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Extended Abstracts

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title: **Hydrogeological mapping of managed aquifer recharge in the lower Yom River Basin, Thailand**

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ABSTRACT

The study area is located in the Lower Yom River Basin embracing an area of about 970 km^2 in the lower part of northern Thailand. Large volumes of shallow groundwater used for rice production has caused groundwater levels to drastically decline to below the normal threshold for viable pumping (8 meters below the ground surface) in some areas. A detailed understanding of the subsurface processes is necessary to underpin the implementation of supply-side interventions such as Managed Aquifer Recharge. The objective of this paper is to characterize the hydrogeological parameters and groundwater flow systems through detailed field investigations. These investigations include field surveys of the hydrology, land use, geological and hydrogeological information at a scale of 1:50,000. A census of all the existing water wells in the area was conducted. This was supplemented by the construction of 40 new piezometers between March to December, 2009. Detailed hydrogeological investigations such as pumping tests of 150 selected wells were conducted. The investigations reveal the presence of two major aquifer layers; a shallow aquifer (5 to 20 m deep) consisting of sand, silt and clay of the Yom floodplain deposits and the deeper aquifer (15 to 60 m deep) consisting of gravel, sand, silt, and clay of an alluvial fan deposits of the Ping-Yom River Basin. The shallow and deeper aquifers are separated by a thin clay layer with an average thickness of one to five meters. Most of the farmer wells (2,400 wells) in the study area pump water from the shallow aquifer with a total annual abstraction of approximately 1,170 million m^3. The transmissivity values of the upper aquifer range from 300-7,000 m^2/day and the thickness varies from five to ten meters. The regional groundwater flows from the west to east, whereas the local flow systems actively flows from north to south and in some areas from south to north. Several geological and hydrogeological parameters were determined from the new hydrogeological map such as the thickness of the top clay layer, the thickness of the aquifer, hydrochemistry, recharge areas, etc. These parameters are important for locating the most prospective zones for establishing managed aquifer recharge schemes. Moreover, based on these findings, detailed water balance as well as surface water and groundwater interaction mechanisms are being simulated through the use of numerical modeling.

INTRODUCTION

In the Lower Northern Region of Thailand, groundwater-based irrigation of rice paddy is a dominant land use for the largely agrarian economy in the region. In the Phitsanuloke area alone, over one million rai of rice is grown, often year-round. As a result of the rapid groundwater development that has occurred in recent decades, groundwater levels have fallen dramatically, and put into question the long-term sustainability of current levels of rice production. The region would benefit greatly from detailed studies of the physical resource as well as the demonstration of technically and economically viable methods to restore the groundwater balance. One such area has been selected for these sorts of investigations.

The study area is located in the Lower Yom River Basin with the topographic elevations vary from 54 to 34 m above mean sea level. The area covers an area of about 970 km^2 in the lower part of the northern Thailand. Large amounts of shallow groundwater usage for rice growing has caused groundwater levels to decline below the normal threshold for viable pumping (8 m below the ground surface, DGR, 2009) in some areas. The objective of this paper is to characterize the hydrogeological parameters and groundwater flow systems by detailed field investiga-

tions. The Lower Yom River Basin consists of 13 subwatersheds and has a tropical monsoon climate with an annual average temperature about 28°C and annual rainfall of about 1,083 mm. The Yom River is the main river which flows from north to the south. The stream flows at Bang Rakham, (Y16) and Sam Ngam (Y.17) districts ranges from 3-550 m^3/s and 5–400 m^3/s, respectively (Figure 1).

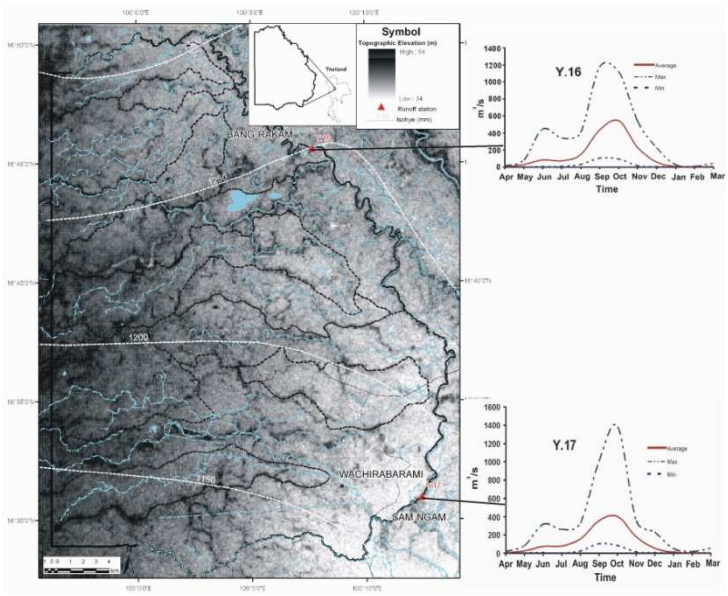

Figure 1. Subwatersheds, isohyets and hydrograph in the study area.

The turbidity of surface water in this area ranges from 40–190 NTU. Paddy field occupies more than 70% of the area. The Lower Yom River Basin is underlain by alluvial fan, floodplain deposits, and channel and natural levee deposits. Alluvial fan deposits are comprised of gravel, sand, and clay. Floodplain deposits consist mainly of clay. Channel and Natural levee deposits are comprised of sand and clay.

METHODOLOGY

The procedure employed commenced with compiling all related information from the existing Quaternary geological map of the Department of Mineral Resources (DMR, 2009) and geological map of the scales of 1: 250,000 (DMR, 1967) and groundwater maps (DMR, 1987 and 1996). Field investigations included water well census and drilling of 120 wells with the depths ranging from 20 to 100 m, landuse mapping, geomorphological mapping, pumping tests of the farmer shallow wells of about 100 wells and database formulation and interpretation by applying ArcGIS 9.3. Groundwater level measurements and groundwater sampling from 80 selected existing water wells were conducted during March to December 2009. Hydrochemistry of groundwater and regional groundwater flow patterns were interpreted and delineated.

RESULTS

The Lower Northern Region Basin is underlain by thick sequences of unconsolidated sediments in the central part and igneous and sedimentary rocks in the north and northeastern areas (DMR, 1983, Figure 2).

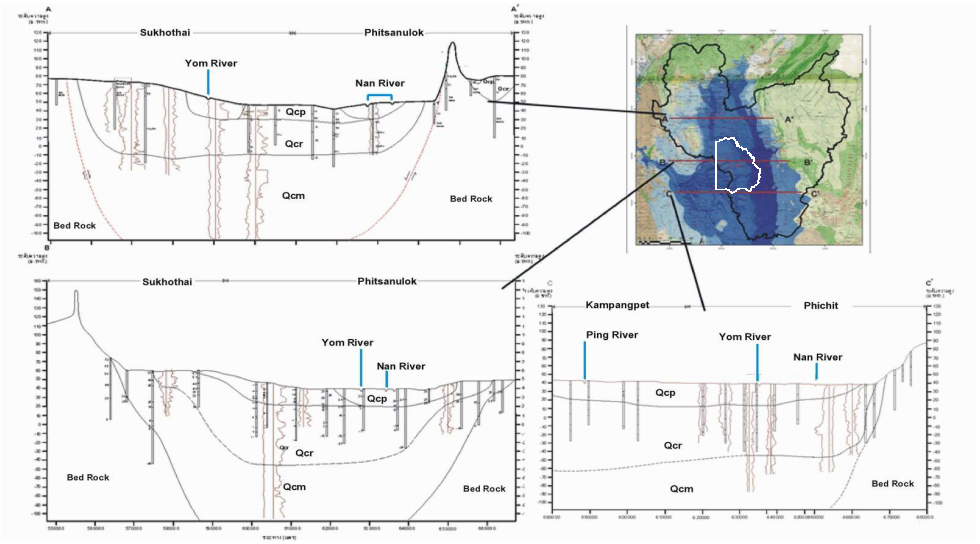

Figure 2. Hydrogeological map of the Lower Northern Region Basin.

The unconsolidated sequence consists of (1) Recent flood plain deposits (Qfd) or Chao Phraya Aquifer (Qcp); consisting of sand and gravel interbeded with clay; with an average thickness of about 30-35 m and well yields ranging from 15-25 m^3/hr. (2) Low terrace deposits (Qlt) or Chiang Rai Aquifer (Qcr) consisting of clay, silt, interbeded with sand and gravel (10-60 m thick) and well yields ranging from 15-20 m^3/hr., (3) High terrace deposits (Qht) or Chiang Mai Aquifer (Qcm) consisting of gravel, sand, and rock fragment with well yields ranging from 30-50 m^3/hr. The consolidated rocks are mainly limestone; interbeded with shale and sandstone with well yields ranging from 2-5 m^3/hr and metamorphic and Igneous rocks with well yields ranging from 1-5 m^3/hr.

The Lower Yom River Basin is underlain by thick sequences of unconsolidated sediments deposited in the block-faulted basin. The objective of this study is to identify the most suitable zones for managed aquifer recharge by using ponding methods of recharge, and therefore, the shallow sequences of unconsolidated sediments are the target areas for mapping. The shallow aquifers consist of an Alluvial fan deposit unit (Qfa), Flood plain deposit unit (Qff), and Channel and Natural levee deposit unit (Qfc) (Fig. 3). The Alluvial fan deposit unit consists of medium-coarse sand interbedded with gravel and clay layers with the thickness ranging from 5 to 60 meters. The Flood plain deposit unit consists of clay and silt with the varying thickness of 2 to 7 meters spreading throughout the study area. The Channel and Natural levee deposit unit consists of very fine-medium sand, fine sand and silt with the varying thickness of 2-5 m. The major aquifer is the Alluvial fan deposit unit that has relatively high transmissivity of 300-7,000 m^2/day.

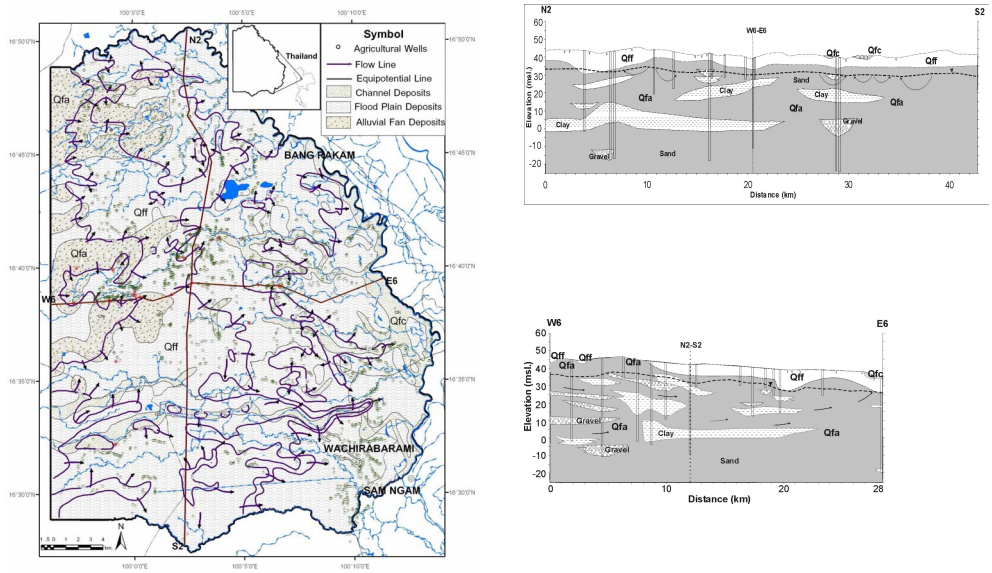

Figure 3. Hydrogeological map and hydrogeological cross sections.

Census data revealed that most of the farmer wells (2,400 wells as shown in Figure 4) in the study area are being pumped from the shallow aquifer with a total annual abstraction of approximately 1,170 million m^3. The highest densities of farmer wells (up to 10 wells/km^2) are located in central part of the study area.

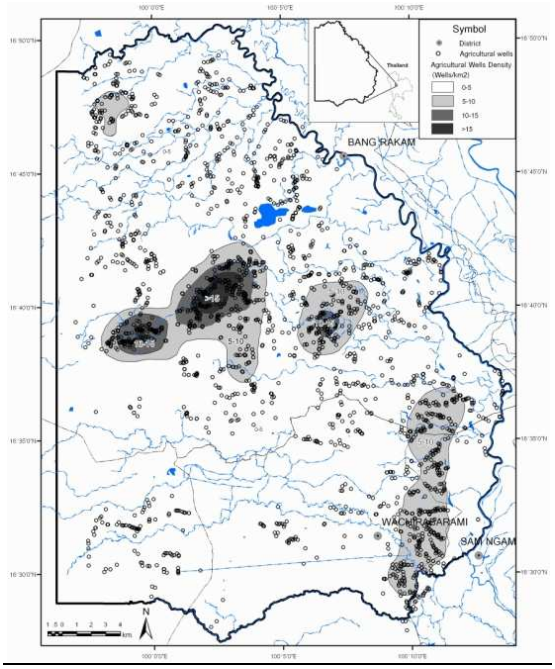

Figure 4. Water well density drilled by the farmers.

The groundwater level survey conducted in May 2009 showed the water level varies from 7-10 meters below the ground surface. Regional groundwater is mainly flows from the west to the east. The local shallow groundwater (6-20 m deep) flows in various directions. The minor steams flow is from west to east and discharge to the Yom River in the eastern region. The main local groundwater flows to the existing streams, such as Huai Lan Ba. The local recharge areas are located in relatively higher topography, especially in the west and south to north portion of the area. Figure 5 shows the thickness of the clay layer overlying the first layer of sand and gravel aquifer. The thin clay layer is identified in the west and locally in the central region. There are several sand pits and gravel excavations located in the central west. Sixty water samples collected from farmer wells were collected in June 2009. The averaged Total Dissolved Solids (TDS) content is relatively low (300 to 500 mg/l). Hydrochemical facies are classified based on Piper's Diagram as shown in Figure 6. There are 12 water types, namely, Ca-Na-HCO_3, Ca-Na-HCO_3-SO_4, Na-Ca-HCO_3, Na-Ca-HCO_3-Cl, Na-Ca-HCO_3-SO_4, Na-HCO_3, Na-HCO_3-SO_4, Na-HCO_3-SO_4-Cl, Na-Mg-Ca-HCO_3, Na-Mg-HCO_3-SO_4, Na-Mg-SO_4-Cl, Na-SO_4-HCO_3 type. Water of Ca-Na-HCO_3-SO_4 water type is one of the dominant type and found in the west and east regions. Water type Ca-Na-HCO_3 is locally found in the western recharge areas. Whereas Na-HCO_3 water type is mainly found in the central area.

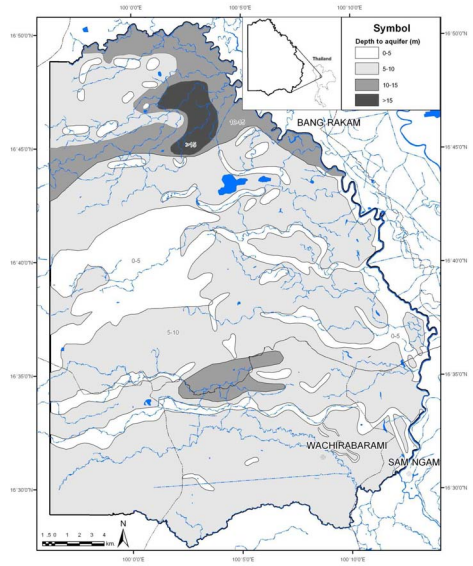

Figure 5. Depth to aquifer map.

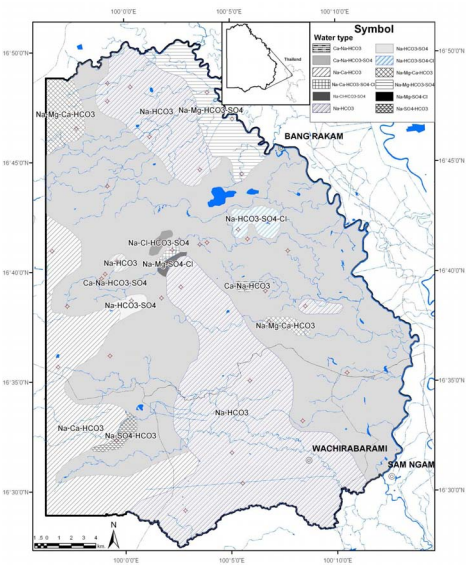

Figure 6. Hydrochemical facies map.

CONCLUSIONS AND RECOMMENDATIONS

The main shallow aquifer in the Lower Yom River Basin is the alluvial fan deposit. The data for the managed aquifer recharge (MAR) using ponding system is being complied and analyzed by several techniques. The data on regional water balance of the area will be analyzed by numerical modeling. In addition, several types of MAR techniques such as trenching, aquifer storage recovery (ASR), roof recharge, check dam recharge and others are being classified in accordance with the suitable potential areas.

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REFERENCES

Department of Groundwater Resources (DGR), 2009: Pilot Study and Experiment on Managed Aquifer Recharge Using Ponding System in the Lower North Region River Basin, Pitsanulok, Sukhothai, and Pichit Provinces. Progress Report No. II, Groundwater Research Center, Khon Kaen University, Thailand.

Department of Mineral Resources (DMR), 1976: Geologic Map of Thailand, scale 1:250,000. Bangkok, Thailand.

Department of Mineral Resources (DMR), 1987: Hydrogeologic Map of Thailand, scale 1:100,000. Bangkok, Thailand.

Department of Mineral Resources (DMR), 1996: Groundwater Map of Sukhotahi, Pichit and Pitsanulok Provinces. Bangkok, Thailand.

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