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OPERATION OF MOSUL – DOKAN RESERVOIRS AND SAMARRA BARRAGE USING HEC – RES.SIM MODEL DURING FLOOD PERIOD

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Abstract: Major dams on Tigris River were designed and constructed as multi – purposes reservoirs. Since the flood event may occur for a specified period of the year, simulation model could be developed for rapid release decision according to time series reservoir inflow. This study deals with the application of HEC – ResSim version 3.1 in order to simulate and evaluate the behavior of the reservoirs system represented by Mosul, Dokan reservoirs, and Samarra barrage during the flood period 1987-1988 which is considered as a flood period. The release function of date was applied as an operating rule in order to provide safety reservoir storage accompanied with downstream release control. The results obtained from simulation of operating alternatives had been compared with the historical recorded data for the same time of simulation period, and exhibit flood control caused by specifying reservoir outflow with an appropriate limits yields appreciable matching between reservoirs' rule curves and computed pool elevation for both reservoirs. The simulation plots revel the ability of the existing projects to assist in sizing flood risk during flood event, and the storage level in the reservoirs reached a suitable elevation according to the time period of inflow, storage, and release values with the ability of Samarra barrage to divert excess flood water towered Tharthar Lake.

Keywords: *alternative, simulation, HEC-ResSim, rule curve, operation*

1. Introduction

Flood control requires free volume in the reservoir to catch and store floods. The captured flood waters are gradually released at rates that do not cause damage to downstream users. HEC – ResSim software is the reservoir simulation model developed by U.S. Army Corps of Engineers, hydrologic engineering center, was used in order to predict the reservoirs performance during specified operation period [1]. This software offers different operational rules to support reservoir simulation. One of these powerful operation rules is release function of date used as it allows maximum and minimum flow to be released from reservoir elements. Reservoir releases are related with planning purposes, represented by specifying the target release known as rule curve (time varying pool elevation) [2]. HEC – ResSim model involves three main modules, as they accomplished the model established, starting with watershed module which is related in

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specifying all of the streams, lakes, reservoirs projects, country border, and computation points. All of these elements applied with the aid of ARC – GIS layers. Reservoir network is the next module. The configuration of the watershed is fully created by identifying all reservoirs with their physical properties including length of dam, height of crest level, reservoirs storage, evaporation rates, time series data associated with reservoirs inflow and outflow in addition reservoir pool elevations versus storage. In this study all physical data and ArcGIS shape file were obtained from ministry of water resources (unpublished). The setting of an operational data required establishing an operating rules specified for the zone. The result of model formulation is achieved by time processing window dealing with operational alternatives edited within reservoir network module. The yield of simulation run described as simulation module [3]. Barra E.A. Jebbo, et al. (2016) present simulation model for operating Mosul reservoir using HEC – ResSim Software and compared model results with previous studies [4]. Masoud Meshkat, et al. (2018), design a HEC – ResSim Model for Tiago – Hammond reservoirs system, located in Chemung river basin to control flow during rising pools elevation[5]. Eliza I.Tica, et al. tested the HEC – ResSim Program to optimize vidraru hydropower power station, and provide review of papers concern with HEC – ResSim application [6]. The main goal of this study is to execute HEC – ResSim program in order to mimic operating scenario for the reservoirs system represented by the reservoirs of Mosul, Dokan dams, and Samarra barrage during wet season and present the mechanism of HEC– ResSim to mitigate and sizing flood during flood period.

2. Material and Methods

2.1. Study Area

The study area under consideration comprise of Mosul dam located on Tigris river , Dokan dam take place on lesser Zab and Samarra barrage situated on Tigris River in Iraq.

The project of Mosul Dam is located about 50 km north east of Mosul city at the coordinates 36° 37′ 49″ N and 42° 49′ 23″ E. The main purposes of Mosul dam are flood protection, hydropower production, serving water for irrigation, and environmental enhancement. The dam is type of an earth embankment with height of 113 m, and 3650 m length and has a total storage capacity of 11.1 billion cubic meter. The dam supplied with four penstocks diverting water to the power station [4].

Dokan dam is situated on lesser Zab river in Sulymania governorate north Baghdad with the coordinate 35° 57′ 15″ N and 44° 57′ 10″ E nearby from Ranya city. The height of dam is 116.5 m and 360 m length and the top elevation is 516 m with storage capacity of 6.1 billion cubic meter. The main functions of the dam are reducing flood risk, generation of electric power, and supply water for irrigation projects [7].

Samarra barrage is type of low head structure constructed on Tigris River, near Samarra city north of Baghdad city, with coordinate 34^0 11′ 27″ N and 43^0 51′ 19″ E. The chief tasks of this structure are mainly for convey excess water from Tigris river during flood season into Tharthar depression with coordinates $34^0$16′ 29″ N and 43^0 18′ 28″ E covered an area 2000 km^2 received diverted water from Samarra barrage by an artificial canal. Irrigation is another purpose, in addition hydropower station installed with a capacity of 87 megawatts [8]. The position of the reservoirs system are illustrated in Figure (1).

Figure 1. Schematic diagram of the reservoirs (from google earth)

2.2. Model Configuration

The pattern of of HEC–ResSim software, consist of three successive modules as shown in Figure (2), these modules specify the model output by demonstrate the simulation of the reservoirs operation within study area. These modules are as follow:

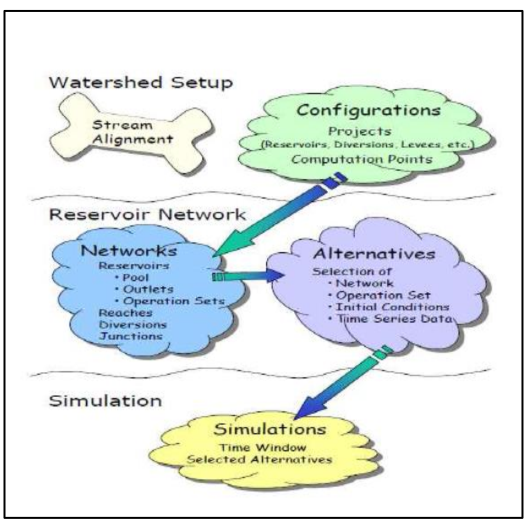

Figure 2. Stages of model development

1- Watershed module: this module is the primary stage of model development, in which, the reservoir network with the main rivers are established by imported reservoirs, lakes, rivers, and country border from shape file. Watershed configuration has been done with this module.

2- Reservoir network module: this module is an essential part of model development. A scheme of the reservoir system under consideration shown in Figure (3). The module involves two types of data denoted as physical properties and operation function. The physical data for a specific reservoir are Data concern time varying storage elevation, storage – elevation relationship, evaporation rates, parameters dealing with editing reaches by identifying routing coefficients X and K values required for Muskingum method an approach used for routing stream segment between two junction points, the whole Data are listed in tabulated form by assigning each type of data for the required elements such as dam, reservoir, reach. The second is operating rule, imply specifying operation set for each reservoir, allocate operation zone, and edit the operating rule (release as function of date was used in this study), flow type of maximum limit [9]. Two sets of releases are considered, the first one is specify constant release values as 1500 m^3/s, 500 m^3/s, and 1000 m^3/s for Mosul, Dokan, and Samarra reservoirs system respectively with the corresponding look back elevations 310m, 500m, and 68m. The set of releases depend on both reservoir inflow and storage related with assigned elevation. Figure (4), gives a description for operation set of Mosul reservoir. The second set is specifying same values for Mosul and Dokan reservoir and applying time varying release rather than constant release for Samarra barrage, as shown in Figure (5) in order to examine the effect of changing the operation rule on Samarra barrage releases (outflow) during the period of simulation time.

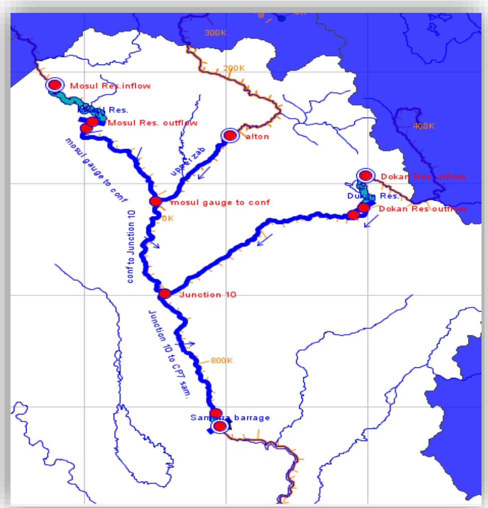

Figure 3. Schematic of reservoirs module

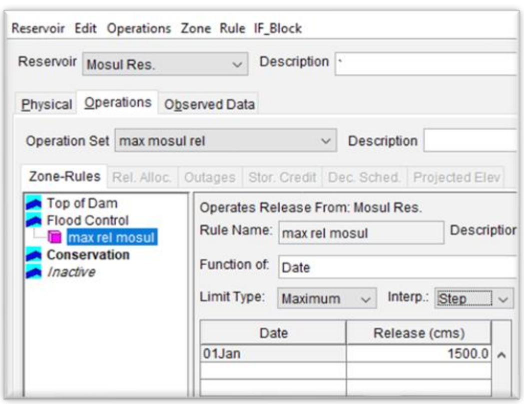

Figure 4. Operation set for Mosul reservoir

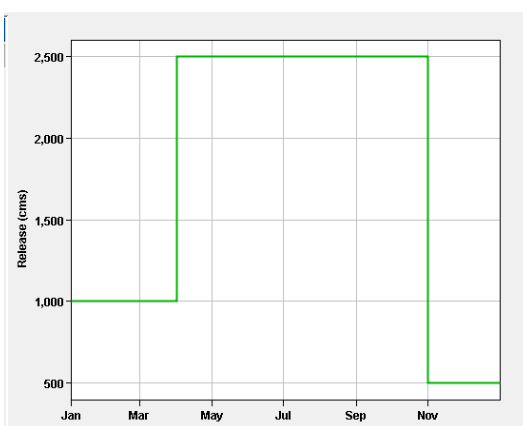

Figure 5. Multi step Release function of date for Samarra barrage

3- Simulation module: In HEC– ResSim, the mechanism of simulating operation alternatives consist of formulate an operation set assigned for each reservoir in the network, select an operating function, and from edit alternative menu, insert the look back period with the historical inflow data, all these rules should be edit with reservoir network module [10]. the results of simulation run are accomplished by selecting a simulation periods known as date of starting simulation, specify look back period date, and the date of the elapsed time of simulation run in the menu of simulation time window. These periods are illustrated in Figure (6).

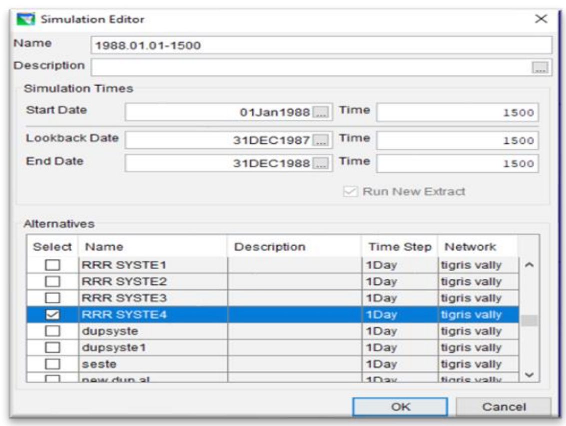

Figure 6. Simulation time window of selective alternative

3. Results of Simulation Module

The edit of simulation module during allocated time periods are illustrated by Figure (7), Figure (8) and Figure (9) for Mosul, Dokan, and Samarra reservoirs respectively assigned for the first alternative. The simulation for the second alternative in case of modified releases from Samarra barrage illustrated in Figure (10).

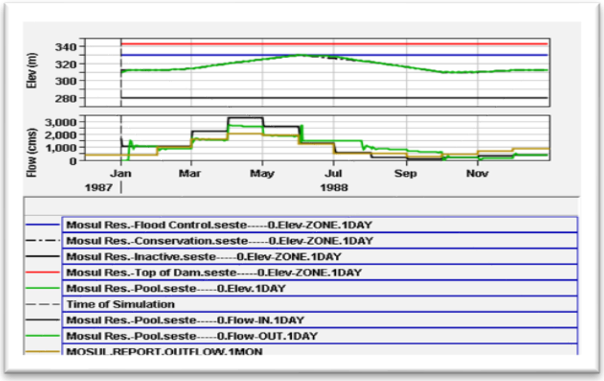

Figure 7. Mosul reservoir releases

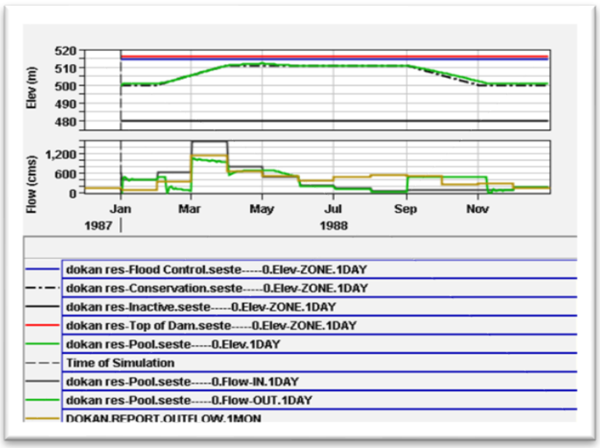

Figure 8. Dokan reservoir releases

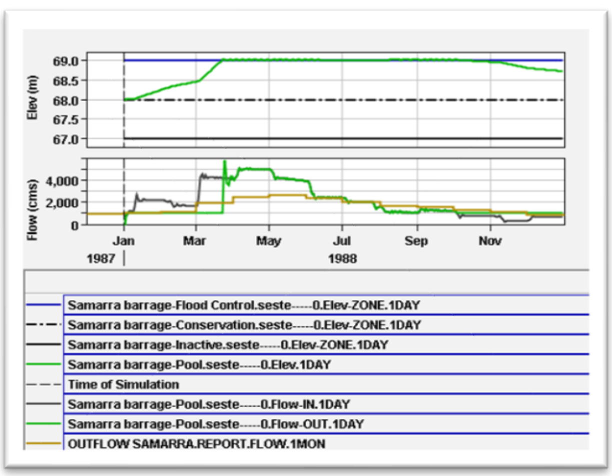

Figure 9. Samarra reservoir releases

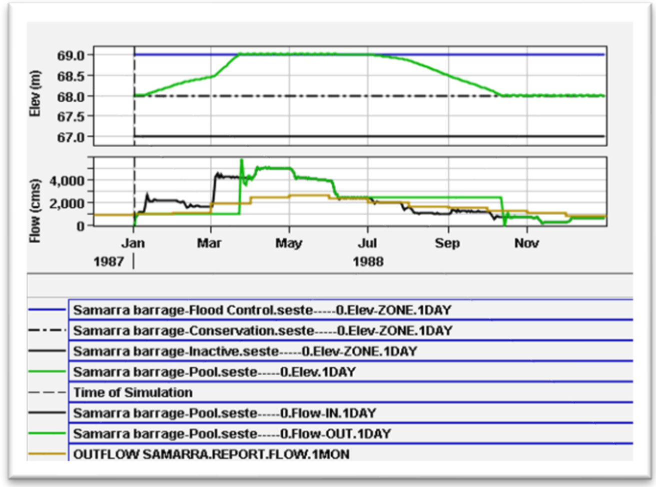

Figure 10. Modify release for Samarra barrage

4. Results Analysis

The simulation results are obtained by applying the release function as an operational rule. The flow of maximum limit type ($1500 m^3/s$),($500 m^3/s$), and ($1000 m^3/s$) specified for Mosul, Dokan, and Samarra barrage respectively, the corresponding look back elevations are, 310m,500m,and 68m. Figures (7), (8), and (9), illustrate the characteristics of reservoirs operation for the first alternative. The upper region of the scheme shows, the reservoir operating zones, computed elevation of the reservoir pool, and the reservoir rule curve. The yield of the lower scheme, are recorded and computed releases, and time – series inflow data.

The upper portion of the Figures (7) and (8) illustrate matching between computed pool elevation (green line) and the conservation pool elevation (black dash line) for Mosul and Dokan reservoirs. This matching is mainly belong to the outflow values from Mosul and Dokan reservoirs (green line in the lower portion of the above figures). The reservoirs releases are compared with the historical reported data (dark orange line in the lower portion). Despite the constant release values applied as a primary operation function for Mosul and Dokan reservoirs, the plots of

HEC–ResSim Yields variation in releases during time of operation. This reflects the ability of HEC–ResSim to attain the balance between reservoir storage and release values in order to obtain operation pool level within reservoir rule curve (observed level) [11]. Reservoir operation within conservation zone is preferable to keep the reservoir safe against extreme flood or successive flood events which are the target of the operating alternatives [12].

For Samarra barrage, since inflow values (black line in the lower portion) are greater than the release value (green line in the lower portion) (1000 m^3/s) during the first six months causes rising in reservoir pool elevation (green line in the upper portion) to flood level (69m) during end of March to November as shown in figure(9). This alternative has been modified by applying time varying release rather than constant release, as shown in Figure (10). This alternative result in reduce the flood wave period, and Re – operate Samarra barrage within conservation zone. As the difference between inflow and outflow values increases, especially during flood period, excess water should be diverted toward Tharthar Lake in order to avoid downstream flooding as illustrated in Figure (11). This allocation was controlled by the flood control release functions [13].

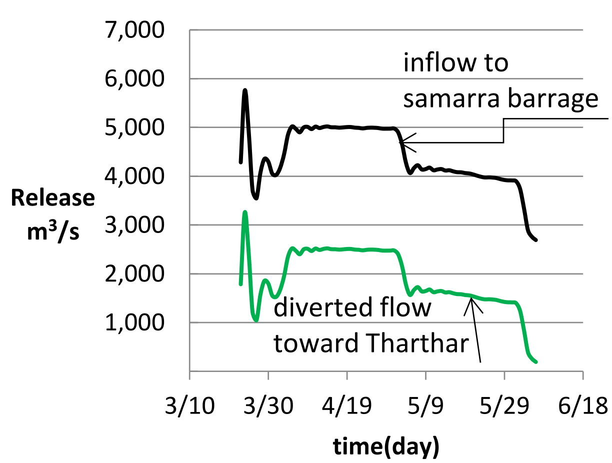

Figure 11. Samarra barrage releases

5. Conclusion

1. The HEC-ResSim software is a powerful tool provide the mechanism to simulate the operation of the reservoir system represented by Mosul, Dokan, and Samarra barrage reservoirs using the release function as an operational rule causes matching between design and operation rule curve.
2. From simulation schemes, the derived rule curves are within the higher stage of the conservation zone that's not encroach the flood zone, since the HEC—ResSim looking for reaching the stage of conservation zone during simulation period, causes variations in the release values despite applying constant release operating function.
3. Simulation results performed effective management of reservoirs in storing and supply appropriate releases causes operating reservoir curve approach to the reservoir rule curve.
4. The reservoirs releases could be read directly from the simulation plots as a function of storage level and inflow rate.
5. The system management of extreme flow analysis is carried out through Samarra barrage during flood in order to let pass through the regulator an assigned flow towards Baghdad city.
6. Flood in Samarra depends on natural flood on Greater Zab (unregulated flood), and on Mosul dam flood management, and to a smaller extent on Lesser Zab regulated flood.

Conflict of interest

The authors confirm that the publication of this article causes no conflict of interest

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