Alternative Management Plan for Flash Floods/ Flows of Mithawan Hill Torrents in Pakistan

Zeshan Yasin[1], Ghulam Nabi[2]

Abstract— Water is a back bone not only for Agriculture but for every industry. One of the major sources of water is the Hill Torrents which emerges from the mountains and diverted towards Agriculture fields for irrigation. Due to steep gradient, flood flows with high velocity which results in damaging to standing crops, irrigation system, houses, roads and sometime human lives also. The flood of hill torrents having a lot of potential for agriculture to meet the shortage of food if manage wisely. Dera Ghazi Khan (D.G. Khan) hill torrent zone is one of the largest zone in Punjab province of Pakistan which emerge from mountains of Suleiman range. Mithawan Hill Torrent is one of the largest hill torrents of D.G. Khan Zone. Different options have been studied during this research to know that how the barren land will convert into lush green fields to meet the food requirements of the country. Peak discharge of Mithawan at Darraha was estimated 79,045 cusecs[1] at 25 year return period by interpolating rainfall data. The study includes detail analysis and investigations of four options for Mithawan Hill Torrent management. The 6000 cusecs discharge of Kachhi Canal is beneficial for the agriculture of Baluchistan province of Pakistan only if safe cross drainage structures will propose at the crossing of Mithawan Hill Torrent. Result of the study revealed that flow of Mithawan hill torrent can be managed through a number of ways. It is concluded that flow of Mithawan can be managed by a combination of reservoir and utilization in pachad[2] area (Option-4). Present study will be helpful in developing the Agro based community in the Hill torrents affected areas and for the design of cross-drainage structures & storage reservoir at different locations.

Key Words— Agriculture, Pachad Area, HEC Geo-RAS, HEC-RAS, Alternative management plan, Arc-GIS, EAC[3], Cross Section.

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1 It's a unit of volume i.e. cubic feet per second
2 Area Irrigated with hill torrent water.
3 Elevation Area Capacity Curve

1. INTRODUCTION

Hill Torrents contributes about 65% (517,461 Sq. Km) area of Pakistan and almost entire area of Baluchistan (347,190 Sq. Km) [9]. The pattern of rain fall in D.G. Khan hill torrent areas is very un-realistic as a year with heavy rain fall in catchment generating intense run-off may followed a drought year with low or no rainfall. This zone falls in arid to semi arid zone as average annual rain fall is of the order of 400 mm.

Mithawan Hill Torrent leaves the mountains near village Choti Bala and fans out in pachad area into number of creaks. These are Northern Branch, Southern Branch and Ganahar Branch. After utilization sufficient amount of flood water for irrigation in these branches the remaining flow directly hit Kachhi Canal. Some damages scenarios of Kachhi canal because of Mithawan hill torrent is shown in figure 1, which is taken from Google Earth.

Figure1, Damages of Kachhi Canal due to Mithawan hill torrent flow.

Kachhi Canal is a project of National interest to supply 6,000 cusecs (170 Cumecs) water to Baluchistan province for irrigation purposes. Management of flood during low flows is not an issue as this water easily being consumed in Pachad area. The real problem starts during high flows as these flows are above the bearing capacity of pachad area. Being a contour channel, the Kachhi canal would irrigate on its left side. D.G. Khan Canal will also have its command area on the left side, whereas, no arrangement is available or proposed to irrigate the right bank side. The hill torrents will also emerge from the right side of the canal, passes through canal and fall in the Indus River.

During 1958, Mr. G. E. Meads, an FAO[4] expert [8] visited the area and suggested different options for safe disposal of hill torrent water. These included storage dams, retarding dams and check dams on various hill torrents. At later stages it was found that geological formation is very poor. Therefore, these proposals were not executed so far.

Various flood management strategies have been reviewed by NESPAK[5] 1998 [11] and it has been concluded that the most prudent strategy would be to construct appropriate flood dispersion and diversion structure supported by a surface drain to safely carry the left overflow to the Indus.

Tate et al. 2002 [15] mentioned that the process for the development of a terrain model by using HEC-RAS hydraulic model can be facilitated with the help of geographic information system (GIS) based approach. The first step in this process is to export channel data from HEC-RAS to GIS, on the basis of this data, the hydraulic model coordinates can be converted to geographic coordinates. The terrain model so formed is much accurate when compared with high-resolution terrain data acquired through aerial photographs.

Alemaw et.al, 2003 [1] mentioned that GIS has the capability of handling large amounts of spatially detailed information derived from various sources such as remote sensing and ground surveys. With the advent of increasing computing power and GIS techniques, physical-based hydrologic modeling has become important in contemporary hydrology for assessing the impact of human intervention and/or possible climatic change on basin hydrology and water resources.

Nawaz and Han 2006 [9] concluded that if the proper storage facility and modernized structures are provided in hill torrent affected areas then not only the flood is controlled but also the drought conditions can be mitigated and the crops yield can be enhanced.

Recommendation by Mr. Javed et al 2007 [8] is comprised of the following strategies for hill torrent affected areas.

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[4] *FAO, Food and Agriculture Organization*

[5] *National Engineering Services of Pakistan*

- Different diversion/distribution structures can be used in Pachad Area to utilize flood flows for agriculture purposes;
- Excess flows can be diverted to River Indus through channelization in CRBC6 command area;

Garry W. Brunner 2010 [6] describe that HEC-RAS is an integrated system of software, designed for interactive use in a multi tasking, multi user network environment. The system is comprised of a graphical user interface (GUI), separate hydraulic analysis components, data storage and management capabilities, graphics and reporting facilities.

2. The Study Area

Mithawan hill torrent situated in District Dera Ghazi Khan of Punjab Province of Pakistan between longitudes 69o 10′ E to 70o 49′ E and latitudes 28o 27′ N to 31o 20′ N, having almost polygonal shape, drains an area of 710 square kilometer at an elevation of 2107 meter above mean sea level (AMSL). The location map and catchment area is shown in figure 2. Kachhi Canal off-takes from Taunsa barrage over the river Indus in Punjab Province and irrigate about 713,000 acres of culturable command area in Kachhi plain of Baluchistan. Highly silted water of Mithawan directly hit Kachhi canal, breach its banks and enter in canal, disturb canal supply, damage infrastructure, roads, crops and effect live stock and humans also. The safe drainage of Mithawan hill torrent flow at Kachhi canal is very necessary for efficient use of canal water. During flood season the existing cross drainage structures are chocked due to heavy sediments and overtopped Kachhi Canal which affects downstream areas. In extreme flood situation it needs to breach the canal and irrigation supplies are affected.

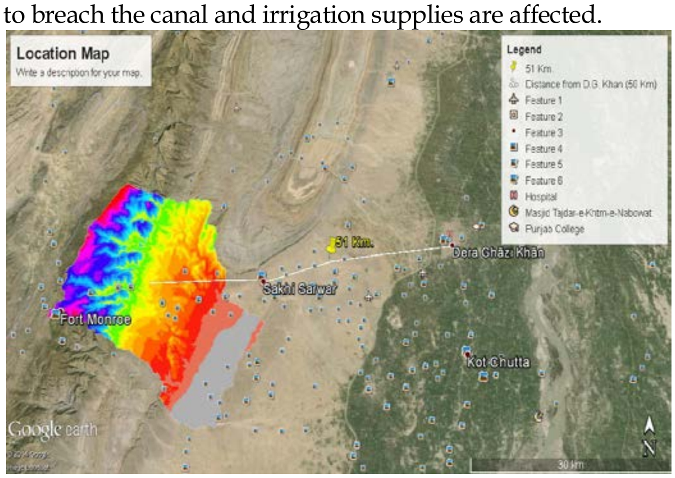

Figure-2. Location map and Catchment area of Mithawan hill torrent

3. METHODOLOGY

Frequency analysis has been carried out by using Gumbel Extreme value Type-I distribution. It was estimated that 79,045 cusecs discharge has been reached at Darraha at 25 years return period. This flood has to be managing in the catchment of Mithawan hill torrent as this flood is above the capacity of Agriculture fields. During this research four alternatives have been proposed for management of Mithawan hill torrent flow;

- Management through Pachad Region and through Cross Drainage structures at Kachhi Canal (Flow chart figure 3).
- Management through Sub-Mountainous Region, Pachad Region and through Cross Drainage structures at Kachhi Canal (Flow chart figure 4).
- Management in Mountainous region through reservoirs (Flow chart figure 5).
- Management in Mountainous region through reservoir and Pached Region (Flow chart figure 6).

[6] *Chashma Right Bank Canal Project*

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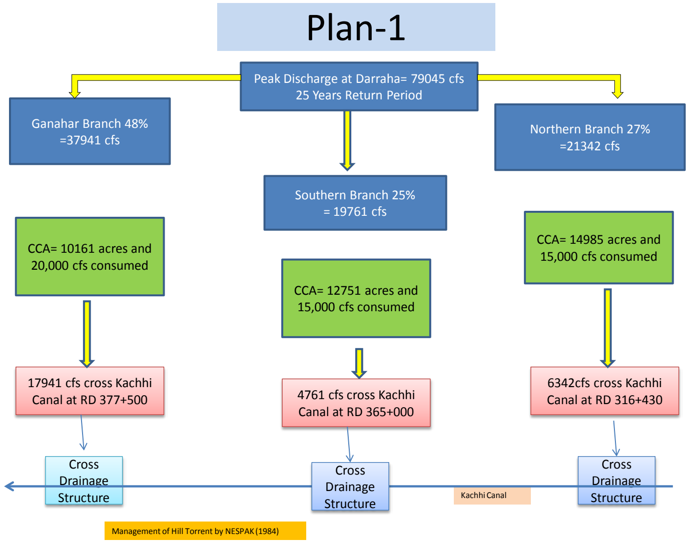

Figure 3 Schematic view of paln-1

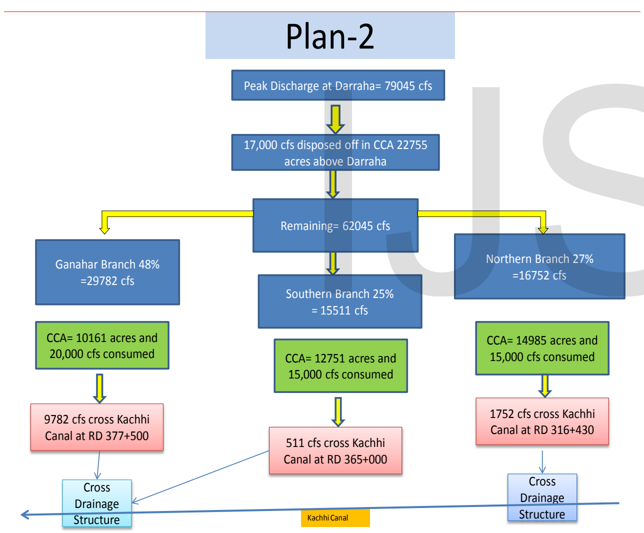

Figure 4 Schematic view of paln-2

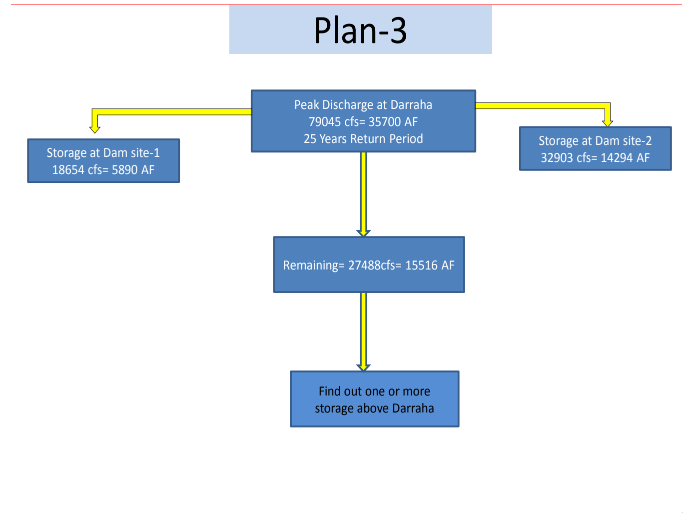

Figure 5 Schematic view of paln-3

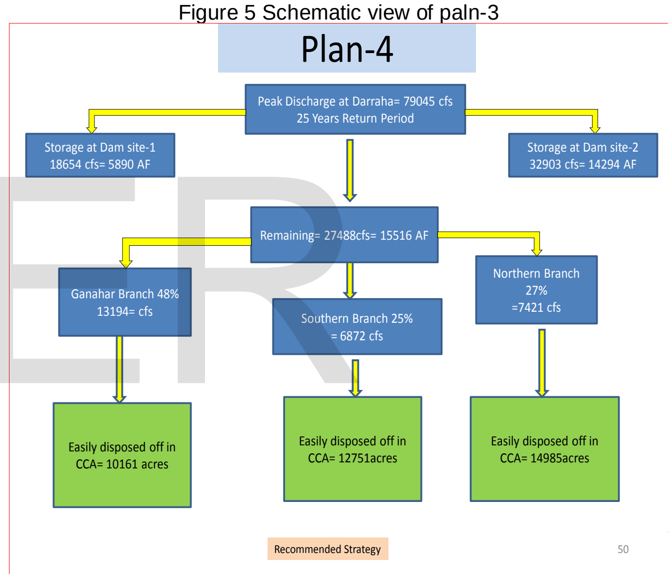

Figure 6 Schematic view of paln-4

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All the plans mentioned above seem good for management of Mithawan flow. The plan 3 and plan 4 found quite reasonable as the main strategy behind this is to consume/ utilize the water where it generates. The peak discharge to be estimated at 25 year return period is 79,045 cusecs at Darraha. The structural safety of Kachhi Canal is the necessity for the people of Baluchistan province of Pakistan. Ample quantity of water was found wasted with plan 1 and plan 2 as flow crosses Kachhi Canal and finds its way to Indus River after causing damages. I started working on plan-3 as discussed below and suggested plan-4 as perfect to meet the demand of the area for irrigation and then to save surplus water which could be consumed in drought season or when demand arises. The following steps are used for plan-4.

3.1 Dam site Option-I and Option-II

Marked the approximate catchment area of Dam site-1 and the Dam Axes location on Google Earth. Import this file into Arc GIS to draw contours at 10 m interval. Surface areas and Surface volumes were determined by using Arc hydro tools option of GIS. Finally, Elevation Area Capacity Curve (EAC) was finalized.

3.2 HEC-Geo RAS

HEC-Geo RAS is a Geographic river analysis system developed using Desktop and Arc GIS Spatial Analyst and 3D Analyst extensions. The geo data base design supports analysis of spatial data for hydraulic modeling and floodplain mapping. HEC-RAS is River Analysis system used to find out water surface profiles, area of the stream, Discharge through stream, Wetted perimeter, velocity and slope of the channel. The geometry of cross section of Dam site option-1 is shown in figure 7.

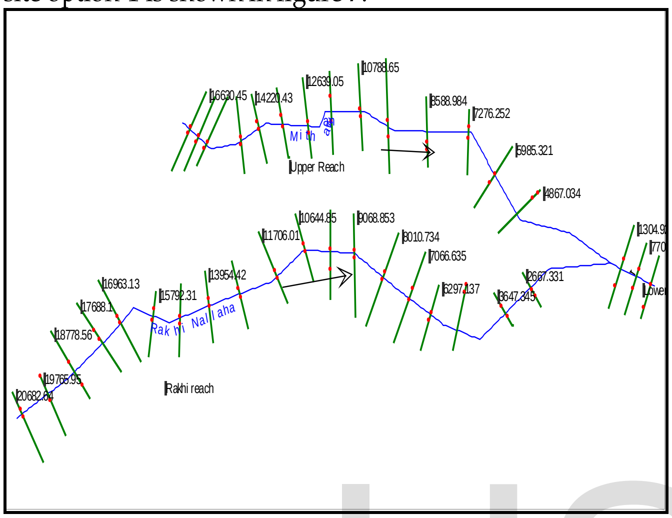

Figure 7 Geometry of Dam site-1 in HEC-RAS

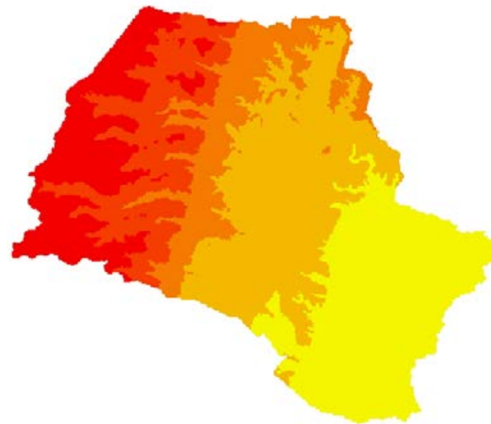

Figure-8 (a) Fill Sinks

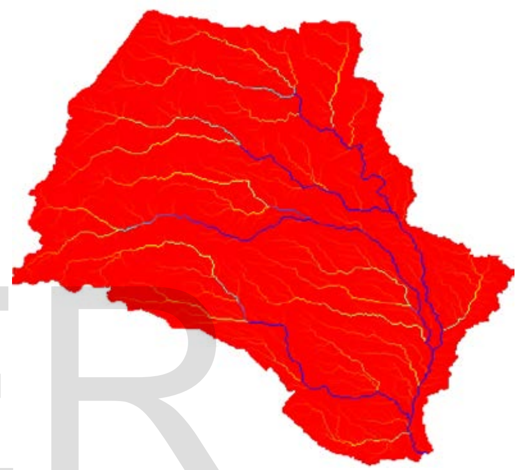

Figure-8 (b) Flow Accumulation

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3.3 Steady flow data

Flow data and reach boundary conditions (upstream slope value and downstream slope value) have been inserted in HEC-RAS model. The "2" number of profiles have been added to estimated the water surface profiles at 25 year and 100 year return period.

3.4 Compute the Model

HEC-RAS model was run after adding all the necessary inputs for hydraulic simulation.

4. RESULTS AND DISCUSSION

The results of the preprocessing of terrain pre processing are shown in figures 8 (a) and 8 (b). The resultant Raw DEM of Mithawan is shown in Figure 9 (a) and Slope of the study area is shown in Figure 9 (b).

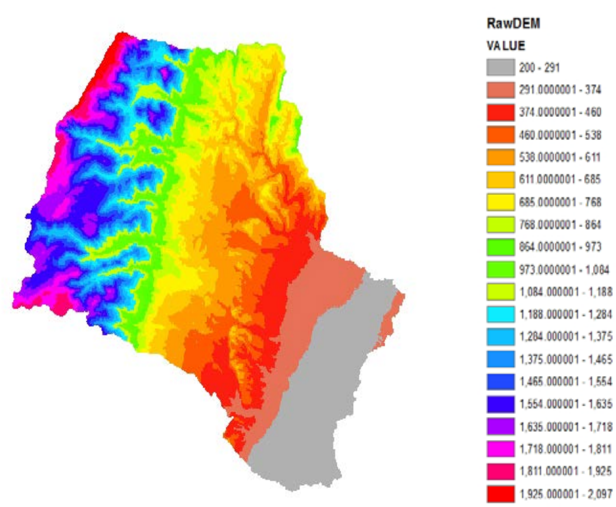

Figure 9 (a) Raw DEM and Elevations

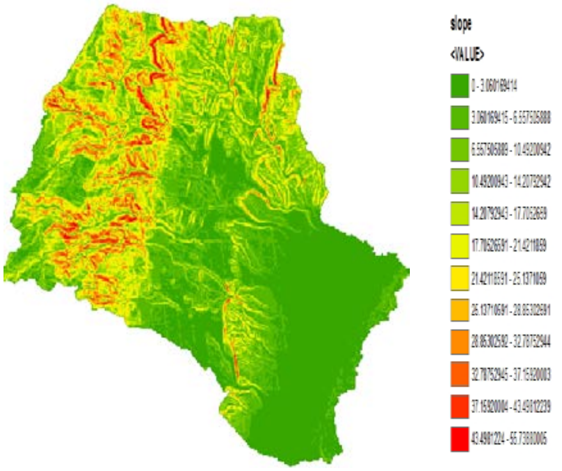

Figure 9 (b) Slope Difference of catchment

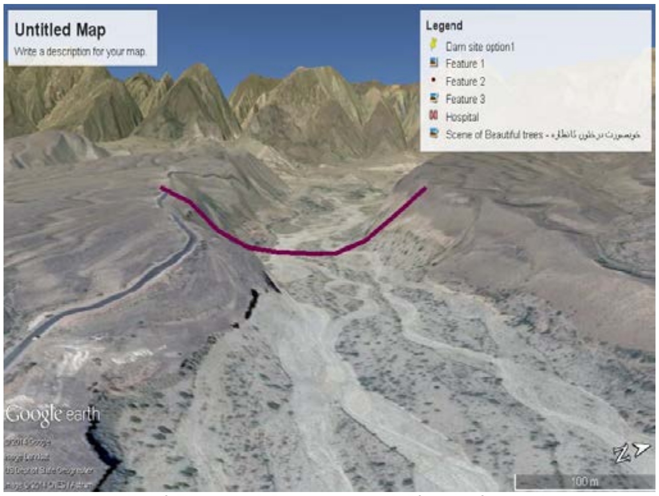

Figure 12 Dam Axes Dam site Option-1

Figure 11 Drainage line extracted from Arc GIS

4.1 Dam site Option-I and Option-II

The resultant figures for Dam site option 1 are shown from figure 10 to figure 13. Elevation Area Capacity Curve (EAC) and Cross Section at Dam Site option-1 is shown in Figure 14 and Figure 15 respectively. The cross section in HEC-RAS at outlet is shown in figure 16.

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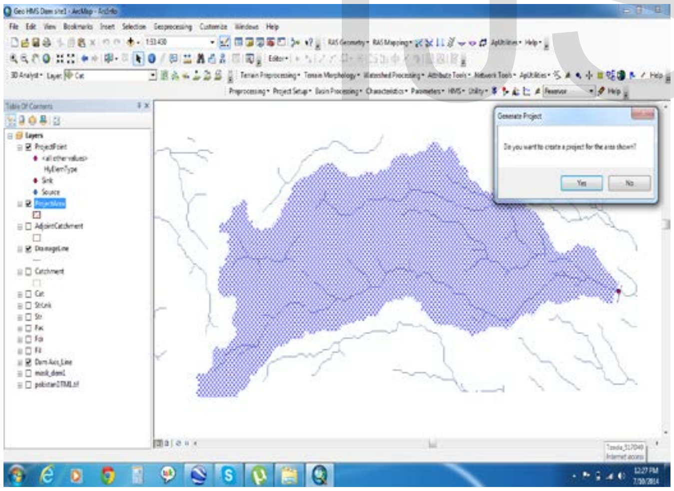

Figure 10 Area of Dam site Option-1

Figure 13 Cross Section along the centre line

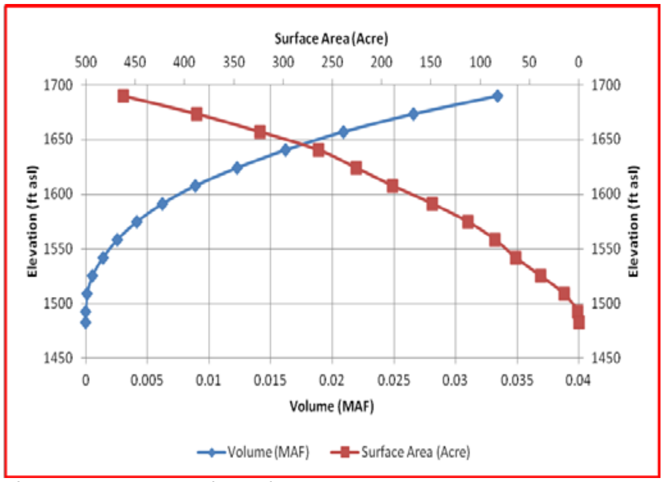

Figure 14 EAC Dam site option-1

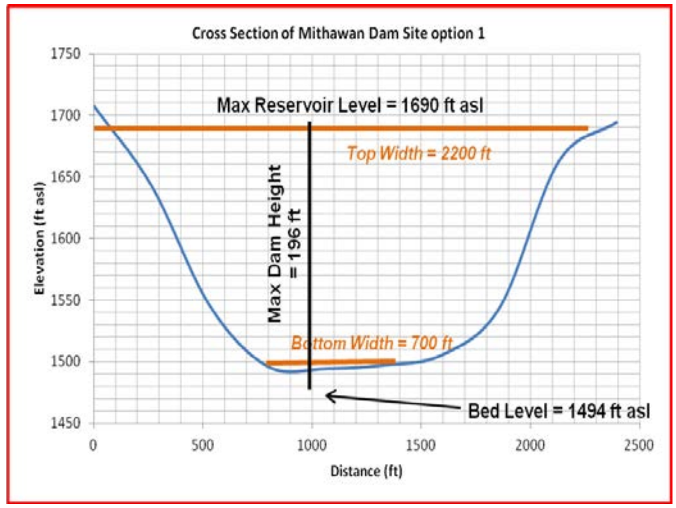

Figure 15 Cross section of Dam site Option-1

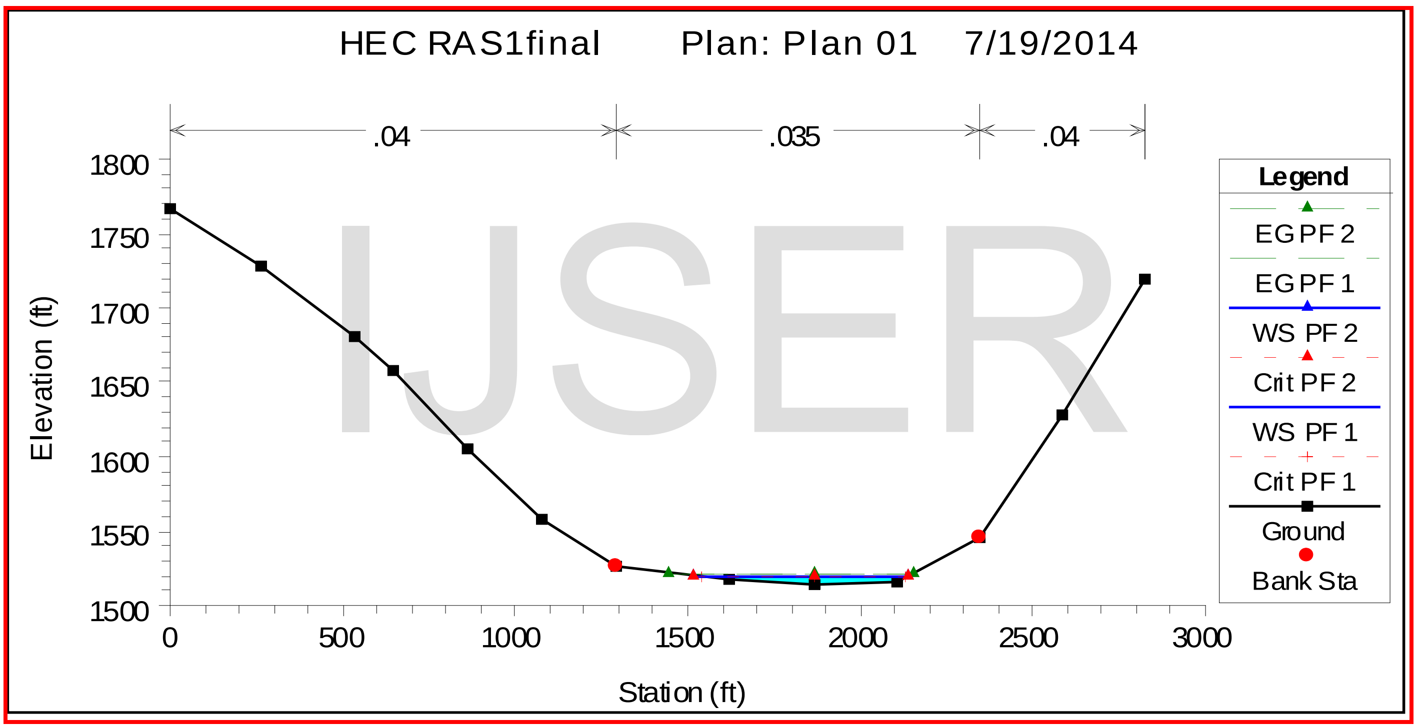

Figure 16 Cross section of Dam site along with water profile at 25 and100 year return period using HEC-RAS.

4.2 Geometric Parameters

The Summary of Geometric Parameters of Dam-1 and Dam-2 is shown in table 1. Height of dam-1 and dam-2 were 196 ft and 209 ft. with storage capacity of 0.018 MAF7 and 0.026 MAF respectively. Maximum Reservoir level is 1690 ft and 1417 ft for Dam-1 and Dam-2 respectively.

[7] *MAF is Million Acre Feet*

TABLE 1

SUMMARY OF GEOMETRIC PARAMETERS.

Description	Dam option-1	Dam option-2
Max. Reservoir Level	1690 ft	1417 ft
Bed Level	1494 ft	1208 ft
Top Width	2200 ft	3600 ft
Bottom Width	700 ft	1200 ft
Height of Dam	196 ft	209 ft
Storage Capacity	0.018 MAF	0.026 MAF
Water availability at 25 years return period	5,890 AF	14,294 AF

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5. CONCLUSION

The total capacity of two storages is about 52,000 cusecs (20,000AF). The remaining 27,000 cusecs (15,700 AF) can be easily used in Pachad area i.e 48% (7,536 AF) in Ganahar Branch, 25% (4,000 AF) in Southern Branch and 27% (4,200AF) in Northern Branch. Three cross-drainage structures of 17,941 cusecs, 4,761 cusecs and 6,342 cusecs capacities have been finalized at Kachhi Canal Crossing RD[8] 377+500, RD 365+00 and RD 316+430 respectively. Various management plans for Mithawan hill torrent flow have been studied and found four options suitable for present case study. These management plans will also save Kachhi Canal from siltation and also save entire humanity from damages of floods and in this way the 6,000 cusecs discharge of Kachhi Canal is beneficial for the Kachhi plain of Baluchistan (Pakistan). It is recommended that management plan-4 i.e. management through a combination of storage dam and utilization in Pachad area is the best option for the current scenario, the same is recommended by [8], [9] and [11].

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[8] *RD is Reduce Distance used for canal miles i.e. 1RD=1000 ft.*

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