



**UNIVERSITI PUTRA MALAYSIA**

***FLOOD MODELING FOR THE NEKA CATCHMENT IN MAZANDARAN  
PROVINCE, NORTHERN IRAN***

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**FLOOD MODELING FOR THE NEKA CATCHMENT IN MAZANDARAN  
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**By**

**ALI HAGHIZADEH**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,  
in Fulfilment of the Requirement for the Degree of Doctor of Philosophy**

**August 2011**

## ***Dedication***

***This work is dedicated to my wife who is always giving me encouragement and support***



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

**FLOOD MODELING FOR THE NEKA CATCHMENT IN MAZANDARAN PROVINCE, NORTHERN IRAN**

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**Chairman: Professor Ir. Lee Teang Shui, PhD**

**Faculty: Engineering**

Flood damage is a very serious disastrous problem in northern Iran; specifically at the Neka river basin. Contemporaneous data and information, as well as predictions and pre-emptive warnings on impending flood threats has become a prominent focus in flood protection and alleviation in this province. Loss of life along with extensive destruction to properties and infrastructure affected by large floods and inundations is what instigated this movement to strengthen flood preventative measures and systems. An integration between a distributed hydrological model (WETSPA) and a hydraulic GIS base model HEC-RAS, is the focus of this study to simulate and predict flooding in the basin. This is done by simulating flooding, thereby making it possible to identify precursors and patterns in flooding and also making flood predictions for this basin a more exact science. A model primary function of WETSPA is to provide data input to the hydrologic model by replicating and predicting the Neka river basin's flow in its upstream sub-catchments. Using data of stream flow of all seasons from 1986 to 1999, the hydrologic model was calibrated and then validated for the 2002 to 2004 flood seasons. It has proven to be accurate

with the hydrographical predictions showing a baseline of 0.87 on the Nash-Sutcliffe efficiency for high flow and square correlation coefficient 0.974 and modified correlation coefficient 0.747 with an aggregated measure of 0.85, the performance is deemed excellent for the validation phase. The HEC-RAS hydraulic model, on the other hand, imitates flow and water profiles in the Neka river basin's downstream flood plain. Hydrograph phases studied during the flood seasons of 1986-1999 and from 2002-2004 were used to calibrate and verify the hydraulic model respectively. Simulations of peak flood stages and hydrographs' evaluations are congruent with studies and observations, with the former showing errors of below 0.107m. A 3D flood mapping for the flood plain is then constructed from the projected water profiles. The assimilation of the hydrological model (WETSPA) with the hydraulic (HEC-RAS) model is found to be suitable in gauging flood threats on top of flood forecasting at the Neka river basin from the research findings obtained. This is done by developing an effective flood prediction method, thereby producing a system for the management of its processes. The application and integration of the aforementioned models were done by incorporating data handling utilities and interfaces from this process management system. Collected stream flow data from calibrations cycles (flood seasons 1986 to 1999) and verification cycles (flood seasons 2002 to 2004) in the catchments were compared to the simulation results, and then used for the calibration and verification of the WETSPA model, which was performed specifically for upstream watersheds. Flow volumes, concentration time and peak discharges as well as hydrographs predictions reflected in the results established that the model produces good assessments and high accuracy estimate. Using the WETSPA model to calculate upstream inputs and employed as a boundary conditions, the HEC-RAS model is applied in the downstream flood plain of the river

basin. The predicted results show that the system can effectively perform WetSpa and HECRAS calculations and forecast flood water levels. Nash-Sutcliffe effectiveness (CR3) is more than 0.92 along with elevated levels of water which were created with some effectiveness (CR5) of 0.94 for the validation period. Next the multilayer perceptron (MLP) Artificial Neural Networks (ANN) and WETSPA models were tested and compared in a comparative study of daily flow estimates. Results of the study basically showed that both models are capable and practical in calculating and estimating the hydrologic response. To determine their efficiency and practicality in hydrologic predictions, both models were used to construct flow predictions at the Neka basin. The square correlation coefficient ( $R^2$ ) and root mean square error (RMSE) for the WETSPA model was in a range of 0.964 to 0.974 and 0.00184 to 0.0021 mm/h respectively while that for the ANN model was in a range from 0.917 - 0.960 and 0.0022-0.0040 mm/h. It was shown that WETSPA was more accurate than ANN at short-term (2002-2004). However, the ANN model shows greater  $R^2$  and the lower error RMSE for forecasting at long- term (1986-1999).

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

**PEMODELAN BANJIR UNTUK KAWASAN TADAHAN NEKA DI DAERAH  
MAZANDARAN, IRAN UTARA**

oleh

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**Ogos 2011**

**Pengerusi: Profesor Ir. Lee Teang Shui, PhD**

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Kerosakan disebabkan banjir merupakan malapetaka serius di Iran Utara; khususnya di lembangan sungai Neka. Data semasa dan maklumat, termasuk ramalan dan amaran terlebih dahulu tentang berlakunya acaman banjir telah menjadi focus penting di daerah ini dalam usaha membentuk perlindungan terhadap banjir serta cara mengatasinya. Kehilangan nyawa dan pembinaan keatas harta benda dan infrastruktur oleh banjir besar memerlukan cara dan system demi memperkuat pencegahan banjir. Satu kaedah bersepadu merangkumi model hidrologic teragih (WETSPA) dan model hidraulik HEC-RAS berasaskan GIS merupakan focus kajian ini demi untuk menyelaku serta meramalkan banjir di lembangan tersebut. Demi sains hidrologi tepat, capaian melalui penyelakuan banjir semoga membenarkan kepastian prapenanda dan corak banjir dan juga ramalan banjir lembangan perlu dilaksanakan. Satu fungsi asas WETSPA ialah membekalkan data masuk bagi model hidrologi melalui proses pengreplikaan serta ramalan aliran sungai lembangan sungai Neka di dalam kawasan sub-tadahan di hulu. Dengan data aliran sungai musim 1986 ke 1999, model hidrologi ditentukan kemudian dipastikan bagi musim banjir 2002 ke 2004. Ini dibuktikan dengan ramalan hidrologi bergaris-dasar 0.87 bagi cekapan Nash-Sutcliffe untuk aliran tinggi serta angkali korelasi kuasa dua bernilai 0.974, angkali korelasi ubahsuai 0.747 dengan ukuran agregat 0.85 membayangkan prestasi

yang unggul bagi fasa kepastian. Sebaliknya, model hidraulik HEC-RAS mencerminkan aliran dan profil air di kawasan hilir banjir datar lembangan sungai Neka. Grafhidro yang dikajikan untuk musim banjir 1986-2002 dan daripada 2002-2004 digunapakai masing masing untuk menentukur dan pastikan model hidraulik. Penyelakuan kemuncak paras ukuran banjir dan penilaian grafhidro adalah serbasama dalam kajian dan cerapan dimana dalam kajian terdapat ralat kurang daripada 0.1meter. Satu peta banjir 3D untuk kawasan datar dibentukkan berasas gambaran profil air. Daripada penemuan kajian didapati bahawa pencernaan model hidrologi (WETSPA) dengan model hidraulik sesuai untuk mengukur ancaman banjir selain daripada peramalan banjir di lembangan sungai Neka. Ini dicapai melalui pembinaan satu kaedah ramalan banjir yang berkesan supaya menghasilkan satu sistem pengurusan prosesnya. Aplikasi dan kebersepaduan model model tersebut dibuat dengan menggabungkan kemudahan dan antara muka dalam system pengurusan proses. Data aliran sungai daripada musim untuk penentukran (musim banjir 1986 ke 1999) dan musim untuk kepastian (musim banjir 2002 ke 2004) kawasan tadahan dibandingkan dengan keputusan penyelakuan, dan kemudian digunapakai untuk penentukran dan kepastian model WETSPA, yang mana di lakukan khas untuk kawasan tadahan dihulu. Isipasu aliran, masa tumpuan dan aliran kemuncak bersama sama peramalan gerafhidro yang dicerminkan dalam keputusan memastikan bahawa model itu memberi penaksiran yang baik dan anggar yang jitu. Dengan mengguna model WETSPA untuk mengira input dihulu dan diguna sebagai keadaan sempadan, model HEC-RAS di guna di tanah rata banjir dihilir lembangan sungai.. Keputusan yang diramalkan menunjuk bahawa system itu dapat melakukan kiraan dan ramala paras air banjir. Keberkesanan Nash-Sutcliffe (CR3) didapati melebihi 0.92 bersama sama kenaikan paras air yang dihasilkan dengan keberkesanan (CR5) sebanyak 0.94 bagi nilai kepastian. Model model peseptron lapisan-multi (MLP) Rangkaian Saraf Buatan (ANN) dan WETSPA diuji dan dibandingkan didalam satu kajian taksiran aliran harian. Didapati daripada keputusan kajian pada asasnya menunjukkan bahawa kedua dua model berkemampuan dan praktik diguna untuk buat kiraan dan penaksiran respon hidrologi. Demi untuk menentu keberkesanan dan kepraktikan untuk peramalan hidrologi, kedua dua model diguna untuk membina peramalan aliran di lembangan Neka. Parameter regresi R dan ralat punca kuasa dua min (RMSE) bagi bagi WETSPA berjulat 0.964



sehingga 0.974 0.00184 ke 0.0021 mm/j masing masing, manakala bagi model ANN berjulat 0.917 sehingga 0.96 dan 0.0022 ke 0.004 mm/j. Ini bermaksud bahawa untuk jangkamasa pendek (2002 – 2004) WETSPA adalah lebih jitu daripada ANN. Akan tetapi, bagi jangkamasa panjang (1986 – 1999), model ANN menghasil R yang lebih besar dan ralat RMSE lebih rendah untuk peramalan.



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## **APPROVAL**

I certify that an examination committee has met on 15. 08. 2011 to conduct the final examination of Ali Haghizadeh on his Doctor of Philosophy thesis entitled “Flood modelling for the Neka catchment in Mazandaran Province, Northern Iran” in accordance with Universiti Pertanian Malaysia (higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination committee are as follows:

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## DECLARATION

I declare that the thesis is my original work except for equations and citations, which have been duly acknowledged. I also declare that it has not been previously and is not currently submitted for any other degree at Universiti Putra Malaysia or other institutions.

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**ALI HAGHIZADEH**

Date: 15 August 2011

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