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Mitigation of Flash Flood Hazards And Optimum Utilization Of Surface Water Runoff Of Wadi Nesah, Al – Hayathim municipality, AL – Kharj governorate, south AL – Riyadh, Saudi Arabia. "

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Abstract:

Comprehensive management approaches to water resources that integrate groundwater and surface water may greatly reduce human vulnerability to climate extreme changes and promote global water and flood security. Flood under estimation may lead to losses in life and properties. On the other hand, flood over estimation leads to waste of investments. Hydrologists have long been searching for appropriate methods to improve accuracy of flood estimation procedures. Wadi Nesah has been chosen as a case study for estimation the peak discharge of flash flood and implementation of the advanced harvesting techniques of flood water and avoiding the damage on the infrastructures and urban community in the Wadi. Wadi Nesah covers an area of about 1890 km^2 and runs from west to east and connects Wadi Ghayadh south AL – Kharj city. It lies between longitudes 45° 57′ 51″ &47° 20′ 23″ E and Latitudes 23° 50′ 39″ & 24° 20′ 45″ N. Geomorphologically, the morphometric parameters of the catchment basin of the study Wadi have direct relationship with the surface runoff processes which occur within the basin. The calculated values of peak discharges of Wadi Nesah during recurrence intervals 25, 50, 100 years respectively are 84.92, 135.6, 190.66, m^3/ sec. For flood mitigation purpose, two alternative solutions are suggested; building a dam on the main channel is the first alternative, while the second alternative is based on excavation of three artificial collection ponds in the basin to collect surface runoff of flood water and reduce the flood risk.

Introduction:

Wadi Nesah covers an area of about 1890km^2 and runs from west to east and connects Wadi Ghayadh south AL – Kharj city. It lies between longitudes 45° 57′ 51″ &47° 20′ 23″ E and Latitudes 23° 50′ 39″ & 24° 20′ 45″ N (Fig. 1). The flash floods which have been carried out within the main channel of Wadi Nesah have direct impact on AL – Hayathim city, west of AL – Kharj city. Structurally, the study area between the Arabian Gulf at the east and the Arabian Arch at the west, the structural setting has direct influence on the hydrological and the geological characteristics. This phenomenon is very clear in the western province, where, the sedimentary

deposits overlay the igneous rocks along the boundaries of the catchment basins. In addition, the predominance of faults joints and folds due to the tectonic movements during the formation of Arabian Arch at the west. It is worth to mention that the structural setting plays an outstanding role in the rate of infiltration for the surface soil. Therefore, this phenomenon should be taken into consideration in the calculation processes of peak discharges of surface runoff within the main channel of the study Wadi. Geomorphologically, the morphometric parameters of the catchment basin of the study Wadi have direct relationship with the surface runoff processes which occur within the basin (Table .1)

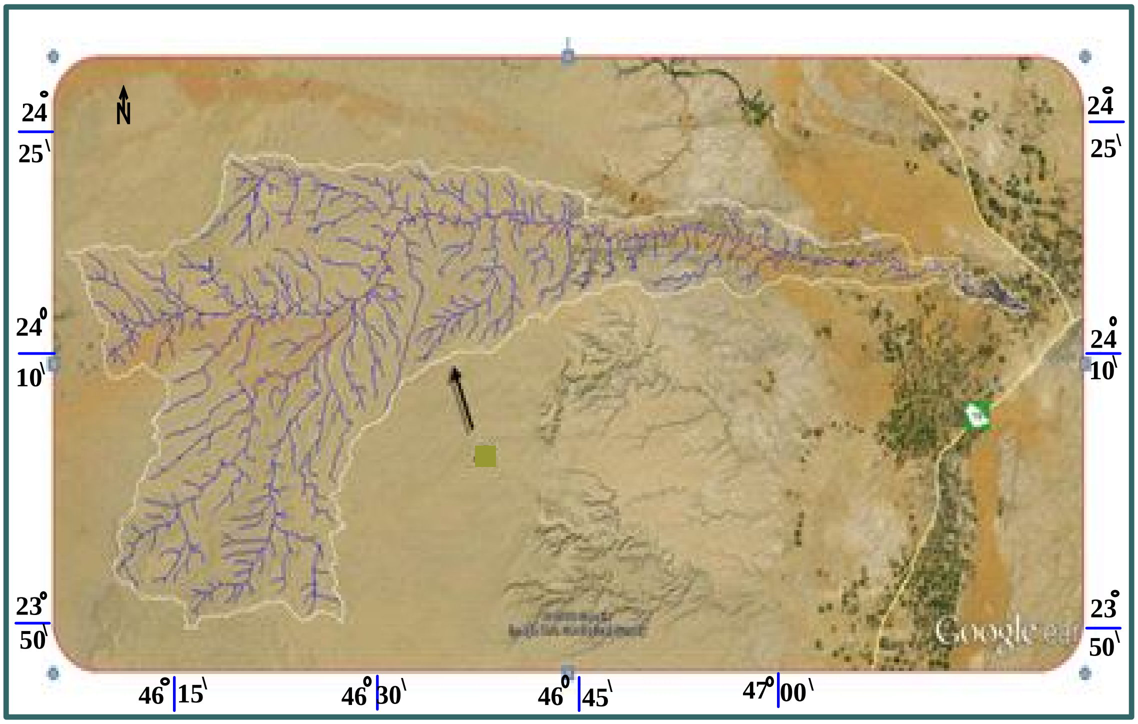

Fig. 1 : Location Map of Wadi Nesah, AL – Hayathim municipality, AL – Kharj governorate

Table (1) Main Morphometric parameters of Wadi Nesah

Parameters	Symbol	Unit	Calculated value
Catchment Area	A	Km^2	1890
Slope of the basin	BS	m/m	0.0965
Length of the main channel	MLS	km	158
Slope of the main channel	MSS	m/m	0.0029
Length of the main channel from the outlet to point opposite the centroid	CSD	km	112
Slope of the main	CSS	m/m	0.0026

channel from the outlet to point opposite centroid			

Geological setting:

From the geological point of view, the study area characterized by the following formations from the top to the bottom Figs. (2):

1- Quaternary Formation comprises from sand dunes deposits, gravels and mud. These deposits are predominant in the main channel and the delta of the Wadi.

2- AL – Kharj Formation, consists of limestone belongs to Miocene and Pliocene ages.

3- Biyadh Sandstone Formation, it is composed of intercalation of sandstone, clay and some iron oxides. It belongs to Lower Cretaceous age.

4- Buwaib Formation, it includes fossiliferous soft limestone overlying by sandstone of Lower Cretaceous age.

5- Yamama Formation, it consists of brownish Calc – arinite of Lower Cretaceous.

6- Sulaiy Formation, it represented by intercalation of Breccia with pale brown of limestone and some dolomite rocks and belongs to Lower Cretaceous age.

7- Arab Formation, it consists of brownish limestone, dolomitic rocks and Calc- arinite of Jurassic age.

8- Jubaila Formation, it comprises of white limestone and some Calc- arinite of Upper Jurassic

9- Hanifa Formation, it shows an intercalation of white limestone with Marl, clay and some Calc- arinite of Upper Jurassic age.

10- Tuwayq Formation, it elucidates the intercalation of white limestone with Marl and some Calc – arinite . It belongs to Upper Jurassic age.

11- Dhruma Formation, it reflects Middle Jurassic age which, consists of brownish limestone intercalated with greenish Calc- arinite , some sandstone and iron oxides .

12- Marrat Formation, it includes limestone and dolomitic rocks accompanied by fine sheets of sandstone and clay. It related to Lower Jurassic age.

13- Minjur Formation, it represents the intersections of sandstone with different layers of clay, thin layers of iron oxides and quartz. It belongs to Triassic and Jurassic ages.

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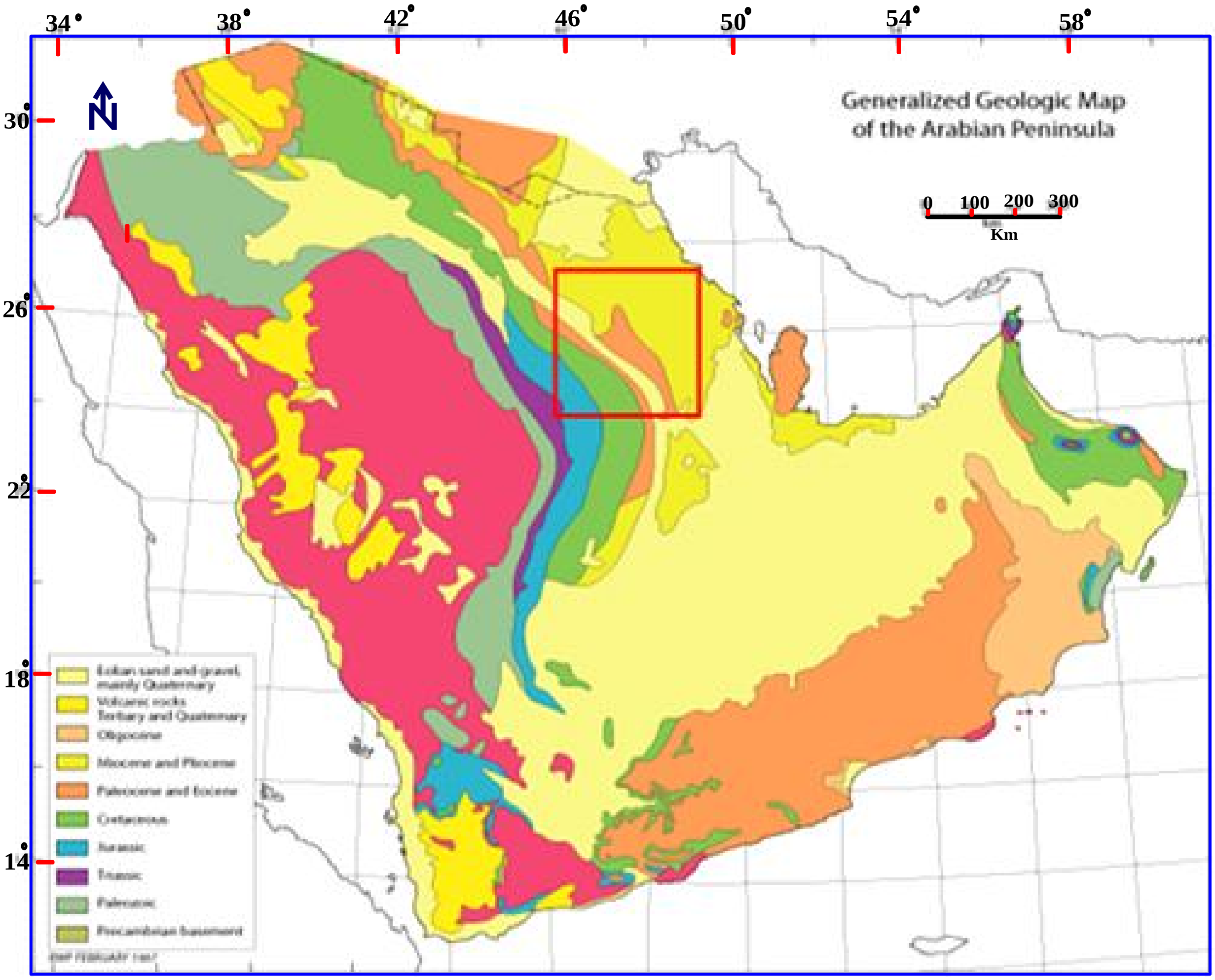

Fig .(2) Generalized Geologic map of the Arabian Peninsula

Rainfall – runoff relationship

During the progress of this work, rainfall data collected at the meteorological stations in the study area and its vicinities. A statistical software package (SMADA) (Storm water Management and Design Aid) was used to estimate the peak discharge of surface runoff from 25 years to 100 years return period by unit hydrograph method, Table 2 & Fig. 3.

Table (2) The calculated values of peak discharges of Wadi Nesah

Recurrence interval (Year)	Peak discharge (m^3/ sec.)	Volume of runoff (Million m^3)
25	84.92	6.0
50	135.60	9.6
100	190.66	13.5

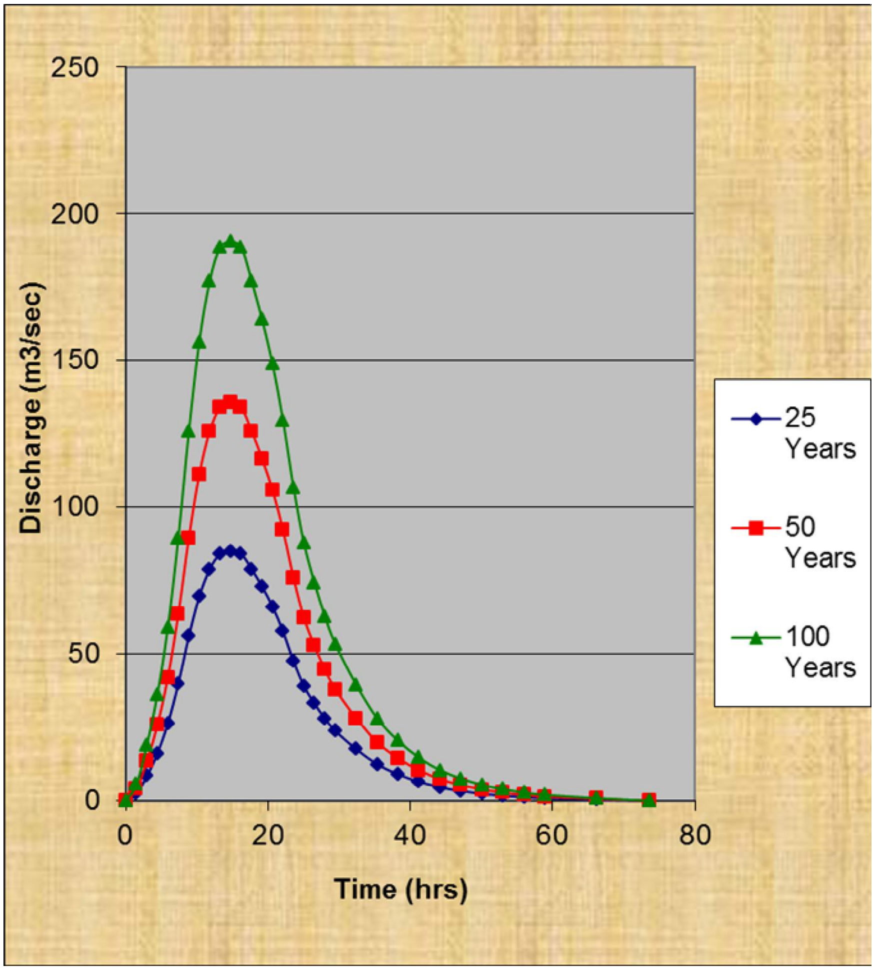

Fig. (3) Hydrograph Distributions of Wadi Nesah

Infiltration capacity of the surface Soil

The first process that occurs after flow starts in an ephemeral Wadi is the infiltration of the water into the Wadi bed. This is very important process to study the soil characteristics within the investigated Wadi, through the calculation of the infiltration rates through it. The majority of the surface soil of the study Wadi characterized high infiltration due to the occurrence of sandy soil. On the other hand, the minority of the surface soil is composed of wadi fill deposits and characterized by moderate infiltration rate Fig. (4). Therefore, the construction of water collectors or concrete dam should be recommended for harvesting surface runoff in the central portion of the wadi. The building of spill way in this portion is a best tool to use the collected water for agriculture purposes directly

The rainfall losses due to interception and infiltration were calculated by SCS Curve number, as follow:

Sedimentary Rocky soil 75 %

Wadi fill deposits 25 %

Curve Number: 68

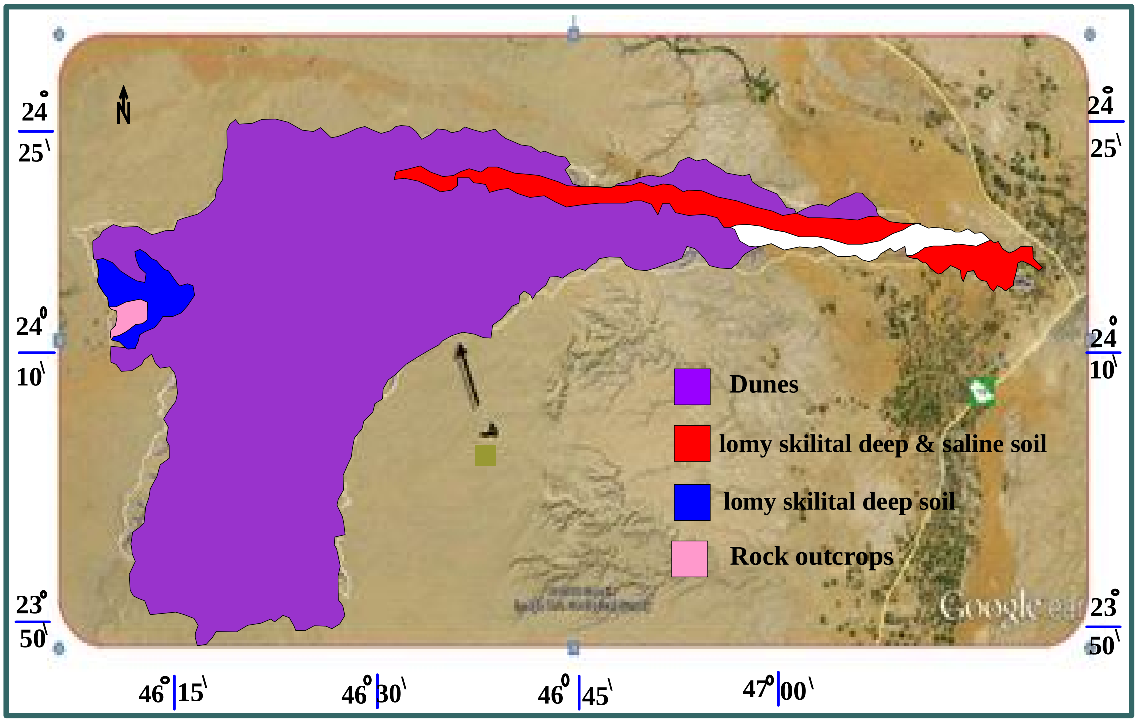

Fig. (4) Soil Distribution map of Wadi Nesah

Suggested alternative solutions for flood mitigation of Wadi Nesah

For flood mitigation purpose, two alternative solutions are suggested; building a dam on the main channel is the first alternative, while the second alternative is based on excavation of three artificial collection ponds in the basin to collect surface runoff of flood water and reduce the flood risk. (Figs 7&8 & Tables 3&4).

First alternative solution

The specifications of the suggested dam and its spillway are shown as follow (Figs 5,6&7 &Tables 3,4,5 &6).

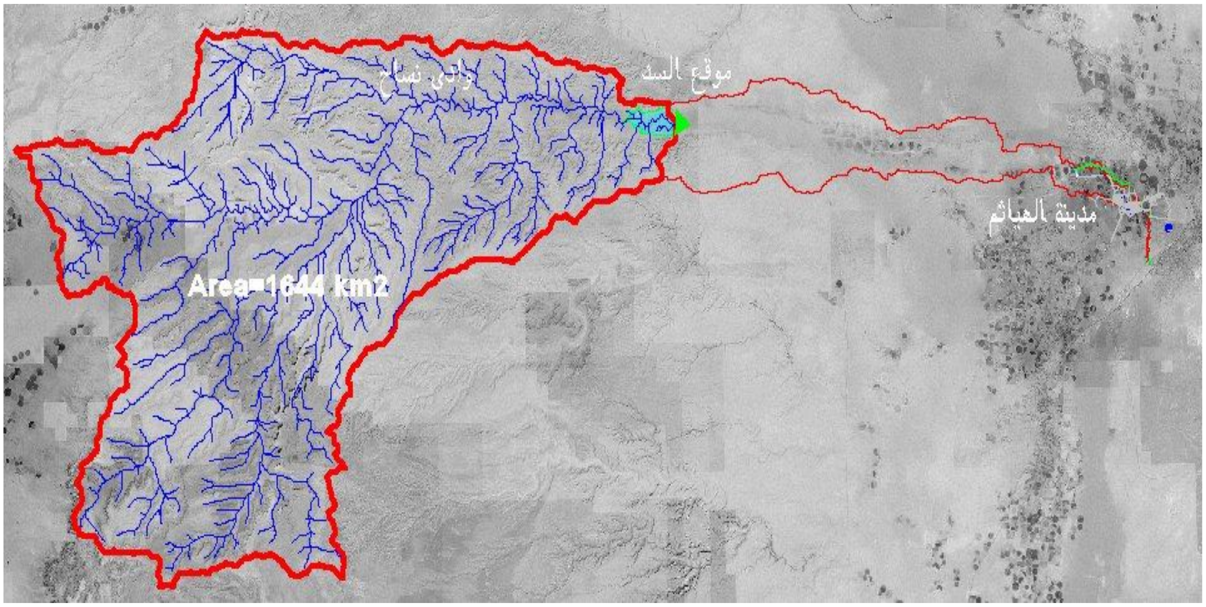

Fig. (5) Location of suggested dam of Wadi Nesah

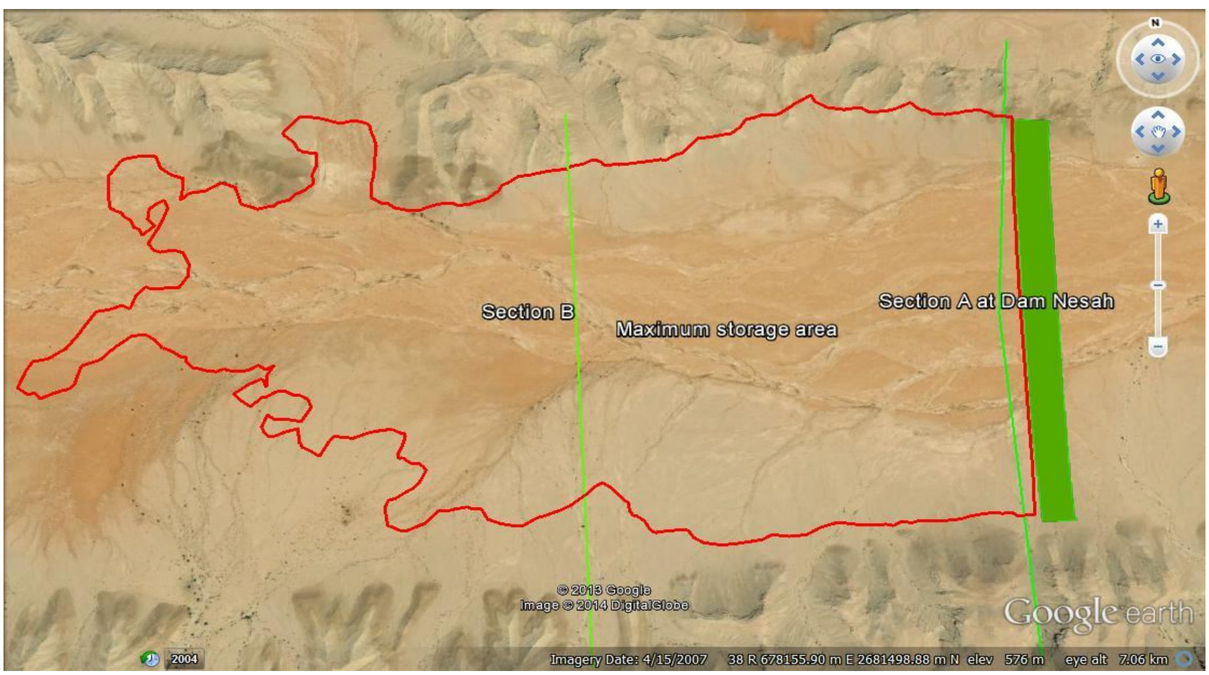

Fig. (6) The expected boundaries of collection pond in the front of dam

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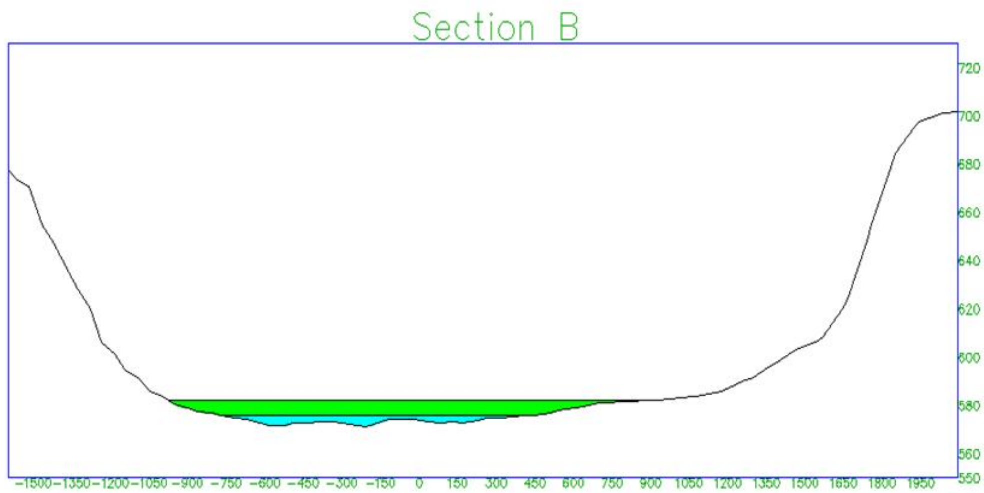

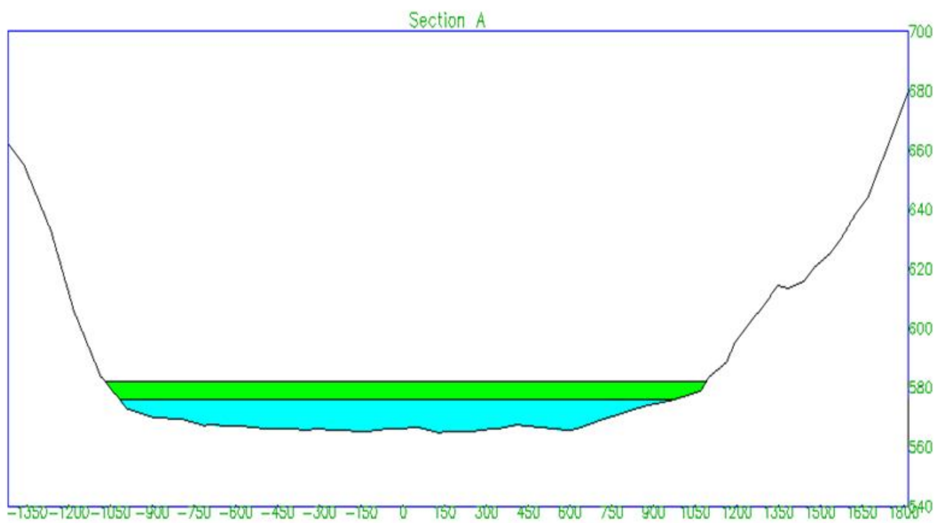

Fig . (7) Two cross section within the extended pond in the front of the suggested dam

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Table (3) coordinates of the suggested dam

Longitude	Latitude
46° 48 ′	24 ° 13 ′

Table (4) Specifications of suggested Dam

Specifications	Purpose & Dimensions
Type of dam	Earth dam
Purpose of dam	Protection and recovery
Height of dam	13 m
Length of dam	2070
Storage capacity	19 million cubic meters
Volume of runoff for Recurrence interval 100 years	17.86 million cubic meters

Table (5) Specifications of the spillway of the suggested dam

Parameters	Unit	Specifications
Type of the spillway		Ogee type
Bottom level	(m)	566
Top Level	(m)	579
Height of the spillway	(m)	10
Peak discharge for recurrence interval (100yeays)	(m3/sec.)	191
Length of the spillway	(m)	90
Water level above the spillway	(m)	1.05
Free depth	(m)	1.95

Table (6) Morphometric parameters of Wadi Nesah in the back zone of the suggested dam

Parameters Calculated	Symbol	Unit	
Catchment area 1644.0	A	Km^2	
Slope of the basin 0.104	S	m/m	
Length of the main channel 98.5	MSL	km	
Slope of the main channel 0.0033	MSS	m/m	
Length of the main channel from the outlet to			
point opposite centroid	CSD	km	56.0
Slope of the main channel from the outlet to			
point opposite centroid 0.0025	CSS	m/m	

Second alternative solution

Table (7) and Fig.(8) illustrate the suggested locations of the artificial collection ponds, which considered the second alternative solution. On the other hand, the technical comparisons of the two solutions are shown in Table (8).

Table (7) Coordinates of the suggested collection ponds

Ponds	First Pond		Second Pond		Third Pond	
Coordinates	Longitude	Latitude	Longitude	Latitude	Longitude	Latitude
First point	46° 48′	24° 13′	46° 50′	24° 13′	46° 53′	24 ° 13′

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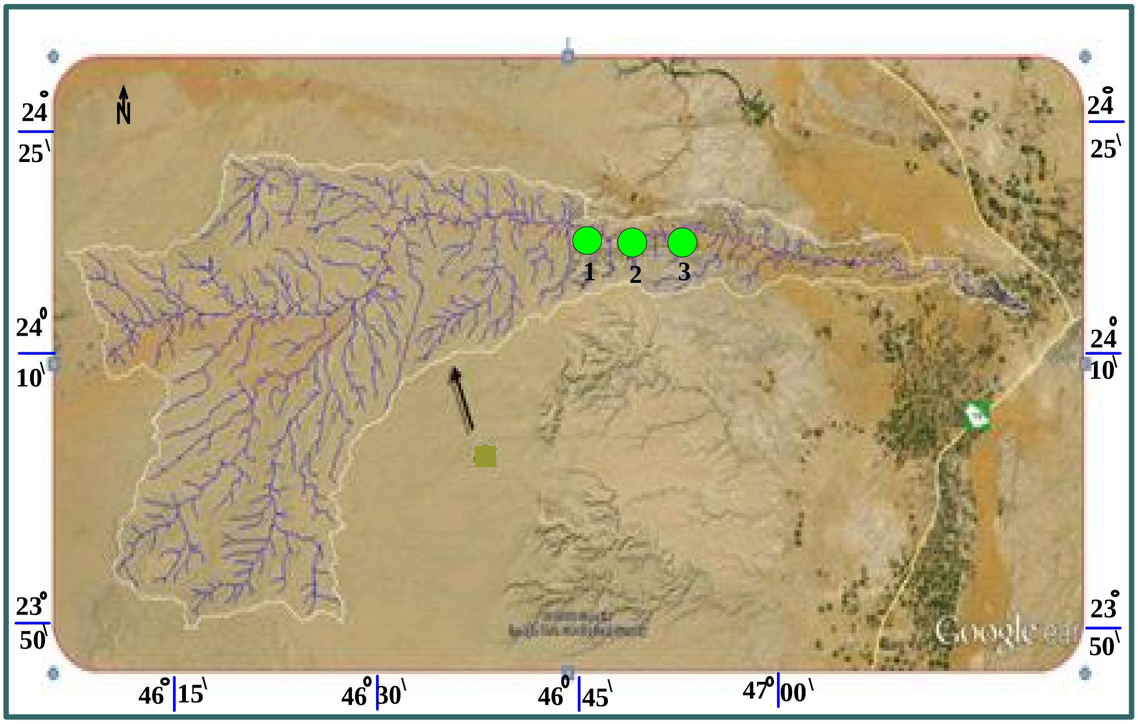

Fig (8 location map of suggested collection ponds.

Table (8) Technical comparison of the two alternative solutions

Parameters	Dam	Collection ponds
Estimated storage volume (million m^3)	19	8.55
Replenishment of shallow aquifer	Applicable	Applicable
Benefits of the stored water	Always applicable in case using dam's gates	Possible in case of pumping water
Environmental hazard of stored water	Minimum	Higher when not using collected water
Range of protection	Full protection, for recurrence interval 100 years of the storm rainfall	Partial protection for recurrence interval 50 years of storm rainfall
Environmental hazard during construction	Can be recovered by using certified environmental methodology	Can be recovered by using certified environmental methodology
Hazard on the back zone	High in the case of failure	no
Sedimentation	Partial sediments in the dam lake	Amount of sediments in the pond
Possibility of recovering sediments	Possible by pumping	Possible by pumping

Recommendations

The following recommendations may be useful for a future plans in the study area:

1. Develop sustainable flood protection and drainage systems design criteria. The effects of climate change may be of concern for new and existing storm-water dam and lake designs.

2. Appropriate assumptions need to be developed for future climate change.

3. Develop a flood plain zone map with different risk categories and encourage the public to maintain this zone and to restrict new construction within it

4. Develop an environmentally friendly storm-water management plan, including water conservation principles, as a prime factor in enhancing clean runoff.

5. Plan and design a storm-water drainage system for the study area: this can be implemented by upgrading the existing system and developing a storm-water management plan, including watershed management, environmental issues, and land-use planning for the region.

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