SIMULATION OF CHANGES OF RED RIVER SYSTEM PROFILE USING HEC-6 MODEL
(Da river reach from Hoa Binh to Thao-Da confluence and Red river reach from Thao-Da confluence to Ha Noi)

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Abstract. Hoa Binh reservoir was built in Da river to carry out two top important duties that are generation electricity and flood prevention for lowlands. Since operation, Hoa Binh reservoir has been bringing about very big usefulnesses, but also has been causing unfavourable changes, such as deposition in the reservoir, local scour in lower of the dam and disseminated scour towards lower. Estimation, simulation and prediction these changes to limit damages always are pressing and necessary problems. Mathematical models are effective and economic tools to solve these problems.

HEC-6 is a one-dimensional movable boundary open channel flow numerical model designed to simulate and predict changes in river profiles resulting from scour and/or deposition over moderate time periods.

This paper studies and applies HEC-6 model to simulate changes of Da river profile (reach from Hoa Binh to Thao-Da confluence) and Red river profile (reach from Thao-Da confluence to Ha Noi). The results of model calibration and verification show that HEC-6 model with the selected set of optimal parameters can use to simulate changes of Red river system profile in the future with acceptable accuracy. The results of Red river bed change simulation using the set of selected parameters; initial condition is Red river bed, which surveyed in 1992; upstream conditions are typical discharge process (average type of period 1988 - 1998) at hydrological stations: Hoa Binh, Yen Bai, Vu Quang, Thuong Cat and downstream conditions is typical stage process (average type of period 1988 - 1998) at Hanoi hydrological station show that:

Deep scour phenomenons resulting from regulating effect of Hoa Binh reservoir happen almost only in Da river and transmit only to Trung Ha station.

Deep scour speed reduces gradually. Therefore, Da river bed will become gradually stability (to reestablish the new balance state).

1. Introduction

Red river network, the second biggest river network in Vietnam, has been playing a significant role in the socio-economical development of the country. Red river rises from a height of 2000 m AMSL in Van Nam (China). It has a total length of 1126 km. The basin occupies total area of 165794 km^2, in which 82630 km^2 lies within in Vietnam. Red river acts as waterways and flood conveyance to protect the most Northern part of Vietnam from flooding and inundation. Red river is created from three main tributaries: Da, Thao and Lo rivers. Thao river originates from Dai Ly Lake in Van Nam of China, where it is called Nguyen river. Flowing down from the altitude of 2000 m AMSL in a Northwest-Southeast direction, it enters Vietnam-China border at Laocai province and is known as Thao river. It has a total length of 902 km in which 332 km within in Vietnam. From Yen Bai to Viet Tri, its widths range from 100 - 150 m in average. Riverbank elevations vary below the values of 25 m; the average depth is around 5 m corresponding with the bank-full discharge. The bed slope is approximately 1‰. Total catchment area of Thao river inside Vietnam is 12100 km^2. Da river rises from the highly mountainous area in the same vicinity of Thao river's source. Running in a Northwest-Southeast direction to Hoa Binh, it then changes the flowing direction to South-North, and joints Thao river at Trung Ha, 12 km upstream from Viet Tri town. The total length from border to Viet Tri is about 570 km with the catchment area of 26800 km^2. It is the most important tributary of Red river network and normally contributes up to 50% total inflow for Red river. Lo river also originates from Van Nam mountains area located in China. Its total length is 470 km; the catchment area is 136900 km^2. In Vietnam territory, the bed slope of Lo river is 26‰. In the downstream course from Tuyen Quang to Viet Tri, its width is about 200 m at flow depth raging from 1.5 to 3 m. The total basin of Red river network considered at Son Tay is approximately 70700 km^2, occupying 45% of Northern part area of Vietnam. Red river considered from Viet Tri, flows through important urban centers, Son Tay province and Hanoi capital where the populations are the highest comparing throughout out the nation.

Hoa Binh reservoir, located on Da river, 55 km far from Thao-Da confluence, was put into operation partially in 1990 and fully in 1994. The effects of the construction have been seen obviously in Da reach after of closure. Previously, there were some researches predicting the impact of Hoa Binh reservoir on downstream morphological conditions in design stages. Each of the previous sudies has merit points and limitations due to the deficiency in data for vertication and computational methods.

In recent years, data and observations obtained by Department of Management & Flood Control and Research Institute of Water Resources show that the degradation of Da riverbed has been propagating to the downstream. Bank erosions and avulsions during resent years in downstream have been seriously occurring at alarming rates. The riverbeds in outer bank are being deepened rapidly, the flow path approaching the riverbank creating serious avulsions in both flood and transitional stages. This situation threatens the safety of national dike system and will cause big damages if there is no in-time action to prevent the erosion.

This reseach applies HEC-6 model to simulate and predict changes of Da river profiles (reach from Hoa Binh to Thao-Da confluence) and Red river profiles (reach from Thao-Da confluence to Ha Noi).

2. Theoretical basis of movable boundary calculation of HEC-6

HEC-6 is a one-dimensional movable boundary open channel flow numerical model. It is designed by USA Hydrological Engineering Center to simulate and predict changes in river profiles resulting from scour and/or deposition over moderate time periods (typically months or years, althrough applications to single flood events are possible). HEC-6 used in this research is HEC-6 version 4.1 published in 1993.

In HEC-6 model, a continuous flow records is partitioned into a series of steady flows of variable discharges and durations. For each flow, a water surface profile is calculated thereby providing energy slope, velocity, depth, etc. at each cross section. Potential sediment transport rates are then computed at each section. These rates, combined with the duration of the flow, permit a volumetric accounting of sediment within each reach The amount of scour or deposition at each section is then computed and the cross section adjusted accordingly. The computations then proceed to the next flow in the sequence and the cycle is repeated beginning with the update geometry. The sediment calculations are performed by grain size fration thereby allowing the simulation of hydraulic sorting and amoring Features of HEC-6 include: capability to analyze networks of streams, channel dredging, various levee and encroachment alternatives, and to use several methods for computation of sediment transport rates.

2.1 Theoretical Basis for Hydraulic Calculations

The hydraulic parameters needs to calculate sediment transport potential are velocity, depth, width and energy slope-all of which are obtained from water surface profile calculations. Water surface profiles are calculated using the standard-step method to solve the continuity equation and one-dimensional energy equation (Equation 2.1) and the hydraulic parameters are calculated at each cross section for successive discharge. Figure 2.1 shows a representation of the terms in the energy equation.

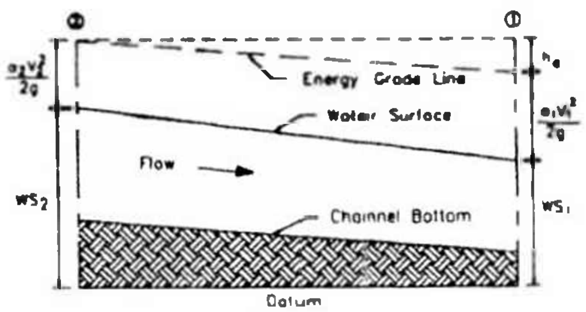

Figure 2.1

$$WS_2 + \frac{\alpha_2 V_2^2}{2g} = WS_1 + \frac{\alpha_1 V_1^2}{2g} + h_e. \quad (2.1)$$

where: g = acceleration of gravity; h_e = energy loss; V_1, V_2 = average velocities (total discharge ÷ total flow area) at ends of reach; WS_1, WS_2 = water surface elevations at ends of reach and α_1, α_2 = velocity distributation coefficients for flow at ends of reach.

The energy loss term, h_e, in equation 2.1 is composed of friction loss, h_f, and form losses, h_o, as shown in equation 2.2. Only constraction and expansion losses in the geometric form loss term.

$$h_e = h_f + h_o \quad (2.2)$$

To approximate the transverse distribution of flow, the river is divided into strips having similar hydraulic properties in the direction of flow. Each cross section is subdivided into portions that are referred to as subsections. Friction, h_f, loss is calculated as shown below:

$$h_f = \left[\frac{Q}{K_t}\right]^2 \quad (2.3)$$

in which:

$$K_t = \sum_{j=1}^{NSS}\left[\frac{1.49}{n_j}\right]\frac{\frac{(A_2 + A_1)_j}{2}\left[\frac{R_2 + R_1}{2}\right]_j^{2/3}}{L_j^{1/2}} \quad (2.4)$$

where: A_1, A_2 = downstream and upstream area, respectively, of the flow normal to the cross section; NSS = total number of subsections across each cross section; K_t = length-weighted subsection conveyance; L_j = length of the j^{th} strip between subsections; n = Manning's roughness coefficient; Q = water discharge and R_1, R_2 = downstream and upstreamhydraulic radius, respectively.

Energy losses due to constractions and expansions are computed by the following equation:

$$h_o = C_L\left[\frac{\alpha_2 V_2^2}{2g} - \frac{\alpha_1 V_1^2}{2g}\right], \quad (2.5)$$

where: C_L = loss coefficient for expansion or constraction.

2.2 Theoretical Basis for Sediment Calculations

Sediment transport rates are calculated for each flow in the hydrograph for each grain size. The transport potential is calculated for each grain size class in the bed as though that are comprised 100% of the bed material. Transport potential is then multiplied by the fraction of each size class present in the bed at that time to yield the transport capacity for that size class. These fractions often change significantly during atime step, therefore an iteraction technique is used to permit these changes to effect the transport capacity.

The sediment transport function for bed material load is selected by user. Transport functions available in the program are th following:

- Toffaleti's (1966) transport function
- Madden's (1963) modification of Laursen's (1958) relationship
- Yang's (1973) stream power for sands
- Duboys' transport function (Vanoni 1975)
- Ackers-White (1973) transport function
- Colby (1964) transport function
- Toffaleti (1966) and Schoklitsch (1930) combination
- Meyer-Peter and Muller (1948)
- Toffaleti and Meyer-Peter and Muller combination
- Madden's (1985, unpublished) modification of Laursen's (1958) relationship
- Modification by Ariathurai and Krone (1976) of Parthenaides' (1965) method for scour and Krone's (1962) method for deposition of cohesive sediments.
- Copeland's (1990) modification of Laursen's relationship (Copeland and Thomas 1989)
- User specification of transport coefficients based upon observed data.

This research is chosen Yang's sediment transport function to calculate the unmeasured sediment input for HEC-6 model. This is his unit stream power equation (Yang, 1973), namely:

$$\lg C_{ts} = 5{,}345 - 0.286\lg\frac{\omega d}{\nu} - 0.457\frac{\sqrt{gDS}}{\omega} + \left[1{,}799 - 0.409\lg\frac{\omega d}{\nu} - 0{,}314\lg\frac{\sqrt{gDS}}{\omega}\right]\lg\left(\frac{VS}{\omega} - \frac{V_{cr}S}{\omega}\right) \qquad (2.6)$$

where: C_{ts} = total sand concentration (in ppm by weight); ω = terminal fall velocity; d = median sieve diameter of sediment particles; ν = kinematic viscosity; g = gravitational acceleration; VS = unit stream power and $V_{cr}S$ = critical unit stream power required at incipient motion.

The basis for adjusting bed elevations for scour or deposition (simulating vertical movement of the bed) is the continuity equation for sediment material (Exner equation):

$$\frac{\partial G}{\partial x} + B_o \frac{\partial Y_s}{\partial t} = 0 \qquad (2.7)$$

where: B_o = width of movable bed; t = time; G = average sediment discharge (ft^3/sec) rate during time step Δt; x = distance along the channel and Y_s = depth of sediment in control volume.

Equations 2.8 and 2.9 represents Exner equation expressed in finite diffrence form for point P using the terms shown in Figure 2.2

$$\frac{G_d - G_u}{0.5(L_d + L_u)} + \frac{B_{sp}(Y'_{sp} - Y_{sp})}{\Delta t} = 0. \qquad (2.8)$$

$$Y'_{sp} = Y_{sp} - \frac{\Delta t}{(0.5)B_{sp}} \cdot \frac{G_d - G_u}{L_d + L_u}, \qquad (2.9)$$

where: B_{sp} = width of movable bed at point P; G_u, G_d = sediment loads at the upstream and downstream cross sections, respectively; L_u, L_d = upstream and downstream reach lengths, respectively, between cross sections; Y_{sp}, Y'_{sp} = depth of sediment before and after time step, respectively, at point P; 0.5 = the "volume shape factor" which weights the upstream and downstream reach lengths and Δt = computational time step.

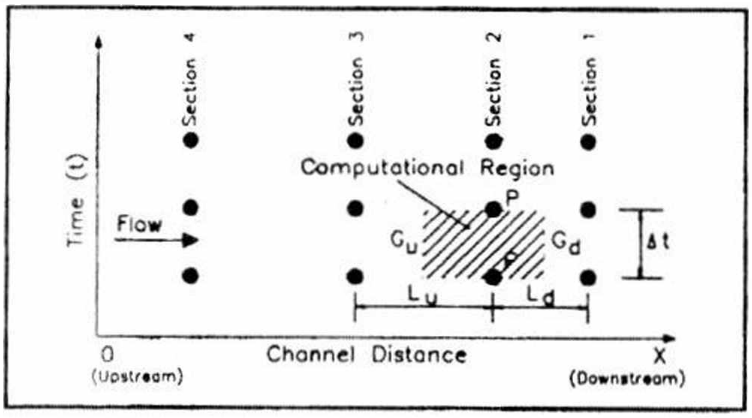

Figure 2.2. Computation grid

3. Simulation of changes of red river system profiles using HEC-6 model

3.1 Collected data

Research river reach is Da river reach (from Hoa Binh to Thao-Da confluence) and Red river reach (from Thao-Da confluence to Hanoi). The following data has been collected to simulate changes in the profile of this river reach:

- *Geometric data:*
  - 47 cross sections (from 1 to 47) in Da river reach (from Hoa Binh to Thao-Da confluence) sounded in 1992.

- 17 cross sections (from 48 to 64) in Red river reach from Thao-Da confluence to Hanoi sounded in 1992.
- 10 cross sections in Thao river (from Yen Bai to Thao-Da confluence) sounded in 1992
- 6 cross sections in Lo river (from Vu Quang to Viet Tri) sounded in 1992
- 2 cross sections in Duong river sounded in 1992
- Thalweg profiles of Red river (from Hoa Binh to Thao-Da confluence) sounded in 1992, 1994, 1997

- *Hydrological data:*

- Flow data: daily average water discharges in years from 1988 to 1998 at Ha Noi and Son Tay stations in Red river, Thuong Cat station in Duong river, Yen Bai station in Thao river, Hoa Binh station in Da river and Vu Quang station in Lo river.

- Water level: daily average water level in 1993 year at Son Tay station and in years from 1988 to 1998 at Hanoi station.

- Water temperature: monthly average water temperature of period from 1988 to 1998 at 6 stations: Hoa Binh, Yen Bai, , Vu Quang, Son Tay, Hanoi, Thuong Cat, stations.

- *Sediment data:*

- Daily average suspended sediment concentrations and discharges years from 1988-1996 at 7 stations: Hoa Binh, Yen Bai, Vu Quang , Son Tay, Hanoi, Thuong Cat.

- Monthly average grain size composition of suspended sediment at 7 stations: Hoa Binh (64-70, 72-75, 77-78), Yen Bai (64-70, 72-75, 77), Vu Quang (65-70, 72-75, 77-78) , Son Tay (65-70, 72-75, 77-78), Ha Noi (65-70, 72-75, 77-78), Thuong Cat (65-70, 74, 77).

- Grain size gradation curve of suspended sediment and table of grain composition percentages corresponding to grain diameters at cross sections: 2 in Lo river; 10 and 37 in Da river; 1 in Thao river; 54, 63, 70 in Red river and 2 in Duong river (surveyed in October 1996).

- Grain size gradation curve of bed sediment and table of grain composition percentages (%) corresponding to grain diameters (mm) surveyed in May 1996 at cross sections 63, 65, 67 in Red river and cross section 4 in Duong river (downstream of Thuong Cat station).

3.2 Computational scheme

Depending on the data availability, hydrologic stations and principles used in HEC-6 model, the whole research river network is schematicalized in figure 3.1. Upstream boundaries used in the model are Hoa Binh, Yen Bai, Vu Quang and Thuong Cat stations. Downstream boundarie is Hanoi station. Computational scheme for the river network consists of 1 main river and 3 tributaries with total 82 cross sections. Main river of the computational scheme is Red river reach with downstream boundary is Hanoi hydrological staion and upstream is Hoa Binh hydrological station. The first tributary (tributary of division water) of the computational scheme is Duong river reach with upstream boundary is flow divisional point between Red river and Duong river and downstream boundary is Thuong Cat hydrological station. The second tributary of the computational scheme is Lo river reach with downstream boundary is junction of Red river and Lo river and upstream boundary is Vu Quang hydrological station. The third tributary of the computational scheme is Thao river reach with upstream boundary is Vu Quang hydrological station and downstream boundary is Thao-Da confluence.

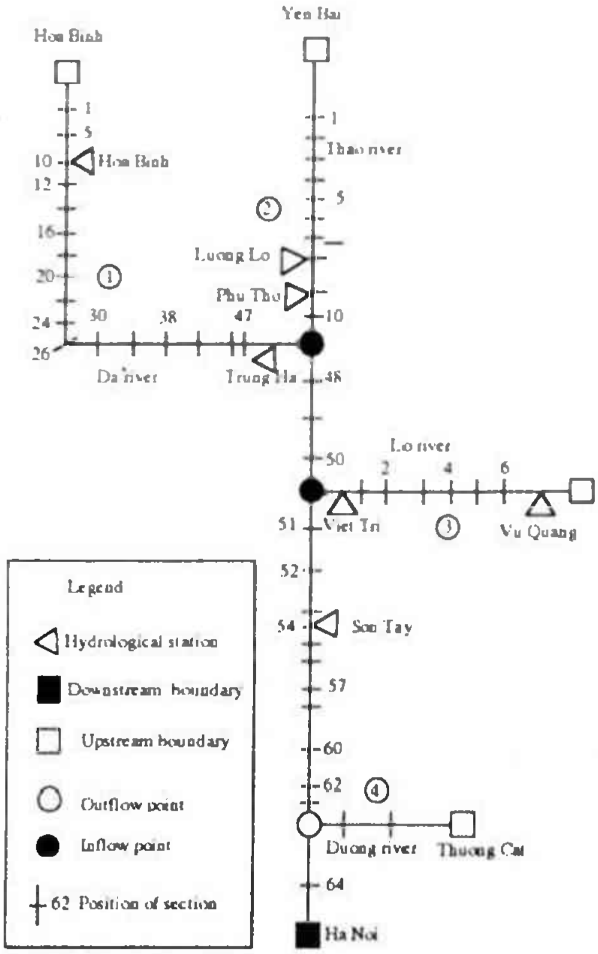

Figure 3.1. Computational scheme of Red river network (research reach)

3.3 Input data

Input data file of HEC-6 is organized into 3 groups: the first group is geometric data, the following group is sediment data and the last group is hydrological data. Geometric data is arranged in following order: the position of local junction and diversion points in the river network, the position of cross sections in the river network, the geometry of cross sections (coordinate points of cross sections and the distances between cross sections), the values of Manning's roughness n in cross sections (include Manning's n values of the main channel and overbank areas) and conveyance limits of channel at cross sections. Sediment data includes fluid and sediment properties, the inflowing sediment load data, the gradation of material in the stream bed, the transport capacity relationship and unit weights of deposited material. Hydrological data includes water discharges, temperatures, downstream water surface elevations and flow duration.

3.4 Initial and boundary conditions

Initial condition is cross section geometry of river segments in computational scheme at the time that computation is started. Measured geometric data of 82 cross section in computational scheme in 1992 is used as the initial condition. This data is represented in coordinate point form (stations, elvations) of positions in cross sections in the order from the left to the right (downstream). The elevations may be positive, zero or negative. The cross sections are arranged from downstream to upstream, starting from cross sections of the main river, then to cross sections of the tributary river.

In a river system there are three types of boundaries: upstream, downstream and internal. The upstream and downstream boundaries are at the cross sections that are most upstream and most downstream, respectively, on a stream segment. There are three types of internal boundaries: a local inflow, a tributery junction, and a hydraulic control point. There are also three boundary conditions that can be prescribed by HEC-6: water discharge, sediment discharge, and surface elevation (stage). The water and sediment discharges must be defined at each upstream boundary and at each local inflow point. Stage must be prescibed at the downstream boundary of the primary stream segment; and it can be precribed at hydraulic control points. In study river network the upstream boundary conditions include water discharge, sediment discharge and daily average temperature at Hoa Binh, Yen Bai, Vu Quang and Thuong Cat stations. The downstream boundary condition is daily average stage (water surface elevation) at Hanoi station. The computational time step is one day.

3.5 Model calibration

HEC-6 model simulates changes of river profiles combined using three models: hydraulics model, sediment transport model and morphologic model. Hydraulics model is used to compute water surface profile at each time step. Sediment transport model is used to compute sediment transport discharge across each cross section in computational schema at each time step. Morphological model is used to compute changes of river bed elevations for scour or deposition. Parameters needed calibration in HEC-6 are mainly parameters of hydraulics model, that are Manning's roughness coefficients of river bed, left and right over banks.

The study used hydrological and sediment transport data in 1993 to calibrate hydraulic and sediment transport model.

The calibration process of hydraulic model is carried out as follows:

- Preliminary selection a set of roughness coefficients at all of cross sections in computational scheme. This preliminary selection is carried out on experience: selection roughness coefficients from 0.1 to 0.15 for over bank part and from 0.022 to 0.042 for river bed part.

- Using HEC-6 model, in turn smulation hydraulcs with the selected set of hydraulics parameters in condition that the channel is regarded fixed channel. Input data of hydraulics are daily average water discharge of Hoa Binh, Yen Bai, Vu Quang, Thuong Cat stations and daily average stage (water surface elevation) at Hanoi station in 1993. Results of hydraulics simulation are the stage at all of cross sections in the computational scheme at each time step.

- Take Son Tay station in Red river (section 54) to make control section. From hydraulics simulation results with the selected set of parameters, extraction and drawing on graph computed daily average stage process at Son Tay station 1993. Comparison it with measured daily average stage process at Son Tay station 1993 and estimation agree level by Nash norm.

After a lot of try and error times with many different couples of river bed and over bank roughness coefficients, the study selected a couple of river bed and over bank roughness coefficients that results in the best hydraulics simulation result: river bed roughness coefficient is 0.029, left and over bank roughness coefficients is both equal 0.10. With this set of hydraulic parameters, effective level of the model computed on Nash norm is the highest (98.9%) and the forms of computed and measured water suface elevation process graph agree highly each other (Figure 3.2).

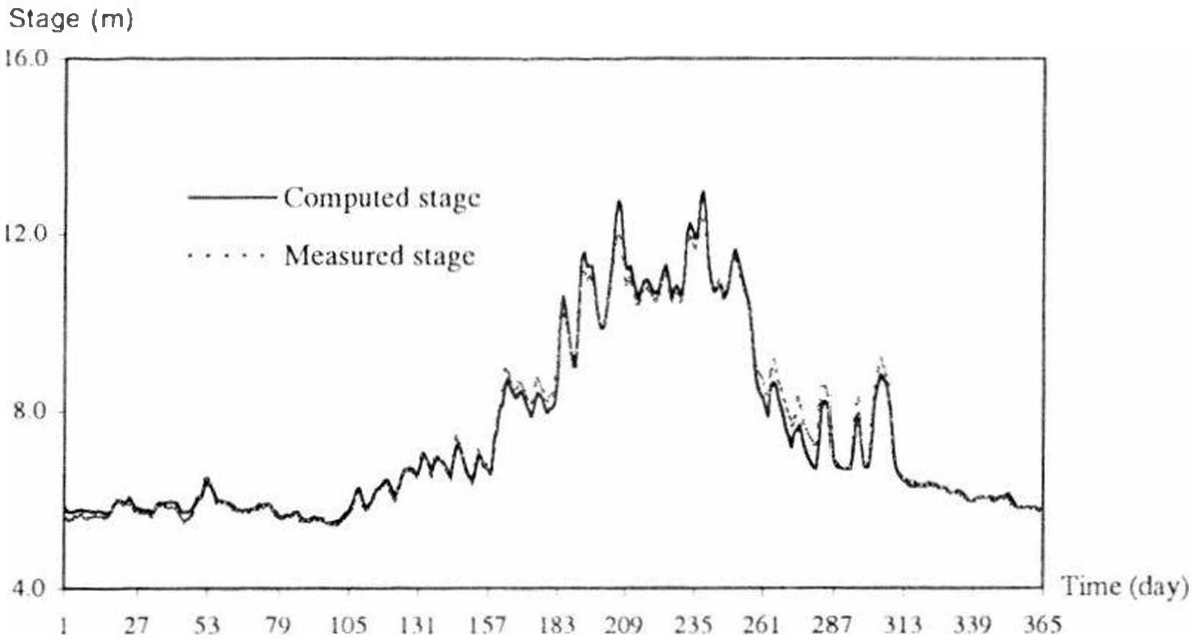

Figure 3.2
Computed and measured daily stage process at Son Tay station in 1993

Accuracy of sediment transport simulation of river network depends on accuracy of hydraulic simulation results, on accuracy of definition parameters of sediment transport model and selected sediment transport function. The study defined carefully parameters of sediment transport model basing oneself on collected data, selected Yang's sediment transport function and ran sediment transport model using the set of hydraulic parameters that selected when calibration hydraulic model. The simulation results are daily sediment discharges across each cross section in computational scheme in 1993. From these results, the study extracted daily sediment discharge process data across cross section of Son Tay station, drew combinatively computed and measured daily sediment discharge process graphs at Son Tay station in 1993 on the same coordinate system, and estimated effective level of sediment transport model on Nash norm. These results showed that computed and measured sediment discharges agree rather each other (Figure 3.3), effective level computed on Nash norm reachs 0.76.

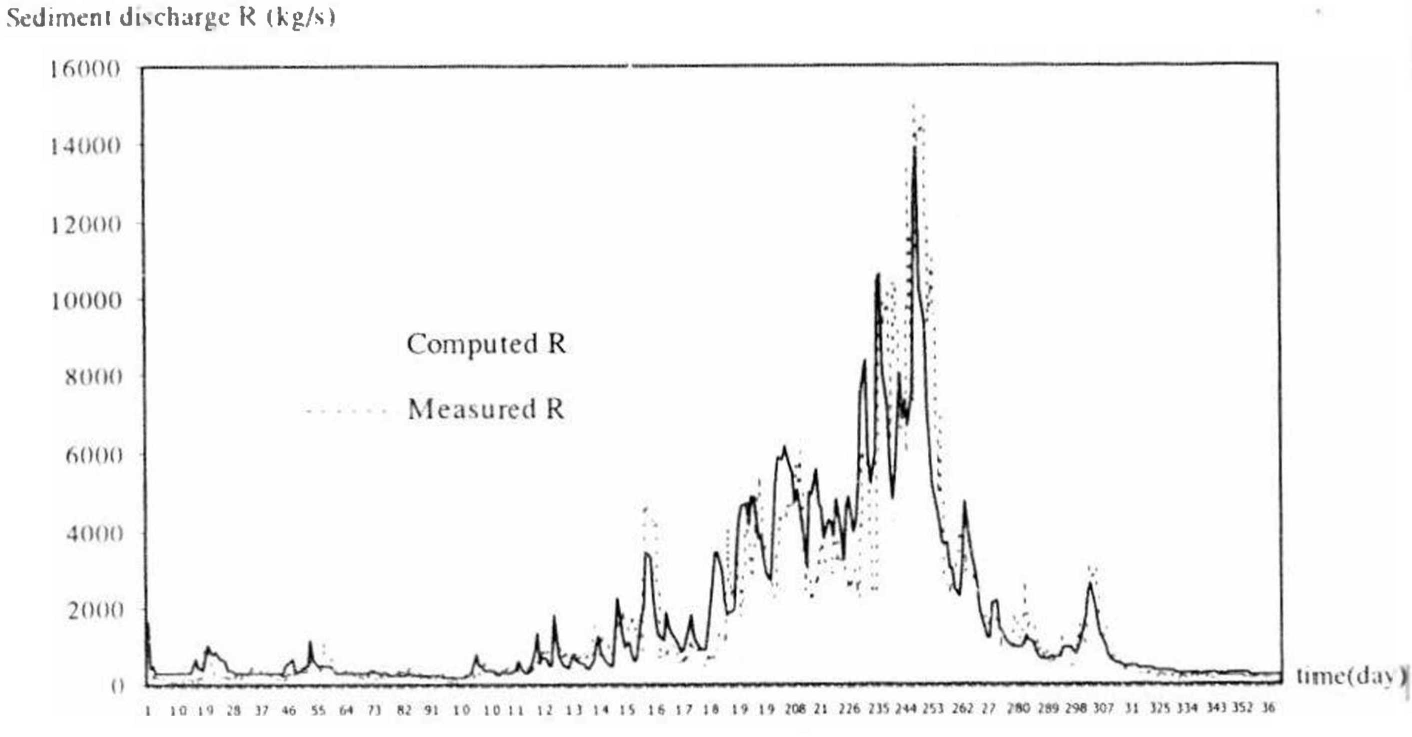

Figure 3.3. Computed and measured daily sediment discharge process graphs at Son Tay station in 1993

3.6 Model verification

Morphological model is simulated based on computational scheme established for hydraulic model with ultimate hydraulic and sediment parameters. River thalwegs measured in 1994 of reach from Hoa Binh to Trung Ha and in 1997 of reach from Hoa Binh to Ha Noi are used to verify the model. Input data is daily average discharge from 1992 to 1997. The results include: total sediment discharge inflow and outflow each river reach for each grain type at each time step, quantity of scour or deposition sediment on each river reach at each time step, water surface and river bed elevations at cross sections of computational scheme at each time step, total sediment discharge from tributaries inflow main river and outflow main river, total scour and deposition sediment quantity over study river reach.

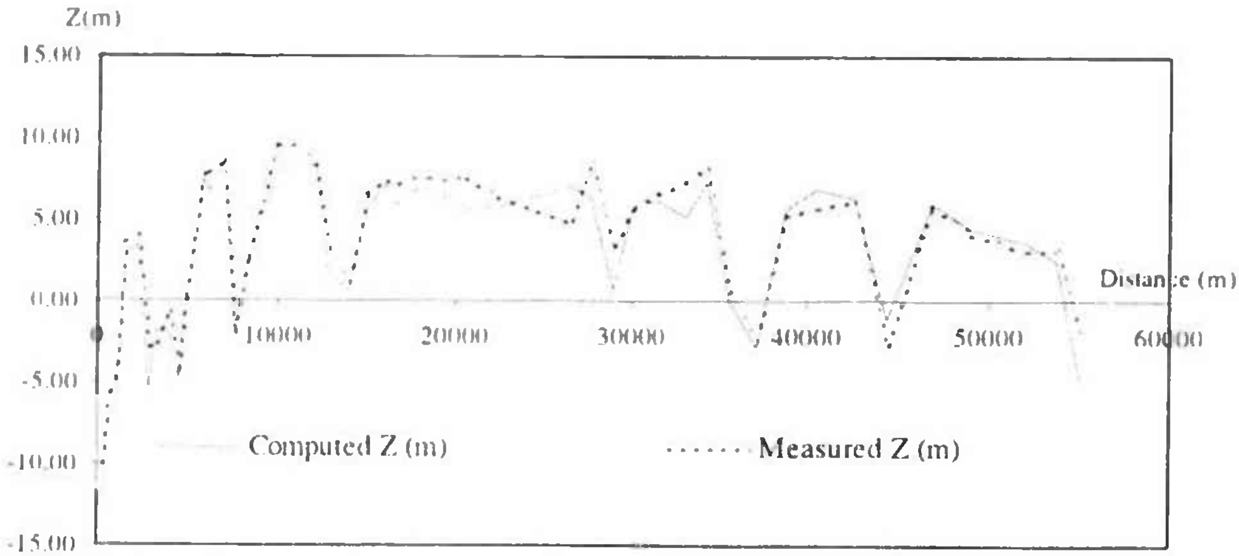

Figure 3.4. Computed and measured Da river thalweg of reach from Hoa Binh to Trung Ha in 1994

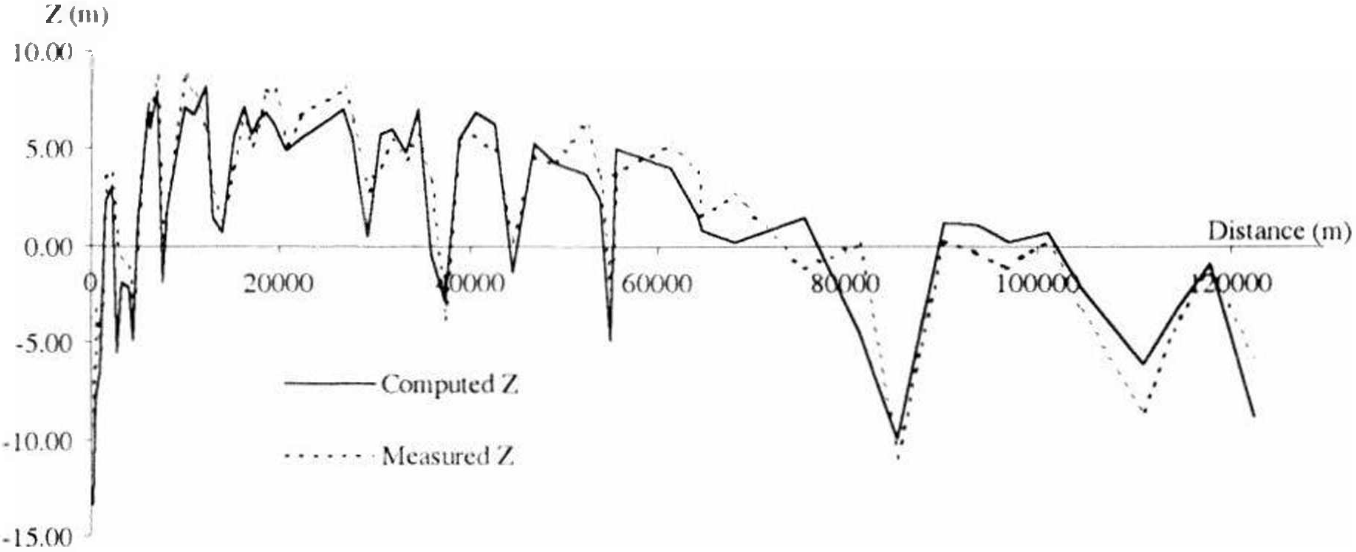

Figure 3.5. Computed and measured river thalweg of reach from Hoa Binh to Ha Noi in 1997

Results of comparison between computed and measured thalwegs of Da river reach from Hoa Binh to Trung Ha in 1994 and Red river reach from Hoa Binh to Ha Noi in 1997 are shown in Figures 3.4 and 3.5. These figures show that computed river thalweg agree rather with measured river thalweg. Effective level of the model computed on Nash norm of 1994 reachs 0.93 and of 1997 reachs 0.87.

3.7 Simulation changes of Red river bed to 2032

The results of model calibration and verification show that HEC-6 model with the set of selected optimal parameters can use to simulate changes of Red river bed in the future.

With intinial condition is measured river bed profile in 1992, the symbolic water discharge processes (average of 11 years fom 1988 to 1998) at Hoa Binh, Yen Bai, Vu Quang, Thuong Cat stations are the upstream boundaries and the symbolic stage processes (average of 11 years fom 1988 to 1998) at Ha Noi station is the downstream boundary, the study simulated changes of Red river bed to 2032. The rersults are showed in Figure 3.6. These results show that:

- Deep scour phenomenons resulting from regulating effect of Hoa Binh reservoir happen almost only in Da river and transmit only to Trung Ha station.
- The deep scour speed in Da river reduces gradually (See table 3.1). Da river bed will become gradually stability (to reestablish the new balance state).

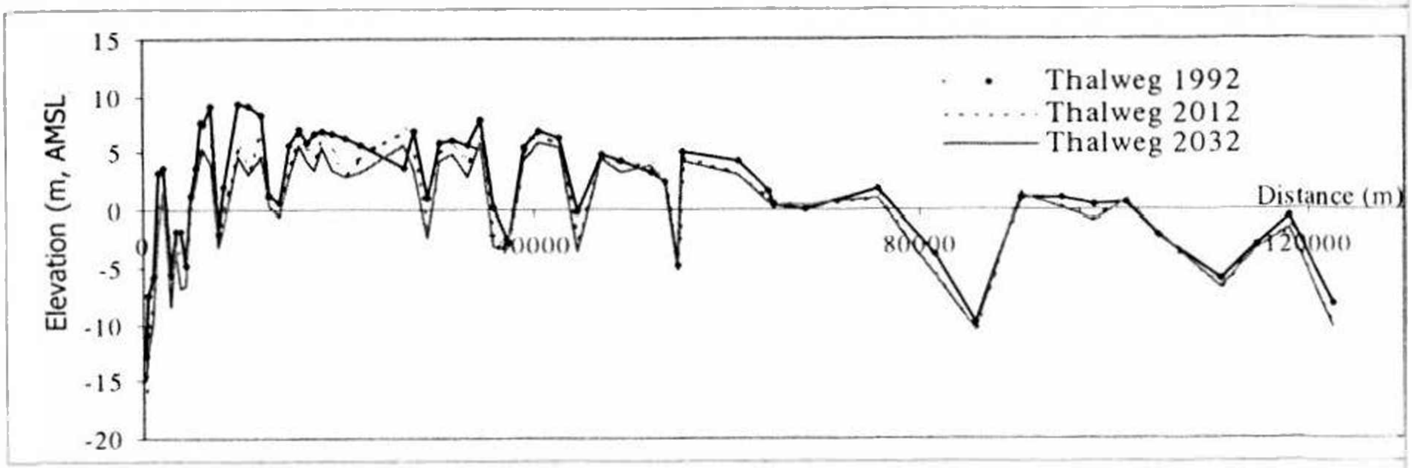

Figure 3.6. Predited result of Red river bed changes to 2032
(reach from Hoa Binh to Ha Noi)

Table 3.1 Average deep scour speed at some cross section in deffrent period (m/year)

Cross section	1992 - 2002	2002 - 2012	2012 - 2022	2022 - 2032
Section 5	0.380	0.168	0.062	0.000
Section 18	0.061	0.003	0.001	0.000
Section 48	0.021	0.017	0.014	0.013

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MÔ PHỎNG DIỄN BIẾN LÒNG DẪN HỆ THỐNG SÔNG HỒNG BẰNG MÔ HÌNH HEC-6

(Đoạn sông Đà từ Hoà Bình đến ngã ba Thao Đà và đoạn sông Hồng từ ngã ba Thao-Đà đến Hà Nội)

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Với hai nhiệm vụ quan trọng hàng đầu là phát điện và phòng lũ cho hạ du, từ khi vận hành, hồ Hoà Bình đã và đang đem lại những lợi ích hết sức to lớn nhưng cũng đã và đang gây ra những thay đổi khá bất lợi như bồi lắng lòng hồ, xói cục bộ hạ lưu đập và xói lan truyền về hạ du... Đánh giá, mô phỏng và dự báo các thay đổi sau khi xây dựng các công trình trên sông để đề xuất các biện pháp hạn chế các thiệt hại luôn là đề tài cấp thiết và có ý nghĩa thực tiễn lớn. Công cụ hữu hiệu và kinh tế để giải quyết các đề tài này là mô hình toán.

HEC-6 là mô hình số thủy động lực một chiều trong lòng dẫn hở có biên di động được Trung tâm Kỹ thuật Thủy văn Hoa Kỳ thiết kế để mô phỏng và dự báo các thay đổi trong trắc diện dọc sông do xói hoặc bồi trong các thời đoạn vừa.

Bài báo này nghiên cứu ứng dụng mô hình HEC-6 để mô phỏng diễn biến lòng sông Đà phía hạ lưu đập Hoà Bình (đoạn từ Hoà Bình đến ngã ba Thao-Đà) và lòng sông Hồng (đoạn từ ngã ba Thao-Đà đến Hà Nội). Kết quả hiệu chỉnh và kiểm định mô hình cho thấy mô hình HEC-6 với bộ thông số tối ưu đã lựa chọn có thể sử dụng để mô phỏng diễn biến lòng sông Hồng trong tương lai với mức độ chính xác có thể chấp nhận được. Kết quả mô phỏng diễn biến đáy sông Hồng bằng mô hình HEC-6 với bộ thông số đã lựa chọn với điều kiện ban đầu là lòng sông Hồng đo đạc năm 1992, điều kiện biên trên là đường quá trình lưu lượng điển hình (dạng trung bình nhiều năm thời kỳ 1988-1998) của các trạm Hòa Bình, Yên Bái, Vụ Quang, Thượng Cát và điều kiện biên dưới là đường quá trình mực nước điển hình (dạng trung bình nhiều năm thời kỳ 1988-1998) của trạm Hà Nội cho thấy:

- Hiện tượng xói sâu do ảnh hưởng điều tiết của hồ Hoà Bình chủ yếu chỉ xảy ra trên sông Đà và chỉ lan truyền đến trạm thủy văn Trung Hà.
- Tốc độ xói có xu hướng giảm dần. Lòng sông Đà dần dần trở nên ổn định (lập lại trạng thái cân bằng mới).