Runoffs and Phreatic Surfaces Behaviours over Large Floodplain and Lowland Paddy Field

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Abstract

Research of the exchange between surface and subsurface flows over large floodplain and lowland paddy field within recharge zone was carried out. A case study in the Yom River, Phichit Province, Thailand was selected to this research during 2001-2004. Field measurements of infiltration, flood depths and phreatic surface changes were observed during such period. The water budget modeling and regression analysis were applied for fitting those comparative parameters. The results showed that the relationships between the daily water tables and inundated depth were fitted with R^2 approx. 0.90. Those comparisons of the rising limb and recession limb hydrographs within the large flood year in 2002 and less flood year in 2003 were presented. Baseflows were investigated according to time series of river flow and yielded R^2 greater than 0.90.

Keywords: Surface-subsurface flow interaction, infiltration, phreatic surfaces, floodplain.

1. Introduction

In general the behaviors of surface flow and subsurface flow over the catchment's area are interacted particularly in floodplain of large river. The hydrologic phenomenon and parameters influencing phreactic surface should be investigated. Infiltration from surface may change the soil water storage and become the interflow and groundwater as baseflow of the stream. This paper described the effect of surface and subsurface interaction in large floodplain paddy field.

2. Materials and Methods

Study Area

The catchment's area of the Yom River in Phichit Province, Thailand about 1,698 sq. km. was chosen to study surface runoff. Its basin covered by RID's gauging stations namely Y17 (Samngam) at upstream and Y5 (Phothale) at downstream with a stream length of 71.88 km. (**Fig. 1**). It comprised of 7 sub-catchments connecting the river with the average slope of 0.000337. The core area of some 153.05 sq. km for studying runoff and phreactic exchanged was located in Phopratabchang District in Phichit Province. About 60 % of this area is normally affected by flood from the Yom River.

The core of study area is very flat slope of 0.000138 and average ground surface level of +32.889 m(MSL). There are 3-local streams via this area namely Phairob, Nongkla, and Dongsualuang, respectively with average slope of 0.000286 (**Fig. 2**). Most of land-use classifies by high-yield-variety (HYV) rice of 86% of total area that growing into 2 times a year with depend on the amount of remaining water from the sources and inundated seasons. Its geomorphology conforms by shallow clay or silt layer at ground surface. Unconfined aquifer is the second priority source of water from farmer in order to survive the plants during lack of surface water which lays at the upper layer with average porosity of 0.26 (Mekpruksawong, 2004). There are 22-observation wells ranged 15-30 m in depth in order to study the phreatic surface behaviors (**Fig. 3**). The 15-observation wells namely P3, P7, P8, P9, P10, P11, P12, P13, P14, P15, P20, P21, P22, P23, and P24, respectively were situated on floodplain with the area of 50.41 sq.km.

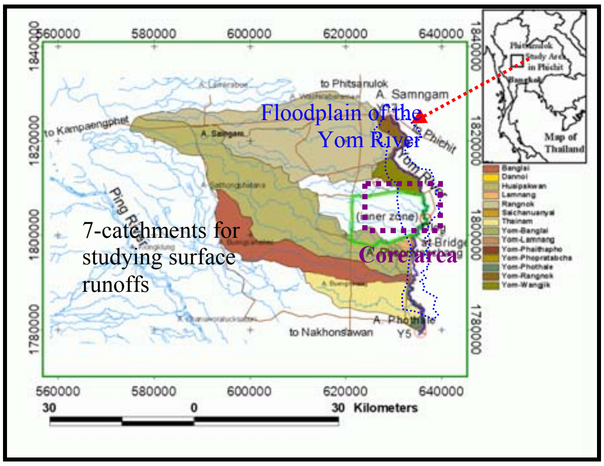

Fig. 1: Map of study area of the Yom River.

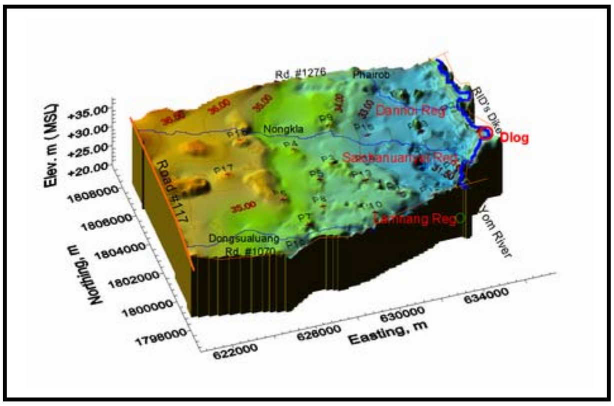

Fig. 2: The enlarger of core area (inner zone) used for studying runoff and phreatic surfaces behaviors by existing 22-observation wells.

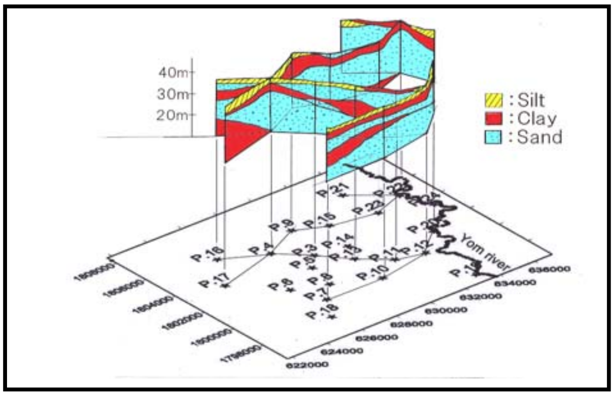

Fig. 3: Hydrogeological profiles and location of 22-observation wells in the core study area (after Mekpruksawong, 2004)

Modeling and Parameters

The water budget model was applied for studying the water balance in the cases of non-flooded and flooded over the year round (**Fig. 4**). Rainfall (*P*) accounting over the river basin is assumed to be disposed of as follows: surface runoff: inflow (Q_{in}) at upstream and outflow (Q_{out}) at downstream, evapotranspiration (*ET*), and groundwater accretion as the following equation.

$$I = (P-ET)+(Q_{in}-Q_{out}) - \Delta S \quad (1)$$

Whereas *Q* can be calculated using existing water level with flow through bounded structures: Q_{in} = volume of upstream runoff included over-bank flow from the river, Q_{out} = volume of surface flow out the downstream, I = infiltration varied by *t* (measured from the field experiment), and ΔS = change of water storages over floodplain estimated by generated contour map. *ET* (based on FAO's pan or Penman-Monteith method) can be evaporation (*E*) during flooded otherwise ET_{crop}. $I(t)$ by rainwater or floodwater above ground and ET_{crop} will be recharged and withdrawn to and from aquifer which leads to the change of phreatic surface.

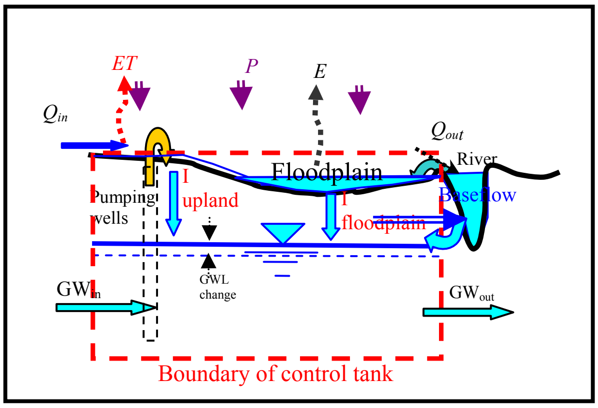

Fig. 4: Conception model as water budget for surface and subsurface interactions was applied.

The infiltration (*I*) was replaced by seepage coefficient ($a_c = K/H$) [mm/d/m] as the rate of infiltrated per head of ponded water above ground in case of soil surface is saturated (Mekpruksawong, 2004).

3. Results and Discussion

The result of field infiltration was averaged 1.355 mm/d (1.568x10^{-6} cm/s) with a_c of 16.245 mm/d/m and distributed over the study area presented in **Fig. 5**.

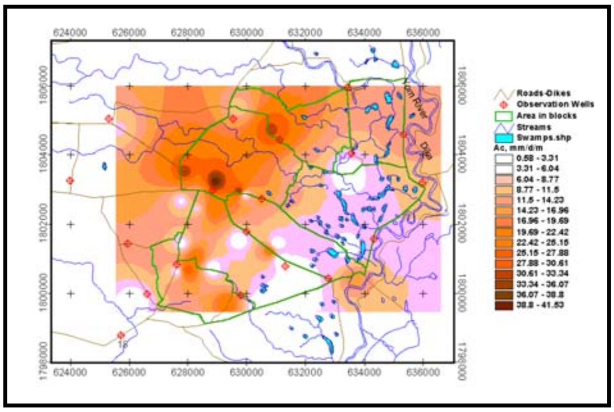

Fig. 5: The distributed infiltration flux (a_c) on floodplain.

The result of daily *P*, ET_o, Q_{in}, runoff and annual *P*, and ET_o over floodplain in the inner zone in 2000-2003 were presented in **Fig. 6** and **Fig. 7**. The phreatic surfaces versus river stages were shown in **Fig. 8** and **Fig. 9**.

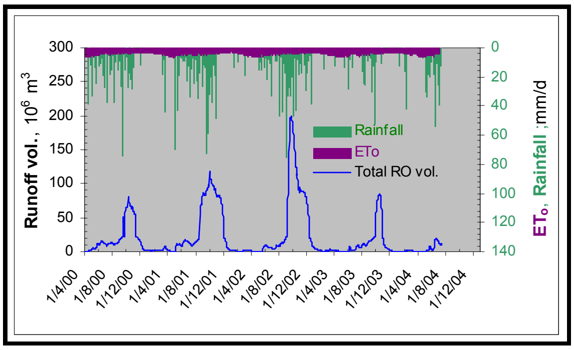

Fig. 6: Daily *P*, *ET*, total runoff volume on floodplain and river channel in 2000-2003.

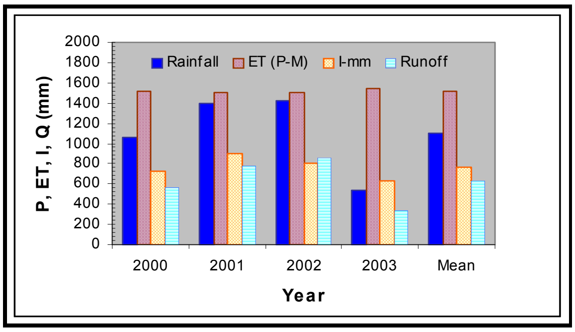

Fig. 7: Annual *P*, *ET*, *I*, Q_{in} in year 2000-2003

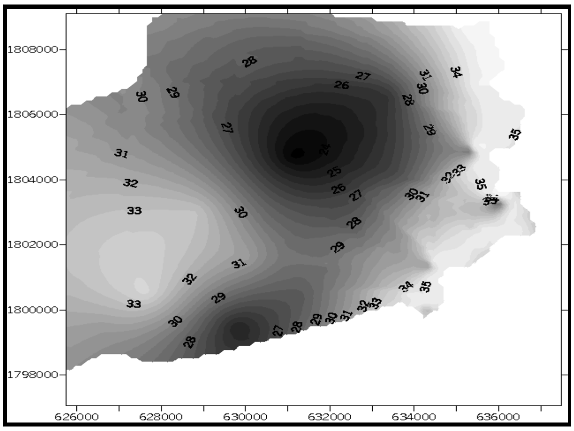

Fig. 8: Distribution of phreatic surfaces vs maximum flood level of +35.00 MSL an example on 24/09/2002.

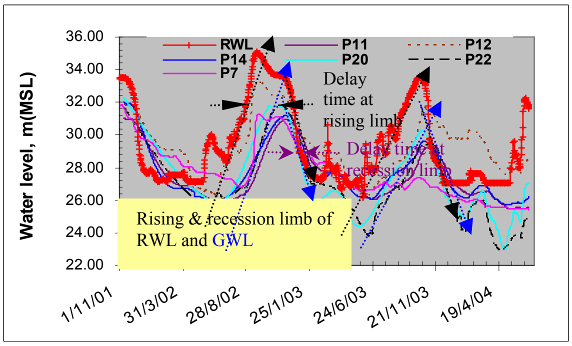

Fig. 9: Comparison daily river stage (RWL) vs phreatic surface (GWL) at each observation well in floodplain.

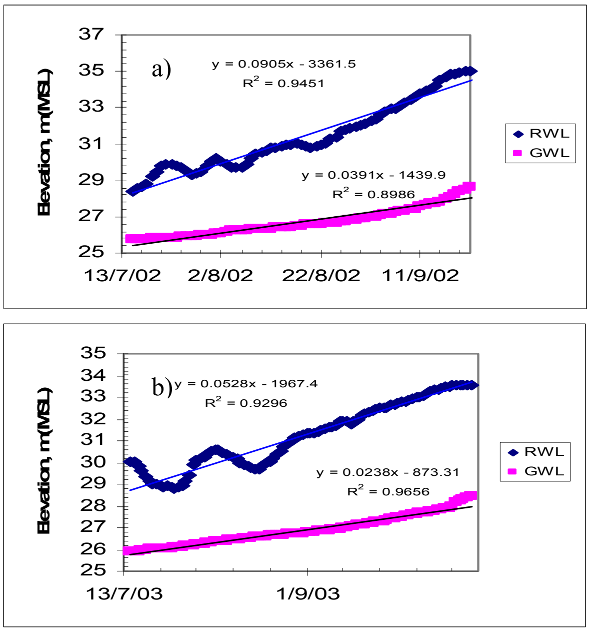

Fig. 10: Trend lines of river stages (RWL) and phreatic surfaces (GWL) in a) 2002 and b) 2003.

From the relationship of daily stages (RWL) versus phreatic surfaces (GWL) in **Fig. 9** and **Fig. 10**, the lag-time between rising and recession limbs of those RWL and GWL hydrographs in 2002 and 2003 were 75 days and 105 days during rising limb, and 10 days and 6 days during recession limb, respectively. The trend lines during rising and recession limbs were fitted with R^2=0.90. The difference on slope of trend lines and time delayed during rising and falling limbs were shown because of flood volume and ponded time in 2002 was more and longer than 2003. The recession constant (K_{rb}) for baseflow separation into groundwater flow (K_{rg}) and interflow (K_{ri}) in 2000-2003 were fitted average of 0.783 and 0.936, respectively and R^2=0.9672. The amount of annual baseflow per total runoff via the measuring point is average 10.7%. However, during dry season from mid of January to May, there is zero baseflow in the river has been obviously seen. Because of there is some withdrawal water from users by using small pumping machines along the river. The trend of baseflow is going downward from that reason and also causes by over groundwater withdrawal from farmer during drought period.

4. Conclusion and recommendation

There are many parameters effect the change of phreatic surface in floodplain hydrologic basin that should be paid more attention in the field observation and modeling by using water budget or water balance technique. The result of the streamflow and phreatic surface hydrograph can be used for further monitoring and forecasting the effect of the change of groundwater withdrawal.

References

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