

Shifts in Tarali River Channel, a Tributary of Krishna, in Post- Monsoon Low Flow Condition

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Abstract

The channel geometry in section or plan is basically the result of the interaction between the channel forming materials and the discharge that is passing through them. This is more evident in the areas where channels exist in alluvial materials which are highly erodible. Catastrophic events of high floods are well known for their devastating effects as well as for causing shifts in channel beds. The excessive deposition, within the channel and / or intensive erosion along the channel banks, changes the channel geometry both in plan and section. However it is not necessary that always such changes are the results only of catastrophic events. Slow but definite erosion selectively along one of the banks may also eventually lead to shift of channel.

Changes in the bed of the channel leading to its shift can also be introduced by anthropogenic factors. Human interventions in natural processes are increasingly causing such effects and at times assume such magnitude of scale that they are beyond the limits of corrective mechanism of normal, natural processes. Removal of river alluvium as building materials in the form of coarser bed load (sands) or finer components of alluvial material for brick manufacturing is one such intervention, which leads to changes in channel geometry. The author of this paper has been monitoring the effect of such an activity along the lower reaches of River Tarali, a tributary of Krishna in its upper reaches. In the present paper an attempt was made to highlight the effects of human interventions on the channel geometry.

Introduction

The river channels, being the containers of discharges passing through them, are considered to be the most dynamic components of the drainage basin. While it is true that the channel get defined as a result of flow of water, it is the discharge that is considered as the independent variable in the study of channel geometry. Any variation

in the discharge is immediately reflected in the channel geometry both in plan and cross section. This is particularly true of the segment of the channel, which is characteristically 'mobile' in nature as the erodible materials often respond to flow variations with slightest provocation.

A continued of repetitive attack by flow along a bank eventually leads of the shift of

the channel location. Any catastrophic event of large flood would also bring about change in the location of the channel bed. The natural processes leading to change or shift in the location of channel bed are sometimes aided by human interventions. A number of cases can be sighted of such changes that are the results of human activity, at times not necessarily a deliberate one. Plantation of thick vegetation along side of channel, possibly to protect agriculture land, may cause a slow shift to the opposite side. However, such interventions are of low magnitude and these may not lead to serious problems. At times when the interventions are of high magnitude the effects too can be quite serious.

The brick industry is one such activity that depends on the annual yield of river alluvium. If the demand for the river sediments is well within the limits of the annual yield, it may sustain the industry for longer periods but will certainly cause considerable changes in the bed configuration of the channel. If, however, the excavation of alluvium from the riverbed exceeds the annual yield, it will have far reaching effects. A large-scale brick making activity has been noticed in the lower reaches of River Tarali, a tributary of River Krishna in its upper reaches. The effects of this activity, in the form of shifts in the channel during the post monsoon period, are described in the following pages.

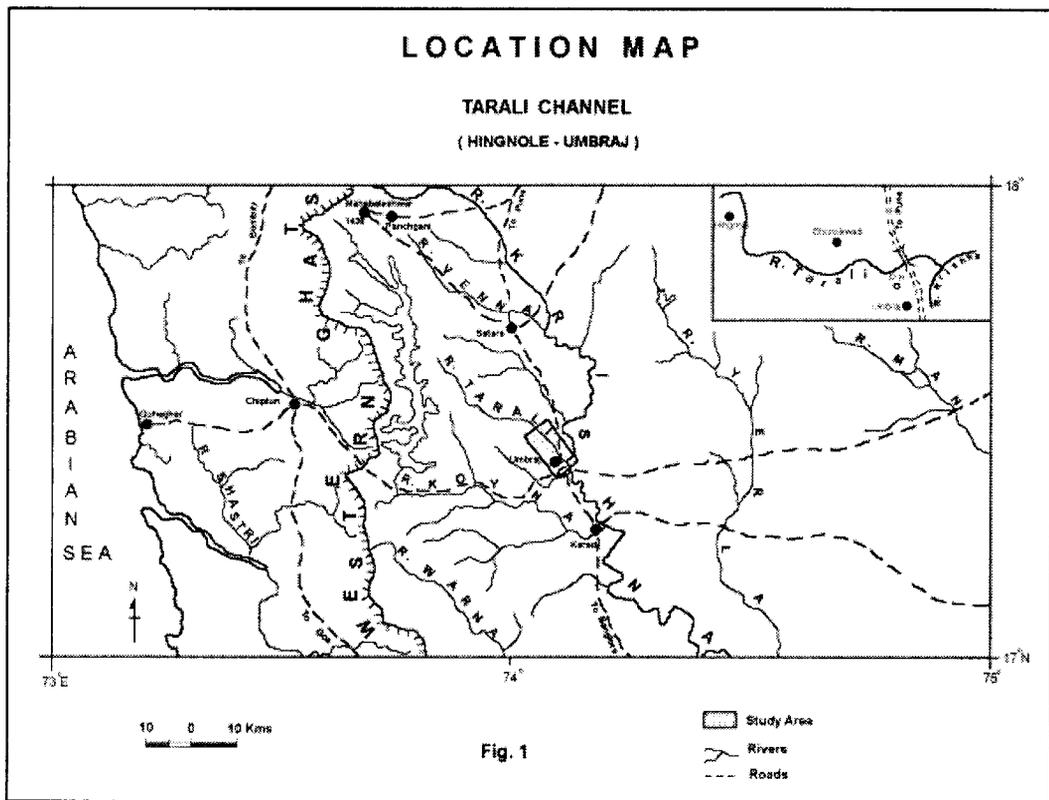
Study Area

The area under consideration forms a small segment of the channel of river Tarali near its mouth. River Tarali is a major tributary of river Krishna in its upper reaches and has a length of 50 km. For most of the major

ivers of upland Maharashtra, the Western Ghats forms the source region. However, there are few major tributaries of River Krishna that collect their headwaters from the transitional zones close to the Ghats. Tarali is one such river apart from river Urmodi, river Venna and river Mand. All these rivers have their sources in the high-level lateritic plateau complex extending for over 50 km from Mahabaleshwar in the north to Patan in the south. River Tarali collects its headwaters from the southern portion of the lateritic plateau, popularly known as "Kas-Plateau". After cascading from a near vertical fall at Thoseghar, along the scarp of the plateau, it continues its eastward journey and joins River Krishna near Umbraj. The stretch of river channel, which forms the study area, extends for a distance of a little over 4 km from the confluence of river Tarali and river Krishna in the upstream direction. It is along this stretch that large-scale excavation of river alluvium is in progress.

Methodology

The aim of this paper is to study shifts of Tarali channel. Detailed observations of the channel were carried out during a three-year period from 1994-97. It was noticed that the shifting of channel was the result of large-scale alluvium excavation all along the river stretch under consideration. Therefore, detailed periodic ground surveys with the help of transit theodolite were conducted. These surveys facilitated the understanding of bed configuration, extent of within channel siltation, human intervention, changes in channel morphology, cross-sectional changes and the effect of vegetation on within channel siltation.



The excavation activity normally starts after the monsoonal flood discharges are reduced considerably. The work extends all through the post monsoon period. Therefore the surveys were conducted in December/January and April/May. This helped to determine of bed configuration in the post monsoon period (Dec/Jan survey) and the extent of excavation carried out in any one season (April/May survey). From 1994-95 till 1996-97 in all six surveys were conducted. Before the actual survey, a number of field visits were organized and through personal interviews as well as observations, those segments of the channel were identified where the sediment excavation was carried out. It was found that for a distance of about 3 km before the

confluence of Tarali and Krishna the excavation of alluvium is highly concentrated, and beyond the next one kilometre there are but a few locations of sediment exploitation. Therefore the channel extending for a distance of 4.325 km upstream the confluence was selected for the periodic survey.

Thus the stretch of the river channel which formed the study area extend for a distance of a little over 4 km from the confluence of river Tarali and river Krishna in upstream direction. In the present paper, maps prepared for three post monsoon seasons are used to discuss the shift of the channel. Detailed maps on scale 1:1000 with contour interval of 1m were prepared. During the surveys both, block contouring

and cross section measurement, were attempted. While block contouring helped in getting the plan details of the channel under consideration, the cross-section surveys facilitated the understanding of channel geometry in section. In all 90 cross-sections have been measured. Besides the ground surveys, a number interviews of the local people were taken in order to understand the type of material they use for brick making.

It may be noticed that the present paper attempts to describe shifts of flow line within the banks of the river. Thus it focuses on the variation in bed configuration. The term 'shift' being used here may convey a wrong notion that the channel as a whole is shifting. Considering the scale at which the excavation of alluvium is going on such a possibility cannot be ruled out for long-term prediction. However, only the changes in the location of the flow lines in the post monsoon period are discussed here. When the monsoonal flood discharges are almost over the stream flow is maintained largely by the base flow. A cursory glance at the channel location diagrams (fig. 2 to 3) reveals the fact that the shift of the channel bed varies in its extent along longitudinal as well as transverse direction. Superimposing three maps representing post monsoon conditions has been used in identifying the shifts. The mean dislocation of the left or right bank, as has been noticed, is given in the table along with the channel length along which the shift has been observed. The shifts of the left as well as right banks are separately recorded in the table. L1, L2, L3, and R1, R2, R3 refer to the left bank and right banks as observed in 1st, 2nd, and 3rd year respectively. The following description relates only to a few

selected sites out of 25 marked on the map. Along with the location of shifts, the locations where the excavation of alluvial material is carried out have also been shown on the maps (Table 1).

Shifts of Channel Bed

Shifts in the low flow lines within the confines of the bank are basically the result of removal and redistribution of the load by the discharge. During the monsoon period huge amounts of load are moved into the drainage system which then gets reworked in low flow period. The development of central bars, alteration along the point bar location, selective erosional action along the base of banks by low flows, and the resulting bank failures are the normal processes leading to the shift of low flow channels within the confines of the bank. However, these natural processes get accelerated through human interventions, though apparently they are of a lower order. The removal of clay, silt or sand from the bed is a normal practice in case of most of the channels. The easy availability of brick making materials in the lower section of the Tarali combined with the increased demand of the building industry in areas close to major urban centres has lead to the large scale exploitation of these materials from the river stretches under consideration. To the selective removal of materials from such areas, if of sizable magnitude, the most likely response from the channel bed would be in the form of change in flow pattern. Such an accelerated erosive action would subsequently lead to changes in the location of flow lines.

There are as many as 25 locations, which could be easily identified along the

Table No. 1: Shift of Tarali Channel as observed from 1994-97

LOCATION OF SHIFT	SHIFT OF TARALI CHANNEL AS OBSERVED FROM 1994-97																								
	1st YEAR →				IInd YEAR →				3rd YEAR →																
	L1 →		L2 →		R1 →		L3 →		R2 →		L3 →		R3 →												
SHIFT LEFT	SHIFT RIGHT	SHIFT LEFT	SHIFT RIGHT	SHIFT LEFT	SHIFT RIGHT	SHIFT LEFT	SHIFT RIGHT	SHIFT LEFT	SHIFT RIGHT	SHIFT LEFT	SHIFT RIGHT	SHIFT LEFT	SHIFT RIGHT												
1 (CS - 1.2)	7.5	145	*	*	16.5	155	*	*	2	140	5.3	75	*	*	6.3	140	*	*	17.3	165	*	*			
2 (CS - 3)	*	13.7	70	*	*	19	95	*	*	5	70	*	*	19.6	145	*	*	10	90	12.3	140	*	*		
3 a (CS - 4.5)	*	44	200	*	*	50.3	185	*	*	7.5	60	*	*	12.8	100	*	*	45	200	*	*	56	160		
3 b (CS - 4.5)	*	11	150	*	*	*	*	*	*	*	*	*	*	*	*	*	*	12.3	110	*	*	9.5	120		
4 (CS 6.7.8)	2.6	150	*	*	4.3	110	*	*	*	18.3	160	*	*	13.7	140	*	*	16.3	150	*	*	11.2	145		
5 (CS - 9 - 12)	*	21.5	250	*	*	3.7	120	*	*	14.5	220	*	*	17.8	250	*	*	29.7	250	*	*	19.3	250		
6a (CS - 13.14)	*	13	190	10.7	95	*	*	10	100	*	*	5	90	*	*	5.7	100	*	*	14	135	*	5	95	
6b (CS-13.14)	*	*	*	*	*	*	*	*	*	*	*	5.7	100	*	*	5.7	100	*	*	14	135	*	5	95	
7 (CS - 15.16)	*	29	200	*	*	11.8	190	12.7	75	*	*	5.4	55	*	*	8	150	*	*	24.7	200	*	14.5	215	
8 (CS - 17-19)	*	7.7	70	*	*	13.4	60	*	*	*	*	5.4	55	*	*	8	150	*	*	7	72	*	10	60	
9a (CS - 20-22)	8	155	*	*	20	70	*	*	*	*	*	10	52	*	*	6	60	6.8	155	*	*	12.3	135	*	*
9b (CS-20-22)	*	*	*	*	*	*	*	*	*	*	*	10	52	*	*	6	60	6.8	155	*	*	12.3	135	*	*
10 (CS - 23.24)	12	85	*	*	16	95	*	*	*	*	*	10	52	*	*	2.7	60	13.4	85	*	*	10.7	85	*	*
11a (CS - 25-29)	*	52.5	188	*	*	24.7	185	15.4	100	*	*	12.7	112	*	*	12.4	105	*	*	59.7	188	*	25.8	180	
11b (CS - 25-29)	*	*	*	*	*	*	*	*	*	12.7	112	*	*	12.4	105	*	*	59.7	188	*	*	25.8	180	*	*
12 (CS 30-36)	*	20.8	330	*	*	17.3	335	*	*	15.3	245	*	*	20.4	335	*	*	34.3	330	*	*	37.7	335		
13 (CS - 37-40)	*	13.8	150	*	*	17	92	*	*	23	150	*	*	22	140	*	*	31.8	175	*	*	32.5	175		
14 (CS - 41-47)	*	12.5	210	*	*	6.4	210	*	*	14.8	210	*	*	17.5	235	*	*	26.8	210	*	*	20.8	235		
15 (CS 48-52)	*	5.4	75	*	*	10.4	56	*	*	16.2	185	*	*	20.8	170	*	*	20	185	*	*	27.4	170		
16 (CS 53-58)	*	21	255	*	*	18.5	175	*	*	25.8	235	*	*	25.8	305	*	*	36	235	*	*	36.5	305		
17 (CS - 59.61)	6	78	*	*	10.7	84	*	*	*	44.4	90	*	*	44.7	80	*	*	41.7	75	*	*	35.7	80		
18 (CS - 62.63)	*	*	*	*	9.7	95	*	*	7.7	75	*	*	9	230	*	*	16.4	205	*	*	12.6	230			
19 (CS - 64-70)	*	4.8	100	*	*	3.5	145	*	*	16.8	180	*	*	19.7	80	*	*	19.4	65	*	*	19	80		
20 (CS - 71.72)	*	*	*	*	17	145	*	*	5	150	*	*	23.5	182	6.8	180	*	*	19.4	65	*	*	15	180	
21 (CS - 73-77)	11	180	*	*	21	85	*	*	16	83	*	*	18.8	85	*	*	19.3	100	*	*	10.4	90	*	8	50
22 (CS 78.79)	16.7	83	*	*	14.7	105	*	*	19	95	*	*	33	125	*	*	34.7	125	*	*	13.7	50	11.4	110	
23 (CS - 80.81)	10	96	*	*	11	72	7	52	*	34	132	*	*	19	145	*	*	13.7	50	11.4	110	*	*		
24 (CS - 82.85)	*	*	*	*	21.7	145	*	*	22.4	155	*	*	19	145	*	*	13.7	50	11.4	110	*	*	*	*	
25 (CS - 86-90)	13.4	155	*	*	21.7	145	*	*	22.4	155	*	*	19	145	*	*	13.7	50	11.4	110	*	*	*	*	
1	9.69	18.8	2510	1127	14.1	1236	1648	10.8	345	17.6	2742	9.2	427	17.8	3167	8.33	560	24.3	3230	12.2	816	22.4	3195		
2	9.69	18.8	2510	1127	14.1	1236	1648	10.8	345	17.6	2742	9.2	427	17.8	3167	8.33	560	24.3	3230	12.2	816	22.4	3195		
3	9	15	15	12	12	12	12	4	4	19	19	5	5	21	21	4	4	21	21	7	7	19	19		

L1 LEFT BANK YEAR 94-95 R1 RIGHT BANK YEAR 94-95 1 TOTAL SHIFT LENGTH ALONG THE CHANNEL LENGTH
 L2 LEFT BANK YEAR 95-96 R2 RIGHT BANK YEAR 95-96 2 MEAN SHIFT WIDTH ALONG THE CHANNEL LENGTH
 L3 LEFT BANK YEAR 96-97 R3 RIGHT BANK YEAR 96-97 3 NUMBER OF LOCATION INVOLVED
 SHIFT LEFT W MEAN WIDTH OF SHIFT ZONE (IN METERS)
 SHIFT RIGHT L LENGTH OF SHIFT ZONE (IN METERS)

lower stretches of river Tarali, where the channel appears to have been shifted. Out of 25 sites listed in the table, details of 4 sites are described in the following paragraphs. The shifts have been of cognisable order, at times as high as 50-60 m. The table records the extent of shifts as observed in three post monsoon periods from 1994-95 to 1996-97. The table records the values of shift of left and right sides. Left bank moving to its left side (or right bank to its right side) normally would result in widening of the channel (if there is no parallel shift in the opposite bank). The reversal of this situation would lead to shrinking of the width. These variations in the width conditions are sure to influence the velocities of flow.

Site 3

The channel at this location has a maximum width of 75-80 m. This is because a central bar developed in the channel has caused bifurcation of flow lines (Fig 2). The length of the monitored stretch is around 150 m. In the 1995-96 post monsoon period the central bar has grown by 7-8 m towards its right bank side. The flow line observed in 1994-95 post-monsoon period (Nov/Dec.94), located along the left side of the central bar, has become almost defunct as the entire channel now flows on the right side of the central bar. The channel, which maintains an over all straight direction till this point, then takes a sharp turn to its right. Normally one would expect accumulation of materials along the base of right bank. The central bar here may have been developed initially as fast growing point bar at the turn of the channel. However, as the channel strikes a spur, its further migration

to its left is restricted. The monsoonal discharges must have developed strong currents at the base of the right bank causing the breaching in the point bar. Eventually, as a greater component a discharge passed over this point bar and with the tendency of the flow to shift towards the right bank, this must have caused the detachment of the point bar thus turning it into a central bar. This is evident from the location of the 96-97 channel, which shows its tendency to shift further towards the right side. However, it must be mentioned here that at this location quarrying is not practiced, and the shift noted here is largely the result of natural processes.

Site 11 and 12

This stretch is around 400 m long, and severe changes have been noticed in this section with the flow channel shifting by 55-60 m towards the right bank during the last three years. At location 11-12, large-scale excavation of material was observed. Upstream of location 11, the channel width is of the order of 20-25 m. At the site 11 it suddenly increases to 60-65 m, and the stream enters into a small pool like feature with water spreading on either side. The excavation along the right bank of the channel at site 11 and along left bank at site 12 extends for a distance of 200 m and 500 m respectively. However, in both the cases the shift of the channel is towards the right bank. From 94-95 to 96-97 this width of the channel including the pond, which was as much as 60 m wide, has shrunk to 12 m at the above site. The water accumulated at the excavated space, having greater depth must have caused severe down cutting and hence the entire flow has shifted to right bank side.

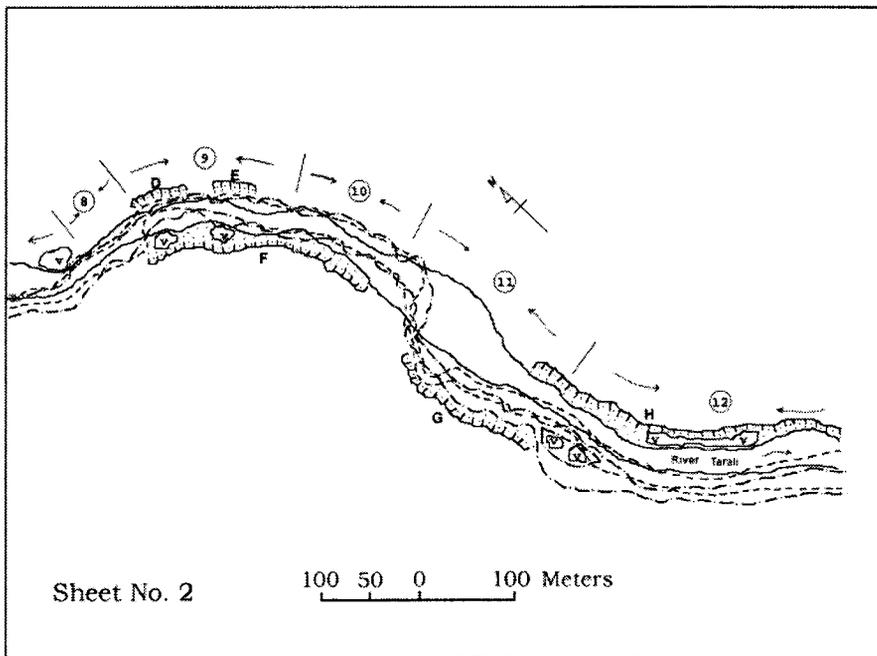
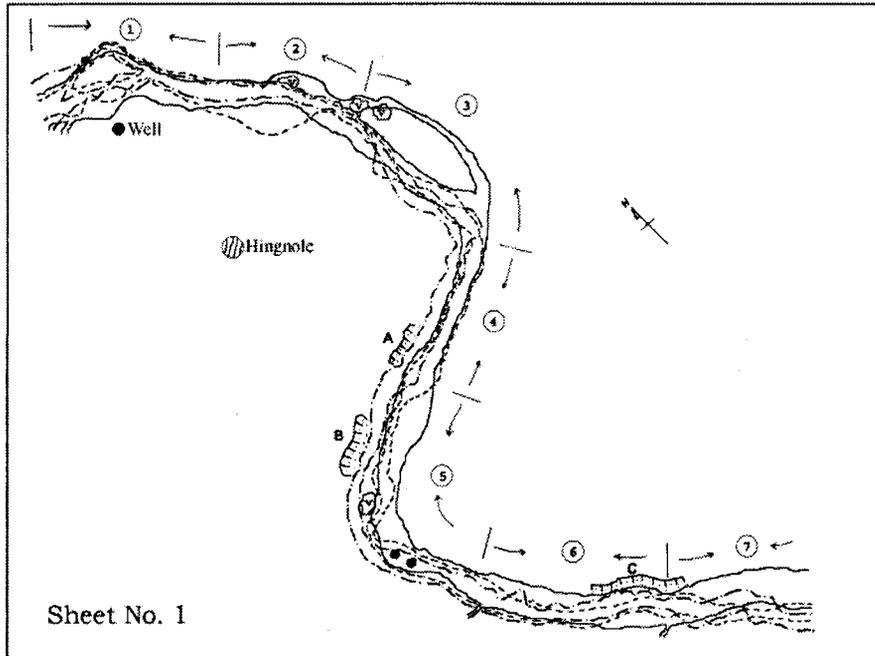


Fig. 2: Sections of Tarali River Channel

On the other hand, though considerable excavation takes place on the left bank for a much longer distance due to a slight but definite turn in the channel, the greater depth have remained confined to the right bank. Another major aspect, which needs a mention here, is the practise of farmers to plant *Garwel (Ipomea Carnea)* and *Shevari (Sesbania aegyptiaca)* along the bank and in the bed areas respectively. This also influences the shift of the channel. The *Shevari* is planted almost like a crop every year. It is a fast growing bush attaining a height of 2-3 m. The bushes are planted closely. Their roots penetrate deep into the alluvial deposits. The dense and fast growing bushes trap the silt almost acting as a vegetal 'sieve' for the discharge. As a result, the silt settles down in the field. *Shevari* is allowed to stand in some cases for 2-3 years and is replanted in same field so as to ensure greater accumulation of sediments only to be excavated in subsequent years.

Site 15-16-17

The channel in this part follows a slight sinuous path. The channel observed in 94-95 showed a definite shift to its right side between sites 16 to 17. This has led to increment in the degree of sinuosity of the channel. The shift of the left bank is more pronounced as compared to the right bank. The width of the channel was reduced from 25 m to 6 m between the 1994-95 and 1995-96 post-monsoon period. From the 95-96 locations the channel has migrated further south in the 96-97 periods. Thus, in a period of two years the channel has completely shifted from its original position at the base of left bank to the base of right bank. Large-scale excavation of material took place along

the right bank involving a channel length of 400 m. The excavation sites along the northern bank are of narrow length. The high degree of excavation for 400 m along the right bank was found to have an average depth of 1.5 to 2 m. A huge amount of material is removed right up to the base of the bank. Normally, towards the channel side a hump like threshold is maintained all along the length, of course with breaks for the transporting vehicles to reach the site. The threshold maintained restricts the outflow of flood discharges entering into the excavation sites and retains some amount of the water to stand in the area for sufficiently long a period. This leads to percolation of waters at the base and the near vertical faces of the site become weaker facilitating an easy excavation in the subsequent period.

The observed shift from 94-95 to 96-97 was in the same direction in all three seasons. If we consider the length from site 15 to 18, the channel in 94-95 appears to have a definite sinuous course deviating considerably from its more or less straight path immediately in upstream direction. The channel deviates and moves more to the left bank side (Site 15). At site 16 it migrates to its right hand. There has been considerable excavation of brick material along the bank, and as a result, the stream appeared at the right bank during the period under consideration. The width of the channel also has become narrower in the 1996-97 season, as the entire channel has been confined to the base of the excavation site. The excavation at this place is of high order. Almost 6-7 m depth of the material has been removed all along 550 m of the length.

Site 24-25

This site is just in the vicinity of the confluence of river Tarali and river Krishna. In this section the channel shows shifts in both directions. From its 94-95 location the channel shifted to its left bank. The width of the channel in 94-95 was 25 m, which got reduced to 8 m in the 95-96 season. From its 95-96 position the channel shifted towards the right bank and got confined to the base of the excavation site. However, site 25 does not show much variation as compared to the site 24. The excavation along site 24 and 25 is seen on both the banks. The reduction in the width from the 94-95 to the 95-96 position and the confinement of the channel to its left bank had caused considerable damage to the channel walls in this section. A number of bank failures along the channel walls have been noticed in 95-96. This may be attributed to the narrowing of the channel and also to the oblique erosion noticed at the base of the channel wall. The width of the channel did not change much from 95-96 to 96-97, though the shift was considerable. In 95-96, as mentioned above, it had moved towards the left bank, and in 96-97 it moved in opposite direction to the base of right bank wall.

Some Observation and Conclusions

The table records the extent of shifts and the length along which the shifts have occurred in the off monsoon channel of the Tarali. The shifts observed in the left and right banks are separately recorded. It may be observed that the extent of the left bank shifting to its left is always more moderate than its shift to the right. The movement of the left bank to its right or right bank to its

left would lead to narrowing of the width, if the other bank does not show any shift. The opposite of this situation i.e. the left bank moving to its left and the right bank moving to its right would lead to widening of the channel. In most of the cases what is observed is that the shifts of the banks have generally caused narrowing discharges. The narrowing of the width leads to an increase in the erosive action. The pattern of shifts of banks shows a peculiar condition. The shift of both the banks is on an average 8 to 12 m in case the shift is to its left side of the original position whereas it is almost double if the shift is towards the right of the original position.

The lengths of the segments, along which these shifts in the low flow channels are noticed, show quite interesting conditions. It may be noted that shifts of both the banks towards their left are invariably less as compared to the shifts towards their right side. In the period 94-95 to 95-96 a shift towards the left was noticed along 1127 m and 1236 m in case of left and right banks respectively. As against this, shifts toward the right side were 2510 m for the left and 1848m for the right banks. In the period 95-96 to 96-97, the differences were further enhanced to a considerable extent. The shifts towards the left side in case of both the banks (left and right) are as low as 345 m and 427 m respectively, whereas these are 2742 to 3167 m in case of shifts to the right side for left and right banks respectively.

It may be observed that shifts for the first 1000-1200 m distance of the riverbed have taken place at fewer locations as compared to the locations in downstream direction. The frequency as well as the scale

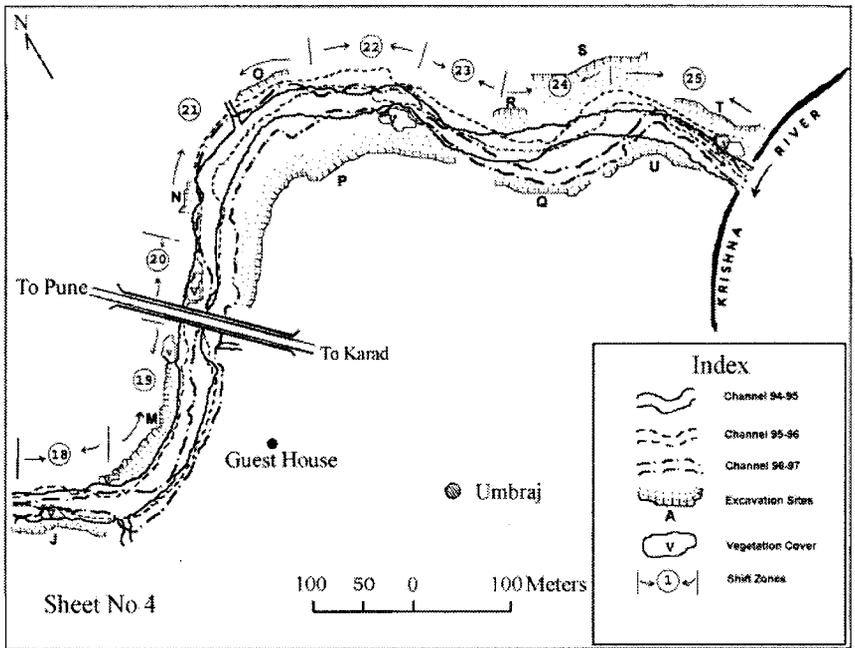
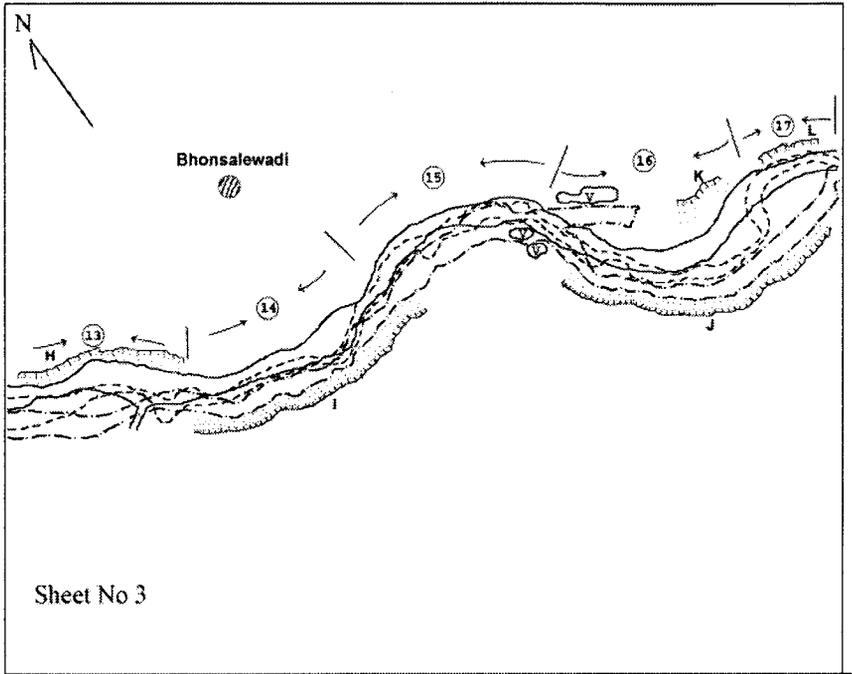


Fig. 3: Sections of Tarali River Channel

of excavation activity was quite low in first 1 to 1.5 km of the channel length under consideration. The excavation of material along the bank walls provides excess width for the floodwaters, compared to normal cross sectional conditions. The excavated plots generally are slightly raised, about 30-40 cm, above the bed. The water entering into excavated plots during the flood season goes into the soil column and causes severe bank failure.

Besides the excavation activities, another factor, which leads to shifts of low flow channels within the confines of channel walls is that of plantation of *Garvel* and *Shevari* in the channel by farmers. As mentioned above, these plants are put within the bed of the channel and also in the areas of excavated plots with the purpose to trap more load in subsequent years. They are planted with greater density and practically act as sieves forcing the sediments associated with monsoon discharges to get settled.

Most of the time the Tarali discharge does not get easy entry into the Krishna channel as the discharges in the Krishna is also high during the same period. The Krishna water practically acts as a hydraulic dam for Tarali water resulting in the piling up of the water within the confines of its channel wall in the form of slack waters. This leads to the forced settling of the load brought by river Tarali, which is being economically exploited for brick

manufacturing. As a result of the ongoing excavation and the cultivation of *Shevari* plant in the channel and in the excavation plots, the low flow channels of the post monsoon period appear to have shifted from their locations in earlier year.

By and large, it may be said that shifts in the Tarali channel during low flow conditions have a definite tendency or a preference to shift towards the right bank. This is mainly because of the fact that the excavation activity is more prominent along the right bank as compared to the left bank.

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