ANNEX III

Hydrological Designing for Control Structure in MOJA-Golestan

HYDROLOGICAL DESIGNING FOR CONTROL STRUCTURES IN MOJA-GOLESTAN

1. ISSUES TO BE ADDRESSED

A series of disastrous floods, occurred in the year 2001, 2002 and 2005, has attacked human societies along the river systems in the Golestan province. Not only human beings and livestocks but also various kinds of infrastructures were severely damaged during these floods. Furthermore flood and sediment control structures constructed by MOJA, such as sediment control dams and flood control dams, were severely damaged as well.

Improper hydrological designing process for determination of flood discharges and hydrographs could be pointed out as one of the reasons behind the damages, due to insufficient hydrological data. As a result, floodwater overtopped over the spillway due to insufficient reservoir capacity to store the excessive flood inflow, and further flood peak overflowed over the earth dam body due to insufficient spillway capacity. These disastrous events occurred in the 2001 and 2005 floods revealed the following issues to be addressed for elaboration of the design process.

- Tangrah station under MET-Golestan has only observed hourly rainfall data during the 2005 flood in the basin. The station observed an intensive rainfall of 80 mm/hr for one hour in the flood time. Such amount of rainfall intensity extremely exceeds 100-year return period in comparison with the MOJA-Golestan design standards shown in Table 1.

Table 1 Rainfall Intensity Curves for Structural Designing in MOJA-Golestan

Rainfall Duration (hour)	Return Period (year)					
	2	5	10	25	50	100
1	10.39	17.60	22.43	28.47	32.90	37.26
2	5.96	9.49	11.79	14.63	16.68	18.69
3	4.10	6.54	8.14	10.10	11.52	12.91
6	2.37	3.98	5.06	6.40	7.38	8.35
7.6	2.09	3.51	4.46	5.65	6.51	7.37
12	1.30	2.20	2.81	3.57	4.13	4.68
24	0.69	1.10	1.38	1.73	1.99	2.24

unit: mm/hour

- In addition, Gorgan station under MET-Golestan (IRIMO) can provide the most reliable and longest rainfall records in the Golestan Province. However, the rainfall intensity curve of Gorgan station as presented in the table below also shows quite small amount of probable rainfall similar to the value presented in Table 1, because of topographic differences between both stations of Gorgan and Tangrah. Gorgan is located in the Gorgan Plain, while Tangrah is located in the foot of mountain slope of the Golestan Forest.

Table 2 Rainfall Intensity Curve at Gorgan Station (IRIMO)

Rainfall Duration (Hour)	Return Period (year)		Rainfall Duration (Hour)	Return Period (year)	
	20	100		20	100
1	28.08	34.33	6	10.12	12.49
2	18.65	22.77	7	8.81	10.76
3	15.10	18.47	8	7.80	9.45
4	13.51	16.82	9	6.97	8.40
5	11.66	14.52			

unit: mm/hour

- Based on the result of quick review on the gaps between existing rainfall intensity curves and actual heavy downpour occurred in the current floods, the design rainfall intensity curves (Table 1) shall be reestablished in near future through restudying newly observed hourly data. However, accumulation of reliable records is time-taking process. Thus some modification for urgent use shall be temporarily necessary bridging to the future complete establishment of the rainfall intensity curves.

2. FUTURE DIRECTION

The rainfall distribution in the region obviously has the following patterns (refer to Fig. 1 showing the daily rainfall distribution of the 2001 Flood, on 11 August as an example):

(1) In the wide floodplain area along the Gorgan River it has moderate rainfall intensity. This area, however, can be excluded for the target area since MOJA has no responsibility for sediment and flood control.

(2) In the hilly area located between the floodplain and the mountain slope, the rainfall intensity is also in-between.

(3) In the northern mountain slope, it receives the most intensive orographic rainfall since high moist air is transported over the Caspian Sea from the north.

(4) Beyond the mountain area, some wide inland area with relatively mild slope extends, and this area receives much smaller rainfall than the other areas.

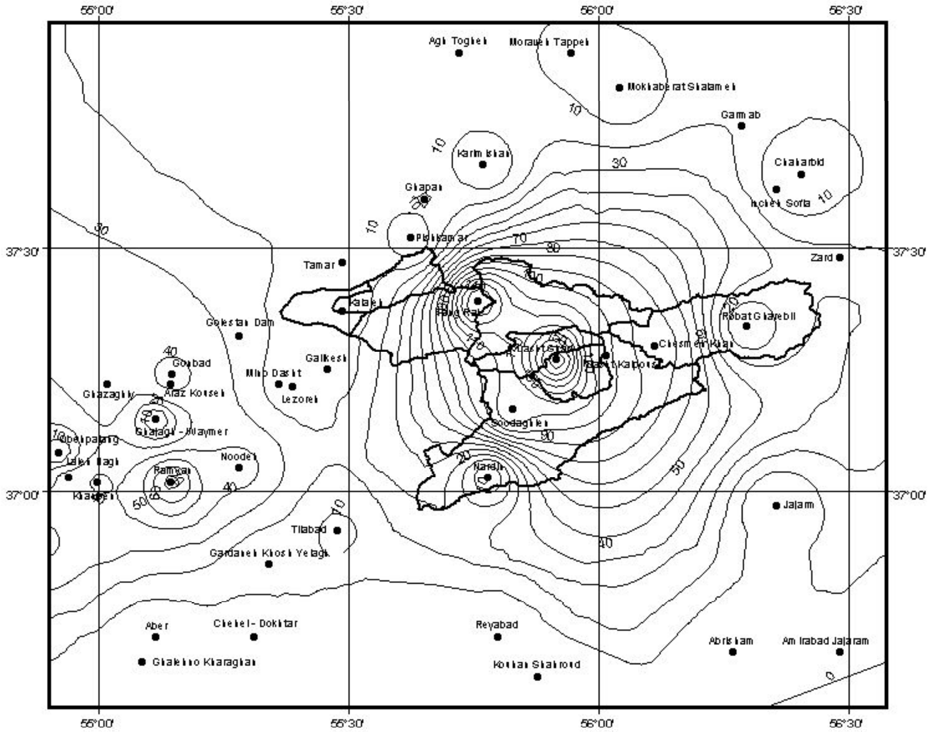


Fig. 1 Rainfall Isohyets (11 August 2001)

The above situation is common precipitation patterns along the Caspian coastal areas. Considering the Madarsoo River basin as a typical basin for development of improved hydrological designing process, the representative rainfall stations shall be designated or newly installed at the following three or four locations (see Fig. 2 simultaneously):

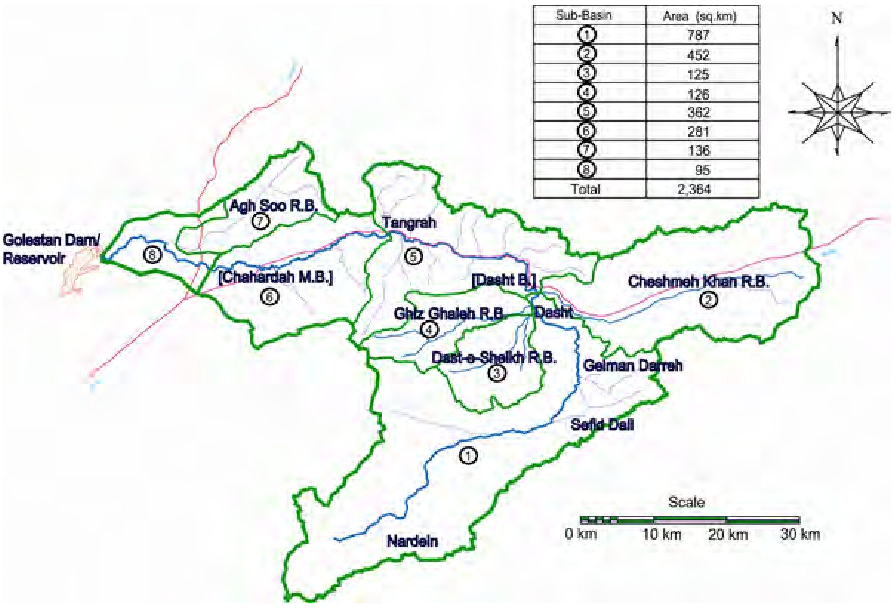


Fig. 2 Sub-basin of the Madarsoo River

(1) To represent rainfall in the hilly area being adjacent to the Gorgan Plain, sub-basins 6 and 7 in Fig. 2, the rainfall recorder shall be newly installed in some village on the hill slope because of no existing rainfall recorders. New Besholly village might be a suitable site for installation.

(2) To represent rainfall in the mountain slope area, sub-basins 4 and 5 in Fig. 2, Tangrah and Dasht Shad shall be selected because of suitable location and existence of rainfall recorders.

(3) To represent rainfall in the inland basin, sub-basins 1, 2 and 3 in Fig. 2, the rainfall recorder shall be newly installed in some villages in the Gelman Darreh basin in parallel with flood forecasting purposes. Nardin village might be a suitable site for this purpose.

After installation and data recording for some significant years, the intensity-duration-frequency (IDF) analysis shall be made using the observed rainfall records. Even if IDF curves are established, the periodical review using latest records shall be necessary. Thus establishment of the IDF curves is a time consuming process.

3. TEMPORARY APPROACH

For the time being, some practical estimation of design rainfall is proposed hereunder, utilizing the existing data collected in the JICA study. The methodology taken for the practical estimation is summarized in the following flowchart.

Probability analysis is made using sub-basin rainfall that is computed in the JICA study.

↓

Compared the computed probable 2-day rainfall to the 24-hour probable rainfall in the MOJA- Golestan standard, multipliers (f) are estimated by sub-basin and design probability.

↓

The results summarized in the practical table for easy usage.

(1) Computation of Sub-basin Probable Rainfall

Using sub-basin 2-day rainfall, probability analysis was made to check the suitable probability function of which curve fitted best to the observed values, and to compute the sub-basin probable rainfall based on the best fitted probability functions. The results are illustrated in Fig. 3 at the end of the paper, and are summarized in the following table.

Table 3 Probable 2-day Rainfall in Sub-basin of the Madarsoo River

Return Period (year)	Sub-Basin					
	Downstream Hilly Area	Golestan Forest	Ghyz Galeh	Dasht-e-Sheik	Cheshmeh Khan	Gelman Darreh
2	35.3	41.8	40.8	20.7	11.3	26.9
3	46.1	54.0	54.5	28.9	15.7	33.8
5	59.7	69.2	71.7	40.1	21.0	42.4
10	78.1	90.5	96.1	58.0	28.3	54.3
20	96.5	113.2	122.3	80.2	36.0	67.0
25	101.9	120.3	130.5	88.0	38.4	70.9
50	120.9	145.9	160.3	118.7	47.0	85.0
80	133.4	164.0	181.4	143.7	53.1	95.0
100	139.3	172.9	191.7	157.1	56.2	99.9
250	150.1	189.5	211.2	184.3	61.9	109.0
200	157.7	201.7	225.5	206.0	66.1	115.7
P.D.C	EXP	SQRTET	SQRTET	GEV	GEV	SQRTET

unit: mm
P.D.C: Probable Distribution Curve, EXP: Exponential, SQRTET: Square-Root Exponential Type,
GEV: Generalized Extreme Value.

(2) Preparation of Multipliers

For each sub-basin and each probability, probable 2 day rainfalls shown in Table 3 are compared to the 24-hour rainfalls shown in Table 1. Multiplier f is estimated as shown in Table 4. Table 4 also shows one-hour probable rainfall after multiplying by the multiplier for reference. Table 4 implies that the design rainfall intensity from the present standard of MOJA-Golestan is too much smaller than the actual rainfall experienced in the recent years, in some disaster-prone areas such as Golestan Forest area and Ghyz Ghaleh River basin.

Table 4 Multipliers for Area-wise Design Rainfall Computation

Return Period		Downstream Hills	Golestan Forest	Ghyz Galeh	Dasht-e-Sheik	Chesmeh Khan	Gelman Darreh
100-year	Multiplier	2.59	3.22	3.57	2.92	1.05	1.86
	R one-hour (mm/hr)	96.5	119.8	132.9	108.9	39.0	69.2
50-year	Multiplier	2.53	3.05	3.36	2.49	0.98	1.78
	R one-hour (mm/hr)	83.3	100.5	110.4	81.8	32.4	58.6
25-year	Multiplier	2.45	2.90	3.14	2.12	0.92	1.71
	R one-hour (mm/hr)	69.9	82.5	89.5	60.3	26.3	48.6
10-year	Multiplier	2.36	2.73	2.90	1.75	0.85	1.64
	R one-hour (mm/hr)	52.9	61.3	65.1	39.3	19.2	36.8
5-year	Multiplier	2.26	2.62	2.72	1.52	0.80	1.61
	R one-hour (mm/hr)	39.8	46.1	47.8	26.7	14.0	28.3
2-year	Multiplier	2.13	2.52	2.46	1.25	0.68	1.62
	R one-hour (mm/hr)	22.1	26.2	25.6	13.0	7.1	16.9

It is recommended to take the following procedure for estimation of design rainfall intensity.

(1) At first, rainfall intensity (r) is estimated using the present standard.

(2) The multiplier (f) is selected from Table 4 considering area located and design scale.

(3) Design rainfall intensity (rd) is estimated multiplying r by f.

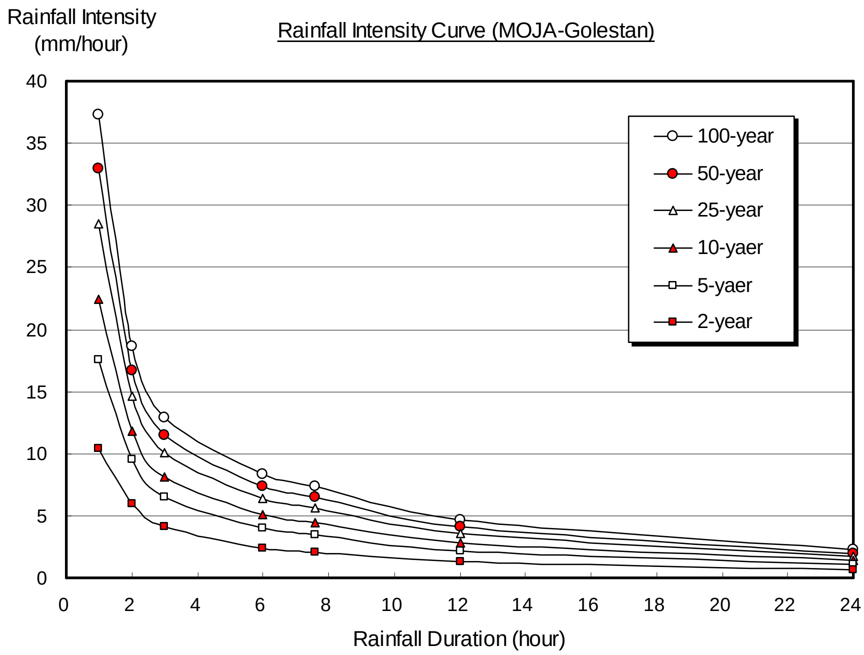


Fig. 4 Rainfall Intensity Curve in MOJA-Golestan Standard

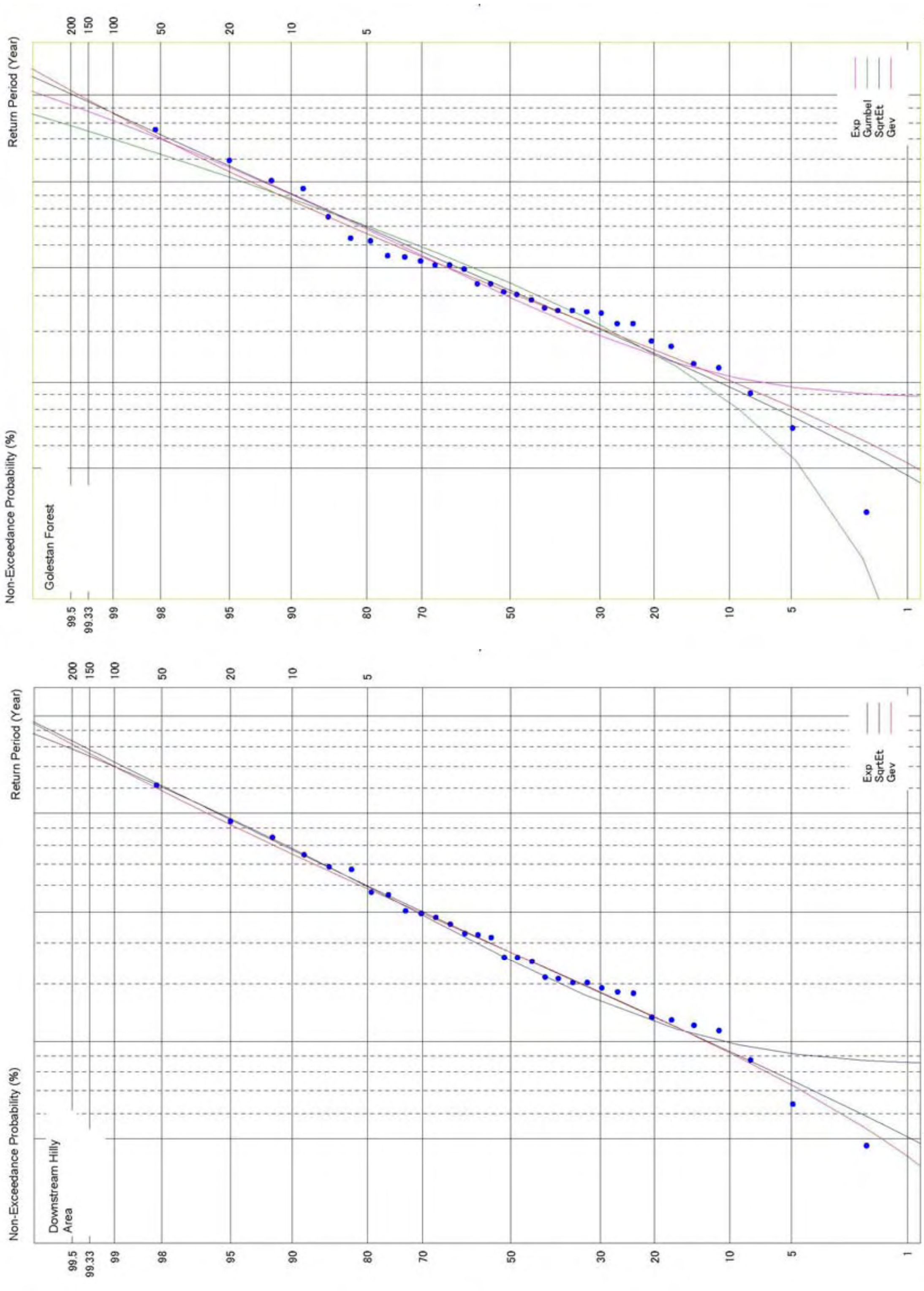


Fig. 3 (1/3) Probability Curves and Observed Rainfall in Downstream Hilly Area and Golestan Forest Area

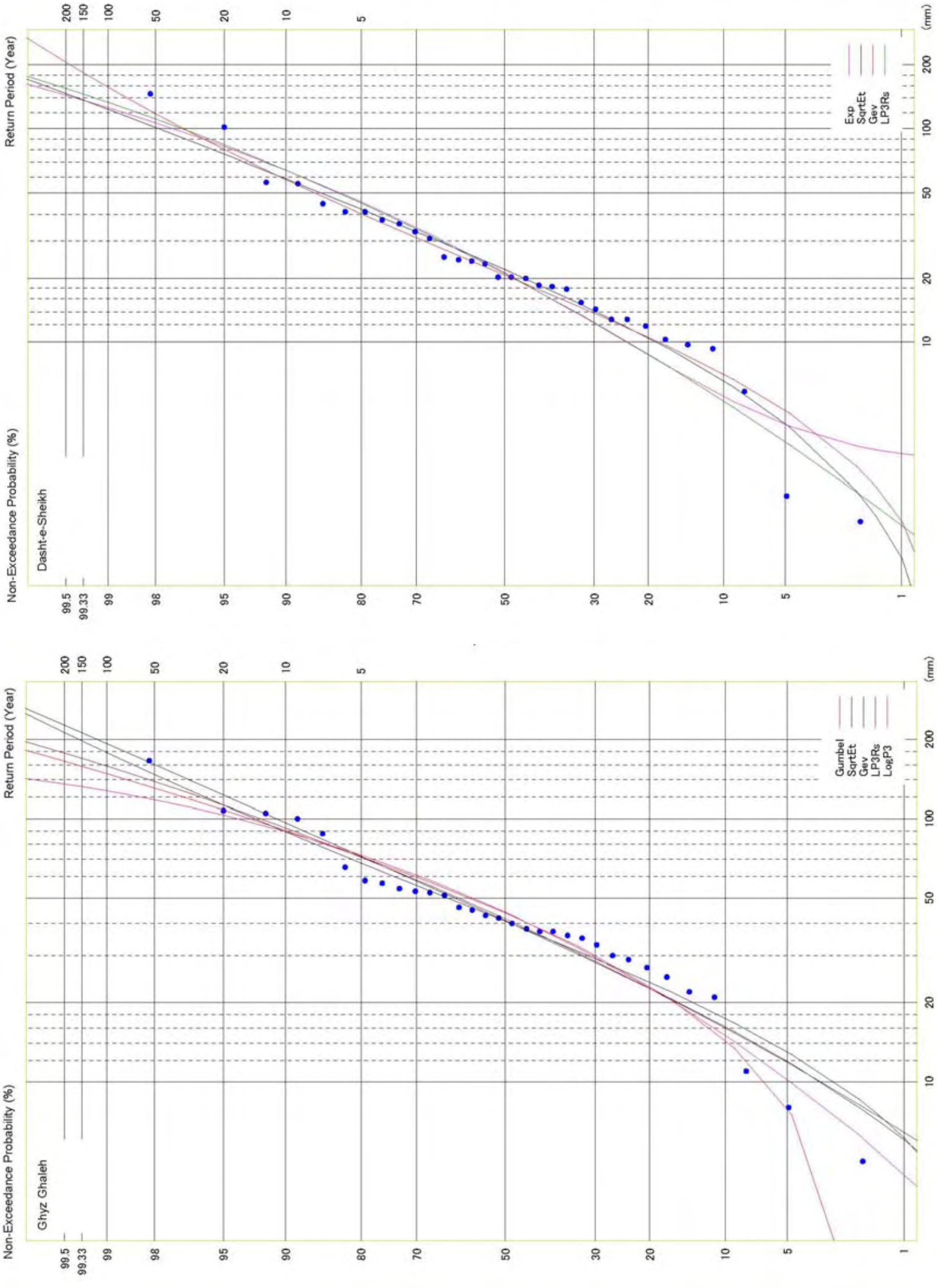
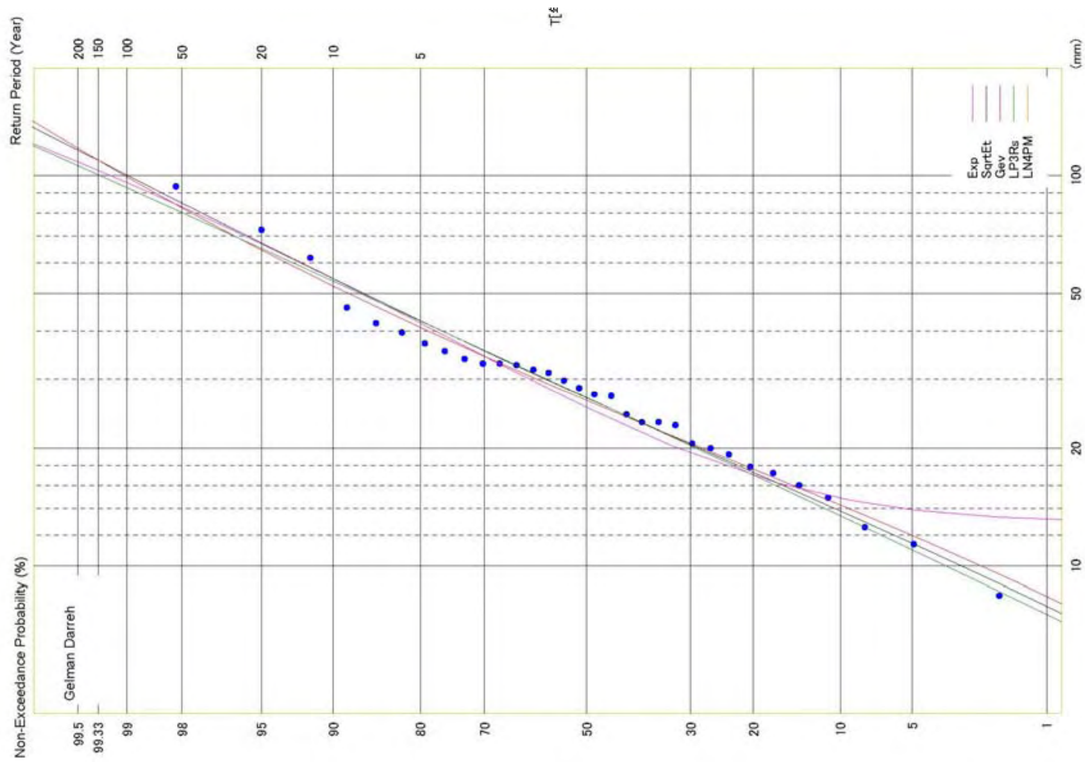


Fig. 3 (2/3) Probability Curves and Observed Rainfall in Ghyz Ghaleh and Dasht-e-Sheikh Basins



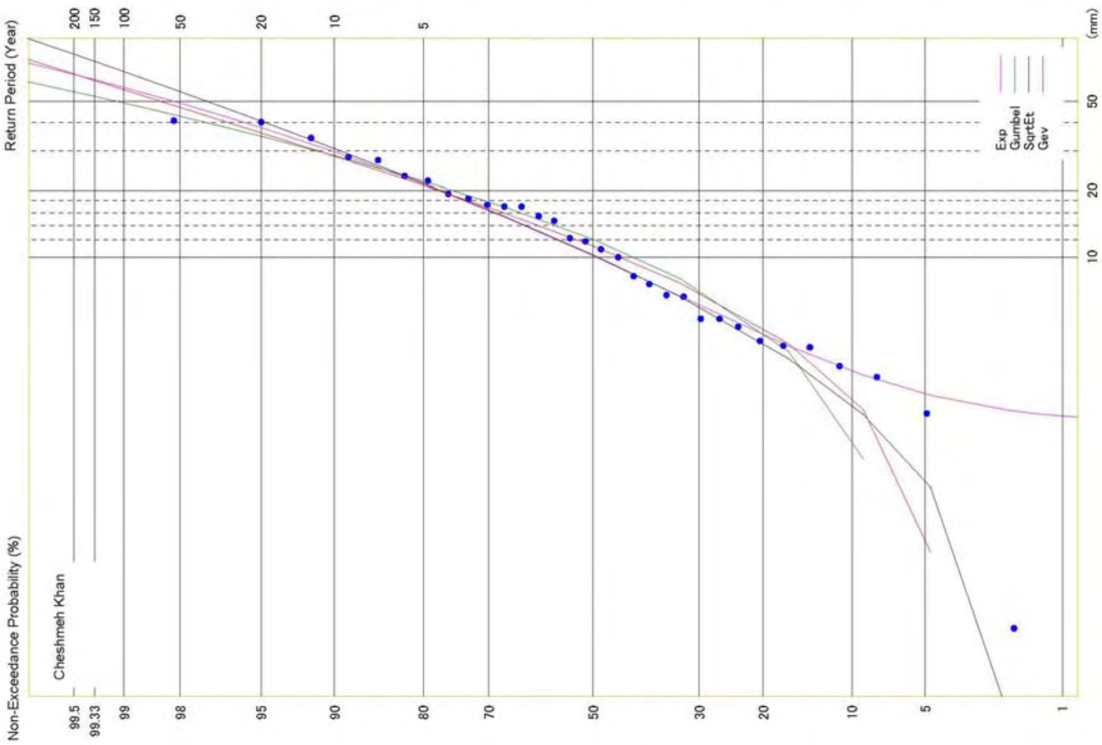


Fig. 3 (3/3) Probability Curves and Observed Rainfall in Cheshmeh Khan and Gelman Darreh Basins

ANNEX IV

Hydrological Study on Dam Planning in the Gelman Darreh

HYDROLOGICAL STUDY ON DAM PLANNING IN THE GELMAN DARREH

1 INTRODUCTION

A dam has been incorporated in Gelman Dareh River basin at 56°05’00’’ E and 37°16’28’’ N location to assess impact of the dam on flood regulation on downstream parts of Madarsoo River. The floodwater is fully controlled by the dam to see the impact of the dam on peak flows reduction at downstream parts of Madarsoo River. For this, MIKE SHE model is coupled with MIKE 11 river modeling system to simulate flows in the river system.

2 PROBABLE RIVER-FLOWS WITH WATERSHED MANAGEMENT PROJECTS

Peak flows, with planned watershed management project in basin, generated by the model in river system for 25 year return period with 2005 flood type rainfalls are: 92 m^3/s in Gelman Dareh at upper part; 373 m^3/s in Gelman Dareh at middle part; 430 m^3/s in Gelman Dareh at Dasht; 85 m^3/s in the Dasht-e-Sheikh; 157 m^3/s in the Ghyz Ghale; and in the Madarsoo 651 m^3/s at location prior to confluence with Chesmeh Khan; 696 m^3/s at Dasht Bridge; 1,003 m^3/s at Tangrah; 1,089 m^3/s at Dar Abad; and 1,060 m^3/s at Golestan Dam (Fig. 1).

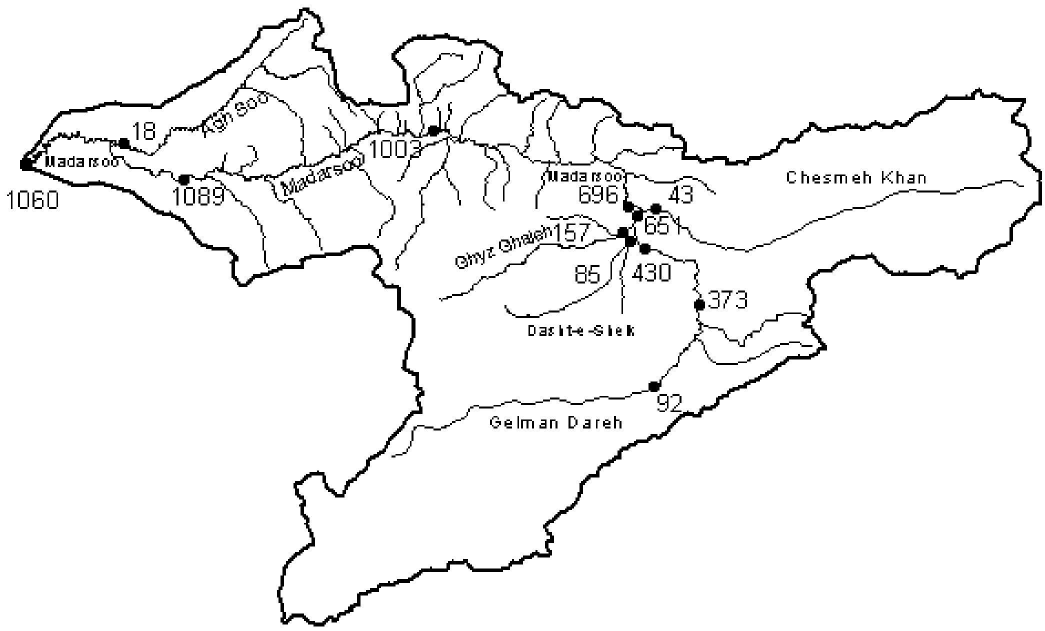


Fig. 1 Probable Peak Flows in River System with Watershed Management Project (25-year return period; 2005 flood type)

Similarly, peak flows, with planned watershed management project in basin, generated by the model in river system for 50 year return period with 2005 flood type rainfalls are: 133 m^3/s in Gelman Dareh at Upper part; 520 m^3/s in Gelman Dareh at Middle part; 607 m^3/s in Gelman Dareh at Dasht; 119 m^3/s in the Dasht-e-Sheikh; 215 m^3/s in the Ghyz Ghale; and in the Madarsoo 921 m^3/s at location prior to confluence with Chesmeh Khan; 1,006 m^3/s at Dasht Bridge; 1,430 m^3/s at Tangrah; 1,554 m^3/s at Dar Abad; and 1,509 m^3/s at Golestan Dam (Fig. 2).

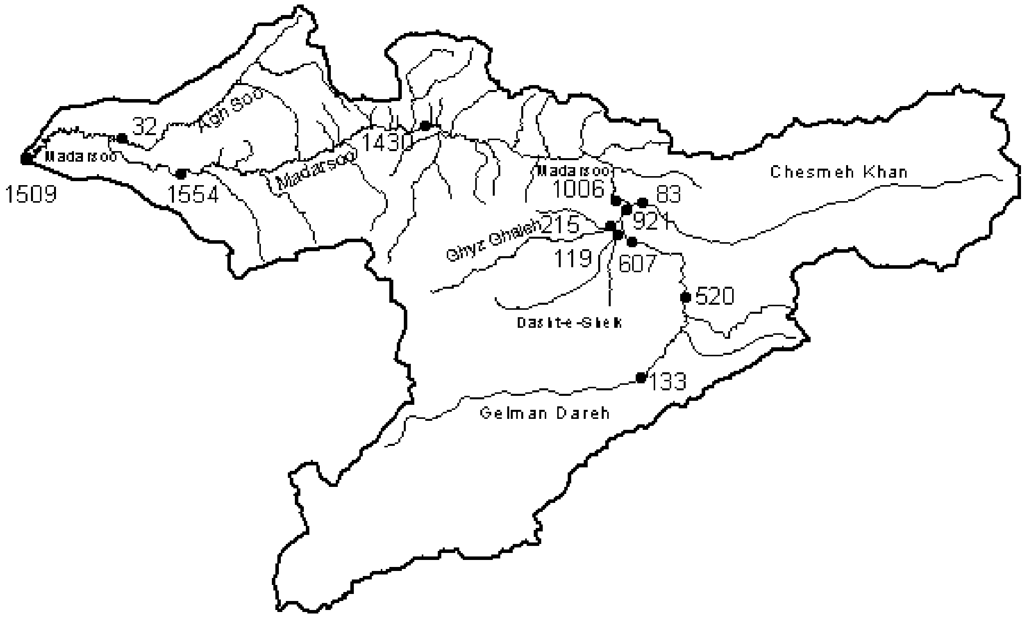


Fig. 2 Probable Peak Flows in River System with Watershed Management Project (50-year return period; 2005 flood type)

3 DAM IMPACT ASSESSMENT (WITH 50-YEAR PROVABLE FLOOD)

Further, peak flows, with planned watershed management project in basin and flood water full control dam in Gelman Dareh River, generated by the model in river system for 50-year return period with 2005 flood type rainfalls are: 133 m^3/s in Gelman Dareh at Upper part; 520 m^3/s in Gelman Dareh at Middle part; 80 m^3/s in Gelman Dareh at Dasht; 119 m^3/s in the Dasht-e-Sheikh; 215 m^3/s in the Ghyz Ghale; and in the Madarsoo 423 m^3/s at location prior to confluence with Chesmeh Khan; 507 m^3/s at Dasht Bridge; 970 m^3/s at Tangrah; 1,117 m^3/s at Dar Abad; and 1,111 m^3/s at Golestan Dam (Fig. 3).

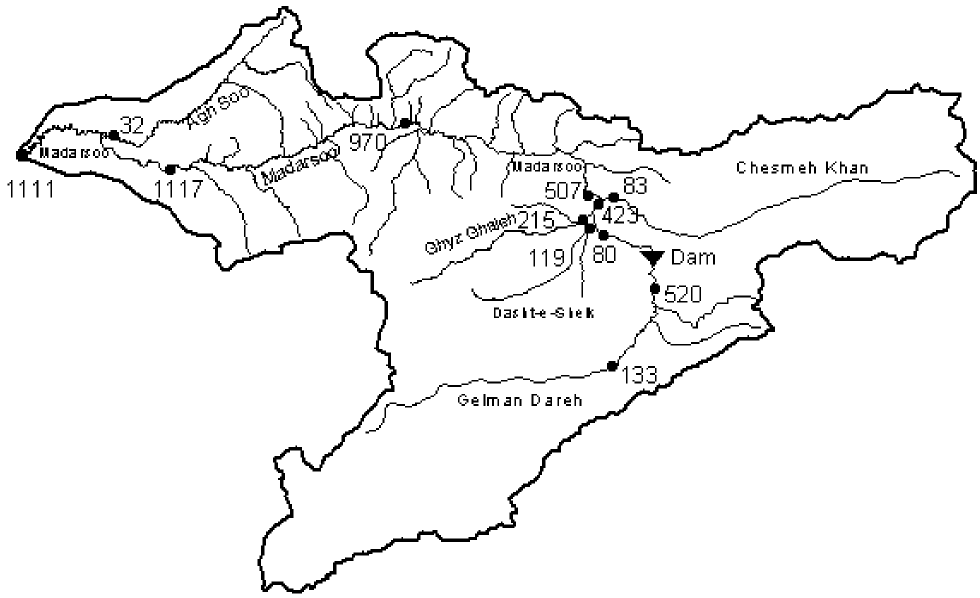


Fig. 3 Probable Peak Flows in River System with Watershed Management Project and Dam in Gelman Dareh River (50-year return period; 2005 flood type)

Results show if the dam is constructed in Gelaman Dareh River and floodwater is fully controlled then peak flows of 50-year provable flood can be reduced to level of 25-year provable flood. Simulated peak flows in Madarsoo River for 25-year provable flood with watershed management project are: 1,003 m^3/s at Tangrah; 1,089 m^3/s at Dar Abad; and 1,060 m^3/s at Golestan Dam, while the simulated peak flows in Madarsoo River for 50-year provable flood with watershed management project and a dam (with full control of floodwater) in Gelman Dareh River are: 970 m^3/s at Tangrah; 1,117 m^3/s at Dar Abad; and 1,111 m^3/s at Golestan Dam. These figures are almost similar magnitudes so that it implies the urgent river improvement works for 25-year flood could be upgraded for 50-year safety level after construction of the Gelman Dareh Dam.

Flood Hydrographs

As a reference for dam impact assessment, flood hygrographs of Madarsoo River at Tangrah, Dar Abad and Golestan Dam are presented considering scenarios of: (1) 25-year flood with watershed management project, (2) 50-year flood with watershed management project, and (3) 50-year flood with watershed management project and full controlled dam in Gelman Dareh River (Figs. 4 to 6). As mentioned above, if the dam is constructed in Gelman Dareh River and flood water is fully controlled by the dam then peak flows of 50-year flood can be reduced to level of 25-year flood which is clearly presented in flood hydrographs.

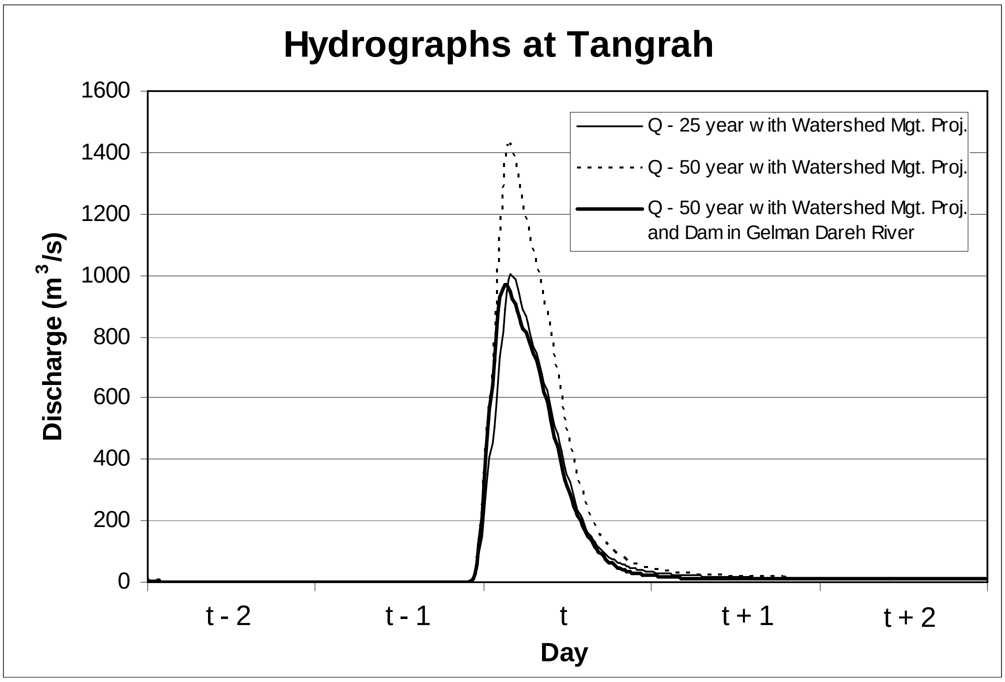


Fig. 4 Flood Hydrographs of Madarsoo River at Tangrah (2005 flood type)

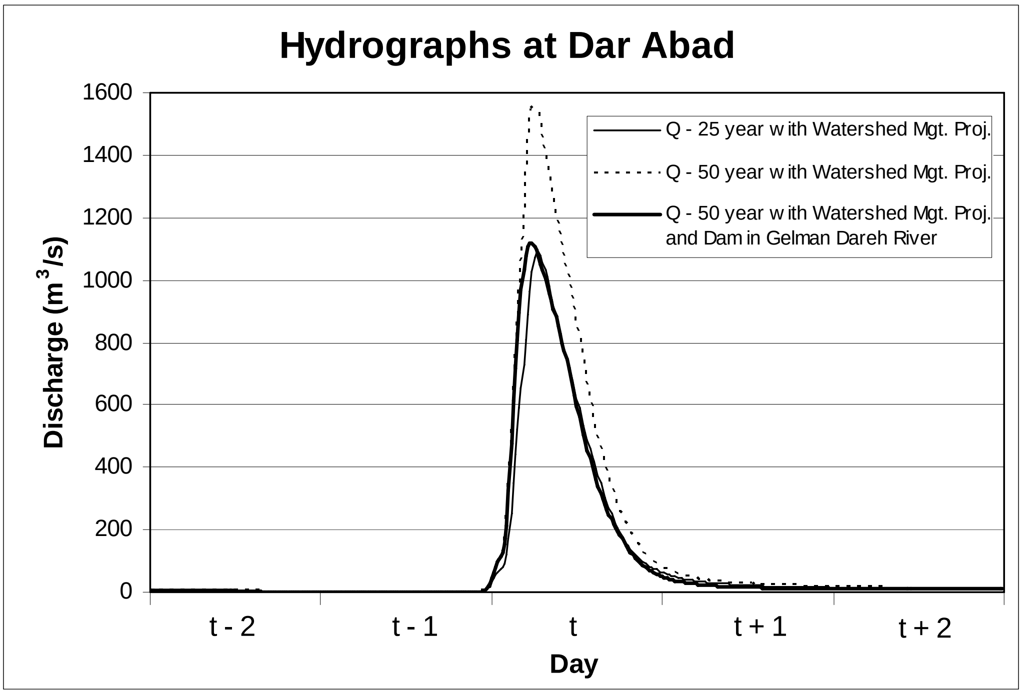


Fig. 5 Flood Hydrographs of Madarsoo River at Dar Abad (2005 flood type)

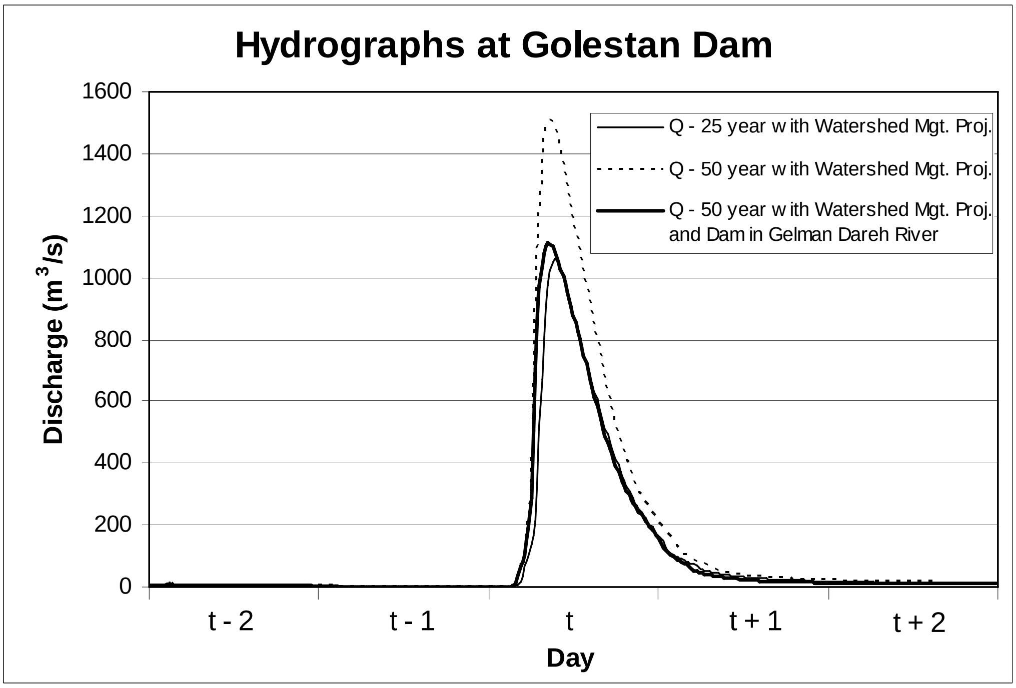


Fig. 6 Flood Hydrographs of Madarsoo River at Golestan Dam (2005 flood type)

Dam Reservoir Storage Potential

Expected maximum water level in dam reservoir, while 50-year provable flood is fully controlled by the dam, is simulated. The maximum water level in dam reservoir is expected to reach up to 1,102.4 m; at this water level corresponding water depth in the reservoir will be 29.6 m (Fig. 7). Further, floodwater storage potential of the dam reservoir is also investigated. The water depth and corresponding storage volume relationship (H – V Curve) of the dam reservoir is developed (Fig. 8). The maximum floodwater storage volume will be about 15,000,000 m^3 when water depth in the reservoir reaches to 29.6 m.

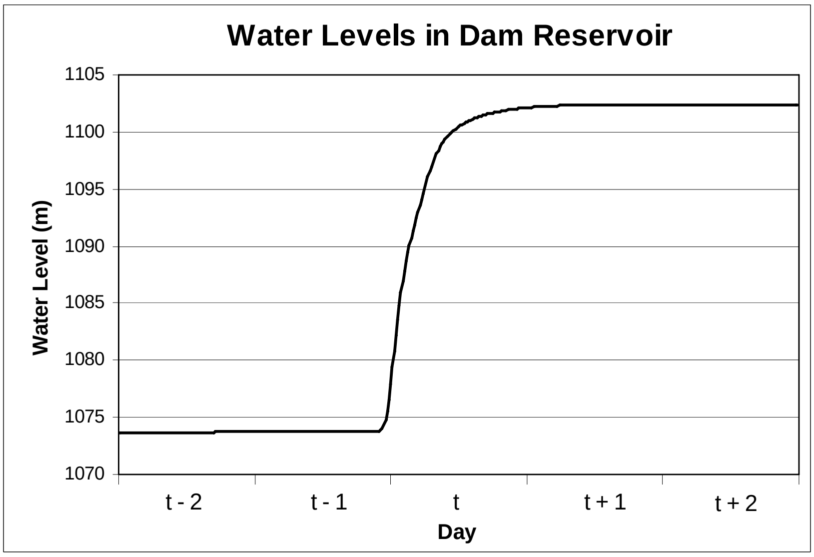


Fig. 7 Expected Water Levels in Dam Reservoir (50-year return period; 2005 flood type)

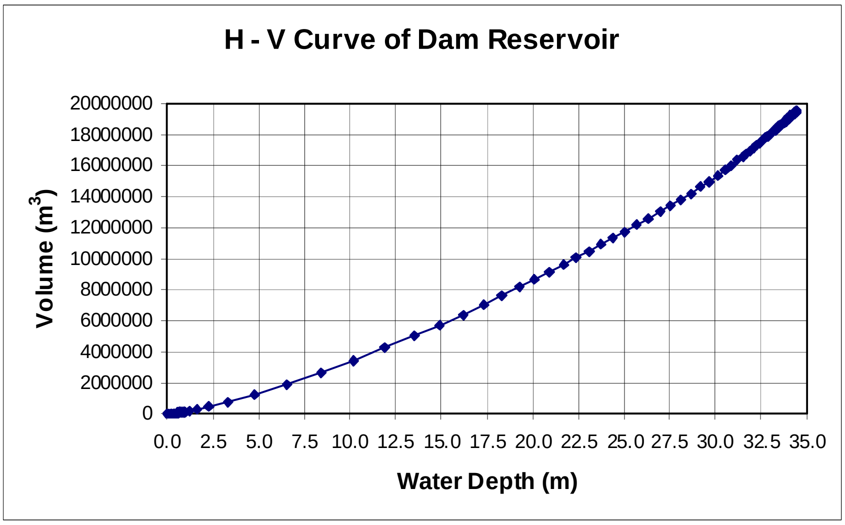


Fig. 8 H – V Curve of Dam Reservoir

4 DAM IMPACT ASSESSMENT (WITH 100-YEAR PROVABLE FLOOD)

Flood peak flows, with planned watershed management project in basin and floodwater full control dam in Gelman Dareh River, generated by the model in river system for 100-year return period with 2005 flood type rainfalls are: 180 m^3/s in Gelman Dareh at Upper part; 670 m^3/s in Gelman Dareh at Middle part; 103 m^3/s in Gelman Dareh at Dasht; 151 m^3/s in the Dasht-e-Sheikh; 278 m^3/s in the Ghyz Ghale; and in the Madarsoo 556 m^3/s at location prior to confluence with Chesmeh Khan; 679 m^3/s at Dasht Bridge; 1,278 m^3/s at Tangrah; 1,461 m^3/s at Dar Abad; and 1,458 m^3/s at Golestan Dam (Fig. 9).

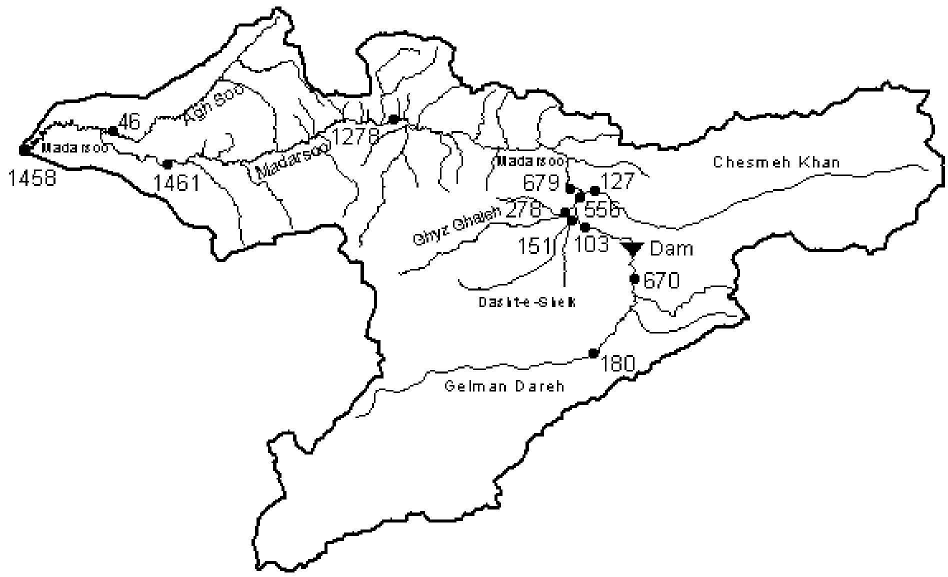


Fig. 9 Probable Peak Flows in River System with Watershed Management Project and Dam in Gelman Dareh River (100-year return period; 2005 flood type)

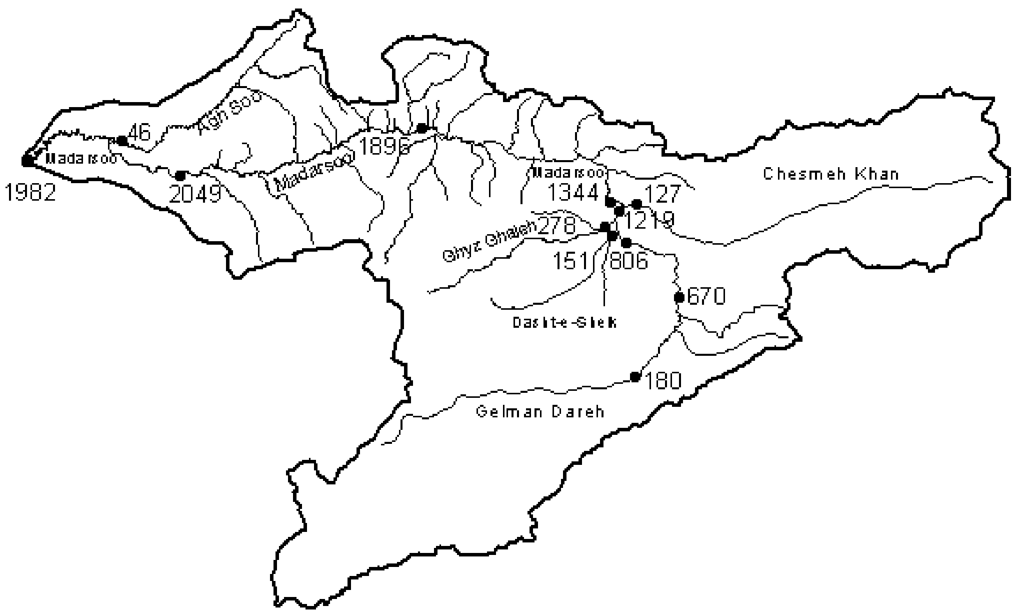


Fig. 10 Probable Peak Flows in River System with Watershed Management Project (100-year return period; 2005 flood type)

Probable peak flows, considering watershed management project and 100-year return period, with 2005 flood type rainfall are presented in Fig. 10. Results show if the dam is constructed in Gelaman Dareh River and floodwater is fully controlled by the dam then peak flows of 100-year flood in Madarsoo River can be reduced by 618 m^3/s at Tangrah; 588 m^3/s at Dar Abad; and 524 m^3/s at Golestan Dam.

Flood Hydrographs

For reference of dam impact assessment, flood hygrographs of Madarsoo River at Tangrah, Dar Abad and Golestan Dam are presented considering scenarios of: (1) 100-year flood with watershed management project, and (2) 100-year flood with watershed management project and full controlled dam in Gelman Dareh River (Figs. 11 to 13). As mentioned above, if the dam is constructed in Gelman Dareh River and flood water is fully controlled by the dam then peak flows of 100-year flood can be reduced by 520 – 620 m^3/s at downstream parts of Madarsoo River which is clearly presented in flood hydrographs.

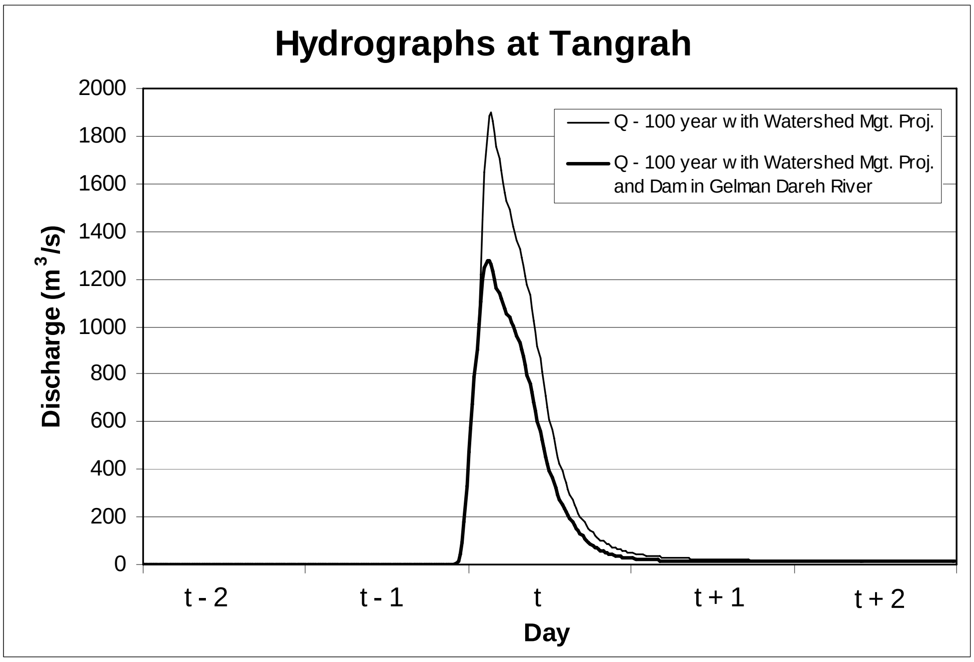


Fig. 11 Flood Hydrographs of Madarsoo River at Tangrah (2005 flood type)

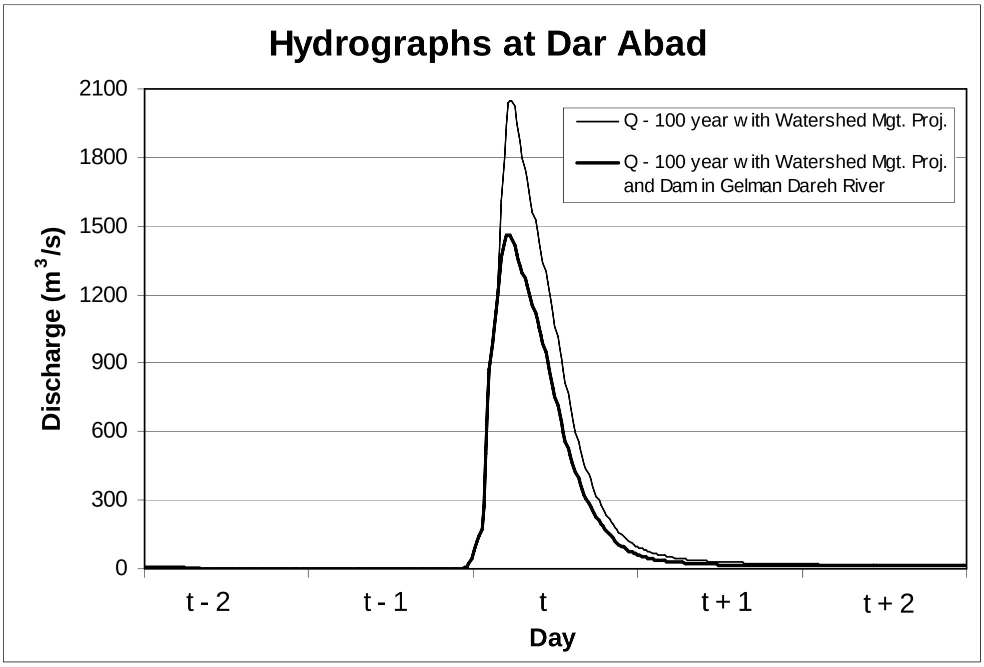


Fig. 12 Flood Hydrographs of Madarsoo River at Dar Abad (2005 flood type)

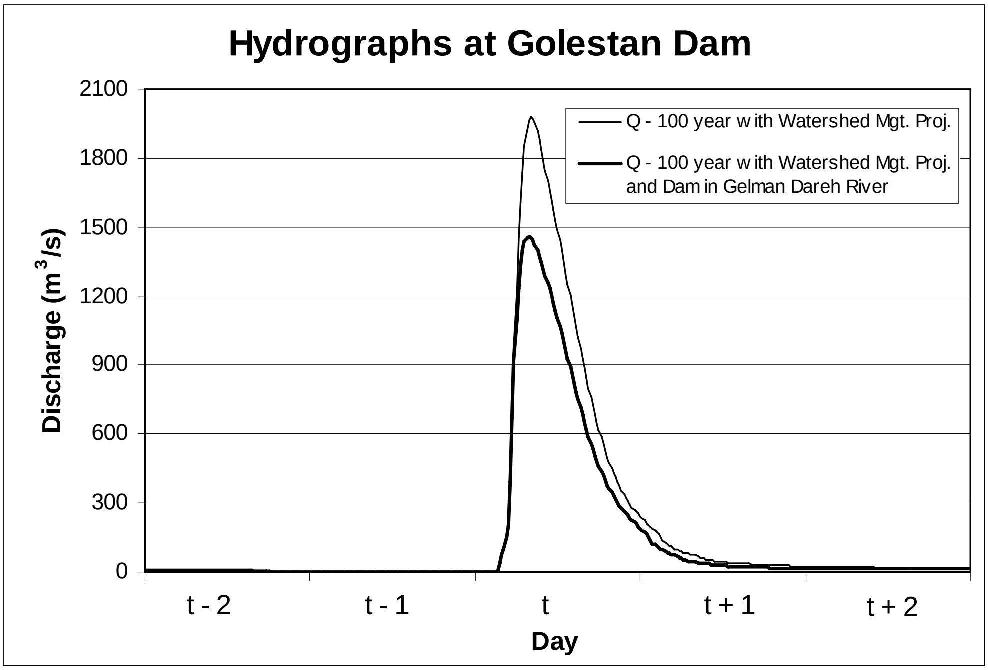


Fig. 13 Flood Hydrographs of Madarsoo River at Golestan Dam (2005 flood type)

<u>Dam Reservoir Storage Potential</u>

Expected maximum water level in dam reservoir, while 100-year flood is fully controlled by the dam, is simulated. The maximum water level in dam reservoir is expected to reach up to 1,107.3 m; at this water level corresponding water depth in the reservoir will be 34.4 m (Fig. 14). Moreover, floodwater storage potential of the dam reservoir is also investigated. The stage-volume relationship (H-V Curve) of the dam reservoir is referred to Fig. 8. The maximum floodwater storage volume will be about 19,500,000 m^3 when water depth in the reservoir reaches to 34.4 m.

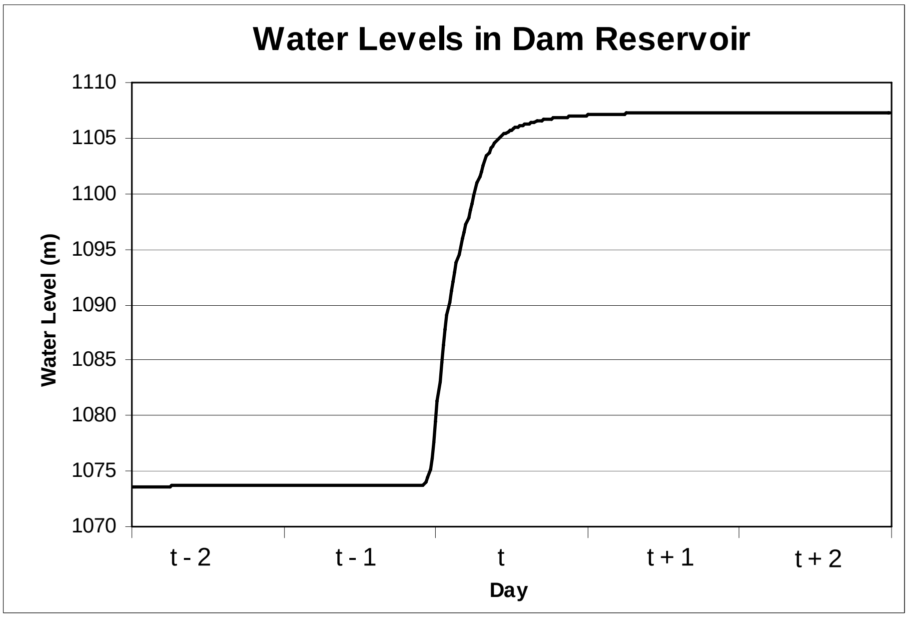


Fig. 14 Expected Water Levels in Dam Reservoir (100-year return period; 2005 flood type)

5 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are drawn throughout the hydrological modeling and simulation regarding dam planning in the Gelman Darreh.

The magnitude and severity of 50-year probable flood can be reduced to the level of 25-year return period if dam is constructed over Gelman Darreh River and floodwater is fully controlled by the dam. However, it should be noted that even 25-year flood can cause severe damages in the basin. Although detailed studies on feasibility and effectiveness of the dam are necessary for making any conclusion regarding the dam, it takes long time to prepare and accumulate necessary meteo-hydrological observed records and related data.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF JIHAD-E-AGRICULTURE
THE ISLAMIC REPUBLIC OF IRAN

THE STUDY
ON
FLOOD AND DEBRIS FLOW
IN THE CASPIAN COASTAL AREA
FOCUSING ON THE FLOOD-HIT REGION
IN GOLESTAN PROVINCE

FINAL REPORT
VOLUME I
MAIN REPORT II (FEASIBILITY STUDY)

OCTOBER 2006

CTI ENGINEERING INTERNATIONAL CO., LTD.

THE STUDY ON FLOOD AND DEBRIS FLOW IN THE CASPIAN COASTAL AREA FOCUSING ON THE FLOOD-HIT REGION IN GOLESTAN PROVINCE

FINAL REPORT
VOLUME I-2
MAIN REPORT II (FEASIBILITY STUDY)

TABLE OF CONTENTS

ANNEX

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

Organization

DOE	Department of Environment
FFWC	Flood Forecasting and Warning Center
FRW	Forest, Rangeland and Watershed Organization
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
MET	Meteorological Organization
MOJA	Ministry of Jihad-e-Agriculture
MOE	Ministry of Energy
MOHUD	Ministry of Housing and Urban Development
MOI	Ministry of Interior
MORT	Ministry of Roads and Transportations
MPO	Management and Planning Organization
NRGO	Natural Resource General Office
PDMC	Provincial Disaster Management Committee
RCS	Red Crescent Society
UNESCO	United Nations Educational, Scientific and Cultural Organization
WMO	World Meteorological Organization

Technical Terms

ADSL	Asymmetric Digital Subscriber Line
B/C	Benefit - Cost Ratio
BCD	Binary Coded Decimal
CPT	Cone Penetration Test
CSG	Cemented Sand and Gravel
DEM	Digital Elevation Model
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EL	Elevation
FFWS	Flood Forecasting and Warning System
F/S	Feasibility Study
GIS	Geographic Information System
GSM	Global System for Mobile Communication
IEE	Initial Environmental Examination
ISDN	Integrated Service Digital Network
MODEM	Modular-Demodular
NPV	Net Present Value
OCC	Opportunity Cost of Capital
ODA	Official Development Assistance
O/M	Operation and Maintenance

PRA	Participatory Rural Appraisal
PSTN	Public Switched Telephone Networks
RCRI	Radio Communication Regulatory of Iran
SPT	Standard Penetration Test
S/W	Scope of Work
TIN	Triangulated Irregular Network
VAT	Value Added Tax
VES	Vertical Electric Sounding
VHF	Very High Frequency
WLL	Wireless Local Loop

ABBREVIATIONS (MEASUREMENT UNIT)

Length		**Velocity**	
mm	millimeter	m/s	meter per second
cm	centimeter	**Sound Volume**	
m	meter	dB	decibel
km	kilometer	**Electric Power**	
Area		V	volt
m^2	square meter	**Time**	
km^2	square kilometer	sec	second
ha	hectare	min	minute
Volume		hr	hour
m^3	cubic meter	yr	year
l, L	liter	**Currency**	
MCM	million cubic meter	IRR	Iranian Rial
Flow Rate		JPY	Japanese Yen
m^3/s, CMS	cubic meter per second	USD	United States Dollar
Weight		**Others**	
mg	milligram	%	percent
g	gram	℃	degree centigrade
kg	kilogram	10^3	thousand
ton	metric ton	10^6	million
		10^9	billion

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

The Caspian region, a northern part of the Islamic Republic of Iran including provinces of Gillan, Mazandaran and Golestan, has been frequently affected by the disasters of flood and debris flow. In the Madarsoo River basin, which is one of the disaster-affected areas in this region, about 260 people and 60 people were killed due to disasters of flood and debris flow during summer time in 2001 and 2002, respectively. Furthermore, thousands of livestock were lost and a lot of infrastructures, such as bridges and roads, were washed out or destroyed.

The Madarsoo River basin is located in the Golestan, North Khorasan and Semnan Provinces. It originates in the north side (the Caspian Sea side) of the Alborz Mountains running from the east to the west through the northern part of the country, and joins the Gorgan River that finally empties into the Caspian Sea. The Madarsoo River has a catchment area of 2,360 km^2 and a length of about 100 km. The population in the basin is about 60,000 people and the average annual rainfall is about 1,000mm in this area. The road running paralleled to the river course is a part of important international corridor linked to neighboring countries, Turkmenistan and Afghanistan, and the sacred place of Shiite Muslim, Mashhad. The peak traffic density of the road is about 25,000 units/day.

In addition to the Madarsoo River basin, there are some river basins being composed of similar situations in hazardous topography and climate in the region. For instance about 50 people were killed by the disasters of flood and debris flow in the Nekka River basin in the Mazandaran Province, and the Maslee River basin in the Gillan Province is also under similar situation to these basins.

Under such vulnerable situations suffering from flood and debris hazards in the Caspian region, effective countermeasures have not carried out yet. Furthermore the Government of the Islamic Republic of Iran (hereinafter referred to as “the Government of Iran”) has not formulated the master plan for disaster mitigation and management to rationalize and integrate various components of the structural and non-structural measures/schemes. Therefore formulation of the master plan in the Madarsoo river basin and transfer of technologies, which are based on the study/research experiences and technical standards for the similar basins, are urgently required in the Caspian region.

In response of the official request of the Government of Iran, the Japan International Cooperation Agency (hereinafter referred to as “JICA”) dispatched the preparatory study team, headed by Mr. Hara Yoshifumi, to Iran in the end of August 2003. After continuous discussion between the team and the Government of Iran, the both parties finally agreed upon the Scope of Work (hereinafter referred to as “S/W”) and the Minutes of Meetings for the better understandings of the S/W on 3rd September 2003.

Based on the S/W and the Minutes of Meetings, JICA decided to commence the captioned development study on “Flood and Debris Flow in the Caspian Coastal Area focusing on the Flood-hit Region in the Golestan Province in the Islamic Republic of Iran”, and to dispatch the study team to Iran in the end of October 2004.

1.2 Objectives of the Study

Objectives of the study are as follows:

1) To formulate a master plan up to the target year 2025 for prevention of flood and debris flow disaster in the Madarsoo River basin,
2) To select priority projects among the measures/schemes proposed in the above-mentioned master plan and to carry out the feasibility study on them,

3) To prepare technical manual and guidelines, containing planning and designing of flood and debris flow countermeasures, applicable not only to the Madarsoo basin but also to similar other basins in the Caspian coastal area, and

4) To pursue technology transfer to counterpart personnel in the course of the study, mainly focusing on planning and designing processes on flood and debris flow disaster mitigation and management.

Throughout the study to be conducted in accordance with the above objectives, the following overall goals will be realized in the study area:

1) The projects, which are proposed through the study, will be carried out and disaster of flood and debris flow will be mitigated, and

2) The Provincial Offices in the Caspian coastal area will conduct the proper planning and designing with necessary measures for flood and debris flow disaster mitigation and management.

1.3 Study Area

The study area is mainly the Madarsoo River basin of the Golestan Province with a drainage area of about 2,300 km^2. In addition the other similar river basins in the Caspian coastal area shall be covered in the study, for instance the Nekka River basin of the Mazandaran Province and the Maslee River basin of the Gillan Province.

1.4 Work Schedule

Fig. 1.1 shows a work schedule of the study. The study started in the middle of October 2004 in a manner of Home Work. Then the field survey in Iran started at the end of October and it will continue until the beginning of September 2006.

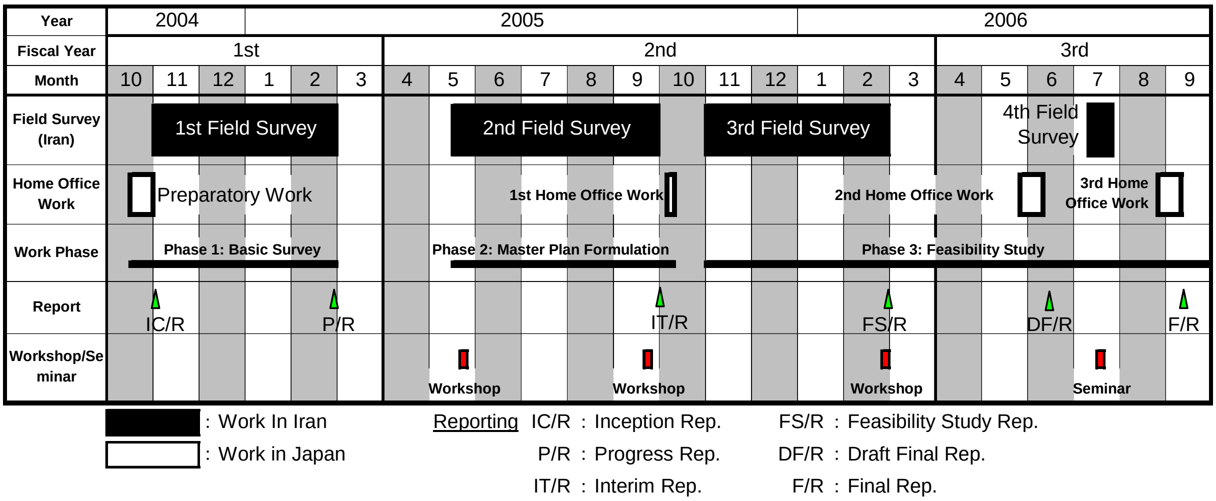


Fig. 1.1 Work Schedule of the Study

1.5 Selected Priority Projects

1.5.1 Criteria for Selection of Priority Projects

Among the master plan components summarized in Table 1.1, priority projects shall be selected for the feasibility study stage. For this purpose, the following criteria are set up to screen the suitable priority projects out of the components. The high priority shall be given to:

(A) Project(s) being located in the most seriously damaged areas; around 200 casualties in the Golestan Forest Park in the 2001 Flood and various cropping damages as well as casualties in Dasht village in the 2001 and 2005 Floods,

(B) Project(s) bringing out the project effects to save human lives or to improve worsening conditions for a short period; for instance, improvement or rehabilitation works to the existing system such as flood forecasting system and rehabilitation of breached dam in the Ghiz Ghaleh,

(C) Project(s) having high economic efficiency for mitigation of flood damages and saving human lives; flood forecasting and warning system in the Golestan Forest Park,

(D) Project(s) having suitable and essential themes on technology transfer; sediment and erosion control dams on hydrological designing, structural designing and construction methodology, and preparation of flood hazard map on hydraulic simulation,

(E) Project(s) being core concepts with possibility of future expansion in their legal frame work or to the similar river basin; preparation of hazard map in floodplain management and flood preparedness.

On the other hand, the on-going project(s) and projects that preliminary designing was already completed shall be excluded.

1.5.2 Priority Projects

In due consideration of the criteria enumerated above and salient features of the master plan components, selection process of priority projects are tabulated in Table 1.1. As a selection result, the following three projects are selected.

(1) Construction of sediment and erosion control structures in Dasht area,

(2) Flood forecasting, warning and evacuating system for Golestan Forest Park disaster management, and

(3) Publication of flood and debris flow hazard map.

In addition, educational assistance for community disaster management will be demonstrated in the feasibility study stage as a pilot project.

Regarding on-going projects, the team can provide necessary information and assistance for safe and reasonable designing in the course of the study. These projects are (1) debris flow control plan by MOJA, (2) flood control plan by MOE, and (3) elevating road for emergency activities by MORT. These projects are also essential to mitigate flood damages and to save human lives from disastrous floods.

Flood and Debris Flow Mitigation and Management Master Plan and Priority Project

No.	Component	Target Area	Major Measures	Specific Features	Priority Project
1	Watershed Management Plan	Headwaters and middle reaches	Watershed management program following the program that the MOJA formulated: mechanical, bio-mechanical, and biological measures	MOJA: planning & implementing	Completion of designing
2	River Restoration Plan	Headwaters: Ghiz Ghaleh, Dast-e-Sheikh, Gelman Darreh Rivers	(1) Construction of sediment control dams for consolidation of stored sediment by the dam breached in the 2001 Flood, (2) Erosion control downstream of Dasht village	New proposition by JICA Team	Urgent needs in Ghiz Ghaleh basin and in the downstream of Dasht village
			(3) River improvement along the three rivers		Long term process
3	Golestan Forest Park Disaster Management Plan	Middle reaches: Golestan Forest Park	Flood forecasting, warning and evacuating system (1) Establishment of real time monitoring system (2) Establishment of early warning system (3) Establishment of evacuating system	New proposition by JICA Team for improvement of existing system	Urgent needs
4	Debris Flow Control Plan	Hillside of middle reaches: Tangrah to Beshoily	(1) Construction of sediment control dam and canal (2) Land treatment and biological measures	MOJA: planning & construction	On-going
5	Flood Control Plan	River course of middle and lower reaches: Tangrah to Golestan Dam entrance	(1) Bank protection in/around housing areas of villages and immediately up and downstream stretches of bridges (2) Improvement of major riparian structures: bridges, revetment	MOE & MORT: planning & construction	On-going
			(3) Elevating road for emergency activities	New proposition by JICA Team	Long term process
6	Floodplain Management	Middle and lower reaches	(1) Publication of flood and debris flow hazard map	New proposition by JICA Team	Urgent needs
			(2) Land use regulation in flood-prone areas		Long term process
7	Flood Preparedness Plan	Entire basin	(1) Extension of flood warning system	New proposition by JICA Team	Long term process
			(2) Educational assistance for community disaster management		Conducting in F/S stage

Table 1.1 Flood and Debris Flow Mitigation and Management Master Plan and Priority Projects

CHAPTER 2 PRESENT CONDITIONS OF THE PRIORITY PROJECT AREAS

2.1 Dasht Area

2.1.1 Topography

Three major river systems of the Madarsoo River meet in the Dasht basin (flat depression); namely, Gelman Darreh, Dasht-e-Sheikh and Ghiz Ghaleh. After the confluence of three rivers, it is named the Madarsoo. Geomorphological classification in Dasht basin is presented in Fig. 2.1.

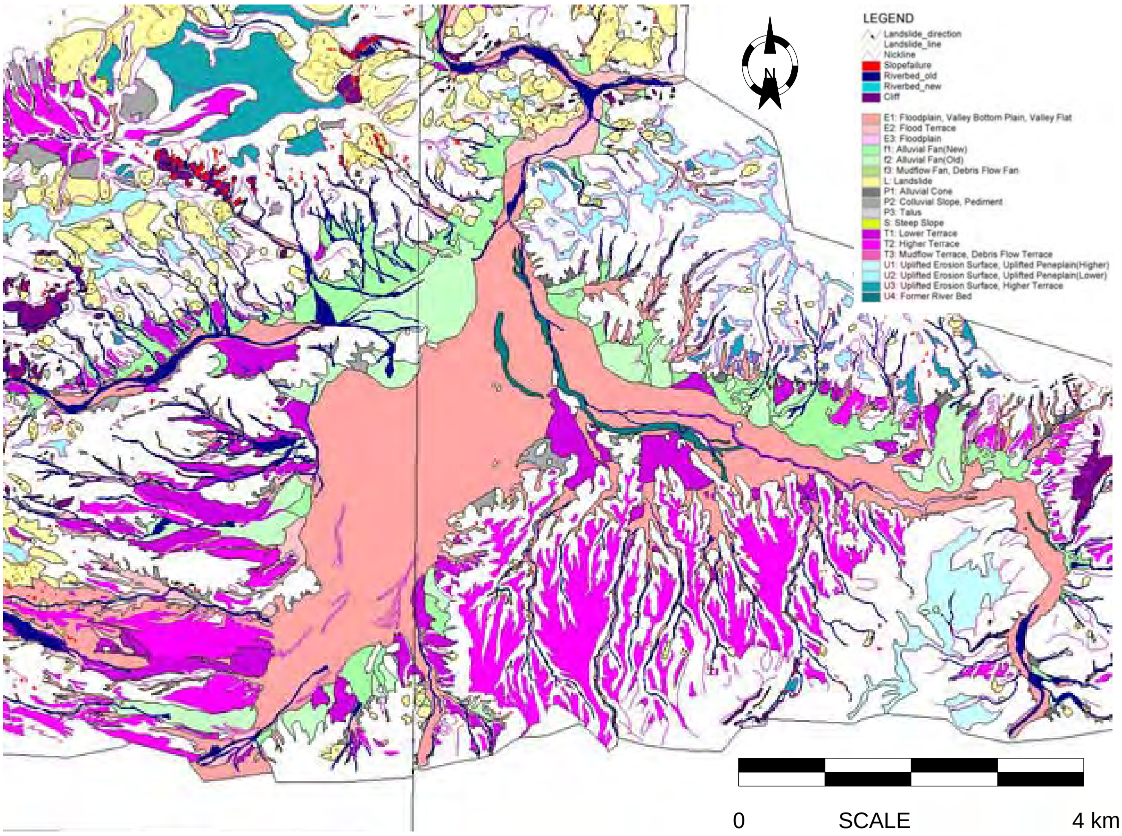


Fig. 2.1 Geomorphological Classification in Dasht Basin

As presented in Fig. 2.1, topographic features in each river are summarized below.

Gelman Darreh River

River course of 350 to 600m wide runs western-ward from the entrance of the Dasht basin to confluence with the Dasht-e-Sheikh. Around the confluence, the river course is getting wide downward up to 1,100 m.

The mainstream from the entrance flows forming downcutting channel with meandering on the valley-bottom plain in a stretch of 4 km long. From 2.5 km upstream of Dasht village, height difference between mainstream and valley-bottom plain becomes very little. In vicinity of Dasht village, valley-bottom plain become narrower due to extrusion of alluvial fan from the Ghiz Ghaleh River.

Alluvial fans from numerous tributaries developed along the right bank of the Gelman Darreh in the Dasht basin.

Dasht-e-Sheikh River

The topography of the basin could be characterized as wide valley-bottom plain of alluvial fan origin in the downstream area. Around 5.5 km upstream of Dasht village valley width of mainstream is about 150 m, while around 2 km upstream of Dasht village the valley plain changes to broad one with some undulations and 2.2 km wide.

Upper reaches have the trace of sediment movement and flooding, but the middle and lower reaches with wide valley have little trace of sediment movement. In particular river channels are not prevailing at present in the lower reaches, and partly form the shallow and discontinuous gully valley. This valley is categorized as valley-bottom plain in geomorphological land classification.

Numerous erosive valleys developed in the hilly areas and terraces along the left bank. In the upper and middle reaches, sediment movement could be seen in the existing river channel, but could not be seen in the downstream area. A few river channels could be identified up to the valley-bottom plain of Gelman Darreh River.

Ghiz Ghaleh River

The Ghiz Ghaleh River is focused on sediment control issues so that rehabilitation work is planned for the earth dam breached in the 2001 Flood as a priority project. The basin can be divided into three parts from the geomorphologic features; namely upper, middle and lower reaches. Basin divide of the Ghiz Ghaleh is shown in Fig. 2.2 as a reference.

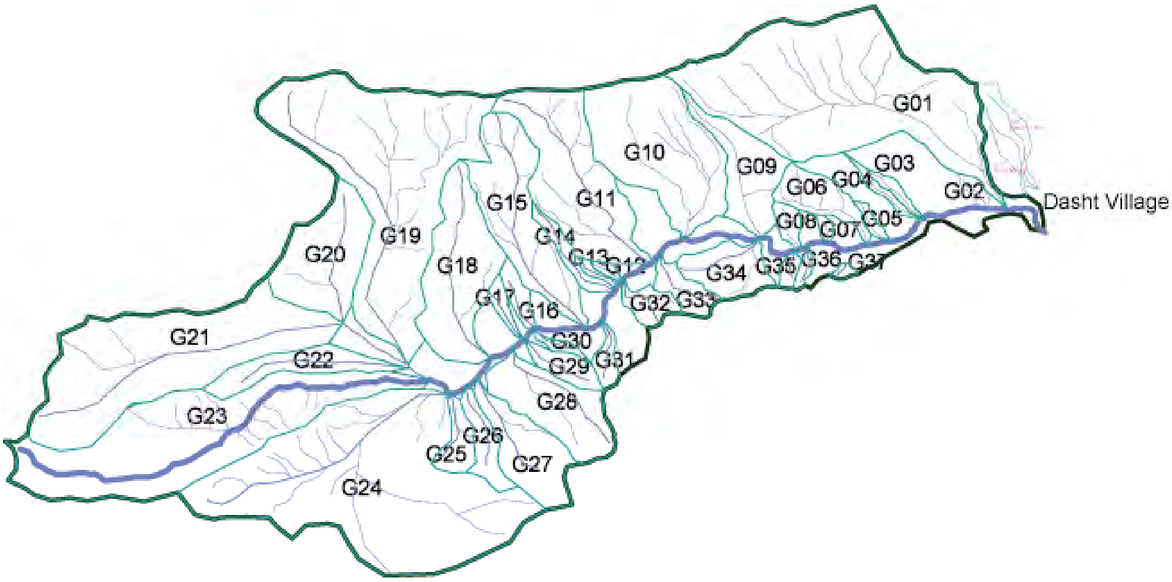


Fig. 2.2 Valley Code of the Ghiz Ghaleh River Basin

(1) Upper Reaches (Upstream of G16)

Large well-developed river terraces extend in the upper reaches. Boundaries of both sides to the Madarsoo River and the Dasht-e-Sheikh River are made up of terrace, lower uplifted erosion surface and uplifted peneplain with gentle slopes. Dasht-e-shad village is located on the terraces in the upper most area of the boundary between the Madarsoo basin and the Ghiz Ghaleh basin. The higher terrace among the higher and lower ones extends widely with 30 to 50 m high above the existing riverbed. The Ghiz Ghaleh River and tributaries down-cut the higher terraces and flow down forming box-shaped valley. The widest part of the valley including lower terrace is about 850 m, and even valleys of tributaries extend to about 200 m wide. Lower terraces can be found inside the box-shaped valley, and some of them are covered with fan deposits because of small height differences between lower terrace and existing riverbed.

Flat field and gentle slope extend widely, and less landslide terrain and gully developed in the upper reaches. Thus sediment yielding may not be intensive compared with those of middle and lower reaches.

(2) Middle Reaches (G15 to G07)

In contrast to the upper reaches, wide valley bottom plain did not develop in the middle reaches. The middle reaches are narrow path of river valley, and topography of both banks is distinctly different. Elevation of the boundary is 2,000 m in the left bank, while it is 1,200 to 1,400 m in the right bank. As a result, river stream is biased toward the right bank. In addition, large-scale tributaries occur in the left bank, while no large ones occur in the right bank. Sediment movement can be seen in both channels of the Ghiz Ghaleh and tributaries in the downstream stretch from the confluence with G15.

In the middle reaches there are many slope failures, small unsteady landslide terrains and new unsteady talus terrains so that they could have been source areas to yield sediment. Especially the mountain crests in sub-basins G07 and G09 may be intensively weathered and deteriorated because of lineament like dividing the shape of mountain and lying east to west. Active erosion and sediment yielding take place in this area because of significant topographic deformation as a result of river captures, earth movements.

(3) Lower Reaches (Downstream of G06)

The river channel runs with biased shift toward the right bank similar to the middle reaches. Elevation of the basin boundary is about 1,800 m in the left bank, while it is about 1,000 m in the right bank. The reaches show extremely asymmetric features, in which the distance from the river channel to the boundary of the left bank is 4.5 km and it is 0.5 km in the right bank. Thus large-scale tributaries have developed only in the left bank as similar to the middle reaches.

Valley bottom plain with 150 to 600 m width has developed in the river stretch downstream of confluence with G07. Originally the river has formed alluvial fans with gentle slope that had the fan end extending at vicinity of Dasht village, and had joined to the Gelman Darreh River. At present the Ghiz Ghaleh River was diverted to the Dasht-e-Sheikh River due to construction of polder diking system after the 2001 Flood.

There are some points at which the floodwater flowed over the boundary of the right bank in the past. The lower terrace with a little height from existing riverbed exists in the left bank forming board valley bottom plain 2.5 km upstream of Dasht village. This terrace is higher than the saddle portion of the boundary in the right bank so that floodwater and sediment runoff seemed to flow over it to the Dasht-e-Sheikh basin in the past.

Steep slope alluvial fans were formed on valley bottom plain along the tributaries in the left bank. The fans in a stretch upstream of G03 became terrace, while the fans in the downstream area expand their end onto the valley bottom plain of the Ghiz Ghaleh River resulting in narrowing the plain. Lots of sediment yielding and transporting can be seen in these tributaries of the left bank.

G01 is the down-most tributary of the left bank in the basin, and it formed a large alluvial fan. In the upstream area of this tributary, there are gentle slopes and flat surfaces. Meanwhile, there is a v-shaped canyon in the middle stream. Many slope failures can be identified along the steep valley wall, and they are one of sediment supply sources in this sub-basin.

Upper Madarsoo River

In upper stretch of confluence with the Cheshmeh Khan River, the mainstream of the Madarsoo was gully-like valley with slight erosion, and formed nick point upstream of the confluence, before the 2001 Flood. In the 2001 Flood the gully head significantly widened and progressed upward together with nick point. These topographic changes were caused by the following geomorphologic mechanism during the flood.

Damming up floodwater might occur in the lower reaches of the entrance to the Golestan Forest gorge during the 2001 Flood, due to debris avalanche from tributary or similar incident.
↓
Dammed-up materials were suddenly collapsed and flood surge occurred with tremendous riverbed scouring.
↓
Riverbed scouring/channel degradation progressed intensively upward with bank erosion and valley-head erosion during the 2001 Flood.
↓
Finally big gully head was formed after the 2001 Flood.

In the 2005 Flood, gully head also progressed up to 30 to 50 m upward. The agricultural lands around gully are threatened with bank erosion and collapse.

2.1.2 Flood and Sediment Runoff Issues

Two major tributaries join to the mainstream in the flat topography of Dasht basin. The mainstream is named Gelman Darreh with a drainage area of 787 km^2, while two tributaries are Dasht-e-Sheykh with 125 km^2, and Ghiz Ghaleh with 126 km^2. In the 2001 Flood, three disastrous events occurred in the Dasht area.

(1) Swollen floodwater along the Ghyz Ghaleh breached an earth dam located 4 km upstream of Dasht village, and floodwater convolving stored sediment by the dam rushed towards the village area. After the 2001 Flood polder dike was constructed to protect the village from the direct hitting of floodwater.

(2) Larger and long-lasting floodflow came from the Gelman Darreh after the flood of Ghiz Ghaleh, and it washed away crops and fruit trees in the valley-bottom plain of Dasht area. The simulation results of the 2001 Flood are shown in Fig. 2.3.

(3) Damming up might occur along the Madarsoo River at some upper part of the Golestan Forest during the 2001 Flood, and suddenly collapse due to overtopping stored floodwater. This rapid hydraulic change might induce serious channel scouring and bank erosion along the river course, and valley-head erosion around the upper end of water temporarily impounded occurred and progressed upward.

In due consideration of the above mentioned situations during floods, the following three issues shall be addressed in the River Restoration Plan so that the Dasht village becomes safer and its agriculture-based economy becomes more productive.

(1) Sediment Consolidation in the Ghiz Ghaleh River

The left bank in the middle reaches of the Ghiz Ghaleh basin is the most devastated area in the Madarsoo River basin due to widely extending slope failures caused by deterioration and weathering of base rock. To protect Dasht village against floodflow hit, consolidation of stored sediment in the breached dam basin and controlling of excessive sediment during large floods shall be given a first priority. Otherwise transported sediment will accumulate around immediately upstream of existing polder dike, and finally floodwater easily will rush to the village over the dike.

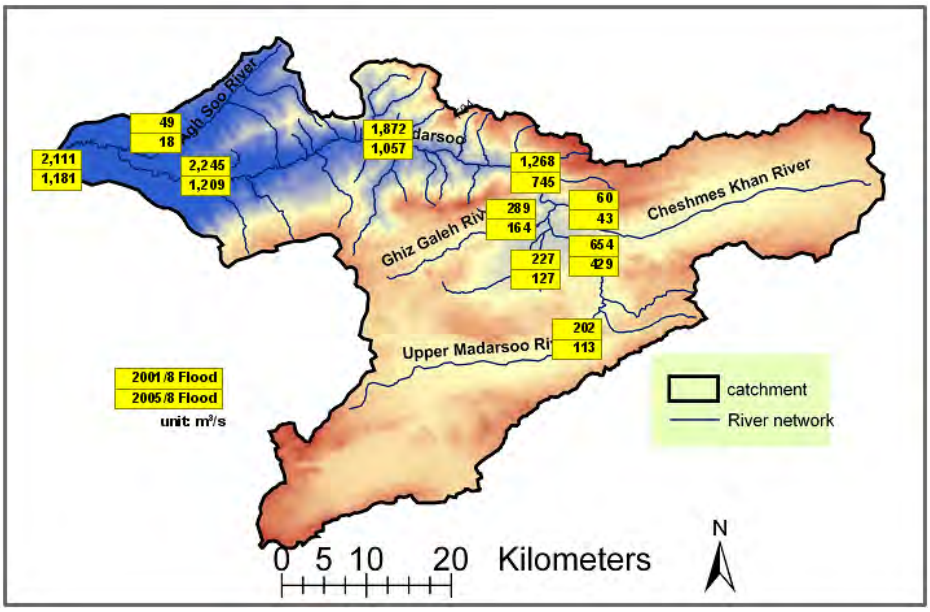


Fig. 2.3 Flood Peak Discharge in the 2001 and 2005 Floods (Simulation Results)

(2) Flood Control of Channel Network

Hydrological effects of watershed management shall be premised for the flood control because of already progressing program. After land treatment such as terracing, banquette, furrow and reforestation, the design discharges of the three rivers in 25-year flood are tabulated below and shown in Fig. 2.4 as spatial distribution of design discharges.

Table 2.1 25-Year Design Flood Discharge without and with Projects

unit: m^3/s

River	without Projects	with Watershed Management
Gelman Darreh	430	430
Dasht-e-Sheikh	130	90
Ghiz Ghaleh	170	160
After Confluence	710	660

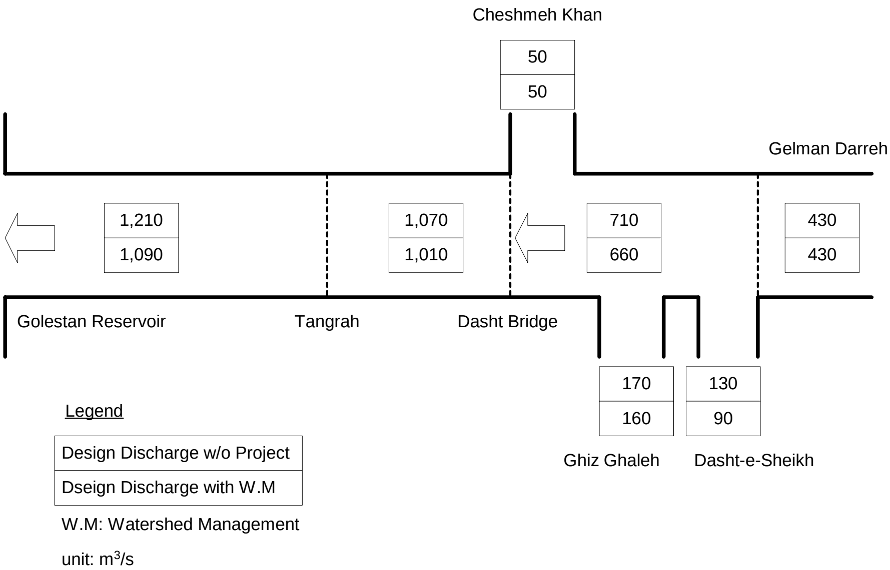


Fig. 2.4 Spatial Distribution of 25-Year Design Discharge

To reduce the flood loss of crops in the widely extending farmlands, the river channel improvement shall be planned in parallel with Watershed Management.

In addition spatial distribution of 100-year design discharge is presented in Fig. 2.5 as a reference.

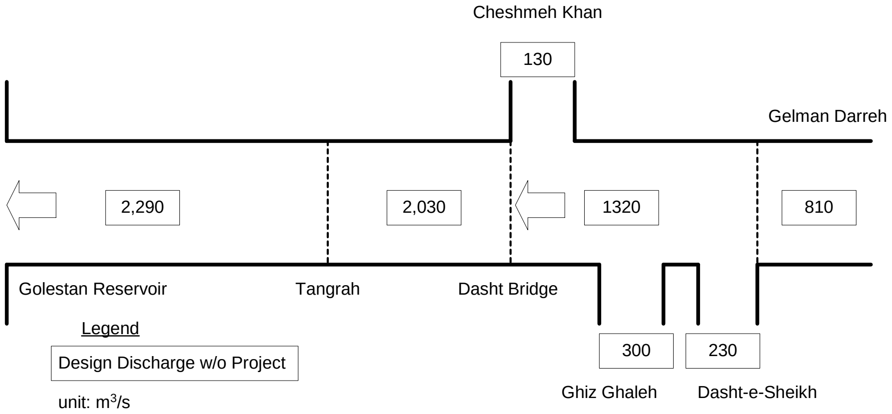


Fig. 2.5 Spatial Distribution of 100-Year Design Discharge

(3) Erosion Control

As described above, valley-head erosion occurred in parallel with river channel degradation around the confluence with the Cheshmeh Khan River in the 2001 Flood. In addition, the erosion head progressed some 50 m upstream in the 2005 Flood. Under this situation, some part of farmlands will be lost flood by flood. Thus erosion control measures such as a gully control dam or channel works shall be done in this area.

2.1.3 Geological Investigation Results

Objectives

Objectives of geological investigation are to investigate the geological condition of foundation for proposed structures such as sediment control dam and erosion control dam. The electric prospecting aims to mainly investigate the depth of basement rocks.

Location and Quantity

The location and quantity of the geological investigation is summarized in the following table.

Table 2.2 Location and Quantity of Geological Investigation

Site	Drilling No.	Location	Coordinates	Ele-vation (m)	Drilled depth (m)	S.P.T* (times)	Electric Prospecting
Sediment Control Dam	SB-1	River center, Riverbed	N=4128268.83 E=408047.25	1080.80	25	12	3 lines: 300 m, 150 m, 150 m (14 points)
	SB-2	Left bank, dam crest	N=4128356.70 E=407986.20	1096.10	25	25	
Confluence	CB-1	Riverbed	N=4131711.96 E=413412.00	957.29	25	25	-
Total	3 drillings				75m	62 times	3 lines, 600 m

*: Standard Penetration Test; No SPT is required for foundation rocks.

The lithological map along the lower Ghiz Ghaleh River is presented in Fig. 2.6. The locations of drilling and electric prospecting are shown in Fig. 2.7 and 2.8. Furthermore Fig. 2.9 shows geological cross-sectional profile of the project sites.

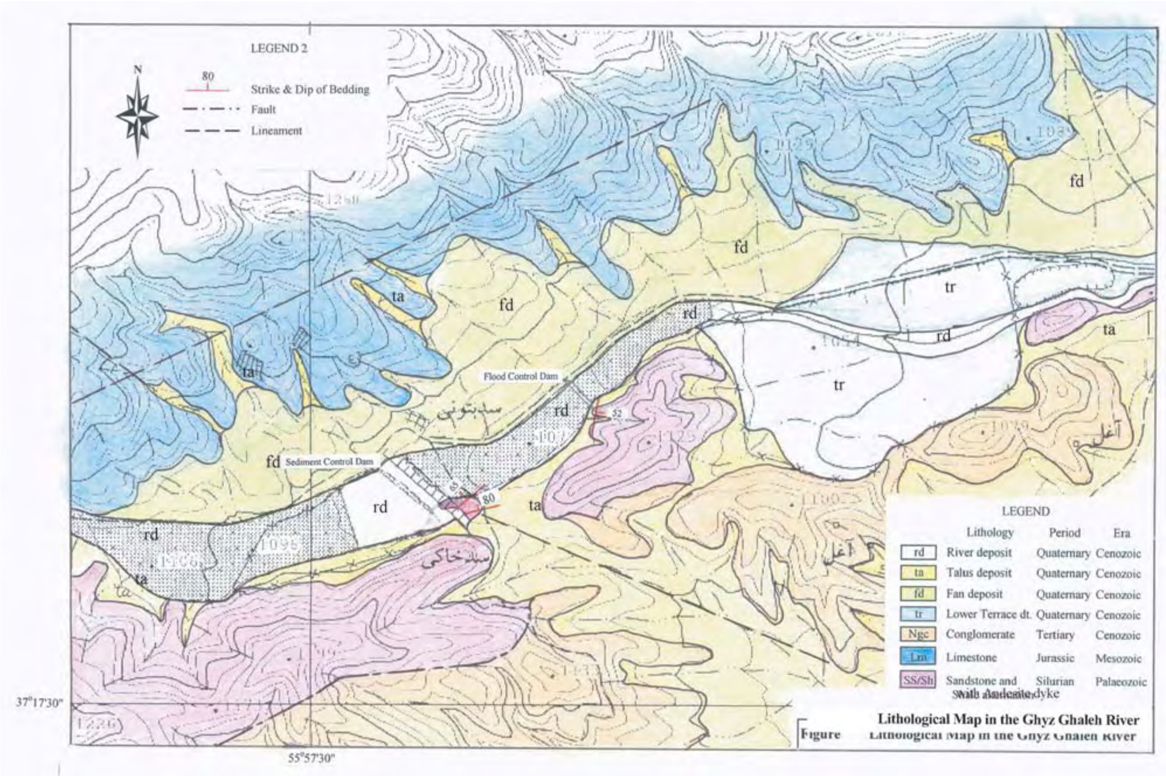


Fig. 2.6 Lithological Map in the Lower Ghiz Ghaleh River

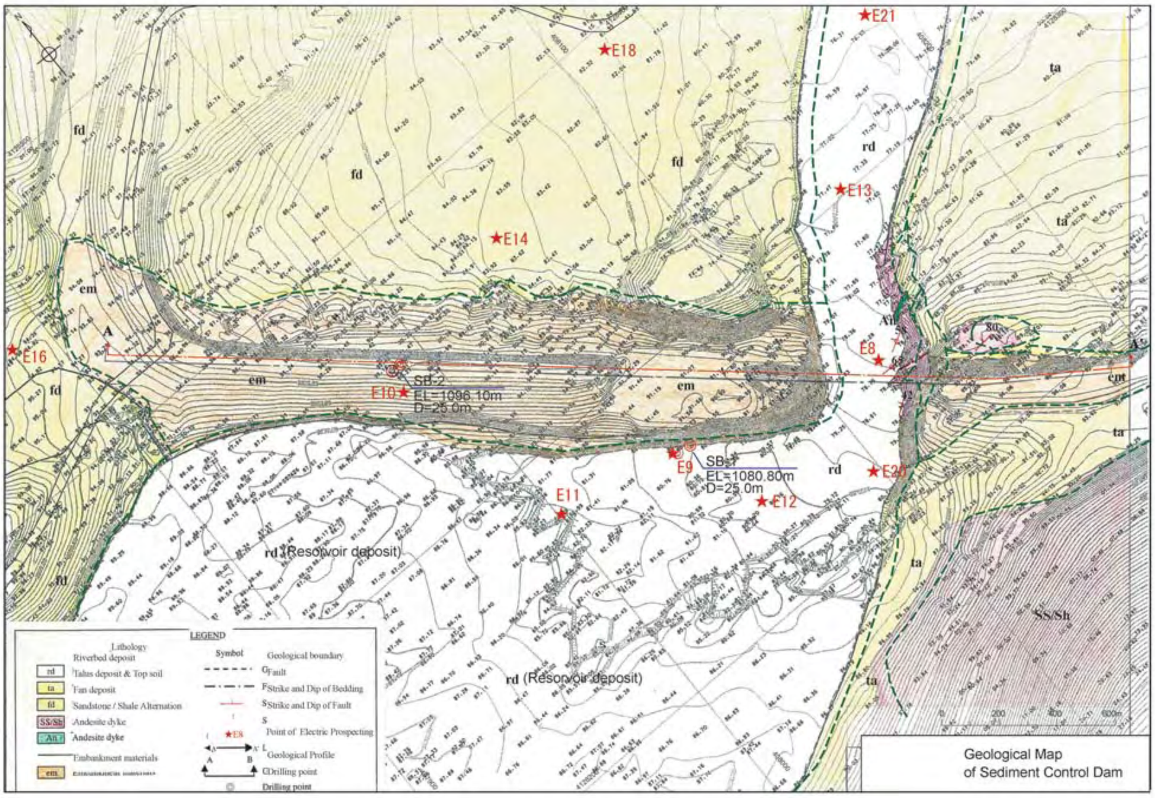


Fig. 2.7 Geological Map on the Sediment Control Dam

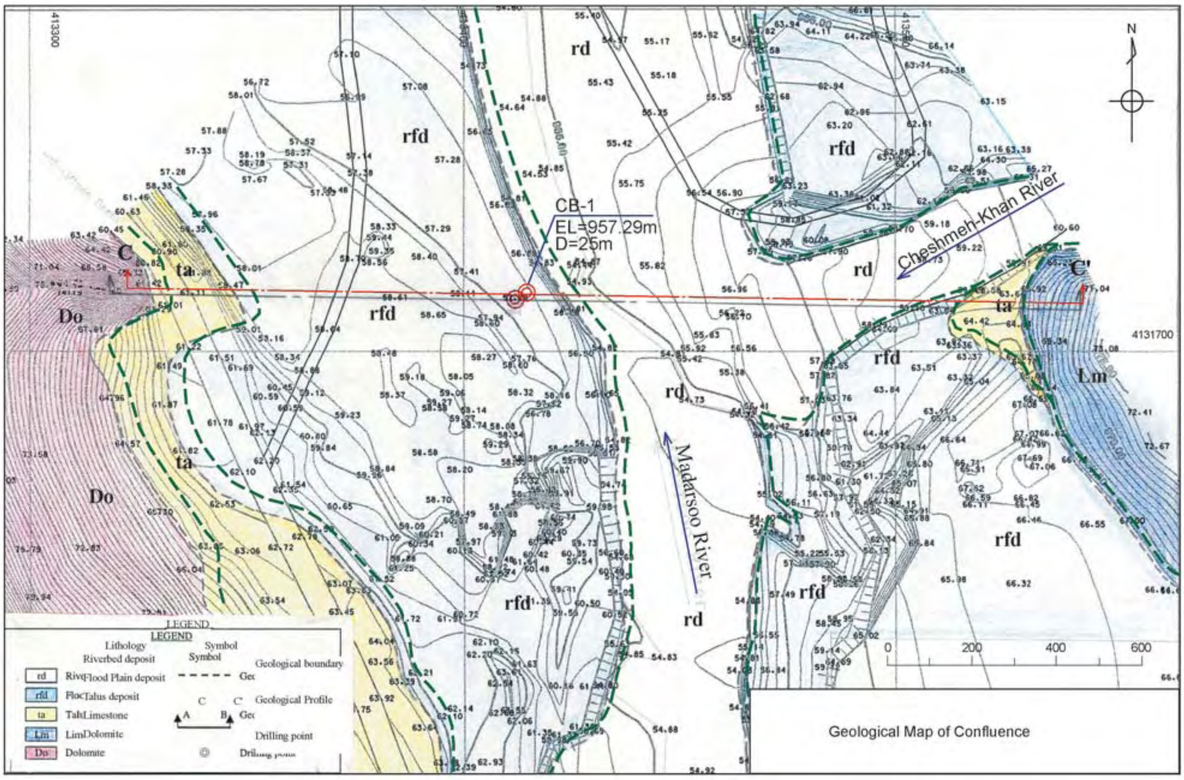


Fig. 2.8 Geological Map around the Confluence with the Cheshmeh Khan River

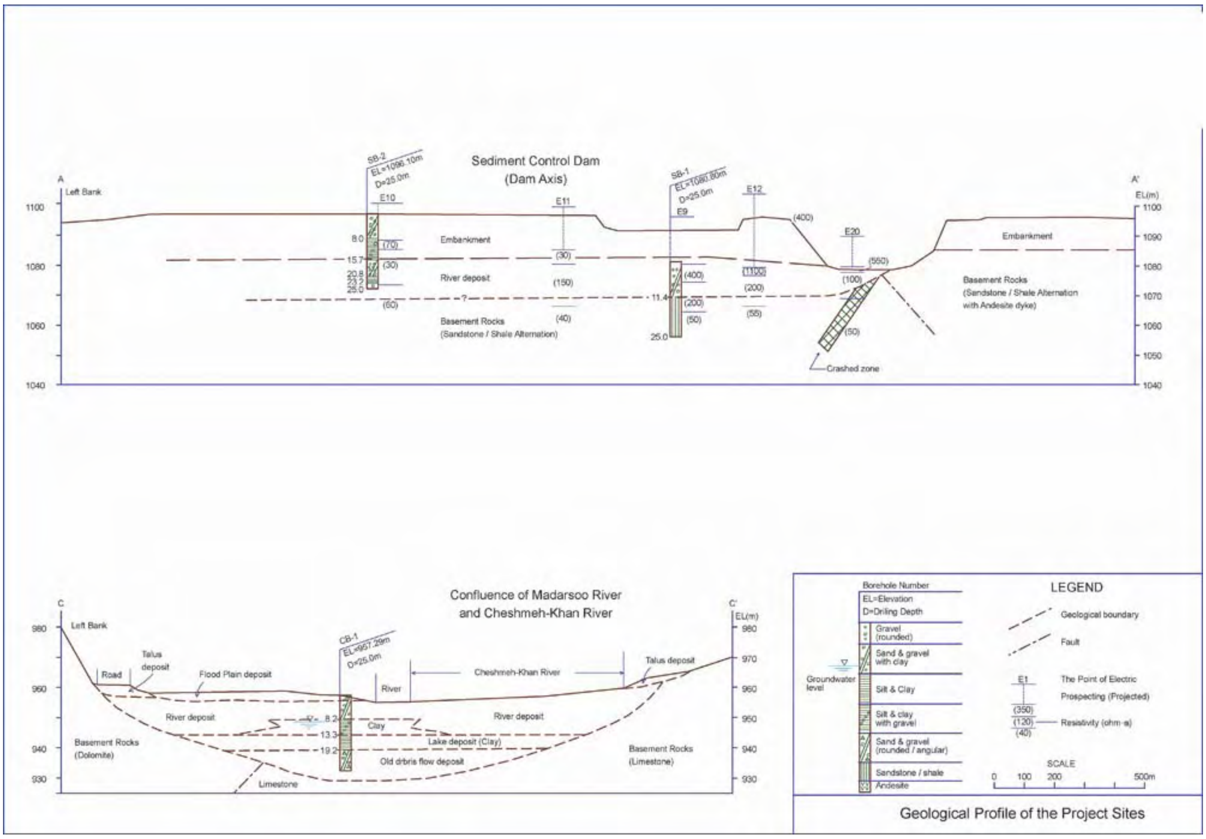


Fig. 2.9 Geological Cross-sectional Profile of the Proposed Structure Sites

Methodology

(1) Drilling

The rotary drilling method and large bit diameter of 100 mm are applied for taking core sample. Core samples are kept in core box with 5 m in each core box and they are stored in the warehouse of the Guest House of MOJA-North Khorasan Office at Dasht village.

Standard Penetration Test (SPT) was conducted to investigate the strength of soil. Cone Penetration Test (CPT) is applied only for gravel layer and its results were converted to N-value. Empirical conversion formula for gravel layer is as follows:

N=1.0Nd – 1.3Nd (N is N-value, Nd is CPT-value)

N=Nd is applied in this report.

(2) Electric Prospecting

The Vertical Electric Sounding (VES) is applied for the electric prospecting. Total 14 points of VES were conducted to clear the geological condition for 3 lines and 600 m in total.

Geology of the Proposed Sediment Control Dam in Ghiz Ghaleh River

The fan deposit is widely distributed in the left bank and basement rocks are distributed in the right bank. The foundation of dam will be fan deposit in the left bank, recent riverbed deposit in the riverbed, and basement rocks of Sandstone and Slate Alternation in the right bank. Sandstone and Shale Alternation will come into NIUR Formation in Silurian period of Paleozoic Era.

Based on the result of electric prospecting, the ground layers can be divided into the following three layers from the resistivity:

1st layer [30 to 1,100 ohm-m]:	It may be mainly composed of dried gravel. Points of E10 and E11 may indicate clayey embankment materials having low resistivity of 30 to 70.
2nd layer [30 to 200 ohm-m]:	It may be composed of gravel with clay.
3rd layer [40 to 60 ohm-m]:	It may be mainly composed of basement rocks.

The depth of 3rd layer coincides approximately with the depth of basement rocks. It is also supposed that low resistivity of 40 to 60 will hint the distribution of sedimentary rocks such as sandstone, shale, and slate.

(1) Fan Deposit

The fan deposit is composed of loose sand, gravel, and clay/silt with comparatively high permeability. Gravel is well sorted and mixed with rounded to sub-angular that are almost composed of limestone falling down from the mountains of the left bank. The gravel size varies from a few cm to 2 m. The thickness is estimated more than 10 m.

(2) Recent River Deposit and Floodplain Deposit

It is composed of loose sand and rounded gravel with fine materials and organic matters. Sand and silt layers are also distributed. These sand and gravel layer are covered by layered fine materials that is deposited in the reservoir of breached sediment control dam with the thickness of about 2 to 3 m. Before the 2001 Flood, these fine materials might be deposited approximately 5 m.

The thickness of the recent river deposit totals up to 11 m based on the drilling of SB-1 located in the recent riverbed and the field reconnaissance.

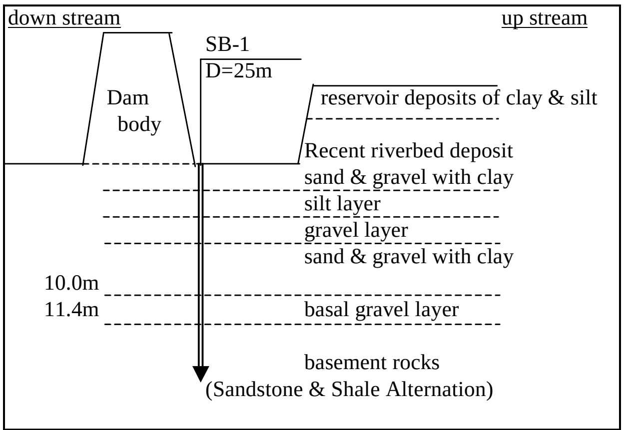
Sand and Gravel layers are well sorted and rounded that are composed of mainly limestone with a few other rocks. The gravel size will be a few cm in an average with 1 to 1.5 m in maximum. These layers contain comparatively high fine materials in general, but some layers contain a few fine materials. The basal gravel layer is also distributed on the basement rocks with a thickness of about one meter. These gravel layers will have high permeability, and seepage and piping should be considered for the design of structures.

(3) Basement Rocks

The basement rocks are composed of the alternation of Sandstone and Shale. Andesite is also distributed in the right bank as dyke. Sandstone will be sound rock with a few weathering, but shale is a slightly crashed and its surface has been slaked.

The strike and dip of them are N45-51^{o}E and 42-65^{o}N running parallel to the river and dipping to the left bank. The stratum is faulted with the strike and dip of N80^{o}E and 80^{o}N that is crushed and heavily weathered at the just downward of right bank. These rocks have the sufficient soundness for the basement rocks of sabo dam and other small-scale river structures.

According to the drilling SB-1, surface part of rocks from 11.5 to 13.6 m are weathered and softened, and they are loosened with clay between the joints up to 15.4 m. The rocks in deeper part from 15.4 m, they will be fresh and sound.



Schematic Geological Condition at Drilling SB-1 Point

Fig. 2.10 Schematic Geological Condition at Drilling Point of SB-1

(4) Embankment Materials

The drilling SB-2 aims to investigate the characteristics of embankment materials and the contact condition with the basement rocks. The embankment materials are distributed up to 15.7 m in depth and deeper part is the natural ground of the riverbed deposit.

The result is as follows:

- The upper part of embankment materials up to 5.7 m: mainly composed of sand and gravel with clay that might be taken from fan deposit distributed in the left bank.
- 5.7-6.6 m: clay and sand.
- 6.6-8.0 m: sand, gravel, and clay (gravel; rounded mixed with angular).
- 8.0-10.3 m: clay with gravel (gravel; rounded & angular).
- 10.3-11.0 m: clay and sand.

- 11.0-11.2 m: sand, gravel, and clay (gravel; rounded mixed with angular).
- 11.2-15.7 m: clay and sand with gravel (gravel; rounded mixed with angular). The boundary between embankment materials and basement contacts well. No seepage and piping are found.
- 15.7-20.8 m: riverbed deposit of sand and gravel with clay (gravel; rounded and sub-rounded).
- 20.8-23.2 m: riverbed deposit of silt.
- 23.2-25.0 m: riverbed deposit of sand and gravel with clay (gravel; rounded and sub-rounded).

(5) Engineering Geology

N-Value of Standard Penetration Test (SPT) is more than 50 for the riverbed deposit mainly composed of sand and gravel. The angle of internal friction will be estimated more than 44.5 degrees on the basis of Dunham's conversion formula ($\phi = (12N)^{1/2} + 20$).

Confluence of the Madarsoo and the Cheshmeh Khan

(1) Soil Condition

Dolomite of MILA Formation in Cambrian Period is distributed in the left bank and Jurassic limestone is distributed in the right bank. Riverbed and floodplain deposits are distributed in the riverbed with a thickness of about 19 m. Old debris flow deposit or old talus deposit is distributed with a thickness of more than 5 m under the riverbed deposit.

The horizontal layered silt with granule to pebble layers is distributed on the floodplain of the Madarsoo River at the confluence with the Cheshmeh Khan River with the thickness of more than 5 m. These fine materials might have been deposited in a lake that might be naturally formed by damming-up by debris flows of the Cheshmeh Khan River in the past.

The lower part of the riverbed deposit, cohesive clay layer with a few granules is distributed from the depth of 13 to 19 m. This might be also lake deposit.

Under the riverbed deposit, there is some deposit including rounded and angular granule to pebble of limestone, sandstone, and shale. This layer may be talus deposit or debris flow deposit in the past in consideration of mixing rock type and various forms of rounded and angular.

(2) Engineering Geology

N-Value of Standard Penetration Test (SPT) is more than 50 for the riverbed deposit composed of sand and gravel. The angle of internal friction will be estimated more than 44.5 degrees on the basis of Dunham's conversion formula ($\phi = (12N)^{1/2} + 20$).

Clay layer of riverbed deposit distributed from 8.2 to 13.3 m of borehole CB-1 is categorized "hard" with a N-value of 29 to 41. The bearing capacity (qa) will be estimated 29 to 41 tf/m^2 (qa=(1.0-1.3)N). But, clay layer of lake deposit distributed from 13.3 to 19.2 m of borehole CB-1 is categorized "stiff to very stiff" with a N-value of 14 to 24. The bearing capacity (qa) will be estimated 14 to 24tf/m^2 (qa=(1.0-1.3)N).

Old talus deposit or old debris flow distributed under the lake deposit is also categorized "hard" with a N-value of more than 50.

It is supposed that the bearing capacity of the horizontal layered silt with granule to pebble layers on the floodplain will be almost same as lake deposit from the result of SPT.

2.2 Golestan Forest National Park

2.2.1 Topography

According to geological study results, geological structures are clearly different between left and right banks. For instance, there is no fault and fold in the left bank, while there are many faults and folds in the right bank. The Madarsoo River may flow following the boundary of geological structures like faults. The geomorphological classification is shown in Fig. 2.11.

The Madarsoo River flows through gorge in both sides of steep valley wall with about 300 m high from existing riverbed. Valley of mainstream is about 60 to 200 m wide. From the photographs taken before the 2001 Flood, riverbed with no vegetation was only about 20 to 50 m wide. In contrast, the riverbed extends over the valley bottom plain after the 2001 Flood. Furthermore, intensive bank erosion occurs along the flood terraces and the end of alluvial fans.

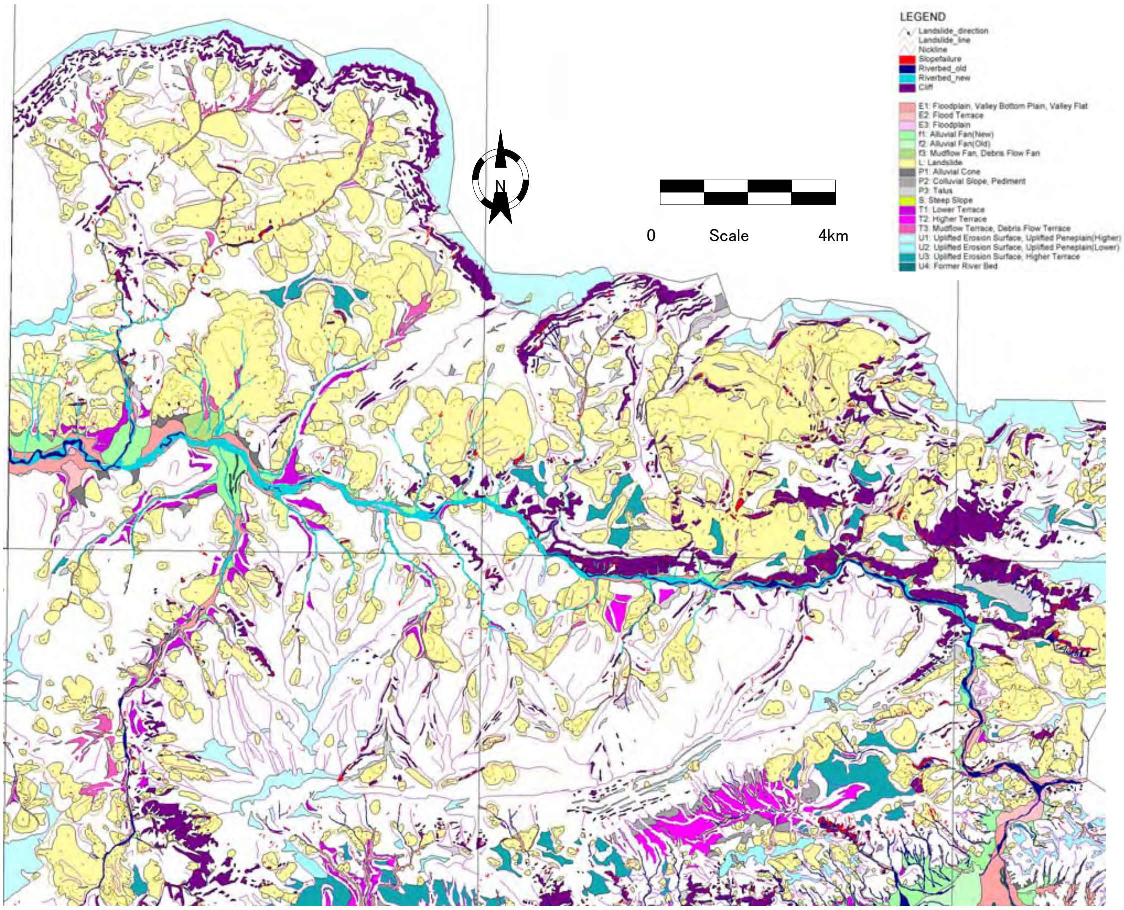


Fig. 2.11 Geomorphological Classification in Golestan Forest

2.2.2 Flood and Sediment Runoff Issues

In the 2001 Flood, around 200 visitors and campers died in the park. Most of the camping sites are situated on the previous debris flow deposits due to flat topography, and usually campers and visitors enjoy its natural environment extending over 15 km along the riverbank. In the 2001 flood, debris flow occurred in the six mountain streams in the park. Debris flow in five streams out of six attacked the camping sites. Furthermore extremely large floodflow coming from the upper stretch simultaneously swept away visitors and campers as well as natural forest alongside of the Madarsoo River course in the park. Thus the Golestan Forest Park area is the most disastrous part in the Madarsoo River basin from floods.

Recently the large-scale flood attacked the Golestan Forest Park again on 10 August 2005. Beforehand Meteorological Office-Golestan announced flood warning as their weather forecast on 8 August, and Traffic Police shut off the connection road and drove visitors out of the Park in the afternoon on 9 August. As a result these activities achieved no casualties being affected by the 2005 Flood in the Golestan Forest Park.

For instance, the floodwater depth is simply computed using average river width and riverbed slope, and flood discharge shown in Fig. 2.3. In order to know the rough situation of floodwater in the Golestan Forest gorge, floodwater depth was calculated using uniform flow formula of manning with average slope, river width in minimum and maximum cases. Table 2.3 tabulates the computation results, and it indicates that floodwater might rise 3 to 4 m in the narrow portion of the gorge in the 2001 Flood. This computation implies that people visiting the forest park cannot find the suitable evacuating way under tremendous downpour such as the 2001 and 2005 floods. Therefore early warning and evacuation out of the park is crucial in saving lives of the visitors.

Table 2.3 Flood Flowing Situation in the Golestan Park

Flood	Golestan Forest	Peak Discharge (m^3/s)	Riverbed			
			Average Slope (%)	Width (m)	Roughness Coefficient	Floodwater Depth (m)
2001	Entrance	1,270	1.9	60	0.045	3.3
				200		1.6
	Outlet	1,870		60		4.2
				200		2.0
2005	Entrance	750		60		2.4
				200		1.1
	Outlet	1,060		60		3.0
				200		1.4

Issues on the total flood forecasting and warning system could be broadly categorized into three items through carefully reviewing the activities during the 2005 Flood and the existing hydro-meteorological monitoring system.

(1) Improvement on Meteo-Hydrological Data Collection System

Existing meteo-hydrological data monitoring and collection system has various issues, if the system is utilized for flood forecasting and warning system in the Madarsoo River basin. These are:

- Meteorological Organization-Golestan (MOG) collects past 1-, 3-, 6- and 24-hour data for weather forecasting purpose in the normal time. Once rain starts, MOG will connect only two stations through their online network to obtain real time data at the same time. It is not automatic real time observation system.
- Ministry of Energy (MOE) collects past 2-hour data for meteo-hydrological data collection purpose. The flood forecasting and warning system requires to monitor real time rainfall and water level data at least 1 hour interval. This system is also not automatic real time observation system.
- The data transmission network using public telephone line has not high reliability. It is easily disconnected during heavy storms and floods.
- There are two water level monitoring sites in the basin, namely Tangrah and Dasht Bridge. Those stations are located at the entrance of the Golestan Forest

Park and upstream end of the Park along the Madarsoo River. Monitoring data at those two stations cannot be utilized for flood forecasting and warning to protect visitors and campers in the Park since there is no lead-time gaining for warning and evacuation activities. Thus another stations shall be installed in the upper part so as to gain the lead-time for the emergency activities.

(2) Establishment of Responsible Organization for Flood Forecasting and Warning

There is no data exchange between MOG and MOE. Furthermore there is no responsible organization to integrate meteo-hydrological data, to analyze those data, to determine an announcement of flood warning, and to strongly support the decision making by the Provincial Disaster Management Center (PDMC). Such responsible organization is necessary as a Center of Flood Forecasting and Warning System.

(3) Improvement of Smooth and Efficient Emergency Activities for Evacuation

So far weather bulletin issued by MOG is only a basis for initial action of emergency activities against flood disaster. The weather bulletin gives global weather information and no precise rainfall data. As a result, hitting ratio of the forecast is rather low. If the ratio is too low, people concerning will not believe the official information, and preparation activities for floods may be considered loss of budget.

In the 2005 Flood, it was proven that emergency activities to evacuate people from the Golestan Forest Park area were very effective and mounted. It might be great learning effects from the disastrous 2001 Flood. Therefore improving hitting ration of the forecast shall be a succeeding target to create the safer region against the flood disaster.

2.3 Valley-bottom Plain and Gorgan Floodplain Areas

2.3.1 Topography

The Madarsoo River forms the valley with 400 to 600 m width at the vicinity of Tangrah village. Valley-bottom plains as well as alluvial fans and lower terraces formed by the tributaries can be found in the valley. Valley-bottom plains consist of river channel, high-water channel with thick vegetation, and general surface of valley-bottom plain.

In a stretch of about 21 km downward from Tangrah, the Madarsoo mainstream runs to the west on the valley-bottom plain with meandering constricted by both sides of hill slope. The valley-bottom plain gradually becomes wider in accordance with going downward.

In vicinity of Agha Mish village, the wide lower terrace can be seen along the mainstream. From geomorphological viewpoints, the river stretch of about 6 km from Agha Mish to Kalaleh Bridge can be defined as a transition segment, in which the geomorphologic features change from valley-bottom plain to the Gorgan plain.

From Kalaleh Bridge, the Madarsoo enters onto the wide plains, which was formed by the Gorgan River. In a stretch of about 15 km from the bridge to entrance of the Golestan reservoir, the Madarsoo River freely meanders forming lower terraces with 300 m to 1,000 m, and river channel downcuts the erosive materials of the Gorgan plain. The lower terraces are situated at about 10 m lower than the plain surface. Fig. 2.12 presents the lower terraces and the mainstream on the Gorgan plain near Kalaleh Airport using satellite imagery.

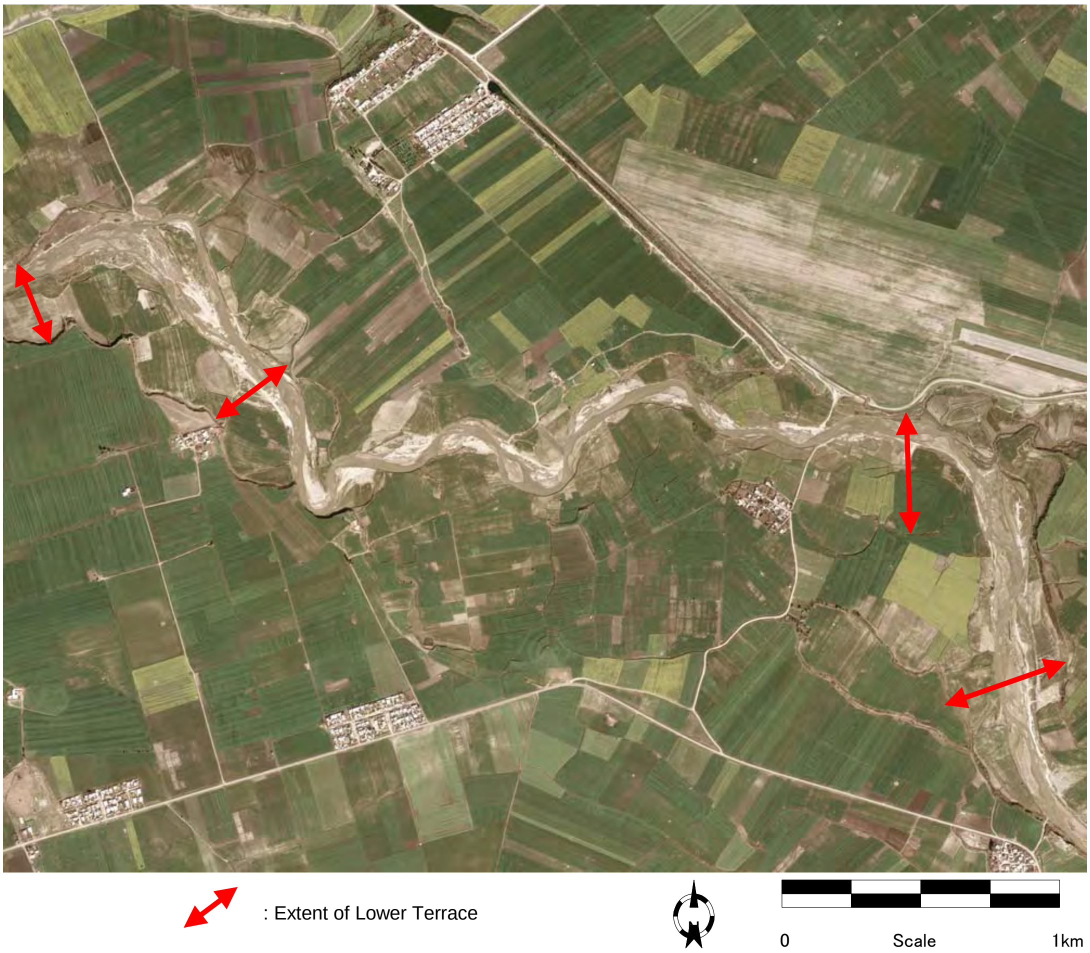


Fig. 2.12 Lower Terrace near Kalaleh Airport along the Lower Madarsoo

2.3.2 Flood and Sediment Runoff Issues

Structural Measures

After demolition of structures of road and riverbank during the disastrous 2001 flood, MOE and MORT conducted urgent rehabilitation works to the damaged structures. In particular, MOE has a responsibility to hydrological and hydraulic analysis for river structures. MOE is preparing two-phased plan: namely urgent measures and master plan.

The urgent measures were carried out at various damaged portions, such as protective revetment along the bends of river course, and transversal structures of bridges to connect villages to the arterial road running along the Madarsoo River. Some structures were completed and others were under construction in summer 2005.

The 2005 Flood made an attack to the Madarsoo River basin. The recently rehabilitated structures and newly installed flood control structures were seriously damaged again. After the flood disaster, MOE is preparing or modifying their rehabilitation plan based on the damages experienced. Furthermore the master plan being prepared by MOE should be also adjusted to the statistic background of rainfall affected by recent successive floods in 2001, 2002 and 2005. The MOE master plan and rehabilitation plan will be elaborated, and the structures to be constructed by MOE and MORT shall be much more strengthened to the previous one.

Non-structural Measures

Some villages located in the valley-bottom plain, in particular villages located between Kalaleh Bridge and 14-metry Bridge, are partially submerged in the large-scale flood time.

According to the interview survey to the villagers, the flooding water had not high velocity in the inundation areas of the villages. Thus there can be high possibility to save resident’s lives from flooding if appropriate information was given to the villagers and proper knowledge was built in them.

On the other hand, all villages located in the Gorgan Plain downstream of the Kalaleh Bridge are situated on the higher terrace of the plain. The floodwater flows down confining in the lower terrace along the river course. In this area resident’s lives can be completely saved from the flood disaster if proper knowledge was built in them.

Therefore in the valley-bottom plain and Gorgan Plain, non-structural measures of knowledge building on floods are indispensable to save the villager’s lives from the flood disaster.

CHAPTER 3 RIVER RESTORATION PLAN IN DASHT AREA –SEDIMENT CONTROL DAM-

3.1 Basic Design Conditions

The river restoration plan in the Ghyz Ghale River has the structural countermeasures of the sediment control dam construction and diversion channel of the Ghyz Ghaleh River in the master plan.

In this section, the preliminary design of the said sediment control dam works, which has been selected as priority project in the master plan, is described on the main points of structural type selection, determination of essential structural scales and project cost estimate.

The purpose of the sediment control dam works is to control sediment, aiming exclusively at preventing the excessive sediment, which has been stored in the reservoir area until the dam breached in the 2001 flood, from flowing out to the downstream of the Ghyz Ghaleh River during the probable flood and preventing the direct flood damage to the Dasht village.

Basic design criteria of the sediment control dam works are shown as follows;

- Design Discharge flow is taken into account of followings;

  for dam designing; 100-year flood, 300 m^3/s

  for channel designing; 25-year flood, 160 m^3/s

- Invert elevation of spillway section in floodway is set to cover the reservoir sediment surface with future sediment surface assumed with 1 % in slope derived from half of 2 % of the present streambed in the site.
- Floodway flow capacity is calculated with conventional formula derived from weir formula, while the channel flow capacity is provided with the uniform flow calculation suggested by Manning.
- New earth dam to close the opening section of the existing dam is to be placed directly on the permeable riverbed materials or sand and gravel layers. Therefore foundation treatment is necessary to secure the water-tightness for preventing a piping problem through the bottom of the foundation.
- Regarding countermeasures against piping problem, it is proposed with soil blanket, which is constructed with an impermeable material such as silt or clay soil, in the immediate upstream of the dam to extend the effective seepage length.
- In case of the earth dam scheme, the riverbed material for 2.0 m deep underneath the new earth dam is replaced with the appropriate soil blanket material or equivalent since the riverbed surface in the breached dam section is turbulent by flood flow and has insufficient bearing capacity.
- In case of concrete dam scheme, it is proposed that the foundation improvement is employed with cement mixing into the sand-gravel-layer such as soil cement method or Sabo Cement-Sand-Gravel method (hereinafter called as Sabo-CSG) to ensure the subgrade reaction improvement and seepage length extension.

3.2 Alternative Study

Three cases are elaborated for the alternative study based on the field topographical conditions and environmental aspects. These alternatives features are described as follows:

First one is as Case-A, which consists of the concrete main dam located at the opening section of the existing earth dam, the concrete apron, the sub-dam for stilling basin, and also concrete blocks for riverbed protection.

Second one is as Case-B, which consists of newly excavated floodway located on the exposed basement rock of the right bank, the concrete intake, the concrete revetment along the floodway and concrete blocks for channel bed protection.

Third one is as Case-C, which composes of newly excavated floodway located on the left existing earth dam, the concrete intake, the concrete revetment along the floodway and concrete blocks for channel bed protection.

Those are compared and the optimum case is selected from the viewpoints of construction cost, effects to the environment and workability.

3.2.1 Geological Condition of Foundation

Result of the geological survey is shown as follows;

- The geological structure under the existing earth dam from the left bank to the middle of the stream course of the Ghyz Ghaleh River is founded on the dense, coarse sand and gravel layer, with 12 m depth from the riverbed surface to the bed rock.
- The existing earth dam in the right bank has been placed on the solid rock foundation, surface of which is located at elevation of EL+1086 m and is partially exposed at the riverbank. It is assumed that the rock foundation is intruding into the streambed at around elevation of EL+1079 m.
- The core drilling works results show a base rock at the around elevation of EL+1070 m and no groundwater in any course of the drilling works in the streambed. It is expected that 10 m height class dam can be constructed at the site from the viewpoint of strength of the layers since the core drilling result that the N-value is over 50 with Standard Penetration Test (SPT) under the riverbed surface. Regarding permeability of the riverbed material, it is concluded that the said sand and gravel layers generally have quite high values based on the field reconnaissance.
- As long as the dam is planned for sediment control, not storing water, high permeability itself is not adverse condition but against piping. Therefore, height of dam should be limited not to cause high water head and some kind of treatment or improvement should be given to the sand and gravel layers underneath the dam foundation so as not to encourage piping problem.

3.2.2 Design Conditions in Common to Alternatives

The individual proposed floodway on the alternatives should be satisfied with the requirement shown as follows;

- To locate the invert level of the proposed spillway, which the future sediment surface in the upstream should cover the present riverbed surface so as not to scour the sediment in the reservoir area of the old dam,
- To design the spillway flow capacity with discharge of a 100-year return period and channel capacity with a 25-year return period, and
- To design the structure to satisfy stability against tilting and sliding.
- Freeboard for proposed floodway should be 0.8 m added at the elevation of the high water level.

Design conditions for earth dam section should be satisfied as follows:

The crest elevation of proposed earth dam should be added with 2 m high to the elevation of the crest of the spillway sidewall section to take into account of unknown factor like surging water, which has been happened in the 2001 Flood, while frequently crest of earth dam type is added with 1m higher than the concrete dam crest.

3.2.3 Case-A for Concrete Dam with Spillway

Case- A is consisted of concrete dam with spillway to close the opening of the existing earth dam and to connect up the existing earth dam. Basic design of the Case-A is set as follows:

(1) Structure of Case-A

Typical cross section is shown in Fig. 3.1 as follows:

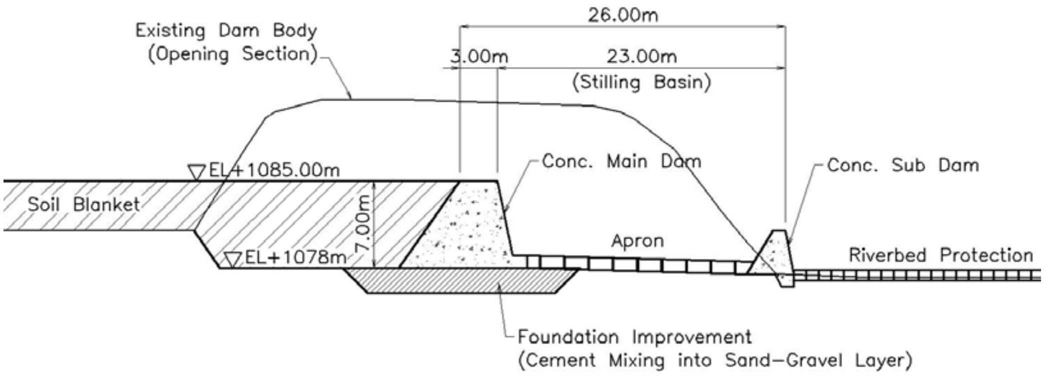


Fig. 3.1 Typical Cross Sections of Case-A

The preliminary structural stability requires the essential structural dimensions as follows:

Table. 3.1 Structural Features of Case-A

Item	Value	Remarks
Crest Width (B)	3.0 m	
Downstream Slope Gradient	1: 0.20	With footing for stability against tilting
Upstream Slope Gradient	1: 0.70	

(2) Effects to the Environment of the Golestan National Park

The construction works of Case-A might be executed within the area of the existing earth dam and the required construction material is limited to obtain from a part of the existing dam and reservoir area.

Consequently, the construction works of Case-A could hardly affect the environmental state of the Golestan National Park.

(3) Workability

Critical condition for workability on the construction stage is to deal with floodwater occurrence during construction period. Concrete dam could be constructed in stepwise, i.e. at first a half in the right side and at second in the left side.

During the dam construction in the one of the halves is executed, the other side of the opening section could be utilized as temporary spillway.

Therefore, not much additional cost is required to the temporary works for cofferdam.

(4) Work Quantity

Quantity to be constructed of the major item is estimated and shown as follows;

Table.3.2 Summary of Quantity on Major Items in Case-A

Case−A
Summary of Quantity : Case of Floodway in Existing River Channel

items	classification	unit	quantity			
			Exisitng Section	River Section	Dam & Apron Section	sub-total
excavation						
	soil	cu.m	66,000	14,000		80,000
	rock	cu.m	1,000	400		1,400
	sub-total	cu.m	67,000	14,400	0	81,400
embankment						
	main dam	cu.m	6,000			6,000
	soil blanket	cu.m	35,000			35,000
	random fill	cu.m	3,000	8,000		11,000
	sub-total	cu.m	44,000	8,000		52,000
concrete						
	main dam	cu.m			4,000	4,000
	Apron	cu.m			1,400	1,400
	Sub-dam				700	
	Training Wall			1,300	500	
	River protection	cu.m		2,000		
	Slope protection	cu.m		200		
	sub-total	cu.m		3,500	6,600	10,100

On the above table, the amount of excavation in the existing dam section is significantly more than another alternatives since the spillway width is set in accordance with the downstream river width of 65m to keep the sequence of river course and it is necessary to excavate the existing earth dam section, additionally.

3.2.4 Case-B for Floodway at Right Bank

Case- B is consisted of new floodway and new earth dam to close the opening section of the existing earth dam. The floodway is composed of inlet section, weir section and chute channel section. The floodway is located on the exposed bedrock in the right bank.

The amount of right hilly area excavation shall be utilized to close the opening section of the existing earth dam since the floodway construction works generates more quantity of excavation than the other alternatives. Taking such condition into account, basic design is carried out as follows;

(1) Structure of Case-B

Proposed profile along the floodway is shown in Fig. 3.2.

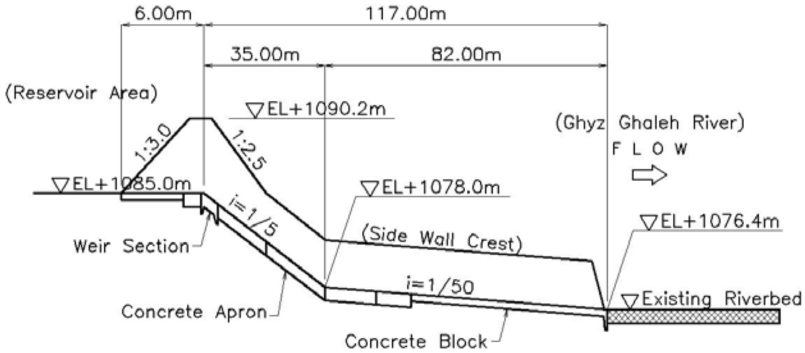


Fig. 3.2 Longitudinal Cross Section of Floodway in Case-B

(2) Work Quantity

Quantity of the major item is estimated and shown as follows;

Table. 3.3 Summary of Quantity on Major Items in Case-B

Case B

Summary of Quantity : Case of Floodway at Right Side Bank

items	classification	unit	quantity				
			Exisitng Section	New Dam Section	Inlet Section	Chute Section	Total
excavation							
	soil	cu.m	31,000	15,000	16,000	38,000	100,000
	rock	cu.m	0	0	3,000	0	3,000
	Total	cu.m	31,000	15,000	19,000	38,000	103,000
embankment							
	main dam	cu.m	9,900	27,000			36,900
	soil blanket	cu.m	20,000	6,400			26,400
	random fill	cu.m	2,000	500			2,500
	Total	cu.m	31,900	33,900			65,800
concrete							
	wall	cu.m		100	500	2,000	2,600
	floor	cu.m			900	4,000	4,900
	slope protection	cu.m		400			
	river protection	cu.m		1,800			1,800
	Total	cu.m		2,300	1,400	6,000	9,700

(3) Effects to the environment

Excavation in the inlet area creates the new large man-made slope on the right hillside with around 1,800 square meters, which might cause slope failure without proper slope protection and maintenance works.

Therefore, it is required to execute the appropriate hillside works and regular maintenance and monitoring of the large slope area after construction.

(4) Workability

The new floodway is to be constructed without cofferdam because floodwater is passing through the opening section of the existing dam during the flood time.

However, there should be difficulty of the construction plan on the execution of the closing works because there is no space to divert the floodwater unless the closing works is designed with concrete works to prevent the construction material swept away by the flood or cut-in channel is provided through the existing dam to secure the floodwater passing.

Both of the schemes on the temporary works cause the requirement of additional work volume to the above estimate.

3.2.5 Case-C for Floodway at Left Bank

Case-C consists of new floodway located at the left bank and new earth dam to close the opening section of the existing dam. Basic design of Case-C is made as follows;

(1) Structure of Case C

Proposed Profile along the floodway is shown in Fig. 3.3.

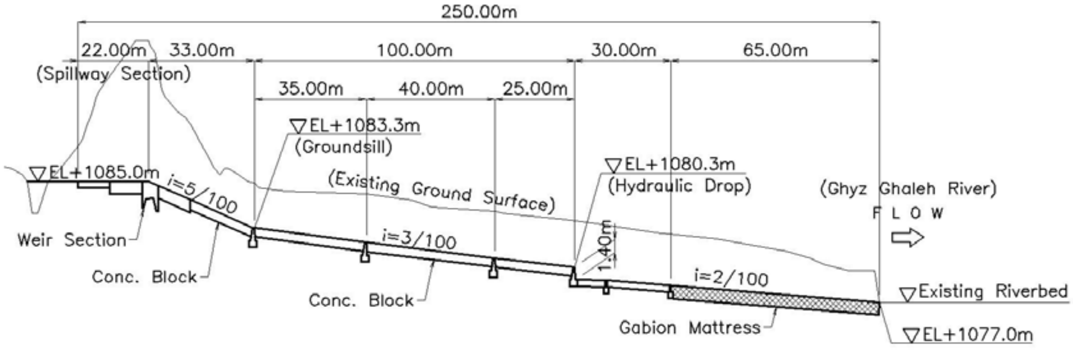


Fig. 3.3 Longitudinal Profile of Floodway

(2) Work Quantity

Quantity of the major items is estimated and shown as follows;

Table 3.4 Summary of Quantity on Major Items in Case-C

Case-C
Summary of Quantity : Case of Floodway at Right Side Bank

items	classification	unit	quantity				
			Inlet Section	Channell Section	Exsiting Dam Section	Closing Embankment	sub-total
excavation							
	soil	cu.m	1,900	36,000	37,000		74,900
	rock	cu.m	0	0			0
	sub-total	cu.m	1,900	36,000	37,000		74,900
embankment							
	main dam	cu.m			9,200	27,000	36,200
	soil blanket	cu.m			18,000	6,400	24,400
	random fill	cu.m		200	2,000	500	2,700
	sub-total	cu.m	0	200			63,300
concrete							
	wall	cu.m	500	1,400			1,900
	Apron	cu.m	1,900				1,900
	Slope protection	cu.m		200			200
	Ground sill	cu.m		500			500
	river protection	cu.m		2,900			2,900
	sub-total	cu.m	2,400	5,000	0		7,400

(3) Effects to the environment

Construction works of this case is only carried out within the existing dam area including dam reservoir. The new floodway is designed in the area of the existing floodway and there might be no adverse effects to the environment.

(4) Workability

The new floodway construction works can secure the safety against flood occurrence because the opening section of the existing dam is functioning as spillway during the flooding period.

During the closing works of the opening section, temporary cofferdam located in immediate upstream of the site could divert the floodwater to the newly constructed floodway.

Therefore, the construction works should be planned with stepwise construction like the newly construction of floodway at first stage and the closing works at second stage.

3.2.6 Comparison of the Structural Measures

Comparison of Case-A, -B and -C is summarized and shown in the Table 3.5 as follow;

Table 3.5 Comparison among the Alternatives

Case	Profile	Advantage	Disadvantage	Quantity (cu.m) of Main Dam Section			Direct Construction Cost
				Excavation	Embankment	Concrete	
A	Construction of concrete dam with spillway to close the opening of the existing dam	Flood water shall be discharged into the existing water course with the original flow direction since a center line of the proposed spillway on the concrete dam is set on the center line of the existing water course. It is not necessary to construct a new floodway. It is expected to minimize the change for natural environmental and existing hydraulic conditions in the upstream and downstream of the existing dam.	Flood might flow over the dam construction site or additional diversion works is required during the construction period. A turbulent flow is prone to appear in immediate downstream of the dam since the high velocity flow fallen down from the spillway is created thought the dam height. The foundation of proposed dam shall be improved to resist the required subgrade reaction generated by main dam body stability since the existing riverbed has been turbulent caused by several flood.	81,400	52,000	10,100	3.87 Billion Rials
B	Construction of new floodway on the right bank Construction of new earth dam to close the opening of the existing dam	New floodway can be placed on the solid foundation as exposed basement rock and the floodway distance can be shorter than the Alternative Case- C. It is expected to reduce construction volume of the required riverbed protection along new floodway.	Flood might flow over the dam construction site or additional diversion works is required during construction period. There is an unknown factor for the hydraulic influence on confluence between the new waterway and the Ghyz Ghaleh River because of new floodway construction. The heavy excavation volume, which is generated from the open cut of the right mountain, is required to construct spillway section of the new floodway.	103,000	65,800	9,700	3.93 Billion Rials
C	Construction of new floodway on the left bank Construction of new earth dam to close the opening of the existing dam	The new floodway construction site is not close to the exiting dam rehabilitation site, comparatively. New floodway, after construction, can be utilized as temporary diversion channel during closing works of the existing dam opening section. It is expected to continuously execute the construction work for all year around and to contribute the construction period and expense reductions.	Floodway shall be constructed on the soil or sand-gravel layer. There is an unknown factor for the hydraulic influence on confluence between the new waterway and the Ghyz Ghaleh River because of new floodway construction.	74,900	63,300	7,400	3.35 Billion Rials

Note: Quantities and costs above the table show the amount of construction work volume for respective essential structures only.

The comparison results are described below.

- The most expensive works is extracted as Case-B because of the largest quantity of excavation and comparative larger amount of concrete placement among the alternatives.
- Case-B has also environmental negative effects because of the largest man-made slope appearance on the right side mountain due to excavation works for new spillway construction. Thus it is apprehensive about the natural environment changing after construction period.
- Case-A is the second expensive case and this case has disadvantage on workability, which could cause additional cost of temporary cofferdam.
- Case-C is the most inexpensive and its disadvantage is not critical because the modification scheme based on the Case-C can overcome the problems.

Therefore, Case-C is most preferable among the three alternatives.

3.3 Updating of Selected Case-C

Among the three alternatives as first screening, Case-C is selected as the most efficient plan based on economic, environmental and technical aspects, and the F/S study has the task of the hydrological characteristics review with the Master Plan Study results.

In the middle of F/S study period, the latest hydraulic characteristics in the Madarsoo River basin are provided by the review of hydrological analysis. As long as preliminary designs for alternative study, there are some points to improve the plan Case-C with the said hydraulic conditions. The design flow and profile arrangement of floodway as well as some more details on the design are made to improve the precision of construction cost.

Additionally, it is confirmed that the review for hydraulic condition can hardly affect the result of structural measure's selection on the initial screening.

3.3.1 Modification

Design Discharge

Inlet and weir sections of spillway shall be designed to accommodate discharge of 100-year flood, while floodway channel section is designed on the discharge of 25-year flood because inlet section would have more destructive damage than channel section due to probable floods.

Here is that inlet and weir section are defined with the section between the weir of the spillway to B1, and channel section are between B2 to the downstream end of the channel.

Therefore, the dimension of the channel section is given as follows;

The spillway section is applied with weir formula due to effects of backwater and water head loss, while hydraulic characteristics of channel section is provided with uniform flow calculation, resulting as follows;

Table. 3.6 Required Dimension of Guide Wall in Inlet Section

h3 (m)	2.4
B1 (m)	45
Q (cu.m/s)	302
Qd100	300
h'3 (m)	0.8
Total Depth of Spillway (m)	3.2

h3 (m)	1.6
B1 (m)	45
Q (cu.m/s)	163
Qd25	160
h'3 (m)	0.6
Total Depth of Channel (m)	2.2

The proposed channel section is applied with uniform flow calculation by manning formula. The results are tabulated as follows;

Table. 3.7 Required Dimension of Channel Section

Section with Channel Slope Gradient of 3/100

Item	Value	Remarks
Design Riverbed Width	B = 45.0m	
Design Water Depth	H = 0.5m	
Design Side Slope Gradient	1:0.5	
Roughness Coefficient	n = 0.015	
Design Flow Velocity	V = 7.22 m/s	
Design Discharge	Q = 160.0 m^3/s	25-year flood

Section with Channel Slope Gradient of 2/100

Item	Value	Remarks
Design Riverbed Width	B = 45.0m	
Design Water Depth	H = 0.5m	
Design Side Slope Gradient	1:0.5	
Roughness Coefficient	n = 0.015	
Design Flow Velocity	V = 6.61 m/s	
Design Discharge	Q = 160.0 m^3/s	25-year flood

Based on proposed channel bed gradient of Case-C on the initial screening, the hydraulic estimation with Manning's formula shows that design water depth is significantly reduced instead of high design flow velocity appearance.

The high flow velocity appearance causes that the channel bed requires the riverbed protection, like a concrete structure, to prevent riverbed scouring. However, the requirement of riverbed protection against high flow velocity is prone to increase overall construction cost since the riverbed protection is completely placed along the floodway. Consequently, the channel slope gradient should be revised to minimize the construction cost.

3.3.2 Alternative Plan to Economize the Project Cost

Alternative Case-C is studied further to seek more economical cases. The original case is designed as channel works without any hydraulic drops, while the new alternative is considered with hydraulic drops to gentle the channel bed gradient more than the original one for minimization of channel bed protection.

<u>Channel Bed Protection</u>

Channel bed protection is designed with combination of groundsill or hydraulic drop, apron and concrete blocks. Design is carried out in individual sections enclosed by groundsill or hydraulic drop since the proposed water surface profile is broken off by a completed overflow appearance at the hydraulic drop structure. Profile arrangement of respective sections is shown in Fig. 3.4.

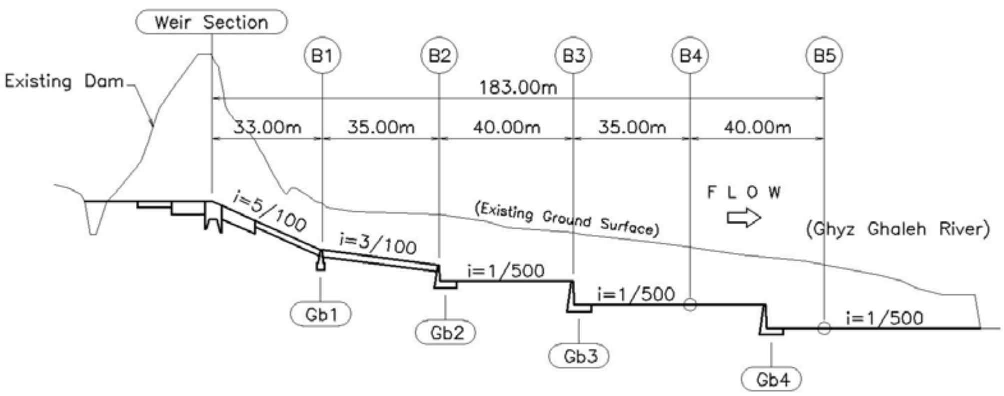


Fig. 3.4 Schematic Profile Arrangement for Bed Protection

Furthermore, a groundsill is designed to control flow direction at the bending portion of the channel and/or riverbed unstable section and hydraulic drop is set to gentle the channel bed gradient more than the original one.

(1) Channel Stretch between B1 and B2

Channel bed slope gradient in this stretch is applied for I = 3/100 following existing ground surface gradient and the upstream end, which is close to the proposed weir section, is changed into steeper slope gradient of around 5/100.

For a convenience of hydraulic examination, average of two slope gradients is employed for I = 4/100.

According to the Manning's formula, the flow velocity is estimated with almost 8 m/sec as shown in the followings;

Table. 3.8 Structural Features of Channel Stretch between B1 and B2

Item	Value	Remarks
Design Riverbed Width	B = 45.0m	
Design Water Depth	H = 0.5m	
Design Side Slope Gradient	1:0.5	
Roughness Coefficient	n = 0.015	
Design Flow Velocity	V = 7.96 m/s	
Design Discharge	Q = 160.0 m^3/s	25-year flood

Therefore, the channel bed still needs bed protection with concrete flooring as well as the original scheme on the initial screening in order to prevent channel bed from scouring during flooding time.

(2) Channel Stretch between B2 and B3

Channel bed slope in this section is set on slope gradient of 1/500 to reduce the design flow velocity, but B1-B2 section in the immediate upstream of this section has the slope gradient of 3/100 following the existing ground surface gradient and it is necessary to place the adjustment structure to different riverbed elevation at the changing point of slope gradient.

In order to dissipate flow energy, dissipater is required in this section to force the flow into hydraulic jump.

(3) Channel Stretch of B3 to B4 and B4 to B5 Sections

Channel bed slope is to be 1/500 supposed the flow is uniform without influence of the upstream section where the flow dissipater functions.

Flow capacity is calculated with Manning Formula and the calculated flow velocity is significantly reduced showing as follows;

Table. 3.9 Structural Features of Channel Stretch between B3 and B5

Item	Value	Remarks
Design Riverbed Width	B = 45.0m	
Design Water Depth	H = 1.9m	
Design Side Slope Gradient	1:0.5	
Design Channel Bed Slope	I = 1/500	
Roughness Coefficient	n = 0.035	
Design Flow Velocity	V = 1.87 m/s	
Design Discharge	Q = 160.0 m3/s	25-year flood

Such a flow velocity does not require protection works in the channel bed except immediately downstream of drop structure portions. The hydraulic calculation for the proposed hydraulic drop structure results that complete hydraulic jump is occurred in this case and the countermeasure against supercritical flow on the riverbed is required.

According to the hydraulic calculation, the required apron length is set for 5 m and distance of riverbed protection works is required for more than 20 m.

The result of modification on the slope is shown in Fig. 3.5.

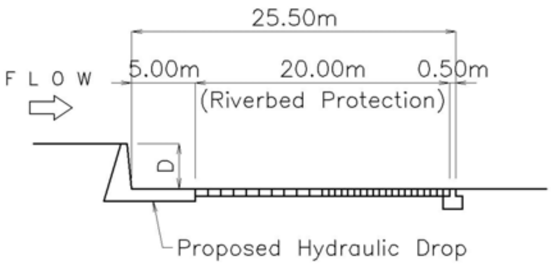


Fig. 3.5 Typical Cross Section of Channel Bed Protection Works

Guide Wall

(1) Spillway Section

Height of guide wall

The required height of guide wall in the spillway section is 3.2 m including freeboard height of 0.8 m. This required height is based on the consideration with the design discharge of 100-year flood.

Type of guide wall

The structural type of guide wall is proposed as concrete gravity wall, taking into account the unity between spillway structural member and sidewall member on the construction workability.

The structural type consideration shall be conducted in the detail design stage with the required additional information.

(2) B1 to B2 Section

Height of guide wall

The required height of guide wall in this section is 1.1 m in minimum, including freeboard height of 0.6 m. This required height is provided with the consideration of the channel structural scale determination on 25-year flood.

In considering continuation from the spillway section, the wall height should be gradually changed in a transition zone, which should be 10 m from B1 to the downstream.

Type of guide wall

The structural type of guide wall is proposed as concrete gravity wall or leaning wall type. The structural type consideration shall be conducted in the detail design stage with the required additional information.

(3) B2 to B3 and B3 to B5 Sections

Height of guide wall

The required height of guide wall in this section is 2.5 m including freeboard height of 0.6 m. This required height is provided with the consideration of the channel structural scale determination on 25-year flood.

Type of guide wall

The structural type of guide wall is proposed as concrete gravity wall or leaning wall type. The structural type consideration shall be conducted in the detail design stage with the required additional information.

3.4 Proposed Sediment Control Dam Works

3.4.1 Structural Dimensions

The proposed plan, longitudinal profiles along the dam axis and along the channel center line designed as alternative modified from Case-C are shown in Figs. 3.6 to 3.8. The typical cross section of the new earth dam to close the opening of the existing dam is shown in Fig. 3.9.

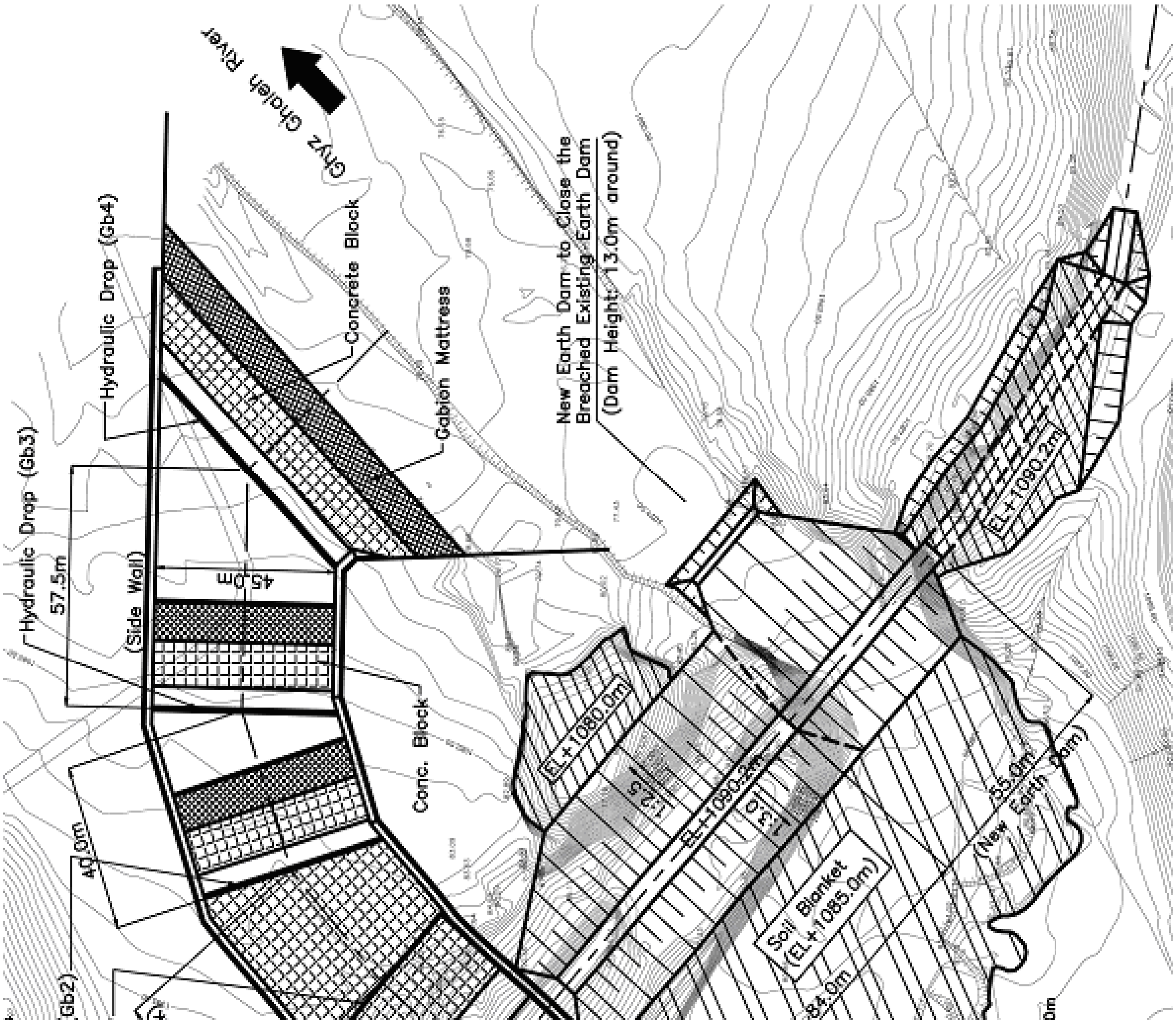


Fig. 3.6 Plan of Proposed Sediment Control Dam Works

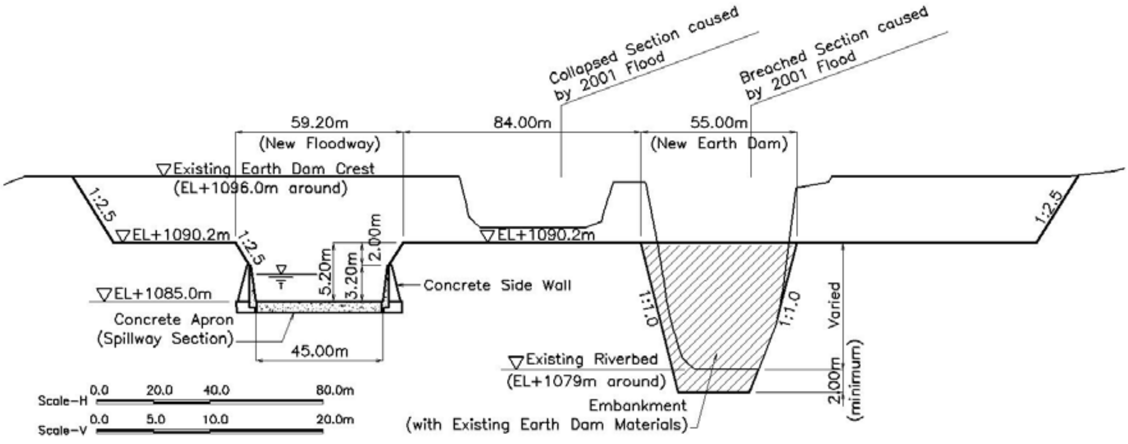


Fig. 3.7 Typical Cross Section of Proposed Sediment Control Dam Works

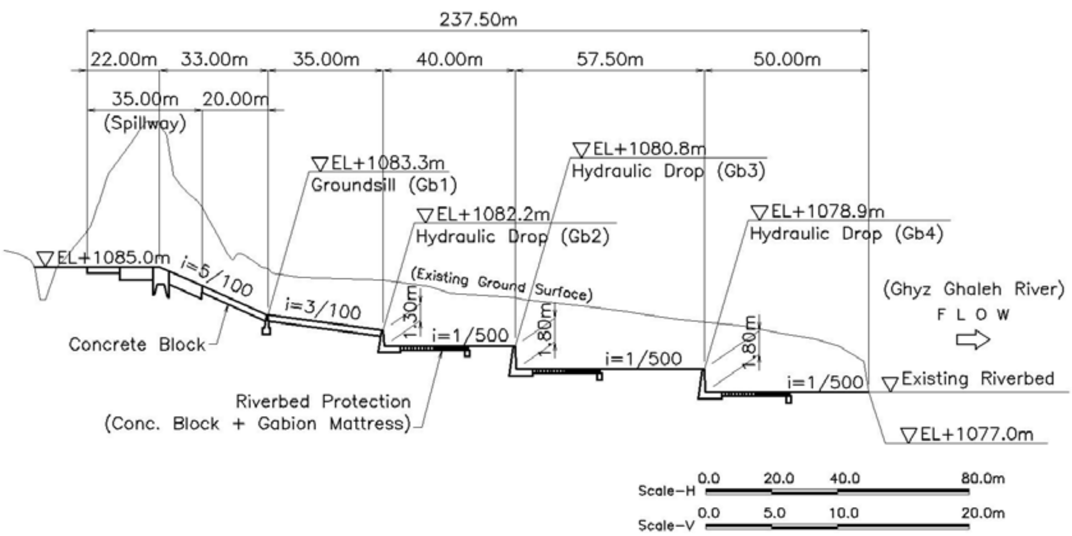


Fig. 3.8 Longitudinal Profile of Proposed Floodway

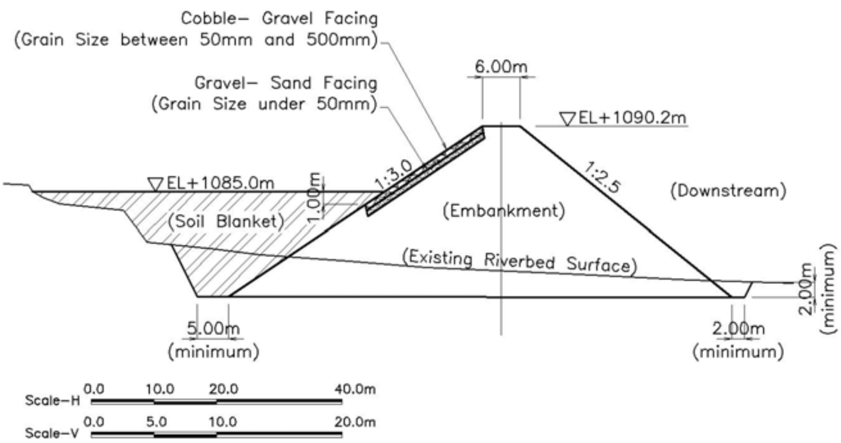


Fig. 3.9 Typical Cross Section of New Earth Dam

3.4.2 Project Cost

Works quantity and project cost for the sediment control dam works are estimated based on the abovementioned plan and the summary is shown in the following table;

Table 3.10 Summary of Project Cost

Alternative-C

Work Item	Quantity	Unit	Unit Price (Rials)	Amount (1,000 Rials)
I. Construction Base Cost				**8,739,000**
1. Preparatory Works	1	l.s.		795,000
(10% of Sub-total of Item 2 to 3)				
2. Sediment Control Dam (including rehabilitation of the breached existing dam)				7,944,000
a. Excavation				
- Sand & Gravel	92,300	m^3	7,000	646,100
b. Random Backfilling	2,500	m^3	7,000	17,500
d. Embankment	36,000	m^3	11,000	396,000
c. Soil Blanket	24,900	m^3	11,000	273,900
e. Removal of the Surplus Soil	29,000	m^3	19,000	551,000
f. Sodding	2,500	m^2	1,000	2,500
g. Concrete				
- Plain Concrete	2,010	m^3	270,000	542,700
- Reinforced Concrete (including 20kg rebar)	2,350	m^3	355,000	834,250
- Wet Stone Masonry	830	m^3	227,000	188,410
h. Slope Facing				
- Cobble- Gravel Facing (t=50cm)	1,930	m^3	34,000	65,620
- Gravel- Sand facing (t=50cm)	1,930	m^3	9,000	17,370
i. Gabion Mattress	2,090	m^3	149,000	311,410
j. Concrete Block				
- 1.9ton/piece		nos.	602,000	0
- 1.2ton/piece		nos.	443,000	0
- 0.6ton/piece	9,146	nos.	301,000	2,752,946
- 0.5ton/piece		nos.	235,000	0
- Gravel Bedding under the Conc. Block	2,200	m^3	9,000	19,800
k. Miscellaneous	1	l.s.		1,324,494
(20% of "a" to "j")				
II. Land Acquisition Cost				**0**
a. Dry Farming Land	0	m^2	400	0
b. Irrigated Land	0	m^2	4,200	0
c. Orchard	0	m^2	11,000	0
d. Residential Area		m^2	60,000	0
III. Administration Cost	1	l.s.		**437,000**
(5% of Item I)				
IV. Engineering Cost	1	l.s.		**874,000**
(10% of Item I)				
V. Physical Contingency	1	l.s.		**2,010,000**
(20% of Item I + II + III + IV)				
VI. Total				12,060,000
Round Total				**12,060,000**

Note:
-Unit price is as of 2004 (in accordance with the Islamic Year of 1383).
-Unit price is provided from the Iranian work efficiency issued by the Management and Project Organization (PMO) in 2004.
-Number of individual ratio for indirect cost is referred with the previous JICA study adopting.

3.5 Conclusion

Alternative study is carried out with three alternatives selecting Case-C and modification of the Case-C is also carried out in some aspects to confirm the technical feasibility. The execution with the Case-C plan is presenting the following technical advantages and resulting in confirming that the scheme of Case-C is technically feasible.

- Discharge of the sediment accumulated in the reservoir area of the Ghiz Ghaleh River is restricted on the site with the crest elevation at EL+1085 m of the new spillway weir in the upstream end of floodway and that is the main purpose of this project.
- Stability of the new earth dam is secured to utilize watertight soil employed from some part of the existing dam with enough quantity located in situ.
- Risk of flood during construction period is minimized with applying two phased construction works with temporary cofferdam.
- Adverse effects to the environment are minimized with excavation carried out only in the existing dam area.
- It can be realized to reduce the construction cost for riverbed protection works employing hydraulic drop structures more than the original scheme without the hydraulic drop structures since the hydraulic drop structure contributes to maintain the gentle channel bed slope gradient and avoid the high flow velocity occurring during the flood time.

3.6 Recommendation

This study has been carried out as preliminary survey so that the more detail in survey, planning and design should be conducted to elaborate the implementing plan. In this regard, followings are recommended;

- To carry out further site survey to identify watertight layer with trial excavation.
- To conduct the laboratory test for embankment applicability to know how much of the density is obtained as well as trial compaction test in situ using actual site material.
- To execute the detailed design with the required additional survey results to determine the detail dimension of the structures, to estimate the project cost precisely and to elaborate the implementation schedule.
- To consider the protection work on the front slope of dam body against overtopping floodwater such as concrete lining or placement of concrete block, if necessary after detailed hydrological designing, for securing the safety of dam body.