*Malaysian Journal of Civil Engineering 30(3):442-456 (2018)*

# ASSESSING THE EFFECTS OF LAND USE CONVERSION ON RUNOFF AND NUTRIENT LOAD

Khairul Anuar Mohamad[1], Noorbaharim Hashim[1], Ilya Khairanis Othman[1*] & Mohd Syazwan Faisal Mohd[2]

[1] *Department of Hydraulics and Hydrology, Faculty of Civil Engineering, Universiti Teknologi Malaysia, Skudai, Johor, Malaysia*
[2] *Research Centre for Water Resources and Climate Change, National Hydraulic Research Institute of Malaysia, Seri Kembangan, Selangor, Malaysia.*

*Corresponding Author: *ilya@utm.my*

**Abstract:** An agricultural land with intensive cultivation, large catchments with extended rivers and agricultural population of high-density are the primary reasons for higher pollutant loads in freshwater. However, there are problems in pursuing nutrient losses since several parameters, such as variability in soils and climate are associated with heavy rainfall, especially in tropic regions; plant management, limited resources, and insufficient technical support are not consistent in every crop management. Changes in agricultural practices and unmonitored point sources discharge from watershed, have led to algal bloom in abundance, and thus generated eutrophication at the downstream. The complex watershed processes and forecasting the effects of land use change on water quality can be determined by using tools of watershed models. The Hydrological Simulation Programme-FORTRAN (HSPF) uses lumped parameters, continuous model to predict the long-term evaluation, and deterministic for simulating the water quality and quantity process that occur at the watershed. Pervious land segments (PERLND), impervious land segments (IMPLND), and channel reach (RCHRES) modules were used to determine the general water quality and quantity on Johor watershed. Based on calibration and validation, the HSPF model was capable of simulating different runoff seasons. An increment of 60% in agricultural land had increased the annual mean total phosphorus (TP) load and total nitrogen (TN) load by 3.82% and 5.34%, respectively. A 2-fold increase in agricultural land would result in an approximately 2-fold increase in the quantity of annual TN and TP loads. Between TN and TP loads, TP load has potentially increased more than TN load during the dry, wet, and base-flow years. Upon the long-term of water quality and quantity simulation, this study provides essential knowledge for a method-based runoff and nutrient management plan for the Johor watershed.

**Keyword:** *Nutrient, agricultural land, total nitrogen (TN), total phosphorus (TP), HSPF.*

*Article history:*
*Received 27 July 2017*
*Received in revised form 29 August 2018*
*Accepted 1 October 2018*
*Published online 1 Dec 2018*

## 1.0 Introduction

Complex watershed processes and to forecast the effects of land use change or climate change on water quality and quantity can be determined by tools of watershed models (Amirreza, 2017; Nguyen & Gunter, 2015). The watershed models simulate all hydrologic activities, such as runoff, sediment, and water quality components in a comprehensive way which involves a combination of processes at a big field scale by including watershed area laterally to a river (Oogathoo, 2006; Yin *et al.*, 2016). The watershed models include various modules to investigate the decision-making factors in land use management in recent and future situations. The use of watershed models as an important scientific research and management tool is beneficial to understand and control water contamination (Melone *et al.*, 2005; Box and Jenkins, 1970; WMO, 1994; Yurekli, 2005; Chibanga *et al.*, 2001). One of the watershed models is the Hydrological Simulation Programme-FORTRAN (HSPF). This model uses lumped parameters, continuous model to predict the long-term evaluation, and deterministic for simulating the water quality and quantity process that occur at river basins and in a river system (Nathan, 2005). As compared to the Soil Water Assessment Tool (SWAT), HSPF integrates result from the amount of runoffs and water quality pollutants from the upstream to downstream land, albeit in smaller scales (Hui *et al.*, 2015). For a time-based simulation, HSPF can simulate from a few minutes to more than a hundred years. Normally, HSPF model runs for a time range of five to twenty years by using hourly time series (Duda *et al.*, 2012). In the Upper North Bosque River study, HSPF was capable to model urban land impacts of various point and nonpoint pollutions to predict the daily phosphate (Saleh and Du, 2004; Borah *et al.*,2004). It is also efficient to predict the sediment yield since it has a strong in-stream component for sediment routing (Syed *et al.*, 2014).

Since oil palm plantation counts for major land use in Johor watershed, Ng *et al.* (2013) discussed the contribution of pollution along the Johor straits due to agricultural land. They found that the contribution of pollutants from the eastern part (Johor river estuary) was larger than the west. Due of this concern, many researchers have conducted environmental and hydrological studies on the river. Their studies consisted the application of Artificial Neural Network (ANN) to capture the total dissolved solids, electrical conductivity and turbidity (Najah *et al.*, 2009), examination of land use impacts and climate variability on hydrological components and the application of CMIP5 General Circulation Model ensemble (Mou *et al.*, 2014a; Mou *et al.*, 2014b) as well as investigating the geochemistry of plumbum isotope exchange at river mouth (Chen *et al.*, 2016). Among these studies, none has attempted to conduct the effect of land use conversion on water quality, especially from forestland to cropland (oil palm plantations). Accordingly, this study was carried out to develop a watershed model to seek the HSPF model performance in simulating a long-term runoff simulation at different stations (Bukit Besar and Jambatan Johor Tenggara) and investigate the impact of forestland conversion to agricultural land on nitrogen and phosphate loads in the Johor watershed. This study also establishes an effect on how much of flow will contribute nutrient loads into the river.

## 2.0 Materials and Methods

### *2.1 Study Sites*

Located in the south-east of Peninsular Malaysia, the Johor river basin (JRB) consists of natural forest with lowland swamps and agricultural lands. A Johor watershed, which is located in the southern Johor, was selected as the study watershed for this research due to the availability of the long-term historical data input on stream flow, water quality constituents, and land use. The Johor watershed is selected since it has agriculture land use predominantly represented as oil palm plantations. Johor River is 122.7 km in length and flows from Gunung Belumut at the north of the watershed (Valizadeh *et al.*, 2014). Johor River consists of two major tributaries known as the Linggiu River and Sayong River located on the northern site. The highest point of Johor watershed is 977m, and the lowest part is 3m, located between latitudes (1°30’ to 2°10’ N) and longitudes (103°20’ to 104°10’ E) (Figure 1). The Ultisols series (Rengam-Jerangau) are predominant in this watershed with yellowish-brown sandy clay and medium permeability (Mou *et al.*, 2014b). The Johor watershed has an average of $37.7m^3/s$ on the flow at Rantau Panjang station (1737451) and 2,500 mm for its annual rainfall (Razi *et al.*, 2010).

The distribution of land use and basic physical information of Johor catchment are synopsised in Table 1. Agricultural activities, mainly oil palm plantations, cover around 61% of the watershed. Sub-watershed 5 covers mostly forest and agricultural land. The agricultural land is dominant in Sub-watershed 3 and Sub-watershed 5 (more than 90%), meanwhile forestland is predominant in Sub-watershed 1 and Sub-watershed 2 (more than 50%). The most impervious area (industry and residential) is located in Sub-watershed 1 (6%).

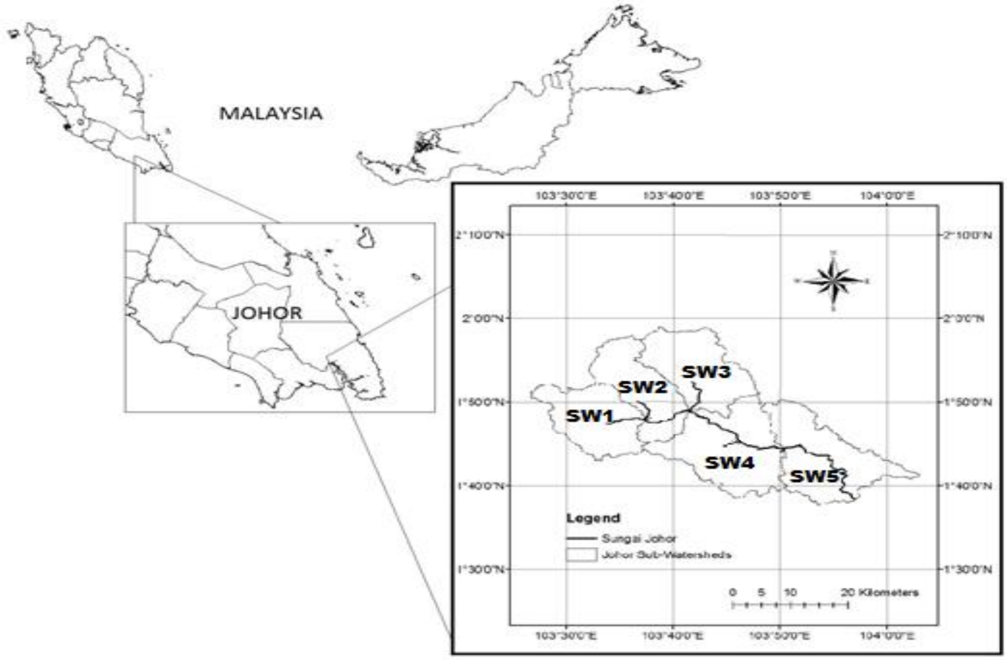



Figure 1: Location of Johor watershed

Table 1: Physical attributes of sub-watersheds and rivers.

| *Parameters* | *Sub-watersheds (SW)* | | | | |
|---|---|---|---|---|---|
| | *SW1 Stream 1* | *SW2 Stream 2* | *SW3 Stream 3* | *SW4 Stream 4* | *SW5 Stream 5* |
| Sub-watershed area (hectare) | 57,564 | 26,573 | 51,480 | 23,216 | 11,205 |
| River length (mile) | 10.7 | 6.57 | 7.77 | 6.13 | 7.61 |
| Water elevation from upstream to downstream (feet) | 79 | 36 | 43 | 36 | 49 |

### 2.2 *Description of Models*

The HSPF model has three element types of modelling all river basins and processes. They are the free-flowing river (RCHRES), pervious land segment (PERLND), and impervious land segment (IMPLND) (Bicknell *et al.*, 2001). All simulations done in HSPF completely used lumped parameters and are partially distributed (numerous sub-catchments which are interlinked). The water budget in pervious land (PWATER) submodule from PERLND, water budget in impervious land (IWATER) sub-module from the IMPLND and hydraulic processes in river channel (HYDR) sub-module in the RCHRES are the core modules to simulate hydrology in the watershed. Components of PWATER involve evapotranspiration, infiltration capacity, surface runoff and interflow processes. Evapotranspiration is simulated separately in five sources, such as crop interception, upper soil and lower soil zone, groundwater zone, and base flow. Infiltration capacity is determined by using soil moisture and areal method over the land segment (Philips, 1957). This study used the outflow depth and detention storage relationship, associating with Chezy-Manning Equation to determine surface runoff (Bicknell *et al.*, 2001). In addition, interflow is represented by a flow process which involved vertical percolation towards soil permeability (Bicknell *et al.*, 2001). IWATER is similar to PWATER but it has no infiltration and sub-surface processes. HYDR uses geometric and hydraulic characteristics that relate to river width and depth (Bicknell *et al.*, 2001). Non-point sources input in this model used atmospheric deposition and fertiliser applications. The point sources comprised of proper discharge attained from Indah Water Konsortium Sdn. Bhd (IWK). The nutrient loadings from non-croplands were simulated by using the PQUAL/IQUAL module, which used a simplified method based on the nutrient accumulation and removal rates over the land segments. The PQUAL sub-routines can be used if adequate data are not obtainable and the study location does not entail full processes of nutrient balances (Bicknell *et al.*, 2001). Nutrients from impervious lands into streams under non-croplands used the IQUAL sub-routines. The RQUAL subroutine was used to simulate the nutrients routing.

Table 2: Definition of PQUAL/IQUAL module in HSPF

| *Parameter* | *Definition* |
|---|---|
| *MON-ACCUM | The accumulation rates of nutrients at the beginning of each month |
| *MON-SQOLIM | The limiting storage of nitrate-N and phosphate at the start of each month |
| *MON-IFLW-CONC | The interflow outflow of concentration of nitrate-N and phosphate at the start of each month |
| *MON-GRND-CONC | The groundwater of concentration of nitrate-N and phosphate at the start of each month |
| POTFW | The orthophosphate wash off potency factor |
| MALGR | The unit algal growth rate for phytoplankton in maximal value |
| PHYSET | The phytoplankton settling rate |

*All values in monthly time step

During the nutrient calibration, there were seven parameters involved. Table 2 describes the seven parameters involved in the adjustment process, which are MON-ACCUM, MON-IFLW-CONC, MON-GRND-CONC, MON-SQOLIM, MALGR, and PHYSET. The agrichemical (AGCHEM) section consists of solute transport in soil (MSTLAY), nitrogen (NITR) and phosphorus (PHOS) processes sub-modules in PERLND. These sub-modules comprehensively simulate nutrient cycle and balances that occur in the agricultural land. AGCHEM also simulates both chemical and biological as well as the association of any non-sensitive tracer in the land use. The AGCHEM section permitted demonstration of a detailed chemical/nutrient stability method for establishing the modelling of soil processes. The MSTLAY module section was simulated first before the next sections run, as it provides the storage and movement of solutes data. The NITR and PHOS module sections simulate the plant and nutrient components in soil.

### *2.3 Model Calibration and Validation*

Calibration was done by selecting the most sensitive parameters for different variables until the simulated outputs matched with the observed measurements. The best values for HSPF parameters calibration process included the overland flow, groundwater, soil moisture specifications, and vegetation cover. The Department of Irrigation and Drainage (DID) and Department of Environment (DOE) at the Bukit Besar Station recorded an hourly stream flow and nutrient concentration. The hydrology and water quality calibration were completed from 1 January, 2000 until 14 October, 2015. The flow calibration was achieved by using an hourly time step while the results of the simulated stream flow and water quality were accessed at a daily time step for evaluation with the DID Bukit Besar station records. The model calibration was completed by using the HSPF calibration procedure that comprised: (1) running the HSPF model with the preliminary set of parameters in the model (values were acquired from GIS record, reference from HSPF articles, or suggested by the HSPF model itself); (2) altering the model parameters within the specified range; (3) simulating and observing data and comparing between the stream flow and water quality; and (4) reiterating Step 2 and Step 3 until the lowest mean relative error and uppermost correlation between the observed and simulated data were attained. The selection of initial parameter values was based on field data, GIS evaluation, soil map surveys, and EPA BASINS Technical Note 6 (USEPA, 2000). Based on the sensitivity analysis, high-sensitivity of model parameters was taken with care since a small variation can cause a large value in the model output. Guidelines on how to calibrate flow are found in BASINS Technical Note 6 (USEPA, 2000). These guides allowed a progressive approach for defining which parameters to fine-tune the flow calibration. Flow calibration was involved in regulating the parameters that regulate water balance, seasonal changes, and storm events. The hydrology and nutrient validation completed on 1 January, 2000 until 12 October, 2015 at the Jambatan Johor Tenggara since there was no addition for model parameter adjustment. The HSPF model statistical performance was determined by using the statistical performances of the coefficient of determination ($R^2$) and Nash-Sutcliffe (NS). The relationships of both statistical performances are presented as:

$$R^2 = \left\{\frac{\sum_{i=1}^{n}(O_i - P_i)^2}{\left[\sum_{i=1}^{n}(O_i - \bar{O})^2\right]^{0.5}\left[\sum_{i=1}^{n}(P_i - \bar{P})^2\right]^{0.5}}\right\}^2 \quad (1)$$

$$NS = 1.0 - \frac{\sum_{i=1}^{n}(O_i - P_i)^2}{\sum_{i=1}^{n}(O_i - \bar{O})^2} \quad (2)$$

where $O_i$ and $P_i$ are the observed and simulated values, $\bar{O}$ and $\bar{P}$ are the average observed and simulated values, and n is the total number of data.

### *2.4 Simulation scenarios*

There were two simulation scenarios presented in this study. The initial scenario (base scenario) examined the total nitrogen (TN) and total phosphorus (TP) loads, without conversion into oil palm plantations (i.e., 0% land use conversion). In this scenario, all simulation requirements and input parameter values were similar as those used for model validation. The second scenario was chosen to assess the influences of land use conversion from forestland to agricultural land (oil palm) upon the total nitrogen and total phosphorus load estimations by converting 30%, 60%, and 90%. The evaluation of the simulation results (i.e., including and not including agricultural land use conversions) allowed us to assess the effects of agricultural land conversion upon the daily, seasonal, and annual total nitrogen and total phosphorus transport in addition to their load estimations. The simulation was for 15 years, starting at the early days of 2000 and ended in 2015, for each scenario.

## 3.0 Results and Discussion

### *3.1 Flow Calibration and Validation*

The comparison of the observed and simulated monthly river flow during calibration is shown in Figure 2. With the $R^2$ value of 0.85 and NS value of 0.82 for daily flow Figure 2(a) as well as the $R^2$ value of 0.88 and NS value of 0.96 for monthly flow Figure 2(b), a decent agreement was found between the model predictions and site observations during the calibration process. The best fit of monthly flow is graphically shown Figure 2(c), presenting that the highest flow from the simulated model was significantly close to those from site observations for most of the simulations. The validated model is shown in Figure 3. This figure compares the river flow between site observations and model simulated over a period from January 1, 2000, to October 12, 2015. This was similar to the case of model calibration and with the value of $R^2$ = 0.85 and NS value at 0.84 for daily discharge Figure 3(a) as well as $R^2$ = 0.87 and NS value at 0.93 for the monthly mean flow Figure 3(b).

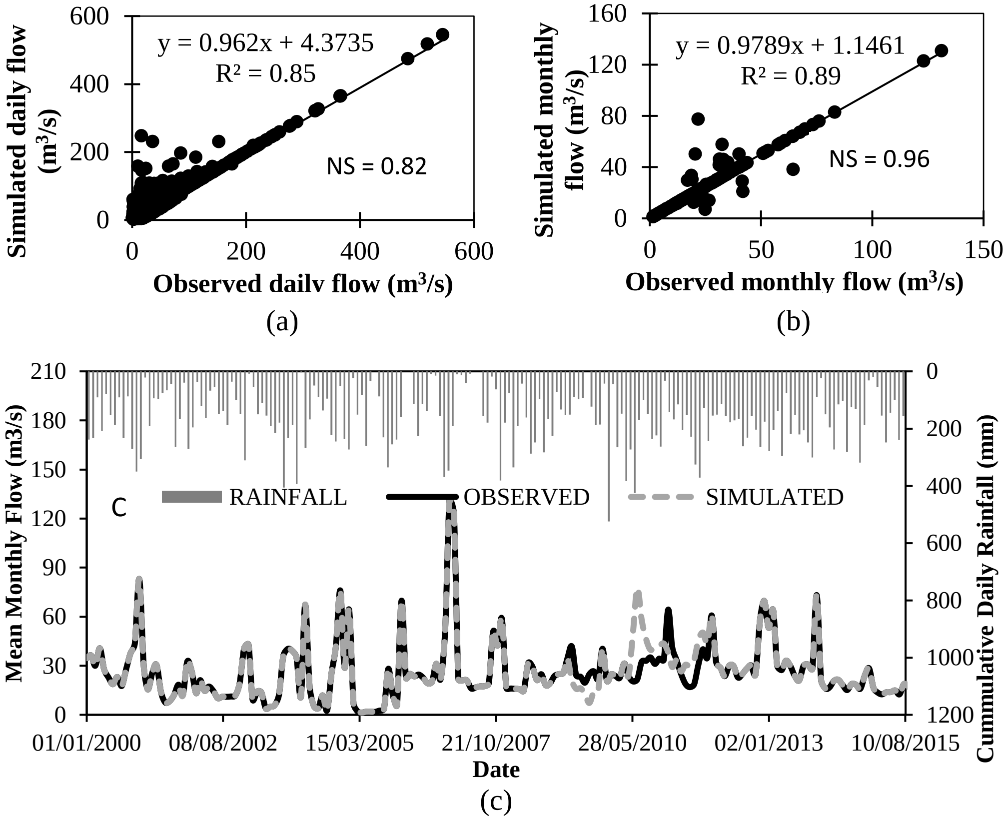
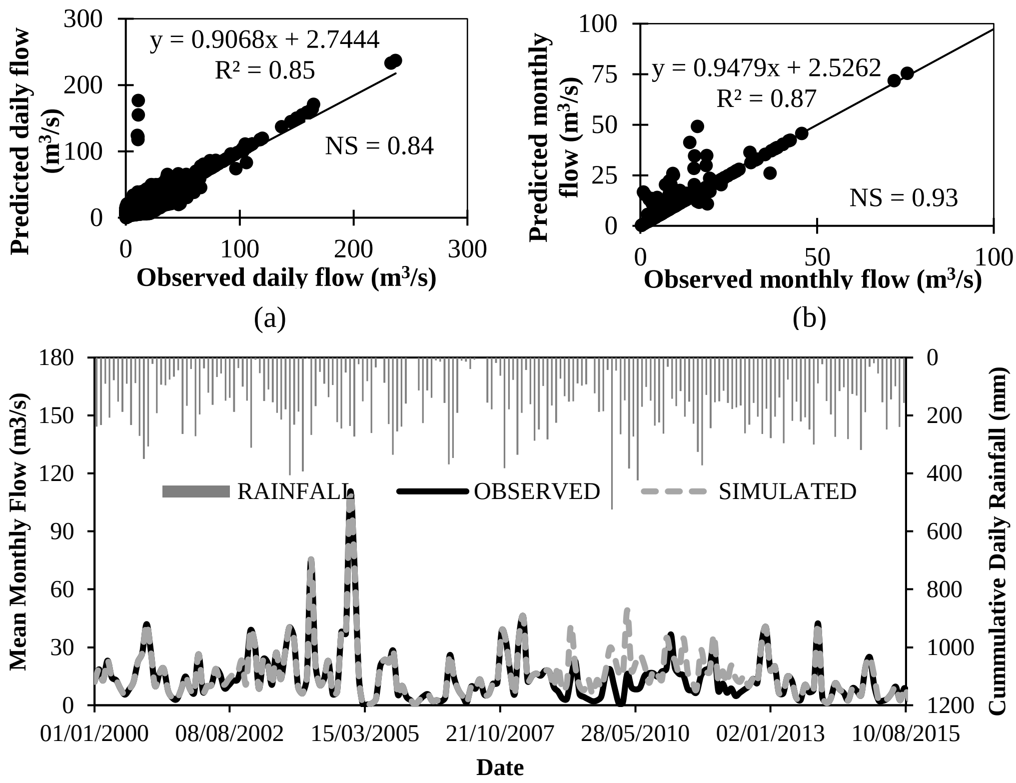



Figure 2: Calibrated and observed mean daily flow (a), calibrated and observed monthly mean flow (b), and visual comparison of simulated and observed daily flow during the calibration phase (c).



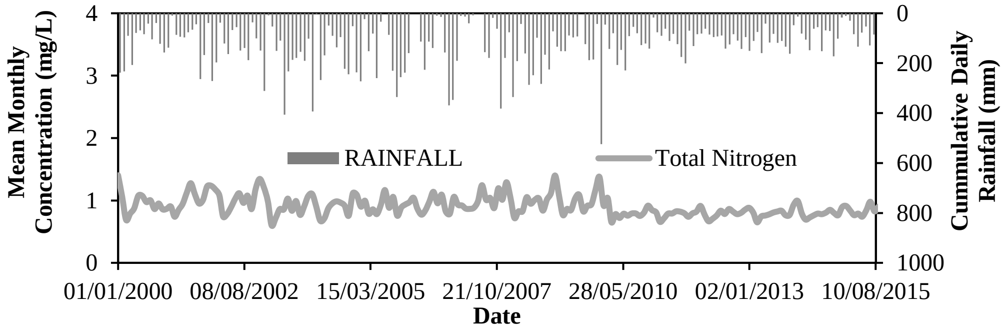

(c)

Figure 3: Validated and observed mean daily flow (a), validated and observed monthly mean flow (b), and visual comparison of simulated and observed daily flow (c) during the validation phase.

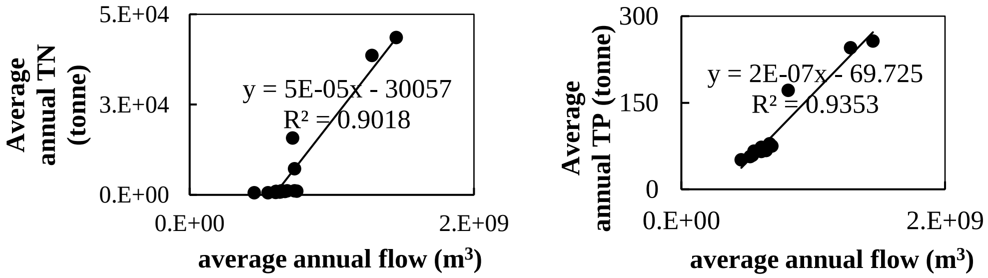
A good correlation was established between the site observation and model prediction during the validation process Figure 3. A graphic comparison of the highest flows between the site observation and model prediction Figure 3(c) indicated that the hydrological model precisely simulated the long-term daily flow and categorised as “good” according to the HSPF model efficacy level. The peak flows were indicated to be almost similar with the observed peaks during the high flood season of 2006 and early 2007. The simulation results with single peaks during mid -March 2005 acted better than multi peaks (from 2009 until 2012) within almost wet years Figure 3(c). The relative errors between the total annual observed and simulated runoffs were 12.2% and 12.7% for the calibration and validation periods, respectively. The error presented that the HSPF model had a lower precision on the long-term watershed hydrological processes and sensitive to the quantity of rainfall.

### *3.2 Nutrient Load without Changes*

Figure 4 shows the rainfall event, TN and TP loads without modifications of forestland, which occurred from 2000 to 2015 (base scenario). The relationship between simulated TN and TP loads and rainfall variations revealed that decreased rainfall rate caused lower TN and TP loads. For example, the minimum rainfall rate was found in early 2010 until the end of simulation, and the decrement of TN and TP loads simulated correspondingly towards that period Figure 4(a) and (b). Based on the whole simulation, watershed characteristics, such as land elevations, soil types, variations of land use cover, the soil moisture content regime, and initial N and P soil condition might play significant functions in the daily differences of TN and TP loads (Ouyang *et al.*,2015). Figure 5 shows the relationships of annual mean flow to TN and TP loads over a simulation period from 2000 to 2015 for the base scenario. This figure illustrates two linear regression equations with good correlations between the flow and both TN and TP loads. The $R^2$ values of TN and TP loads were equal to 0.902 and 0.935, respectively; hence, both equations could be useful to estimate the JRB annual TN and TP loads in the future. Based on both equations, it is shown that the ratio of the mean annual total nitrogen and total phosphorus load to the average annual flow was 6.0 x $10^8$ $m^3$ and 3.5 x $10^8$ $m^3$, respectively. In other words, each of the 6.0 x $10^8$ $m^3$ and 3.5 x $10^8$ $m^3$ of flow could separately flush out one tonne of total nitrogen and total phosphorus from the watershed outlet.




(a)




(a) (b)

Figure 5: Relationships of total nitrogen (a) and total phosphorus (b) loads to flow from the base simulation scenario.

### 3.3 Nutrient Load with Agricultural Land Use Changes

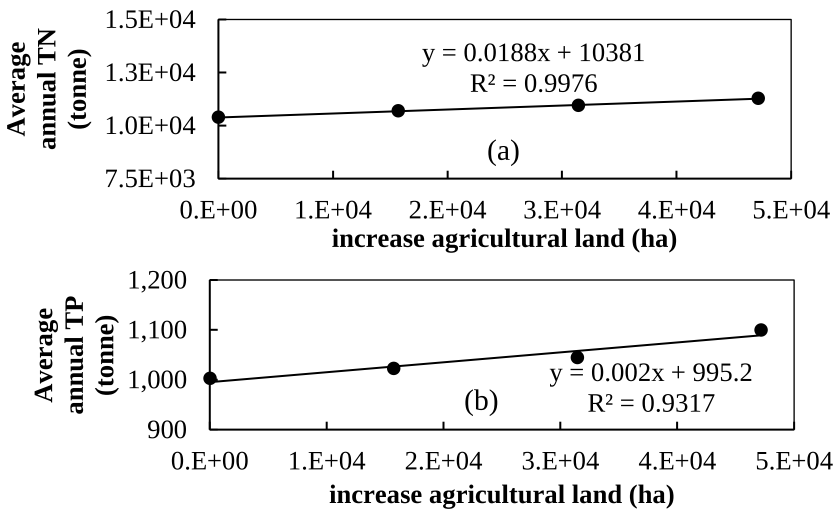
The annual loads of total nitrogen based on three different levels of land use change (i.e., 0%, 30%, 60%, and 90% changes of forests into agricultural lands) and association with percentage variations of the increment of both loads are shown in Table 3. Overall, a conversion of forests into agricultural lands increased the annual load of total nitrogen. For instance, a 60% reduction of forests increased the total nitrogen load by 5.34% throughout the year (Table 3) while a 90% reduction of forests increased the total nitrogen load by 8.65%. Based on these results, the almost 2-fold upsurge in the agricultural land would result in a roughly 2-fold increase in the quantity of annual total nitrogen load, which apparently comes from the application of fertilisers during the planting period. The relationship between the mean annual total nitrogen load and agricultural land increment for the Johor watershed is shown in Figure 6(a). With an $R^2$ = 0.998, it can be concluded that good linear regression is present between the annual total nitrogen load and agricultural land increment. However, in this study, an increase in agricultural area increased the mean annual flow volume. This study shown that land use change has significantly altered flow volume. Ouyang *et al.* (2013) supported this result in their work which studied the vice-versa area at the Lower Yazoo River Watershed, in Mississippi.

The annual total phosphorus load increment from the Johor watershed outlet between three different rates of land use conversion (i.e., 0%, 30%, 60%, and 90% changes of forests into agricultural lands) is shown in Table 3. An increase in agricultural land, relating to the decrease of forests, increased the annual total phosphorus load. For example, a 30% reduction of forests increased the total phosphorus load, which arose because of the intensified surface runoff and soil loss, and thus increasing the total phosphorus load in the rivers. Parallel to the event of mean annual total nitrogen load increment, the mean annual total phosphorus load also gave similar results. A 30% increment in agricultural land increased the annual mean total of phosphorus load by 1.63%, whereas a 60% increment in agricultural land increased the annual mean total phosphorus load by 3.82%. Based on these results, the almost 2-fold upsurge in the agricultural land would result in a roughly 2-fold increase in the quantity of annual total phosphorus load, which apparently comes from the application of fertilisers during the planting period. Figure 5(b) illustrates the relationship between the annual mean flow volume and the annual mean total phosphorus load. With an $R^2$ = 0.935, the best linear regression was inferred to exist between the annual mean flow volume and annual mean total phosphorus load. The relationship between the annual mean total phosphorus load and the forestland conversion for Johor watershed is given in Figure 6(b). With an $R^2$ = 0.932, the agricultural land increment may affect the higher concentration of total phosphorus load based on linear correlation between them. Similar to the total nitrogen load, the percentage of total phosphorus load increased significantly with the agricultural land if no conditions were altered, except for the conversion of forests into agricultural lands.

These findings concluded that fertilisation via agricultural land changes increased TN and TP loads into rivers. Yin *et al.* (2016), who determined the quantity of nutrient at the Hong-Ru River Basin by using different hydrological model, supported this view. They pointed out that more nutrient loads were caused by fertilisers during planting seasons in the lowland area. In another major study, Nguyen *et al.* (2015) investigated that the combination of flow condition via extreme flood event with the fertilisation scheme had increased total nitrogen and phosphorus concentrations in the river.

Table 3 Comparison of total nitrogen and total phosphorus load increases among four percentages of land use changes from forestland into agricultural land

| *Time* | *0% conversion from forestland into agricultural land* | | *30% conversion of forestland into agricultural land* | | *60% conversion of forestland into agricultural land* | | *90% conversion of forestland into agricultural land* | |
|---|---|---|---|---|---|---|---|---|
| Total Nitrogen Load | | (TN) | | | | | | |
| | Load (Ton) | Change (%) | Load (Ton) | Change (%) | Load (Ton) | Change (%) | Load (Ton) | Change (%) |
| Annual | 10383.9 | 0.00 | 10685.4 | 2.81 | 10944.8 | 5.34 | 11281.9 | 8.65 |
| Total Phosphorus Load (TP) | | | | | | | | |
| | Load (Ton) | Change (%) | Load (Ton) | Change (%) | Load (Ton) | Change (%) | Load (Ton) | Change (%) |
| Annual | 1002.38 | 0.00 | 1022.47 | 1.63 | 1044.20 | 3.82 | 1099.37 | 9.61 |
| Total Runoff | | | | | | | | |
| | Runoff ($m^3$) | Change (%) | Runoff ($m^3$) | Change (%) | Runoff ($m^3$) | Change (%) | Runoff ($m^3$) | Change (%) |
| Annual | 6.78E+09 | 0.00 | 7.79E+09 | 14.82 | 8.80E+09 | 29.69 | 9.81E+09 | -31.50 |



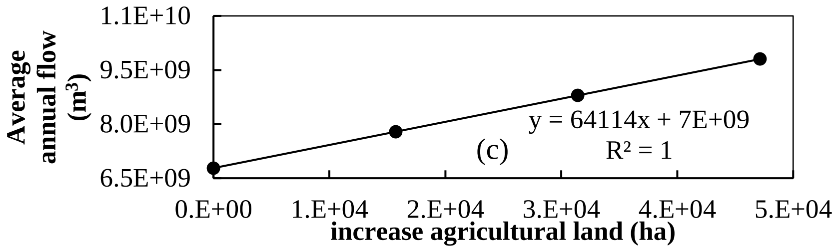



Figure 6: Relationships of annual mean total nitrogen (A), total phosphorus (B) and flow (C) with agricultural land increment.

## 4.0 Conclusions

The results of this study indicated that the calibrated HSPF model produced significant hydrological and water quality processes in this type of agricultural watershed in the tropical area of Malaysia. The results presented that the HSPF model was useful to simulate the average monthly and daily flows due to the good correlation and agreement ($R^2$ = 0.85 and NS = 0.82 for average daily simulation, and $R^2$ = 0.88 and NS = 0.96 for average monthly simulation) during the calibration phase (2000-2015). By using similar model parameters, there was a significant positive correlation between the validated and observed values ($R^2$ = 0.85 and NS = 0.84 for average daily simulation and $R^2$ = 0.87 and NS = 0.93 for average monthly simulation); thus, it can be suggested that all calibrated parameters had a definite representation in Johor watershed. The simulations presented that a conversion of forestland into agricultural land greatly increased TN and TP loads due to fertilisation; reducing surface runoff and permitting soil erosions. A 2-fold increase in the agricultural land would result in an approximately 2-fold increase in the quantity of annual TN and TP loads. Under the hypothesis that other conditions continued the same, except for agricultural land use conversion, the percentage decrease in forestland was relative to the percentage increase in total quantity of TN and TP loads throughout the Johor watershed outlets. The model will be expanded by considering the climate change issues, especially on rainfall depth and air temperature.

## 5.0 Acknowledgements

This study was supported by the Malaysian Department of Irrigation and Drainage (DID), the Department of Environment (DOE), and Indah Water Konsortium (IWK), Malaysian Palm Oil Board (MPOB), National Hydraulic Research Institute of Malaysia (NAHRIM) and Universiti Teknologi Malaysia (UTM) grant. We also wish to thank all reviewers whose valuable comments and suggestions have significantly enhanced the quality of the manuscript.

## References


Amirreza, S., Haw, Y., Kathleen M.B. Boomer., Latif Kalin., Xuyong Li., and Donald E.Weller. (2017). *Using multiple watershed models to assess the water quality impacts of alternate land development scenarios for a small community*. Catena 150 (2017) 87–99.

Ali Najah., Ahmed Elshafie., Othman A. Karim., and Othman Jaffar. (2009). *Prediction of Johor River Water Quality Parameters Using Artificial Neural Networks*. European Journal of Scientific Research. Vol.28 No.3 (2009), 422-435.

Bicknell,B.R., Imnoff JC, Jr., Jobes TH., and Donigian AS. (2001). *Hydrological Simulation Program-FORTRAN (HSPF) version 12, User's Manual*. Prepared for AQUA TERRA Consultants Mountain View, Califronia in cooperation with Water Resources Discipline, U.S. Geological Survey Reston, Virginia, USA.

Borah and M. Bera. (2004). *Watershed−Scale Hydrologic and Nonpoint−Source Pollution Models: Review Of Applications.* Vol. 47(3): 789−803 2004. Transactions of the ASAE, American Society of Agricultural Engineers ISSN 0001−2351.

Box GEP and Jenkins GM. (1970). *Time series analysis, forecasting and control. San Francisco,* CA: Holden-Bay Inc.

Chibanga R., Berlamont J., and Vandewalle J. (2001). *Artificial neural networks in hydrological watershed modelling: surface flow contribution from the ungaged parts of a catchment*. In: Proceedings of the 13th International Conference on Tools with Artificial Intelligence, 7-9 November 2001, Dallas, Texas, USA.

Chen.M, Boyle EA., Lee J-M., Nurhati I, Zurbrick C., Switzer AD., and Carrasco G. (2016). *Lead isotope exchange between dissolved and fluvial particulate matter: a laboratory study from the Johor River estuary*. Phil. Trans. R. Soc. A 374: 20160054.

Eugene Ng, Y.J., Yap, C.K., Zakaria, M.P., and Tan, S.G. (2013). *Assessment of heavy metal pollution in the straits of johore by using transplanted caged mussel, Perna viridis*. Pertanika J. Sci. Technol. 21, 75–96.

Hui Xie., Lei Chen., and Zhenyao Shen. (2015). *Assessment of Agricultural Best Management Practices Using Models: Current Issues and Future Perspectives.* Water 2015, 7, 1088-1108; doi:10.3390/w7031088.

Melone F., Barbetta S, Diomede T.(2005). *Review and selection of hydrological models – Integration of hydrological models and meteorological inputs.* Contract No. 12. Gennaio, Italy.

Mou Leong Tan., Darren L. Ficklin., Ab Latif Ibrahim., and Zulkifli Yusop. (2014a). *Impacts and uncertainties of climate change on streamflow of the Johor River Basin, Malaysia using a CMIP5 General Circulation Model ensemble*. Journal of Water and Climate Change. IWA Publishing.676-695.

Mou Leong Tan., Ab Latif Ibrahim., Zulkifli Yusop., Zheng Duan., and Lloyd Ling. (2014b). *Impacts of land-use and climate variability on hydrological components in the Johor River basin, Malaysia*, Hydrological Sciences Journal, DOI:10.1080/02626667.2014.967246.

Nathan William Johnson (2005). *ArcGIS and HSPF Model Development.* Master of Science in Engineering thesis. The University of Texas at Austin. August 2005.

Nguyen Hong Quan and Günter Meon (2015). *Nutrient Dynamics During Flood Events in Tropical Catchments: A Case Study in Southern Vietnam.* Clean – Soil, Air, Water 2015, 43 (5), 652–661.

Oogathoo S. (2006). *Runoff simulation in the Canagagigue Creek watershed using the MIKE SHE model (Master of Science).* Montreal, Canada: McGill University.

Ouyang, Y., Leininger, T.D., and Moran, M. (2013). *Impacts of reforestation upon sediment load and water outflow in the Lower Yazoo River Watershed, Mississippi*. Ecol. Eng.61, 394-406.

Ouyang, Y., Leininger, T.D., and Moran, M. (2015). *Estimating effects of reforestation on nitrogen and phosphorus load reductions in the Lower Yazoo River Watershed, Mississippi*. Ecol. Eng.61, 449-456.

Philips, J.R. (1957). *The Theory of Infiltration: The Infiltration Equation and Its Solution*, Soil Science, 83:345-375.

P.B. Duda., P.R. Hummel., A.S. Donigian Jr., and J.C Imhoff. (2012). *BASINS/HSPF: Model use, calibration, and validation.* American Society of Agricultural and Biological Engineers Vol. 55(4): 1523-1547

Razi, M.A.M., Ariffin, J., Tahir, W and Arish, N.A.M (2010). *Flood Estimation Studies using Hydrologic Modeling System (HEC-HMS) for Johor River, Malaysia*. Journal of Applied Sciences, 10. 930-939

Saleh and Du (2004). *Evaluation of SWAT and HSPF within basins program for the Upper North Bosque River watershed in Central Texas*. American Society of Agricultural Engineers ISSN 0001−2351. Vol. 47(4): 1039−1049.

Syed I. Ahmed., Amanjot Singh., Ramesh Rudra., and Bahram Gharabaghi. (2014). *Comparison of CANWET and HSPF for water budget and water quality modelling in rural Ontario.* Water Quality Research Journal of Canada. 49.1.53-71

USEPA (2000). *BASINS Technical Note 6: Estimating hydrology and hydraulic parameters for HSPF*. EPA-823-R-00-012, July 2000.

Valizadeh, N., Ahmed, E., Majid, M., Hadi, G., Muhammad, M., and Othman, J. (2014). *Accuracy Enhancement for Forecasting Water Levels of Reservoirs and River Streams Using a Multiple-Input-Pattern Fuzzification Approach*. The Scientific World Journal, 9

WMO. (1994) *Guide to hydrological practices.* WMO No. 168. 5th Ed.World Meteorological Organization, Geneva.

Yurekli K., and Kurunc A. (2005). *Testing the residuals of an ARIMA model on the Cekerek stream watershed in Turkey.* Turkish J Eng Environ Sci; 29: 61-74.

Yin, Y., Jiang, S., Pers, C., Yang, X., Liu, Q., Yuan, J., and Zheng, Z. (2016). *Assessment of the Spatial and Temporal Variations of Water Quality for Agricultural Lands with Crop Rotation in China by Using a HYPE Model*. International Journal of Environmental Research and Public Health, 13(3), 336.