 4 inches. A tank with 1 inch in thickness and 5-6 inches in width was placed on the two cylinders and then it was hammered little by little. Then, a level measuring instrument was used for examining the level of orifice of the cylinders. After that, poured water into the outer cylinder until it was 3 inches above the soil surface. Then, poured water immediately into the inner cylinder until it was 3 inches about the soil surface. Then measured the distance from the orifice of the inner cylinder to the water level and timing was conducted. Kept on pouring water into the outer cylinder which it could be observed that its water level decreased more rapidly than that of the inner cylinder. The water level was measure every 1, 3, 5, 10, 20, 30, 45, 60, 90, 120 minutes and every next hours. An appropriate time for water level measuring differed based on infiltration rate. Generally, it must not infiltrate for more than 1 inch of each measuring time. When the water level was at 1 inch, poured water again until it was 3 inches in height.

Equation

seepage coefficient and infiltration capacity

The equation was used used as shown below.

$$AC = \frac{I}{H} \quad \dots(3)$$

Where

AC = seepage coefficient (mm/day/m)

I = Infiltration capacity from the equation (Horton, 1939) (mm/day)

H = Water depth per unit of remaining water depth above soil surface (m)

Similar to infiltration capacity, the seepage capacity decrease with time and nearly constant at some value, called "see-page coefficient (AC)"

Natural Recharge

Groundwater systems might be termed like that of surface water systems, i.e. inputs, outputs, and storage. The significant difference was: water infiltration through soil layers to artesian well water level. The team of researcher used the following equation:

1) In the case of there was no flood in the area

$$Q = (Q_R - ET_c) \times AC \quad \dots(4)$$

2) In the case of the was fold in the area

$$Q = Q_F \times AC \quad \dots(5)$$

3) In the case of there was no rain and flood in the area and there was no cultivation in the area

$$Q = 0$$

Where

- Q = Recharge (m3/month)
- D_R = An amount of rain (mm./month)
- ET_C = Crop water requirement

DATA ANALYSIS

Distribution of infiltration and seepage coefficient

For estimation of seepage, infiltration rate was tested in the field and then the distribution map was produced. Infiltration capacity is used for ponding or flooding water in ground surface and seepage capacity is used for rainfall.

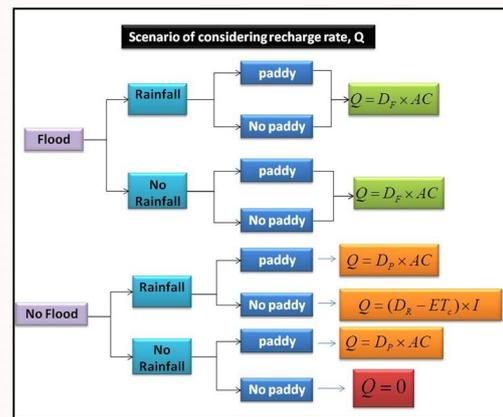


Fig.7 Scenario of considering recharge rate

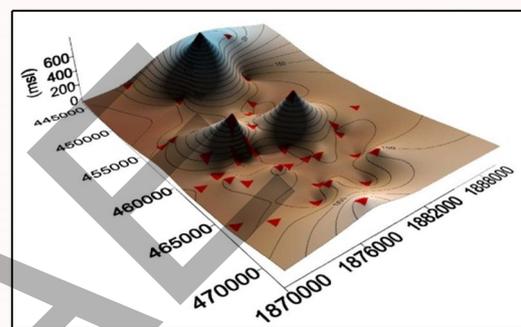


Fig.8 Distribution of infiltration capacity (unit mm/day) in the Lower Namkam River Basin area

Infiltration capacity

Fig.8 shows the distribution of infiltration capacity in the field. Infiltration rate was calculated using rainfall data.

Seepage coefficient

Fig. 9 shows the distribution of seepage coefficient. From this map, seepage was calculated by ponding or flooding water in the field.

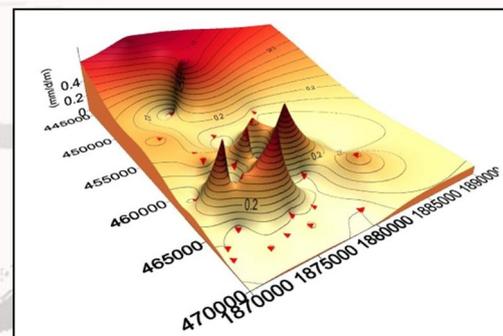


Fig.9 Distribution of seepage coefficient (unit m/day/m) in the Lower Namkam River Basin area

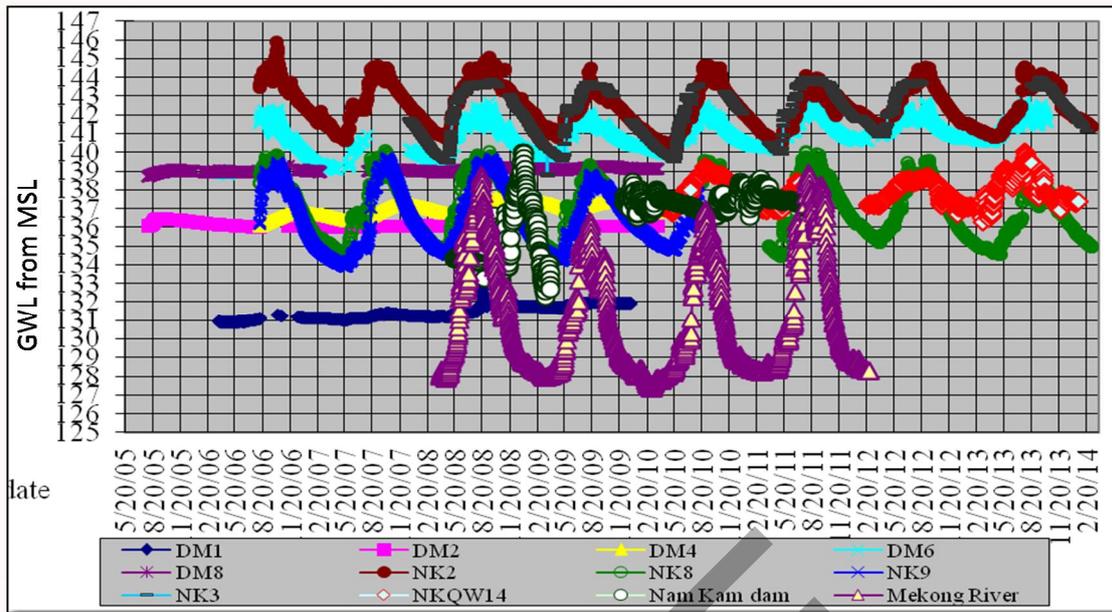
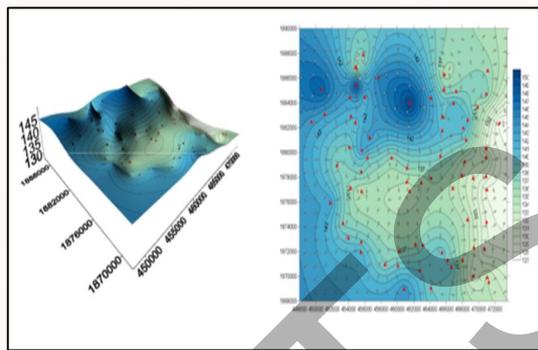
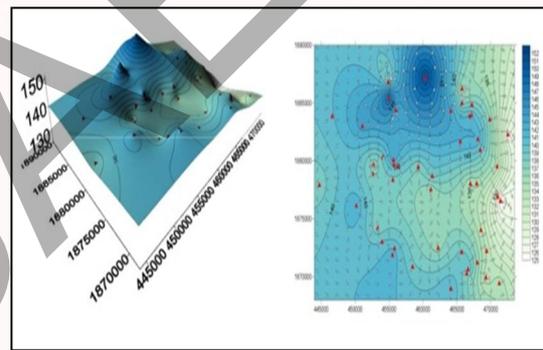


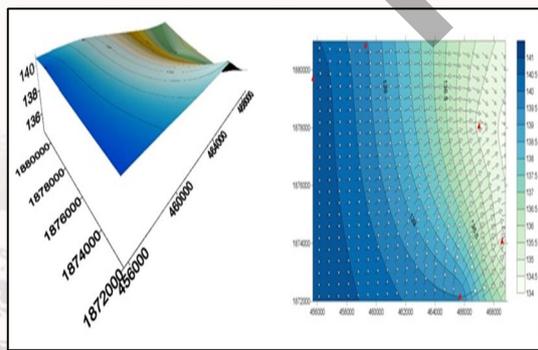
Fig.10 Groundwater level change in the Lower Namkam river basin



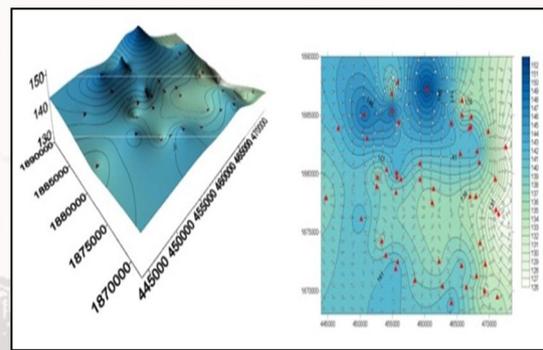
2006



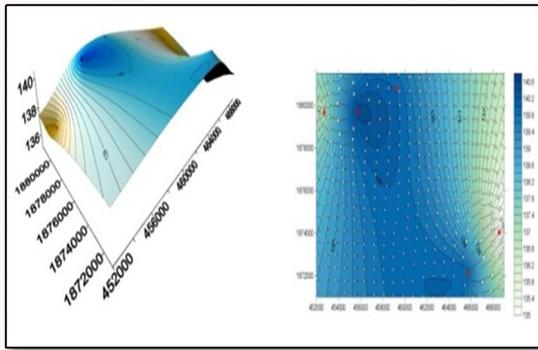
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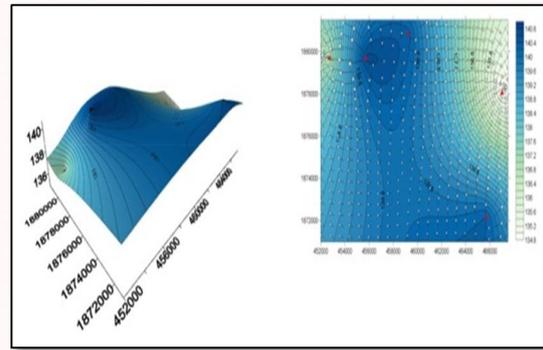
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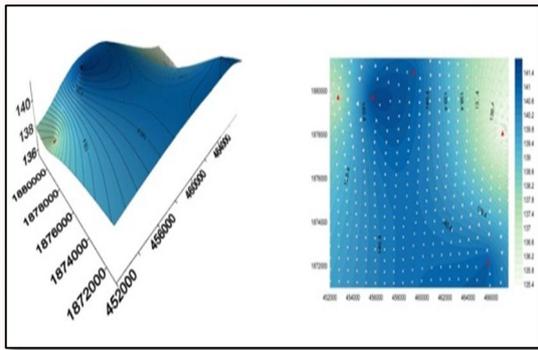
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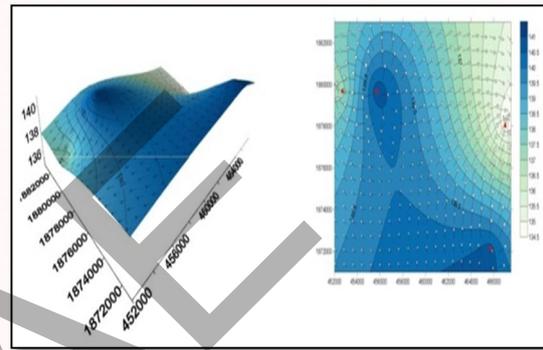
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2011



2012



2013

Fig. 11 Groundwater distribution map in April in each year during 2005-2013

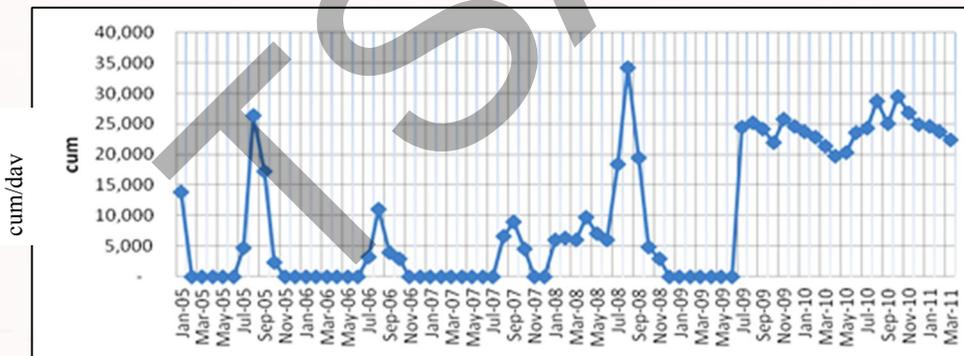


Fig.13 Recharge rate in the Lower Namkam River Basin area during 2005-2011

Recharge rate through ground surface

To calculate groundwater recharge through ground surface by flooding and ponding, the grids were set with interval 100 m. as shown in Fig. 12. In these grids, the author set the ponding water level and seepage capacity. And summation in each grid is total seepage rate. Fig. 13 shows the calculation results in each month during 2005-1011. We can understand that seepage rate before setting the Namkam dam is only flooding period, but seepage rate after setting the Namkam dam is almost same value during year.

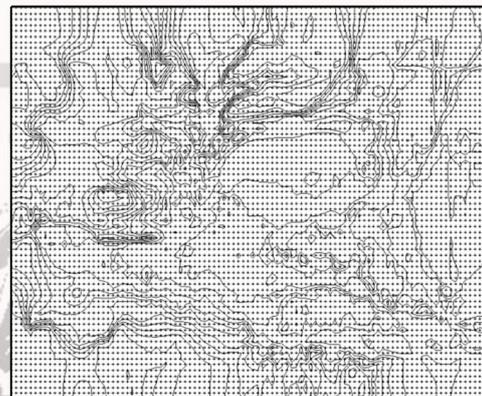


Fig. 12 Calculation of grid

GROUNDWATER BEHAVIORS

Groundwater Level

The groundwater levels (GWL) in boundary before the Namkam Dam has constructed have 71 observation wells in shallow aquifer, now 5 shallow observation wells. The station DM6, NK2, NK3, NK8 and NKOW14 are located in shallow aquifer (less than 50 or 60m from ground surface). The electric conductivities (EC) station is 3 sight; i.e. DM6, NK3 and NKOW14. The groundwater level change in these observation sights is shown in Fig. 8. As shown in Fig. 10, deep groundwater levels (DM1, DM2, DM4 and DM8) are almost same level. Then it is said that deep ground-water is not contact with shallow ground-water

Groundwater Level Distribution

Using observed groundwater level data, the author made GWL distribution map in April during 2005-2013 as shown in Fig. 11.

CONCLUSION

As the following results, the influence of the setting Namkam dam to shallow groundwater were estimated.

1. Research area has lack of irrigation water in the dry season, because of high change of water level in the Mekong River.
2. The author observes groundwater level in these periods and observes another factor of groundwater movements.
3. The result of seepage rate calculation in grid a 100 m interval, seepage through ground surface is only flood period until setting the amkam dam, but seepage through ground surface causes every month after setting the Namkam dam. The volume of seepage is almost 25,000m³ per day. This causes the change of groundwater move-ments.
4. From analyzed data when floodgate was operate, shallow groundwater level and the distribution of groundwater at DM6, NK2, NK3, NK8, and NKOW14 was increased to 1.115, 0.15, 1.918, 0.51, and 0.6 metre, respectively.

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