HYDROLOGICAL STUDY AND ANALYSIS OF TWO FARM DAMS IN ERBIL GOVERNORATE

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ABSTRACT

This research presents hydrological study and analysis for two proposed farm dams (Chaluk and Zurgazraw) located in Erbil Governorate - Iraqi Kurdistan Region. Many site visits were made to the Chaluk and Zurgazraw areas to select the most suitable site for the farm dams. The area and properties of the catchment area for both farm dams were measured by arc GIS software and were equal to 1.99, and 3.97 km^2 for Chaluk and Zurgazraw farm dams, respectively. The topographic study and surveying of the selected sites aimed to construct the contour maps of the sites, determine the capacity of the reservoir for different heights of the farm dam embankment, and locate the centerline of the dam and spillway. In the hydrological analysis, as the proposed farm dam's streams are ungauged streams with no runoff data records, the U.S. Soil Conservation Service (SCS) method was used to find the annual runoff yield. This method depends on physical parameters of the catchment area and daily rainfall depth data taken from Erbil Meteorological station; the calculated minimum, maximum, and average runoff yield were equal to 16556, 233407, and 103957 m^3 for Chaluk, and 33030, 456641, and, 207393 m^3, Zurgazraw farm dam. The Australian (ARR) organization method was used to determine the 50 year return period peak discharge for the farm dams catchment area, which were equal to 14.71, and 24.07 m^3/sec for Chaluk, and Zurgazraw farm dams, respectively. Based on the calculated average annual inflow and calculated annual sediment inflow into farm dams by Universal Soil Loss Equation, the dead, and live storages elevations, and volumes were fixed to be equal to 411, and 418 m.a.s.l. (meters above sea level) and 7741, and 103425 m^3 for Chaluk, and 404, and 412 m.a.s.l 20863, and 293822m^3 for Zurgazraw farm dam.

Keywords: Farm dam, Runoff, Catchment area, Peak discharge, Curve number, Sediment inflow

1. INTRODUCTION

Kurdistan region of Iraq is frequently subjected to a severe drought, which causes shortages, as the available water resources do not satisfy water demands for domestic, livestock consumption, agriculture, tourism and environment requirements. Therefore, the water resources management becomes one of the most important facility to solve the drought issues. Water harvesting is a useful practice to capture runoff and utilize it in situ for various uses especially supplemental irrigation during drought spells [1].

Investigations and studies started for water harvesting through the construction of small reservoirs (farm dams) everywhere feasible, that aims at collection of excess rainfall water and conservation of the eroded soil, in addition to groundwater recharge. Two locations near Chaluk and Zurgazraw villages in Erbil Governorate were proposed for conducting the feasibility studies and design of small reservoirs (farm dams) in order to reclaim water resources in the region. The present study is a part of feasibility study and design of Chaluk and Zurgazraw farm dams, and was conducted at the request of International Center for Agriculture Research in the Dry Areas (ICARDA).

2. GENERAL DATA

2.1 SITE SELECTION

Many site visits were made to the Chaluk and Zurgazraw areas to select the most suitable site for the farm dams; three potential locations were selected for each area to construct the farm dam in it. For each area, the selection of the suitable one, among the three locations, has been done based on the followings [2]:

a. Topography and storage capacity: For economic feasibility of storage project, it is necessary that the length of the farm dam embankment body should be as small as possible and for a given height it should store a maximum volume of water, this factor was taken into consideration in the selection of both farm dams site.
b. Catchment Area and Hydrology: The catchment area upstream the farm dam location is sufficient catchment and it is expected that it will bring enough amount of water to fill the reservoir. To be sure about this factor, the hydrological study of the catchment area has been being prepared.

c. Foundation: A good foundation for the farm dam embankment body will be provided after a geotechnical investigation of the selected site, it is very important to find the soil permeability, the location of bedrock and to know whether the foundation is pervious or impervious.
d. The availability of the materials for construction: It is very important for the economic feasibility of the project to have a suitable material for construction near the selected site to minimize the cost of the project, which has been ensured for both areas of studies.
e. Spillway Location: The selected site of the farm dam has a suitable location for the spillway structure to release surplus water during the floods.
f. Irrigation Command: The selected site is suitable for irrigation purposes; the site is upstream of the cultivated areas, hence these areas can be easily irrigated during the drought days, so the supplementary irrigation technique can be easily provided to the area.

The Topographic study and surveying of the selected sites aimed to construct contour maps of the sites, determine the capacity of the reservoir for different heights of the farm dams' embankment and locate the axes of the lake and spillway. Two reference points were taken GPS; then, data were collected using total station (Topcon GTS235) every 10 to 15m for the construction of topographic maps and surface details. Chaluk and Zurgazraw villages (farm dams' locations) are situated to the South and South East of Erbil city, Iraqi Kurdistan region. Additional details for the farm dams' locations are listed in the Table (1), and shown in the prepared counter maps in Figure (1).

TABLE 1.
Coordinates for the Proposed Farm Dams

No.	Farm Dam and Village Name	Sub- District to which they belong	UTM Coordinates		
1	Chaluk	Khabat	X	Y	Z
	BM1		383599.55	4010641.7	415.97
	BM2		383485.42	4010675.3	419.62
	BM3		383604.82	4010537	417.8
2	Zurgazraw	Shamamik			
	BM1		397310.08	3974029	416.85
	BM2		397454.12	3973812	415.12
	BM3		397253.14	3973890.2	412.08

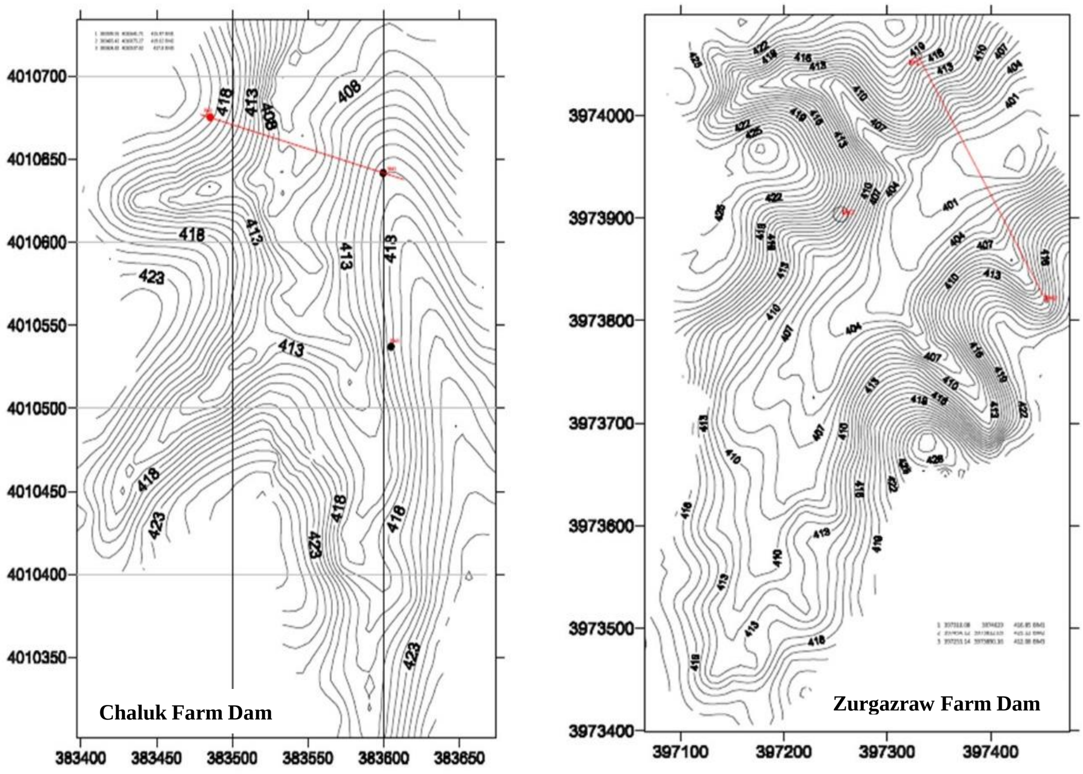

FIGURE 1. Contour Maps of Proposed Farm Dams

2.2 CLIMATE

The Chaluk farm dam site is situated 25 km west of Erbil city and 3.5 km east of Khabat District, and the Zurgazraw farm dam site is situated 30 km South of Erbil city. The farm dams are located in a semi-arid zone, with hot summer and cold winter, and the rainfall occurs from October to May. Full and complete meteorological data records for the areas are available at Erbil meteorological station; this is because there is no closer meteorological station near the farm dams' sites. Erbil Metrological station has records for the daily rainfall data for the period from 1992-1993 to 2010-2011, and the maximum 24hr rainfall depths the period from 1975-1976 to 2010-2011. The recorded minimum and maximum monthly temperature in Erbil metrological station for the period 1993-2010 is 4.1 C^o in January, and 41.8 C^o in July. The recorded average annual evaporation for the period 2001–2010 was 2485.3 mm, and the minimum and maximum average monthly humidity for the period 2000-2010 are 26.5%, in July and 68.8% in January, respectively. The average annual rainfall depth for the period from 1941-1942 to 2010-2011 is 403 mm, and the max 24hr rainfall depth for the period from 1975-1976 to 2010-2011 is 75.7 mm, which occurred in February,1995 [3].

2.3 TARGET BENEFICIARIES

Villages downstream of the farm dams will benefit from the stored water of the farm dam for supplemental irrigation, and livestock watering. Table (2) shows general Socio-Economic data of the proposed farm dams.

TABLE 2.
General Socio-Economic Data for Proposed Farm Dams

No.	Hill Lake Name	Beneficiary Village	No. of Families	Population	No. of Animals		Agriculture (ha)
					Small	Large	
1	Chaluk	Chaluk	80	400	900	105	50
2	Zurgazraw	Zurgazraw	45	225	500	255	125

3. HYDROLOGICAL ANALYSIS

3.1 CATCHMENT AREA

The catchment area shape and properties of the proposed farm dams, measured by arc GIS software, are shown in figure (2) and table (3). In general, the catchment areas shape has rather a hilly topography, very little flat land with steep slopes at some parts of the basin. The rainfall-runoff take places in the valleys in winter, but no historical flow measurements are available for the streams of the catchment area.

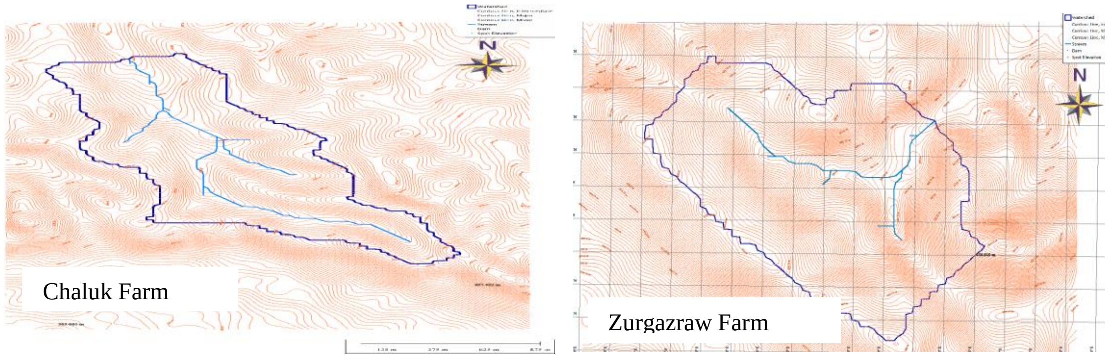

FIGURE 2. Proposed Farm Dams Catchment Area

TABLE 3.
Farm Dams Catchment Properties

Farm Dam Name	Chaluk	Zurgazraw
Basin Area	1.99 km^2	3.97 km^2
Basin Length	2722.76 m	11750.88 m
Basin Slope	0.0923 m/m	0.0819 m/m
Basin Perimeter	9256.43 m	5733.16 m
Basin Shape Factor	3.73 mi^2/mi^2	1.28 mi^2/mi^2
Mean Basin Elevation	431.39 m	411.99 m
Maximum Stream Length	3315 m	4550m
Maximum Stream Slope	0.03016 m/m	0.034 m/m

3.2 ESTIMATING THE CATCHMENT ANNUAL YIELD FROM SURFACE RUNOFF

The most readily available source of water is the surface water in rivers and lakes. This water is usually stored in dams. In certain parts, fortunate farmers have ‘run of the river’ schemes, that is, they do not need storages because the flows in the rivers are so reliable that they can meet all requirements. This is the situation in areas of consistently high rainfall.

The proposed farm dams’ streams are ungauged streams with no runoff data records. There are many methods to calculate the runoff yield for ungauged streams; they depend on the stream catchment area characteristics and measured annual rainfall depth. The variability of rainfall limits the accuracy of forecasting, and hence, the reliability of these methods. It therefore follows that, despite the most careful calculations, it is difficult to guarantee that a farm dam will always meet requirements. However, a method of estimating the potential catchment yield must be adopted so that a farm water supply scheme can be planned on a reasonably sound basis. Usually, the most accurate method for estimating the yield of the ungauged streams is SCS (Soil Conservation Services); this method is used for the calculation of the daily runoff by using daily recorded rainfall data for the farm dam site and catchment area characteristics. In 1954 [4], SCS derived the following equation for calculating surface runoff depth in (mm):

$$\mathrm{SRO} = \frac{(\mathrm{P}-0.2\mathrm{S})^2}{(\mathrm{P}+0.8\mathrm{S})} \quad \ldots\ldots\ldots (1)$$

Where:

P is daily rainfall depth in (mm), and

S is a potential maximum retention in (mm), that can be calculated from the following equation:

$$\mathrm{S} = \frac{25400}{\mathrm{RCN}} - 254 \quad \ldots\ldots.. (2)$$

RCN: is runoff coefficient called runoff curve number, which depends on the soil type, land use and infiltration rate.

The Runoff Curve Number (RCN) technique has been proven to be a very useful tool for evaluating effects of changes in land use and treatment on surface runoff. It is the procedure most frequently used within the SCS and by hydrologists worldwide to estimate surface runoff from ungauged watersheds. The infiltration rate is the rate at which water enters the soil at the surface and which is controlled by surface conditions. The hydrologic soil groups, as defined by SCS soil scientists according to infiltration rate, are: A type Soils having high infiltration rates (greater than 0.76 cm/hr), B type Soils having moderate infiltration rates (between 0.38 – 0.76 cm/hr), C type Soils having slow infiltration rates (between 0.13 – 0.38 cm/hr), and D type soils having very slow infiltration rates (less than 0.13 cm/hr). SCS gives RCN corresponding to above soil groups in tables [5].

In the SCS method of runoff estimation, the effects of the surface conditions of a watershed are evaluated by means of land use and treatment classes. Land use is the watershed cover and it includes every type of vegetation suggested by SCS [4].

SCS prepared a table gives RCN corresponding to the land uses. The tabulated RCN values are for normal soil moisture conditions which are referred to as Antecedent Moisture Condition II (AMC-II). AMC-I has the lowest runoff potential and the watershed soils are dry. AMC-III has the highest runoff potential as the watershed is practically saturated from antecedent rainfall. The following equations shall compute RCN for AMC-I or AMC-III [6]:

$$\mathrm{RCN(I)} = \frac{4.2\ \mathrm{RCN(II)}}{10 - 0.058\ \mathrm{RCN(II)}} \quad \ldots\ldots.. (3)$$

$$\mathrm{RCN(III)} = \frac{23\ \mathrm{RCN(II)}}{10 + 0.13\ \mathrm{RCN(II)}} \quad \ldots\ldots.. (4)$$

For each Farm dam catchment area, the runoff curve number (RCN) was calculated from SCS tables based on the hydrologic soil groups and the nature of the antecedent moisture condition for AMC-II group (weighted mean) without dividing the area into sub-areas; as the areas are not large. In the calculation, the following were assumed:

a- Soil cover of the Farm dam catchment areas are Loam soil, type C, Soils having slow infiltration rates.

b- The land use of the Farm dam catchment areas is Small grain, Straight row.

c- Months October and November are regarded as AMC-I condition because the land is at its lowest moisture content, a period of starting rainfall, the duration between two rainfalls are almost long then the probability of runoff is low. Months December, January, and February are considered to be AMC-II condition; this is because the soil moisture increases, the duration between two successive rainfalls is short and the probability of runoff increases. Months March, April and May are considered as AMC-III due to the fact that the soil is almost saturated and the possibility of runoff is at the maximum level.

Based on the above steps and conditions, the runoff curve numbers for the farm dam catchment areas were found to be equal to 84, 68.8 and 92.4 for groups AMC-II, AMC-I and AMC-III, respectively.

Based on the daily rainfall data for the interval from (1992-1993) to (2010-2011) and using Equations (1) and (2), the daily, monthly, and annual runoff depth were calculated as summarized in Table (4). Based on this table, the average annual runoff depth is found to be 52.24 mm, and by multiplying the runoff depth by the catchment area of each farm dam, the annual inflow volume in (m^3) is calculated, as shown in the Table (5).

TABLE 4.
Summery of average, minimum, and maximum annual surface runoff calculation

Month	Oct.	Nov.	Dec.	Jan.	Feb.	march	April	May	Total
Year	Runoff (mm)	Runoff (mm)	Runoff (mm)	Runoff (mm)	Runoff (mm)	Runoff (mm)	Runoff (mm)	Runoff (mm)	Runoff (mm)
1992-1993	0.0	12.9	11.4	6.5	3.4	11.9	57.1	14.1	117.3
1993-1994	0.0	0.0	2.5	10.0	11.6	52.8	16.0	0.4	93.2
1994-1995	0.9	1.6	6.9	9.8	46.3	22.9	13.3	0.0	101.8
1995-1996	0.0	1.6	0.0	7.0	0.1	20.4	6.1	0.0	35.1
1996-1997	0.0	0.0	7.2	10.9	2.5	15.5	11.9	0.0	48.1
1997-1998	0.0	0.0	9.4	11.3	0.0	16.2	4.6	0.0	41.5
1998-1999	0.0	0.0	0.7	1.8	4.0	1.3	0.4	0.0	8.3
1999-2000	0.0	0.0	6.3	2.4	0.2	2.2	1.6	0.2	13.0
2000-2001	0.0	0.0	2.4	1.7	3.1	44.2	11.1	0.0	62.5
2001-2002	0.0	0.0	1.1	8.7	0.2	32.9	9.4	0.0	52.3
2006-2007	0.4	0.0	0.6	4.5	14.6	7.0	3.2	0.4	30.8
2007-2008	0.0	0.0	0.0	0.1	1.4	31.5	0.0	0.0	33.1
2008-2009	2.2	0.0	0.1	0.0	0.2	22.3	1.8	0.1	26.7
2009-2010	0.0	0.0	6.9	0.3	9.2	26.0	2.3	2.8	47.4
2010-2011	0.0	0.0	0.9	11.2	2.0	5.9	52.2	0.4	72.5
Total	3.5	16.1	56.2	86.1	98.9	313.2	191.2	18.4	783.6
Average	0.2	1.1	3.7	5.7	6.6	20.9	12.7	1.2	52.2
max	2.2	12.9	11.4	11.3	46.3	52.8	57.1	14.1	117.3
Min	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	8.3

TABLE 5.
Catchment yield from surface runoff for the both proposed farm dams

No.	Farm dam name	Annual Runoff Depth (SRO) in (mm)			Catchment area (A) in (Km^2)	Runoff yield volume (V) in (m^3)		
		Max.	Min.	Avg.		Max.	Min.	Avg.
1	Chaluk	8.32	117.29	52.24	1.99	16,556	233,407	103,957
2	Zurgazraw	8.32	117.29	52.24	3.97	33,030	465,641	207,393

3.3 PEAK (FLOOD) DISCHARGE CALCULATION

The peak flood is the maximum flood to be expected from a catchment following a rainfall of estimated intensity and duration for a selected return period. In many parts of the Iraqi Kurdistan region, information is not available or smaller streams are not gauged to allow estimation of such floods for spillway design purposes. A very approximate peak flood estimate can be made by taking the highest daily rainfall figure for the catchment and making the assumptions that all farm dams in the same catchment is 100 percent full, the ground is saturated, and 100 percent run-off will occur. An important element in designing spillways of a farm dam is to establish run-off within a specified return period (recurrence interval). Selection of a return period depends on the economic balance between cost of periodic repair or replacement and the cost of providing additional capacity to reduce the cost of repair or replacement. Most spillways on farm dams are cut into the earth because concrete is too expensive but concrete lined spillways are more resistant to flood current erosion and more stable than earth type spillway. The generally accepted flood frequency return periods used for Minor dams and farm dams are (depending on consequences of overtopping) 10-50 years [2].

As the farm dams' catchment area streams are ungauged streams (no data record for flood discharges), the Peak (flood) discharges were calculated using empirical methods, which depends on the maximum rainfall depth and catchment area characteristics. The main methods are:

1- **SCS Unit Hydrograph method** [7]

This method involves determining the peak rate of runoff (Qp) expressed in (m^3/sec) per cm of runoff from a given drainage area. This (Qp) is primarily a function of the time it takes for runoff to travel through the basin to the design point. Once this rate of runoff is determined, it can be multiplied by the amount of runoff to produce a discharge. The SCS model can be considered the most suitable for medium and large catchment areas.

2- **Run-off (ARR)-A Guide to Flood Estimation** [2]

This method is used for small to medium-sized ungauged rural catchments for an Average Recurrence Interval (Return period) of 50 years especially for farm dam spillway discharge design. This method is developed in Australian (ARR) organization takes into consideration rainfall intensity, catchment characteristics and size, the average slope of the waterway and its length from source to the Farm dam site. The formula is:

$$Q_Y = 0.278 * C_Y * I_{TC} * A \quad \ldots\ldots (5)$$

Where Q_Y is the flood discharge for 50 years return period (m^3/sec), C_Y is run-off coefficient (dimensionless) depends on return period (Y) for 50 years return period is equal to 0.25 [1], I_{Tc} is average rainfall intensity (mm/hr) for design duration of (T_c), and A is area of catchment (km^2).

$$I_{TC} = \frac{P_T}{T_C} \quad \ldots\ldots (6)$$

Where Tc is the design duration or concentration time in (hr), for ungauged watersheds. it can be worked out by the California formula, which is:

$$T_C = \left(\frac{0.871L^3}{\Delta H}\right)^{0.385} \quad \ldots\ldots (7)$$

Where T_c in (hr), L is the length in (km) of the particular flow path and ΔH is the maximum elevation difference in the catchment area. Table (6) shows the calculation of T_c for all proposed farm dams catchment areas.

TABLE 6.
Calculation of time of concentration (T_c)

No.	Farm Dam Name	Length (m)	ΔH (m)	T_c (hr)
1	Chaluk	3315	100	0.643
2	Zurgazaw	4550	155	0.784

P_T is maximum 24hr design rainfall depth. As the Normal practice in this method is to use 24 hours as the design rainfall duration, the current study is based on the available recorded 24 hr max rainfall depth in the Erbil meteorological station for 36 years' period from (1975-1976) to (2010-2011).

Using the frequency analysis by Gumble distribution Equations (8), (9), (10), (11), and (12) below [8], the max. 24 hr rainfall amount for return periods (2, 3, 4,5,10, 25, and 50) years were obtained for the farm dams catchment area under study as shown in the Table (7).

$P_T = P` + K_T\sigma$ ………… (8)

Where P_T is 24hr max. rainfall depth for any return period (T) (mm), P` is Average values of 24hr max. Rainfall depth data σ is Standard Deviation of 24hr max, which is calculated using Equation (9):

$$\sigma = \sqrt{\frac{\sum(Pi-P`)^2}{(n-1)}} \quad \ldots\ldots (9)$$

$$P` = \frac{\sum Pi}{n} \quad \ldots\ldots. (10)$$

Where n is No. of recorded rainfall data,

$$K_T = -(0.779) * (0.577 + y) \ldots\ldots\ldots (11)$$

$$y = \ln\{\ln(\frac{T}{T-1})\} \ldots\ldots\ldots (12)$$

TABLE 7.
24hr max. Rainfall calculation by Gumble distribution

T (year)	2	3	5	10	25	50
y = -ln{-ln(1-1/T)}	0.367	0.903	1.500	2.250	3.199	3.902
K_T	-0.164	0.254	0.720	1.305	2.044	2.592
P_T in (mm)	35.0	40.1	45.7	52.8	61.7	68.4

Using the values of T_c and P_T obtained in Tables (6) and (7), the rainfall intensity in (mm/hr) from Equation (6), and the flood discharge (Q_Y) in (m^3/sec) from Equation (5) for (50) years return period were calculated for both farm dams' catchment area, as shown in Table (8).

TABLE 8.
Flood discharge by (ARR) Method for both proposed farm dams

Farm Dam Name	P_T (mm)	Tc (hr)	I (mm/hr)	C_Y	A (Km^2)	$(Q)_T$ (m^3/ sec) for T= 50 years
Chaluk	68.40	0.643	106.38	0.25	1.99	14.71
Zurgazraw	68.40	0.784	87.24	0.25	3.97	23.07

4. FARM DAMS CHARACTERISTICS

4.1 FARM DAMS SEDIMENTATION

The loss of soil by erosion in the farm dams' catchment area was calculated using Universal Soil Loss Equation [9]:

$$A = R * LS * K * C * P \ldots\ldots\ldots (13)$$

Where: A is mean annual soil loss (ton/ hectare/ year), R is rainfall erosivity index, R value for the farm dams site is found from the iso-rodent map for northern Iraq prepared by Nikolav, 1983 using the Wischmeir equation, 1962 [10], which is equal to 50. K is soil erodibility in the metric unit (Ton/hectare/unit of rainfall erosivity), K=o.5, is calculated from the map for northern Iraq prepared by Nikolav,1983 [10].

P is the soil conservation practice factor, which is defined as the ratio of soil loss from the field with supporting practices as contouring, strip cropping, minimum tillage or terracing to that with straight row farming up and downslope, depending on the land slope P value can be found from a table prepared by Nikolav, 1983 [10]. For the farm dams site, the average land slope is equal to 4%, and from Nikolav table, P would be equal to 0.5.

C is the cropping management factor, which is the ratio of soil loss from land cropped under the specified condition to the corresponding soil loss from tilled continuous fallow. C is equal to 0.16 for Biennial rotation (a common practice in Iraq) [10].

LS is the topographic factor for the site calculated as a function of the slope length (L) and slope steepness (S) from Equation (14) below, in which L is in meter and S is in percentage. The slope steepness (s) for the catchment area was taken as 4 % for average slope length (L=50 m), yielding LC to be equal to 0.52 from Equation (14) and A to be equal to 1.4 Ton/hectare/year from Equation (13).

$$LS = l^{0.5}(0.0138 + 0.00965 * S + 0.00138 * S^2 \qquad \ldots\ldots\ldots \quad (14)$$

Table (9) presents the procedure to calculate the volume of the accumulated sediment for 50 years return period, which is the product of the multiplication of the catchment area, mean annual loss (A) and 50 years return period divided by the sediment density (1.6).

TABLE 9.
Mean annual soil loss for the farm dams

Farm Dam Name	Catchment Area (hectares)	A (mean annual soil loss) (ton/ha/year)	A (mean annual soil loss) (ton/year)	Sediment Density	A (mean annual soil loss) (m^3/year)	Volume of sediment for T=50 years (m^3)
Chaluk	199	1.04	206/96	1.6	114.97	6467.5
Zurgazraw	397	1.04	412.88	1.6	229.37	12900

4.2 FARM DAMS AREA - VOLUME CAPACITY TABLES

Based on contour maps of 1m contour interval (H) prepared for both surveyed farm dams, the volume between two successive contours has been calculated using the cone formula (Equation 17) based on the area of top counter (A_1) and the area of the bottom counter (A_2). Repeating these calculations for all counter intervals, the storage capacity table for each farm dams has been prepared as shown in Table (9).

$$V = \left(\frac{H}{3}\right) * (A_1 + A_2 + \sqrt{A_1 + A_2 + A_1 A_2}\,) \ \ldots\ldots\ldots \ (17)$$

Based on the sediment volume calculations, Table (10) has been prepared to determine the elevations and the storage capacity for the proposed farm dams. The elevation and volume of the dead storage were fixed as 411 m.a.s.l., and 7741 m^3 for Chaluk, and 404 m.a.s.l., and 20863 m^3 for Zurgazraw farm dams, respectively. The normal water storage (spillway crest) and Embankment crest elevations were fixed at 418, and 420 m.a.s.l. for Chaluk, and 412, and 414 m.a.s.l. for Zurgazraw farm dams respectively. The live storage volume was calculated to be equal to 103425 m^3 for Chaluk, and 293822 m^3 for Zurgazraw farm dams respectively.

TABLE 10.
Farm Dams Elevation, Storage Capacity Calculation

Contour (m)	Area (m^2)	Volume (m^3)	Accumulative Volume (m^3)	Contour (m)	Area (m^2)	Volume (m^3)	Accumulative Volume (m^3)
407	123	41	41	401	1660	553	553
408	612	337	378	402	5224	3276	3829
409	1616	1074	1452	403	8498	6795	10625
410	3122	2328	3780	404	12084	10239	20863
411	4864	3961	7741	405	16449	14211	35074
412	6986	5893	13634	406	21227	18787	53862
413	9483	8203	21836	407	27363	24230	78092
414	12074	10753	32589	408	35149	31175	109267
415	15258	13635	46224	409	43363	39184	148451
416	19251	17216	63440	410	51450	47349	195800
417	23930	21548	84988	411	59287	55322	251123
418	28493	26178	111166	412	67936	63563	314685
419				413	67936	67936	382621
420				414			
Chaluk Farm Dam Elevation, Storage Capacity Table				Zurgazraw Farm Dam Elevation, Storage Capacity Table			

Based on the sediment volume calculations, Table (11) has been prepared to determine the elevations and the storage capacity for the proposed farm dams.

The elevation and volume of the dead storage were fixed as 411 m.a.s.l., and 7741 m^3 for Chaluk, and 404 m.a.s.l., and 20863 m^3 for Zurgazraw farm dams, respectively. The normal water storage (spillway crest) and Embankment crest elevations were fixed at 418, and 420 m.a.s.l. for Chaluk, and 412, and 414 m.a.s.l. for Zurgazraw farm dams respectively. The live storage volume was calculated to be equal to 103425 m^3 for Chaluk, and 293822 m^3 for Zurgazraw farm dams respectively.

TABLE 11.
Storages and Levels of Proposed Farm Dams

Item	Chaluk Farm Dam	Zurgazraw Farm Dam
Dead Storage Level (m.a.s.l)	411	404
Dead Storage Volume (m^3)	7,741	20,863
Dead Storage Flooded area (m^2)	4,864	12,084
Live Storage (Spillway Crest) Level (m.a.s.l)	418	412
Live Storage Volume (m^3)	103,425	293,822
Live Storage Flooded area (m^2)	28,493	67,936
Total Volume (m^3)	111,166	314,685
Embankment Bed level at the center line (m.a.s.l)	407	401
Embankment crest level (m.a.s.l)	420	414
Embankment height (m)	13	13

5. CONCLUSIONS

The purpose of Construction of the Chaluk and Zurgazraw proposed farm dams will be for supplemental irrigation, and livestock watering. The catchment area of the proposed Chaluk and Zurgazraw farm dams have been calculated by arc GIS software are, equal to 1.99, and 3.97 km^2, respectively. Based on the topographic study of the sites, the capacity of the reservoir for different heights of the farm dams' embankment determined.

The daily, monthly and annual runoff depth and volume have been calculated based on SCS equation for the farm dams' catchment areas using recorded daily rainfall depth in Erbil metrological station for the period from 1992-2011. The minimum, maximum, and average annual runoff volume have been found to be equal to 16556, 233407, and 103957 m^3 for Chaluk farm dam, and 33030, 465641, and 207393 m^3 for Zurgazraw farm dam, respectively.

The Peak (flood) discharges for the farm dams' catchment areas have been determined (using ARR method) based on the recorded maximum (24hr) rainfall depth in Erbil metrological station for the period from 1975-2011, which were found to be equal to 14.71, and 24.07 m^3/sec for the Chaluk and Zurgazraw farm dams, respectively.

The elevations of embankment crest were fixed at 420, and 414 m.a.s.l., and the normal water level at 418, and 412 m.a.s.l. for Chaluk and Zurgazraw farm dams, respectively. Based on the calculated sediment accumulation volume in the farm dams for 50 years return period, the dead storage elevation was fixed at 411, and 404 m.a.s.l., these elevations resulting a dead storage volume of 7741, and 12084 m^3, and live storage capacity equal to 103425, and 293822 m^3 for Chaluk and Zurgazraw farm dams, respectively.

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