Sindh Univ. Res. Jour. (Sci. Ser.) Vol. 45 (1): 149-152 (2013)

SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)

Hydraulic Modeling of Natural Waterways of left bank of River Indus in Sindh with HEC-RAS

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Received 8th November 2012 and Revised 19th February 2013

Abstract: The heavy monsoon rainfall of 2011 in Sindh brought great miseries for the people of the area. Looking at the quantum of runoff generated the need for additional drainage facilities in the area were felt. It was observed that in addition to the Left Bank Outfall Drainage (LBOD) system working in the area, a large amount of water got drained due to natural waterways in the area. An analysis is thus carried out to ascertain the conveyance carrying capacity of the natural waterways using HEC-RAS software. The results show great potential for draining rainwater with the revival of these waterways

Keywords: River Indus, monsoon rainfall, Left Bank Outfall Drainage.

1. INTRODUCTION

As a result of high rainfall during the monsoon 2011 in Sindh and looking at the existing drainage facilities in the province, the need for additional facilities to cater for the removal of excess flood water was felt (Ansari *et al*, 2013). It was also seen that the natural waterways (locally called dhoras) where ever were in good shape helped a lot in disposal of quick storm water from the area. A survey was thus carried out to look into the prospect of utilizing these waterways in case a more than normal rainfall again occurs in the area. The survey through satellite images and field visits showed a number of dhora systems present in the study area which if revived could be very beneficial in the quick disposal of storm water from the area.

2. Natural Waterways (Dhoras) Systems in the Study Area

The first task after the heavy monsoon of 2011 was the identification of the natural waterways (dhoras) systems. These systems have been in place since centuries but have been disturbed in the name of development from time to time. A comprehensive survey was carried out in the area to look into the areas where the rainwater converged. This was a difficult task but was amicably done with the help of satellite images and field visits to the areas which were under water for a long time.

As the drainage system comprised of a very large area with large number of smaller sub-systems, it was decided to do the hydraulic analysis of some of these drainage basins to ascertain the workability of the whole system.

3. MATERIAL AND METHODS

Natural Waterways Modeled

Four dhoras were carefully selected to be modeled in the Hydrologic Engineering Centre's River Analysis System (HEC-RAS) software for the hydraulic analysis. **(Table 1)** lists the dhoras with their lengths in reduced distance (RD) as well as the length that has been modeled.

Table 1: The total lengths and the lengths of dhoras modeled.

Dhoro	Total Length (RDs)	Modeled Length (RDs)
Pithoro	90	90
Hakro	273	273
Nabisar	49	49
Puran	606	212
Total		**624**

The four dhoras that were selected are Pithoro, Hakro, Nabisar and Puran with a combined length of 624 RDs. A complete field survey was carried out in each of these dhoras at 5 RDs or less. The survey included the cross sections of these dhoras as well as any structures built across or beside it. It may be mentioned here that the cross sections of the channels as an input are the pre-requisites of the software. The cross sections of the dhoras were surveyed after every 5 RDs or less. The sites wherever there was some abrupt change in width of the channel or in curvature were considered.

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Table 2: The number of cross sections of each dhora modeled.

Dhoro	No. of cross sections modeled
Pithoro	24
Hakro	74
Nabisar	18
Puran	57
Total	**173**

(Table 2) shows the number of cross sections modeled in each of the drainage basin. In all 173 cross sections of the four basins were surveyed and modeled in the software. These cross sections showed the variation in quality of the drain at various places.

An analysis was carried out to ascertain the ability of the dhoras to carry the storm water in its existing condition. A design discharge of 20 year return period is selected for the analysis.

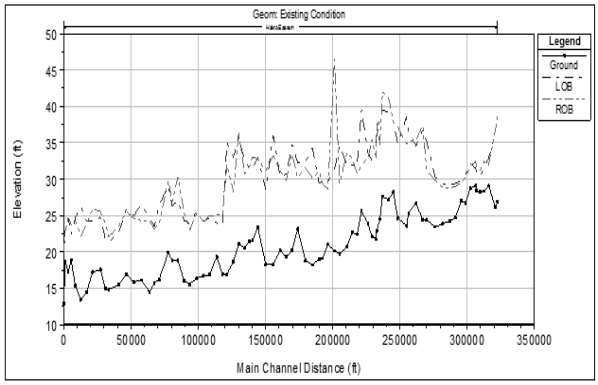


Fig. 1: Longitudinal section of Pithoro and Hakro Dhoras.

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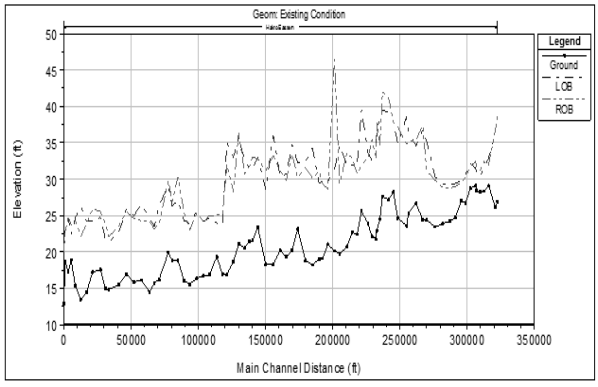


Fig. 1) shows the longitudinal section of the Pithoro and Hakro Dhoras with the lowest bed levels and the two bank/ground levels. It can be seen that the dhoras are silted up or have been filled up by the local people at various places and these are the vulnerable sections which create hindrances in the flow of water and need urgent attention.

4. RESULTS AND DISCUSSION

Hydraulic Analysis For Existing Condition

Hydraulic analysis for existing condition of the dhoras is done. The purpose was to see if these dhoras are able to carry out the storm water as intended during a high rainfall event. Table 3 shows the discharge calculated in various dhoras as a result of rainfall of 20 years return period. The hydraulic analysis of the dhoras was done with these discharges.

Table 3: Design discharges for various dhoras.

Dhoro	RD	Discharge (cusecs)
Pithoro	Complete	1675
Nabisar	Complete	1400
Hakro	273	2685
Puran	324 to 242	7535
	242 to 110	10525

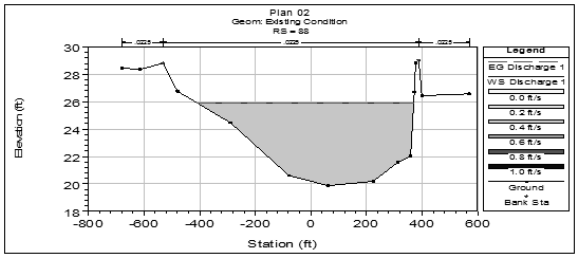


Fig. 2: Existing cross section of Nabisar Dhoro at RD 29+831 with a discharge of 1400 cusecs.

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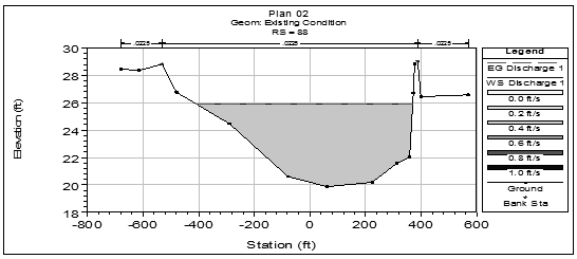


Fig. 2) shows the section of Nabisar Dhoro at RD 29+831 with the discharge of 1400 cusecs flowing inside it. It is clearly seen that the water is well within the boundaries of the channel and is flowing with a good velocity. This is a good section as discussed earlier and this is confirmed by looking at the results.

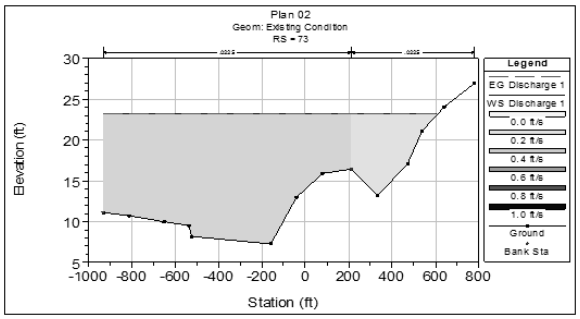


Fig. 3: Existing cross section of Hakro Dhoro at RD 33+831 with a discharge of 5085 cusecs.

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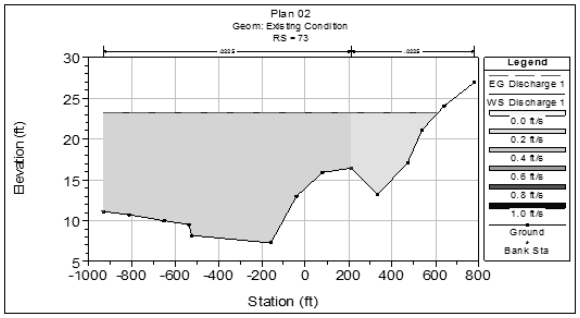
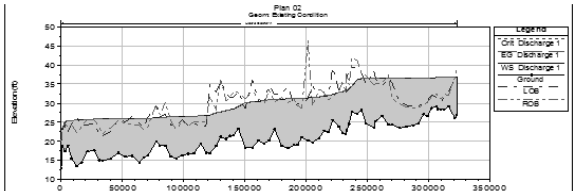


Fig. 3) shows the section of Hakro Dhoro at RD 33+831 with the discharge of 5085 cusecs flowing inside it. It is clearly seen that the water is not flowing well within the boundaries of the channel and is found to be overflowing on the left bank. An embankment needs to be constructed along this section so as to convey the storm water within the channel.



Dhoras with design discharge.

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Fig. 4), show the longitudinal sections of Pithoro and Hakro dhoras with their respective design discharges. It can be seen that the dhoras are not able to carry the design discharges and are found to be overflowing are various sections along their path.

5. Hydraulic Analysis For Proposed Channels

Hydraulic analysis for proposed channels the dhoras is done. The purpose was to see if these dhoras will be able to carry out the storm water as intended during a high rainfall event i.e. for a flood of 20 year return period.

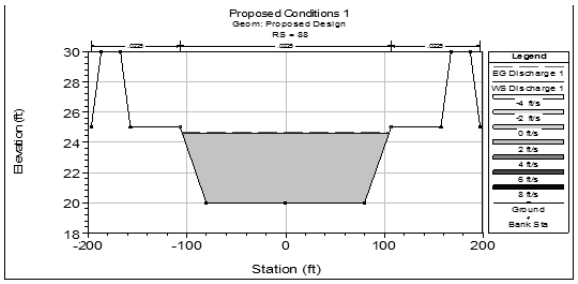


Fig. 5: Proposed cross section of Nabisar Dhoro at RD 29+831 with a discharge of 1400 cusecs.

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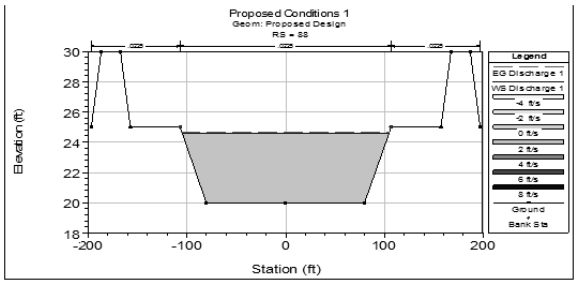


Fig. 5) shows the section of Nabisar Dhoro at RD 29+831 with the discharge of 1400 cusecs flowing inside it. It is clearly seen that the water is well within the boundaries of the channel and is flowing with a good velocity. This is a good section as discussed earlier and this is confirmed by looking at the results.

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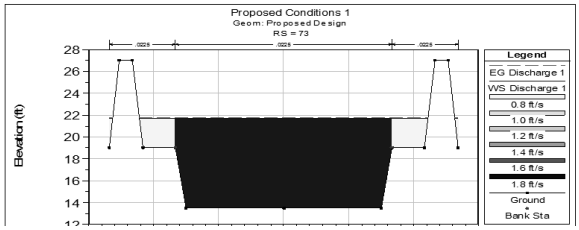


Fig. 6) shows the section of Hakro Dhoro at RD 33+831 with the discharge of 5085 cusecs flowing inside it. It is clearly seen that the water is flowing well within the boundaries of the channel unlike the section of the existing condition when it was found to be overflowing on the left bank.

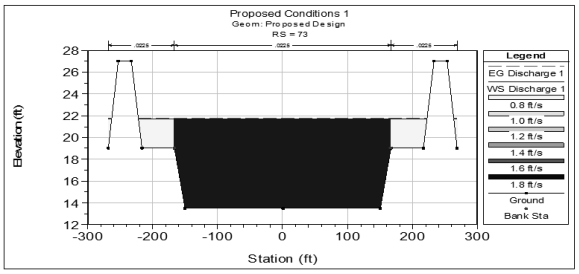


Fig. 6: Proposed cross section of Hakro Dhoro at RD 33+831 with a discharge of 5085 cusecs.

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Fig. 7), 12 and 13 show the longitudinal sections of all the four dhoras with their respective design discharges. It can be seen that the dhoras are able to carry the design discharges and are found to be flowing within their boundaries.

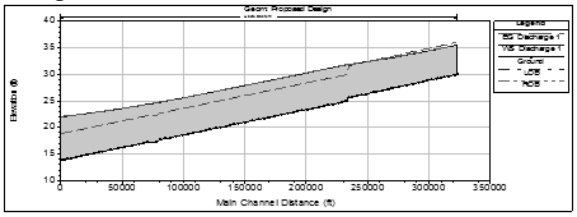


Fig. 7: Proposed longitudinal cross section of Pithoro and Hakro Dhoras with design discharge.

6. ANALYSIS OF RESULTS

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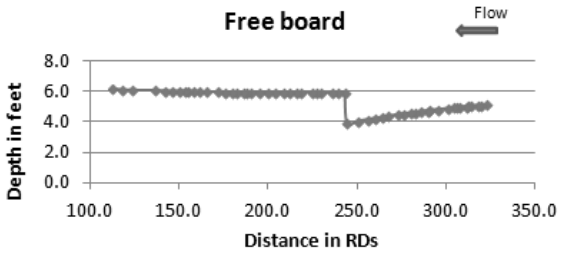


Fig. 8) shows the Free board available below the top of the bank of the proposed channel inside Dhoro Puran from RD 322+882 to RD 110+000. It can be seen that there is a clear free board of four to six feet is available throughout the whole length of the channel. The availability of the free board shows that the channel is flowing well below the top of the banks and will be able to accommodate additional storm water in case of higher rainfall events.

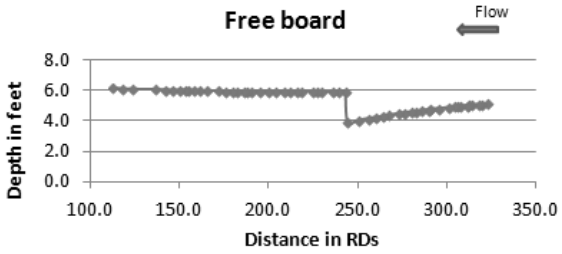


Fig. 8: Free board available below the top of the bank of the proposed channel inside Dhoro Puran from RD 322+882 to RD 110+000.

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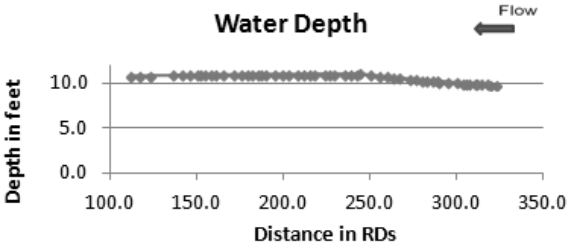


Fig. 9) shows the depth of water in the proposed channel inside Dhoro Puran from RD 322+882 to RD 110+000. The depth is found to be around 10 to 11 feet. The rise in the water depth in the upstream part is due to the addition of water in the channel from Bhai Khan Dhoro and then it starts to recede.

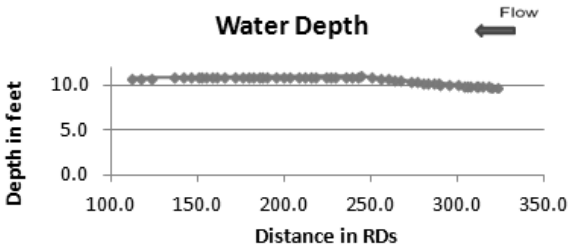


Fig. 9: Water depth of the proposed channel inside Dhoro Puran from RD 322+882 to RD 110+000.

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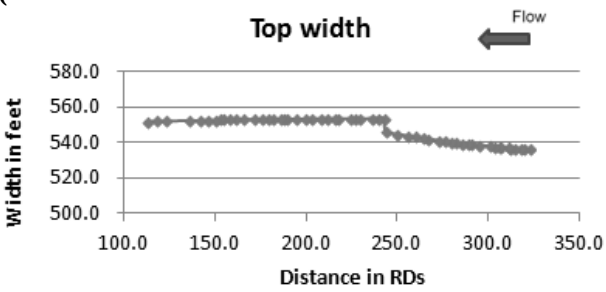


Fig. 10) shows the top width of water in the proposed channel inside Dhoro Puran from RD 322+882 to RD of the open channels and is thus analysed here as well.

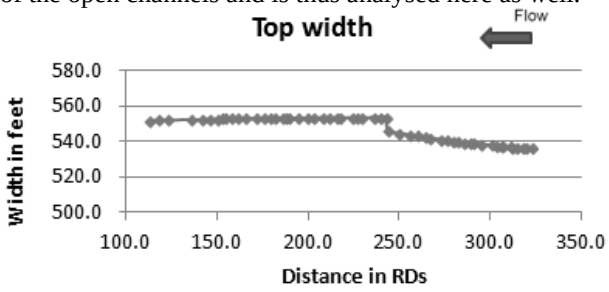


Fig. 10: Top width of the proposed channel inside Dhoro Puran from RD 322+882 to RD 110+000.

7. CONCLUSIONS

The following conclusions are drawn in the light of the above analysis:

- There is great potential of conveyance / disposal of flood water through the revival of natural waterways (dhoras).
- At some of the places these dhoras are in good shape and can be utilized efficiently.
- In some sections these dhoras have silted up / filled up and need to be cleared.
- Some sections specially the ones passing through towns have been encroached upon and may be reconstructed bypassing the town.
- Some of these dhoras have been blocked by irrigation canals where additional hydraulic structures such as siphons may be constructed.

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