DEVELOPING EXPERT SYSTEM FOR OPERATING HADITHA DAM

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This search presents the development and application of an Expert System for operating Haditha dam, which is considered the second biggest dam in Iraq. Haditha dam is a multi – purpose hydro – development designed to control the Euphrates River flow in the interests of irrigation, electric power generation and for partial accumulation of extreme Euphrates River inflows into Haditha reservoir.
Haditha dam was constructed on the Euphrates River in the Middle West of Iraq (8km) upstream from Haditha town. In 1988 the project was completed. Central and southern parts of Iraq get the benefit of irrigation water from its reservoir. It is consist of the body of the dam, hydro-power station generates (660 Mw) from (6 generator units), Spillway with (6 opening controlled by radial gates) and two Bottom outlets.
Ministry of Water Resources denoted that year (2009) is a drought year for that reason the good management for water resources is very important. Haditha dam was taken as case study because the important of the project and its [water level elevation became (116 m.a.s.l.) for the mentioned year while its dead water level is (112 m.a.s.l.),(G.S.D.R.),(2012)] which means that the reservoir is almost empty, where the hydro-power station is stopped for (4 months) (from 9/2009 to 12/2009) and the release was just from the Bottom outlets. Therefor an Expert System is developed to operate the dam. Expert System (ES) is a branch of artificial intelligence (AI) that has achieved considerable success in recent years. The area of expert systems involves investigation into methods and techniques for constructing human-machine systems with specialized problem solving expertise. Expert system has many applications in the field of water engineering such as construction, design, planning, operation and maintenance of hydraulic structures. The language used to program the Expert System in this search is (VISUAL BASIC) program within windows environment. The Expert System has developed depending on actual data for operating dam for (21 years) from 1991 to 2011),[G.S.D.R.,(2012)]. It is found that using the developed Expert System for operating Haditha dam monthly and daily was very efficient where randomly the measured average monthly water levels for (10/1991) and (9/2011) were (136.95 and 135.72, respectively) while the calculated by the program (136.80 and 135.59, respectively) were the results calculated showed that the difference between the calculated water levels and the measured water levels was as average (15 cm) which means that the development of expert system is correct.

KEY WORDS: Dam, Operation, Expert, System, Haditha, Operation Rules.

تطوير نظام خبير لتشغيل سد حديثة

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البحث يتناول تطوير وتطبيق نظام خبير لتشغيل سد حديثة ، ولأهميته حيث يعتبر ثاني اكبر سد في العراق. تم تصميم سد حديثة كسد متعدد الاغراض اهمها السيطرة على نهر الفرات والاستفادة من مياهه لأغراض الري و توليد الطاقة الكهربائية و خزن المياه في خزان سد حديثة.

تم انشاء سد حديثة في الغرب الاوسط في العراق ويبعد 8 كلم عن مدينة حديثة وتم الانتهاء من تشييده عام 1988 تستفيد المناطق وسط وجنوب العراق من المخزون المائي في السد لاغراض الري يتالف السد من جسم السد ومحطة كهرومائية بقدرة (660 ميكا واط) متألفة من 6 وحدات توليد و مسيل مائي يحوي على 6 فتحات مسيطر عليها بواسطة بوابات شعاعية بالإضافة الى منفذي تفريغ .

اعلنت وزارة الموارد المائية عام 2009 هي سنة جفاف ولذلك يستوجب ايجاد ادارة جيدة للموارد المائية في القطر . وقد تم استخدام سد حديثة (كحالة مدروسة) بسبب اهمية السد ولكون منسوب الماء في السد للسنة المذكورة قد وصل الى منسوب (116 فوق مستوى سطح البحر) في حين ان المنسوب الادنى للسد (112 فوق مستوى سطح البحر) (هيئة السدود و الخزانات، (2012)) وذلك يعني ان خزان السد كاد ان يفرغ، وان المحطة الكهرومائية تم ايقافها لمدة اربعة اشهر من 9 / 2009 و لغاية 12/ 2009 وكان الاطلاق فقط من منافذ التفريغ ولذلك تم تطوير نظام خبير لتشغيل السد. و النظام الخبير هو احد فروع الذكاء الاصطناعي والذي اثبت نجاح في السنوات الاخيرة وبالاعتماد على مساحة التحريات للحالة المدروسة لعمل نظام يحاكي الخبرة البشرية لحل المشاكل في المجالات المختلفة.

تم تطبيق نظام الخبير في الكثير من مجالات الهندسة المائية كالإنشاء والتصميم و التخطيط والتشغيل والادارة للمنشآت الهيدروليكية وقد تم استخدام لغة (فيجوال بيسك) لبرمجة نظام خبير ضمن بيئة ويندوز وتم تصميم النظام الخبير بناءاً على بيانات تشغيلية حقيقية للسد خلال 21 سنة من 1991 ولغاية 2011 (هيئة السدود و الخزانات، (2012)) حيث كانت النتائج التشغيلية (الشهرية واليومية) والتي تم التوصل اليها باستخدام النظام الخبير مقاربة جدا مقارنة مع البيانات التشغيلية للسد فمثلا عشوائيا كان معدل منسوب الماء المقاس لشهري (1991/9) و (2011/10) كما يلي(136.95) و(135.72) بينما كان المنسوب المحسوب لكل شهر كما يلي (136.80) و (135.59) حيث كان الفرق بين منسوب المياه المحسوب مع منسوب المياه المقاس كمعدل (15) سم مما يدل على صحة بناء النظام الخبير.

1. INTRODUCTION

Water is a very important resource, which makes its management one of the greatest challenges facing us globally; therefore, the human beings constructed dams to have a most benefit from water. Haditha Dam is an earth-fill dam on the Euphrates River, north of Haditha, creating Lake Haditha.

The purpose of the dam is to generate hydroelectricity, regulate the flow of the Euphrates and provide water for irrigation. It is the second-largest hydroelectric contributor to the power system in Iraq behind the Mosul Dam. All that mentioned above show the importance of good dam operation. Since reservoir operation involves very complex decision-making processes; thus, an Expert System will be very efficient to make the decisions of operation.
Artificial intelligence is the science of making machines do things that would require intelligence if done by men (**Kumara and Soyster (1986)**). Expert system is a branch of artificial intelligence that makes extensive use of specialized knowledge to solve problems at the level of a human expert. It is an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution. Expert system depends on the knowledge acquired from human experts. The user supplies facts or other information to the expert system and receives expertise in response. Internally, the expert system consists of two main components.
The knowledge base contains the knowledge with which the inference engine draws conclusions. These conclusions are the expert system's responses to the user's queries for expertise (**Giarratano and Riley (1962)**).The knowledge of an expert system may be represented in many ways. It can be encapsulated in rules and objects. One common method of representing knowledge is in the form of IF... THEN type rules. Expert systems have experienced tremendous growth and popularity since their commercial introduction in the early 1980s. Expert systems have been applied to many fields of knowledge such as: chemistry, electronics, medicine, engineering, and geology. The use of expert system has many advantages including increased availability of expertise at reduced cost, reduced risk, improved permanence, the use of multiple expertise, increased reliability, fast response, availability of intelligent tutor, intelligent database and steady, unemotional, and complete response at all times. However, lack of knowledge and expertise is considered the main limitation of building expert systems (**Giarratano and Riley (1962)**).

2. THE PREVIOUS RESEARCHES

(**Simonovics , S. P. (1990)**) in his paper discussed issues involved in both phases of the development of an expert system for flow measurement method selection. Where development of the system was done in two phases with very different emphasis. During the first phase, the emphasis was on the selection process, while during the second phase logic control was the major issue. The advisory system for flow measurement method selection has been designed to aid the user in the selection process . Two aspects of selection are considered: physical characteristics of the gauging site and/or structures at the gauging site. The system has been designed for potential use by Environment Canada.
(**Mohan, S. and Arumugam, N. (1995)**) presented a hybrid expert system that has been developed for operation of a tank irrigation system in South India. The heuristics and optimal knowledge are integrated with algorithmic techniques to operate the system under real-time conditions.
(**Varas, E.A. and Chrismar, M. V. (1995)**) presented an expert system to help select the best method to estimate design flood flows for civil engineering works based upon the procedures available, the nature and characteristics of the basin and existing hydrological records. The system presents the user with a list of possible methods ranked in descending grade order and optionally presents explanations which support the selected choices. Ordering is achieved using the knowledge base provided by the expert. The system recommends procedures for both preliminary estimates and final designs. The system also constitutes a valuable aid for junior engineers and experienced hydrologists in the selection of methods. Its conceptual structure can be easily generalized to treat other problems of a similar nature in the field of hydrology and water resources.
(**Al-Matlabie, A.H. (1999)**) produced the Expert System (ESORSA) which means (the Expert System for Operation of the Multi-Purpose Reservoir System of Al-ADHEEM Dam), where this system developed to give the advice to operate the reservoirs depending on the knowledge of the

experts and the previous researches on operating reservoirs, Al-Adheem reservoir is used as a case study. The researcher focused to optimize the operation of the multi-purpose reservoir system using the (DDDP)(Discrete Differential Dynamics Programming) to prevent flood, provide water requirements and generating electric energy from the hydro-power station. The (ESORSA) built by (CRYSTAL) which is software has the ability of taking knowledge.

(**Tospornsampan , J., Kita, I. , Ishii, M. , and Kitamura, Y. (2005)**) proposed and developed a combination of genetic algorithm and discrete differential dynamic programming approach (called GA-DDDP) which is used to optimize the operation of the multiple reservoir system. The demonstration is carried out through application to the MaeKlong system in Thailand. The objective of optimization is to obtain the optimal operating policies by minimizing the total irrigation deficits during a critical drought year. The performance of the proposed algorithm is compared with the modified genetic algorithm. The results show that the proposed GA-DDDP provides optimal solutions, converging into the same fitness values within a short time. The GA is able to produce satisfactory results that are very close to those obtained from GA-DDDP but required a lot more computation time to obtain the precise results. The difficulties in selecting optimal parameters of GA as well as finding a feasible initial trial trajectory of DDDP are significant problems and time-consuming. The significant advantage obtained from GA-DDDP is saving of computational resource as GA-DDDP requires no need for optimizing parameters and deriving feasible initial trial trajectories. Because DDDP is a part of GA-DDDP, the good performance of GA-DDDP is obtained when applied to a small system where numbers of discretization and variables have no influence to the dimensionality problem of DDDP.

(**Emiroglu, M. E.(2008)**) the objective of his study is making Expert System to discuss the factors influencing the selection of the type of dam by giving examples from rules of thumb and also to present typical cross sections for types of dams to be constructed on different foundations.

(**Swart, H. S. ,Van Rooyen, P. G. , Mwaka, B. and Ntuli, C. (2009)**) purposed in his assessment general and drought curtailment rules for the major dams situated within the Great Marico River System. The climate of the Marico catchment is semi-arid with the result that flow in the Marico River is highly variable and intermittent. The Water Resources Yield Model (WRYM) was used for the historic as well as the longer and short-term stochastic yield analyses that were undertaken for each of the major dams.

(**Abd-Elhamid, H. F., Javadi, A.A. Negm, A.M. Elalfi,A.E. and Owais,T.M. (2011)**) developed Expert System for maintenance and repair of masonry barrages. The CLIPS 6.0 software was used for building the expert system and a user interface was implemented using Visual Basic 6.0. The advantages of using an expert system are that facts and rules can be easily modified to respond to changes and new rules can be added to deal with unconsidered problems. The developed expert system can help users to identify the possible causes of problems and suggest a suitable method of repair. The proposed system was verified using field data collected from MWRI for barrages on the Nile River in Egypt. The use of the proposed expert system will save time in the process of taking maintenance decisions and will help in making the expected life of the structure as long as possible.

3. CASE STUDY

The dam is situated in a narrow stretch of the Euphrates Valley where a small secondary channel branched off the main channel. The width of the main channel was (350 m) whereas the secondary channel was (50 m) wide. The hydroelectric station is located in this secondary channel. The Haditha Dam is (9,064 m) long and (57 m) high, with the hydropower station at (3,310 m) from the dam's southern edge. The crest is at (154 m.a.s.l.) and (20 m) wide, (**Kamnev, N. M.; Sonichev, and N. A.; Malyshev, N. A. (1984)**). In cross-section, the dam consists of an asphaltic concrete cutoff wall at its core, followed by mealy detrital dolomites, and a mixture of sand and gravel. These materials were chosen because they are readily available near the construction site. This core is protected by a

reinforced concrete slab revetment on the upstream side of the dam, and a rock-mass revetment on the downstream side, (**Kamnev, N. M.; Sonichev, and N. A.; Malyshev, N. A. (1984)**).
The power station contains six Kaplan turbines capable of generating (660 MW). The turbines are installed in a hydro-combine unit that comprises both the spillway and the hydro-power plant in one structure. Maximum discharge of the spillway is (11,000 m^3/s)),[G.S.D.R.,(2012)]. Two bottom outlets on the dam can discharge (3,000 m^3/s) irrigation. Both these outlets and the spillway are controlled by radial gates Iraqi Ministries of Environment, Water Resources and Municipalities and Public Works (2006)
Haditha Reservoir has a maximum water storage capacity of (8200 million m^3) and a maximum surface area of (500 million m^2). Actual capacity is however (6591 million m^3), at which size the surface area is (415 million m^2), [G.S.D.R.,(2012)]. The details of the dam data which are required for the expert system are tabulated in **(Tables 1, 2, 3, 4, 5, 6 and 7).**

4. MATHEMATICAL MODEL

For the operating Haditha Dam reservoir's two curves represented (the upper rule and the lower rule for operating Haditha dam, **Figure 1**, which is produced by(**Ali, A.A.,(1994)**) (Ali, A.A. is prof. PhD in water resources engineering) he used one of the best Mathematical Models (DDDP) (Discrete Differential Dynamic Programing) for representing the previous curves where he found the upper value of storage for Haditha reservoir and the lower value of storage for each month, therefore the program of (Expert System for Operating Haditha Dam) (ESOHD) is based to make sure that the storage in the reservoir will be no more than the upper rule and not less than the lower rule, in normal and flood operation and made the storage not less than the minimum storage in the drought operation, the equations used to reach that aim , are:
Water balance equation for monthly operation:

$$S_{m\,(i,j+1)}=S_{m\,(i,j)}+[I_{(I,j)}-O_{(i,j)}]*t+[P_{(j)}-E_{(j)}]*A_{(i,j)} \quad (1)$$

where: j=No. of months :1,2,…,12

i=1,2,…,n

And for daily operation:

$$S_{d(k,l+1)}=S_{d\,(k,l)}+[I_{(k,l)}-O_{(k,l)}*t+[p_{(k)}-E_{(k)}]*A_{(k,l)} \quad (2)$$

where: l=No. of days according to the month:1,2,…,(28,29,30,31days)

k=1,2,…m

where:

$Sm_{(i,j)}$=average monthly storage,(m^3).
$I_{(i,j)}$=average inflow to the reservoir,(m^3/s).
$O_{(i,j)}$=average outflow from the reservoir,(m^3/s).
$P_{(j)}$=average monthly precipitation,(m).
$E_{(j)}$=average monthly evaporation,(m).
$A_{(i,j)}$=surface area of reservoir,(m^2),where it is change with elevation of water in the reservoir.
t = period of time,(s).
n =No. of operating years.

where:

$S_{d(k,l)}$=daily storage,(m^3/s).

$I_{(k,l)}$= daily inflow to the reservoir for day(l) and month(k),(m^3/s).
$O_{(k,l)}$=average outflow from the reservoir for day(l) and month(k),(m^3/s).
$P_{(k)}$=average monthly precipitation on the reservoir,(m).
$E_{(k)}$=average monthly evaporation from the reservoir,(m).
$A_{(k,l)}$=surface area of reservoir (for day(l) and month(k),(m^3/s),where it is change with elevation of water in the reservoir.
t =period of time,(s).
n =No. of operating months.

(Ishaq,(1998)) produced two equations representing the relationships between volume with water level and surface area with water level, **Fig. 2** represent the previous relationships, the two equations are:

$$V=0.24114(elev-100.062)^{\mathbf{2.7114}} \quad (3)$$

with R^2=0.99553

$$A=0.000588(elev-81.992)^{\mathbf{3.252}}+37.018 \quad (4)$$

with R^2=0.9947

The limits of these equations are (110-150) m.a.s.l.

a. operating the power station is related directly by the water requirements downstream the dam where the release from the dam is used for operating by the power station to generate electric power then the excess water will be released from the bottom outlets or from the spillway if the water level in the reservoir is above the crest level of the spillway.

   To calculate the production power , (Ali, A.A., (1994)) produced:

$$P= (9.81 * Qp* hn*e*10^{-3}) \quad (5)$$

where:
P= power production , (mw).
Qp = Discharge the station , (m^3/s).
hn = net water head (m).
e = Efficiency of the generated units (0.9).

$$hn = hg – h_l \quad (6)$$

where:
hg = gross water head (m).
h_1 = losses in head (m).
h_1 = 3.0 m , (Ali ,A.A., (1994))

$$hg = USWL – DSWL \quad (7)$$

where:
USWL = is the elevation in the reservoir (m.a.s.l.)
DSWL = is the water level downstream the dam , (in the river), (m.a.s.l.)
Downstream water level can be calculated by :

$$DSWL = 0.14063886 * (Q + 919.4654)^{0.56108517} + 94.049683 \quad (8)$$

This equation is produced by (Ali, A.A., (1994)).
Where:
DSWL = downstream water level (in the river) , (m.a.s.l.).
Q = the total discharge (release) from the dam, (m3/ s).
The limits for this equation are water level elevation (118 – 129.5) (m.a.s.l.) where (118) is enough to operate just one unit from the power station while 129.5 is the minimum operation elevation enough to operate the all six units.

b. operating the Bottom outlets means finding gate opening of the Bottom outlets with required specific discharge depended to reach that aim, a diagram represent the relation between (discharge and gate's opening, **Figure 3**, the diagram have (8 curves) each curve represent a special water elevation . After analysis of the diagram (8 equations produced) to represent each one of the curves to find the gate opening as shown in **Figure 4** and for other water elevations a (linear interpolation) can be down , the equations are:

$$opeb1 =(Qb- 11.921)/45.108 \quad (9a)$$

with $R^2 = 0.9854$

$$opeb2 = (Qb- 12.929) / 71.624 \quad (9b)$$

with $R^2 = 0.9892$

$$opeb 3= (Qb - 11.723) / 127.31 \quad (9c)$$

with $R^2 = 0.9876$

$$opeb4= (Qb - 12.22) / 163.14 \quad (9d)$$

with $R^2 = 0.9907$

$$opeb5 = |(Qb + 14) / 220.8 \quad (9e)$$

with $R^2 = 0.99$

$$opeb6 = (Qb+ 22.352) / 247.8 \quad (9f)$$

with $R^2 = 0.9889$

$$opeb7 = (Qb+ 9.3514) / 255.53 \quad (9g)$$

with $R^2 = 0.9855$

$$opeb8 = (Qb+ 1.2505) / 264.18 \quad (9h)$$

With $R^2 = 0.9788$

Figure 4 showed that the fitting curves are linear while the real curves are almost linear but the results of R^2 are very high therefore the obtained equations are used.

c. Operation of the spillway means finding the opening gate of the spillway for a specific discharge, (Al- Janabi, W.K.K.,(2004)) produced a very efficient mathematical procedure to calculate the gate opening and as follows:

1. Specified the released discharge from spillway (Q_{sp}).
2. Calculating (h_{sp}) depending on the water level in the reservoir.
3. Calculating (cd) depending on (h_{sp}) and assuming of the open of gate (a) by using the relationship shown in **Figure 5.**
4. After finding (h_{sp}) and the values of (cd) then spillway flow equation can be used as follows:

$$a = Q_{sp} / cd * n_g * b * \sqrt{2gh_{sp}} \tag{10}$$

The previous steps are repeated until having good agreement between the calculated and the assumed open gate.

Where:

Q_{sp} = discharge (m^3 / s)

a= opening the gate (m)

cd = discharge coefficient

n_g = number of gates

b = width of one gate (m)

g = acceleration gravity (9.81 (m / s))

h_{sp} = operating head upstream the gate (m).

5. MECHANISM OF OPERATING HADITHA DAM BY USING THE EXPERT SYSTEM (ESOHD)

The style and mechanism for operating Haditha dam have been developed using latest scientific technology (Artificial Intelligence) represented by expert system which programmed using up to date programming language (VISUAL BASIC) within windows environment the expert system has developed on analyze of real working data from 1991 to 2011 and as follows:

1- The first window of (ESOHD) is the main menu demands the user to enter his name and choose the type of operation (daily or monthly) by choosing one of the options, as shown in, **Figure 6 and 10**. In the same window the button “Help" showed the help window **Figure 14** and button "Exit" will end the program.

2-1 For the monthly operation the second window **Figure 7** will appear when (option one is chosen and welcome the user by his name and demand him to enter the required data which are (the file name including (average monthly inflows (m3/s) for the required period of time) the initial outflow (release), the average monthly precipitation and the average monthly demand (m^3)), the No. of years required for operating and the initial water level (m.a.s.l.).

2-2 After entering the required data ("the result "button) must choose to make the program calculating the required results and as the following mechanism:

a. The first storage S (1,1) and the first surface area A (1,1) by equation (4-3) depending on the first entered measured water level , then (the water balance equation (4-1), will calculate the storage for one of the next months, for each year the last storage S (i , 12) will be the first storage S (i+1, 1) for the followed year.
b. The calculated storage will be compered by the [upper rule (S_{up}) and lower rule (S_{low}) of (Ali, A.A., (1994))]. If the storage S(i,i) more than (S_{up}) for that month then the program will take it equal to the (S_{up}) and if the S(i,i) is less than the(S_{low}) then the program will take it equal to the (S_{low}) then the program will calculate a new (water level Eq.(4-3) and release from Eq.(4-1) according to the correct storages.
c. The program (ESOHD) will sure that the calculated releases (Rel (i,i)) are not excess on the maximum river capacity and not less than the water demands for each month.
d. Then the storage will be calculated again by Eq.(4-1) according to the corrected releases and compered with S_{max} (not more than it) and (not less than S_{min}).
e. Calculated depending on the amount of release in step (b.). if the release is more than the capacity of the power station (2034 m^3/s),), [G.S.D.R.,(2012)] then the power station will take just the enough discharge and the excess water will be released from bottom outlets or from the spillway, While if the release is less than the capacity of the power station then the power station will take all the release for its operation, if the water level in the reservoir is enough .
f. Then (ESOHD) will calculate [DSWL by Eq. (4-8), h_g by Eq. (4-7), h_n by Eq. (4-6) to find the production power (Mw) (P) by Eq. (4-5)].
g. All the steps above will be return for the daily operation, if (option two) will be chosen except Eq (4-2) will be used instead of Eq (4-1) as water balance equation.
h. At last the second window **Figure 7** have another two Buttons ("main menu" which return the user to the main menu window if he want to change the option and "Exit" Button to end the program).
3- The results of the monthly operation will appeared in window three **Figure 8** where the [calculated storage (million m^3) , calculated water level (m.a.s.l.) , release (m^3/s) , DSWL (m.a.s.l.) and the prediction power (MW)] will be listed for each year . The results window having four control Buttons [" Back" (which able user to return to the previous window) , " Main menu" (able the user to return to the first window (main menu)), " Details of operation " (which open new window to show the user how to operate the structures of the dam) and "Exit" to end the program].
4- The fourth window is the (details of operation window) **Figure 9** when the user click on any year in the (results window) then the program (ESOHD) will show the user the mechanism of operating each part of the dam (power station , Bottom outlets depending on equations (4-9(a-h)) and/or the spillway depending on equations (4-10) for each month and for the specific year.
5- For daily operation all the steps above will be returned and **Figures 10, 11, 12 and 13** will show the mechanism of operating.

6. THE RESULTS

The results obtained by running (ESOHD) for the monthly operation for the total period (1991-2011) are listed in **Tables 8, 9, 10, 11 and 12**(water level (m.a.s.l.), release (m^3/s), storage (million m^3), production Power (Mw),and DSWL (m.a.s.l.)),it is found:

1. The maximum calculated storage is (8339.8 million m^3) where it is less than the maximum storage of the reservoir (9850 million m^3) while the minimum storage was (474.0 million m^3) for (the drought year) which is more than the minimum storage of the reservoir (188 million m^3).
2. The maximum calculated water level is (147.27 m.a.s.l.) where it is less than the maximum water level of the reservoir (150.2 m.a.s.l.) while the minimum water level was (116.46 m.a.s.l.) which is more than the minimum water level of the reservoir (112 m.a.s.l.).
3. The maximum calculated release is (1163 m^3/s) which is less than the maximum capacity of the river (4730 m^3/s) while the minimum calculated release was (188 m^3/s) which is more than the minimum discharge of the river (70 m^3/s).
4. The maximum power production was (520.4 Mw)less than (660 Mw) while the minimum power production was (0.0 Mw) where the power station stopped for three months in (the drought year) because the water level was less than (118 m.a.s.l.) which is the minimum elevation of water can operate one turbine of the power station and the release was just from the bottom outlets.
5. The spillway has not operate all the period of time and that because all the releases for each month are less than the maximum capacity of the power station therefor they used to generate electric power.
6. The Bottom outlets are operate for (2 months) because the water level was less than the minimum water level for operating power station.

And the results obtained by running (ESOHD) for the daily operation for (two sequence drought months) (9-10/2009) are listed in (**Tables 13 and 14** ,respectively) ,it is found:

1. The maximum calculated storage was (776.55 million m^3) while the minimum storage was (426.50 million m^3) for which is more than the minimum storage of the reservoir (188 million m^3).
2. The maximum calculated water level is (119.73 m.a.s.l.) while the minimum water level was (115.83 m.a.s.l.) which is more than the minimum water level of the reservoir (112 m.a.s.l.).
3. The maximum calculated release is (400.95m^3/s) while the minimum calculated release was (350.12 m^3/s) which are more than the minimum discharge of the river (70 m^3/s).
4. Power station was not operated because the water level was less than (118 m.a.s.l.) which is the minimum elevation of water can operate one turbine of the power station and the release was just from the bottom outlets.
5. The spillway has not operated for the same reason above.
6. The Bottom outlets are operating for (all the two months) because the water level was less than the minimum water level for operating power station.

For both monthly and daily operations it is found that the calculated water level was just (0.10 m) more than the measured water level which is calculated from the correct storage and release which mean that the building of the program is correct.

7. CONCLUSIONS

From the results obtained by running (ESOHD), the next conclusions are deduced:

1. The (ESOHD) gave results with a good agreement for the monthly and the daily operation with the real operation of Haditha dam which mean that the building of the program is correct.
2. The program able the user to update the data that used for operating Haditha dam by taking the new data from a [File].

3. For normal operation years the (ESOHD) program shall take the lower limit of the storage is the minimum operation storage and minimum operation water level (2300 million m^3) with water level (129.50 m.a.s.l.) while in drought years the (ESOHD) program shall take the lower limit of the storage is (188 million m^3) with water level (112 m.a.s.l.) which is the minimum storage and minimum water level of the reservoir.
4. For the (21 years adopted in the search) almost the years were drought years which means that the program satisfying the water requirements for more than a drought year which means it is dependable for operating the dam. There are many causes for the droughts in Iraq in the last years one of them is the dams built on Euphrates river in Turkey and Syria, the increasing in population in Iraq which means increasing in water demands and at last the global increasing in heat temperature.

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Table 1 The basic data of Haditha Reservoir (G.S.D.R.(2012))

Storage in reservoir (m^3*10^6)	value	Reservoir water level (m.a.s.l.)	value
Maximum(Smax)	9850	Maximum(wlmax)	150.2
Minimum(Smin)	188	Minimum(wlmin)	112
Designed operated (SD)	8200	Designed operated (Dwl)	147
Normal operated(SN)	6591	Normal operated(Nwl)	143
Minimum operated(SM)	2362	Minimum operated(Mwl)	129.5

Table 2 The basic designed concepts of Haditha Dam structures and River (Ali,A.A.,(1994))

Property	value
Maximum designed discharge of the river (m^3/s)	4730
Minimum designed discharge of the river (m^3/s)	70
Maximum designed discharge released from Power station (m^3/s)	2034
Maximum designed discharge released from Bottom outlets (m^3/s)	4000
Maximum designed discharge released from Spillway (m^3/s)	11000*

*This discharge will be at waterlevel (154 m.a.s.l.).

Table 3 The water demands downstream Haditha Dam (m^3*10^6) (**Ali,A.A.,(1994**))

The month	Irrigation , artificer , hygiene requirement	Environmental requirement	Total
10	1241.5	187.5	1429
11	859.8	187.5	1047.3
12	391.8	187.5	579.28
1	559.8	187.5	747.3
2	1034.6	187.5	1222.1
3	1526	187.5	1713.5
4	1969.9	187.5	2157.4
5	1846.6	187.5	2034.1
6	2489.8	187.5	2677.3
7	2569.5	187.5	2757
8	2122.4	187.5	2309.9
9	1241.9	187.5	1429.4

Table 4 The average monthly perception and evaporation for Haditha reservoir (From 1991 – 2011)

The month	Perception (mm)	Evaporation (mm)
10	5.7	198
11	9.8	132
12	22.5	88
1	18.8	44
2	16.9	66
3	20.4	110
4	22.2	154
5	5.7	220
6	0	286
7	0	330
8	0	308
9	0	264

Table 5 Upper rule and Lower rule curves for Haditha dam ($m^3 *10^6$)

The month	Upper rule	Lower rule
10	4811.4	2296.6
11	5300.2	2560.3
12	6051.1	3574.6
1	6781.4	4288.9
2	7036.6	4288.9
3	7430.6	4320.4
4	7520.1	4913.7
5	7930.8	5445.4
6	7520.1	4811.4
7	6656.0	3602.7
8	2734.0	5630.3
9	2426.2	5264.3

Table 6 The measured inflow (m^3 / s)

Inflow	10	11	12	1	2	3	4	5	6	7	8	9
1991	457	475	551	510	399	381	194	427	387	410	434	345
1992	274	277	547	496	552	351	296	293	343	280	247	221
1993	340	405	468	414	358	392	337	497	401	408	366	256
1994	432	427	527	486	626	442	458	334	356	418	517	733
1995	950	1150	1232	1286	1235	861	704	351	296	376	513	528
1996	590	1083	920	1169	1309	1411	1497	815	502	696	753	663
1997	750	873	903	1056	1345	1127	1073	732	771	809	586	493
1998	713	989	1220	1132	1350	1443	817	865	580	589	675	644
1999	698	832	1045	1013	945	623	429	370	310	262	258	303
2000	355	611	751	934	1187	802	366	343	336	339	262	250
2001	285	285	303	310	377	287	214	213	153	331	606	281
2002	238	247	613	616	391	216	299	229	303	335	273	287
2003	348	582	825	663	635	788	548	367	288	282	308	457
2004	515	742	547	710	1214	1789	665	1207	554	349	569	650
2005	648	700	903	925	859	665	493	358	465	495	525	339
2006	625	731	537	934	1331	623	512	574	603	809	873	679
2007	382	643	958	1173	751	581	555	621	379	716	821	584
2008	386	374	532	879	758	436	343	307	355	403	542	548
2009	296	312	402	310	278	259	225	263	293	310	288	305
2010	349	386	385	350	405	288	337	314	315	461	756	333
2011	282	446	493	592	576	423	312	475	457	475	551	455

Table 7 The measured water level (m.a.s.l.)

w.l.	10	11	12	1	2	3	4	5	6	7	8	9
1991	136.95	136.90	137.11	137.28	135.88	133.12	131.03	132.59	134.32	135.96	137.04	137.12
1992	136.90	136.23	137.55	140.41	142.64	143.82	144.09	144.35	144.36	143.99	143.55	143.08
1993	143.09	143.92	144.40	144.78	145.06	145.62	145.94	146.52	146.65	145.99	145.82	144.61
1994	144.22	144.63	145.11	145.34	145.90	146.09	146.36	146.49	145.87	144.89	144.14	144.22
1995	144.20	144.81	144.97	145.73	146.27	146.35	146.03	145.22	143.69	142.44	142.17	141.45
1996	141.42	142.33	143.49	143.61	145.28	147.27	147.11	147.00	146.28	144.04	141.98	139.82
1997	139.98	141.07	141.53	142.33	143.67	144.54	146.36	147.03	146.90	145.72	143.26	140.80
1998	139.25	140.27	142.35	143.95	145.52	146.55	147.06	147.27	146.18	143.85	141.38	138.71
1999	138.44	139.41	141.83	143.63	144.83	145.96	146.45	146.37	144.54	140.20	137.17	131.46
2000	128.55	128.45	132.31	135.99	141.26	144.55	144.80	144.61	143.77	142.34	140.63	142.15
2001	136.62	135.17	133.83	134.89	136.13	136.28	135.93	135.96	134.73	133.25	133.91	134.45
2002	132.60	129.83	131.20	135.92	139.29	139.74	139.55	140.20	140.29	140.14	139.09	137.81
2003	137.61	138.64	140.80	142.41	142.14	142.72	143.05	143.00	141.61	139.62	137.21	135.74
2004	136.45	138.01	139.48	140.60	143.51	146.17	146.38	146.90	146.72	145.25	144.15	143.70
2005	143.77	144.03	144.93	146.05	146.14	146.43	146.16	145.48	144.72	143.65	142.45	140.84
2006	139.81	141.38	141.79	143.44	146.02	146.27	146.59	146.51	146.68	145.88	145.53	144.70
2007	143.35	142.07	142.73	145.55	146.22	146.78	146.83	146.96	146.11	145.02	144.71	143.81
2008	142.30	140.21	138.99	139.89	142.32	143.27	142.22	141.39	140.31	138.51	136.52	135.29
2009	131.80	128.68	127.33	127.65	127.04	125.75	124.68	123.96	123.96	123.42	121.19	118.66
2010	116.47	116.46	119.12	122.40	126.23	127.04	127.94	129.13	129.22	128.83	130.56	131.69
2011	129.87	129.11	128.53	131.56	134.05	135.58	135.25	136.26	136.80	136.29	136.76	135.72

Table 8 The calculated water level (m.a.s.l.)

w.l.	10	11	12	1	2	3	4	5	6	7	8	9
1991	136.80	136.90	137.06	137.28	135.88	133.06	131.03	132.59	134.32	135.96	137.04	137.12
1992	136.90	136.23	137.55	140.41	142.64	143.82	144.09	144.35	144.36	143.99	143.44	143.08
1993	143.09	143.92	144.40	144.78	145.06	145.62	145.94	146.52	146.65	145.99	145.67	144.55
1994	144.17	144.63	145.11	145.34	145.90	146.00	146.36	146.49	145.87	144.89	144.14	144.02
1995	144.20	144.81	144.97	145.58	146.27	146.35	146.03	145.22	143.69	142.44	142.17	141.45
1996	141.31	142.33	143.49	143.61	145.28	147.27	147.04	147.00	146.28	144.04	141.98	139.82
1997	139.98	141.07	141.53	142.33	143.67	144.54	146.36	147.03	146.90	145.72	143.26	140.80
1998	139.05	140.27	142.35	143.80	145.52	146.55	147.06	147.22	146.18	143.85	141.30	138.62
1999	138.44	139.41	141.83	143.63	144.83	145.96	146.45	146.21	144.54	140.20	137.17	131.46
2000	128.55	128.45	132.31	135.99	141.26	144.55	144.80	144.61	143.77	142.34	140.63	142.15
2001	136.62	135.17	133.83	134.89	136.13	136.28	135.93	135.96	134.73	133.25	133.91	134.45
2002	132.60	129.83	131.20	135.92	139.29	139.74	139.55	140.20	140.29	140.14	139.09	137.81
2003	137.61	138.64	140.80	142.41	142.14	142.72	143.05	143.00	141.61	139.62	137.21	135.74
2004	136.59	138.01	139.48	140.70	143.51	146.07	146.38	146.72	146.72	145.25	144.15	143.70
2005	143.77	144.03	144.93	146.05	146.14	146.43	146.16	145.48	144.72	143.65	142.45	140.84
2006	139.91	141.38	141.79	143.44	146.02	146.27	146.59	146.51	146.68	145.88	145.53	144.70
2007	143.35	142.07	142.73	145.55	146.22	146.63	146.83	146.96	146.11	145.02	144.71	143.81
2008	142.20	140.04	138.99	139.89	142.39	143.12	142.22	141.39	140.31	138.41	136.52	135.59
2009	131.80	128.68	127.33	127.65	127.04	125.75	124.68	123.96	123.96	123.42	121.19	118.66
2010	116.47	116.46	119.12	122.40	126.23	127.04	127.94	129.13	129.22	128.83	130.56	131.69
2011	129.87	129.11	128.53	131.56	134.05	135.58	135.25	136.26	136.80	136.29	136.76	135.58

Table 9 The calculated release (m^3 / s)

release	10	11	12	1	2	3	4	5	6	7	8	9
1991	351	439.0	446.4	926	792	217	198	188	205	225	304	342
1992	341	318	219	204	230	253	233	260	374	367	308	312
1993	291	279	431	329	223	218	264	347	406	437	432	408
1994	347	325	403	399	470	346	325	304	485	464	440	572
1995	688	893	1063	1100	1163	817	679	504	523	339	474	564
1996	480	715	839	818	845	1088	1519	694	715	863	988	732
1997	521	689	790	783	1044	777	643	593	722	991	918	705
1998	734	684	783	787	930	1123	682	722	830	867	1019	746
1999	576	441	697	673	574	429	342	366	813	794	654	606
2000	399	405	380	232	370	423	386	332	444	452	446	441
2001	417	460	219	173	256	296	160	212	291	330	360	327
2002	411	387.4	211	134.2	184.6	233	160.6	130	223	326	386	289.6
2003	225	290	236.5	558.8	542.9	514.7	337.6	367.4	446.3	457.2	469.9	319.7
2004	258.3	292.2	329.8	272.5	344.0	1127.4	577.2	633.3	587.0	511.8	538.1	536.9
2005	500.6	471.6	537.3	705.6	654.0	571.1	531.5	406.5	486.1	628.6	598.0	471.9
2006	400.5	400	397.7	364.6	881.8	505.8	400.5	399.0	556.7	664.2	685.4	631.1
2007	652.7	609.1	433.2	639.2	665.9	443.3	438.2	568.7	555.2	633.5	700.5	683.7
2008	614.6	609.1	527	415.8	408.8	419.0	353.0	400.2	459.1	600.4	612.4	649.7
2009	546.1	413.7	371.4	300	300	276	250	205	278.3	372.4	400	398.3
2010	369.7	360.3	240.3	211	300	202.1	200	200	282.5	362.9	436.8	488.2
2011	468.0	515.9	399.9	384.1	241.3	338	292.57	255.9	351	439.0	446.4	561.3

Table 10 The calculated storage (million m^3)

Storage	10	11	12	1	2	3	4	5	6	7	8	9
1991	4226.0	4268.7	4290.6	4376.6	3945.1	3158.6	2659.4	3037.9	3496.1	3968.2	4302.6	4326.4
1992	4256.9	4049.0	4463.9	5447.4	6304.1	6789.3	6902.6	7014.4	7019.1	6863.2	6630.9	6481.8
1993	6487.5	6830.4	7038.3	7199.5	7324.0	7571.7	7716.4	7988.4	8048.4	7740.9	7594.1	7101.4
1994	6937.4	7134.3	7346.2	7449.5	7699.5	7744.3	7911.3	7972.5	7686.5	7249.3	6925.7	6875.0
1995	6950.5	7214.2	7284.0	7554.6	7869.8	7906.6	7758.3	7396.2	6736.1	6224.5	6119.2	5839.3
1996	5784.1	6181.2	6652.2	6700.8	7421.3	8339.8	8229.3	8210.2	7876.0	6881.7	6041.9	5234.3
1997	5291.7	5692.5	5868.3	6181.5	6727.1	7096.5	7913.5	8225.3	8164.3	7618.5	6556.1	5593.8
1998	4966.5	5396.6	6188.1	6781.3	7527.5	8001.0	8240.7	8314.5	7828.0	6802.5	5781.3	4818.4
1999	4757.9	5089.6	5984.7	6709.4	7223.4	7728.8	7951.7	7843.8	7097.6	5372.4	4342.2	2760.5
2000	2121.5	2100.1	2966.6	3977.2	5764.3	7099.4	7209.4	7127.1	6770.4	6185.6	5529.3	6110.9
2001	4169.9	3735.3	3361.7	3655.7	4021.6	4065.4	3960.0	3969.0	3611.3	3207.5	3383.6	3533.7
2002	3040.6	2388.7	2699.2	3955.8	5049.1	5206.9	5139.5	5372.2	5404.9	5350.4	4978.8	4548.4
2003	4483.4	4824.7	5592.8	6213.5	6103.8	6335.9	6471.2	6448.1	5898.9	5165.0	4355.5	3903.5
2004	4161.6	4615.3	5113.1	5555.0	6661.7	7776.2	7919.1	8080.0	8081.6	7406.5	6930.4	6738.8
2005	6769.5	6879.8	7267.2	7768.8	7810.3	7945.6	7819.9	7512.5	7176.8	6719.6	6228.3	5608.2
2006	5265.9	5811.2	5970.3	6630.1	7753.4	7870.5	8018.0	7980.1	8060.6	7691.4	7534.2	7165.0
2007	6593.9	6079.5	6342.3	7541.6	7844.8	8038.3	8129.6	8191.2	7794.3	7305.3	7168.7	6785.4
2008	6128.0	5312.9	4944.4	5260.9	6203.8	6497.2	6135.3	5814.8	5411.6	4748.6	4140.3	3772.1
2009	2843.0	2146.0	1884.0	1943.8	1829.7	1601.6	1427.4	1316.5	1317.2	1237.9	942.8	666.9
2010	475.1	474.0	713.0	1096.6	1684.6	1828.7	1999.7	2240.0	2257.6	2176.9	2550.4	2816.0
2011	2397.0	2235.5	2116.9	2784.3	3421.7	3854.9	3760.5	4060.2	4226.0	4068.7	4212.6	3896.6

Table 11 The calculated power produced (MW)

power	10	11	12	1	2	3	4	5	6	7	8	9
1991	96.7	88.5	64.2	250.7	207.4	55.0	46.8	47.1	54.3	62.8	87.0	97.7
1992	98.9	97.0	149.7	65.1	77.7	87.9	81.7	91.5	130.3	126.8	105.5	105.8
1993	120.6	114.5	142.8	116.3	80.1	79.4	96.6	127.9	149.3	157.8	154.8	142.5
1994	232.6	301.9	356.3	142.2	168.9	125.9	119.5	112.3	173.9	162.7	151.6	194.4
1995	152.9	229.4	275.1	373.6	400.3	288.9	240.7	177.6	176.9	112.8	154.7	179.0
1996	159.2	213.9	246.3	269.5	290.2	386.1	520.4	251.7	254.4	286.6	306.9	218.3
1997	213.9	207.6	250.0	249.8	338.5	263.2	230.5	216.9	260.7	340.5	297.2	216.9
1998	167.3	133.5	220.9	261.2	319.3	390.4	247.9	262.7	292.0	286.4	309.7	214.3
1999	83.1	83.9	91.9	224.5	199.1	154.9	125.8	133.6	274.6	238.2	181.2	138.1
2000	116.3	121.8	57.0	64.7	118.9	147.5	135.9	116.9	151.5	148.4	139.8	144.2
2001	100.1	85.2	50.1	46.9	71.6	82.7	44.9	59.2	77.4	83.1	92.4	85.8
2002	66.0	87.2	76.0	37.8	57.2	72.7	50.2	41.5	70.7	101.9	116.4	84.9
2003	73.2	86.2	101.2	182.2	175.9	169.8	114.1	123.7	143.8	139.1	132.8	87.6
2004	170.0	161.7	187.4	87.0	117.6	387.0	208.0	229.2	213.2	180.3	184.0	181.4
2005	123.5	128.6	129.3	249.8	233.0	206.2	191.2	145.3	169.4	210.5	194.4	148.4
2006	216.4	195.9	144.0	124.2	307.8	182.9	147.1	146.3	202.5	234.9	239.9	217.2
2007	198.2	184.9	156.3	224.6	237.4	162.5	161.4	208.0	199.1	219.7	239.8	228.9
2008	127.0	86.4	73.6	128.0	134.9	140.9	116.6	128.7	142.4	173.8	166.8	169.3
2009	0.00	0.00	0.00	61.0	59.4	51.7	44.6	35.6	47.7	61.0	57.3	48.1
2010	101.9	108.2	83.2	33.7	57.2	40.6	41.8	43.9	61.5	76.8	98.2	113.9
2011	129.6	121.2	115.5	90.3	63.1	92.0	79.2	71.8	99.1	120.9	124.7	149.7

Table 12 The calculated DSWL (m.a.s.l.)

dswl	10	11	12	1	2	3	4	5	6	7	8	9
1991	101.77	101.69	101.34	103.61	103.22	101.34	101.27	101.23	101.29	101.37	101.64	101.78
1992	101.60	101.56	102.08	101.29	101.38	101.47	101.39	101.49	101.89	101.86	101.66	101.67
1993	101.79	101.72	101.98	101.73	101.36	101.34	101.50	101.79	101.99	102.10	102.08	102.00
1994	102.90	103.52	104.01	101.97	102.21	101.79	101.72	101.64	102.26	102.19	102.11	102.54
1995	102.24	102.98	103.36	104.11	104.29	103.29	102.87	102.32	102.38	101.77	102.22	102.51
1996	102.37	102.90	103.21	103.30	103.38	104.08	105.23	102.92	102.98	103.43	103.79	103.04
1997	103.04	102.89	103.19	103.19	103.95	103.17	102.76	102.60	103.01	103.80	103.59	102.95
1998	102.55	102.11	102.93	103.20	103.63	104.17	102.88	103.01	103.33	103.44	103.88	103.08
1999	101.97	101.99	101.91	102.85	102.54	102.07	101.78	101.86	103.28	103.22	102.80	102.65
2000	102.03	102.17	101.34	101.39	101.87	102.05	101.93	101.74	102.12	102.15	102.13	102.11
2001	102.01	101.93	101.31	101.18	101.48	101.62	101.13	101.32	101.60	101.73	101.84	101.72
2002	101.37	101.60	101.41	101.03	101.22	101.39	101.13	101.02	101.36	101.72	101.93	101.59
2003	101.48	101.60	101.73	102.49	102.44	102.35	101.76	101.86	102.13	102.16	102.21	101.70
2004	102.31	102.21	102.43	101.53	101.78	104.19	102.55	102.73	102.58	102.34	102.43	102.42
2005	101.97	101.97	101.97	102.96	102.80	102.53	102.41	102.00	102.26	102.72	102.62	102.21
2006	102.79	102.65	102.08	101.85	103.49	102.32	101.97	101.97	102.49	102.83	102.89	102.72
2007	102.67	102.65	102.39	102.75	102.83	102.12	102.10	102.53	102.48	102.73	102.94	102.89
2008	102.45	102.02	101.88	102.03	102.00	102.04	101.81	101.97	102.17	102.63	102.67	102.78
2009	101.87	101.84	101.42	101.63	101.63	101.55	101.45	101.29	101.55	101.88	101.97	101.97
2010	102.20	102.36	101.97	101.31	101.63	101.28	101.28	101.28	101.57	101.85	102.10	102.27
2011	102.35	102.30	102.10	101.92	101.42	101.76	101.60	101.48	101.81	102.10	102.13	102.50

Table 13 The daily operation for (month 9/2009)

2009/9	water elevation (m.a.s.l.)	Relaese (m3/s)	Storage (million m3)
1	119.73	401.22	776.55
2	119.58	400.71	760.60
3	119.45	400.28	746.94
4	119.37	400.01	738.61
5	119.3	399.77	731.38
6	119.2	399.44	721.11
7	119.14	399.24	715.00
8	119.11	399.14	711.96
9	119.08	399.04	708.92
10	119.07	399.00	707.91
11	119.1	399.10	710.94
12	119.09	399.07	709.93
13	119.04	398.90	704.88
14	118.98	398.70	698.86
15	118.93	398.53	693.86
16	118.83	398.20	683.93
17	118.64	397.56	665.32
18	118.48	397.03	649.90
19	118.36	396.62	638.48

20	118.23	396.19	626.26
21	118.07	395.65	611.42
22	117.97	395.32	602.26
23	117.88	395.02	594.08
24	117.75	394.58	582.41
25	117.64	394.21	572.64
26	117.53	393.84	562.97
27	117.42	393.47	553.41
28	117.29	393.04	542.25
29	117.09	392.37	525.35
30	117.03	392.17	520.34

Table 14 The daily operation for (month 10/2009)

2009/10	water elevation (m.a.s.l.)	Release (m3/s)	Storage (million m3)
1	116.86	400.95	506.33
2	116.68	400.33	491.75
3	116.53	399.81	479.81
4	116.36	399.23	466.50
5	116.23	398.79	456.48
6	116.08	398.27	445.09
7	115.94	397.79	434.62
8	115.83	397.41	426.50
9	115.84	397.45	427.24
10	115.9	397.65	431.65
11	115.95	397.82	435.36
12	115.98	397.93	437.59
13	115.99	367.20	438.34
14	116.07	362.40	444.33
15	116.16	358.21	451.14
16	116.26	355.55	458.78
17	116.37	352.00	467.27
18	116.49	351.21	476.66
19	116.59	350.95	484.56
20	116.64	350.72	488.55
21	116.66	350.52	490.15
22	116.66	350.15	490.15
23	116.68	350.12	491.75
24	116.67	350.10	490.95
25	116.65	350.21	489.35
26	116.6	350.46	485.36
27	116.55	350.79	481.39
28	116.51	350.42	478.23
29	116.5	350.89	477.44
30	116.48	350.99	475.87
31	116.46	350.69	474.30

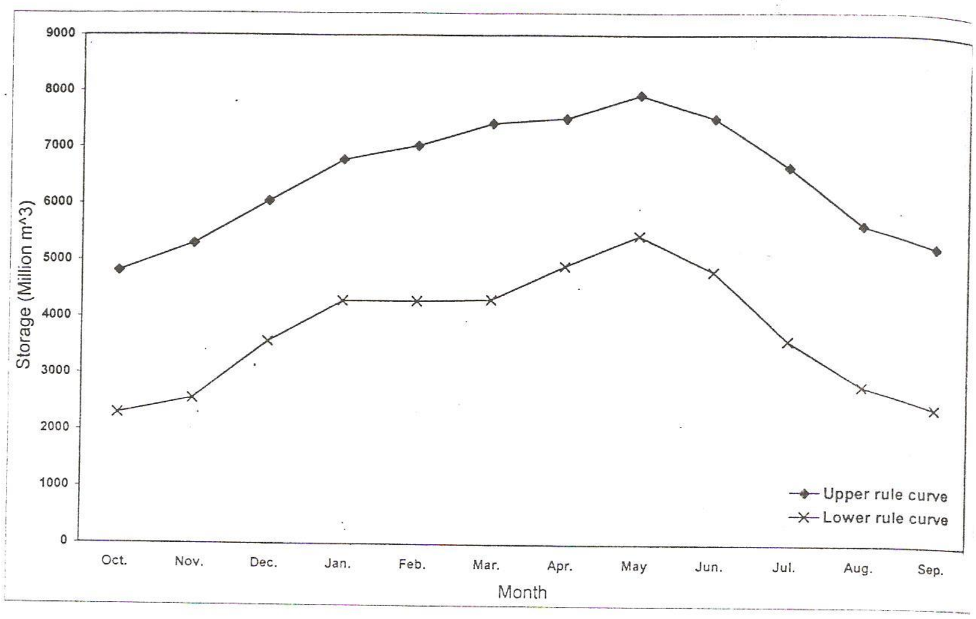

Figure 1 The upper and the lower rule curve by (Ali A.A. , (1994))

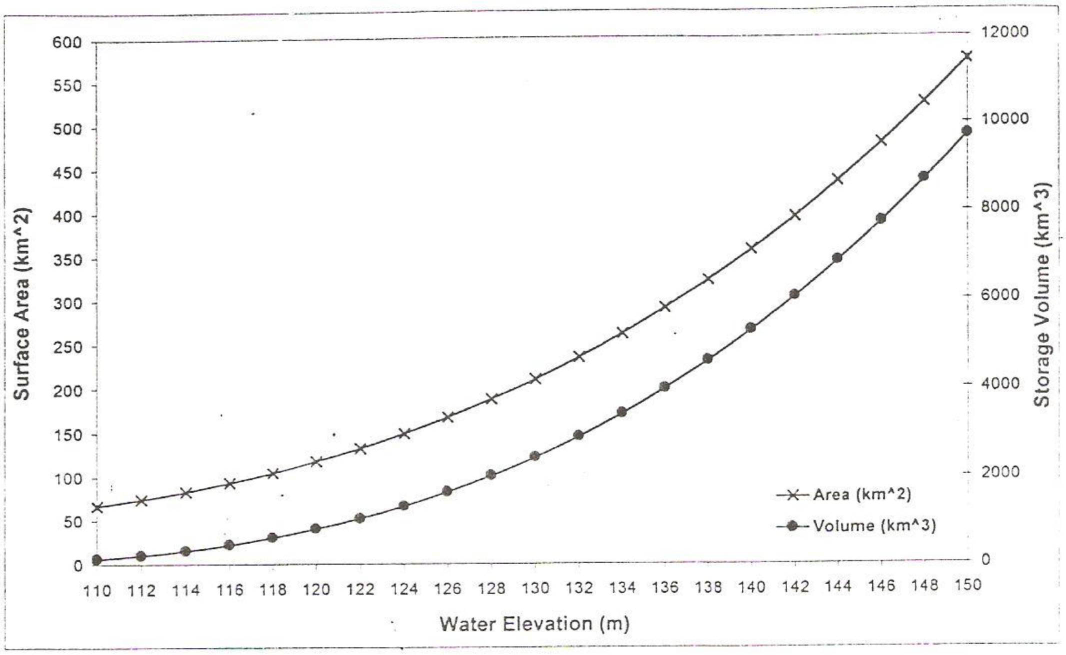

Figure 2 The relationship between storage, surface area and water level of the reservoir by (Ishaq, **(1998)**)

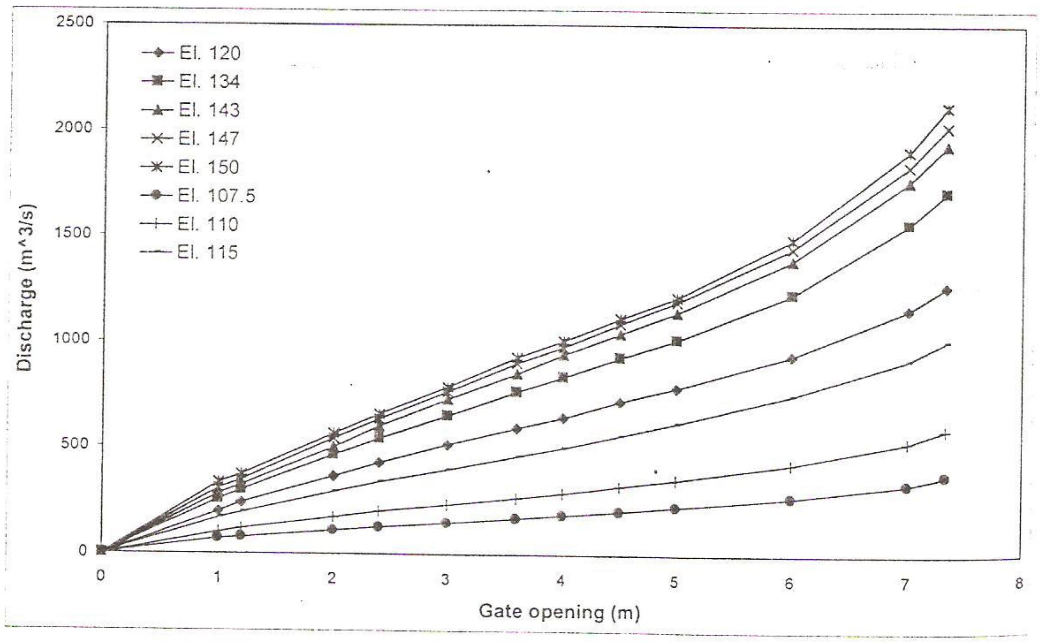

Figure 3 Curves represented the relation between gate opening and the discharge for the bottom outlets for different water level by (G.S.D.R. (2012))

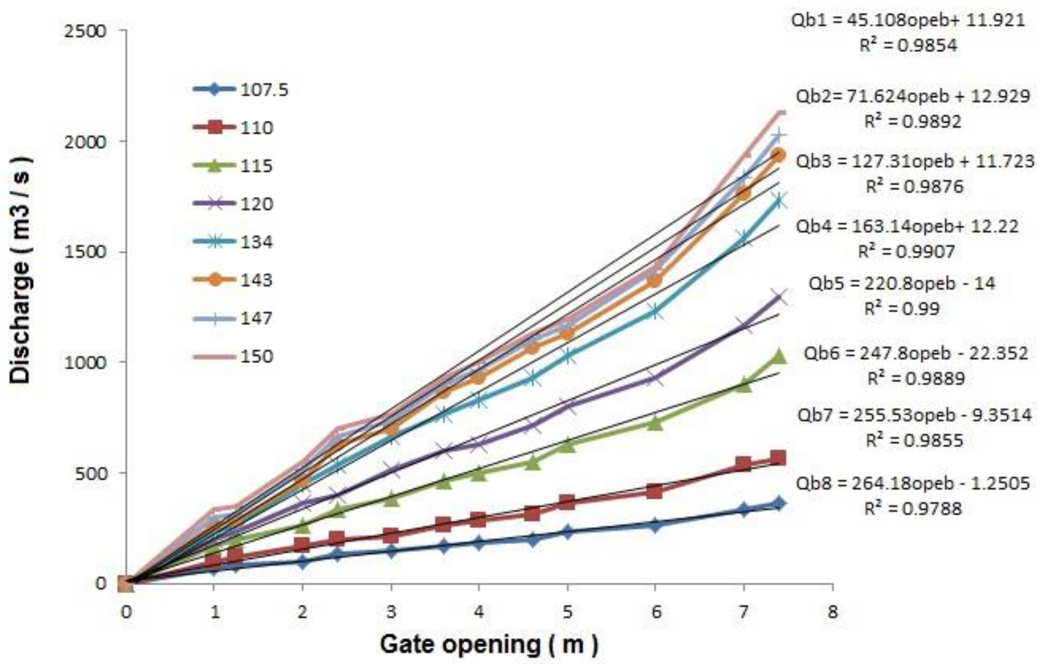

Figure 4 Analysis of previous figure .

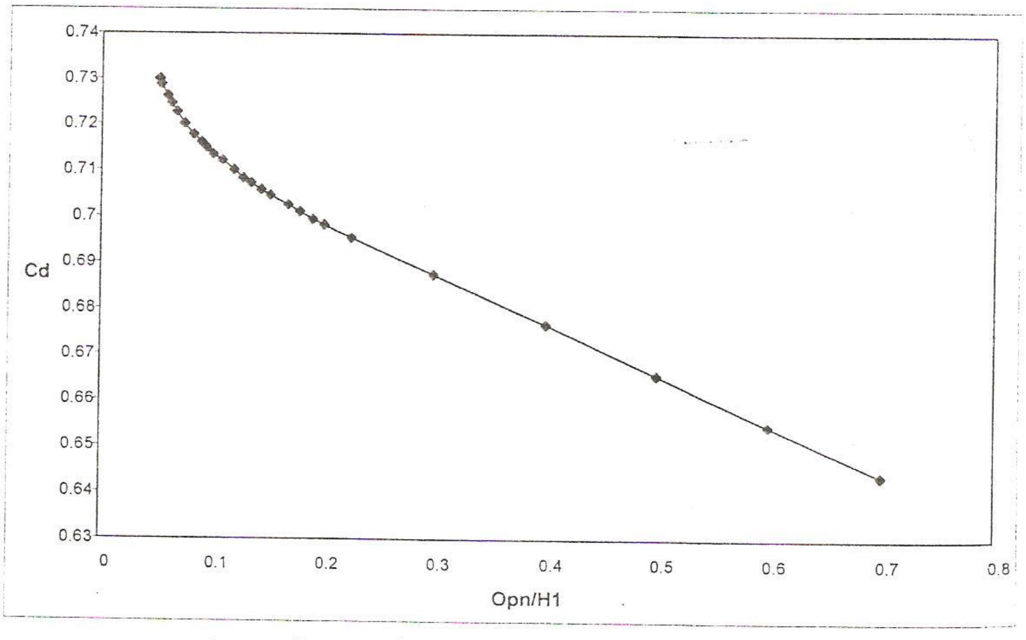

Figure 5 The relation between Cd and ratio of (open gate/pressure head)by (Chow,(1959)

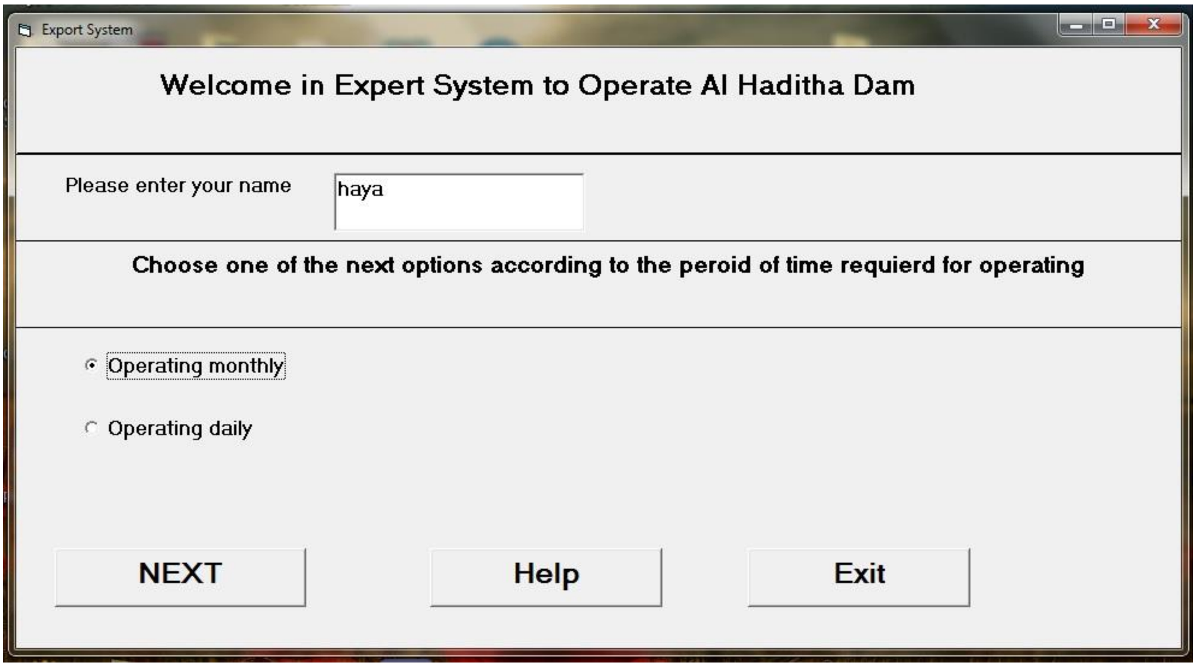

Figure 6 The main menu of (ESOHD) for monthly option

Figure 7 The welcome window of monthly operation

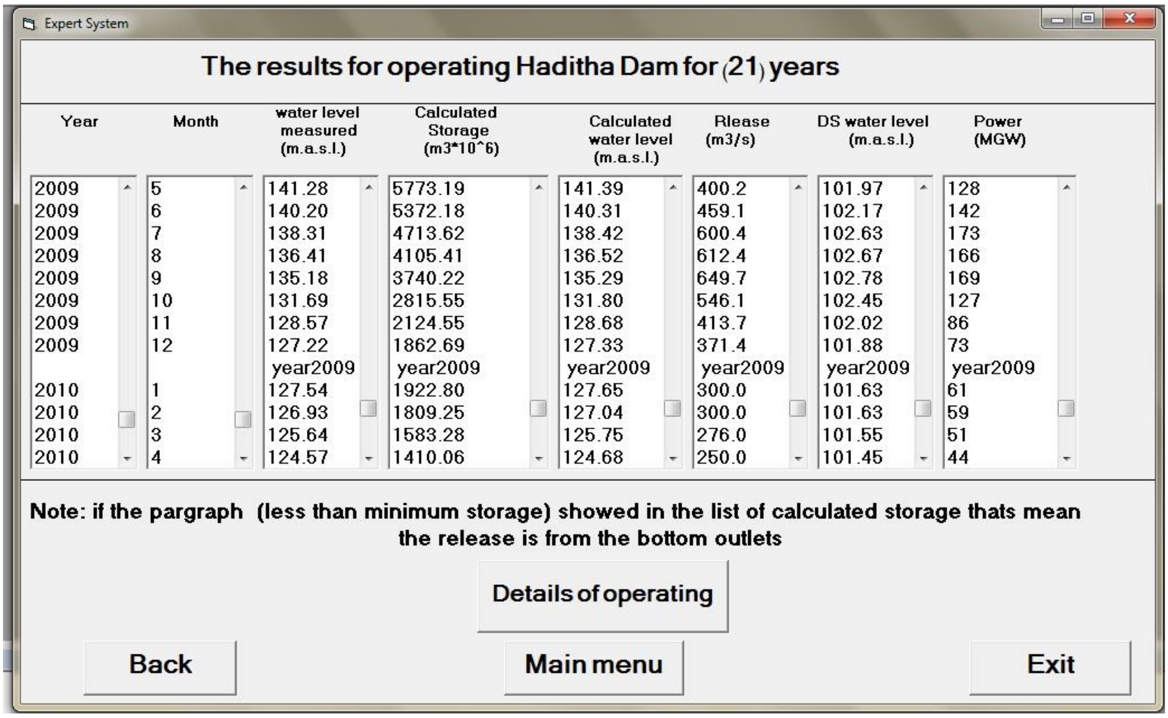

Figure 8 The results for monthly operating

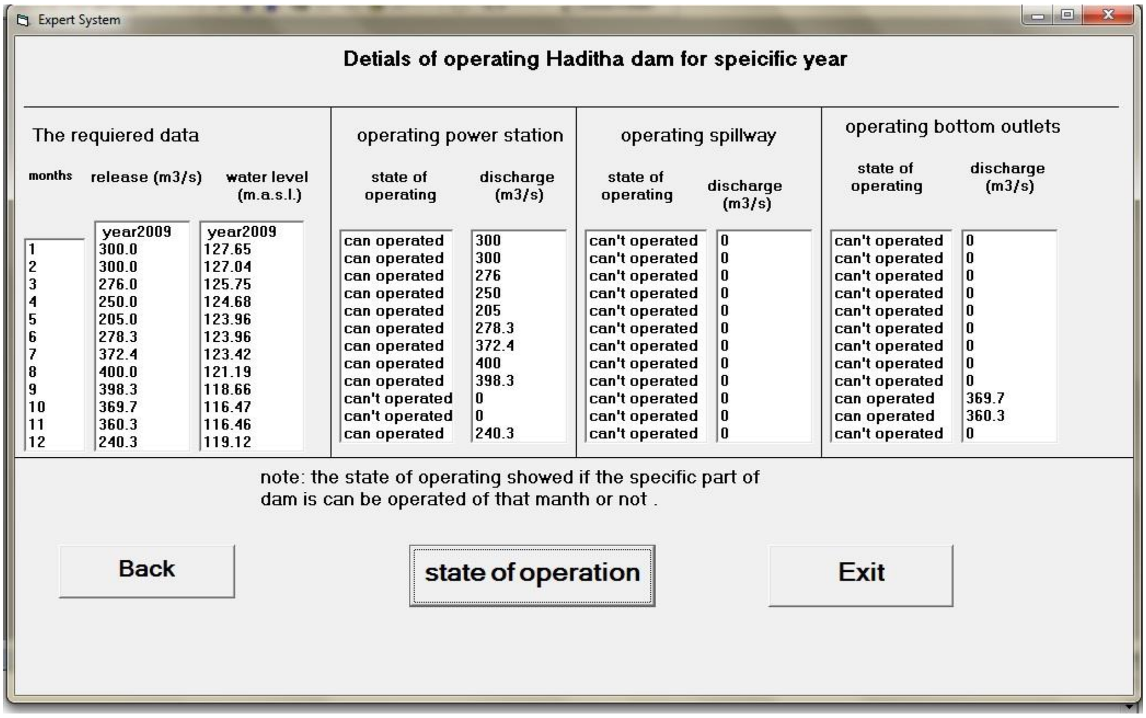

Figure 9 The details for operating year (2009)

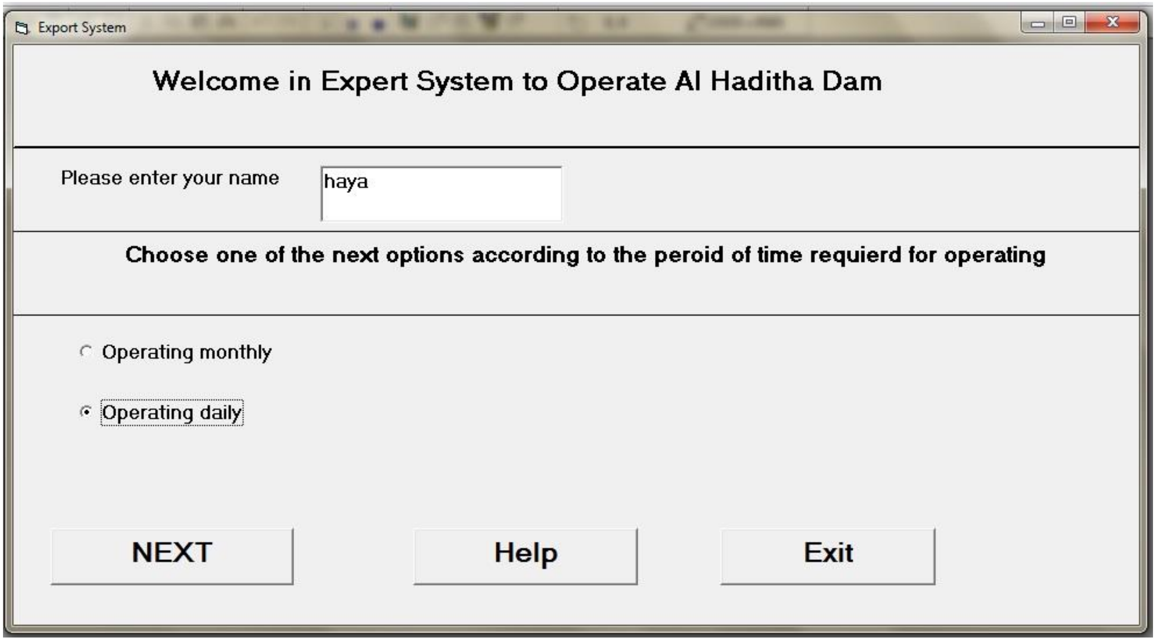

Figure 10 The main menu with daily operating option

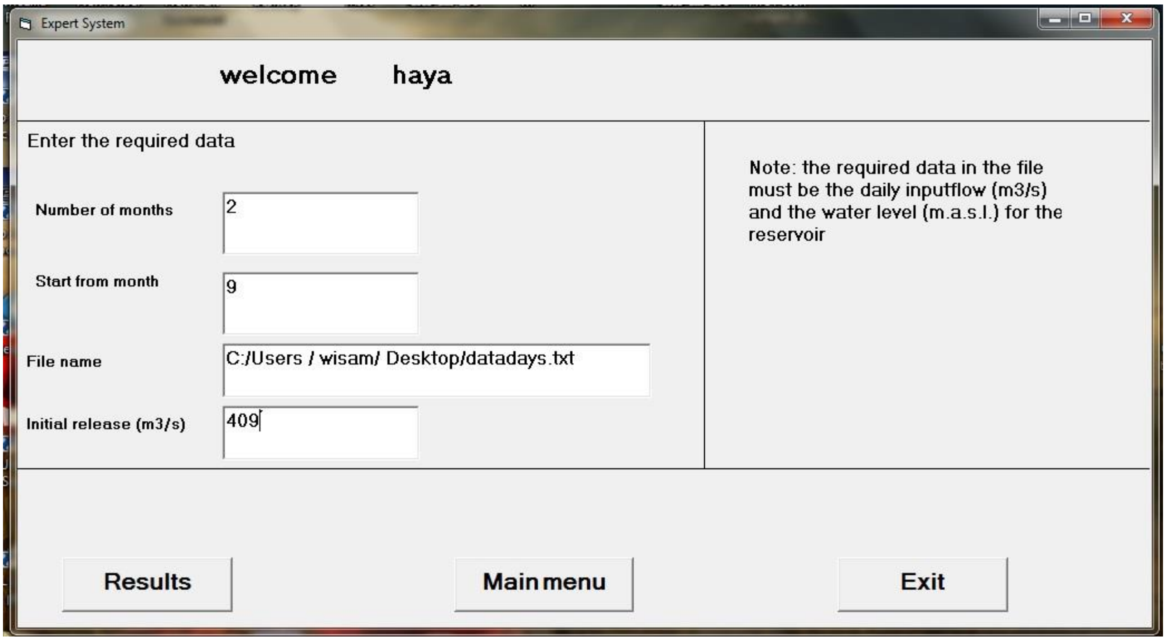

Figure 11 The welcome window of daily operation

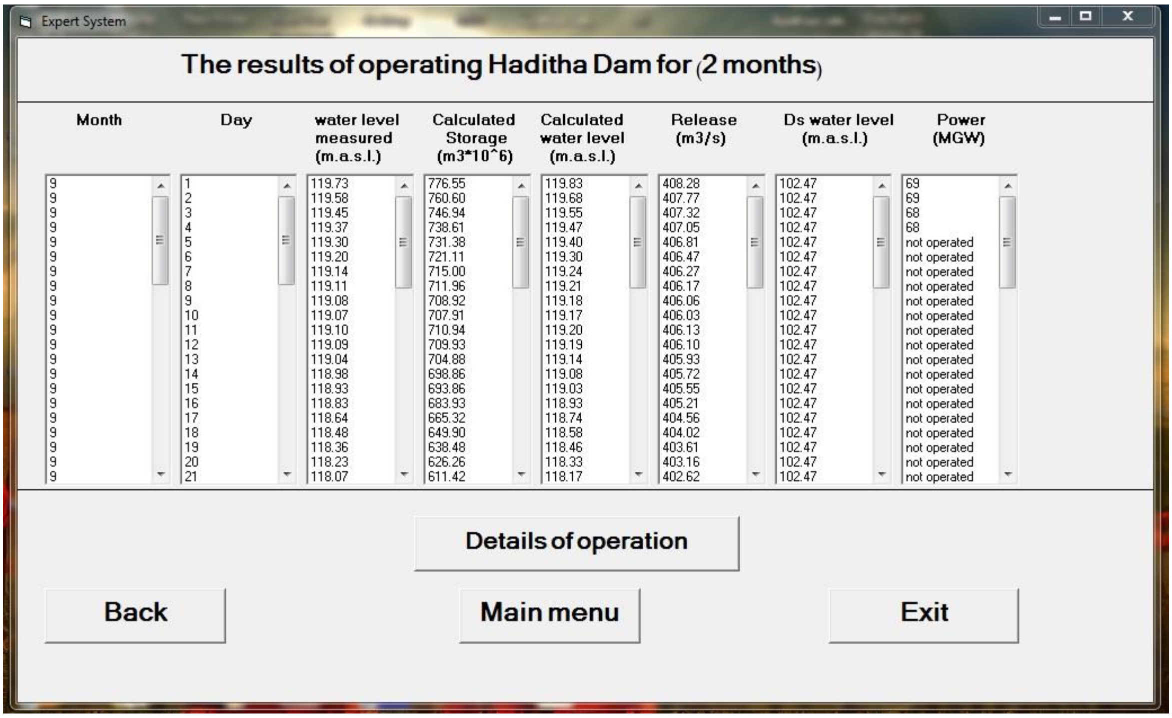

Figure 12 The result for operating two month (9-10/2009)

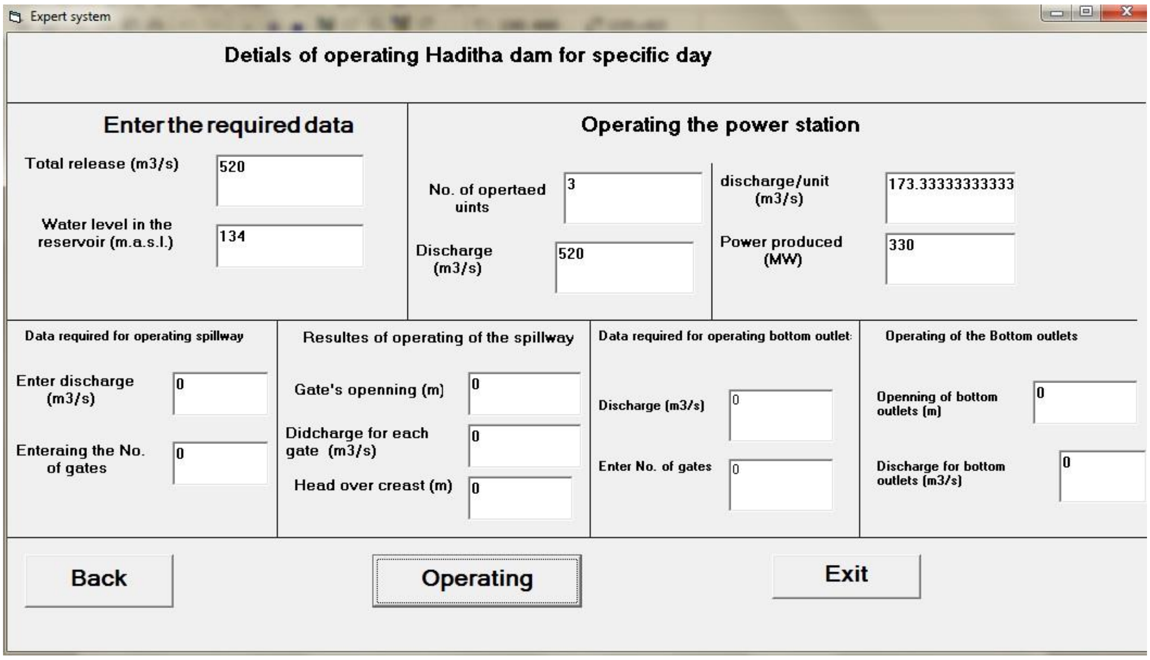

Figure13 The details for daily operating