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Civil Engineering

**ANALYSIS OF THE PERFORMANCE OF MAKHOOL
DAM FOR ACHIEVING OPTIMUM STATE**

Salah IBRAHIM

Master's Thesis

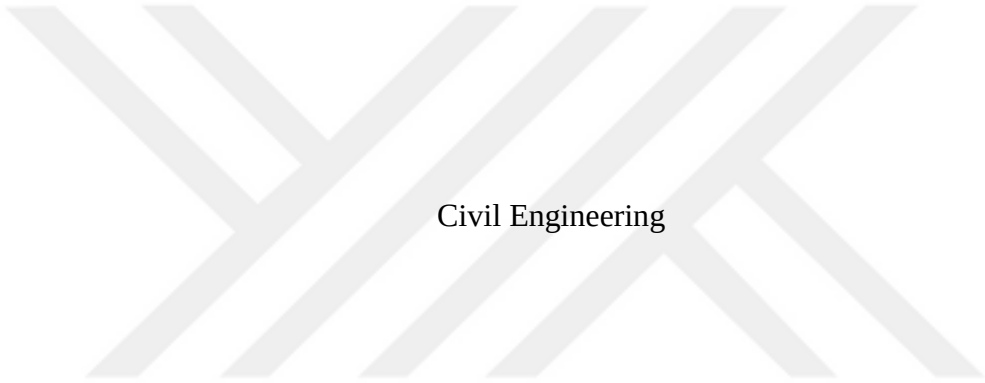
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The thesis titled "ANALYSIS THE PERFORMANCE OF MAKHOOL DAM FOR ACHIEVING OPTIMUM STATE" prepared by Salah IBRAHIM and submitted on X/X/2022 has been **accepted unanimously** for the degree of Master of Science in Civil Engineering

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ABSTRACT

ANALYSIS THE PERFORMANCE OF MAKHOOL DAM FOR ACHIEVING OPTIMUM STATE

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The construction of a dam on the streamline of the water resource can be back important benefit in controlling the amount of water that been stored or spread toward the downstream region for various demand. In Iraq, the Tigris river and it attributes included number of dams that build for different purposes. The place of Lesser Zab stream that joins the stream of Tigris river lead to the important step for building Makhool dam as the projected designed for controlling the amount of water in middle and southern region of Iraq. The management of the makhool dam is important strategy to be move through for conserving sufficient but not excessive quantity of water before the dam and sharing sufficient amount of water to be flow out the dam to several requirements. The study aimed to examine the monthly water balance that based on the amounts of flow rate toward and outward the dam. The study also in balance condition took the effect of the precipitation and the evaporation in the overall resultant of the water stored. The study arranged its pathway analysis by deriving main equation for each month that control the main parameters into negative and positive quantities so that, the summation gave the resultant quantity. The outflow rate per month was assumed as percentage of the inflow rate for studying the influence of various magnitudes of water that spreading after the dam toward the downstream region on the management stability. The topographic of the region of reservoir was studied by using Surfer program in which fed by the GIS data then analyzed for evaluating the amounts of volumes and the areas that formed between each two adjacent contour lines. The study build management plan for each month and showed the details by figures and tables that included

the influence of changing the outflow rates and also the amount of water that stored on the elevation of water surface in the reservoir. The study then used the technique of simulation based on HEC RAS program. The study explained the speed of flooding that result by predicted overtopping cases as the water elevation reach the crest elevation of the dam. The simulation showed that the flood wave reach the distance of 33 km from the dam obstacle line after 53 hours.

Keywords: Construction of Dam, Makhool Dam, Tigris River, Zab River, HEC RAS.



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ABBREVIATIONS

I	:	Inflow Rate At I Month
A	:	Total Surface Area
EL	:	Elevation
HEC RAS	:	Hydrologic Engineering Center River Analysis System



LIST OF SYMBOL

R	:	Rainfall Quantity Rate
QI	:	The Inflow Rate
GI	:	The Inlet Base Flow
ETO	:	The Potential Evaporation
QO	:	Outflow Rate
GO	:	Outlet Baseflow
ΔS	:	Different in Storage Volume



1. INTRODUCTION

1.1 INTRODUCTION

Dams are type of structures that can be built over a river to retain water for single or more determined purposes. Reservoirs are considered as a form of hydrological state in which found behind a dam. Construction of dams usually built in a way across a stream of a river, or an estuary to in order to retain water [1]. A significant large number of dams have been constructed in the past two centuries in the United States. These dams' ability to regulate downstream flooding has received world-wide attention. Dams are constructed to provide quantity of water for human consumption for different activities like for irrigating arid or for using of in industrial operations. The dams are using to increase the amount of quantity of water available for creating hydroelectric power or to reduce maximum or peak rate of flow that generated in the streamline in the downstream zones which caused by large storms or by heavy snowmelt [2]. Dams also improve the matter of increment of the depth the can the quantity of water has in a river on in tank to improve navigation and also allow ships to travel in more easily conditions [3]. Ancient dams were built in Mesopotamia and the Middle East for water control. The earliest known dam is the Jawa Dam in Jordan, dating to 3,000 BC. Egyptians also built dams, such as Sadd-el-Kafara Dam for flood control. Dams can same manner provide a lake or recreational operations such as boating, and swimming [4]. Dams and reservoirs are essential structures that are critical for providing us with some of our basic needs. Dams are structures built to retain water by forming a reservoir behind the structure. These are usually built across, or near, naturally flowing water to manage the water for human use. Many dams can be built for bigger quantity than one purpose; for example, quantity of water in single state of reservoir can be consumed to generate hydroelectric power. Moreover it can be used to support an irrigation system. The contractions of this kind are often designated for achieving multipurpose dams [5]. A reservoir is considered as a body of quantity of water that has been formed or changed by human activity in the way of specific purposes for providing actual and controllable amount of water resource. Dams and reservoirs are able to serve a different types of purposes. The purpose of a reservoir can also in alteration over time [6]. Reservoirs may premise for flood protection: Some dams are designed specifically in which for flood protection. Dam may involve a secondary state of function that can be used for excessive water leading to flood protection [7]. If appropriate

planning is assumed, the level in which of a reservoir considered able to be lowered. The flow in downstream sites after the dam in the river in future will depend on the amount of flow that the dam designed to control in ordinary cases. The volume of water is considerably decreased during the eliminate of wetting season. As a result of these climate conditions, the downstream may be altered accompanied with dry weather in which for the lack in the water feeding in water resource zones [8].

1.2 PROBLEM STATEMENT

The significant role that played by the position of dams can be noticeably considered as these structures control in their action the vital source of life which is the water. The hydrological state in a region reflect many parameters that must be considered in the way of better controlling of the streamlines and flow rate that obtained from the dam operation. The problem of overtopping as leading to possible flood can also form critical point to operation strategy for the dam. The hydrological behavior in Iraq are in various and distributed state. Better controlling of dams can enhance the validity of water consumption and lead to improvement in water resource conserving. Makhool Dam is one of the important dams in Iraq which requires the optimum condition in operation for better performance. Optimum conditions can be achieved as the monthly water quantities (inlet and outlet quantities) been controlled for conserving suitable storage amount of water behind the dam without the chance of overtopping nor reducing in non-desire percent the amount of that stored water

1.3 CONTRIBUTION

The study lead to improve the controlling of the vital project of Makhool Dam by analyzing the monthly quantities of water toward the dam and the impact of the weather conditions on the storage volume and the work of the Dam in stable conditions without possibility of overflow case. The study used the simulation technique based on HEC RAS program as better analytical procedure Applicable model had been built by the study in order to reach optimum controlling of the dam. Different parameters were used that related to the performance of the dam and the quantity of water gained. these parameters included the discharge before and after the dam, weather conditions, and ground nature.

1.4 AIM OF THE STUDY

The study aimed to derive applicable model that can be confirmed in the way of better operation of Makhool dam. The study tried to use all required data like studying the situation of upstream sites behind the dam including the geological and hydrological behavior of reservoir, and also studying the conditions that impact the entire storage like seepage and evaporation. All needed data was uploaded toward Hec Ras software in the way for analyzing the dam site toward best simulation that can be obtained.

1.5 OBJECTIVE OF STUDY

- i. Gathering the necessary data including the detected amount of flowrates toward the dam that join from the main stream of Tigris River with Lesser Zab River and also gathering the data of the monthly precipitation and evaporation rates.
- ii. Investigation the elevations of the reservoir form and nature of ground and collecting data relating to the parameters of weather including temperature, humidity, and rain intensity.
- iii. Using of Golden Software to determine the behavior of upstream and downstream sites
- iv. Applying and analyzing previous data in Hec Ras software to simulate the hydrologic state of the dam along the year including the examination of the chance for flood in the case of top flow.
- v. Building of mathematical model that can be used in controlling the operation of dam and drive the performance of the dam depending on the results of the software in different periods of time.

2. LITERATURE REVIEW

2.1 INTRODUCTION

Dams have many benefits that include securing water for cities as well as agricultural purposes, in addition to their important role in flood management, as well as in the process of generating electric power. Despite the existence of economic and social effects that are sometimes undesirable, for example the displacement of the population as well as the flooding of river valleys and the impact on many economic activities in those places [9]. There are effects of dams, as well as the process of their operation, which is long-term. These effects are not understood in the organizational community as well as in the dam industry, and for this reason, the impact of these effects is rarely reduced when constructing, designing and operating dams. Dams can have a significant impact and also many consequences that have an impact on the social and economic well-being of people dependent on services and goods as well as the environmental health of rivers. Thus, many assessments of the social, economic and environmental impacts of dams have focused primarily on some areas directly adjacent to the dam as well as to the reservoir [10]. In addition, dams can modify river ecosystems on a wide and many kilometers downstream direction through changes in water flow, i.e. timing and volume of water, as well as the physical structure of flood plains and river channels, and water chemistry. Chemical and physical changes that occur in the river's environment may lead to changes in many biological conditions, including the process of losing animals or plants that are valued by many local communities for recreation, building materials, food, tourism and other cultural purposes [11]. Since recent decades, many scientists have collected the most important evidence showing that river flows have different shapes and patterns that change from high flow to low flow throughout a specific period of time and there may be variation that is over many years and has a high impact on many River ecosystems. All components of the flow system have a significant role in the flows that are low-level in relation to the floods, which have an important role in the process of forming the ecosystem of the river. Because of the significant impact of flows on all important environmental factors, which include (water quality, biological composition and physical habitat), river scientists show that considering the system of river flow is one of the main variables [12]. For the reason of ecological movements that is so essential for the health towards ecosystems of the river that sustain

passable to flow of the river, all circumstances are essential in supporting the ecosystem goods and those service upon which the local community depends for livelihoods and production. Iraq has a vast area under irrigation. This irrigated area is continuously increased so as to establish ensured irrigated cropping and avoid cropping failure due to famine or untimely water. To secure the benefits of irrigated land, a tremendous amount of capital has been invested in irrigation projects. Moreover, projects constructed at the upstream (in Turkey and Syria) for storing and consuming water have resulted in reducing the quantity and quality of water that arrives to Iraq. Due to the construction of the Makhool Dam some kilometers upstream of where the river Tigris breaks through the mountain chains of Jebel Makhool and Jebel Hamrin, an area of more than 45 km² will be inundated by a future reservoir. Accordingly, the dam is aimed at reserving “more than three billion cubic meters of water which is the minimum requested level for the agricultural and humanitarian use . When the ecological flow that manages that process is incorporated into a dam, it is essential that the ecological flow that is released from the dams can be designed to meet a social arrangement with economic goals, and to reach a level of diverse protection of the ecosystem. Methods for seepage monitoring and internal erosion detection give essential information for the safety evaluation of earth embankment dams. Experiences from dam safety work indicate that the use of existing methods is in many cases insufficient, and there is a considerable need for improved surveillance on dams worldwide [13].

2.2 RESERVOIR CAPACITY

The total volume of water that is stored in the tank. The storage capacity represents the private part of the tank capacity, which cannot be used for operational purposes. For the term of dead storage, it represents the volume that is opposite to water stream or what considered inert part of water which not moves by gravity toward the dam spillway gates. The other than dead storage included in the live storage of water which represents the capacity of the tank all except for the dead storage capacity, since the presence of the direct storage quantity represents the corresponding volume of water [14]. The flood storage capacity, which represents the part of the water in the reservoir, that is, the capacity that represents the reserve quantity of the temporary storage quantity of the flood waters required for the purpose of regulating the flows from downstream of the river. In the case for the additional storage capacity, which represents the capacity of the tank between the upper uncontrolled part of

the drain or that is above the summit gates relative to the normal position that is closed and the maximum height of the water [15] [16].

The main reason for which the dam is designed is for the process of additional storage of water quantities, which shows quantities in excess of the corresponding volume of water. The normal operation of dams usually shows that the storage water conservation represents the volume that is the water stored for specific period of time without influence the ability of the reservoir to catch this magnitude of water in addition to what coming from the nature sources [17]. The energy storage capacity, which represents the storage capacity that is intended for the purpose of use in the generation of electric power, as it means reversible quantities of water to the corresponding volume of water. From the mentioned terms, it can be clear noticed that the common storage capacity represents the storage capacity of water conservation, which excludes the capacity of energy storage [18]. For understanding and for better analysis of normal storage capacity of the reservoir, the dead storage level, which represents the amount of water level in the tank corresponds to the quantities of dead storage with this capacity, under which the tank does not work, which means that the water level in the tank at that index leading for the case of reserved storage capacity [14].

2.3 DAM AND POPULATION

Since ancient times, man has been trying to shape the environment in a way that is suitable for the life he lives. That was the period in which the existence of this struggle was observed, which is intense, especially in the period that represents the transition from a primitive society to a society that represents hunting, as well as gathering to the transition to a life of agriculture and hunting. At this time, as more than one environmental modification began to be contrary to nature that had been achieved within human history. Even the development of many civilizations and the process of overthrowing them are linked to this interaction between man and nature. Dams are considered one of the most important roles that are responsible for the exploitation of all water resources [19]. Construction began for a long time, before many current information on hydrology and hydromechanics was obtained. Dams are considered to have a large positive and negative impact on that environment in addition to their advantage, such as the process of controlling many sewage systems, and thus work to prevent floods as well as obtaining domestic water and irrigation water obtained from stored water that works on power generation. Wherever the dam is located, all its

environmental consequences are identical [20]. The environmental impact of dams that are classified according to different criteria as long term and less term effect, and the effects of this are on the area that is close to the dams and the impact on the area in which the dam services are, in addition to the social and non-social effects, and some effects are beneficial and that these effects are arranged in a complex and intense manner such as climatic, hydraulic, biological, social, cultural, archaeological and so on. That environment In relation to sustainable development, these impacts and their solutions are taken into account in the concept of environmental impact assessment [21]. The increase in the benefit that is on the environment causes many contradictions, including engineers, planners, and some of those who oppose dams and engineering buildings from among the groups of society. On the other hand, the construction of the mentioned buildings and laboratories must be carried out for the purpose of improving them. There is a need to assess the real need, which represents a balance between the water supply as well as the distribution of the population. In addition, the necessary importance of water projects appears in many environmental relations that have an impact on the process of water pollution, where there must be an assessment of the real necessity of constructing dams [22]. The water projects are continuous, as well as all the general studies that are acceptable in providing public health and also security. There may be an exchange for some types of projects. The hydroelectric projects can replace the insufficiency of oil for fuel. There must be thought of many purposes such as providing hydroelectric power, flooding, irrigation, as well as places for recreation. Storage contamination is variable when the treatment process is most effective and important in eliminating the contamination. In the event that there is a need to establish a new project, the planners must assess all kinds of environmental impacts for the purpose of improving the project in a way that has less dangerous effects [23]. There are many changes in many operating systems as well as production systems which must begin before the dam is built, including the type of land, the machinery used to transport construction materials to the site, and the process for hiring construction workers. At the same time, the dams significantly reduce all the effects related to pollution in the lower part by reducing the pollution load from the source, these benefit relates to the large storage tanks. In addition, dams work to reduce the impact of pollution that occurs for a second time through the quantities of water that are constantly present during periods of drought, as dams reduce the risks of floods that occur downstream, through the process of storing them, and this shows that there are possible

benefits and A real one of these projects [24].

2.4 EFFECT OF DAMS ON HYDRAULIC SYSTEM

The main hydraulic effect is the result of the emptying of the collection basin, which is transmitted to a reservoir that is stationary, instead of the water course. The instantaneous change that occurs in the direction of the river; the downstream partly or completely dries up when the reservoir begins to accumulate water. Within a period of time that is periodically recurring or temporary, there can be a breakdown of the hydrological balance; the disappearance of many structural leaps found in an ecosystem that is highly dependent on water can be observed [25]. The flow of the source water could be polluted, especially in the deep parts, which is dark in color for a long time and most likely has a rotten smell, and that is due to the process of getting rid of hydrogen and sulfur. The ecosystem and water balance and even the marine environment that includes current with the sea has the opportunity to achieve its former purity [26].

The change that occurs in the biological life of the river, which occurs rapidly, may be downstream or in the reservoir. The parts of the vital system that are greatly affected by the dam are the parts that are irrigated on the shore. During the work of the filling process of the dam, at a time when the lands are completely submerged in water, this causes the land part of the specific area to diminish. However, there is an extension in the boundary of water and land. For this reason, many areas of human, plant or animal settlement are changing. Agricultural and forest areas may be exposed to water inundation [11]. Due to the large difference that occurs in the water level and which continues periodically, where some species of organisms begin to live under the water at different times, the tidal zone in this area turns into a swampy land or turns into a reed, which depends on the structure of the soil. The relationships that exist between water and soil as well as nutrients, which are settled after the end of the floods that occur downstream, and the change occurs over a long period of time. Despite this, many changes are taking place in the agricultural traditions of the peoples of the region. The extension of this effect can be for many kilometers [27].

2.5 EFFECTS OF DAMS ON IRRIGATION

The consumptive use represents the withdrawal of a large part of the water that is stored behind the dams for irrigation works, which usually include great amount for plant's needs. There should be an assessment of all defects of the dams in advance for the purpose of planning improvement measures. For farms and for irrigated crops, there are often many possibilities for seasonal irrigation, which is related to the flooded land [28]. Most of the dams built in all parts of the world, which are multi-purpose in nature, but the irrigation process is considered the main consumption branch of withdrawn water but irrigation does not lead to keep the required portion of water for the purpose of storage. water projects must also be juxtaposed with the positive effect that dams and irrigation schemes contribute substantially to renewable energy production, food security, and social and economic development. Dams have been responsible for many years for additional areas and for growing crops, as well as entering into the green revolution through high-yielding crops in addition to the use of fertilizers, as this provides food security in the process of facing every growing number of population [17]. However, where the importance of water used in many of the needs that are redundant in the system appears as groundwater or surface water, even if its quality is deteriorating in quality, the main reason for this is due to the presence of pesticides and fertilizers, in addition to minerals that are taken from the soil it is necessary to reduce this waste [29]. A large part of the water is not consumed and is returned to the system. The deterioration that occurs in the quality and efficiency of wastewater, which results from industrial and municipal withdrawals. There must be treatment of wastewater for the purpose of improving the quality as well as the frequency of its use to benefit from it for subsequent uses [30]. The requirement of these uses are increasing with the presence of economic development around the world which is important while planning to configure withdrawals for the purpose of multiple uses of storage space which is limited [17].

2.6 DAMS AND FLOOD

The total volume, frequency and quantity of flow as well as the most peak floods, especially in the flood season, start decreasing in the downstream area in common stable cases. The possible mitigation of floods by dams and the risk to dams from floods are key problems. The People's Republic of China is now leading world dam construction with great success and efficiency. .Most of the dams that are built around the world are multi-purpose in nature

so it can be used for reducing the impact of the dangers caused by floods as it accompanied many problems for human being in downstream areas and also its ability to cause the inundation of crops, properties, and lands, which may lead to many economic disturbances. In addition, it reduces the presence of runoff in coastal lands and plains [31]. Reservoirs, dams and river training works constitute a number of structural measures for the purpose of improving flood management. In addition, some of the non-structural measures such as the process of river phases as well as reservoirs, rainfall monitoring, flow forecasting measurement method, appropriate disaster warning, strategy and early warning, which are also important in the flood management process [32]. Globally, flood risk is projected to increase in the future due to climate change and population growth. Here, we quantify the role of dams in flood mitigation, previously unaccounted for in global flood studies, by simulating the floodplain dynamics and flow regulation by dams. We show that, ignoring flow regulation by dams, the average number of people exposed to flooding below dams amount to 9.1 and 15.3 million per year. In the lean season, when the river flow volumes decrease in the downstream region, the situation then depends on the withdrawals of water from dams through pipelines or canals; however, it can be increased by many supplies from upstream withdrawals to satisfy relative large flows of many agricultural as well as non-agricultural needed. In addition, if the storage process is used for the purpose of generating hydroelectric power located in the river bed, the seasonal flow process is enhanced to relieve all the difficulties that occur in a parallel direction to the river [33]. Choosing the volume for water storage allows eliminating the mismatch between variable availability and supply, but more often is demanded throughout the year. For a season with excessive water amounts, most tanks are designed for the purpose of transferring storage to another season. When there is high degree of variation in seasons, this can lead to the occurrence of many droughts as well as floods. Especially if it is not taken care by these reservoirs to hold extra water amounts [34]. All types of small and large dams work to improve all conditions and serve different types of similar purposes. All dams facilitate the transfer of water quantities to areas where there is a shortage of water through all closed pipes, open channels and tunnels. In a river basin, a combination of small as well as large dams may be needed for the purpose of water storage so as to facilitate use and withdrawal and with less transport distance to areas of demand [35].

The process of selecting small or large dams, and also choosing the site for each dam,

depends on many factors, including the location of water-deficit areas that need service, as well as technical feasibility and the availability of many related alternatives that are used for this purpose. In addition, the balance between the negatives and the positives due to the presence of a particular dam in many economic, social and environmental aspects helps in determining the decision [36]. The process of providing many reservoirs for the purpose of insurance to provide water reserves due to many climatic fluctuations, as it can work to help reduce the variability process in the presence of low flows that occur in rivers in the season and for the purpose of saving many communities importantly from disasters and economic disturbances as well as losses that It occurs due to the presence of floods and dry seasons. Among the defects caused by dams are that each dam causes temporary or partial flooding of the land in the upstream area, as well as for the displacement of residents and the preservation of their property, in addition to the disruption of animal life and the inundation of plant life. With the process of declining levels of reservoirs [37].

Downstream is often met by flow that occurs through regulated releases into the river or by gravity, while in the upstream, the accumulation of water quantities plays important role in the validity of the reservoir. These fact must be evaluated in advance for the purpose of planning all improvement measures. So that any defect that can occur during operation and during the implementation of the plan require careful management and control [38].

2.7 SISTAINABILITY FOR DAMS

The dams have helped in solving many problems in the communities that they served as well as provided the important purpose of economic development and its sustainability. It also helped reduce private rates as many job opportunities were provided, in addition to the stability of the rural population, and the migration of the unemployed was reflected in the work and movement of the rural people to urban centers. Providing food security for the population, whose number is constantly increasing, and generating the cleanest types of energy, as well as protection from the dangers of floods and protection from desertification and drought areas in increasingly vulnerable areas, and the generation of hydroelectric power, in addition to the existence of additional benefits for the purpose of developing all water resources [39]. Many urban industrial centers have been provided with several water supplies for the purpose of consumption and the process of transporting waste for the purpose of treatment. The gated water storage regions provide an amount that is less than

the amount of immersion for the destination of long-term sustainability which can enhance for the purpose of irrigation service, by avoiding the process of excessive accumulation of silt quantities that are above the top of the stream for water drainage . The largest part of the storage amount of water can be considered almost always more secure [40]. The comprehensive development process of dams is there to be the focus of everyone's attention. There is no doubt that the costs and benefits as well as the risks that increase with the increase in the size of the dam. Dam planners make great efforts in order to reduce costs and maximize benefits as well as build defensive measures in all components of dams for the purpose of taking care of risks through the diffusion of technology features and appropriate design processes. The number of accidents caused by the failure of dams decreases from time to time, and it is better that the safety record is better than in all other sectors for the purpose of infrastructure development [39].

2.8 IMPACT OF DAMS ON RIVERS

Dams reduce river levels by diverting water to obtain energy. Dams remove water that is needed for all types of healthy ecosystems in the stream. It is usually a drying process that occurs in the extensions below the embankments. Dams block rivers by blocking the flow of nutrients and plants, impeding the migration of wildlife and other fish, and preventing recreational use. The river where it makes it unlikely to be safe to travel. Upper reaches of the reservoir may not be affected very much as the original riverine conditions are still retained in most Nepali reservoirs. Downstream of the dam the flow rate in the river will depend on the amount of the compensation flow. Water volume is considerably reduced during the dry season. As a result the downstream may change to pools alternating with dry stretches for about nine months from November to June. Due to decreased water discharges, water temperature will raise in daytime and decline sharply at night. Rooted plants will grow in the riverbed due to the decrease in water volume. Dams slow the movement of rivers, and some types of fish depend on the presence of constant flows for the purpose of expelling them downstream early in their life as well as directing them to the top of the river after several years to reproduce. Stagnant water accumulations in the tank affect the migratory fish and greatly increase the duration of their migration. Dams change water temperatures by slowing the flow of water, as most dams increase the temperature of the water [41]. Dams change temperatures by releasing the cooled water at the bottom of the tank. The fish,

as well as some other species, are sensitive to changes in temperature, and often cause devastation to the indigenous population. Restoration of an unregulated flow regime has resulted in increased biotic diversity through the enhancement of preferred spawning grounds or other habitat. By returning riverine conditions and sediment transport to formerly impounded areas, riffle/pool sequences, gravel, and cobble have reappeared, along with increases in biotic diversity. Fish passage has been another benefit of dam removal. However, the disappearance of the reservoir may also affect certain publicly desirable fisheries. Dams work to change the timing of the flows by blocking the quantities of water and then releasing it for the purpose of generating energy, especially in periods of peak demand. Where dams cause many alternations that occur in the downstream supplies of the river, between the lack of water in addition to the presence of strong floods, which affect and cause soil erosion as well as vegetation cover. These irregular releases affect the special natural changes in the seasonal flow that lead to many cycles of natural growth as well as reproduction in many other species. Dam construction is an important engineering measure in dealing with the relationship between water and human being. However, with dam construction, some disadvantages to the river basin may be caused, including flow flux of downstream changed, flooded area reduced, river species and other organisms changed and substance sedimentation. Furthermore, it brings some diseases to human being and human residential areas reduced too. [42].

2.9 DAMS OPERATION STRATEGY

For the purpose of developing a special assessment of the impact of the dam-building process on the system of hydrological systems, there are a number of studies that compared the hydrographic characteristics of the pre- and post-dam construction process that are capable of flows onto the calibration stations in the downstream region. Hydrological changes that result from the construction of dams. Many global dams are trying to reduce the frequency of peak flow, duration and volume, the increase that causes the frequency of duration and volume of flows, which are usually low, and the analysis of many secondary effects, for example, that are related to changes of the downstream channel due to The presence of dams [43]. The evaluation of the construction process of the dam located on the current flow was also shown by comparing all the hydrographic characteristics that are before and after the dam. Examples of this are the amount of the minimum annual flows as well as the annual

peak flow, as some values are specific to natural flow systems where a certain number is used. It is one of the scales for the purpose of evaluating the differences in the values that are after the dam from the amount of the natural values, i.e. the conditions that are before the dam. Sometimes this type of comparison is very difficult and the reason for this is because most of the characteristics of the watersheds (such as elevations, areas and lines width) which in turn affects many hydrographic characteristics that, in some cases, the effects of the dam construction process cannot be well evaluated [44]. The effects of the operation of the dam that it causes on the records of the almost daily flow, considering that many fluctuations of the flow resulting from the operation of the dam, whose impact is mainly on the sub-daily flow process, the process of the time scale that is daily is considered an approximation for the purpose of characterizing the potential impact of dam operations. It is not simple matter to make an assessment of all the process effects of the recorded flow at the estuary, because the stations are located at varying distances to the operating dams. The watersheds are located at the sources which are operated to varying degrees, with varying operating schedules, and this leads to increased difficulty in the process of determining the signatures that are distinctive for the purpose of operating the dams on the flows that have been recorded [45].

2.10 OVERTOPPING FLOW

The process of overflow is an event that is made up of many possible failure modes still resulting from the effects of floods. The embankments were bypassed from a few inches to more than a foot without breaching, and the other structures failed quickly. Overtopping flow occurs when a water detention structure's capacity is surpassed and flow passes over the structure. Potential sites of overtopping flows are embankments such as dams, levees, detention basins, et cetera. .There can be overflow of bridges and dams with a continuous flow, in case the height of the source of surface water like river or pond exceeds the available obstacle part of the dam. In such cases, it can be relatively easier to calculate the duration and depth of the flow, based on the information that is available for the specific project [46]. For the process of overtaking the waves, where the level of the height of the water surface approaches, but it does not exceed the point that is considered critical as it lies in maximum constraining level of the dam. Otherwise, the waves that are moved by the wind produce many waves that exceed the top of the dam. Wave action can cause a discharge equal to

every linear foot of the structure and can cause failure and possible structural wear. Waves are affected by the direction and speed of the wind, the distance of open water, the depth of the construction, and the slopes of the barrier [47].

2.11 HYDROGRAPH

The runoff measured at the basin exit, when plotted toward time gives the hydrograph. In other explaining, it is the time giving out of runoff provided by a given precipitation on a basin. As the runoff includes the contributions from surface runoff, state of interflow and the matter of groundwater runoff, the hydrograph can be regarded as an integral expression of the physiographic and climatic characteristics that govern the links between rainfall and runoff. Thus it forms the base to relate precipitations and the periods distribution of precipitations produced by it [48]. Detailed analysis of flood hydrographs is usually important in flood control and flood forecasting, or in establishing design flows for hydraulic structures which must pass flood waters. The shape of a hydrograph resulting from a single non-long duration storm happening over the discharge water area follows a general pattern. The hydrograph could be in single peak or multi peak depending on the recorded intensities of runoff. A complex hydrograph may be revealed into the relating simple hydrographs. At all, single peaked hydrographs resulting from separated storms are generally preferred for hydrograph analysis. The upper point discharge represents the most high concentration of runoff from the exiting basin. It occurs repeatedly at a certain time after the rainfall has stopped and this time depends on the aerial distribution of rainfall [49]. Figure (2.1) showed the case when there were no significant matter of flooding in the downstream so the dam work in stable state without storage the extra amount of water behind the dam and the out flow didn't reach the limit of permissible discharge that be considered in the design. The figure (2.2) explained the case of mitigation overtopping when excessive amount of water accumulate behind the dam so that the outflow be in maximum gradually. When the storage behind the dam be close to exceed the storage capacity, the spillway controlled to out more quantity of water under the design limit, these condition explained in figure (2.3) [15].

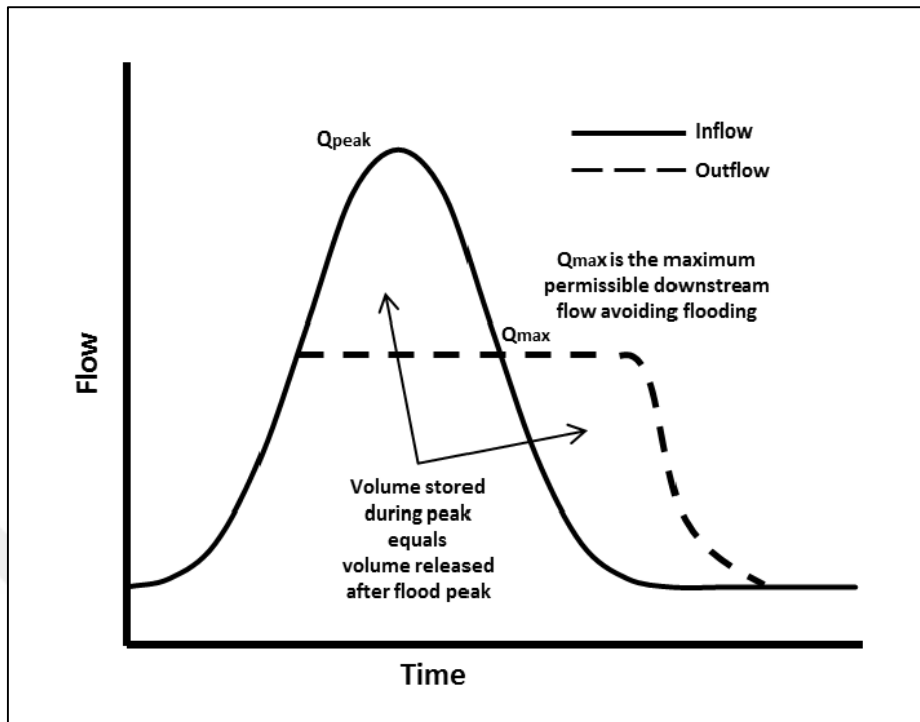


Figure 2.1: Reducing Flood Behind Dam By Direct Outflow [15].

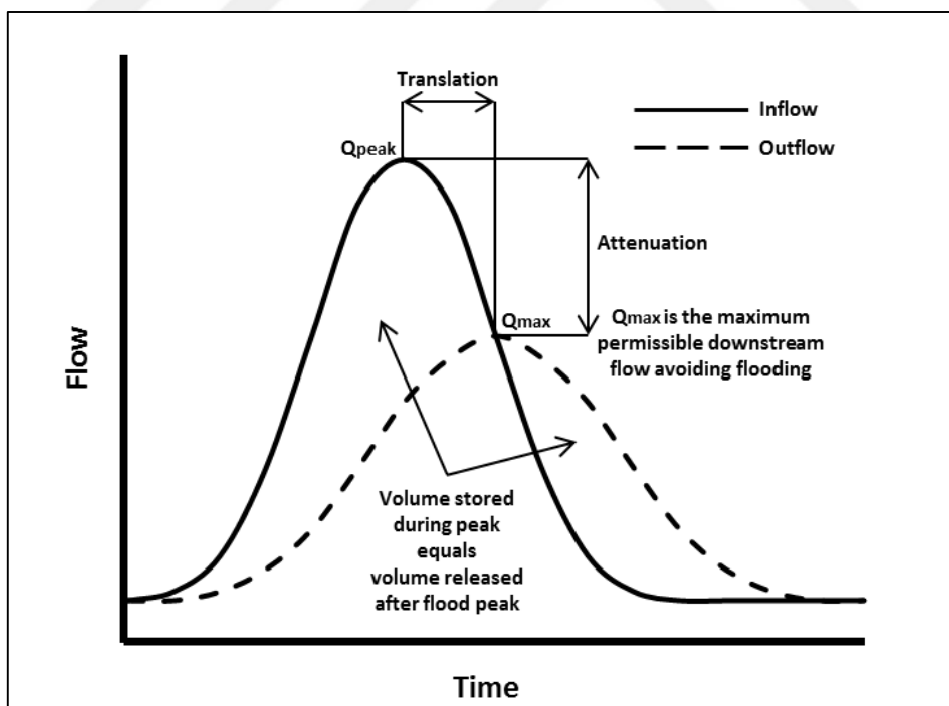


Figure 2.2: Reducing Flood Behind Dam By Storage And Outflow.

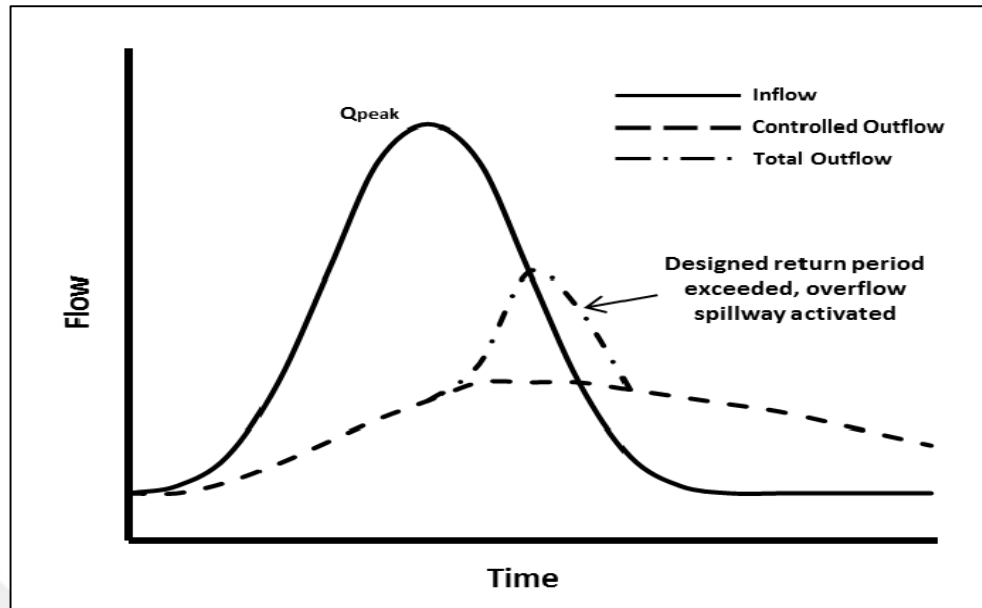


Figure 2.3: Reducing Flood Behind Dam By Controlling Spillways [15].

2.11.1 Flood Frequency

The frequency caused by flooding is considered one of the main factors that cause overtaking risks as well as dam failure. The elements that have an effect on the amount of frequency represent the drainage capacity of the drains, the process of forming the drain stream in addition to the gate, as well as debris blockage [50]. The process of determining the presence of the effects of these factors usually requires multiple paths for the purpose of the hydrograph flow process and for the purpose of determining their possible effects on the water height, as well as determining the depth in addition to the excess period [51] [70].

2.11.2 Spillway Discharge Capacity

The discharge capacity of a watercourse is mostly determined by means of flow design, which is determined by the reclamation process using a hydrograph that is specific to the internal flow, the capacity for drainage is Usually less than the amount of peak flow entering the tanks that are of large volumes. On the contrary, when the tank has a small storage capacity, as the peak flow of the inlet water is equal to the capacity of the drain channel [52] [71]. Spillways typically represent structures at the top of the dam that allow water to go over the dam top in an uncontrolled manner. Up to ten independent spillways can be included in the reservoir. There are three different methods for computing outflow through a spillway: Broad-Crested, Ogee, and User Specified. Excessive and uncontrolled spills can be relied

upon to anticipate potential discharges[72]. The presence of some mechanical faults or the presence of some differences resulting from the difference of some operations from the pre-planning process and the reason for this is due to the inability of the operator to control the dam gate or to take a decision by the operator to delay the process of opening the gate so this state can lead for downstream flood to take place [53] [73].

2.12 DETECTION OF DAM FAILURE

There should be an assessment of the possibility of dam failure whereby by specifying an initial default, the breach must be determined at any breach of the dam, and in the event that the risks exceed all agency risk guidelines, a more precise approach must be determined, especially if the breach is allowed to be a small depth which will It changes the conclusions that cause the failure mode [54] [74]. For the purpose of improvement, the risk analysis team should think about the development process of the fragility curves, for the purpose of linking the probability of failure that causes breach of the top of the dam as well as the erosion with the depth of overrun, as well as there must be development of all possibilities of failure. Dam safety assessment is typically made by comparison between the outcome of some predictive model and measured monitoring data. This is done separately for each response variable, and the results are later interpreted before decision making[75]. In this work, three approaches based on machine learning classifiers are evaluated for the joint analysis of a set of monitoring variables: multi-class, two-class and one-class classification Determine its best estimate [53] [76]. Internal erosion is a cause of embankment dam failure, thus it is important to develop methods for seepage monitoring and internal erosion detection. In order to evaluate the potential of resistivity monitoring to give an early warning of such leakage/erosion. Internal erosion is one of the major reasons for embankment dam failures. Despite this, the knowledge of the temporal development of internal erosion in full scale structures is limited. Detection of internal erosion is complicated using conventional methods, and new or improved methods are appreciated. Hällby was the first Swedish embankment to get a permanently installed monitoring system intended for resistivity measurements. Daily measurements started to take place already in late 1996, which make these long term monitoring data unique. Internal erosion is one of the most frequent reasons of failure and deterioration of embankment dams. Internal erosion is controlled by construction properties (e.g. filter and drain design, grain and pore sizes) and hydrodynamic conditions within the dam. While construction properties

are usually known, poor information is available on the local hydrodynamic situation inside the embankment. Hydrodynamic parameters vary strongly inside the dam due to local inhomogeneities and the most critical hydrodynamic parameter inducing internal erosion (material transportation phenomena) is the pore velocity of the seeping water. The onset of internal erosion starts at low pore velocities. Thus a method for the detection of seepage zones of low pore velocities can prevent the development of damages. The calculation and prediction process for the outflow discharge in the peak that result from the breach of the embankment dam due to the overtopping is the predicting of fundamental matter such that the flow affords an ideal tool for that draw the scenario of rescue to protection against all damage of life due to hazards that result. The situation was analyzed based on the models are generally used by number of the researchers to expect the outflow discharge of the peak due to the embankment of the dam breach via overtopping flow [55]. All models can be considered as simple procedures to explain the situation of flow behind and after dam toward the stability of flow in downstream area as well as the chance for overtopping flow to occur. The related analysis can make development by using some of certain equations relating the discharge of breach outflow of the hydrograph based on the parameters of breach by using technique like regression analysis process and using data in case study. The parameters of breach contain the height of the dam which influence in with other parameters like volume of reservoir storage and rain intensity [56]. Water volume in the behind area of the constructed dam that consider main variable in the most of the equation of regression which used to the prediction of the way to the discharge of peak breach flow. Conversely, the development equations of the discharge for the case of peak breach flow due to process of overtopping that can expected that whole volume of reservoir becomes filled through the time of failure and any excessive feeding source of water like rainfall can lead to enhance the flood problem toward the downstream region [57].

2.13 CURRENT WORK

The present study investigated the ways for reaching optimum operation condition in Makhool Dam, the dam that found in north of Iraq on Tigris River. The study used the necessary related data like the behavior of the discharge behind and after the dam and the influence of climate change on the dam state and the chance for flood to occur and its impact on the downstream region. for analysis the chance for better controlling of flow rate, the

study build outline moved through number of main steps. The steps that taken by the study was the analysis of the inflow rates per month, the intensity of rain, and the potential evaporation. The second step was the analysis of the topographic map of the nearby region by using Surfer program. The study then moved toward the equation of water balance to build management plan for each month based on the monthly negative and the positive quantity of water the predicted to be gained. the plan for each month explained in figures,. The study in final step built simulation work by using HEC RAS program to explain the velocity of wave after the dam in the failure (overtopping) condition

2.14 LITERATURE SURVEY

The study analyzed the performance of Makhool Dam in the way of examined the operation of stilling basin front the dam gates with the action of hydrologic hump as the characteristics of the upstream and downstream discharges. The study used laboratory scale for investigating the energy caused by the outflow of the dam by using specific weirs. The study aimed to find a way for decrease the length stilling basin which was by constructing chute blocks that can dissipate the energy and eliminate the impact of the hydraulic jump [58].

The study covered the procedure of reducing dam flooding problem by analysis the state of water balance in the storage and discharge. The case study was the Perak Dam that located in Malaysia. The outline included controlling of the water levels in dam reservoir along the year. The study investigated the influence of rainfall intensity and topography of the area behind the dam on the chance of increasing of water level leading to flooding. The study aimed to explained the importance of pre-release activity which mean the discharge of water before the impact of heavy rainfall on water storage [59].

The study had analyzed the state of water quantities before and after Langat reservoir located in Malaysia. Modeling and controlling of the water release from the reservoir was the aim of the study. The magnitudes of inflow and the average evaporation were used in the model. The model adopted was linking between stochastic dynamic programming and artificial neural network. The study outline covered the sustainable usage of storage water by improving the controlling status of the reservoir [60].

The study had used mathematical model based on the mixed integer linear programming for tracking and analyzing the operation as a system for number of reservoirs the located in Iran country. The dams of Karaj, Laar, and Latian were used as case study for implementing the

mathematical model. Data related to the discharges after the dams, the quantities of water storage, and the amount of water needing for different usage were taken as input data in the model. The study results were explained in the way of achieving optimum systematic operation conditions for dams performance [61].

The study investigated the way for reaching optimum operation for controlling water releasing and storage for the dams that constructed in Nakdong River, located in Korea. The study used systematic analysis for the hydrological performance of the dams for handling the problem of drought. The amount of dams inflow and water demands for the purpose of irrigation, industrial, and domestic were examined for the achieving the purpose of the study. The study suggested delaying the time that used for keeping then supplying of water in drought seasons for improving the stability of released water [62].

The study analyzed the variation of the quantity of water that reached the downstream area related to Siemianówka Reservoir and the influence on the state of water in Narew River, located in Poland. Statistical analysis was carried out for investigated the quantity of inflow based on the duration of flow and the periods of increasing and decreasing of water levels in the reservoir. The study had examined the influence of precipitation on the flow regime. The study explained in diagrams the annual fluctuation of water discharge in the study area [63].

The study investigated and analyzed the behavior and the impact of the flood that could be happened due two huge amount of discharge from Sultan Abu Bakar Dam, located in Malaysia. The simulation of the hydrological state for the dam and the downstream area was made using HEC RAS software. The amounts of discharge and water levels after the dam were analyzed to improve the controlling of the dam. The result of simulation involved explaining of flood map which can be used as awareness about the problem in the relating area. The study suggested maximum flow rate that can be adopted for decreasing the chance of inundation [64].

The study had analyzed the risk of the flood that can be occurred by the overflow of Way Ela Dam the located in Indonesia. Two dimensional simulation was implemented using HEC RAS software for describing the impact of flood on the downstream area. The data gathered for analysis were the geometry of the dam and the hydrological properties of the area of study. The influence of rainfall intensity was involved in the study. The simulation results explained the maximum outflow and the travelling time of the flooding wave [65] .

The study aimed to investigate the impact of maximum discharge that formed by the activity of Attabad Dam which located in Pakistan. Dam flooding simulation was handled using HEC RAS software. The study analysis the influence of geometric shape of the cross section of Hunza River which located downstream the dam on the water level along the river path. The amounts of water quantity behind the dam were evaluated by the relationship between volume of water and water level which derived for the dam performance. The study considered its outline as assessment procedure for the impact of flood on the downstream zone. The amount of failure outflow was determined for satisfying the scope of the study [66].

The study had analyzed the case of overtopping outflow and flood problem according to historical data of dams' failure. The study aimed to derive a relationship that governs the influence of the hydrological and geometrical parameters in the areas of upstream and downstream for evaluating the maximum outflow. Statistical analysis had been carried out for correlating the data obtained from different failure cases of dams. The study outline included the calculation of outflow hydrograph. Data of the quantities of water storage and the failure time had been gathered for predicting empirical formula that can be used for determining the peak failure outflow [67].

The study covered the influence of water quantities in different reservoirs on the outflow of water toward the downstream area and the validity for matching the water demand. The study explained in diagrams the activity of dams in different places around the world on the irrigation needed. The study based on the formula of annual proportional flow deviation which means the statistical change of monthly flow in each case or state taken in the study. the outline of the study investigated the benefit of making large reservoir on satisfying the agricultural needing in Africa, Asia, and Europe [28] .

3. MATERIAL AND METHOD

3.1 GENERAL INFORMATION OF MAKHOOL DAM

The Makhool dam, which is currently under construction, is located on the Tigris River, 30 kilometers northwest of Baijy town and about 15 kilometers downstream from the convergence of the Lesser Zab River and the Tigris River. The dam's reservoir will stretch to the Sharqat area, with a maximum water level of roughly 150 m. (a.s.l.).

The western limits of the water storage area are defined by scarps that are mostly found on the flanks of the Makhool and Khanoogah anticlines. The eastern borders of the reservoir, on the other hand, are limited by moderate slopes that climb steeply to the northeast and north. The asymmetrical condition in which the reservoir's western and eastern borders are located, as contrasted to the location of the Tigris River. A future reservoir will inundate an area of more than 45 km² due to the construction of the Makhool Dam several kilometers upstream of where the Tigris River breaches through the mountain chains of Jebel Makhool and Jebel Hamrin.

As a result, the dam is intended to reserve more than three billion cubic meters of water, which is the minimum requested amount for agricultural and humanitarian usage. The reservoir's predicted flooding level is 160 meters above sea level. Different settlements, regional routes, and undisturbed landscape regions suited for agriculture will be found in the future territory of the Makhool Dam reservoir [68]. The place of the dam was explained in figure 3.1.

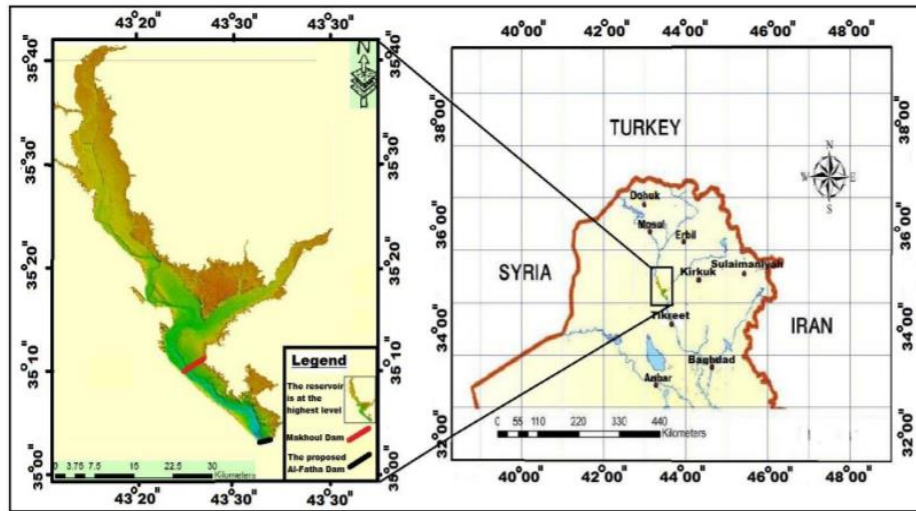


Figure 3.1: Makhool Dam Place Relating to The Map of Iraq [70].

The figure 3.1 showed the region of Makhool Dam, it can be noticed clearly that there are two streams that join before the obstacle of dam body, the first one was the Lesser Zab and the other is river Tigris. The Lesser Zab join the Tigris river before the construction line of the dam cutting. The behavior of the dam state and the income stream was illustrated in figure 3.2.



Figure 3.2: Makhool Dam Region [70].

3.2 DAM REGION TOPOGRAPHY

The elevation of the upstream region behind the Makhool Dam included various graduation of terrain. The minimum elevation in the region as obtained from the Ministry of Water Resources was 142 m above sea level. These elevation included the stream of Tigris river

in the upstream region. The Lesser Zab move through high side's elevation relatively. The terrain behavior in the zones between the Lesser Zab and the Tigris River was showed in figure 3.3.

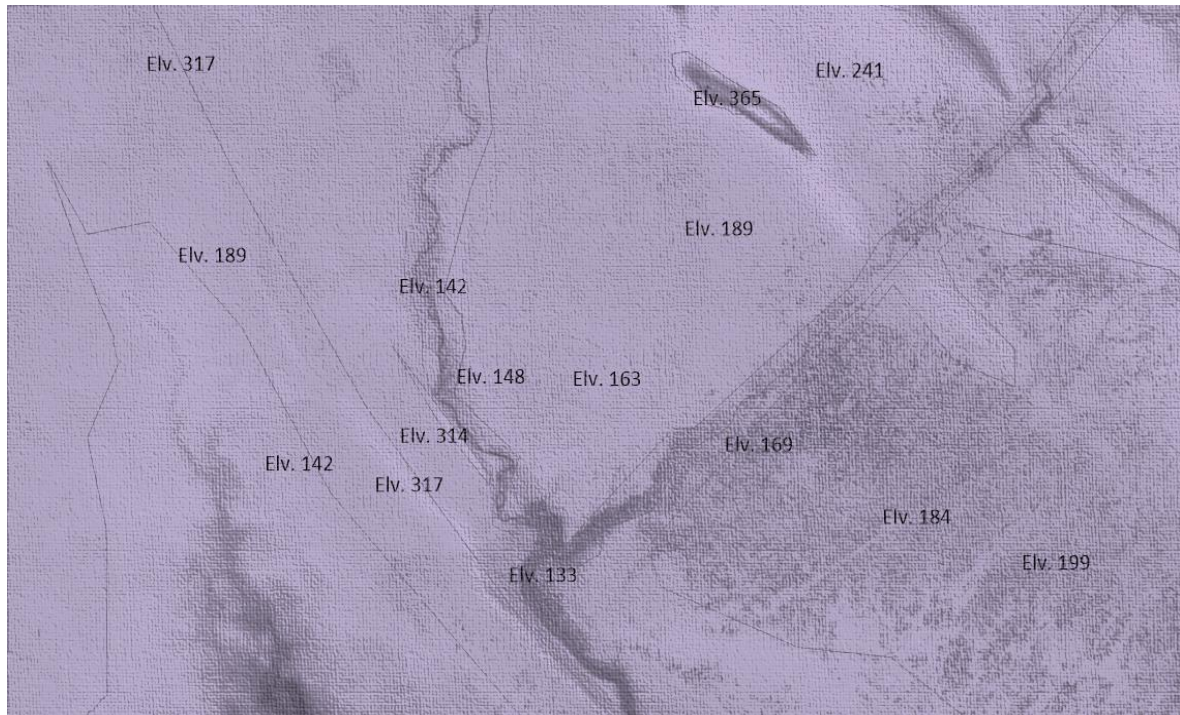


Figure 3.3: Topographic Behavior of Makhool Dam Region.

The data that obtained from figure 3.3 was examined under Surfer 16 program for analysis the areas and the volume that formed by the existing of the terrain before Makhool Dam. the assigning of the upstream and downstream region was showed in figure 3.4:

3.2.1 Analysis of Topographic Region

For achieving the outline of the study, the topographic exiting of the region of the dam including the states of contour lines was examined and analyzed. The study used Surfer program for evaluating the available area and volume that can be formed as result of stooping the stream of Tigris River before Makhool Dam in the region of construction the dam. the formation of the catchment area as well impact mainly by the founding of the relative elevation that existing in the area of upstream. The analysis inside Surfer program was done by treating the topographic map as shown in figures 3.3, and 3.4.

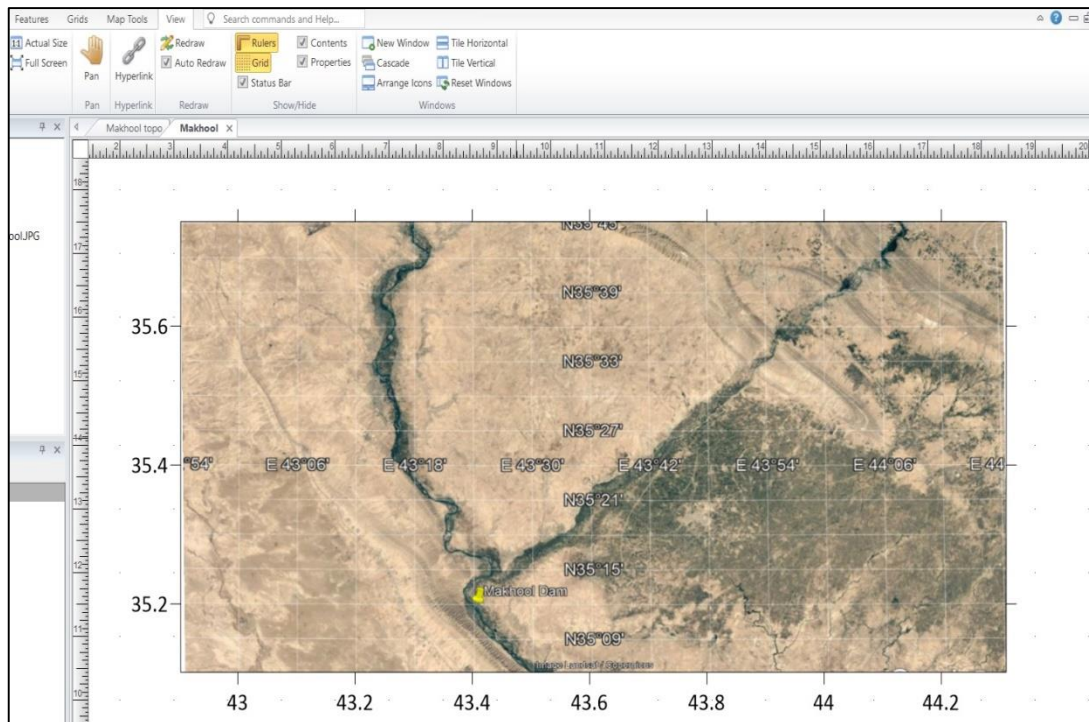


Figure 3.4: Analysis of Topographic Map of Makhool Dam in Surfer Program.

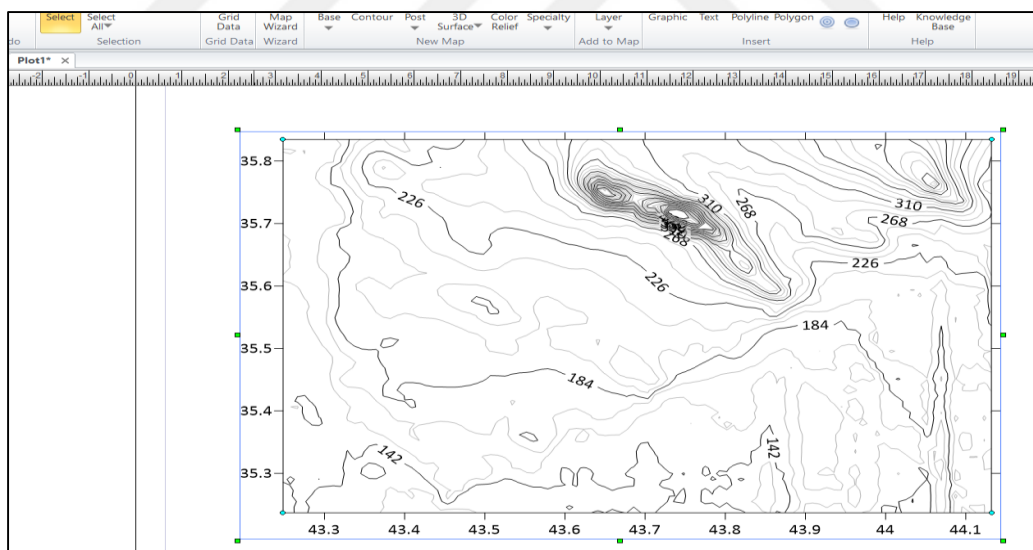


Figure 3.5: Analysis of Contour Lines in Surfer Program.

The amounts of the volume above 142 a.s.l. elevation which considered the lowest elevation in the upstream region were included in table 3.1

Table 3.1: Quantities of Volumes Above Contour Lines.

Elevation (m)	Volume (*1000 m^3)
143	1351831.5
143.5	1432070.3
144	1513499.4
144.5	1600089.1
145	1688257.2
145.5	1780598.5
146	1876352.2
146.5	1976021
147	2078417.6
147.5	2185666.8
148	2294461.4
148.5	2409291.8
149	2526141.7
149.5	2650266.3
150	2776474.1
150.5	2908520.6
151	3044211.6
151.5	3182333.1
152	3322383.3
152.5	3469643.7
153	3619168.5
153.5	3772124.6
154	3929688
154.5	4092197.3
155	4257384.5
155.5	4429406.8

3.3 OPERATION PARAMETERS

3.3.1 Inflow

The inflow toward the region of the dam was determined by the total rate of the flow that coming toward the point of placing the dam cutting. The amount of these rates was included in table 3.2:

Table 3.2: Monthly Inflow Rates.

Month	Inflow (m ³ /sec)
January	1201
February	1065
March	811
April	881
May	977
June	1325
July	2051
August	2016
September	1611
October	1422
November	1377
December	1099

3.3.2 Precipitation

The amounts of rainfall that can be enhance the total quantity of Makhool catchment area before the dam obstacle line were included in table 3.3.

Table 3.3:Monthly Participation rates.

Month	Precipitation mm
January	28
February	23
March	41
April	23
May	18
June	0
July	0
August	0
September	0
October	22
November	24
December	34

3.3.3 Potential Evaporation

The evaporation rate that can be considered as losses in the total quantity of Makhool catchment area were included in table 3.4.

Table 3.4: Evaporation rate in Makhool dam region.

Month	Evaporation mm
January	33.8
February	40.8
March	98.1
April	123.6
May	191.3
June	255.6
July	260.2
August	252.8
September	179.8
October	125.9
November	55.6
December	44.2

3.4 APPLYING OF WATER BALANCE

The logic resultant of the amounts of water that move toward and outward the catchment area of the region of makhool dam can be determined by using the balance equation in which each influence quantity rate considered to get the result of the exiting water in reservoir. The equation formula is as following [69]:

$$R + Qi + Gi - ETo - Qo - Go \pm \Delta S = 0 \quad (3.1)$$

The definition of the elements of the equation in cubic meter per second are as the following:

R : rainfall quantity rate

Qi: the inflow rate

Gi : the inlet baseflow

Eto: the potential evaporation

Qo: Outflow rate

Go: Outlet baseflow

ΔS : Different in storage volume

3.5 HEC RAS WORK

For satisfying the analysis requirement for dam breach analysis, HEC RAS was used to that purpose. The input data were gathered and used as input data inside the program. These data included the inflow, the rate of participation, the potential evaporation, and properties of the dam including the elevation of dam crest and the width of flooding weir. The first step in the program was uploading the real map inside the program including the existing elevation for achieving better results that represents the formation of breaching wave in failure situation as overtopping condition. The program then used to assign the region of upstream and downstream areas as well as the body of dam as cut element between the two regions. Figure 3.5 showed the behavior of map area inside the program and figure 3.6 showed the assigning of upstream and downstream areas.

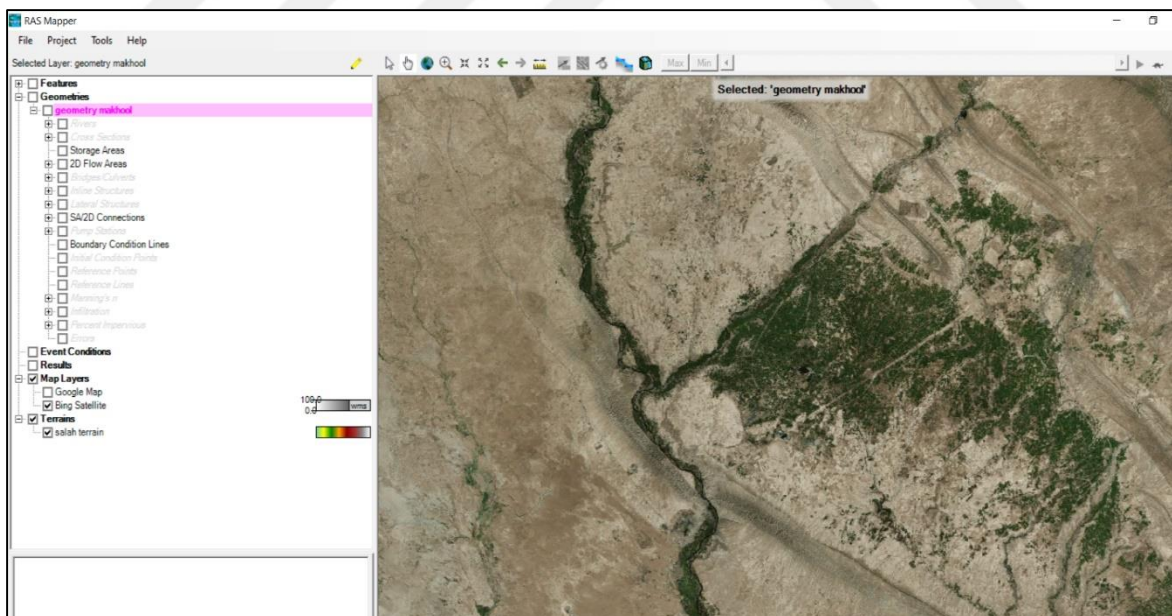


Figure3.6 : Analysis of Contour Lines In HEC RAS Program.

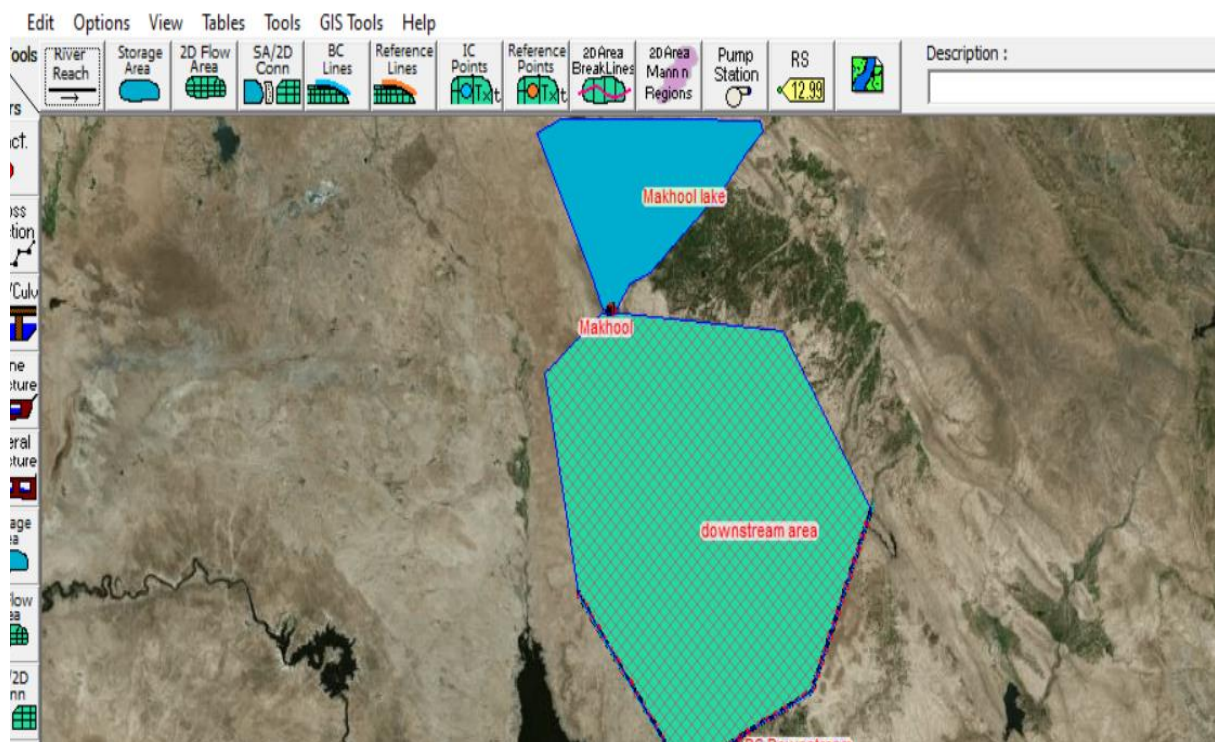


Figure 3.7: Analysis of Makhool Dam Upstream And Downstream in HEC RAS Program.

4. RESULT AND DISCUSSION

4.1 WATER BALANCE MODELING

For evaluating the variation in water storage quantities with respect to the inflow, outflow, precipitation, evaporation quantities, the monthly amount of out flow was assumed to be portion of the inflow flow rate as following:

$$q_i = \lambda Q_i \quad (4.1)$$

$$\text{or } \lambda = \frac{q_i}{Q_i} \quad (4.2)$$

Where:

q_i = the outflow rate at i month

Q_i = Inflow rate at i month

$i = (1, 2, 3, \dots, 12)$

From the data in tables the relationship that link the change in water quantity per month ΔS with the magnitude of λ and with the surface area of reservoir can be obtained as the following formula:

$$\Delta S = Q_i - \lambda Q_i + (P-E) * A \quad (4.3)$$

$$\Delta S = Q_i (1 - \lambda) + (P-E) * A \quad (4.4)$$

The formulas for each month were set in table 4.1

Table 4.1: Change in Water Storage Formula for Each Month.

Month	Inflow rate	P	E	Change in storage (m ³ /month)
1	1201	28	33.8	$\Delta S = 3112992000 (1-\lambda) - 0.0058A$
2	1065	23	40.8	$\Delta S = 2760480000 (1-\lambda) - 0.0178A$
3	811	41	98.1	$\Delta S = 2102112000 (1-\lambda) - 0.0571A$
4	881	23	123.6	$\Delta S = 2283552000 (1-\lambda) - 0.1006A$
5	977	18	191.3	$\Delta S = 2532384000 (1-\lambda) - 0.1733A$
6	1325	0	255.6	$\Delta S = 3434400000 (1-\lambda) - 0.2556A$
7	2051	0	260.2	$\Delta S = 5316192000 (1-\lambda) - 0.2602A$
8	2016	0	252.8	$\Delta S = 5225472000 (1-\lambda) - 0.2528A$
9	1611	0	179.8	$\Delta S = 4175712000 (1-\lambda) - 0.1798A$
10	1422	22	125.9	$\Delta S = 3685824000 (1-\lambda) - 0.1039A$
11	1377	24	55.6	$\Delta S = 3569184000 (1-\lambda) - 0.0316A$
12	1099	34	44.2	$\Delta S = 2848608000 (1-\lambda) - 0.0102A$

4.2 EVALUATION OF MANAGEMENT PLAN

For better managing the quantities of water before and after the dam, the management plan for each month was predicted using the formula for each month, the analytical procedure was based on dividing the formulas in table 4.1 into two main parts:

The positive part that includes the difference between the inflow and outflow rates, as the value of $\lambda < 1$ in other word ($q_i < Q_i$), the first part of the formula for each month is positive. For instance, the positive part of the formula of January is $3685824000 (1-\lambda)$.

The negative part reflects the difference between the effect of precipitation and evaporation, for January, the part is: $-0.1039A$. Based on this analysis, the management plan for each month was explained.

4.2.1 Management plan for January

The effect of the positive part on water balance formula for January month was calculated and included in table 4.2, the value of λ was varied from 0.1 to 0.9

Table 4.2: The Effect of The Positive Part on Water Balance Formula (January).

λ	Positive Part (m ³ /month)
0.1	2801692800
0.2	2490393600
0.3	2179094400
0.4	1867795200
0.5	1556496000
0.6	1245196800
0.7	933897600
0.8	622598400
0.9	311299200

The variation of surface area with elevations was detected by dividing the change in volume data for each elevation by the height between two elevation the calculation series, the surface areas that obtained including in table 4.3.

Table 4.3: The Variation in Surface Area With Elevation.

Elevation (m)	Total Area (km ²)
143.5	160.48
144	162.86
144.5	173.18
145	176.34
145.5	184.68
146	191.51
146.5	199.34
147	204.79
147.5	214.5
148	217.59
148.5	229.66
149	233.7
149.5	248.25
150	252.42
150.5	264.09
151	271.38
151.5	276.24
152	280.1
152.5	294.52
153	299.05
153.5	305.91
154	315.13
154.5	325.02
1550	330.37
155.5	344.04
156	355.89

The relationship between the elevation rising above the base level and the accumulative area was explained in figure 4.1

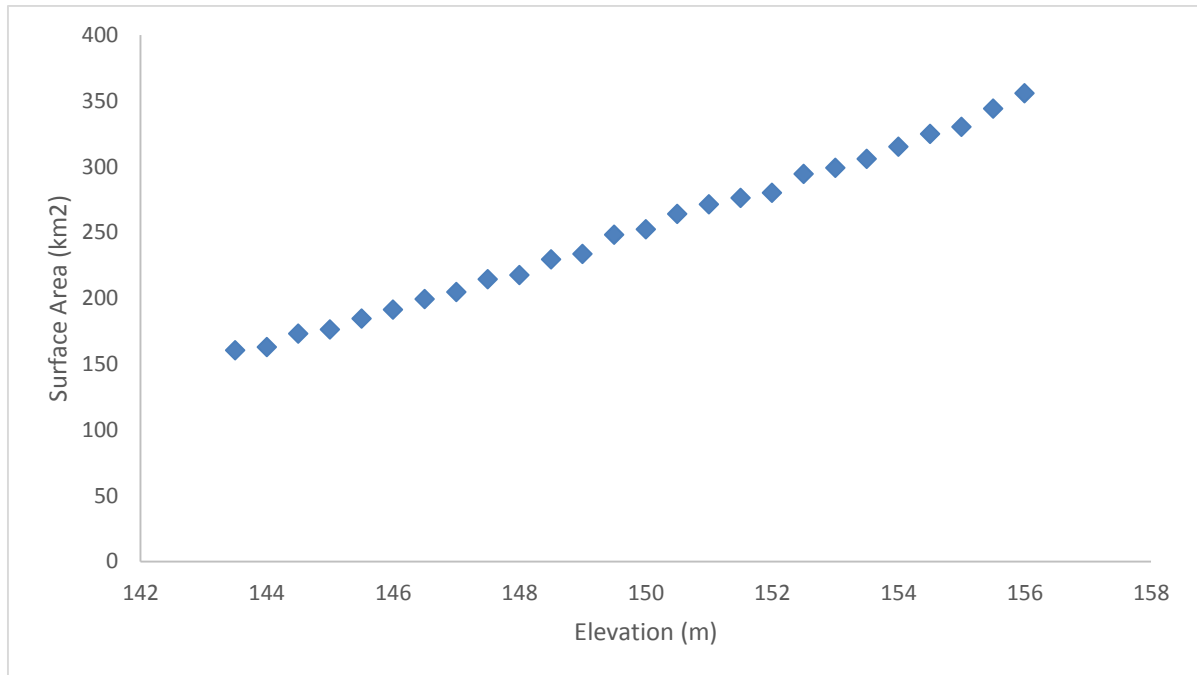


Figure 4.1: The Surface Area with The Level of Water.

By applying the technique of linear regression, the relationship was converted to linear state as shown in figure 4.3

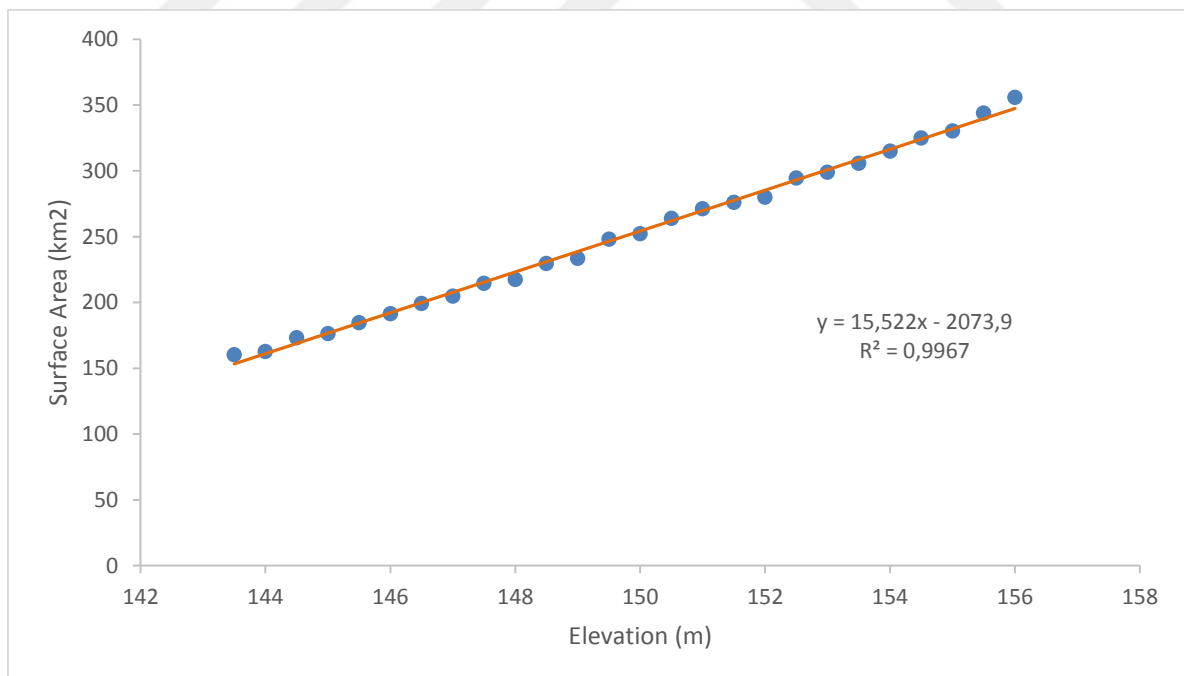


Figure 4.2: The Linear Regression for Area-Elevation Relationship.

The formula that adopted from figure 4.2 that link the total area with the elevation of surface water in storage area was as following:

$$A = 15.522 * El - 2073.9 \quad (4.5)$$

Where A =total surface area

El= elevation

Same way can be adopted for finding relationship between the storage volume and the elevation as the regression technique in figure 4.3.

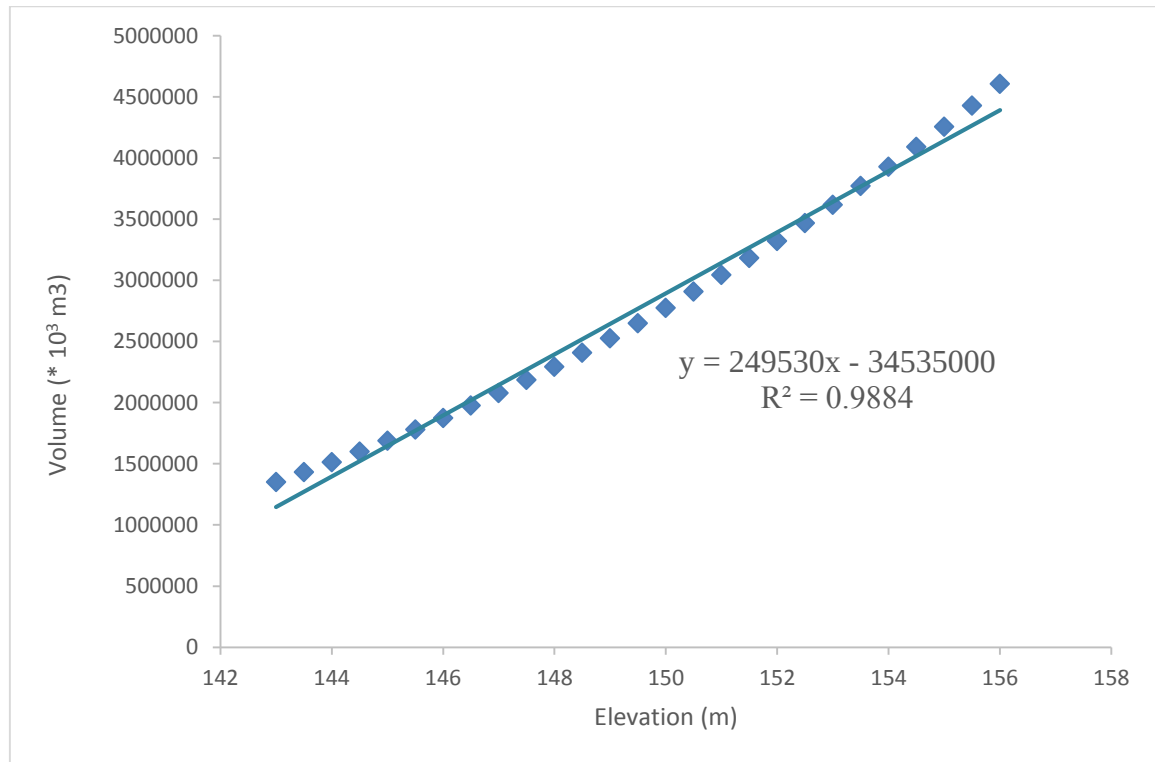


Figure 4.3: The Linear Regression for Volume-Elevation Relationship.

$$V = (249530 El - 34535000) * 10^3 \quad (4.6)$$

$$El = \frac{V + 3453000000}{249530000} \quad (4.7)$$

$$A = \left(15.522 * \frac{V + 34535000000}{249530000} - 2073.9 \right) \quad (4.8)$$

$$A = 6.22 * 10^{-8} * V + 74.35 \quad (4.9)$$

Table 4.4 showed the resultant of the volume of water in Makhool reservoir according to the positive and negative water quantities fluctuation based on the variation of outflow rate as percentage of inflow rate in January month. The other parameter was the variation of the water elevation behind the dam according to increasing or decreasing the outflow percentage in which illustrated in table 4.5.

Table 4.4: The Change in Storage Quantity in January Month with Respect to Various Outflow Rates.

λ	Positive Part (m ³ /month)	Area (km ²)	Negative Part (m ³ /month)	Δs (m ³ /month)
0.1	2801692800	248.62	-1441969	2800250831
0.2	2490393600	229.25	-1329664	2489063936
0.3	2179094400	209.89	-1217360	2177877040
0.4	1867795200	190.53	-1105056	1866690144
0.5	1556496000	171.16	-992751	1555503249
0.6	1245196800	151.80	-880447	1244316353
0.7	933897600	132.44	-768143	933129457
0.8	622598400	113.08	-655839	621942561
0.9	311299200	93.71	-543534	310755666

Table 4.5: The Change in Storage with Water Level In January Month with Various Outflow Rates.

λ	Δs (m ³)	Elevation of water surface
0.1	2800250831	149.6
0.2	2489063936	148.4
0.3	2177877040	147.1
0.4	1866690144	145.9
0.5	1555503249	144.6
0.6	1244316353	143.4
0.7	933129457	142.1
0.8	621942561	140.9
0.9	310755666	139.6

The data in table 4.4 and 4.5 were sketched in figure 4.4 and 4.5 respectively.

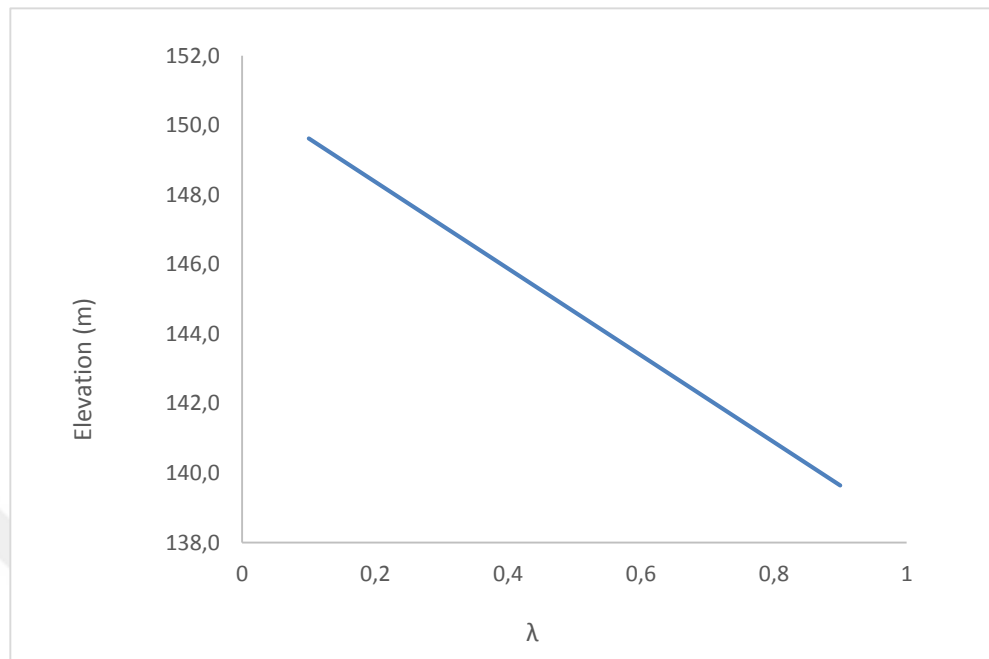


Figure 4.4: The Elevation - λ Relationship (January).

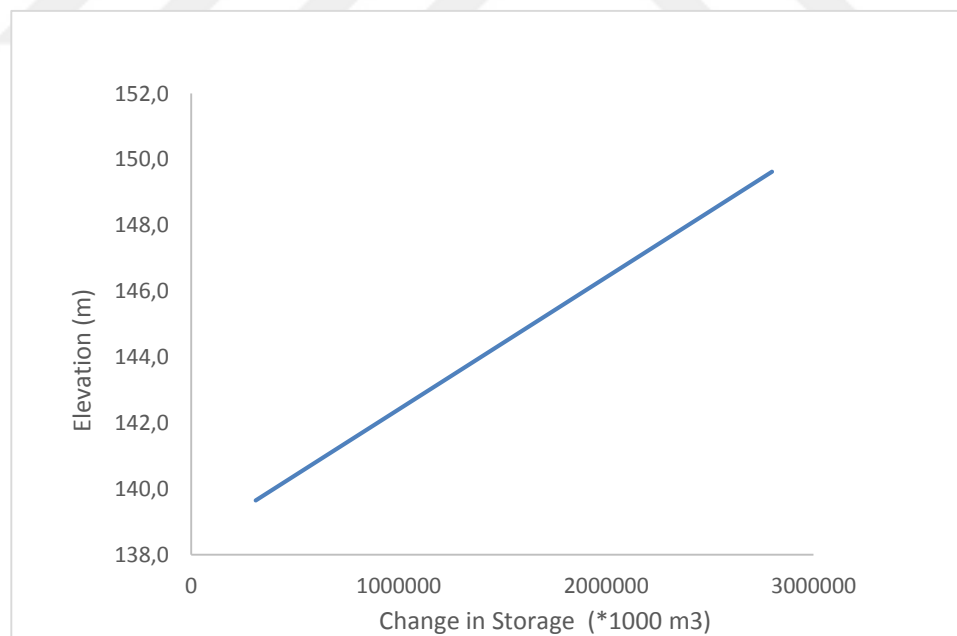


Figure 4.5: The Elevation- ΔS Relationship (January).

The analytical procedure in table 4.4 and 4.5 for January month were calculated and explained in tables 4.6 to 4.27 so that same plans were implemented for the months from

February to December . figures from 4.6 to 4.27 also included the graphs related to the data in tables for each month.

4.2.2 Management Plan for February

Table 4.6: The Change in Storage Quantity in February with Respect to Various Outflow Rates.

λ	Positive Part (m ³ /month)	Area (km ²)	Negative Part (m ³ /month)	Δs (m ³ /month)
0.1	2484432000	228.88	-4074094	2480357906
0.2	2208384000	211.71	-3768464	2204615536
0.3	1932336000	194.54	-3462835	1928873165
0.4	1656288000	177.37	-3157206	1653130794
0.5	1380240000	160.20	-2851577	1377388423
0.6	1104192000	143.03	-2545947	1101646053
0.7	828144000	125.86	-2240318	825903682
0.8	552096000	108.69	-1934689	550161311
0.9	276048000	91.52	-1629059	274418941

Table 4.7: The Change in Storage with Water Level in February with Various Outflow Rates.

λ	Δs (m ³)	Elevation of water surface (m)
0.1	2480357906	148.3
0.2	2204615536	147.2
0.3	1928873165	146.1
0.4	1653130794	145.0
0.5	1377388423	143.9
0.6	1101646053	142.8
0.7	825903682	141.7
0.8	550161311	140.6
0.9	274418941	139.5

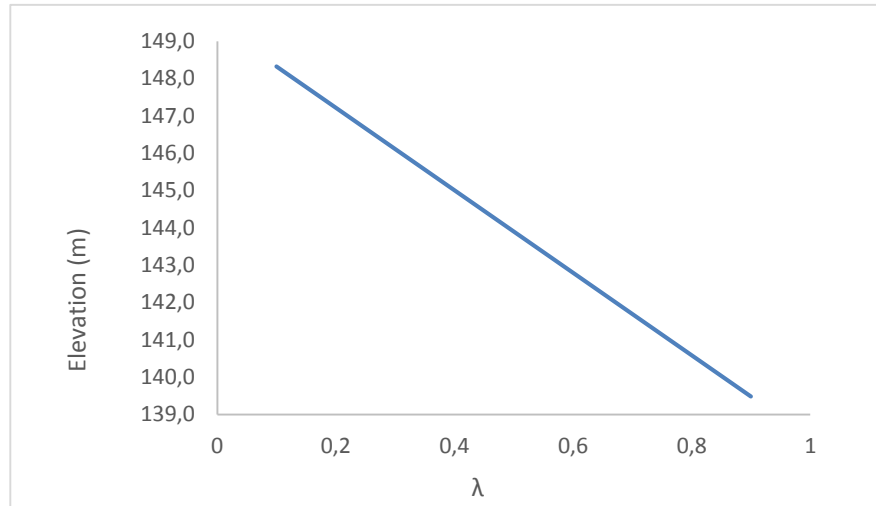


Figure 4. 6: The Elevation - λ Relationship (February).

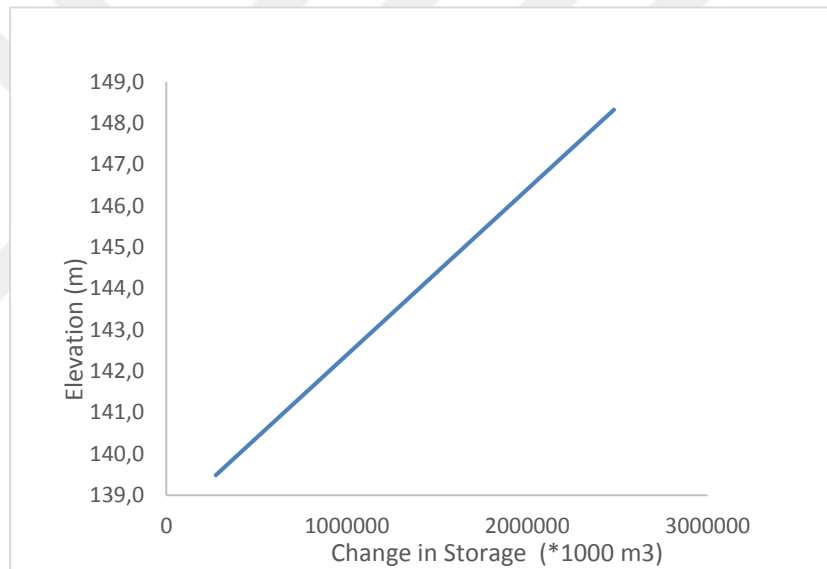


Figure 4.7: The elevation - ΔS relationship (February).

4.2.3 Management Plan for March

Table 4.8 showed the resultant of the volume of water in Makhool reservoir according to the positive and negative water quantities fluctuation based on the variation of outflow rate as percentage of inflow rate in March month

Table 4.8: The Change in Storage Quantity in March with Respect to Various Outflow Rates.

λ	Positive Part (m ³ /month)	Area (km ²)	Negative Part (m ³ /month)	Δs (m ³ /month)
0.1	1891900800	192.03	-10964698	1880936102
0.2	1681689600	178.95	-10218107	1671471493
0.3	1471478400	165.88	-9471517	1462006883
0.4	1261267200	152.80	-8724927	1252542273
0.5	1051056000	139.73	-7978337	1043077663
0.6	840844800	126.65	-7231746	833613054
0.7	630633600	113.58	-6485156	624148444
0.8	420422400	100.50	-5738566	414683834
0.9	210211200	87.43	-4991975	205219225

Table 4.9: The Change in Storage with Water Level in March with Various Outflow Rates.

λ	Δs (m ³)	Elevation of water surface (m)
0.1	1880936102	145.9
0.2	1671471493	145.1
0.3	1462006883	144.2
0.4	1252542273	143.4
0.5	1043077663	142.6
0.6	833613054	141.7
0.7	624148444	140.9
0.8	414683834	140.0
0.9	205219225	139.2

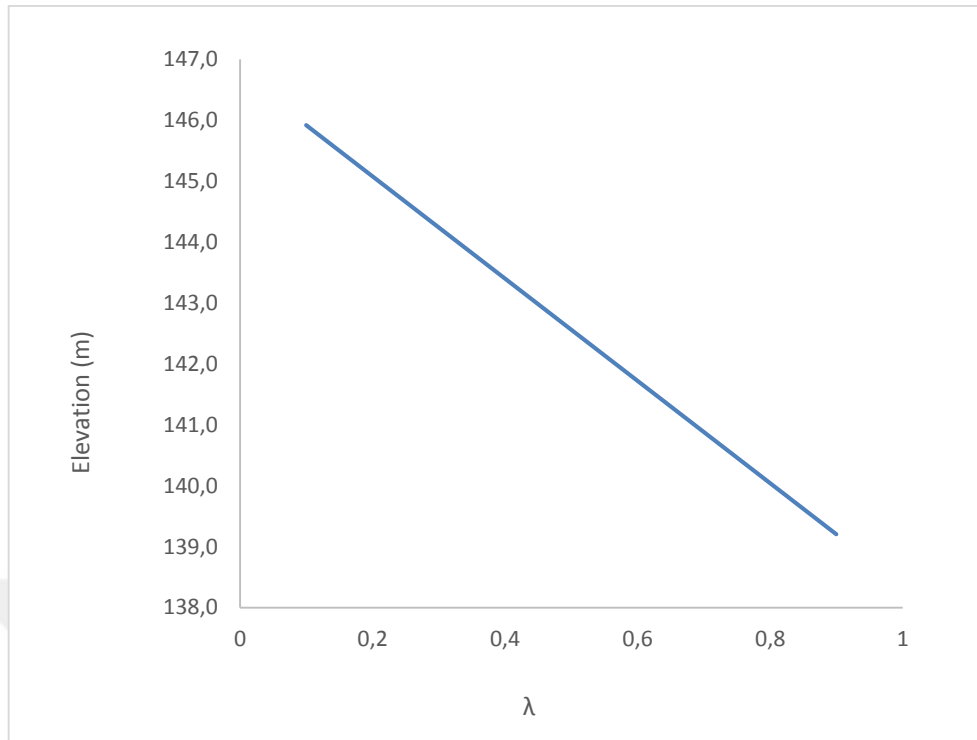


Figure 4.8: The Elevation - λ Relationship (March).

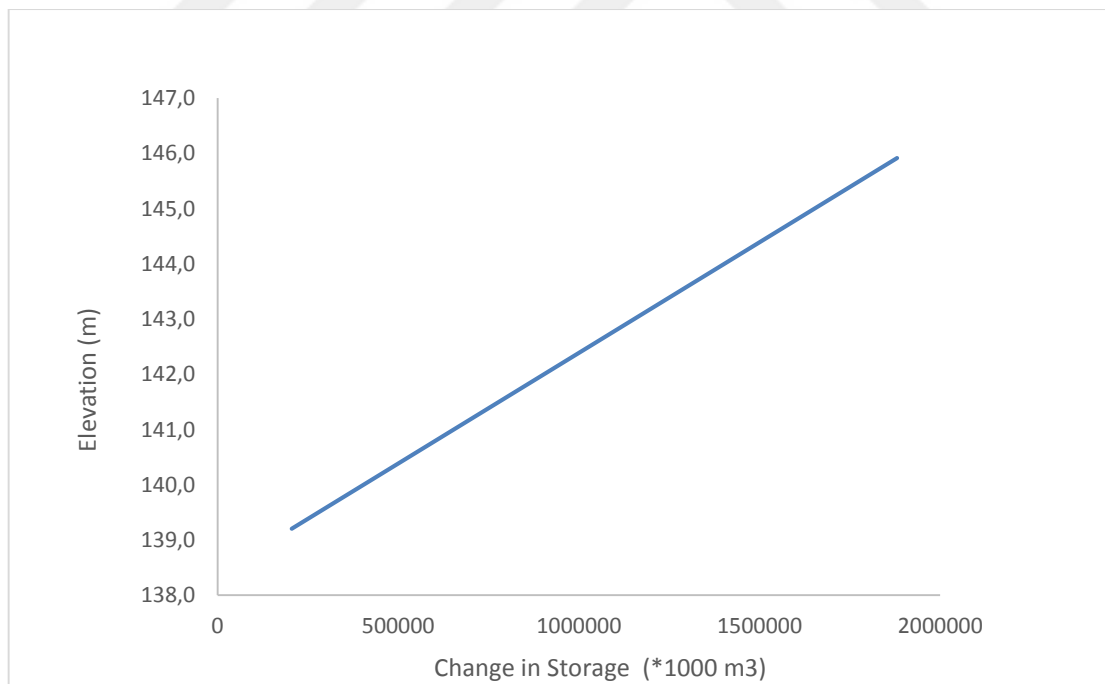


Figure 4.9: The Elevation - ΔS Relationship (March).

4.2.4 Management Plan for April

Table 4.10 showed the resultant of the volume of water in Makhool reservoir according to the positive and negative water quantities fluctuation based on the variation of outflow rate as percentage of inflow rate in April month.

Table 4.10: The Change in Storage Quantity in April with Respect to Various Outflow Rates.

λ	Positive Part (m ³ /month)	Area (km ²)	Negative Part (m ³ /month)	Δs (m ³ /month)
0.1	2055196800	202.18	-20339634	2034857166
0.2	1826841600	187.98	-18910742	1807930858
0.3	1598486400	173.78	-17481851	1581004549
0.4	1370131200	159.57	-16052959	1354078241
0.5	1141776000	145.37	-14624068	1127151932
0.6	913420800	131.16	-13195176	900225624
0.7	685065600	116.96	-11766285	673299315
0.8	456710400	102.76	-10337393	446373007
0.9	228355200	88.55	-8908502	219446698

Table 4.11: The Change in Storage with Water Level in April with Various Outflow Rates.

λ	Δs (m ³)	Elevation of water surface (m)
0.1	2055196800	202.18
0.2	1826841600	187.98
0.3	1598486400	173.78
0.4	1370131200	159.57
0.5	1141776000	145.37
0.6	913420800	131.16
0.7	685065600	116.96
0.8	456710400	102.76
0.9	228355200	88.55

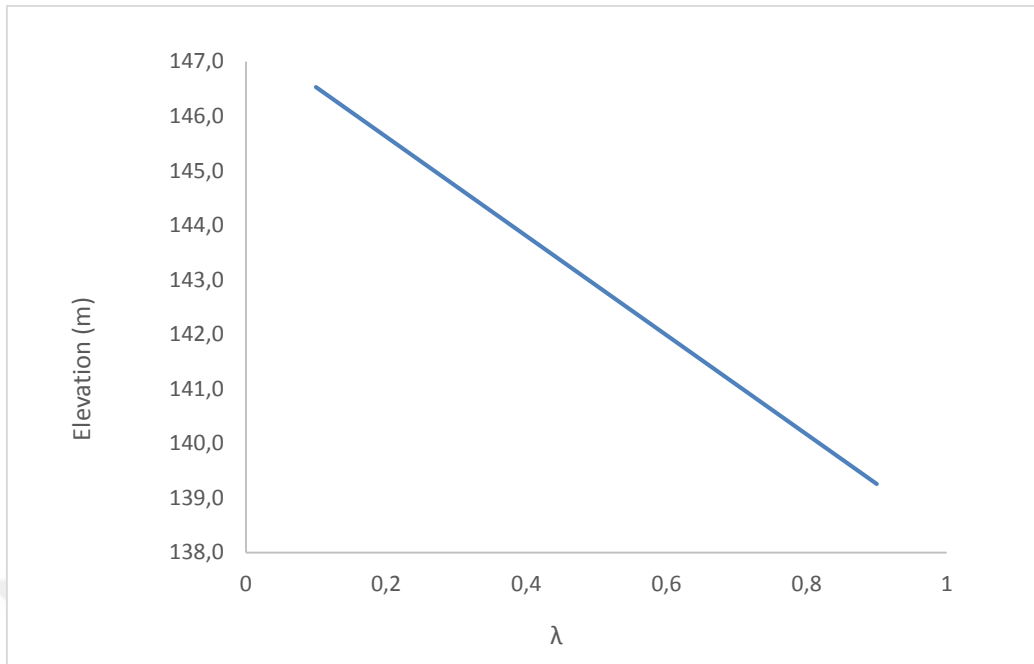


Figure 4.10: The Elevation - λ Relationship (April).

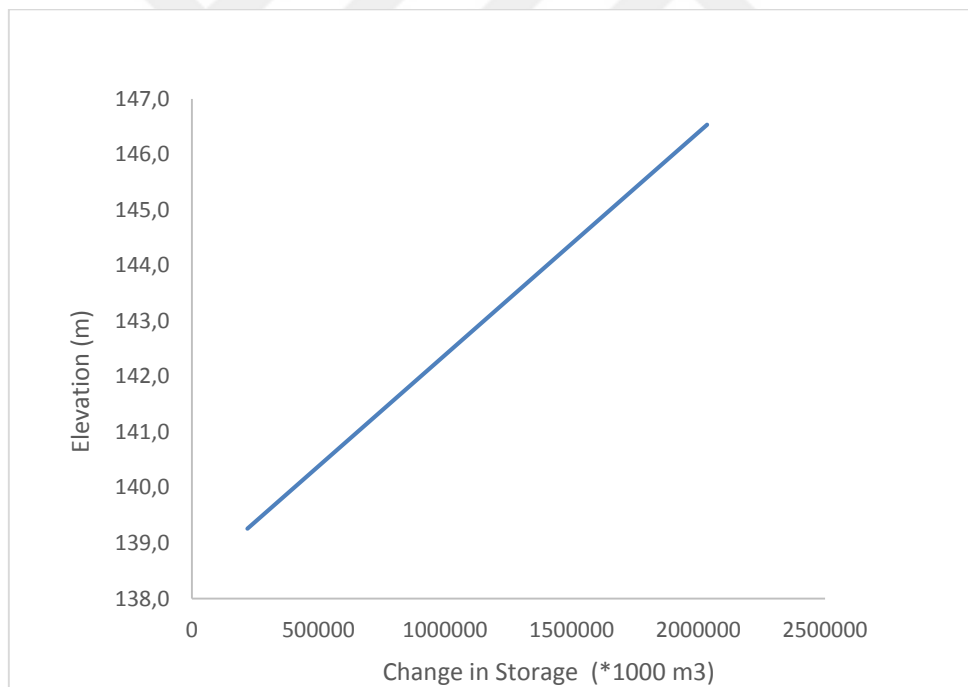


Figure 4.11: The Elevation - ΔS Relationship (April).

4.2.5 Management Plan for May

Table 4.12 showed the resultant of the volume of water in Makhool reservoir according to the positive and negative water quantities fluctuation based on the variation of outflow rate as percentage of inflow rate in May month.

Table 4.12: The Change in Storage Quantity in May with Respect to Various Outflow Rates.

λ	Positive Part (m ³ /month)	Area (km ²)	Negative Part (m ³ /month)	Δs (m ³ /month)
0.1	2279145600	216.11	-37452358	2241693242
0.2	2025907200	200.36	-34722635	1991184565
0.3	1772668800	184.61	-31992913	1740675887
0.4	1519430400	168.86	-29263190	1490167210
0.5	1266192000	153.11	-26533468	1239658532
0.6	1012953600	137.36	-23803745	989149855
0.7	759715200	121.60	-21074023	738641177
0.8	506476800	105.85	-18344300	488132500
0.9	253238400	90.10	-15614578	237623822

Table 4.13: The Change in Storage with Water Level in May with Various Outflow Rates.

λ	Δs (m ³)	Elevation of water surface (m)
0.1	2241693242	147.4
0.2	1991184565	146.4
0.3	1740675887	145.4
0.4	1490167210	144.4
0.5	1239658532	143.3
0.6	989149855	142.3
0.7	738641177	141.3
0.8	488132500	140.3
0.9	237623822	139.3

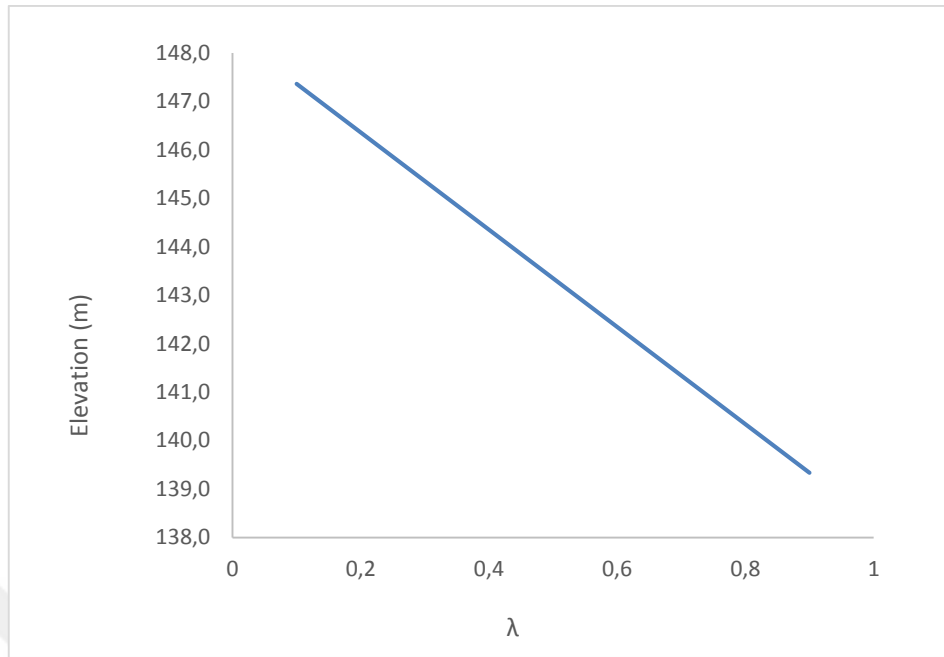


Figure 4.12: The Elevation - λ Relationship (May).

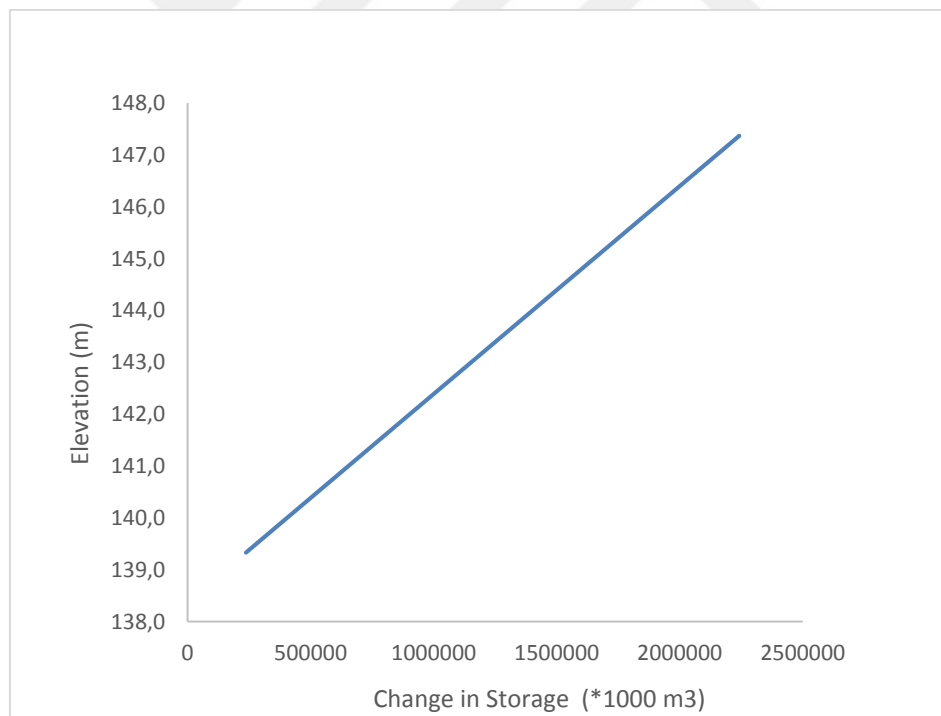


Figure 4.13: The Elevation - ΔS Relationship (May).

4.2.6 Management Plan for June

Table 4.14 showed the resultant of the volume of water in Makhool reservoir according to the positive and negative water quantities fluctuation based on the variation of outflow rate as percentage of inflow rate in June month

Table 4.14: The Change in Storage Quantity in June with Respect to Various Outflow Rates.

λ	Positive Part (m ³ /month)	Area (km ²)	Negative Part (m ³ /month)	Δs (m ³ /month)
0.1	3090960000	266.61	-68144931	3022815069
0.2	2747520000	245.25	-62684812	2684835188
0.3	2404080000	223.88	-57224693	2346855307
0.4	2060640000	202.52	-51764574	2008875426
0.5	1717200000	181.16	-46304455	1670895545
0.6	1373760000	159.80	-40844336	1332915664
0.7	1030320000	138.44	-35384217	994935783
0.8	686880000	117.07	-29924098	656955902
0.9	343440000	95.71	-24463979	318976021

Table 4.15: The Change in Storage with Water Level in June with Various Outflow Rates.

λ	Δs (m ³)	Elevation of water surface (m)
0.1	3022815069	150.5
0.2	2684835188	149.1
0.3	2346855307	147.8
0.4	2008875426	146.4
0.5	1670895545	145.1
0.6	1332915664	143.7
0.7	994935783	142.4
0.8	656955902	141.0
0.9	318976021	139.7

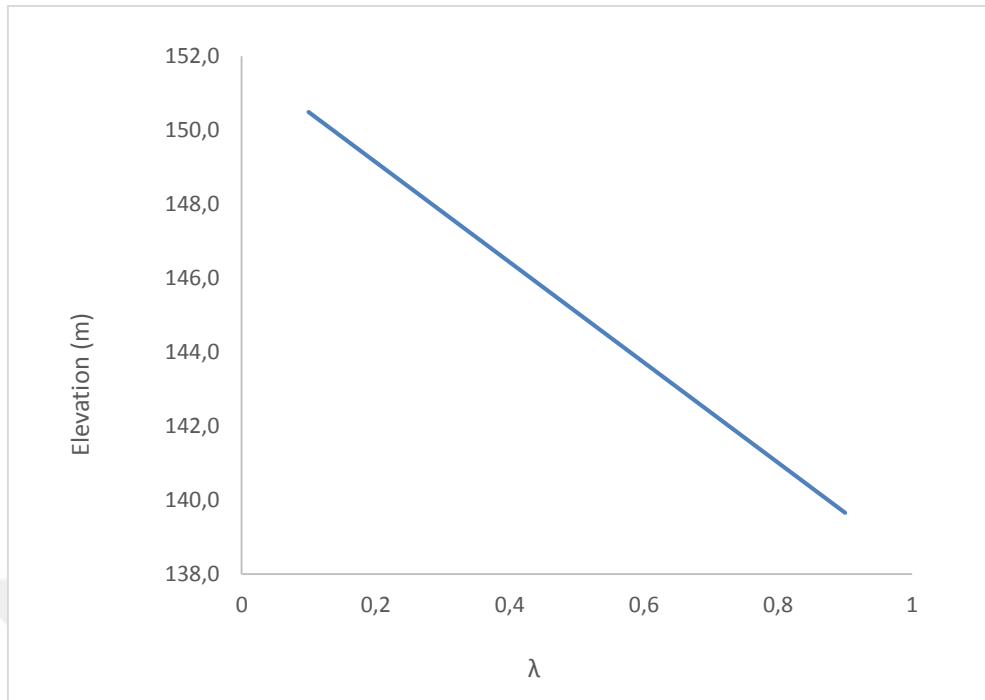


Figure 4.14: The Elevation - λ Relationship (June).

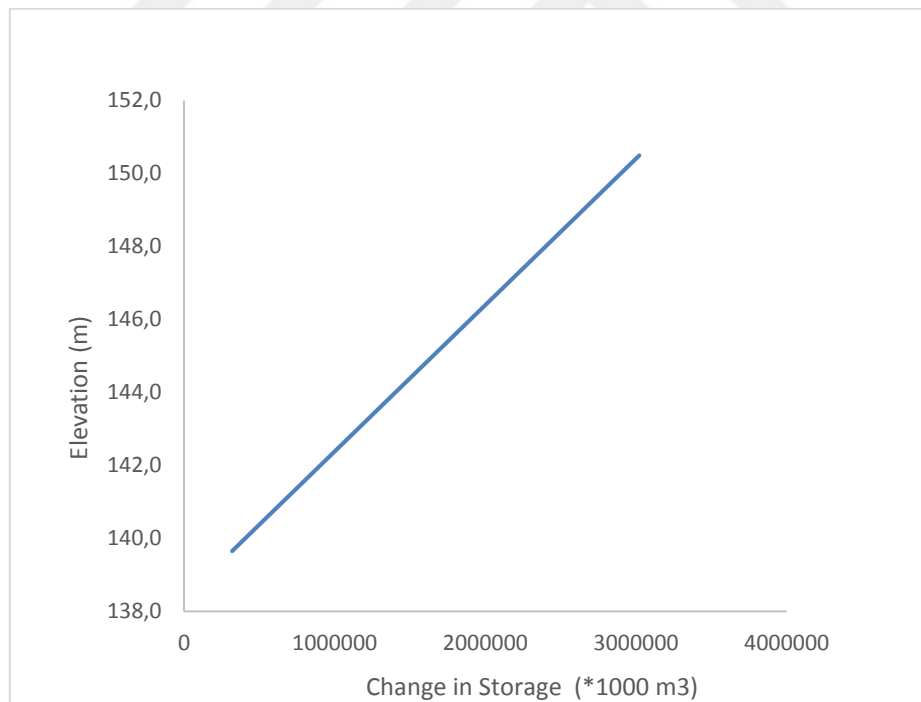


Figure 4.15: The Elevation - ΔS Relationship (June)

4.2.7 Management Plan for July

Table 4.16 showed the resultant of the volume of water in Makhool reservoir according to the positive and negative water quantities fluctuation based on the variation of outflow rate as percentage of inflow rate in July month.

Table 4.16: The Change in Storage Quantity in July with Respect to Various Outflow Rates.

λ	Positive Part (m ³ /month)	Area (km ²)	Negative Part (m ³ /month)	Δs (m ³ /month)
0.1	4784572800	371.95	-96781501	4687791299
0.2	4252953600	338.88	-88177542	4164776058
0.3	3721334400	305.82	-79573583	3641760817
0.4	3189715200	272.75	-70969624	3118745576
0.5	2658096000	239.68	-62365665	2595730335
0.6	2126476800	206.62	-53761706	2072715094
0.7	1594857600	173.55	-45157747	1549699853
0.8	1063238400	140.48	-36553788	1026684612
0.9	531619200	107.42	-27949829	503669371

Table 4.17: The Change in Storage with Water Level in July with Various Outflow Rates.

λ	Δs (m ³)	Elevation of water surface (m)
0.1	4687791299	157.2
0.2	4164776058	155.1
0.3	3641760817	153.0
0.4	3118745576	150.9
0.5	2595730335	148.8
0.6	2072715094	146.7
0.7	1549699853	144.6
0.8	1026684612	142.5
0.9	503669371	140.4

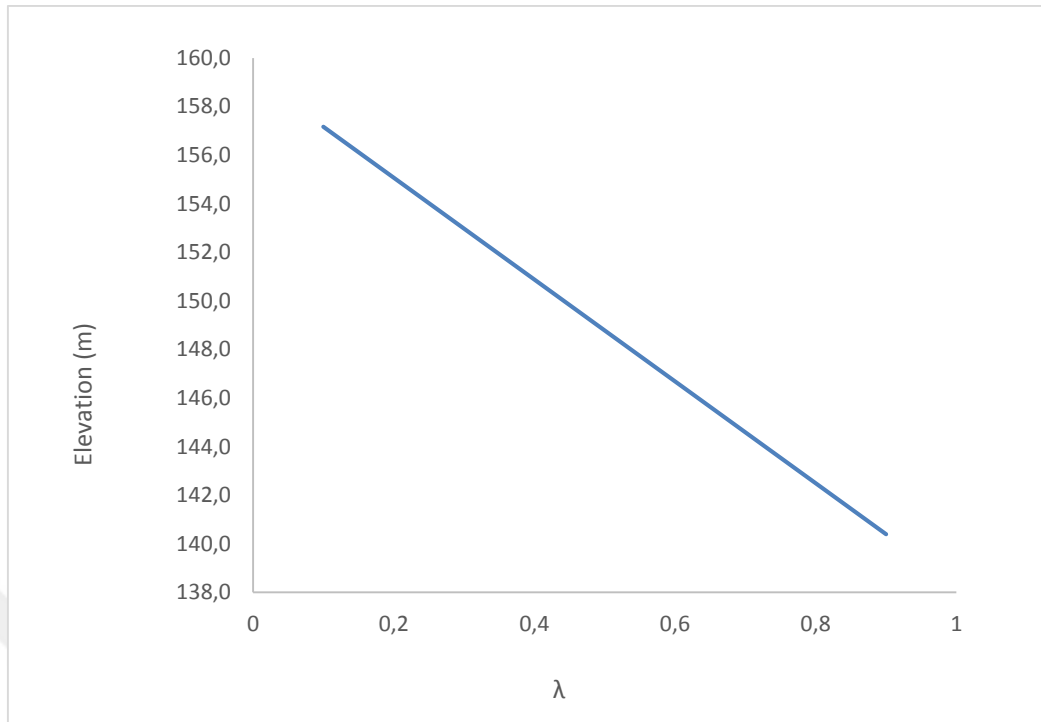


Figure 4.16: The Elevation - λ Relationship (July).

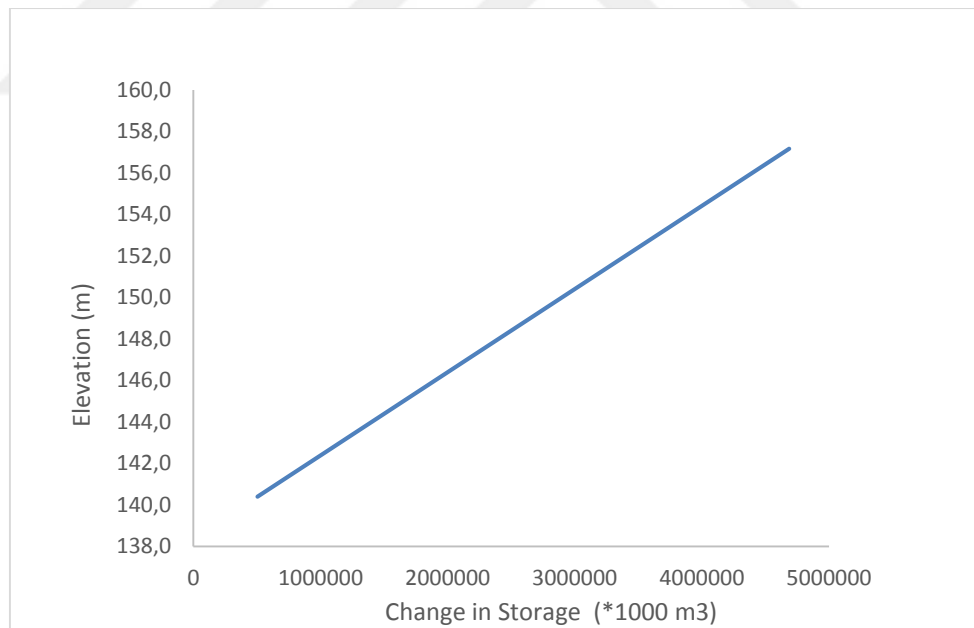


Figure 4.17: The Elevation - ΔS Relationship (July).

4.2.8 Management Plan for August

Table 4.18 showed the resultant of the volume of water in Makhool reservoir according to the positive and negative water quantities fluctuation based on the variation of outflow rate as percentage of inflow rate in August month.

Table 4.18: The Change In Storage Quantity in August with Respect to Various Outflow Rates.

λ	Positive Part (m ³ /month)	Area (km ²)	Negative Part (m ³ /month)	Δs (m ³ /month)
0.1	4702924800	366.87	-92745222	4610179578
0.2	4180377600	334.37	-84528606	4095848994
0.3	3657830400	301.87	-76311990	3581518410
0.4	3135283200	269.36	-68095375	3067187825
0.5	2612736000	236.86	-59878759	2552857241
0.6	2090188800	204.36	-51662143	2038526657
0.7	1567641600	171.86	-43445527	1524196073
0.8	1045094400	139.35	-35228912	1009865488
0.9	522547200	106.85	-27012296	495534904

Table 4.19: The Change in Storage with Water Level in August with Various Outflow Rates.

λ	Δs (m ³)	Elevation of water surface (m)
0.1	4610179578	156.9
0.2	4095848994	154.8
0.3	3581518410	152.7
0.4	3067187825	150.7
0.5	2552857241	148.6
0.6	2038526657	146.5
0.7	1524196073	144.5
0.8	1009865488	142.4
0.9	495534904	140.4

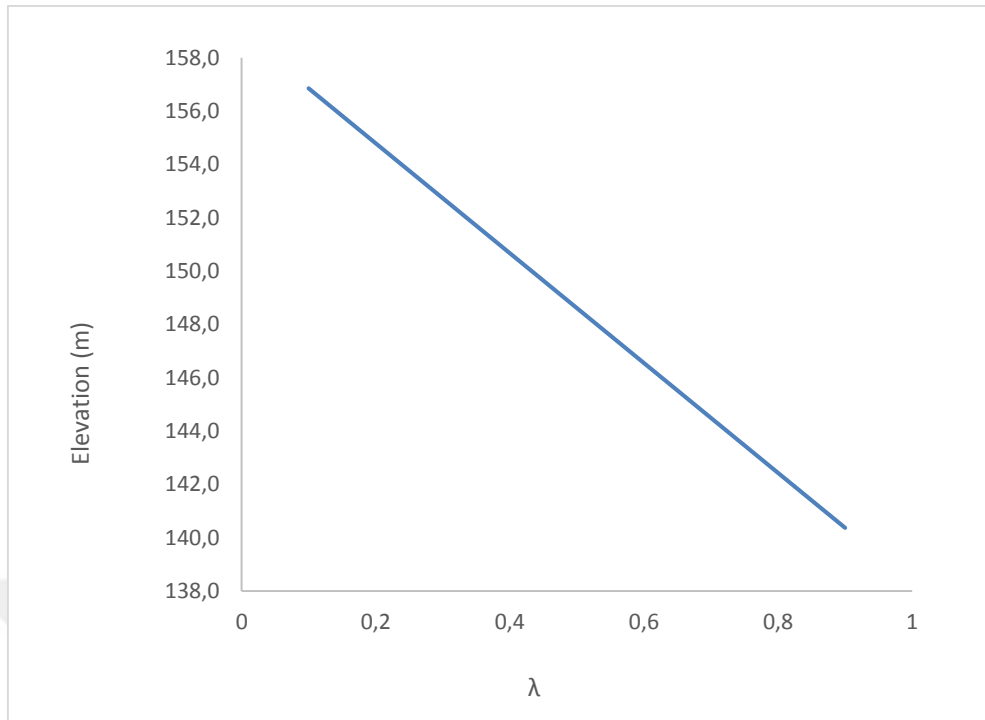


Figure 4.18: The Elevation - λ Relationship (August).

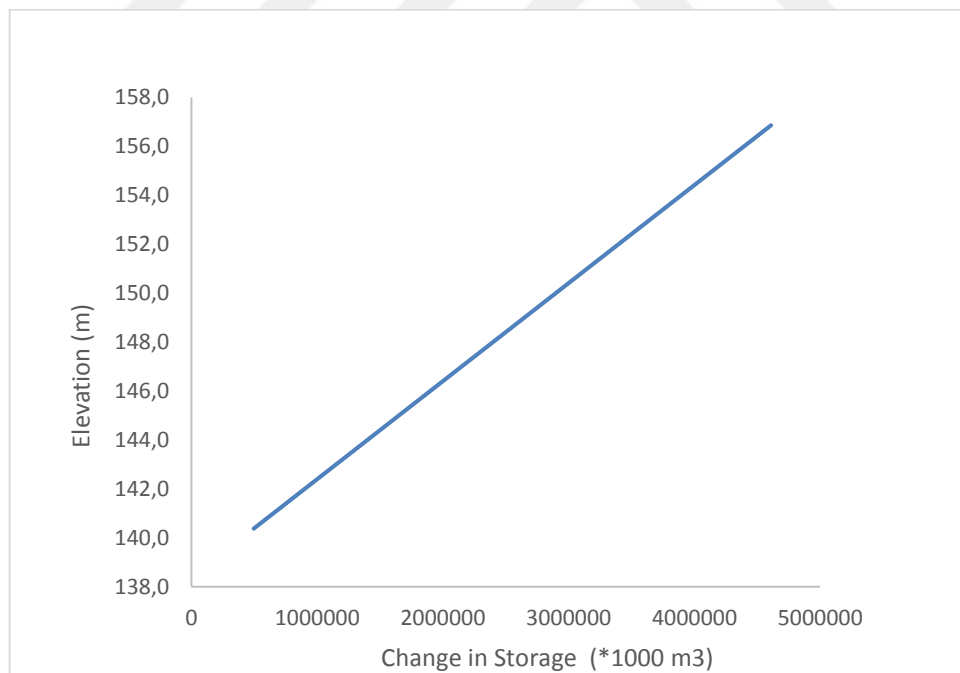


Figure 4.19: The Elevation - ΔS Relationship (August).

4.2.9 Management Plan for September

Table 4.20 showed the resultant of the volume of water in Makhool reservoir according to the positive and negative water quantities fluctuation based on the variation of outflow rate as percentage of inflow rate in September's month

Table 4.20: The Change in Storage Quantity in September with Respect to Various Outflow Rates.

λ	Positive Part (m ³ /month)	Area (km ²)	Negative Part (m ³ /month)	Δs (m ³ /month)
0.1	3758140800	308.11	-55397523	3702743277
0.2	3340569600	282.13	-50727591	3289842009
0.3	2922998400	256.16	-46057658	2876940742
0.4	2505427200	230.19	-41387725	2464039475
0.5	2087856000	204.21	-36717793	2051138207
0.6	1670284800	178.24	-32047860	1638236940
0.7	1252713600	152.27	-27377928	1225335672
0.8	835142400	126.30	-22707995	812434405
0.9	417571200	100.32	-18038063	399533137

Table 4.21: The Change in Storage with Water Level in September with Various Outflow Rates.

λ	Δs (m ³)	Elevation of water surface (m)
0.1	3702743277	153.2
0.2	3289842009	151.6
0.3	2876940742	149.9
0.4	2464039475	148.3
0.5	2051138207	146.6
0.6	1638236940	144.9
0.7	1225335672	143.3
0.8	812434405	141.6
0.9	399533137	140.0

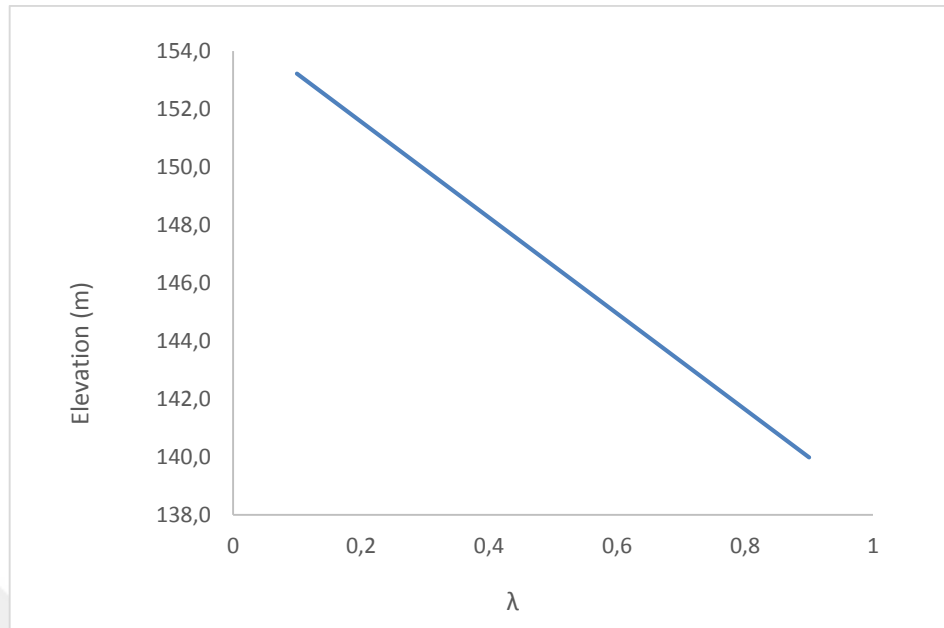


Figure 4.20: The Elevation - λ Relationship (September).

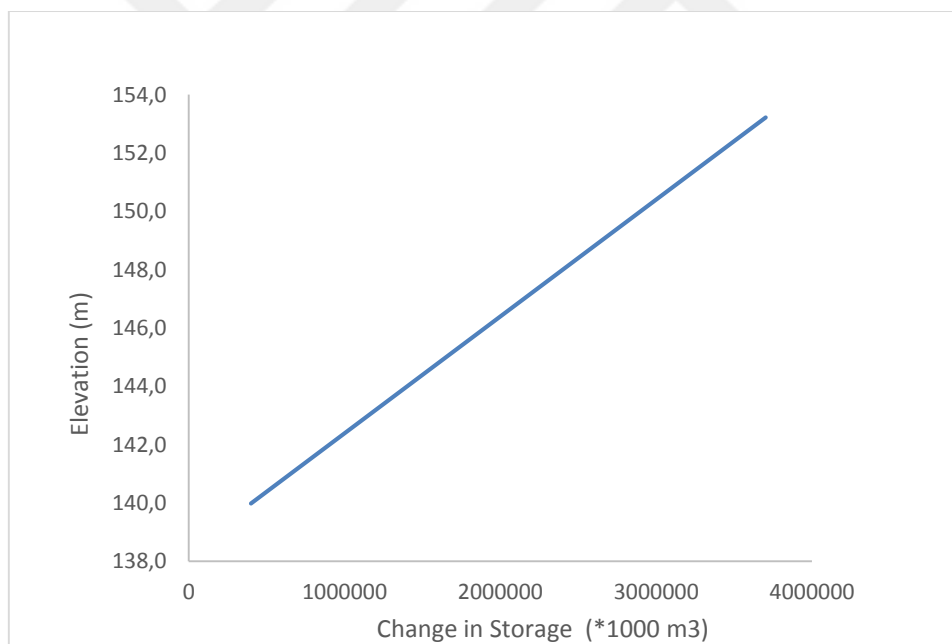


Figure 4.21: The Elevation - ΔS Relationship (September).

4.2.10 Management Plan for October

Table 4.22 showed the resultant of the volume of water in Makhool reservoir according to the positive and negative water quantities fluctuation based on the variation of outflow rate as percentage of inflow rate in October month

Table 4.22: The Change in Storage Quantity in October with Respect to Various Outflow Rates.

λ	Positive Part (m ³ /month)	Area (km ²)	Negative Part (m ³ /month)	Δs (m ³ /month)
0.1	3317241600	280.68	-29162904	3288078696
0.2	2948659200	257.76	-26780911	2921878289
0.3	2580076800	234.83	-24398918	2555677882
0.4	2211494400	211.90	-22016924	2189477476
0.5	1842912000	188.98	-19634931	1823277069
0.6	1474329600	166.05	-17252938	1457076662
0.7	1105747200	143.13	-14870945	1090876255
0.8	737164800	120.20	-12488951	724675849
0.9	368582400	97.28	-10106958	358475442

Table 4.23: The Change in Storage with Water Level in October with Various Outflow Rates.

λ	Δs (m ³)	Elevation of water surface (m)
0.1	3288078696	151.6
0.2	2921878289	150.1
0.3	2555677882	148.6
0.4	2189477476	147.2
0.5	1823277069	145.7
0.6	1457076662	144.2
0.7	1090876255	142.8
0.8	724675849	141.3
0.9	358475442	139.8

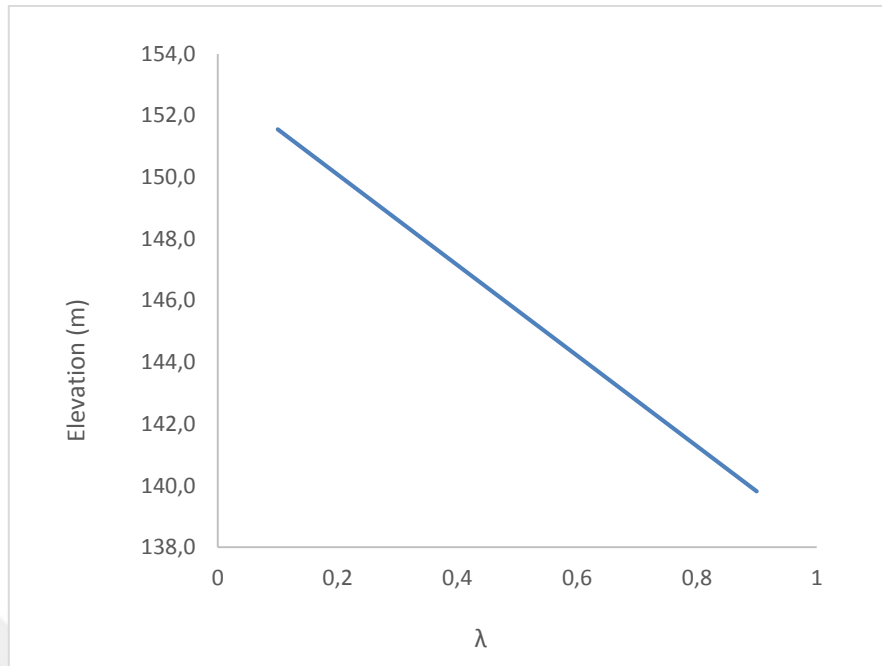


Figure 4.22: The Elevation - λ Relationship (October).

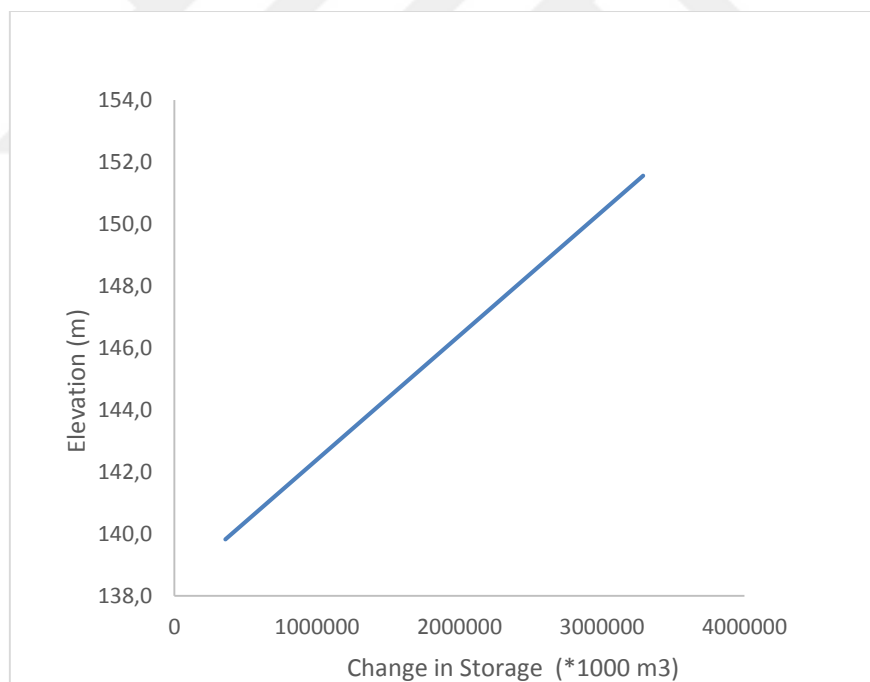


Figure 4.23: The Elevation - ΔS Relationship (October).

4.2. 11 Management Plan for November

Table 4.24 showed the resultant of the volume of water in Makhool reservoir according to the positive and negative water quantities fluctuation based on the variation of outflow rate as percentage of inflow rate in November month

Table 4 24: The Change in Storage Quantity in November with Respect to Various Outflow Rates.

λ	Positive Part (m ³ /month)	Area (km ²)	Negative Part (m ³ /month)	Δs (m ³ /month)
0.1	3212265600	274.15	-8663232	3203602368
0.2	2855347200	251.95	-7961702	2847385498
0.3	2498428800	229.75	-7260172	2491168628
0.4	2141510400	207.55	-6558642	2134951758
0.5	1784592000	185.35	-5857111	1778734889
0.6	1427673600	163.15	-5155581	1422518019
0.7	1070755200	140.95	-4454051	1066301149
0.8	713836800	118.75	-3752521	710084279
0.9	356918400	96.55	-3050990	353867410

Table 4.25: The Change in Storage with Water Level in November with Various Outflow Rates.

λ	Δs (m ³)	Elevation of water surface (m)
0.1	3203602368	151.2
0.2	2847385498	149.8
0.3	2491168628	148.4
0.4	2134951758	146.9
0.5	1778734889	145.5
0.6	1422518019	144.1
0.7	1066301149	142.7
0.8	710084279	141.2
0.9	353867410	139.8

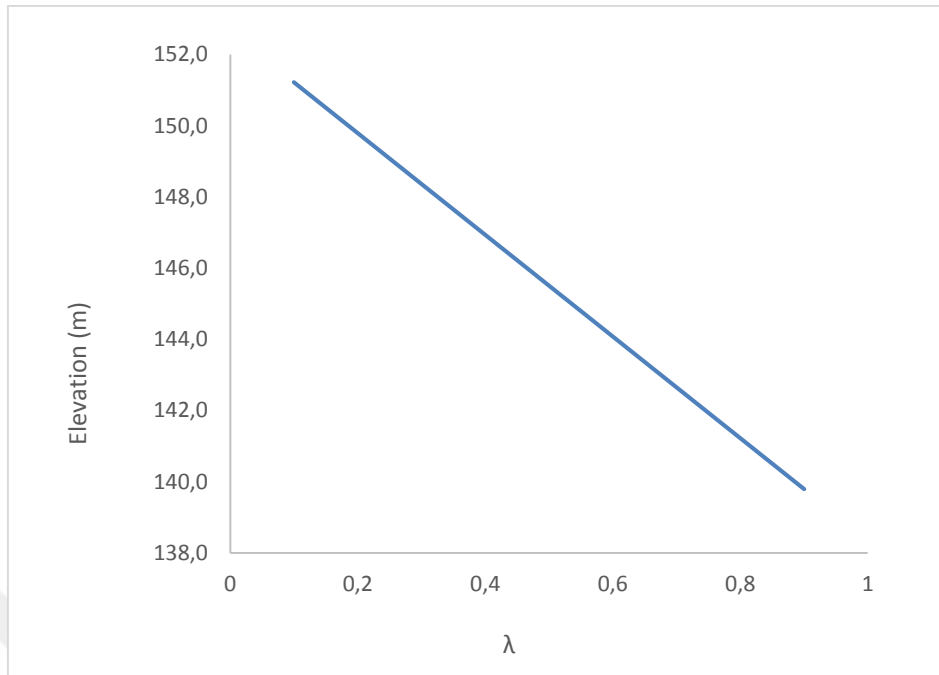


Figure 4.24: The Elevation - λ Relationship (November).

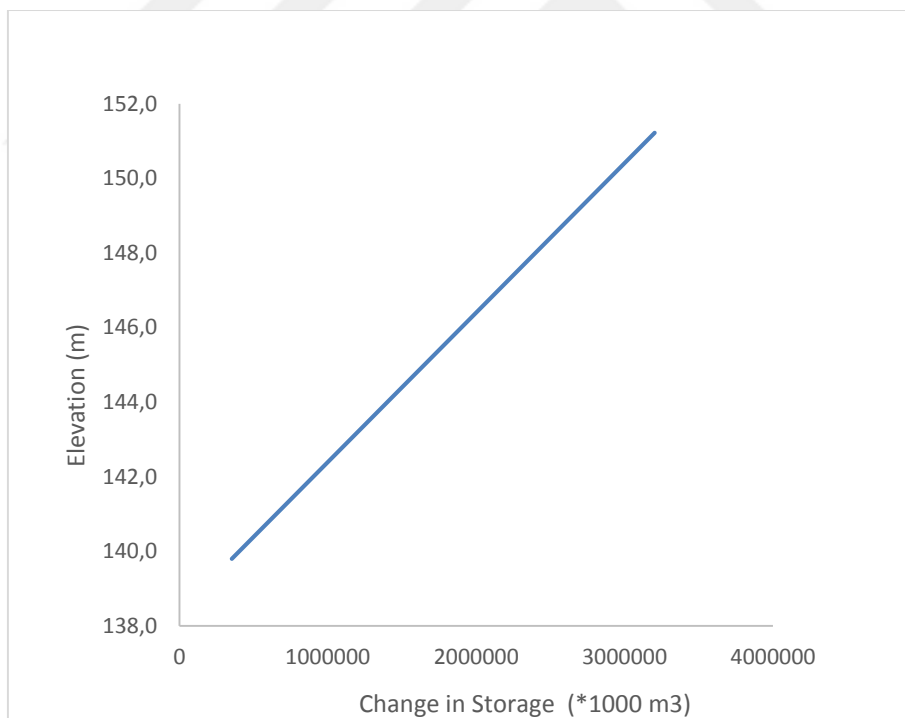


Figure 4.25: The Elevation - ΔS Relationship (November).

4.2.12 Management Plan for December

Table 4.26 showed the resultant of the volume of water in Makhool reservoir according to the positive and negative water quantities fluctuation based on the variation of outflow rate as percentage of inflow rate in December month.

Table 4.26: The Change in Storage Quantity in December with Respect to Various Outflow Rates.

λ	Positive Part (m ³ /month)	Area (km ²)	Negative Part (m ³ /month)	Δs (m ³ /month)
0.1	2563747200	233.82	-2384914	2561362286
0.2	2278886400	216.10	-2204187	2276682213
0.3	1994025600	198.38	-2023460	1992002140
0.4	1709164800	180.66	-1842733	1707322067
0.5	1424304000	162.94	-1662005	1422641995
0.6	1139443200	145.22	-1481278	1137961922
0.7	854582400	127.51	-1300551	853281849
0.8	569721600	109.79	-1119824	568601776
0.9	284860800	92.07	-939097	283921703

Table 4.27: The Change in Storage with Water Level in December with Various Outflow Rates.

λ	Δs (m ³)	Elevation of water surface (m)
0.1	2561362286	148.6
0.2	2276682213	147.5
0.3	1992002140	146.4
0.4	1707322067	145.2
0.5	1422641995	144.1
0.6	1137961922	142.9
0.7	853281849	141.8
0.8	568601776	140.7
0.9	283921703	139.5

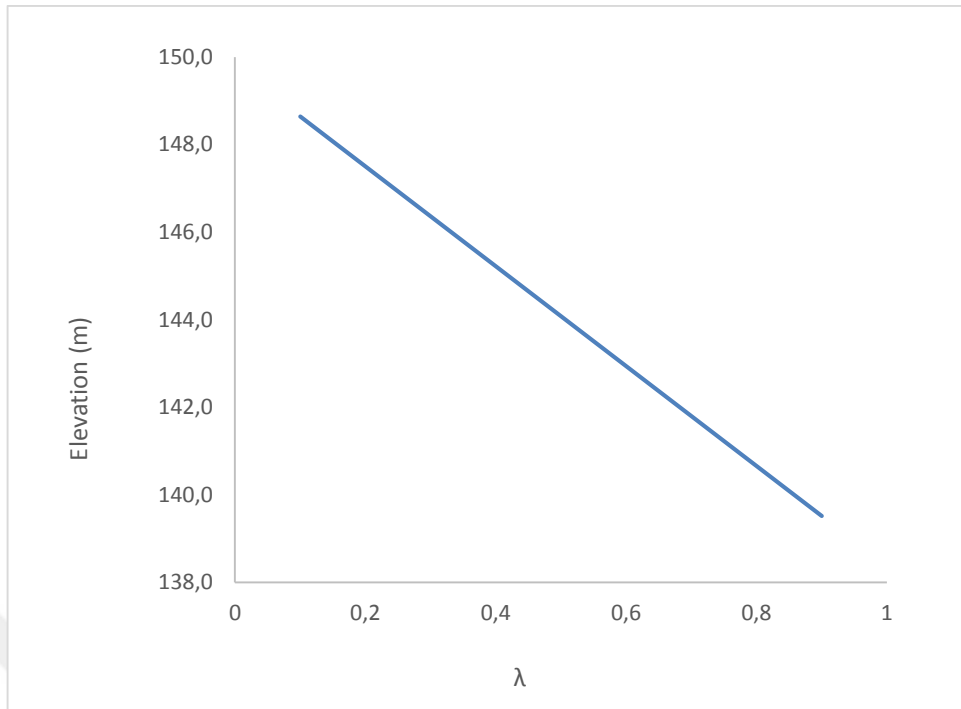


Figure 4.26: The Elevation - λ Relationship (December).

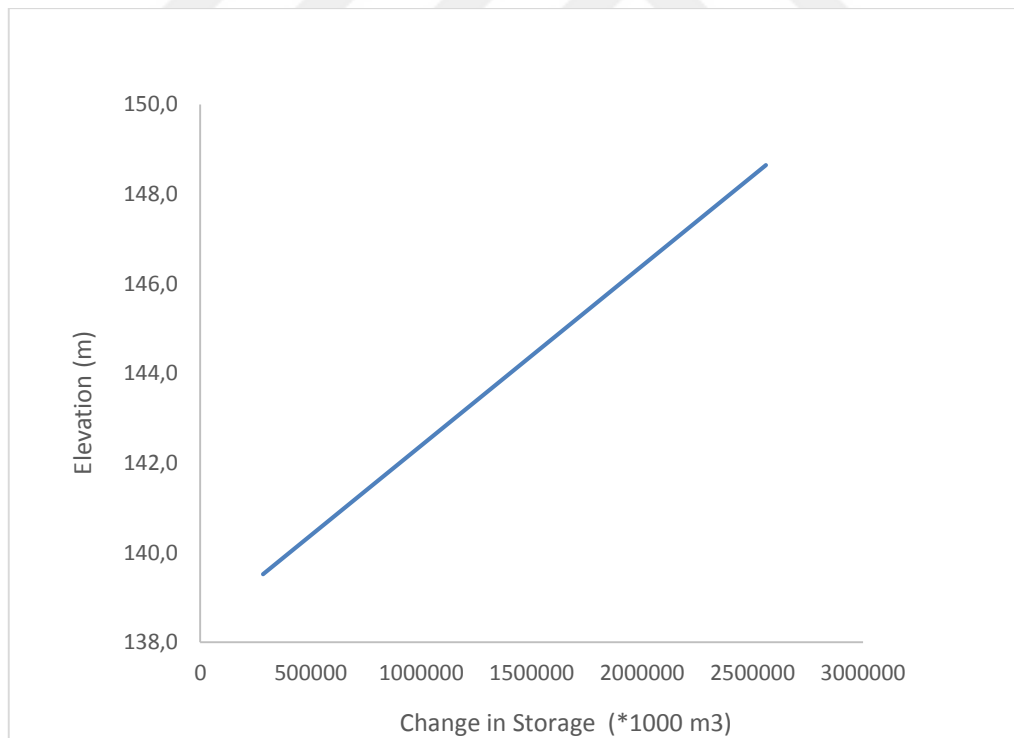


Figure 4.27: The Elevation - ΔS Relationship (December).

5. CONCLUSION

5.1 CONCLUSION

The controlling of Makhool dam was the main concept of the study. The study took the principle of water balance based on the inflow rates toward the reservoir behind the dam and the outflow rates after the dam. The variation of surface area of the water table in the reservoir was evaluated as well as the volumes that formed between two adjacent elevation. These values of areas were linearized by using the linear correlation technique with the volume then linked in the determination of the influence of the monthly rain intensity and the potential evaporation on the resultant quantity of water for each month. The study explained the case of water quantity for each month by deriving equation contained positive and negative parts that effect on the resulted magnitude of water. The outflow rate for each month assumed to be portion of the inflow rate to study the effect of outflow variation on dam operation condition.

The management plan for each month was explained as tables and figures included the effect of the outflow rate and also the change in amount of water stored on the elevation of water stored. The study showed that in huge amount of flowrate that reach the reservoir area like in November plan, the water table elevation can be controlled from (151.2 a.s.l.) to less than that (about 139.8 a.s.l.) by spreading a ratio of half the income flowrate. The study explained the dam breach case by overtopping by using of HEC RAS program. The program fed by the necessary data including the inflow rates and the elevation of the dam crest to build the simulation. The results were showed in figures that indicated the flood wave can reach after 53 hour from the failure a distance of 33km from the dam construction place.

5.2 FUTURE WORK

Investigating the effect of Makhool dam on water demand in the downstream areas like using of water in the sectors of industry, agriculture, and any other lines can be adopted as future work. The upcoming studies can also take the effect of the Tigris river discharge on other water resources like the small river that fed by it on its streamline. The problem of sedimentation and the water quality can be studied based on the variation of the flow rate along the Tigris River path. These conditions can affect the water treatment plants in cities on the downstream regions. The studies can build effective plan for that purposes to explain the best ways for taking the benefit of the available water resources.



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