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Full Length Research Paper

GIS-based multidate flood forecasting using hydraulic model

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Flood plains and the area near to the rivers channels, because of their special circumstances such as fertility and water resources are appropriate situations for the social and agricultural activities, but due to morphological characteristics usually, these area are affected by different flood hazards. However, in these areas, determination of flood zone and its height and also detecting properties of floods in different return periods is most significant. So flood zonation is essential for a proper development and most important parameter for investigate of ecological and environmental consequence. Interaction between some river hydrologic models and geographical information systems (GIS) cause some gains and methods, which are reasonable to the planners. This study was carried out with the purpose of using hydraulic model of HEC-RAS with Arc View software to estimate the flood zone of 5 km distance on Neka River in Northern part of Iran, where during the last decade we had different flood events with a high magnitude damages. Topography maps at 1:1000 scale were used for the flood zonation for different periods of 2, 5, 10, 25, 50, 100 and 200 years. The results obtained attest to the fact that the combination of GIS and HEC-RAS model used in this study is useful and efficient in delineating the flood zonation. Finally the flood zone of 25 years is predicted to be more hazardous than the other periods for the selected areas.

Key words: Neka River, flood zonation, HEC-RAS, geographical information systems.

INTRODUCTION

A theory of forecasting for large rivers has interesting features which demand a high degree of sophistication of concepts. In contrast to small rivers, where a rainfall runoff model may suffice for the forecast, a large river requires also forecasting of discharges by means of upstream stages. Purpose is to estimate the future output at different time (2, 5, 10, 25, 50, 100 and 200 years) as accurately as possible, starting with measurements of present and past input quantities. Therefore, it is data based: data are needed for feeding a forecast model. Because data on rainfall and other natural processes are never accurate, and because hydrological models always simplify actual conditions and thus add uncertainties, the outputs also are uncertain quantities, which in a scientific sound approach should be described by means of probability distributions (Krzysztofowicz, 2001). Although many people see forecasting models as just another application of typical hydrologic rainfall runoff models or hydraulic routing models as used for design purposes, there exists a principal difference between the two types of models.

A forecasting model must yield accurate forecasts of the real discharge or stage within narrow error bounds: this is more important than physical accuracy. On the other hand, for design purposes one needs to know a possible extreme event without regard of its time of occurrence, such as the 100 year flood. However, it is never known if the design flood really is the actual 100 year flood, and one has to live with large uncertainties which must be properly allowed for in design of flood protection works by suitable margins of safety. Such design information is obtained by means of extreme value analysis of discharge time series for gaged locations, or by means of rainfall runoff models for ungaged catchments. Advantage of a physically based rainfall-runoff model is its ability to predict the effects of changes in the river system. Flood protection and awareness have continued to rise on the political agenda over the last decade accompanied by a drive to improve' flood forecasts (Demeritt et al., 2007; Pitt, 2007). Operational flood forecasting systems form a key part of 'preparedness' strategies for disastrous flood events by providing early warnings several days ahead (Wood and Lettenmaier, 2008), giving flood forecasting services, civil protection authorities and the public adequate preparation time and thus reducing the impacts of the flooding. Due to the expansion of agricultural activities along the river banks and concentration of population in the region of submergible areas, the flood-induced compensation is in increasing trend. The complete flood protection with installation of great flood control structures like flood dams are not defensible due to its high cost (Williams, 1994).

It is not environmentally, socially and economically a most advantageous idea either. For this reason, the flood zonation can have a substantial role in flood management through logical consumption of weir gates and dam reservoir (Xiaoliu and Michel, 2000). In this direction, different systems have been innovated in different countries of the world, but lack of equipment and tools, and also high cost of installation are the limiting factors in Iran (Solaimani et al., 2009). According to the recorded data, recently the flood return period has decreased in Neka Basin in the Northern Iran, so appropriate method of prediction to decreasing the flood-damages is required, which can be gained using flood zonation results. The aim of this study is to find out the efficacy of geographical information systems (GIS) technique in simulating a comprehensive hydrological model. For that reason the main requirement of a hydrological model is description of flow channel characteristics and land surface as input data to the watershed model. The flood zonation is actualize, development and perfection of the applied engineering hydrology and its aim is to acquire a real time rainfall data and river flow by short wave, radio and satellite network, and using them in rainfall-runoff models to forecast and also zonation of the floods in consecutive time and space intervals (Cabal and Erlich, 1992). The quality of flood forecasting systems mainly depends on the quality and the amount of the collected basic data about hydrology and the hydrological yield of the related watershed (Ammentrop et al., 1992).

The study area with 5.5 km long of Neka watershed is located between Chaman and Bezminabad villages. The UTM coordinates of the study area is; Xmin=699000, Xmax=704000; Ymin=4058000, and Ymax=4062000, and it is located in northern part of Iran.

The mean annual rainfall of the region is estimated to be 800 mm by Isohyet's method, and 816.2 mm by Theissen system. The main part of the basin has very humid climate and the northern part of the basin which has lower elevations has humid climate which is indicated using De-marten method. Based on Emberger method, the middle and northern part have cold humid conditions and southern part of the basin with higher elevations has mountain climate.

This study which has combined GIS with hydrologic model is based on some of the previous research works. Smith (1995) created a hydrological information development system, by using GIS and hydrological watershed parameters such as design storm, soil hydrology, time of concentration, runoff coefficient, etc (Olivera et al., 1995). Olivera and Maidment (1998, 1999) and U.S Army (2002) used GIS technique, obtained primary stages data including the elevations, separated the reach network and sub-basins, recognized the hydrological elements, created continuity among them and finally input them in the hydrological model. The results obtained from the used HEC-Ras showed that determination of spatial parameters is easy by hydrological models and the results can be extendable.

MATERIALS AND METHODS

To recognize the Neka watershed, the vegetation, geology, soil and the other information are prepared in the structure of the maps. Then through the GIS and evaluation of the effect of the application of pre-processor of GIS for hydrological system, the channel vegetation of the basin is created to acquire a regional model of channel and watershed characteristics. Information from early model of elevations is prepared from GIS processor and is transferred into hydrological model. To compare the results of hydrological model with observed flow data for calibration of the model, the evaluation of the correctness of the input to the model and the modeling system have been performed. For the regional modeling, simulation and flooding levels, some of common techniques and softwares used include: Arc View software and HEC-GeoRAS extension v.3.1, Spatial Analysis and 3D Analysis (Andam, 2003).

To determine the water velocity in the selected reaches, a cross section was surveyed between the highest and lowest main channels for each of hydrological unit. A series of regular sections with a steady shape was considered. After estimation of roughness coefficient using Chow (1988) method, the water velocity was calculated for the main river, and each tributary using Manning equation. The lag time of the sub-basins was calculated from US-SCS formula (Equation 1) described by Chow et al. (1988):

$$Tc = L^{0.8} W[(1000/CN)]-9]^{0.7} 31.68S^{0.5} \quad (1)$$

Finally, for the flood zonation of the 5.5 km section of the Neka watershed, 7 return period of 2, 5, 10, 25, 50, 100 and 200 years was selected. A geometry having different height, level, depth and velocity along the channel was used.

RESULTS AND DISCUSSION

Discharge estimation for different return period

Different statistical discharge distributions was used in preparing the probability maximum discharges for Ablo station using Hyfa software; the best one with different return period for each station was selected. In this study, Pearson type III has shown to be the greatest and best

Table 1. The best statistical distribution data used for simulation of flood discharge in Neka watershed.

Distr./Ret.(yr)	2	5	10	20	25	50	100	200
Log.Normal (2 parametre)	73	189	310	468	527	742	1010	1338
Log.Normal (3 parametre)	73	231	371	532	589	783	1005	1258
Pearson III	62	113	229	406	475	719	1008	1337
Log.Pearson III	74	180	303	480	553	837	1239	1801
Gambel	108	312	447	577	619	745	871	997
Selected Pearson III	62	113	229	406	475	719	1008	1337

Table 2. Determination of coefficient for each section.

No. section	Right bank	Left bank	Main channel	Number for each section
1	0.050	0.050	0.040	1 to 46
2	0.035	0.035	0.030	46 to 93

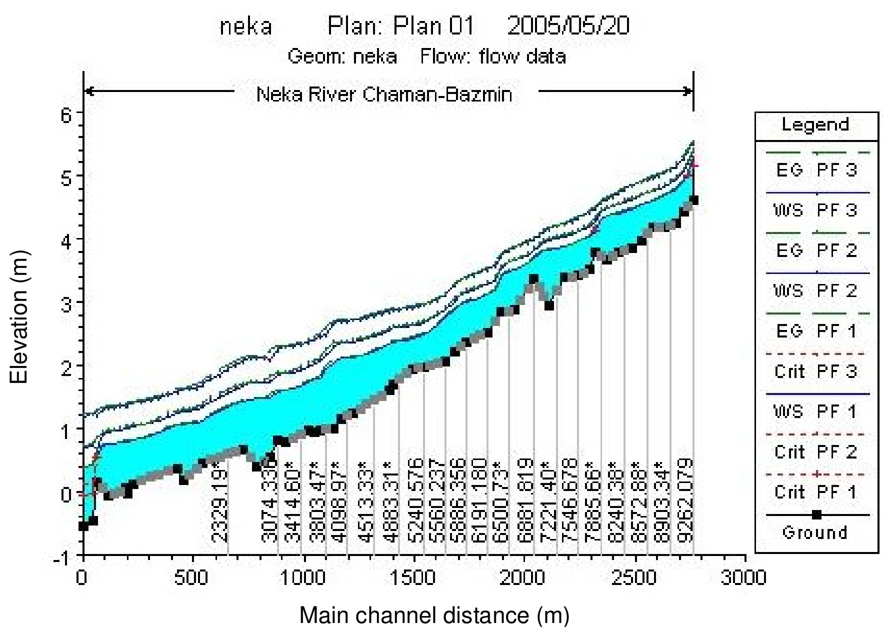

Figure 1. Long profile of water level for the return period of 2, 5 and 10 year.

statistical distribution. The flow rates used in simulation of flood discharge in Neka watershed are shown in Table 1.

Maning roughness coefficient

For determination of Maning coefficient, firstly all characteristics of the selected sections in right, left and the main bed of the river channel separately were measured in the field (Table 2). Figures 1 and 2 shows the hydrological elements of water level profiles during different return period. The amounts obtained in (I) condition for events 2, 3 and 4 are shown in Figures 3, 4 and 5 as simulated and observed hydrographs in Valikben hydrometric station.

From this study, it is concluded that majority of the Iranian watersheds are submergible and the water resources plans are in progress, use of flood zonation models, and techniques like GIS have grow to be more important than the other traditional methods. That is because this method is a combination of management and structures issues which makes the system more efficient and decreases the flood–induced damages. This research which is to investigate the efficiency of using

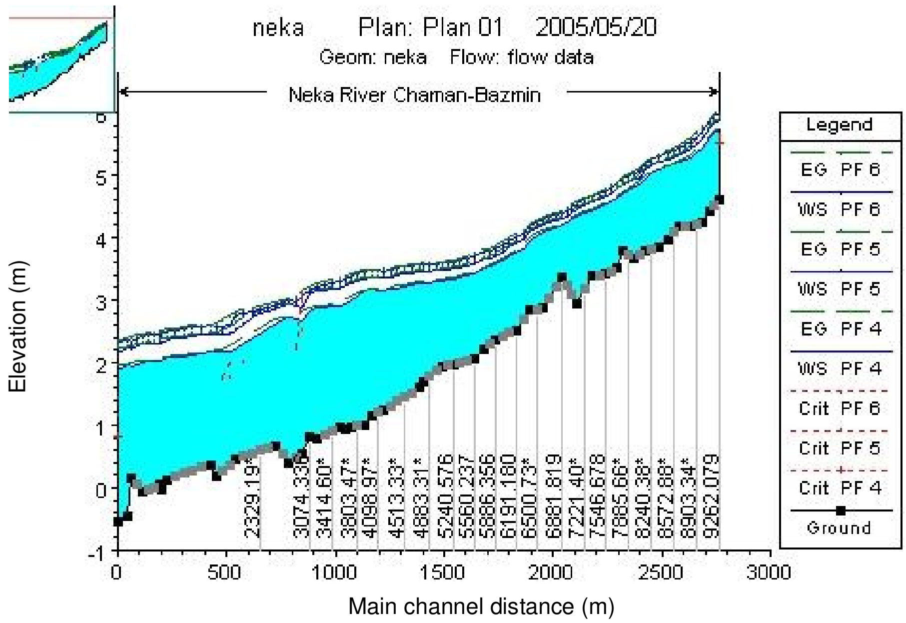

Figure 2. Long profile of water level for the return period of 25, 50 and 100 year.

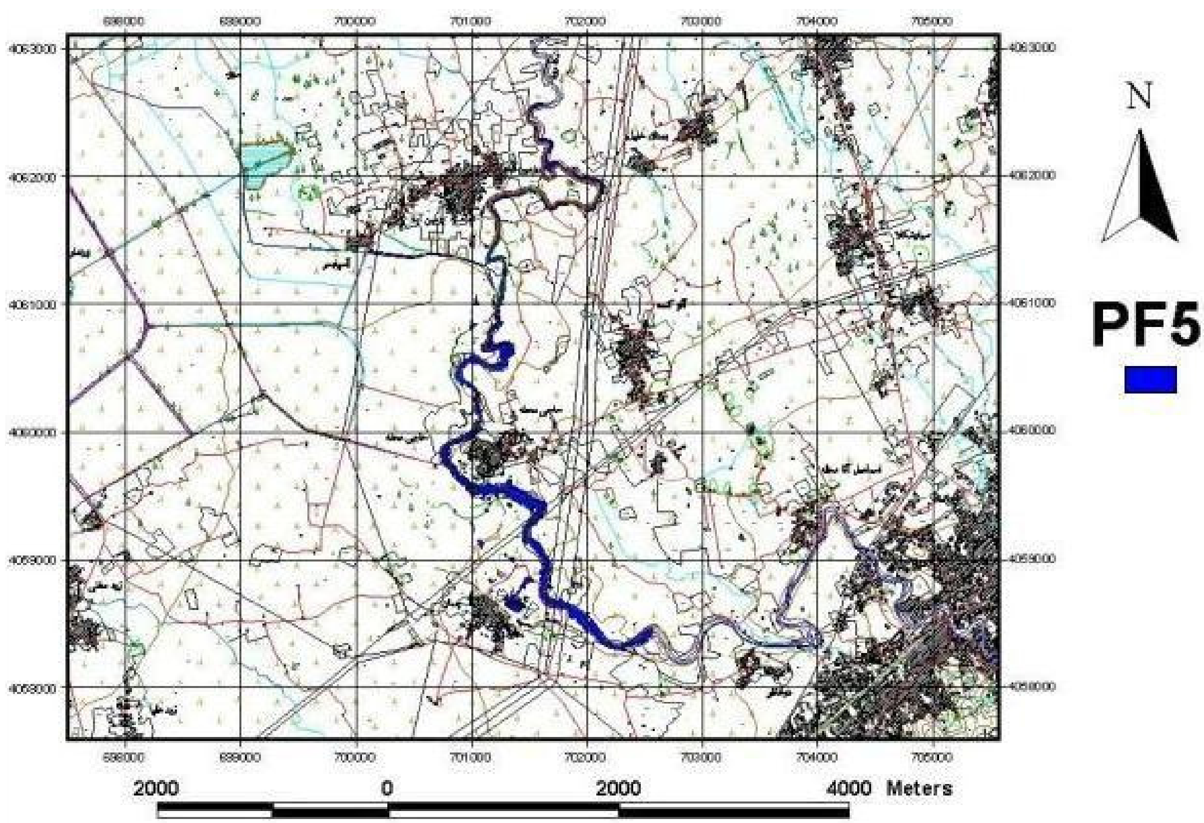

Figure 3. Flood zonation for return period of 5 year.

GIS as a preprocessor for a comprehensive flood zonation models and to improve the flood forecasting systems in Neka watershed, is a sensible gate in comparison to the other methods on this subject and in northern watersheds of Iran. In this study evaluation of the efficiency and use of GIS in hydrological model

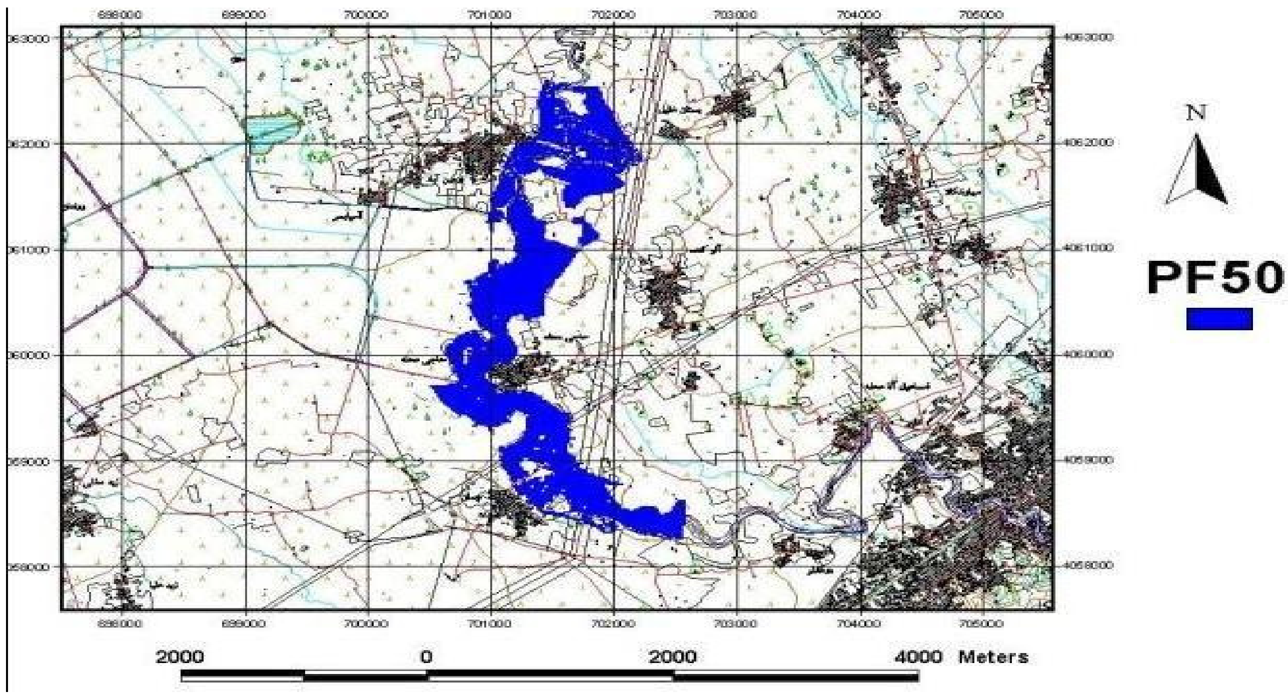

Figure 4. Flood zonation for return period of 50 year.

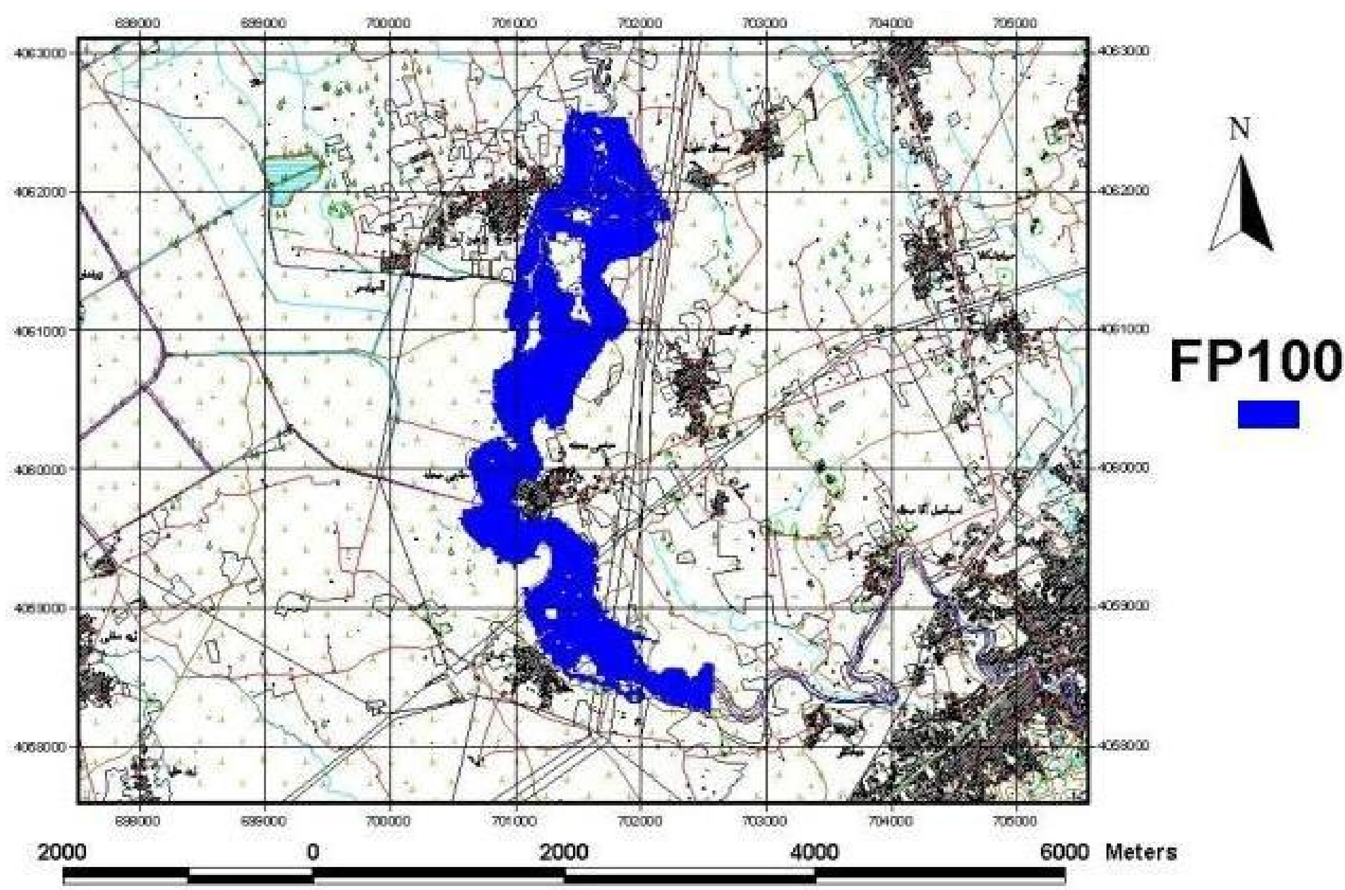

Figure 5. Flood Zonation for return period of 200 year.

system was successful. GIS as an appropriate technique prepares the great and accurate files of the watershed and is constructive for locations with ground data available. For example, the rainfall distribution and conversion to readable format by hydrological model system which combines these components in an applied hydrological models.

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REFERENCES

Ammentrop HC, Havno K, Refsgaard JC (1992). Real time flood forecasting. Int. Symp. Dams extreme floods. Granada, Spain, pp. 103-111.

Andam KS (2003). Comparing Physical Habitat Conditions in Forested and Non-Forested Streams. M.Sc. Thesis, University of Vermont, p. 136.

Cabal A, Erlich M (1992). Design development and implementation of hydrological data base management system for the purpose of real-time flood forecasting. 4th Int. Conf. Hydraulic Eng. Software Hydrosoft/92. Billerica, USA, pp. 395-406.

Chow VT, Maidment D, Ays LM (1988). Applied Hydrology, Macgraw-Hill Publishing Company, p. 68.

Demeritt D, Cloke H, Pappenberger F, Thielen J, Bartholmes J, Ramos MH (2007). Ensemble predictions and perceptions of risk, uncertainty, and error in flood forecasting. Environ. Hazards, 7(2): 115.

Krzysztofowicz R (2001). Integrator of uncertainties for probabilistic river stage forecasting: Precipitation-dependent model. J. Hydrol., 249(1–4): 69–85.

Olivera F, Maidment D (1998). HEC-Prepro v.2: An Arcview pre-processo for Hec,s Hydrological Modeling System. Centre for Research in Water Resources Austin, Texas.

Olivera F, Maidment D (1999). Developing a Hydrologic Model of the Guadalupe Basin/Center for Research in Water Resources, Austin, Texas.

Pitt M (2007). Learning lessons from the 2007 floods: An independent review by Sir Michael Pitt: Interim Report, London, UK.

Smith P (1995). Hydrologic Data Development System, Master Thesis, Department of Civil Engineering, University of Texas at Austin.

Solaimani K, Modallaldust S, Lotfi S (2009). Investigation of the Lar lake fluctuations using remote sensing data. Res. J. Environ. Sci. USA, pp. 574-580.

U.S. Army Corps of Eng. (2002). HEC-RAS Reference Manual Version, 3: 1-243.

Williams PB (1994). Flood control Vs. Flood management. Civil Eng., pp. 51-54.

Wood A, Lettenmaier D (2008). An ensemble approach for attribution of hydrologic prediction uncertainty. Geophys. Res. Lett., p. 35. doi:10.1029/ 2008GL034648.

Xiaoliu Y, Michel C (2000). Flood forecasting with a watershed model: A new model of paprametre updating. Hydrol. Sci. J., 45(4): 537-546.