Pune River Rejuvenation Project

Final Hydrology and Hydraulics Report

19 January, 2018

Pune Municipal Corporation, Pune

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Advance Engineering Consultants

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1. PROJECT BRIEF

1.1 INTRODUCTION/ BACKGROUND

Pune lies on the western margin of the Deccan plateau, on the leeward side of the Sahyadri mountain range, which forms a barrier from the Arabian Sea. Pune city originated at the confluence of the Mula and Mutha Rivers before 8th century. The Mula-Mutha River formed by the confluence of the Mula and Mutha Rivers which further meets Bhima River around 54km east of the city. The Pawana and Indrayani Rivers are also the tributaries of the Bhima River, which traverse in the northwestern side of Pune city.

Figure 1: Mula, Mutha and Mula-Mutha River flowing through Pune City

The total length of the three rivers traversing through Pune Municipal Corporation area is approximately 44km whose widths vary from 80m to 250m. Currently the Mula, Mutha and Mula-Mutha Rivers are unhygienic, neglected and encroached by the unplanned surrounding development. Therefore the city has turned its back to these rivers.

In order to cope up with these current issues and create a meaningful public realm along the river, the Pune Municipal Corporation has taken up the Riverfront Development Plan for Mula, Mutha and Mula-Mutha Rivers in entire Pune Municipal Corporation area.

This report provides a detailed description of the hydrology and hydraulic character of the Mula, Mutha and Mula-Mutha Rivers. It comprehensively analyzes and compiles all the relevant parameters of the existing river with respect to the flood carrying capacity of the rivers within entire sub-basin starting from the upstream reservoirs Pawana dam, Mulshi dam, Temghar dam, Varasgaon dam, Panshet dam and Khadakwasla dam up to the downstream connection with Bhima River. The objective of this report is to understand the existing issues with the river hydrology and hydraulics system of the river and suggest modifications in order to improve the flood capacity of the river.

1.2 REGIONAL AND LOCAL CONTEXT

Pune city is 560 m (1,840 ft) above the sea level on the western margin of the Deccan plateau. It is on the leeward side of the Sahyadri mountain range, which forms a barrier from the Arabian Sea and the city. It is a hilly city, with its highest hill, (Vetal Hill) rising to 800 m (2,600 ft) above sea level. It lies between 18° 32" North latitude and 73° 51” East longitude.

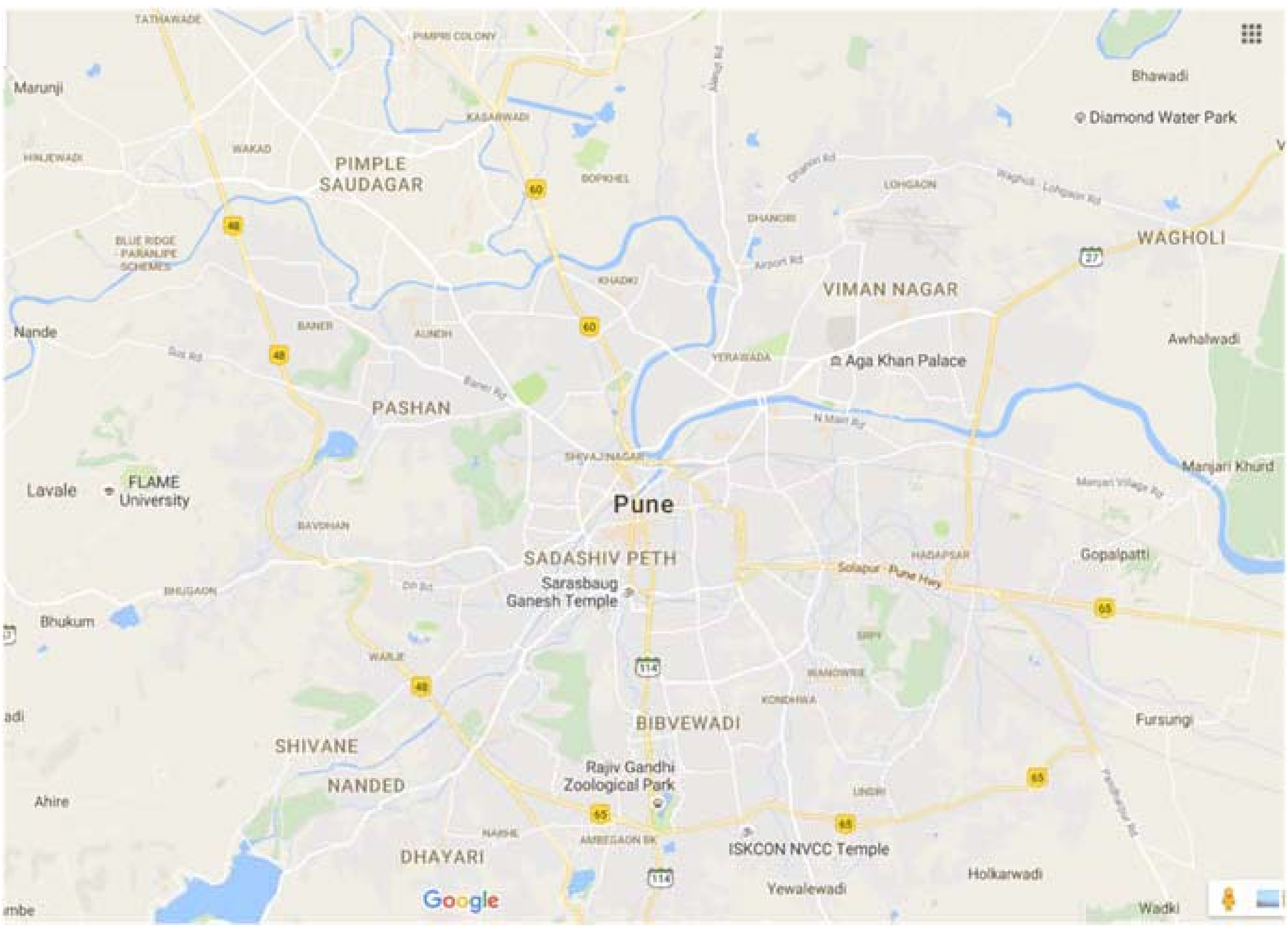


Figure 2: Map of Pune City

Pune has a hot semi-arid climate bordering with tropical wet and dry climate with average temperatures ranging between 19°C to 33 °C (66°F to 91 °F). Typical summer months in the Pune city are from March to June often extending till 15 June, recent years the maximum temperatures have sometimes reached 42°C (108 °F). The warmest month in Pune is between 20 April and 20 May; although summer doesn't end until May, the city often receives heavy dusty winds in May (and humidity remains high). Even during the hottest months, the nights are usually cool due to Pune's high altitude.

The monsoon lasts from June to October, with moderate rainfall and temperatures ranging from 22 to 28 °C (72 to 82 °F). Most of the 722 mm (28.43 in) of annual rainfall in the city falls between June and September, and July is the wettest month of the year.

The entire 44km of river length in project area is not only under Pune Municipal Corporation, but also has adjacency to the other administrations such as Pimpri Chinchwad Municipal Corporation and Defense Area. The Mula River forms the edge between Pimpri Chinchwad Municipal Corporation (PCMC) on the north and the Pune Municipal Corporation (PMC) to the south side of the river. It also flows through Kirkee Cantonment Board, College of Military Engineering and Pimple Nilakh Defense areas before joining Mutha River at the Confluence. Approximately 10.4km length of Mutha River and 11.8km of Mula Mutha River flows within the Pune Municipal Corporation Boundary. Therefore it is very important to involve all the administrations as stakeholders of this project since beginning.

Mula River originates from Mulshi dam and it navigates around 50km to meet Mutha River at Sangam wadi. Out of which around 22.2km of downstream stretch of the river is within PMC area. Villages like Rahatni, Balewadi, Pimple nilakh, Baner, Aundh, Sangvi, Bopodi, Dapodi, Khadaki, Bopkhel, Kalas, Verawada,Bhamburda and Sangam wadi are along the Mula River within the PMC and PCMC area. Similarly Mutha River originates from Khadakwasla dam and it navigates around 15km to meet Mula River at Sangam wadi. Out of which around 10.8km of downstream stretch of the river is within PMC area. Villages like Varje, Ambegaon Budruk, Hingne Khurd, Hingne Budruk, Parwati, Erandwana, Bhamburda and old city area are along the Mutha River within the PMC area. Whereas after the confluence of Mula and Mutha rivers the combined river Mula-Mutha navigates from east to west part of the city and meets Bhima river downstream around 50km away from the confluence. Along the 11.8km of river stretch within PMC area villages like Sangamwadi, old city area, Verawada, Ghorpadi, Vadgaon sheri, Mundhwa and Kharadi are located along the Mula-Mutha River.

1.3 CURRENT STATUS OF THE RIVER

Mula, Mutha and Mula-Mutha Rivers were considered as lifeline of the Pune city. The water of these Rivers was used for drinking, bathing, industrial and irrigation purposes. But due to the increasing urbanization and industrial activity significant disposal of solid wastes, domestic waste, hospital waste and industrial effluents and some amount of agricultural runoff dumped in to the rivers.

The Pune Rivers have become very polluted, unhygienic, neglected and encroached by unplanned surrounding development. Therefore the river has become largely inaccessible from the city and is no longer seen as an asset to the city. The city has slowly turned its back to the river.

The most thriving issues of the existing rivers are as follows

- Untreated sewage is flowing into the rivers
- Garbage is being dumped in the rivers
- Construction debris is being dumped in the rivers
- The river is being encroached upon by the development
- Pune still faces the threat of flooding
- People can’t access the river
- The rivers divide the city instead of uniting it
- Existing projects for improving the river are haphazardly conceived

Figure 3: Present Condition of River

Figure 4: Past Flood Observed in Mula Mutha River

1.4 PROJECT OBJECTIVES

It is evident that the river was imperative for the city and it is losing its importance from the life of the people. In order to cope up with these current issues and create a meaningful public realm along the river the Pune Municipal Corporation has taken up the Mula, Mutha and Mula-Mutha Riverfront Development Project in entire Pune Municipal corporation area. Therefore M/s HCP Design, Planning and Management Pvt. Ltd. has been awarded consultancy work for preparation of detail project report for Riverfront Development work of Mula, Mutha & Mula – Mutha River in Pune and subsequently onsite implementation of the project.

Based on the observations made during the site studies and analysis of the data received from PMC and other relevant Government Departments the major project objectives have been enlisted as below.

i. Reduce the risk of flooding
ii. Retain and replenish water
iii. Clean the River and make it pollution free
iv. Create a continuous public realm along the river
v. Connect and enhance surrounding heritage places and buildings
vi. Integrate slums
vii. Ensure more responsive and context specific development
viii. Improve accessibility and connectivity

For the same, the following hydrology and hydraulic studies imperative to the project were carried out:

- Review of various Hydrology and Hydraulic studies conducted earlier to find out the probable maximum flood and HFL.
- Computation and further confirming the HFL/Water Surface elevation (WSEL) for design food, check flood and various Flood discharge along the project reach in natural as well as in channelized section of various widths before and after the development of the project.
- Designing various bank reclamation and protection work alternatives and assessing its suitability against hydrodynamic forces.

A staged approach has been taken for the preparation of the documents which will enable Pune Municipal Corporation (PMC) to proceed to the implementation of the construction works for flood and bank protection.

The first stage has been the collection of data, both primary i.e. measured directly on the field, and secondary i.e. measured, processed and made available by other organizations.

The second stage has been the planning stage, wherein the data collected and processed was used to analyze the hydrology of the catchment, and the hydraulics and morphology of the river. A design flood has been derived representing a flood event which is estimated to have a statistical recurrence of once every 100 years. Long time series of river flows have been derived from the existing data, to analyze the long term morphological developments in the river.

An alignment of the proposed flood and bank protection works was analyzed for its impact on the river behavior, i.e. flood levels, flow velocities and scour depths. These key parameters were applied to the outline design of the flood and bank protection works.

1.5 ASSUMPTIONS

During the site visits and subsequent reviews, however, it was found that there was serious lack of adequate and authentic data about the continuous observation of water levels in past floods especially for determination of observed flood profiles. Therefore, we had to depend on certain rational assumptions using available data, which could not be verified for authenticity. Our studies have been based on these assumptions.

2. SURVEY AND DATA COLLECTIONS

The riverfront development project for Mula, Mutha and Mula-Mutha Rivers has been taken up by PMC within Pune Municipal corporation limit. The Rivers flowing through the heart of the city and it has encroached by unauthorized Construction, garbage and construction debris dumping at several places. Similarly the low lying properties along the river are vulnerable to the flood based on the current ground conditions. The project proposes to protect low-lying areas along the River from flooding by building a variety of well-modulated embankments along the banks of Pune's Rivers. It has been proposed to remodel and reshape the channel to suitable cross sections that can be varied based on the surrounding context and the additional land available. Building the embankments will also enable the creation of a continuous public realm along both banks of Pune's rivers. Having such a continuous public realm will ensure that unlike today, people will be able to move along the length of the river. This shall also include the river banks development with parks, promenades, access points, ghats, walkways, recreational spaces, public facilities etc.

In order to understand the detailed technical character of the river and surrounding areas; various detailed site investigations, relevant data collections and coordination meetings with technical departments are undertaken by the project team. The prior studies and surveys conducted for feasibility study are as below

- Topographical Survey
- Hydrology and Hydraulics study
- Geotechnical Investigation
- Environmental Monitoring
- Base map preparation based on land records


Figure 5 : Topographical Survey

The studies required collection of elaborate topographical, meteorological, hydrological, morphological and Geotechnical data of the river and its vicinity. In order to understand the local context and verify the study outcomes various site visits have been done by the team. It also includes various meetings, discussions and presentations with all concern departments such as Irrigation Department, CWPRS, PMC etc for data collection, verification and reviews. The hydrological data were collected for as long period as available from old records. The relevant hydrological data set was received from irrigation department for as long as available from old records of the Pune Rivers as listed below-

- Maps indicating red line and blue lines demarcation
- Technical details for flood estimation
- Water shed maps
- Previous hydrology and hydraulics report
- Flood discharge data
- Discharge capacity of upstream dams
- Details of discharge controlling structures
- Details of existing bridges, check dams, weirs and barrages
- Gauging data

Figure 6: Meetings with Irrigation Department and CWPRS regarding Hydrology and Hydraulic Studies

The studies required collection of elaborate topographical, meteorological, hydrological, morphological and Geotechnical data of the river channel and its vicinity as well as at bridges located across the river. The hydrological data were collected for as long period as available from old records. First hand Reconnaissance Survey of the project area was also very essential.

Following assignment are carried out pertaining to the Project.

i. Survey work relating to river cross sections & L-sections is conducted within projected reach in Mula, Mutha and Mula Mutha River.
ii. Geo-technical investigation data along the proposed River Front alignment on both the banks.
iii. Details of Gauging data collected from the Irrigation and concerned Department.

A large part of the data required for the study as indicated in the Proposal and as above was collected from the concerned offices of various State Departments and local offices, and also compiled and analyzed.

2.1 SURVEY WORK

Detailed engineering survey work of the river is the basic requirement for designing and planning of the flood protective schemes, as such it is essential to carry out cross section survey and contour survey of the River. Survey work was carried out in project reach using Total Station with Bench mark co-related with established bench mark by railway department in the city. The Surveyed cross section are surveyed up to 150 m from river center line on either bank at 25m distance interval This length is more than the effective river cross-section for most of the river stretch for normal flooding. Various Bridges data such as Soffit level, Top of bridge and span arrangement causing afflux during flood event are surveyed and marked on survey plan. Also drains discharging drainage into river are demarcated on plan.

2.2 GEOTECHNICAL DATA

In order to obtain samples of the bed material for analyzing the morphological behavior of the river and designing the protection works, 24 boreholes were drilled in the river bed to ascertain the general soil profile and composition. The samples were analyzed in the laboratory of KCT Consultant, Ahmedabad. The strata is rocky with traces of sand up to 1 to 1.5m depth only. Detail bore hole location and project report is enclosed here with for further review.

2.3 GAUGE DATA AVAILABILITY

There are two discharge gauging station located in the catchment area 1) Dhond 2) Pune Bund Garden . Dhond gauging station of CWC (Central water commission) is located at confluence of Bhima River with Mula Mutha River. This gauging data is not used in study as total discharge measured is from both the river catchment i.e. Mula Mutha and Bhima river. Gauging station data located on Mula Mutha river at Pune Bund garden are available from year 1974 to 2015.Also Rainfall gauging data are available from Khadakwasla Dam , Mulshi Dam. These data will be used in present Hydrologic study.

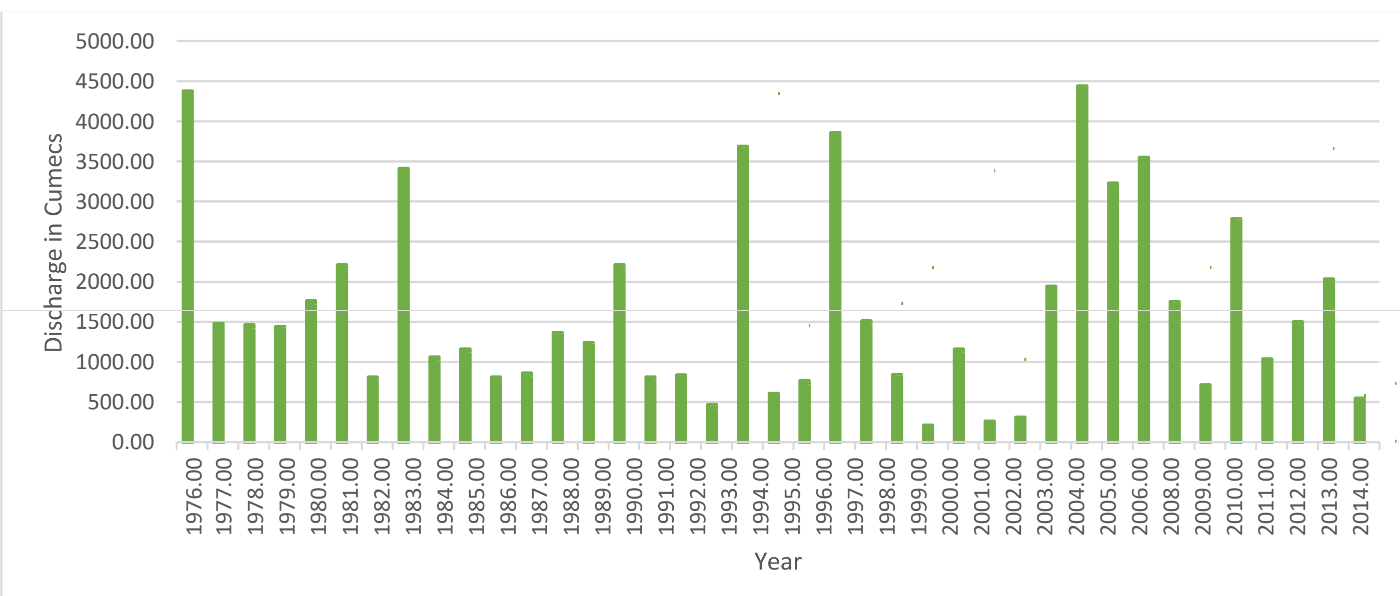


Table1: Maximum Discharge Observed at Bund Garden from year 1976 To 2015

2.4 PAST HYDROLOGY STUDY CARRIED OUT BY PUNE IRRIGATION DEPARTMENT

Pune Municipal Corporation (PMC) and the state irrigation department together have mark the flood lines of Mula and Mutha rivers to demarcate river area, building properties and facilitate disaster management. The work of drawing flood lines involves marking the blue lines (boundaries along the main river bed, enough to carry one-and-a-half times the normal water flow during average floods which occur on an average once in 25 years) in which no construction activity is allowed , and then the red lines (boundaries where water levels reach during major floods that may occur once in a hundred years).As per Hydrology and Hydraulic study carried out by Pune irrigation department flood discharge worked out for 1 in 25 year return period and 1 in 100 hundred year return period for Mula, Mutha and Mula- Mutha are as below

S. NO.	RIVER	1 IN 25 YEAR RETURN PERIOD FLOOD (BLUE LINE)		1 IN 100 YEAR RETURN PERIOD FLOOD (RED LINE)	
		CUSECS	CUMECS	CUSECS	CUMECS
1	Mula River Up to Dr Baba	42,584	1206	43,501	1232
2	Mula River After Dr Baba Saheb Ambedkar Bridge Up to Confluence Of Pawana River	54280	1536	58941	1670
3	Mula River After Confluence Of Pawana River	142991	3345	155633	3971
4	Mutha River	60000	1700	100000	2835
5	Mula - Mutha River	118000	3345	168000	4762

Table 2: Flood Discharge for 25 and 100 Year Return Period in Mula, Mutha, Mula- Mutha as per Irrigation Department, Pune

2.5 DIGITAL ELEVATION MODEL OF THE STUDY AREA

The basin characteristics of study reach has been extracted from terrain analysis using CARTOSAT Data. CARTOSAT is satellite based digital elevation model (DEM). A digital elevation model (DEM) is a digital model or 3D representation of a terrain's surface. This DEM were imported in ARC GIS and has been used for catchment delineation and for deriving elevation. ArcGIS is a geographic information system (GIS) for working with maps and geographic information. It is used for creating and using maps; compiling geographic data and analyzing mapped information.

The DEM is filled to remove any local sink and then used to derive the flow direction and flow accumulation which are further used for defining and segmenting the streams and catchment grid. Once watershed point is defined, the watershed network i.e. stream and catchment boundary is generated. Watershed delineated from DEM/Rater file is shown in figure 7.

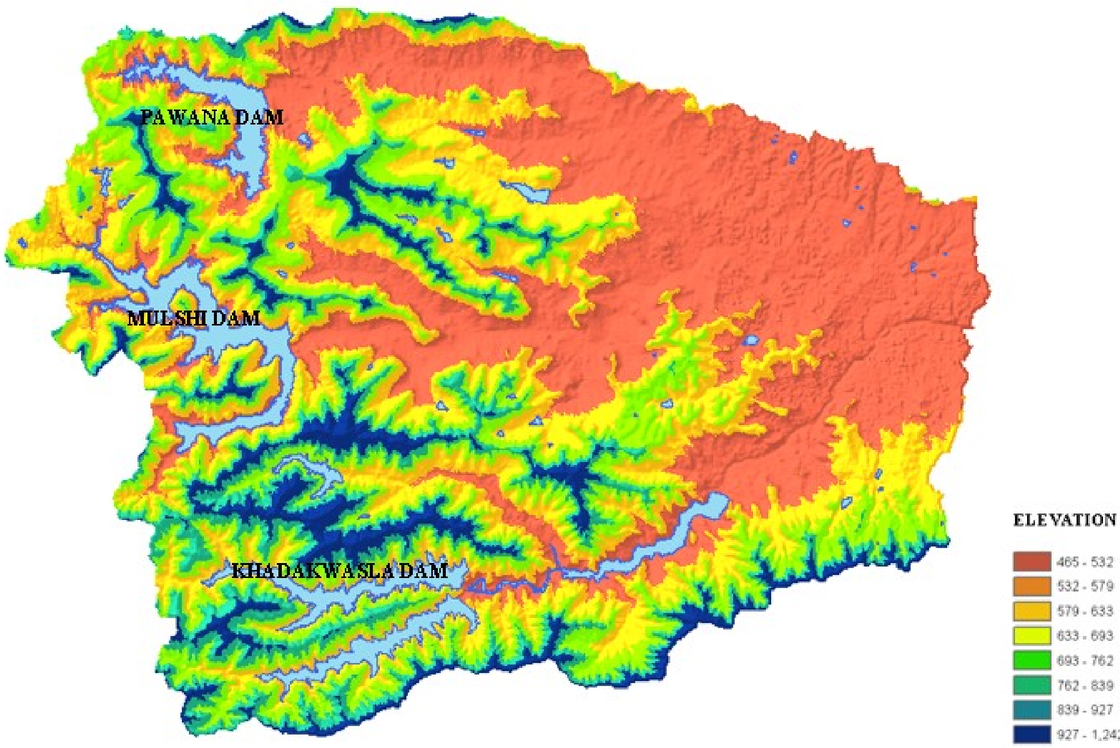


Figure 7: Delineated Watershed Catchment Area and Elevation of Projected Area from DEM Image

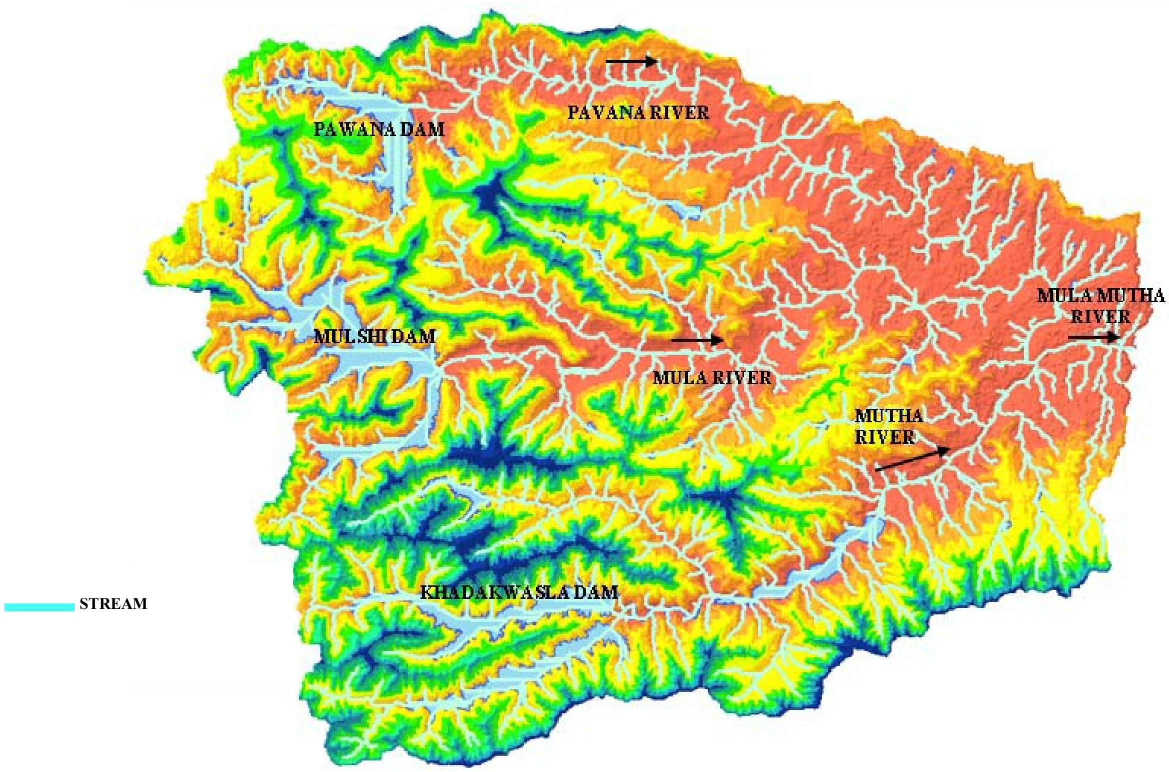


Figure 8: Watershed Stream Extracted from DEM Image

2.6 PHYSIOGRAPHIC PARAMETERS OF THE WATERSHED CATCHMENT

Consultants have selected an overall reach of the river project course for examining the watershed catchment of river for flood estimation purpose. The -catchment characteristic like catchment area, stream length, longest flow path, slope etc for all these sub catchments are computed from the GIS data as well as from the relevant topo sheet and are tabulated in table 2.

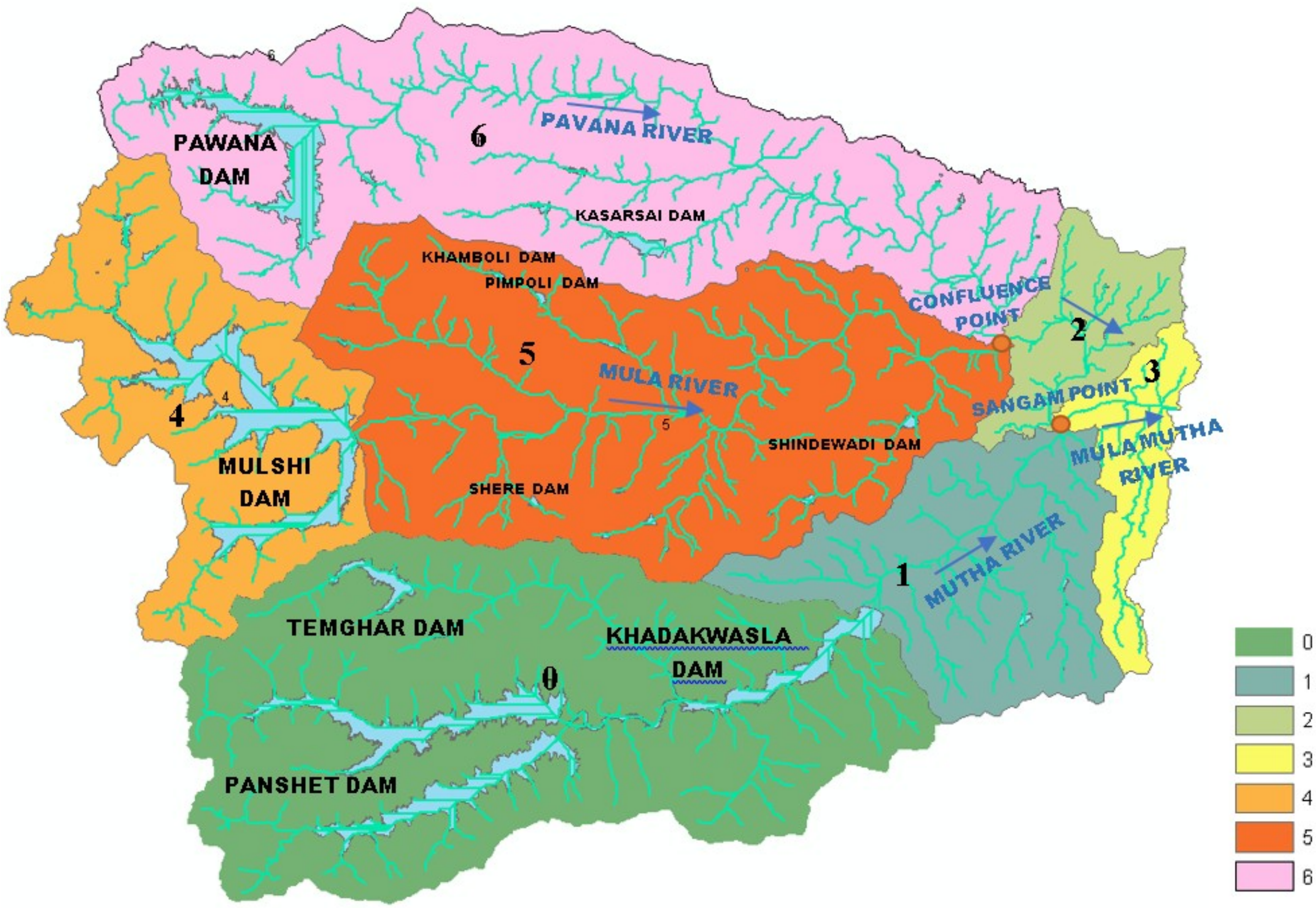


Figure 9: Sub Catchment Watershed Area Plan

a) Catchment Area (A):

Watershed catchment area plan for Mula, Mutha and Mula Mutha River is divided into seven different sub catchment areas. 0) Khadakwasla Dam catchment 1) Mutha river catchment from Khadakwasla dam to Sangam point 2) Mula river catchment after confluence point up to Sangam point 3) Mula Mutha River catchment up to project end point i.e. KT weir 4) Mulshi Dam Catchment 5) Mula river catchment from Mulshi dam up to confluence point 6) Pawana river

Catchment from Pawana dam up to confluence point with Mula River.

b) Main Stream (L & Lc):

River length (L) implies the longest length of the main river from the farthest watershed boundary of rain-fed catchment to the downstream boundary point, whereas Lc is defined as the length of the longest main stream from a point opposite to centroid of the catchment area to the gauging site (i.e., the outlet point) along the main stream. The stream may or may not pass through the center of gravity but the point of the river nearest to the center of gravity is considered to find the length of the main river from the center of gravity to the point of study (Lc).

c) Equivalent Stream Slope (S):

The L-section of the river is derived from relevant topo sheets. It is broadly divided into segments representing broad ranges of slopes. The following formula is used to compute equivalent slope (S).

$$S = \frac{\sum L_i (D_{(i-1)} + D_i)}{L^2}$$

Elevations of riverbed at intersection points of contours reckoned from the bed elevation at the diversion site are considered as datum. D(i-1) and Di are the heights of successive bed locations at contour intersections.

LEGEND NO	SUB CATCHMENT	CATCHMENT AREA KM^2	LENGTH OF LONGEST STREAM (KM)
0	KHADAKWASLA DAM	550.35	44.71
1	MUTHA RIVER UPTO SANGAM FROM KHADAKWASLA DAM	188.04	15.85
2	MULA RIVER FROM CONFLUENCE WITH PAWANA TO SANGAM	67.51	13.79
3	MULA MUTHA RIVER FROM SANGAM UPTO KT WEIR	58.82	15
4	MULSHI DAM	249.20	25.73
5	MULSHI RIVER FROM MULSHI DAM UPTO CONFLUENCE WITH PAWANA RIVER	480.85	45.46
6	PAWANA RIVER CATCHMENT FROM PAWANA DAM UPTO CONFLUENCE WITH MULA RIVER	501.20	69.153

Table 3: Table Showing Sub catchment Watershed Area and longest Stream Length

3. HYDROLOGY STUDY

3.1 INTRODUCTION

Hydrology includes the review of rainfall events and watershed characteristics to determine the runoff rates and resultant surface water flow. A design storm is defining as statistically the worst rainfall event which would occur once within the design time period and which would produce the design flow for that period, for example, a 1:100-year design storm would statistically occur within a 100-year time period and would produce the 1:100-year design flood.

It is often noticed that clear distinction is not made between a flood that can occur at a given location due to certain hydro-meteorological parameters and catchment characteristics and the flood (called the design flood) for which a structure or location is made safe by resorting to appropriate constructions. While the former is more or less uncontrollable as it essentially depends on natural phenomena, in the case of the latter, the owner or the engineer of a structure has the choice to select an appropriate design, which is safe against the selected flood. This involves a socio-economic trade-off between marginal investments and marginal benefits or reduction in losses over a stipulated life time. Such a risk analysis is, therefore, an essential part of the process of selecting a design flood. The design flood has to be selected on the basis of its probability of occurrence, the damage that can occur if it is exceeded and also the existing safety status of the surrounding areas and structures. The protective structure has, therefore, to be selected based on the importance of its hazard potential in case of failure, the resulting economic loss and the cost of rebuilding it as well as the existing safety status of the surrounding areas. The studies that follow have been done in the background of this logic.

3.2 SELECTION OF DESIGN FLOOD

The construction of the proposed flood embankment walls for jacketing the river has two purposes. One, to channelize the flow in a constricted width so that additional side widths are released for other use, and two, to protect the adjacent areas against erosion and damage that may be caused by the increased flood velocities. There are no specific Indian Standards or guide lines for selection of the design flood for such structures. However, the design flood for similar flood protective structures is being normally adopted as a 100-year return period flood in city.

The hazard potential at the probable failure or over flanking of the embankments retaining walls, probable loss to lives and properties on this account and the effect of back water levels on the existing bridges, are the aspects that need to' be accounted for while selecting the design flood for the proposed scheme.

Riverfront is not a flood control scheme and as such it is not supposed to provide greater protection to the areas on the river banks which have even otherwise been damaged by floods. In principle, therefore, it should be acceptable that Riverfront Development works for Mula, Mutha and Mula-Mutha River are so planned that they do not aggravate the situation compared to what occurred in past.

For estimation of the design flood in Mula, Mutha and Mula-Mutha river two approaches have been followed for development of MMRFD

- Flood Frequency Analysis
- Hydro Meteorological approach

3.2.1 FLOOD FREQUENCY ANALYSIS

The statistical approach for design flood estimation, otherwise also called flood frequency analysis, may be performed on the past recorded data of annual flood peak discharges either directly observed at the site or estimated by a suitable method. Alternatively, frequency analysis may be carried out on the available record of annual rainfall events of the region.

Flood frequency analysis studies interpret past record of events to predict the future probabilities of occurrence and estimate the magnitude of an event corresponding to a specific return period. For the estimation of flood flows of large return periods, it is often necessary to extrapolate the magnitude outside the observed range of data.

The Flood Frequency analysis is based on the observed gauging data available from year 1976 to 2015 for Mula Mutha River at Bund Garden in Pune. As gauges are not available on Mula and Mutha river flood frequency analysis are not performed for this river. Since the analysis assumes that the flood events are independent of each other, it is appropriate to take the annual flood peaks and not to base the analysis on the partial duration series, which enhances the risk of flood events not being independent of each other. The annual series is most commonly used and the design flood values derived from it are more appropriate for extrapolation.

Based on Gumble distribution method mentioned by Indian standard code of practice (IS 5477(PART IV)) 25, 50 year and 100 year return period flood as per gauging data at Bund Garden is worked out as below

ANNEXURE 1

FLOOD ESTIMATION BY GUMBLE’S METHOD AT BUND GARDEN

ESTIMATION OF PARAMETERS OF GUMBLE'S EXTREME VALUE DISTRIBUTION AND DETERMINATION OF PEAK FLOW OF LONG TERM RETURN PERIOD

PROJECT NAME: PUNE RIVERFRONT DEVELOPMENT PROJECT

Table: 1 Value of e^{-ax}

Sr. No.	Year	Peak flow rate Cumecs X	X^2	e^{-a1*x} a = 0.001092	Xi * e^{-ak*xi} (Col3*Col5)	$X^2 * e^{-ak*xi}$ (Col4*Col5)
1	2	3	4	5	6	7
1	1976.00	4366.00	19061956.00	0.0085	37.111	162026.626
2	1977.00	1470.00	2160900	0.2008	295.176	433908.72
3	1978.00	1450.00	2102500	0.2053	297.685	431643.25
4	1979.00	1430.00	2044900.00	0.2098	300.014	429020.02
5	1980.00	1750.00	3062500.00	0.1479	258.825	452943.75
6	1981.00	2200.00	4840000.00	0.0905	199.1	438020
7	1982.00	800.00	640000	0.4174	333.92	267136
8	1983.00	3400.00	11560000	0.0244	82.96	282064
9	1984.00	1050.00	1102500	0.3177	333.585	350264.25
1	1985.00	1150.00	1322500	0.2848	327.52	376648
1	1986.00	800.00	640000	0.4174	333.92	267136
1	1987.00	850.00	722500	0.3953	336.005	285604.25
1	1988.00	1354.72	1835266.278	0.2278	308.605216	418073.6582
1	1989.00	1231.38	1516296.704	0.2606	320.897628	395146.9212
1	1990.00	2198.89	4835117.232	0.0906	199.219434	438061.6212
1	1991.00	800.91	641456.8281	0.417	333.97947	267487.4973
1	1992.00	824.69	680113.5961	0.4063	335.071547	276330.1541
1	1993.00	455.39	207380.0521	0.6082	276.968198	126128.5477
1	1994.00	3674.17	13499525.19	0.0181	66.502477	244341.4059
2	1995.00	597.56	357077.9536	0.5207	311.149492	185930.4904
2	1996.00	754.17	568772.3889	0.4389	331.005213	249634.2015
2	1997.00	3847.16	14800640.07	0.015	57.7074	222009.601
2	1998.00	1500.00	2250000	0.1944	291.6	437400
2	1999.00	830.00	688900	0.404	335.32	278315.6
2	2000.00	200.00	40000	0.8038	160.76	32152
2	2001.00	1150.00	1322500	0.2848	327.52	376648
2	2002.00	250.00	62500	0.7611	190.275	47568.75
2	2003.00	300.00	90000	0.7207	216.21	64863
2	2004.00	1931.92	3732314.886	0.1213	234.341896	452729.7957
3	2005.00	4429.06	19616572.48	0.0079	34.989574	154970.9226
3	2006.00	3215.75	10341048.06	0.0298	95.82935	308163.2323
3	2008.00	3539.00	12524521	0.021	74.319	263014.941
3	2009.00	1741.80	3033867.24	0.1493	260.05074	452956.3789
3	2010.00	703.34	494687.1556	0.4639	326.279426	229485.3715
3	2011.00	2772.65	7687588.023	0.0484	134.19626	372079.2603
3	2012.00	1025.00	1050625	0.3265	334.6625	343029.0625
3	2013.00	1490.00	2220100	0.1965	292.785	436249.65
3	2014.00	2022.00	4088484	0.1099	222.2178	449324.3916
3	2015.00	538.00	289444	0.5557	298.9666	160844.0308
	Total	64093.56	157735054.14	10.92	9507.25	11859353.35

(A) No. of Observations = 39 $\bar{x}$ = 1643.42

Standard Deviation **S**

$$S^2 = \frac{\Sigma x^2 - (\Sigma x)^2 / n}{n - 1}$$

$$S^2 = \frac{157735054.1388-64{,}093.56}{39 - 1} \text{ ^ 2 / 39}$$

S^2 = 1,379,003.15650

S = **1,174.3097**

(B) Computation of value a1 , a2 , a3, …an.

$$a1 = \frac{\Pi \ x \ k}{\sqrt{6} \ x \ S}$$

$$a1 = \frac{3.14x\,1}{2.45 \ x \ 1{,}174.3097}$$

value a1= 0.001092

(C) TABLE : 5 FOR VALUES OF ak+1 FROM ak

Sr. No.	Quantity			k=1	k =10
1	ak			0.001092	0.001227558
2	ak log10 ^{e}			0.000474	0.000533116
3	1/ ak			915.75092	814.6251469
4	$(1/\ ak)^{2}$			838599.7397	663614.1299
5	x - 1/ ak			727.6737	828.7994685
6	e^{-ak*xi}			10.92200	9.73459
7	$xi * e^{-ak*xi}$			9507.250221	8068.002806
8	$x_i^{2} * e^{-ak*x_i}$			11859353.35	9495111.002
9	f (ak) = (c-7) - (c-5) *(c-6)			1,559.598074	-0.020212643
10	f' (ak) =-(c-8) + (c-5) * (c-7) - (c-4) * (c-6)			-14,100,363.7671	-9,268,366.0380
11	hk = - f (ak) / f' (ak)			0.000111	-2.18082E-09
12	ak + 1 = ak + hk			0.001203	0.001228

Adopted value of a = **0.001228**

(D) Computation for ' u '

u = loge10 x 1 / ak [log10 (n) - log10 ($e^{-ak * xi}$)

u = 1,130.5988

(E) Magnitude of Peak Flow of a given Return Period T

Return Period T	T/(T-1)	
2	2.000000	1
5	1.250000	2
10	1.111111	3
20	1.052632	4
25	1.041667	5
50	1.020408	6
100	1.010101	7
200	1.005025	8
500	1.002004	9
1000	1.001001	10

XT= u - 2.3026 / a [0.3623 + log10 log10 (T/ (T-1))]

XT= 1,130.5988 - 2.3026 / 0.00122755629051652 [0.3623 + log10 log10 (T / (T-1))]
XT50= 1,130.5988 - 2.3026 / 0.00122755629051652 [0.3623 + log10 log10 (1.02040816326531)]
4309.08423
OR.......

XT= u - 1 / a [loge loge (T/ (T-1))]

XT2	1429
XT5	2352
XT10	2964
XT20	3550
XT25	3736
XT50	4309
XT100	4878
XT200	5445
XT500	6192
XT1000	6757

To determine value " ak "

Sr. No.	**Year**	**Peak flow rate (10000 l / s) X**	**X^2**	**e^{-a1*x} a1= 0.001092**
1	2	3	4	5
1	1976	4366	19061956	0.0085
2	1977	1470	2160900	0.2008
3	1978	1450	2102500	0.2053
4	1979	1430	2044900	0.2098
5	1980	1750	3062500	0.1479
6	1981	2200	4840000	0.0905
7	1982	800	640000	0.4174
8	1983	3400	11560000	0.0244
9	1984	1050	1102500	0.3177
10	1985	1150	1322500	0.2848
11	1986	800	640000	0.4174
12	1987	850	722500	0.3953
13	1988	1354.72	1835266.278	0.2278
14	1989	1231.38	1516296.704	0.2606
15	1990	2198.89	4835117.232	0.0906
16	1991	800.91	641456.8281	0.417
17	1992	824.69	680113.5961	0.4063
18	1993	455.39	207380.0521	0.6082
19	1994	3674.17	13499525.19	0.0181
20	1995	597.56	357077.9536	0.5207
21	1996	754.17	568772.3889	0.4389
22	1997	3847.16	14800640.07	0.015
23	1998	1500	2250000	0.1944
24	1999	830	688900	0.404
25	2000	200	40000	0.8038
26	2001	1150	1322500	0.2848
27	2002	250	62500	0.7611
28	2003	300	90000	0.7207
29	2004	1931.92	3732314.886	0.1213
30	2005	4429.06	19616572.48	0.0079
31	2006	3215.75	10341048.06	0.0298
32	2008	3539	12524521	0.021
33	2009	1741.8	3033867.24	0.1493
34	2010	703.34	494687.1556	0.4639
35	2011	2772.65	7687588.023	0.0484
36	2012	1025	1050625	0.3265
37	2013	1490	2220100	0.1965
38	2014	2022	4088484	0.1099
39	2015	538	289444	0.5557
		64093.56	4107984433	0
	Total	64093.56	157735054.1	10.922

$Xi * e^{-a1*xi}$	$X^2 * e^{-a1*xi}$	e^{-a2*x} a2= 0.0012036	$Xi * e^{-a2*xi}$	$X^2 * e^{-a2*xi}$
37.111	162026.626	0.00524	22.87784	99884.64944
295.176	433908.72	0.17070	250.92900	368865.63000
297.685	431643.25	0.17486	253.54700	367643.15000
300.014	429020.02	0.17911	256.12730	366262.03900
258.825	452943.75	0.12190	213.32500	373318.75000
199.1	438020	0.07095	156.09000	343398.00000
333.92	267136	0.38210	305.68000	244544.00000
82.96	282064	0.01676	56.98400	193745.60000
333.585	350264.25	0.28288	297.02400	311875.20000
327.52	376648	0.25083	288.45450	331722.67500
333.92	267136	0.38210	305.68000	244544.00000
336.005	285604.25	0.35980	305.83000	259955.50000
308.605216	418073.6582	0.19609	265.64704	359877.36453
320.897628	395146.9212	0.22744	280.06507	344866.52245
199.219434	438061.6212	0.07105	156.23113	343535.07934
333.97947	267487.4973	0.38168	305.69133	244831.24215
335.071547	276330.1541	0.37092	305.89401	252267.73507
276.968198	126128.5477	0.57830	263.35204	119927.88413
66.502477	244341.4059	0.01205	44.27375	162669.27853
311.149492	185930.4904	0.48742	291.26270	174046.93614
331.005213	249634.2015	0.40375	304.49614	229641.85202
57.7074	222009.601	0.00979	37.66370	144898.26624
291.6	437400	0.16465	246.97500	370462.50000
335.32	278315.6	0.36856	305.90480	253900.98400
160.76	32152	0.78622	157.24400	31448.80000
327.52	376648	0.25083	288.45450	331722.67500
190.275	47568.75	0.74034	185.08500	46271.25000
216.21	64863	0.69713	209.13900	62741.70000
234.341896	452729.7957	0.09795	189.23156	365580.24312
34.989574	154970.9226	0.00486	21.52523	95336.54227
95.82935	308163.2323	0.02092	67.27349	216334.72547
74.319	263014.941	0.01418	50.18302	177597.70778
260.05074	452956.3789	0.12311	214.43300	373499.39592
326.279426	229485.3715	0.42920	301.87353	212319.72718
134.19626	372079.2603	0.03564	98.81725	273985.63712
334.6625	343029.0625	0.29151	298.79775	306267.69375
292.785	436249.65	0.16665	248.30850	369979.66500
222.2178	449324.3916	0.08789	177.71358	359336.85876
298.9666	160844.0308	0.52361	281.70218	151555.77284
0	0	0.00000	0.00000	0.00000
9507.250221	11859353.35	9.93897	8309.786932	9880663.232

e^{-a3*x} a3 = 0.001227	$Xi *e^{-a3*xi}$	$X^2* e^{-a3*xi}$	e^{-a4*x} a4 = 0.001228	$Xi *e^{-a4*xi}$
7	8	9	10	11
0.00472	20.60752	89972.43232	0.00470	20.52020
0.16478	242.22660	356073.10200	0.16456	241.90320
0.16887	244.86150	355049.17500	0.16865	244.54250
0.17307	247.49010	353910.84300	0.17284	247.16120
0.11688	204.54000	357945.00000	0.11669	204.20750
0.06730	148.06000	325732.00000	0.06716	147.75200
0.37482	299.85600	239884.80000	0.37455	299.64000
0.01544	52.49600	178486.40000	0.01540	52.36000
0.27583	289.62150	304102.57500	0.27557	289.34850
0.24399	280.58850	322676.77500	0.24373	280.28950
0.37482	299.85600	239884.80000	0.37455	299.64000
0.35252	299.64200	254695.70000	0.35225	299.41250
0.18981	257.13940	348351.89230	0.18957	256.81427
0.22081	271.90102	334813.47530	0.22056	271.59317
0.06739	148.18320	325838.55027	0.06726	147.89734
0.37440	299.86070	240161.43644	0.37413	299.64446
0.36364	299.89027	247316.50809	0.36336	299.65936
0.57201	260.48763	118623.46360	0.57177	260.37834
0.01103	40.52610	148899.76283	0.01100	40.41587
0.48047	287.10965	171565.24437	0.48021	286.95429
0.39650	299.02841	225518.25220	0.39622	298.81724
0.00892	34.31667	132021.70939	0.00889	34.20125
0.15883	238.24500	357367.50000	0.15861	237.91500
0.36128	299.86240	248885.79200	0.36100	299.63000
0.78245	156.49000	31298.00000	0.78231	156.46200
0.24399	280.58850	322676.77500	0.24373	280.28950
0.73590	183.97500	45993.75000	0.73573	183.93250
0.69213	207.63900	62291.70000	0.69193	207.57900
0.09350	180.63452	348971.44188	0.09334	180.32541
0.00437	19.35499	85724.42175	0.00435	19.26641
0.01936	62.25692	200202.69049	0.01930	62.06398
0.01302	46.07778	163069.26342	0.01298	45.93622
0.11806	205.63691	358178.36635	0.11787	205.30597
0.42201	296.81651	208762.92653	0.42173	296.61958
0.03334	92.44015	256304.18467	0.03325	92.19061
0.28442	291.53050	298818.76250	0.28415	291.25375
0.16079	239.57710	356969.87900	0.16057	239.24930
0.08372	169.28184	342287.88048	0.08357	168.97854
0.51689	278.08682	149610.70916	0.51663	277.94694
0.00000	0.00000	0.00000	0.00000	0.00000
9.74208	8076.782713	9508937.94	9.73467	8068.097395

$X^{2*} e^{-a4*xi}$	e^{-a5*x} a5 = 0.001228	$Xi *e^{-a5*xi}$	$X^{2*} e^{-a5*xi}$	e^{-a6*x} a6 = 0.001227559
12	13	14	15	16
89591.19320	0.00470	20.52020	89591.19320	0.00470
355597.70400	0.16456	241.90320	355597.70400	0.16455
354586.62500	0.16865	244.54250	354586.62500	0.16864
353440.51600	0.17284	247.16120	353440.51600	0.17284
357363.12500	0.11669	204.20750	357363.12500	0.11669
325054.40000	0.06716	147.75200	325054.40000	0.06716
239712.00000	0.37454	299.63200	239705.60000	0.37454
178024.00000	0.01540	52.36000	178024.00000	0.01540
303815.92500	0.27556	289.33800	303804.90000	0.27556
322332.92500	0.24373	280.28950	322332.92500	0.24373
239712.00000	0.37454	299.63200	239705.60000	0.37454
254500.62500	0.35225	299.41250	254500.62500	0.35225
347911.42840	0.18957	256.81427	347911.42840	0.18957
334434.40112	0.22056	271.59317	334434.40112	0.22056
325209.98503	0.06726	147.89734	325209.98503	0.06725
239988.24310	0.37413	299.64446	239988.24310	0.37413
247126.07628	0.36336	299.65936	247126.07628	0.36336
118573.69239	0.57177	260.37834	118573.69239	0.57177
148494.77708	0.01100	40.41587	148494.77708	0.01100
171472.40410	0.48021	286.95429	171472.40410	0.48021
225358.99593	0.39622	298.81724	225358.99593	0.39622
131577.69018	0.00889	34.20125	131577.69018	0.00889
356872.50000	0.15861	237.91500	356872.50000	0.15861
248692.90000	0.36100	299.63000	248692.90000	0.36100
31292.40000	0.78230	156.46000	31292.00000	0.78230
322332.92500	0.24373	280.28950	322332.92500	0.24373
45983.12500	0.73573	183.93250	45983.12500	0.73573
62273.70000	0.69193	207.57900	62273.70000	0.69193
348374.27150	0.09334	180.32541	348374.27150	0.09334
85332.09030	0.00435	19.26641	85332.09030	0.00435
199582.22761	0.01930	62.06398	199582.22761	0.01930
162568.28258	0.01298	45.93622	162568.28258	0.01298
357601.93158	0.11787	205.30597	357601.93158	0.11787
208624.41413	0.42173	296.61958	208624.41413	0.42173
255612.30175	0.03325	92.19061	255612.30175	0.03325
298535.09375	0.28415	291.25375	298535.09375	0.28415
356481.45700	0.16056	239.23440	356459.25600	0.16056
341674.60788	0.08357	168.97854	341674.60788	0.08357
149535.45372	0.51663	277.94694	149535.45372	0.51663
0.00000	0.00000	0.00000	0.00000	0.00000
9495248.414	9.73462	8068.053995	9495201.988	9.73459

Xi *e -a6*xi	X2* e -a6*xi	e -a7*x	Xi *e -a7*xi	X2* e -a6*xi
		a7 = 0.001228		
17	18	19	20	21
20.52020	89591.19320	0.00470	20.52020	89591.19320
241.88850	355576.09500	0.16456	241.90320	355597.70400
244.52800	354565.60000	0.16865	244.54250	354586.62500
247.16120	353440.51600	0.17284	247.16120	353440.51600
204.20750	357363.12500	0.11669	204.20750	357363.12500
147.75200	325054.40000	0.06716	147.75200	325054.40000
299.63200	239705.60000	0.37454	299.63200	239705.60000
52.36000	178024.00000	0.01540	52.36000	178024.00000
289.33800	303804.90000	0.27556	289.33800	303804.90000
280.28950	322332.92500	0.24373	280.28950	322332.92500
299.63200	239705.60000	0.37454	299.63200	239705.60000
299.41250	254500.62500	0.35225	299.41250	254500.62500
256.81427	347911.42840	0.18957	256.81427	347911.42840
271.59317	334434.40112	0.22056	271.59317	334434.40112
147.87535	325161.63386	0.06726	147.89734	325209.98503
299.64446	239988.24310	0.37413	299.64446	239988.24310
299.65936	247126.07628	0.36336	299.65936	247126.07628
260.37834	118573.69239	0.57177	260.37834	118573.69239
40.41587	148494.77708	0.01100	40.41587	148494.77708
286.95429	171472.40410	0.48021	286.95429	171472.40410
298.81724	225358.99593	0.39622	298.81724	225358.99593
34.20125	131577.69018	0.00889	34.20125	131577.69018
237.91500	356872.50000	0.15861	237.91500	356872.50000
299.63000	248692.90000	0.36100	299.63000	248692.90000
156.46000	31292.00000	0.78230	156.46000	31292.00000
280.28950	322332.92500	0.24373	280.28950	322332.92500
183.93250	45983.12500	0.73573	183.93250	45983.12500
207.57900	62273.70000	0.69193	207.57900	62273.70000
180.32541	348374.27150	0.09334	180.32541	348374.27150
19.26641	85332.09030	0.00435	19.26641	85332.09030
62.06398	199582.22761	0.01930	62.06398	199582.22761
45.93622	162568.28258	0.01298	45.93622	162568.28258
205.30597	357601.93158	0.11787	205.30597	357601.93158
296.61958	208624.41413	0.42173	296.61958	208624.41413
92.19061	255612.30175	0.03325	92.19061	255612.30175
291.25375	298535.09375	0.28415	291.25375	298535.09375
239.23440	356459.25600	0.16056	239.23440	356459.25600
168.97854	341674.60788	0.08357	168.97854	341674.60788
277.94694	149535.45372	0.51663	277.94694	149535.45372
0.00000	0.00000	0.00000	0.00000	0.00000
8068.002806	9495111.002	9.73462	8068.053995	9495201.988

e^{-a8*x}	$Xi * e^{-a8*xi}$	$X^2 * e^{-a8*xi}$	e^{-a9*x}	$Xi * e^{-a9*xi}$
a8 =			**a9 =**	
0.001228			0.001228	
22	23	24	25	26
0.00470	20.52020	89591.19320	0.00470	20.52020
0.16455	241.88850	355576.09500	0.16456	241.90320
0.16864	244.52800	354565.60000	0.16865	244.54250
0.17284	247.16120	353440.51600	0.17284	247.16120
0.11669	204.20750	357363.12500	0.11669	204.20750
0.06716	147.75200	325054.40000	0.06716	147.75200
0.37454	299.63200	239705.60000	0.37454	299.63200
0.01540	52.36000	178024.00000	0.01540	52.36000
0.27556	289.33800	303804.90000	0.27556	289.33800
0.24373	280.28950	322332.92500	0.24373	280.28950
0.37454	299.63200	239705.60000	0.37454	299.63200
0.35225	299.41250	254500.62500	0.35225	299.41250
0.18957	256.81427	347911.42840	0.18957	256.81427
0.22056	271.59317	334434.40112	0.22056	271.59317
0.06725	147.87535	325161.63386	0.06726	147.89734
0.37413	299.64446	239988.24310	0.37413	299.64446
0.36336	299.65936	247126.07628	0.36336	299.65936
0.57177	260.37834	118573.69239	0.57177	260.37834
0.01100	40.41587	148494.77708	0.01100	40.41587
0.48021	286.95429	171472.40410	0.48021	286.95429
0.39622	298.81724	225358.99593	0.39622	298.81724
0.00889	34.20125	131577.69018	0.00889	34.20125
0.15861	237.91500	356872.50000	0.15861	237.91500
0.36100	299.63000	248692.90000	0.36100	299.63000
0.78230	156.46000	31292.00000	0.78230	156.46000
0.24373	280.28950	322332.92500	0.24373	280.28950
0.73573	183.93250	45983.12500	0.73573	183.93250
0.69193	207.57900	62273.70000	0.69193	207.57900
0.09334	180.32541	348374.27150	0.09334	180.32541
0.00435	19.26641	85332.09030	0.00435	19.26641
0.01930	62.06398	199582.22761	0.01930	62.06398
0.01298	45.93622	162568.28258	0.01298	45.93622
0.11787	205.30597	357601.93158	0.11787	205.30597
0.42173	296.61958	208624.41413	0.42173	296.61958
0.03325	92.19061	255612.30175	0.03325	92.19061
0.28415	291.25375	298535.09375	0.28415	291.25375
0.16056	239.23440	356459.25600	0.16056	239.23440
0.08357	168.97854	341674.60788	0.08357	168.97854
0.51663	277.94694	149535.45372	0.51663	277.94694
0.00000	0.00000	0.00000	0.00000	0.00000
9.73459	8068.002806	9495111.002	9.73462	8068.053995

$X^2 * e^{-a9*xi}$	e^{-a10*x} **a10 =** 0.001228	$Xi * e^{-a10*xi}$	$X^2 * e^{-a10*xi}$
27	28	29	30
89591.19320	0.00470	20.52020	89591.19320
355597.70400	0.16455	241.88850	355576.09500
354586.62500	0.16864	244.52800	354565.60000
353440.51600	0.17284	247.16120	353440.51600
357363.12500	0.11669	204.20750	357363.12500
325054.40000	0.06716	147.75200	325054.40000
239705.60000	0.37454	299.63200	239705.60000
178024.00000	0.01540	52.36000	178024.00000
303804.90000	0.27556	289.33800	303804.90000
322332.92500	0.24373	280.28950	322332.92500
239705.60000	0.37454	299.63200	239705.60000
254500.62500	0.35225	299.41250	254500.62500
347911.42840	0.18957	256.81427	347911.42840
334434.40112	0.22056	271.59317	334434.40112
325209.98503	0.06725	147.87535	325161.63386
239988.24310	0.37413	299.64446	239988.24310
247126.07628	0.36336	299.65936	247126.07628
118573.69239	0.57177	260.37834	118573.69239
148494.77708	0.01100	40.41587	148494.77708
171472.40410	0.48021	286.95429	171472.40410
225358.99593	0.39622	298.81724	225358.99593
131577.69018	0.00889	34.20125	131577.69018
356872.50000	0.15861	237.91500	356872.50000
248692.90000	0.36100	299.63000	248692.90000
31292.00000	0.78230	156.46000	31292.00000
322332.92500	0.24373	280.28950	322332.92500
45983.12500	0.73573	183.93250	45983.12500
62273.70000	0.69193	207.57900	62273.70000
348374.27150	0.09334	180.32541	348374.27150
85332.09030	0.00435	19.26641	85332.09030
199582.22761	0.01930	62.06398	199582.22761
162568.28258	0.01298	45.93622	162568.28258
357601.93158	0.11787	205.30597	357601.93158
208624.41413	0.42173	296.61958	208624.41413
255612.30175	0.03325	92.19061	255612.30175
298535.09375	0.28415	291.25375	298535.09375
356459.25600	0.16056	239.23440	356459.25600
341674.60788	0.08357	168.97854	341674.60788
149535.45372	0.51663	277.94694	149535.45372
0.00000	0.00000	0.00000	0.00000
9495201.988	9.73459	8068.002806	9495111.002

(C) **TABLE : 5 FOR VALUES OF ak+1 FROM ak**

Sr. No.	Quantity	k=1	k=2	k=3	k=4	k=5	k=6	k=7	k=8	k=9	k=10	k=11
1	ak	0.001092	0.001203	0.001227	0.001228	0.001228	0.001228	0.001228	0.001228	0.001228	0.001228	0.001228
2	ak log10 ^{e}	0.000474	0.000522	0.000533	0.000533	0.000533	0.000533	0.000533	0.000533	0.000533	0.000533	0.000533
3	1/ ak	915.750916	831.526884	815.242976	814.630568	814.626212	814.625032	814.626559	814.625137	814.626591	814.625147	814.626594
4	$(1/ ak)^{2}$	838599.739699	691436.957984	664621.110577	663622.962633	663615.864664	663613.942537	663616.431029	663614.114151	663616.483028	663614.129907	663616.487802
5	x - 1/ ak	727.6737	811.8977	828.1816	828.7940	828.7984	828.7996	828.7981	828.7995	828.7980	828.7995	828.7980
6	e^{-ak*xi}	10.92200	9.93897	9.74208	9.73467	9.73462	9.73459	9.73462	9.73459	9.73462	9.73459	8068.002806
7	$xi * e^{-ak*xi}$	9507.250221	8309.78693	8076.782713	8068.097395	8068.053995	8068.002806	8068.05399	8068.002806	8068.053995	8068.002806	9495111.002
8	$x^{2} * e^{-ak*x_i}$	11859353.35	9880663.23225	9508937.94	9495248.414	9495201.988	9495111.002	9495201.98760	9495111.002	9495201.988	9495111.002	0
9	f (ak) = (c-7) - (c-5) *(c-6)	1,559.598074	240.359732	8.570931	0.060847116	0.016477277	-0.021332159	0.019861251	-0.020306785	0.020171942	-0.020212643	2808366.241
10	f' (ak) =-(c-8) + (c-5) * (c-7) - (c-4) * (c-6)	-14,100,363.7671	-10,006,137.2518	-9,294,686.8246	-9,268,607.8665	-9,268,459.9840	-9,268,363.2862	-9,268,468.3020	-9,268,365.8066	-9,268,469.0657	-9,268,366.0380	2,515,469,525.3306
11	hk = - f (ak) / f' (ak)	0.000110607	2.40212E-05	9.22132E-07	6.56486E-09	1.77778E-09	-2.30161E-09	2.14288E-09	-2.19098E-09	2.1764E-09	-2.18082E-09	-0.001116438
12	ak + 1 = ak + hk	0.001203	0.001227	0.001228	0.001228	0.001228	0.001228	0.001228	0.001228	0.001228	0.001228	0.000111

ak+ 1 **0.001228**

Sr No.	Flood Return Period	Flood (Cusecs)	Flood (Cumecs)
1	25	1,31,918	3736
2	50	1,52,150	4309
3	100	1,72,242	4878

Table 4: Flood Discharge as per flood frequency Analysis for various Return Period

3.2.2 HYDRO METEOROLOGICAL APPROACH

The standard project flood (SPF) is estimated using the hydro-meteorological approach. The standard project flood (SPF) is the flood resulting from the most severe combination of meteorological i.e. rainfall and hydrological conditions considered reasonably characteristic of the region. The SPF is computed from the Standard Project Storm (SPS) over the watershed considered and may be taken as the largest storm observed in the region of the watershed is estimated using the hydro-meteorological approach. For the calculation of the SPF, the worst observed rainfall pattern (called the Standard Project Storm or SPF) is applied to the unit hydrograph derived for the catchment. Unit hydrograph is the hydrograph that results from unit (e.g. 1 cm) of rainfall uniformly over the watershed at a uniform rate during a given period of time.

As adequate data for developing unit Hydrograph are not available from the gauging sites located within catchment Synthetic unit Hydrograph method is used. Synthetic unit hydrographs are synthesized directly from catchments, which are hydrologically and meteorologically homogeneous, or indirectly from other catchments through the application of empirical relationship. There are numerous method to derive unit hydrograph using synthetic unit Hydrograph approach but in present study two method are used

3.2.2.1 CWC (Central water commission) of India Sub Zone Method.
3.2.2.2 SCS (Soil Conservation Service) Runoff Developed By United States Of Agriculture Department.

Parameters considered in above method for calculation of highest flood discharge within project area are tabulated in table 5.

Sr No.	River	Catchment Area (km^2)	Slope (m/km)	Length Of Longest Stream (km)
1	Mula River up to Confluence of Pawana River	730	0.73	71.23
2	Pawana River	501.2	0.70	69.149
3	Mutha River	738.5	1.59	60.56
4	Mula - Mutha River up to Project End Reach i.e. KT Weir.	2100	0.66	95.79

Table 5: Parameters considered for Estimation of highest flood discharge In Project Area By Sub Zone Method

3.2.2.1 CWC (CENTRAL WATER COMMISSION) OF INDIA SUB ZONE METHOD.

When short interval catchment rainfall and runoff data for flood events at project site are not available, the parameters of unit hydrograph may be evaluated by using CWC sub zonal reports. For the derivation of regional unit hydrograph and its application to compute design flood hydrograph, reference may be made to relevant CWC study report of the sub zone to which the catchment of proposed SHP belongs. In this approach, concurrent storm rainfall and run-off data of the representative catchments over a period of years have been used to develop representative unit hydrographs of the catchments located in the region. Using these data, a method based on synthetic unit hydrograph (SUH) principle has been developed for the various subzones of India. For this purpose, the country has been divided into 26 hydro-meteorologically-homogeneous subzones. These reports have been prepared jointly by Central Water Commission (CWC), Bridges and Flood Wing of Research Designs and Standards Organization (RDSO) of Ministry of Railways. Ministry of Transport (MOT) and India Meteorological Department (IMD).

The unit hydrograph for the rain-fed catchment area of Mula, Mutha, and Mula Mutha has been derived as per procedures and guidelines given in the regional flood report of sub zone 3h.

Estimation of Synthetic Unit Hydrographs (SUH)

The 1-hour Synthetic Unit Hydrograph (SUH) representing effective rainfall depth of 1 cm has been obtained for catchments using the below parameters

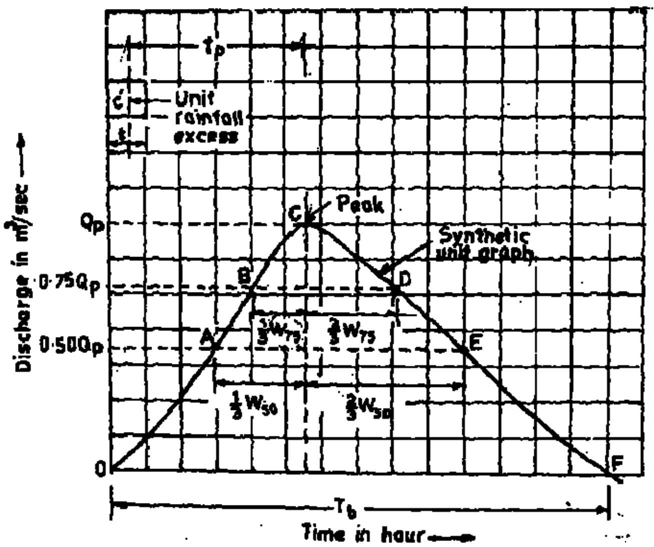


Figure 10. Synthetic Unit Hydrograph

$tp= 0.325(LLc/Sqrt(s))^{-0.447}$
$qp = 0.996(tP)^{-0.497}$
$TB = 7.392(tp)^{0.524}$
$Qp = qp \times A$
$W50 = 2.389(qp)^{-1.065}$
$W75 = 1.415 (qp)^{-1.067}$
$WR75 = 0.558x(qp)^{-1.088}$
$WR50 = 0.753 \times (qp)^{-1.229}$
$QB = A \times qb$

Where,
A = Catchment area in Sq.km.
tp = Time from the center of unit rainfall duration to the peak of unit hydrograph in hours.
qp = Peak discharge per unit of catchment in m^3/s/sq Km
W50 = Width of unit hydrograph in Hr. at 50% peak discharge
W75 = Width of unit hydrograph in Hr. at 75% peak discharge
Tb = Time based of unit hydrograph, Tb in hours
Qp = Quick discharge of unit Hydrograph in m^3/s

The important parameters for deciding critical storm duration are size and shape of the catchment, travel time/base period of unit hydrograph and the direction of the storm movement with reference to the direction of river flow. For all practical purposes, the UG base governs the duration of the storm

Estimation of Flood Hydrographs from SUH

Flood hydrographs for various return periods were estimated for 1-day maximum rainfall. The steps for estimating flood hydro graphs are discussed in following sections.

a) Base flow for design flood

Base flow is the portion of stream flow that comes from the sum of deep subsurface flow and delayed shallow subsurface flow.

b) Design Storm

1 day rainfall for the study area for 100 year return period obtained from isohyets supplied by IMD in CWC manual.

c) Design storm duration

The duration of storm rainfall which causes maximum discharge in a drainage basin is called design storm duration. The 24-hour rainfall depth is converted into short duration design Storm rainfall depth as per conversion ratios provided in the CWC report. Areal reduction factor with respect to area is applied to Design Storm rainfall as per the CWC report.

d) Design loss rate

Generally, infiltration index and the initial losses values are derived from the available rainfall-runoff records for the severe storms in the basin. Assuming the basin would be saturated at the time of design storm the minimum infiltration rate and initial losses values would be considered. The minimum infiltration rate and minimum initial loss, thus obtained, are used to compute the effective rainfall of design storm. For this the initial losses must be subtracted first from the rainfall increments and thereafter a uniform loss rate equal to the minimum infiltration index is applied. Here, a loss rate of 0.10 cm/h is used as recommended in the CWC Report.

e) Estimation of Design Flood Hydrograph

To obtain the critical sequence of rainfall excess, the highest rainfall depth has been placed against the maximum UG ordinate and the next ranking rainfall depth has been placed against the next ranking ordinate of hydrograph. This critical arrangement is then reversed to obtain the maximum flood peak.

3.2.2.2 SCS (SOIL CONSERVATION SERVICE) RUNOFF DEVELOPED BY UNITED STATES OF AGRICULTURE DEPARTMENT.

In hydrological modeling, the runoff estimation is the most important aspect. There are number of empirical methods for its estimation. The most commonly and widely used empirical method is the Soil Conservation Service-Curve Number Method (SCS, 1972) developed by United States Department of Agriculture and Soil Conservation Service (USDA-SCS) to estimate surface runoff. This method is very popular due to its simplicity, flexibility and requirement of a single parameter called Curve Number (CN) for computation of runoff. Hydrologic soil group number, land use type, vegetation cover is the basic catchment characteristics used for curve number calculations.

The equation for surface runoff is given by

$$Q = \frac{(P - I_a)^2}{(P - I_a + S)} \qquad (1)$$

Where,
Q - Accumulated runoff or rainfall excess in mm
P – Rainfall depth in mm
I a – Initial abstraction in mm
S – Potential maximum retention in mm

The term S is given by

$$S = \frac{25400}{CN} - 254 \qquad (2)$$

Where,
CN – Curve Number (which can taken from the tables, Chapter – 7, SCS Hand book, Section – 4 (1972))

For Indian conditions some modifications were done by soil and water conservation Department, Ministry of Agriculture, New Delhi. For Indian conditions Ia = 0.3S. Equation (1) can be written as

$$Q = \frac{(P - 0.3S)^2}{(P - 0.7S)} \qquad (3)$$

Knowing the value of CN, the runoff depth from the watershed is computed from equations (2) and (3). The SCS curve number is a function of the ability of soils to allow infiltration of water, land use and the antecedent soil moisture condition.

Estimation of Synthetic Unit Hydrographs (SUH) from SCS method

The 1-hour Synthetic Unit Hydrograph (SUH) representing effective rainfall depth of 1 cm has been obtained for Sub catchments using the below parameters.

Unit hydrographs were synthesized for the outlet of the watershed using SCS dimensionless unit hydrograph method.

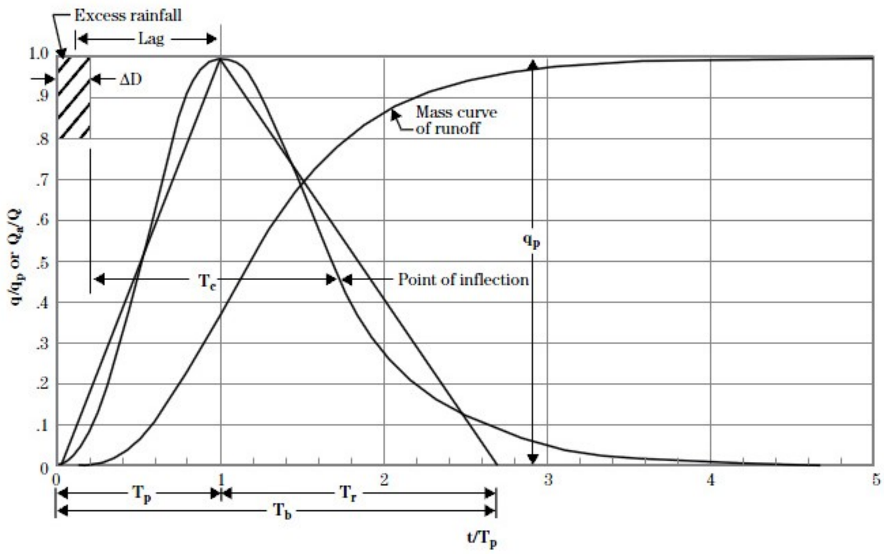


Figure 11. Synthetic Unit Hydrograph By SCS Method

The equations used in this method are

$$Tc = \frac{L^{0.8}\left[\left(\frac{1000}{N}\right)-9\right]^{0.7}}{\left[4407\left(S_g\right)^{0.5}\right]} \quad \text{------------------------------------ (1)}$$

Where
Tc = Time of concentration ,
N = Curve Number
Sg = Slope in %
L= Longest flow length in m

$$T_p = \frac{D}{2} + T_L = \frac{D}{2} + 0.6T_c \quad \text{------------------------------------ (2)}$$

Where
Tp = Time to peak flow

Tlag = Lag time,
D = Duration of the excess Rainfall in cm

$$q = q_n AQ$$ ---(3)

Where
qn = unit flow rate (m3/sec per km/cm of runn off) = 2.08/Tp
Tp = Time to peak flow
Q = Accumulated runoff or rainfall excess in cm
A = Catchment Area in sq m

$$Tb = 2.67\ Tp$$

Where
Tb = Base Storm Duration in hrs

Once we determine Tp and qp, we can calculate D-hr unit hydrograph for our drainage area of interest using following co-ordinates:

t/t_p	q/q_p	t/t_p	q/q_p
0	0	1.70	0.46
0.10	0.03	1.80	0.39
0.20	0.1	1.90	0.33
0.30	0.19	2.00	0.28
0.40	0.31	2.20	0.207
0.50	0.47	2.40	0.147
0.60	0.66	2.60	0.107
0.70	0.82	2.80	0.077
0.80	0.93	3.00	0.055
0.90	0.99	3.20	0.04
1.00	1.00	3.40	0.029
1.10	0.99	3.60	0.021
1.20	0.93	3.80	0.015
1.30	0.86	4.00	0.011
1.40	0.78	4.50	0.005
1.50	0.68	5.00	0
1.60	0.56		

Table 6: SCS Dimensionless Unit Hydrograph Co-Ordinates.

Estimation of Flood Hydrographs from SUH by SCS Method

Flood hydrographs for various return periods were estimated for 1-day maximum rainfall. The steps for estimating flood hydro graphs are discussed in following sections.

a) Base flow for design flood

Base flow is the portion of stream flow that comes from the sum of deep subsurface flow and delayed shallow subsurface flow. The recommended value of base flow 0.05 m3/sec for Subzone-3 (h) is used in this study.

b) Design Storm

The 1 day rainfall for the study area for 100 year return period obtained from rainfall isohyets supplied by IMD in CWC manual for Subzone-3 (h).

c) Design storm duration

The duration of storm rainfall which causes maximum discharge in a drainage basin is called design storm duration . The 24-hour rainfall depth is converted into short duration design Storm rainfall depth as per conversion ratios provided in the CWC report. Areal reduction factor with respect to area is applied to Design Storm rainfall as per the CWC report.

d) Design loss rate

Design loss rate shall be calculated from runoff depth (Q) as calculated from equation 1 prescribed in 2.2.0 from Curve number .

e) Estimation of Design Flood Hydrograph

To obtain the critical sequence of rainfall excess, the highest rainfall depth has been placed against the maximum UG ordinate and the next ranking rainfall depth has been placed against the next ranking ordinate of hydrograph

3.3 ANALYSIS AND RESULTS

Detail analysis to find out flood discharge for 1 in 100 year return period flood as per CWC SUB Zone 3(h) method and SCS method within the project reach for various catchment is appended vide Annexure 1 to 8 in the report and tabulated in table 6.

Sr. No.	Particulars	Sub Zone Method (Cumecs)	SCS Method (Cumecs)	Flood Frequency Analysis By Gumbles Method (Cumecs)	Irrigation Department Pune
1	Mula River Up to Confluence of Pawana River	2221	2868	-	1232 (Up to Babashaheb Ambedkar Bridge) 1670 (Up to Confluence Point with Pawana River)
2	Pawana River	1609	2064	-	2738
3	Mutha River	2537	3497	-	2833
4	Mula – Mutha River Up to Project End Reach i.e. KT Weir	5073	6321	4872	4758

Table 7 : Comparative Statement of Design Flood Discharge For 100 Year Return Period Flood as per various methods.

From the above table following conclusion is made

a) The flood discharge of Mutha river adopted by irrigation department i.e. 2833 Cumecs falls between computed flood by sub zone and SCS method.

b) Flood discharge of Mula Mutha river computed by sub zone method is almost in conjunction with adopted flood of 4758 Cumecs by irrigation department.

c) Variation in flood discharge is observed for Mula and Pawana river as computed by SCS & Sub Zone method and as per flood discharge calculated by irrigation department. However the total discharge after confluence of Mula and Pawana is in conformity with the computed discharge .The dams are located in u/s of Mula and Pawana river ,therefore only control outflow will be discharged and through real time flood management the flood discharge adopted by irrigation department can be achieved.

Looking to the above all aspect the flood discharge as computed by irrigation department is adopted for Mula Mutha river front development project.

ANNEXURE II

FLOOD ESTIMATION REPORT FOR KRISHNA AND PENNAR (SUB-ZONE-3h) BY CWC

MULA MUTHA RIVERFRONT DEVELOPMENT

Project:	**Mula Mutha Riverfront Development**		
River:	Mula	longitude	73^0 75' 08"
City	Pune	latitude	18^0 55' 91"

Table for Computation of Equivalent slope(S)

C.A. **730** km^2

'Datum =Reduced level of river bed = **483** m

TABLE-1

Sr No.	Reduced distance starting (km)	Reduced levels of river bed (m)	Length of each segment Li (km)	Height above datum(Di)= difference between the datum & its R.L. (m)	Di-1 + Di (m)	Li * (Di-1 + Di) (km * m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	483	0.00	0	0	0
2	11.65	485	11.65	2	2	23.302
3	21.02	490	9.37	7	9	84.348
4	30.56	495	9.541	12	19	181.279
5	44.27	500	13.708	17	29	397.532
6	45.94	520	1.667	37	54	90.018
7	65.40	540	19.456	57	94	1828.864
8	67.74	560	2.349	77	134	314.766
9	69.01	580	1.262	97	174	219.588
10	69.97	600	0.959	117	214	205.226
11	70.42	620	0.455	137	254	115.57
12	70.71	640	0.288	157	294	84.672
13	71.24	660	0.53	177	334	177.02
Total			**71.24**			**3722.185**

$$\text{Eq. Slope} = \frac{\text{sum of}(Li*(Di\text{-}1+Di)}{L^2}$$

$= \mathbf{0.73}$ m/km

Design return period:	**100**	years	
From plate no 11 , 100 yr point rainfall from sub zone 3h manual =	**20**	cms	

i) Name & number of subzone — **Lower Ganga Sub Zone -3(h).**

ii) Name of Project — **Mula Mutha Riverfront**

iii) Name of Tributary/River — **Mula**

iv) Site location — longitude 730 75' 08"
latitude 180 55' 91"

Estimation of flood using procedure as recommended in flood estimation report for Krishna & Pennar(SubZone- 3 h) published by Director of 'Hydrology(Small Catchment) CWC New Delhi (September-2000).

Data

C.A. (A)	(Catchment Area up to the project site in km^2)	**730**	km^2	
Length(L)	(Length of Main Stream from farthest point to dam site)	**71.238**	km	
Slope S	(Equivalent stream slope of main stream in m/km)	**0.73**	m/km	(Table - 1)
C.G. (Lc)	(Length of Longest stream from a point opposite to C.G)	**27.30**	km	

(1) Determination of synthetic 1 hr U.G.Parameters

(i) tp= $0.325(LLc/Sqrt(s))^{-0.447}$ (Time to peak less half of unit duration)

= $0.325 \times (71.24 \times 27.30 / sqrt(0.73))^{0.447}$ = **10.2** hrs

tp adopted= **11.0** hrs

(ii) $q_p = 0.996(t_P)^{-0.497}$ (Peak discharge per km^2)

$= 0.996 \times (11.00)^{-0.497}$

= 0.302 cumecs/km^2

(iii) $T_B = 7.392(t_p)^{0.524}$ (Base period of hydrograph)

$= 7.392 * (11.000)^{0.524}$

= 25.969

= 26 hrs

(iv) $\mathbf{Q_p} = q_p \times A$ (Peak Discharge of Unit Hydrograph in cumecs)

$= 0.302 \times 730$

$= 220.46$ cumecs

(v) $\mathbf{W_{50}} = 2.389(q_p)^{\wedge -1.065}$ (Width of U.G. measured at 50% of maximum Discharge)

$= 2.389 \times (0.302)^{-1.065}$

$= 8.55$ hrs Ordinate(Qp) in hrs)

(vi) $\mathbf{W_{75}} = 1.415\ (q_p)^{-1.067}$ (Width of U.G. measured at 75%of maximum Discharge

$= 1.415 \times (0.302)^{-1.067}$

$= 5.08$ hrs Ordinate (Qp) in hrs)

(vii)$\mathbf{W_{R50}} = 0.753 \times (q_p)^{-1.229}$ (Width of rising side of U.G. measured at 50% of maximum

$= 0.753 \times (0.302)^{-1.229}$ Discharge (Qp) in hrs)

$= 3.28$ hrs

(viii)$\mathbf{W_{R75}} = 0.558 \times (q_p)^{-1.088}$

$= 0.558 \times (0.302)^{-1.088}$ (Width of rising side of U.G. measured at 75% of maximum

$= 2.05$ hrs Discharge (Qp) in hours)

(ix) Computation of Design base flow:

$\mathbf{Q_B} = A \times q_b$ (Base Flow)

$= 730 \times 0.05$

36.5 cumecs

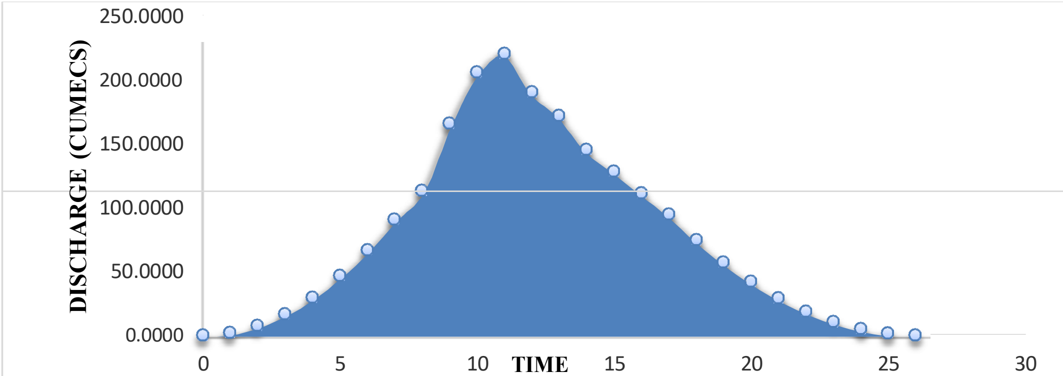
(x) $\mathbf{T_m} = t_p + tr/2$

$= 11.00+1/2$

$= 12.00$ hrs

(2) Drawing of synthatic unit hydrograph

Estimated parameters of U.G.at Plate No.I are plotted to scale on Graph paper as shown in figure and smoothened



(3) Estimation of design storm duration

The design storm duration $T_{DS}= T_m$ hrs = **12** hrs

(4) Estimation of Point rainfall and Areal Rainfall

(I) Point Rainfall

The catchment was located on Plate-10 (Ref C.W.C.Report-Sub Zone-3(h))
showing 100 yr point rainfall = **20** cms

Conversion factor of 100 yr 24 hr point rainfall to 100 yr 12 hr point rainfall
is read from fig-10 section 4.2 = **0.840**

100 yr 12 hrs point rainfall = 20 x 0.84 = **16.8** cm

(ii) Areal Rainfall

Areal reduction factor for TD= 12 hrs corresponding to catchment
area 730 km2 was interpolated from Annexure 4.4 = **0.7720**

100 yr 12 hrs areal rainfall = 16.8x0.772 = **12.97** cms

(5) Time distribution of Areal Rainfall

Loss rate considered = **0.10** cm/hr

For 1 in 100 yr return period flood

100 yr 12 hrs areal rainfall = 12.97 cms was distributed with the distribution coefficient corresponding to 12

Hourly Rainfall Increment

Sr. No.	Duration t (hrs)	Distribution Coefficient	Storm Rainfall (cm)	1-hr rainfall increment (cm)	1-hr rainfall excess (deducting loss of 0.10 cm/hr (cm)
1	1	0.34	4.41	4.41	4.31
2	2	0.50	6.48	2.07	1.97
3	3	0.61	7.91	1.43	1.33
4	4	0.70	9.08	1.17	1.07
5	5	0.76	9.86	0.78	0.68
6	6	0.81	10.51	0.65	0.55
7	7	0.85	11.02	0.51	0.41
8	8	0.89	11.54	0.52	0.42
9	9	0.93	12.06	0.52	0.42
10	10	0.96	12.45	0.39	0.29
11	11	0.98	12.71	0.26	0.16
12	12	1.00	12.97	0.26	0.16

Computation of 1 in 100yr flood: (Peak only)

Time (hrs)	U.G (m^3/sec)	R.F excess in design order	Direct Runoff (cumecs)
7	90.6	0.16	14.50
8	113.1	0.42	47.50
9	165.4	0.68	112.50
10	205.5	1.97	404.85
11	220.5	4.31	950.18
12	190.1	1.33	252.81
13	171.7	1.07	183.73
14	145.0	0.55	79.75
15	127.9	0.42	53.74
16	111.0	0.41	45.52
17	94.3	0.29	27.35
18	74.5	0.16	11.92
Sum=	**1709.7**		**2184.35**

1 in 100 yr flood.

= Sum of direct runoff + Base flow

= 2184.35 + 36.5

= **2220.85 cumecs** **Say 2221 cumecs**

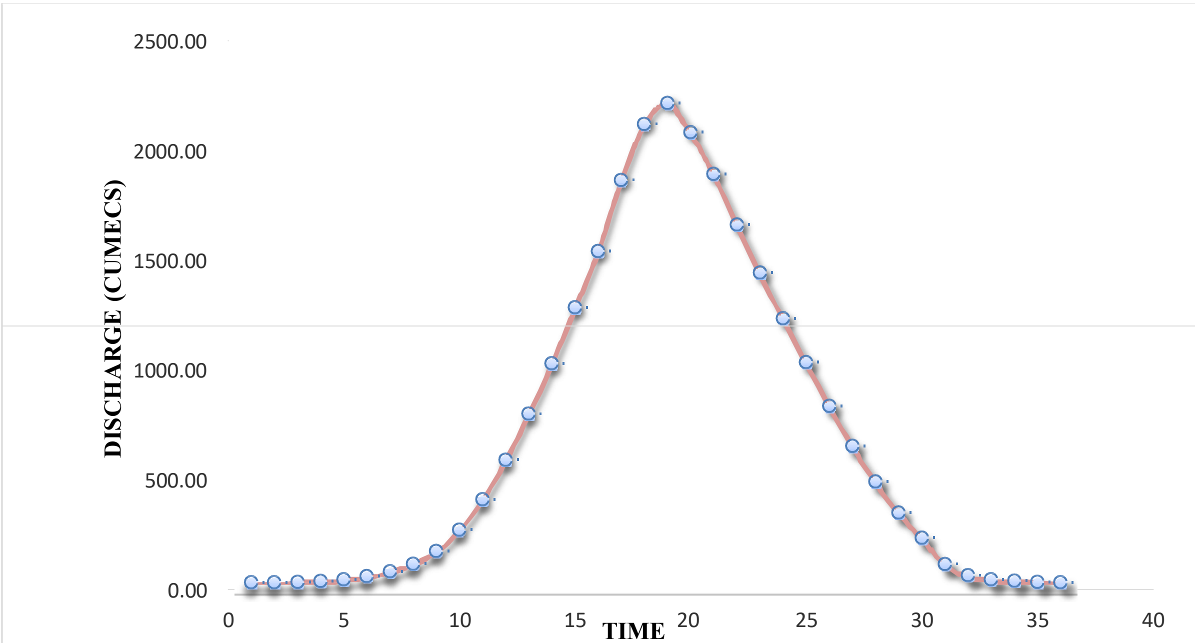
= **78435 cusecs**

Computation of Design Flood Peak hydrograph (1 in 100 Year)

Calculated Peak Flood 2220.85 cumecs

Synthetic U.G. Ordinates	Hourly rainfall excess in cm												Total	Base Flow	Total	Remarks
	0.16	0.29	0.41	0.42	0.55	1.07	1.33	4.31	1.97	0.68	0.42	0.16				
	1	2	3	4	5	6	7	8	9	10	11	12	(Cumecs)	(Cumecs)	(Cumecs)	
0.0	0.00												0.00	36.50	36.50	
1.8	0.30	0.00											0.30	36.50	36.80	
7.4	1.18	0.54	0.00										1.72	36.50	38.22	
16.6	2.66	2.15	0.76	0.00									5.57	36.50	42.07	
29.6	4.73	4.83	3.03	0.78	0.00								13.37	36.50	49.87	
46.2	7.40	8.58	6.82	3.11	1.02	0.00							26.93	36.50	63.43	
66.6	10.65	13.41	12.13	6.99	4.07	1.98	0.00						49.23	36.50	85.73	
90.6	14.50	19.31	18.96	12.43	9.16	7.92	2.46	0.00					84.74	36.50	121.24	
113.1	18.09	26.28	27.30	19.42	16.28	17.81	9.84	7.97	0.00				142.99	36.50	179.49	
165.4	26.47	32.79	37.16	27.97	25.43	31.66	22.14	31.89	3.64	0.00			239.15	36.50	275.65	
205.5	32.88	47.98	46.37	38.06	36.62	49.48	39.36	71.74	14.57	1.26	0.00		378.32	36.50	414.82	
220.5	35.27	59.60	67.83	47.50	49.85	71.24	61.50	127.54	32.79	5.03	0.78	0.00	558.93	36.50	595.43	
190.1	30.41	63.93	84.26	69.48	62.20	96.97	88.56	199.29	58.30	11.32	3.11	0.30	768.13	36.50	804.63	
171.7	27.47	55.12	90.39	86.31	90.99	121.00	120.53	286.98	91.09	20.12	6.99	1.18	998.17	36.50	1034.67	
145.0	23.20	49.80	77.93	92.59	113.03	177.02	150.40	390.61	131.17	31.44	12.43	2.66	1252.28	36.50	1288.78	
127.9	20.47	42.05	70.40	79.84	121.25	219.89	220.03	487.40	178.54	45.28	19.42	4.73	1509.30	36.50	1545.80	
111.0	17.76	37.10	59.45	72.12	104.55	235.89	273.33	713.03	222.78	61.63	27.97	7.40	1833.01	36.50	1869.51	
94.3	15.09	32.20	52.46	60.90	94.44	203.39	293.21	885.74	325.91	76.90	38.06	10.65	2088.95	36.50	2125.45	
74.5	11.92	27.35	45.52	53.74	79.75	183.73	252.81	950.18	404.85	112.50	47.50	14.50	2184.35	36.50	2220.85	**Peak Flood**
57.1	9.13	21.61	38.67	46.63	70.37	155.15	228.38	819.26	434.31	139.75	69.48	18.09	2050.83	36.50	2087.33	
41.9	6.71	16.55	30.55	39.61	61.07	136.90	192.85	740.09	374.46	149.91	86.31	26.47	1861.48	36.50	1897.98	
29.1	4.66	12.16	23.39	31.30	51.87	118.80	170.17	624.95	338.28	129.26	92.59	32.88	1630.31	36.50	1666.81	
18.6	2.98	8.44	17.19	23.96	40.98	100.91	147.67	551.45	285.65	116.77	79.84	35.27	1411.11	36.50	1447.61	
10.5		5.40	11.93	17.60	31.38	79.73	125.43	478.54	252.05	98.60	72.12	30.41	1203.19	36.50	1239.69	
0.0			7.64	12.23	23.05	61.05	99.11	406.48	218.73	87.00	60.90	27.47	1003.66	36.50	1040.16	
				7.82	16.01	44.85	75.88	321.17	185.79	75.50	53.74	23.20	803.96	36.50	840.46	
					10.25	31.15	55.75	245.89	146.80	64.13	46.63	20.47	621.07	36.50	657.57	
						19.93	38.71	180.66	112.39	50.67	39.61	17.76	459.73	36.50	496.23	
							24.78	125.46	82.57	38.80	31.30	15.09	318.00	36.50	354.50	
								80.29	57.34	28.50	23.96	11.92	202.01	36.50	238.51	
									36.70	19.79	17.60	9.13	83.22	36.50	119.72	
										12.67	12.23	6.71	31.61	36.50	68.11	
											7.82	4.66	12.48	36.50	48.98	
											4.40	2.98	7.38	36.50	43.88	
											0.00	1.68	1.68	36.50	38.18	
												0.00	0.00	36.50	36.50	
															2220.85	Cumecs

FLOOD HYDROGRAPH FOR MULA RIVER FOR SUBZONE METHOD



ANNEXURE III

FLOOD ESTIMATION REPORT FOR KRISHNA AND PENNAR (SUB-ZONE-3h) BY CWC

MULA MUTHA RIVERFRONT DEVELOPMENT

Project:	**Mula Mutha Riverfront Development**		
River:	Mutha	longitude	73^0 86' 07"
City	Pune	latitude	18^0 52' 84"

Table for Computation of Equivalent slope(S)

C.A. **738.5** km^2

'Datum =Reduced level of river bed = **473** m

TABLE-1

Sr No.	Reduced distance starting (km)	Reduced levels of river bed (m)	Length of each segment Li (km)	Height above datum(Di)= difference between the datum & its R.L. (m)	Di-1 + Di (m)	Li * (Di-1 + Di) (km * m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	473	0.00	0	0	0
2	3.07	475	3.07	2	2	6.13
3	6.44	475	3.38	2	4	13.5
4	9.09	480	2.653	7	9	23.877
5	13.74	485	4.65	12	19	88.35
6	15.82	500	2.075	27	39	80.925
7	36.66	520	20.837	47	74	1541.938
8	36.83	540	0.178	67	114	20.292
9	54.81	560	17.98	87	154	2768.92
10	58.20	580	3.384	107	194	656.496
11	59.39	600	1.192	127	234	278.928
12	59.98	620	0.587	147	274	160.838
13	60.57	640	0.592	167	314	185.888
Total			**60.57**			**5826.082**

$$\text{Eq. Slope} = \frac{\text{sum of}(Li*(Di\text{-}1+Di)}{L^2}$$

$$= \mathbf{1.59}\ \text{m/km}$$

Design return period: **100** years
From plate no 11 , 100 yr point rainfall from sub zone 3h manual = **20** cms

I) Name & number of subzone	**Lower Ganga Sub Zone -3(h).**
ii) Name of Project	**Mula Mutha Riverfront**
iii) Name of Tributary/River	**Mutha**
iv) Site location	longitude 730 86' 07" latitude 180 52' 84"

Estimation of flood using procedure as recommended in flood estimation report for Krishna & Pennar(SubZone- 3 h) published by Director of 'Hydrology(Small Catchment) CWC New Delhi (September-2000).

Data

C.A. (A)	(Catchment Area up to the project site in km^2)	**738.5**	km^2	
Length(L)	(Length of Main Stream from farthest point to dam site)	**60.568**	km	
Slope S	(Equivalent stream slope of main stream in m/km)	**1.59**	m/km	(Table - 1)
C.G. (Lc)	(Length of Longest stream from a point opposite to C.G)	**26.10**	km	

(1) Determination of synthetic 1 hr U.G.Parameters

(i) tp= $0.325(LLc/Sqrt(s))^{-0.447}$ (Time to peak less half of unit duration)

$= 0.325 \times (60.57 \times 26.10 / sqrt(1.59))^{0.447}$ = **7.8** hrs

tp adopted= **8.0** hrs

(ii) $q_{p} = 0.996(t_P)^{-0.497}$ (Peak discharge per km^2)

$= 0.996 \times (8.00)^{-0.497}$

= 0.354 $cumecs/km^2$

(iii) $T_B = 7.392(t_p)^{0.524}$ (Base period of hydrograph)

$= 7.392 * (8.000)^{0.524}$

= 21.978

= 22 hrs

(iv) $\mathbf{Q_p} =$ $q_p \times A$ (Peak Discharge of Unit Hydrograph in cumecs)

= 0.354x738.5

= 261.429 cumecs

(v) $\mathbf{W_{50}} =$ $2.389(q_p)^{-1.065}$ (Width of U.G. measured at 50% of maximum Discharge)

= $2.389 \times (0.354)^{-1.065}$

= 7.22 hrs Ordinate(Qp) in hrs)

(vi) $\mathbf{W_{75}} =$ $1.415\,(q_p)^{-1.067}$ (Width of U.G. measured at 75%of maximum Discharge

= $1.415 \times (0.354)^{-1.067}$

= 4.29 hrs Ordinate (Qp) in hrs)

(vii)$\mathbf{W_{R50}} =$ $0.753 \times (q_p)^{-1.229}$ (Width of rising side of U.G. measured at 50% of maximum

= $0.753 \times (0.354)^{-1.229}$ Discharge (Qp) in hrs)

= 2.7 hrs

(viii)$\mathbf{W_{R75}} =$ $0.558 \times (q_p)^{-1.088}$

= $0.558 \times (0.354)^{-1.088}$ (Width of rising side of U.G. measured at 75% of maximum

= 1.73 hrs Discharge (Qp) in hours)

(ix) Computation of Design base flow:

$\mathbf{Q_B} =$ $A \times q_b$ (Base Flow)

= 738.5x0.05

36.93 cumecs

(x) $\mathbf{T_m}$ = $t_p + tr/2$

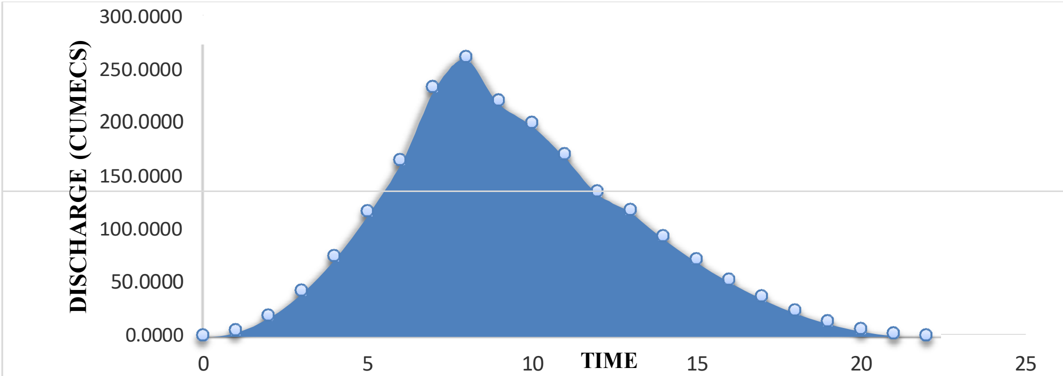
= 8.00+1/2

= 9.00 hrs

But Taking Tm = 12 hrs as per Annexure 4.4 of CWC Report Sub Zone-3(h)

(2) Drawing of synthetic unit hydrograph

Estimated parameters of U.G.at Plate No.I are plotted to scale on Graph paper as shown in figure and smoothened



(3) Estimation of design storm duration

The design storm duration $T_{DS}= T_m$ hrs = **12** hrs

(4) Estimation of Point rainfall and Areal Rainfall

(I) Point Rainfall

The catchment was located on Plate-10 (Ref C.W.C.Report-Sub Zone-3(h))
showing 100 yr point rainfall = **20** cms

Conversion factor of 100 yr 24 hr point rainfall to 100 yr 12 hr point rainfall
is read from fig-10 section 4.2 = **0.840**

100 yr 12 hrs point rainfall = 20 x 0.84 = **16.8** cm

(ii) Areal Rainfall

Areal reduction factor for TD= 12 hrs corresponding to catchment
area 739 km2 was interpolated from Annexure 4.4 = **0.7712**

100 yr 12 hrs areal rainfall = 16.8x0.77115 = **12.96** cms

(5) Time distribution of Areal Rainfall

Loss rate considered = **0.10** cm/hr

For 1 in 100 yr return period flood

100 yr 12 hrs areal rainfall = 12.96 cms was distributed with the distribution coefficient corresponding to 12

Hourly Rainfall Increment

Sr. No.	Duration t (hrs)	Distribution Coefficient	Storm Rainfall (cm)	1-hr rainfall increment (cm)	1-hr rainfall excess (deducting loss of 0.10 cm/hr (cm)
1	1	0.34	4.40	4.40	4.30
2	2	0.50	6.48	2.08	1.98
3	3	0.61	7.90	1.42	1.32
4	4	0.70	9.07	1.17	1.07
5	5	0.76	9.85	0.78	0.68
6	6	0.81	10.49	0.64	0.54
7	7	0.85	11.01	0.52	0.42
8	8	0.89	11.53	0.52	0.42
9	9	0.93	12.05	0.52	0.42
10	10	0.96	12.44	0.39	0.29
11	11	0.98	12.70	0.26	0.16
12	12	1.00	12.96	0.26	0.16

Computation of 1 in 100yr flood: (Peak only)

Time (hrs)	U.G (m^3/sec)	R.F excess in design order	Direct Runoff (cumecs)
4	74.5	0.16	11.91
5	116.3	0.42	48.86
6	164.8	0.54	88.97
7	233.1	1.98	461.51
8	261.4	4.30	1124.14
9	220.3	1.32	290.85
10	199.2	1.07	213.14
11	170.0	0.68	115.61
12	135.3	0.42	56.83
13	117.8	0.42	49.48
14	93.1	0.29	27.00
15	71.3	0.16	11.40
Sum=	**1857.1**		**2499.70**

1 in 100 yr flood.

= Sum of direct runoff + Base flow

= 2499.7 + 36.93

= **2536.63 cumecs** **Say 2537 cumecs**

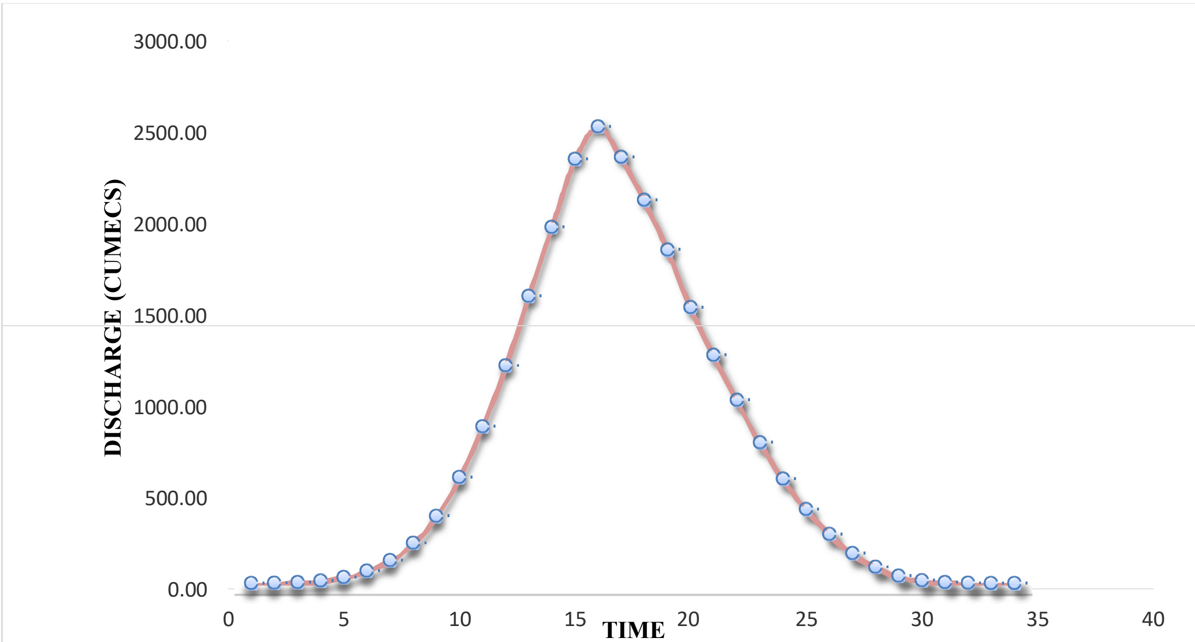
= **89595 cusecs**

Computation of Design Flood Peak hydrograph (1 in 100 Year)

Calculated Peak Flood **2536.63** **cumecs**

Synthetic	Hourly rainfall excess in cm												Total	Base	Total	Remarks
U.G.	0.16	0.29	0.42	0.42	0.68	1.07	1.32	4.30	1.98	0.54	0.42	0.16		Flow		
Ordinates	1	2	3	4	5	6	7	8	9	10	11	12	(Cumecs)	(Cumecs)	(Cumecs)	
0.0	0.00												0.00	36.93	36.93	
4.7	0.74	0.00											0.74	36.93	37.67	
18.6	2.98	1.35	0.00										4.33	36.93	41.26	
41.9	6.70	5.40	1.95	0.00									14.05	36.93	50.98	
74.5	11.91	12.15	7.82	1.95	0.00								33.83	36.93	70.76	
116.3	18.61	21.59	17.59	7.82	3.16	0.00							68.77	36.93	105.70	
164.8	26.36	33.74	31.27	17.59	12.66	4.98	0.00						126.60	36.93	163.53	
233.1	37.29	47.78	48.86	31.27	28.48	19.92	6.14	0.00					219.74	36.93	256.67	
261.4	41.83	67.60	69.20	48.86	50.63	44.81	24.57	20.01	0.00				367.51	36.93	404.44	
220.3	35.25	75.81	97.90	69.20	79.11	79.67	55.28	80.04	9.21	0.00			581.47	36.93	618.40	
199.2	31.87	63.90	109.80	97.90	112.03	124.48	98.28	180.09	36.86	2.51	0.00		857.72	36.93	894.65	
170.0	27.20	57.77	92.54	109.80	158.50	176.28	153.56	320.16	82.92	10.05	1.95	0.00	1190.73	36.93	1227.66	
135.3	21.65	49.31	83.66	92.54	177.77	249.40	217.47	500.24	147.42	22.62	7.82	0.74	1570.64	36.93	1607.57	
117.8	18.85	39.24	71.41	83.66	149.83	279.73	307.68	708.43	230.34	40.21	17.59	2.98	1949.95	36.93	1986.88	
93.1	14.89	34.17	56.83	71.41	135.46	235.77	345.09	1002.28	326.21	62.82	31.27	6.70	2322.90	36.93	2359.83	
71.3	11.40	27.00	49.48	56.83	115.61	213.14	290.85	1124.14	461.51	88.97	48.86	11.91	2499.70	36.93	2536.63	**Peak Flood**
52.4	8.38	20.67	39.10	49.48	92.01	181.92	262.94	947.47	517.63	125.87	69.20	18.61	2333.28	36.93	2370.21	
36.4	5.82	15.18	29.93	39.10	80.11	144.79	224.43	856.56	436.28	141.17	97.90	26.36	2097.63	36.93	2134.56	
23.3	3.72	10.54	21.99	29.93	63.30	126.06	178.62	731.09	394.41	118.98	109.80	37.29	1825.73	36.93	1862.66	
13.1	2.09	6.75	15.27	21.99	48.46	99.60	155.51	581.85	336.64	107.57	92.54	41.83	1510.10	36.93	1547.03	
5.8	0.93	3.80	9.77	15.27	35.61	76.26	122.87	506.59	267.92	91.81	83.66	35.25	1249.74	36.93	1286.67	
1.5	0.23	1.69	5.50	9.77	24.73	56.03	94.08	400.27	233.27	73.07	71.41	31.87	1001.92	36.93	1038.85	
0.0	0.00	0.42	2.44	5.50	15.82	38.91	69.12	306.46	184.31	63.62	56.83	27.20	770.63	36.93	807.56	
		0.00	0.61	2.44	8.90	24.90	48.00	225.15	141.11	50.27	49.48	21.65	572.51	36.93	609.44	
			0.00	0.61	3.96	14.01	30.72	156.36	103.68	38.49	39.10	18.85	405.78	36.93	442.71	
				0.00	0.99	6.23	17.28	100.07	72.00	28.28	29.93	14.89	269.67	36.93	306.60	
					0.00	1.56	7.68	56.29	46.08	19.64	21.99	11.40	164.64	36.93	201.57	
						0.00	1.92	25.02	25.92	12.57	15.27	8.38	89.08	36.93	126.01	
							0.00	6.25	11.52	7.07	9.77	5.82	40.43	36.93	77.36	
								0.00	2.88	3.14	5.50	3.72	15.24	36.93	52.17	
									0.00	0.79	2.44	2.09	5.32	36.93	42.25	
										0.00	0.61	0.93	1.54	36.93	38.47	
											0.00	0.23	0.23	36.93	37.16	
												0.00	0.00	36.93	36.93	
															2536.63	Cumecs

FLOOD HYDROGRAPH FOR MUTHA RIVER



ANNEXURE IV

FLOOD ESTIMATION REPORT FOR KRISHNA AND PENNAR (SUB-ZONE-3h) BY CWC

MULA MUTHA RIVERFRONT DEVELOPMENT

Project:	**Mula Mutha Riverfront Development**
River:	Mula Mutha River
City	Pune

Table for Computation of Equivalent slope(S)

C.A. **2100** km^2

'Datum =Reduced level of river bed = **464** m

TABLE-1

Sr No.	Reduced distance starting (km)	Reduced levels of river bed (m)	Length of each segment Li (km)	Height above datum(Di)= difference between the datum & its R.L. (m)	Di-1 + Di (m)	Li * (Di-1 + Di) (km * m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	464	0.00	0	0	0
2	26.65	466	26.65	2	2	53.3
3	31.50	485	4.85	21	23	111.55
4	36.55	490	5.05	26	47	237.303
5	45.66	495	9.11	31	57	519.27
6	57.14	500	11.48	36	67	769.16
7	81.62	520	24.48	56	92	2252.16
8	92.22	540	10.60	76	132	1399.332
9	93.45	560	1.23	96	172	211.216
10	95.02	580	1.57	116	212	333.476
11	95.80	600	0.78	136	252	196.056
Total			**95.80**			**6082.823**

$$\text{Eq. Slope} = \frac{\text{sum of}(Li*(Di-1+Di)}{L^2}$$

$$= \mathbf{0.66} \text{ m/km}$$

Design return period:	**100**	years
From plate no 11 , 100 yr point rainfall from sub zone 3h manual =	**20**	cms

I) Name & number of subzone **Lower Ganga Sub Zone -3(h).**

ii) Name of Project **Mula Mutha Riverfront**

iii) Name of Tributary/River **Mutha**

Estimation of flood using procedure as recommended in flood estimation report for Krishna & Pennar(SubZone- 3 h) published by Director of 'Hydrology(Small Catchment) CWC New Delhi (September-2000).

Data

C.A. (A)	(Catchment Area up to the project site in km^2)	**2100**	km^2	
Length(L)	(Length of Main Stream from farthest point to dam site)	**95.799**	km	
Slope S	(Equivalent stream slope of main stream in m/km)	**0.66**	m/km	(Table - 1)
C.G. (Lc)	(Length of Longest stream from a point opposite to C.G)	**32.50**	km	

(1) Determination of synthetic 1 hr U.G.Parameters

(i) tp= $0.325(LLc/Sqrt(s))^{-0.447}$ (Time to peak less half of unit duration)

= $0.325 \times (95.80 \times 32.50 / sqrt(0.66))^{0.447}$ = **12.9** hrs

tp adopted= **13.0** hrs

(ii) $q_p = 0.996(t_P)^{-0.497}$ (Peak discharge per km^2)

$= 0.996 \times (13.00)^{-0.497}$

= 0.278 $cumecs/km^2$

(iii) $T_B = 7.392(t_p)^{0.524}$ (Base period of hydrograph)

$= 7.392 * (13.000)^{0.524}$

= 28.344

= 28 hrs

(iv) $Q_P = q_P \times A$ (Peak Discharge of Unit Hydrograph in cumecs)

= 0.278x2100

= 583.8 cumecs

(v) $W_{50} = 2.389(q_p)$^ $^{-1.065}$ (Width of U.G. measured at 50% of maximum Discharge)

$= 2.389 \times (0.278)^{-1.065}$

= 9.34 hrs Ordinate(Qp) in hrs)

(vi) $W_{75} = 1.415 (q_p)^{-1.067}$ (Width of U.G. measured at 75%of maximum Discharge

$= 1.415 \times (0.278)^{-1.067}$

= 5.55 hrs Ordinate (Qp) in hrs)

(vii) W_{R50} **=** $0.753 \times (q_p)^{-1.229}$ (Width of rising side of U.G. measured at 50% of maximum

= $0.753 \times (0.278)^{-1.229}$ Discharge (Qp) in hrs)

= 3.63 hrs

(viii) W_{R75} **=** $0.558 \times (q_p)^{-1.088}$

= $0.558 \times (0.278)^{-1.088}$ (Width of rising side of U.G. measured at 75% of maximum

= 2.25 hrs Discharge (Qp) in hours)

(ix) Computation of Design base flow:

Q_B **=** $A \times q_b$ (Base Flow)

= 2100x0.05

105 cumecs

(x) T_m **=** $t_p + tr/2$

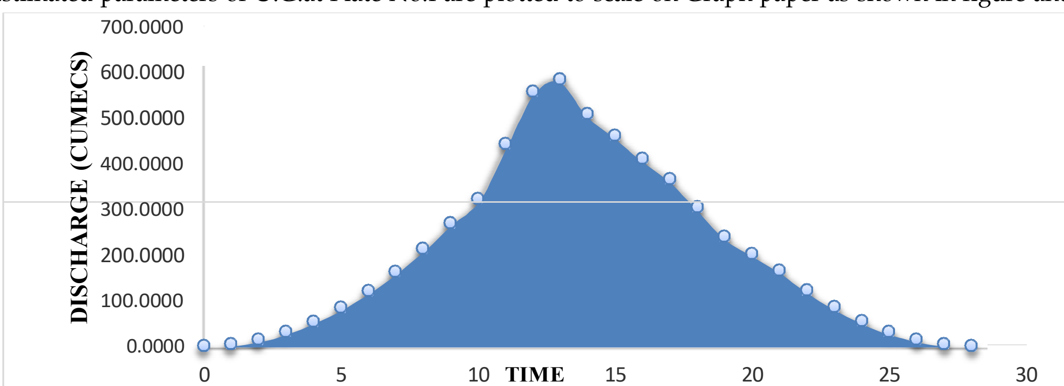
= 13.00+1/2

= 14.00 hrs

SAY **24 hrs for 2 bell distribution as catchment area is long**

(2) Drawing of synthetic unit hydrograph

Estimated parameters of U.G.at Plate No.I are plotted to scale on Graph paper as shown in figure and smoothened



(3) Estimation of design storm duration

The design storm duration T_{DS}= T_m hrs = **24** hrs

(4) Estimation of Point rainfall and Areal Rainfall

(I) Point Rainfall

The catchment was located on Plate-10 (Ref C.W.C.Report-Sub Zone-3(h))
showing 100 yr point rainfall = **20** cms
Conversion factor of 100 yr 24 hr point rainfall to 100 yr 24 hr point rainfall
is read from fig-10 section 4.2 = **1.000**
100 yr 24 hrs point rainfall = 20 x 1 = **20** cm

(ii) Areal Rainfall
Areal reduction factor for TD= 24 hrs corresponding to catchment
area 2,100 km2 was interpolated from Annexure 4.4 = **0.7800**
100 yr 24 hrs areal rainfall = 20x0.78 = **15.60** cms

(5) Loss rate considered = **0.10** cm/hr

(6) Time distribution of Areal Rainfall

1 st 12 hour Bell factor = 0.74
2 nd 12 hour Bell factor = 0.26

Conversion of 1st 12 hour Bell Storm Depth = 0.74 x15.60= 11.54 Cm
Conversion of 2nd 12 hour Bell Storm Depth = 0.26 x15.60= 4.06 Cm

Hourly Rainfall Increment

Sr. No.	Duration t (hrs)	Distribution Coefficient	Storm Rainfall (cm)	1-hr rainfall increment (cm)	1-hr rainfall excess (deducting loss of 0.10 cm/hr (cm)
1 st 12 hour Bell					
1	1	0.34	3.92	3.92	3.82
2	2	0.50	5.77	1.85	1.75
3	3	0.61	7.04	1.27	1.17
4	4	0.70	8.08	1.04	0.94
5	5	0.76	8.77	0.69	0.59
6	6	0.81	9.35	0.58	0.48
7	7	0.85	9.81	0.46	0.36
8	8	0.89	10.27	0.46	0.36
9	9	0.93	10.74	0.47	0.37
10	10	0.96	11.08	0.34	0.24
11	11	0.98	11.31	0.23	0.13
12	12	1.00	11.54	0.23	0.13
2 nd 12 hour Bell					
1	14	0.34	1.38	1.38	1.28
2	15	0.50	2.03	0.65	0.55
3	16	0.61	2.47	0.44	0.34
4	17	0.70	2.84	0.37	0.27
5	18	0.76	3.08	0.24	0.14
6	19	0.81	3.29	0.21	0.11
7	20	0.85	3.45	0.16	0.06
8	21	0.89	3.61	0.16	0.06

9	22	0.93	3.77	0.16	0.06
10	23	0.96	3.89	0.12	0.02
11	24	0.98	3.97	0.08	0.00
12	25	1.00	4.06	0.09	0.00

Computation of 1 in 100yr flood: (Peak only)

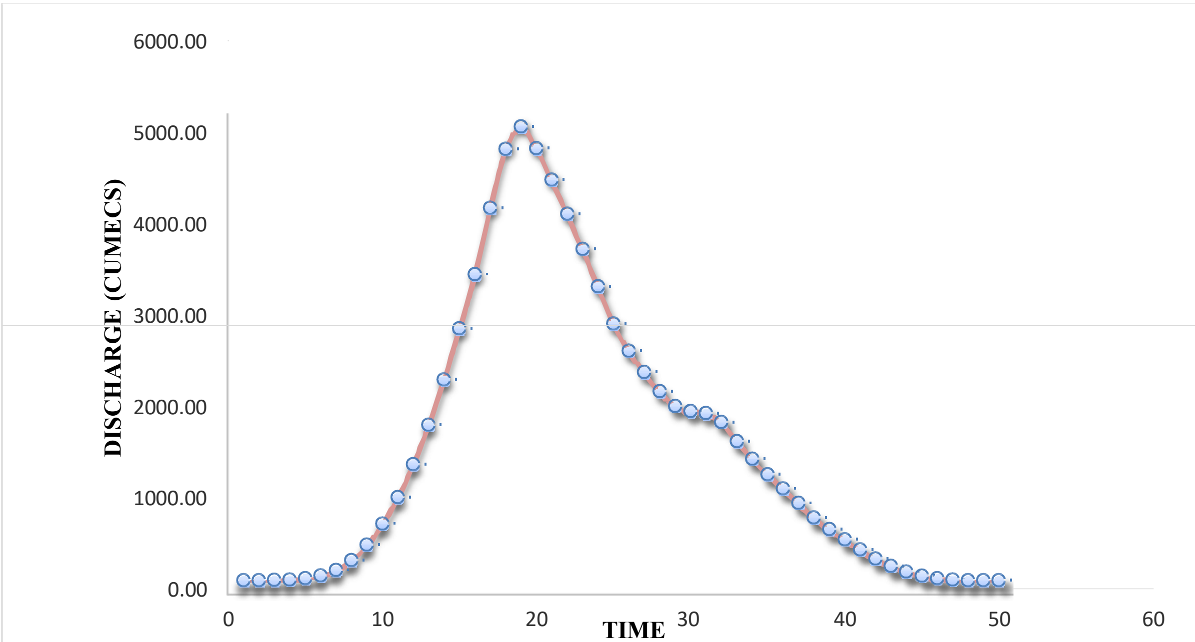
Time (hrs)	U.G (m^3/sec)	R.F excess in design order
1 st 12 hour Bell		
1	269.3	0.13
2	322.3	0.36
3	442.6	0.59
4	557.6	1.75
5	583.8	3.82
6	508.7	1.17
7	460.5	0.94
8	410.0	0.48
9	365.4	0.37
10	304.6	0.36
11	240.0	0.24
12	202.0	0.13
2 nd 12 hour Bell		
1	269.3	0.00
2	322.3	0.06
3	442.6	0.14
4	557.6	0.55
5	583.8	1.28
6	508.7	0.34
7	460.5	0.27
8	410.0	0.11
9	365.4	0.06
10	304.6	0.06
11	240.0	0.02
12	202.0	0.00

Computation of Design Flood Peak hydrograph (1 in 100 Year)

calculated Peak Flood 5072.34 cumecs

Synthetic U.G. Ordinates	0.13	0.24	0.36	0.94	1.17	3.82	1.75	0.59	0.36	0.13	0.13	0.00	0.02	0.06	0.06	0.11	0.27	0.34	1.28	0.55	0.14	0.06	0.00	Total (Cumecs)	Base Flow (Cumecs)	Total (Cumecs)	Remarks
0.0	0.00																							0.00	105.00	105.00	
3.3	0.43	0.00																						0.43	105.00	105.43	
13.3	1.73	0.80	0.00																					2.53	105.00	107.53	
29.9	3.89	3.19	1.20	0.00																				8.28	105.00	113.28	
53.2	6.92	7.18	4.79	3.13	0.00																			22.02	105.00	127.02	
83.1	10.81	12.77	10.77	12.50	3.89	0.00																		50.74	105.00	155.74	
119.7	15.56	19.95	19.15	28.13	15.56	12.70	0.00																	111.05	105.00	216.05	
162.9	21.18	28.73	29.92	50.00	35.01	50.80	5.82	0.00																221.46	105.00	326.46	
212.8	27.66	39.10	43.09	78.13	62.24	114.30	23.27	1.96	0.00															389.75	105.00	494.75	
269.3	35.01	51.07	58.65	112.51	97.25	203.21	52.36	7.85	1.20	0.00														619.11	105.00	724.11	
322.3	41.90	64.63	76.60	153.14	140.04	317.51	93.09	17.65	4.79	0.43	0.00													909.78	105.00	1014.78	
442.6	57.54	77.36	96.95	200.02	190.61	457.22	145.46	31.39	10.77	1.73	0.43	0.00												1269.48	105.00	1374.48	
557.6	72.49	106.23	116.03	253.14	248.95	622.32	209.46	49.04	19.15	3.89	1.73	0.00	0.00											1702.43	105.00	1807.43	
583.8	75.89	133.82	159.35	302.98	315.08	812.83	285.09	70.62	29.92	6.92	3.89	0.00	0.07	0.00										2196.46	105.00	2301.46	
508.7	66.14	140.11	200.74	416.08	377.11	1028.73	372.37	96.12	43.09	10.81	6.92	0.00	0.27	0.20	0.00									2758.69	105.00	2863.69	
460.5	59.86	122.10	210.17	524.14	517.89	1231.25	471.28	125.54	58.65	15.56	10.81	0.00	0.60	0.80	0.20	0.00								3348.85	105.00	3453.85	
410.0	53.30	110.52	183.15	548.77	652.39	1690.88	564.06	158.89	76.60	21.18	15.56	0.00	1.06	1.80	0.80	0.37	0.00							4079.33	105.00	4184.33	
365.4	47.50	98.40	165.78	478.22	683.05	2130.02	774.62	190.17	96.95	27.66	21.18	0.00	1.66	3.19	1.80	1.46	0.90	0.00						4722.56	105.00	4827.56	
304.6	39.59	87.69	147.60	432.87	595.23	2230.12	975.80	261.16	116.03	35.01	27.66	0.00	2.39	4.99	3.19	3.29	3.59	1.13	0.00					4967.34	105.00	5072.34	Peak Flood
240.0	31.20	73.10	131.54	385.40	538.78	1943.42	1021.65	328.98	159.35	41.90	35.01	0.00	3.26	7.18	4.99	5.85	8.08	4.52	4.26	0.00				4728.47	105.00	4833.47	
202.0	26.26	57.60	109.64	343.46	479.70	1759.11	890.31	344.44	200.74	57.54	41.90	0.00	4.26	9.77	7.18	9.14	14.36	10.17	17.02	1.83	0.00			4384.43	105.00	4489.43	
165.7	21.54	48.48	86.40	286.29	427.49	1566.20	805.87	300.16	210.17	72.49	57.54	0.00	5.39	12.77	9.77	13.17	22.44	18.09	38.30	7.31	0.47	0.00		4010.34	105.00	4115.34	
121.8	15.83	39.77	72.72	225.60	356.34	1395.75	717.50	271.69	183.15	75.89	72.49	0.00	6.45	16.16	12.77	17.92	32.32	28.26	68.09	16.46	1.86	0.20	0.00	3627.22	105.00	3732.22	
84.6	10.99	29.22	59.66	189.88	280.80	1163.45	639.41	241.90	165.78	66.14	75.89	0.00	8.85	19.34	16.16	23.41	43.99	40.69	106.39	29.26	4.19	0.80	0.00	3216.20	105.00	3321.20	
54.1	7.04	20.29	43.83	155.79	236.34	916.80	532.99	215.57	147.60	59.86	66.14	0.00	11.15	26.56	19.34	29.62	57.45	55.39	153.20	45.71	7.45	1.80	0.00	2809.92	105.00	2914.92	
30.4	3.96	12.99	30.44	114.45	193.90	771.64	420.00	179.69	131.54	53.30	59.86	0.00	11.68	33.46	26.56	35.45	72.71	72.35	208.53	65.83	11.64	3.19	0.00	2513.17	105.00	2618.17	
13.5	1.76	7.31	19.48	79.48	142.46	633.09	353.50	141.60	109.64	47.50	53.30	0.00	10.17	35.03	33.46	48.69	87.03	91.56	272.36	89.60	16.76	4.99	0.00	2278.77	105.00	2383.77	
3.4	0.44	3.25	10.96	50.87	98.93	465.12	290.03	119.18	86.40	39.59	47.50	0.00	9.21	30.52	35.03	61.34	119.51	109.59	344.71	117.03	22.81	7.18	0.00	2069.20	105.00	2174.20	
0.0	0.00	0.81	4.87	28.61	63.32	323.00	213.08	97.78	72.72	31.20	39.59	0.00	8.20	27.63	30.52	64.22	150.55	150.50	412.57	148.12	29.79	9.77	0.00	1906.85	105.00	2011.85	
		0.00	1.22	12.72	35.61	206.72	147.97	71.84	59.66	26.26	31.20	0.00	7.31	24.60	27.63	55.96	157.63	189.58	566.58	177.27	37.70	12.77	0.00	1850.23	105.00	1955.23	
			0.00	3.18	15.83	116.28	94.70	49.89	43.83	21.54	26.26	0.00	6.09	21.92	24.60	50.65	137.36	198.49	713.72	243.45	45.12	16.16	0.00	1829.07	105.00	1934.07	
				0.00	3.96	51.68	53.27	31.93	30.44	15.83	21.54	0.00	4.80	18.27	21.92	45.10	124.33	172.97	747.26	306.68	61.97	19.34	0.00	1731.29	105.00	1836.29	
					0.00	12.92	23.68	17.96	19.48	10.99	15.83	0.00	4.04	14.40	18.27	40.19	110.70	156.57	651.20	321.09	78.06	26.56	0.00	1521.94	105.00	1626.94	
						0.00	5.92	7.98	10.96	7.04	10.99	0.00	3.31	12.12	14.40	33.50	98.65	139.40	589.44	279.81	81.73	33.46	0.00	1328.71	105.00	1433.71	
							0.00	2.00	4.87	3.96	7.04	0.00	2.44	9.94	12.12	26.40	82.23	124.23	524.80	253.27	71.22	35.03	0.00	1159.55	105.00	1264.55	
								0.00	1.22	1.76	3.96	0.00	1.69	7.31	9.94	22.22	64.80	103.55	467.68	225.50	64.47	30.52	0.00	1004.62	105.00	1109.62	
									0.00	0.44	1.76	0.00	1.08	5.07	7.31	18.23	54.54	81.60	389.85	200.96	57.40	27.63	0.00	845.87	105.00	950.87	
										0.00	0.44	0.00	0.61	3.25	5.07	13.39	44.75	68.68	307.20	167.51	51.15	24.60	0.00	686.65	105.00	791.65	
											0.00	0.00	0.27	1.83	3.25	9.30	32.88	56.35	258.56	132.00	42.64	21.92	0.00	559.00	105.00	664.00	
												0.00	0.07	0.81	1.83	5.95	22.83	41.40	212.13	111.10	33.60	18.27	0.00	447.99	105.00	552.99	
													0.00	0.20	0.81	3.35	14.61	28.75	155.85	91.15	28.28	14.40	0.00	337.40	105.00	442.40	
														0.00	0.20	1.49	8.22	18.40	108.23	66.97	23.20	12.12	0.00	238.83	105.00	343.83	
															0.00	0.37	3.65	10.35	69.27	46.51	17.05	9.94	0.00	157.14	105.00	262.14	
																0.00	0.91	4.60	38.96	29.76	11.84	7.31	0.00	93.38	105.00	198.38	
																	0.00	1.15	17.32	16.74	7.58	5.07	0.00	47.86	105.00	152.86	
																		0.00	4.33	7.44	4.26	3.25	0.00	19.28	105.00	124.28	
																			0.00	1.86	1.89	1.83	0.00	5.58	105.00	110.58	
																				0.00	0.47	0.81	0.00	1.28	105.00	106.28	
																					0.00	0.20	0.00	0.20	105.00	105.20	
																						0.00	0.00	0.00	105.00	105.00	
																										5072.34	Cumecs

FLOOD HYDROGRAPH FOR MUTHA MUTHA RIVER BY SUB ZONE METHOD



ANNEXURE V

FLOOD ESTIMATION REPORT FOR KRISHNA AND PENNAR (SUB-ZONE-3h) BY CWC

MULA MUTHA RIVERFRONT DEVELOPMENT

Project:	**Mula Mutha Riverfront Development**		
River:	Pawana	longitude	73^0 83' 33"
City	Pune	latitude	18^0 56' 66"

Table for Computation of Equivalent slope(S)

C.A. **501.2** km^2

'Datum =Reduced level of river bed = **484** m

TABLE-1

Sr No.	Reduced distance starting (km)	Reduced levels of river bed (m)	Length of each segment Li (km)	Height above datum(Di)= difference between the datum & its R.L. (m)	Di-1 + Di (m)	Li * (Di-1 + Di) (km * m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	484	0.00	0	0	0
2	4.85	485	4.85	1	1	4.85
3	9.90	490	5.05	6	7	35.343
4	19.01	495	9.11	11	17	154.87
5	30.49	500	11.48	16	27	309.96
6	54.97	520	24.48	36	52	1272.96
7	65.57	540	10.601	56	92	975.292
8	66.80	560	1.228	76	132	162.096
9	68.37	580	1.573	96	172	270.556
10	69.15	600	0.778	116	212	164.936
Total			**69.15**			**3350.863**

$$\text{Eq. Slope} = \frac{\text{sum of}(Li*(Di\text{-}1+Di))}{L^2}$$

$$= \mathbf{0.70} \text{ m/km}$$

Design return period: **100** years
From plate no 11 , 100 yr point rainfall from sub zone 3h manual = **20** cms

I) Name & number of subzone — **Lower Ganga Sub Zone -3(h).**

ii) Name of Project — **Mula Mutha Riverfront**

iii) Name of Tributary/River — **Mutha**

iv) Site location — longitude 730 83' 33"
latitude 180 56' 66"

Estimation of flood using procedure as recommended in flood estimation report for Krishna & Pennar(SubZone- 3 h) published by Director of 'Hydrology(Small Catchment) CWC New Delhi (September-2000).

Data

C.A. (A)	(Catchment Area up to the project site in km^2)	**501.2**	km^2	
Length(L)	(Length of Main Stream from farthest point to dam site)	**69.149**	km	
Slope S	(Equivalent stream slope of main stream in m/km)	**0.70**	m/km	(Table - 1)
C.G. (Lc)	(Length of Longest stream from a point opposite to C.G)	**25.20**	km	

(1) Determination of synthetic 1 hr U.G.Parameters

(i) tp= $0.325(LLc/Sqrt(s))^{-0.447}$ (Time to peak less half of unit duration)

= $0.325 \times (69.15 \times 25.20 / sqrt(0.70))^{0.447}$ = **9.8** hrs

tp adopted= **10.0** hrs

(ii) $q_p = 0.996(t_P)^{-0.497}$ (Peak discharge per km^2)

= $0.996 \times (10.00)^{-0.497}$

= 0.317 cumecs/km^2

(iii) $T_B = 7.392(t_p)^{0.524}$ (Base period of hydrograph)

= $7.392 * (10.000)^{0.524}$

= 24.704

= 25 hrs

(iv) $\mathbf{Q_p}$ **=** $q_p \times A$ (Peak Discharge of Unit Hydrograph in cumecs)

$= 0.317 \times 501.2$

$=$ 158.88 cumecs

(v) $\mathbf{W_{50}}$ **=** $2.389(q_p)^{-1.065}$ (Width of U.G. measured at 50% of maximum Discharge)

$= 2.389 \times (0.317)^{-1.065}$

$= 8.12$ hrs Ordinate(Qp) in hrs)

(vi) $\mathbf{W_{75}}$ **=** $1.415\,(q_p)^{-1.067}$ (Width of U.G. measured at 75%of maximum Discharge

$= 1.415 \times (0.317)^{-1.067}$

$=$ 4.82 hrs Ordinate (Qp) in hrs)

(vii)$\mathbf{W_{R50}}$ **=** $0.753 \times (q_p)^{-1.229}$ (Width of rising side of U.G. measured at 50% of maximum

$= 0.753 \times (0.317)^{-1.229}$ Discharge (Qp) in hrs)

$=$ 3.09 hrs

(viii)$\mathbf{W_{R75}}$ **=** $0.558 \times (q_p)^{-1.088}$

$= 0.558 \times (0.317)^{-1.088}$ (Width of rising side of U.G. measured at 75% of maximum

$= 1.95$ hrs Discharge (Qp) in hours)

(ix) Computation of Design base flow:

$\mathbf{Q_B}$ **=** $A \times q_b$ (Base Flow)

$= 501.2 \times 0.05$

25.06 cumecs

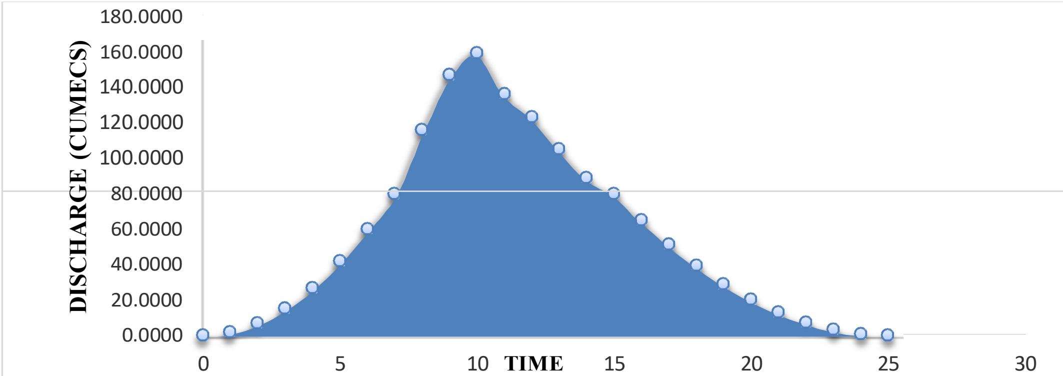
(x) $\mathbf{T_m}$ **=** $t_p + tr/2$

$= 10.00 + 1/2$

$=$ 11.00 hrs

(2) Drawing of synthetic unit hydrograph

Estimated parameters of U.G.at Plate No.I are plotted to scale on Graph paper as shown in figure and smoothened



(3) Estimation of design storm duration

The design storm duration T_{DS}= T_m hrs = **11** hrs

(4) Estimation of Point rainfall and Areal Rainfall

(I) Point Rainfall

The catchment was located on Plate-10 (Ref C.W.C.Report-Sub Zone-3(h))
showing 100 yr point rainfall = **20** cms
Conversion factor of 100 yr 24 hr point rainfall to 100 yr 11 hr point rainfall
is read from fig-10 section 4.2 = **0.820**
100 yr 11 hrs point rainfall = 20 x 0.82 = **16.4** cm

(ii) Areal Rainfall

Areal reduction factor for TD= 11 hrs corresponding to catchment
area 501 km2 was interpolated from Annexure 4.4 = **0.7817**
100 yr 11 hrs areal rainfall = 16.4x0.7817056 = **12.82** cms

(5) Time distribution of Areal Rainfall

Loss rate considered = **0.10** cm/hr

For 1 in 100 yr return period flood

100 yr 11 hrs areal rainfall = 12.82 cms was distributed with the distribution coefficient corresponding to 11

Hourly Rainfall Increment

Sr. No.	Duration t (hrs)	Distribution Coefficient	Storm Rainfall (cm)	1-hr rainfall increment (cm)	1-hr rainfall excess (deducting loss of 0.10 cm/hr (cm)
1	1	0.35	4.49	4.49	4.39
2	2	0.52	6.67	2.18	2.08
3	3	0.62	7.95	1.28	1.18
4	4	0.72	9.23	1.28	1.18
5	5	0.78	10.00	0.77	0.67
6	6	0.83	10.64	0.64	0.54
7	7	0.87	11.15	0.51	0.41
8	8	0.94	12.05	0.90	0.80
9	9	0.96	12.31	0.26	0.16
10	10	0.98	12.56	0.25	0.15
11	11	1.00	12.82	0.26	0.16

Computation of 1 in 100yr flood: (Peak only)

Time (hrs)	U.G (m^3/sec)	R.F excess in design order	Direct Runoff (cumecs)
6	59.9	0.15	8.98
7	79.7	0.41	32.67
8	115.8	0.80	92.60
9	146.7	2.08	305.23
10	158.9	4.39	697.48
11	136.0	1.18	160.51
12	122.8	1.18	144.92
13	105.0	0.67	70.35
14	88.5	0.54	47.77
15	79.4	0.16	12.71
16	64.7	0.16	10.36
Sum=	**1157.4**		**1583.58**

1 in 100 yr flood.

= Sum of direct runoff + Base flow

= 1583.58 + 25.06

= **1608.64 cumecs** **Say 1609 cumecs**

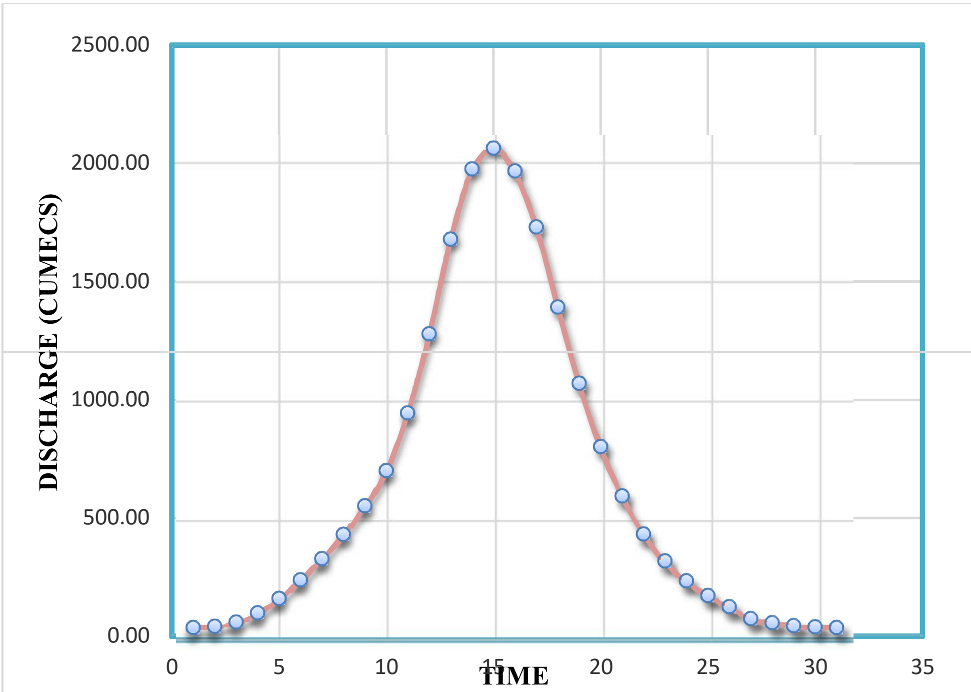
= **56822 cusecs**

Computation of Design Flood Peak hydrograph (1 in 100 Year)

calculated Peak Flood **1608.64** **cumecs**

Synthetic U.G. Ordinates	0.16 2	0.16 3	0.54 4	0.67 5	1.18 6	1.18 7	4.39 8	2.08 9	0.80 10	0.41 11	0.15 12	Total (Cumecs)	Base Flow (Cumecs)	Total (Cumecs)	Remarks
0.0												0.00	25.06	25.06	
1.7	0.00											0.00	25.06	25.06	
6.7	0.27	0.00										0.27	25.06	25.33	
15.0	1.06	0.27	0.00									1.33	25.06	26.39	
26.6	2.40	1.06	0.90	0.00								4.36	25.06	29.42	
41.6	4.26	2.40	3.59	1.11	0.00							11.36	25.06	36.42	
59.9	6.65	4.26	8.09	4.46	1.96	0.00						25.42	25.06	50.48	
79.7	9.58	6.65	14.37	10.03	7.85	1.96	0.00					50.44	25.06	75.50	
115.8	12.75	9.58	22.46	17.84	17.67	7.85	7.30	0.00				95.45	25.06	120.51	
146.7	18.52	12.75	32.34	27.87	31.41	17.67	29.22	3.46	0.00			173.24	25.06	198.30	
158.9	23.48	18.52	43.03	40.13	49.08	31.41	65.73	13.84	1.33	0.00		286.55	25.06	311.61	
136.0	25.42	23.48	62.51	53.39	70.68	49.08	116.86	31.15	5.32	0.68	0.00	438.57	25.06	463.63	
122.8	21.76	25.42	79.24	77.55	94.03	70.68	182.59	55.37	11.98	2.73	0.25	621.60	25.06	646.66	
105.0	19.65	21.76	85.80	98.32	136.59	94.03	262.94	86.51	21.30	6.14	1.00	834.04	25.06	859.10	
88.5	16.80	19.65	73.45	106.45	173.16	136.59	349.83	124.58	33.27	10.91	2.25	1046.94	25.06	1072.00	
79.4	14.16	16.80	66.32	91.14	187.48	173.16	508.15	165.75	47.92	17.05	3.99	1291.92	25.06	1316.98	
64.7	12.71	14.16	56.70	82.28	160.51	187.48	644.20	240.76	63.75	24.56	6.24	1493.35	25.06	1518.41	
51.1	10.36	12.71	47.77	70.35	144.92	160.51	697.48	305.23	92.60	32.67	8.98	1583.58	25.06	1608.64	**Peak Flood**
39.2	8.18	10.36	42.90	59.28	123.90	144.92	597.14	330.47	117.39	47.46	11.95	1493.95	25.06	1519.01	
28.8	6.27	8.18	34.96	53.23	104.40	123.90	539.14	282.93	127.10	60.16	17.36	1357.63	25.06	1382.69	
20.0	4.60	6.27	27.62	43.37	93.75	104.40	460.95	255.44	108.82	65.14	22.01	1192.37	25.06	1217.43	
12.8	3.20	4.60	21.15	34.27	76.39	93.75	388.39	218.40	98.25	55.77	23.83	1018.00	25.06	1043.06	
7.2	2.05	3.20	15.54	26.24	60.35	76.39	348.78	184.02	84.00	50.35	20.40	871.32	25.06	896.38	
3.2	1.15	2.05	10.79	19.28	46.21	60.35	284.18	165.25	70.78	43.05	18.42	721.51	25.06	746.57	
0.8	0.51	1.15	6.90	13.39	33.95	46.21	224.54	134.65	63.56	36.27	15.75	576.88	25.06	601.94	
0.0	0.13	0.51	3.88	8.57	23.58	33.95	171.91	106.39	51.79	32.57	13.27	446.55	25.06	471.61	
	0.00	0.13	1.73	4.82	15.09	23.58	126.30	81.45	40.92	26.54	11.92	332.48	25.06	357.54	
		0.00	0.43	2.14	8.49	15.09	87.71	59.84	31.33	20.97	9.71	235.71	25.06	260.77	
			0.00	0.54	3.77	8.49	56.13	41.56	23.02	16.06	7.67	157.24	25.06	182.30	
				0.00	0.94	3.77	31.58	26.60	15.98	11.80	5.87	96.54	25.06	121.60	
					0.00	0.94	14.03	14.96	10.23	8.19	4.32	52.67	25.06	77.73	
						0.00	3.51	6.65	5.75	5.24	3.00	24.15	25.06	49.21	
							0.00	1.66	2.56	2.95	1.92	9.09	25.06	34.15	
								0.00	0.64	1.31	1.08	3.03	25.06	28.09	
									0.00	0.33	0.48	0.81	25.06	25.87	
										0.00	0.12	0.12	25.06	25.18	
											0.00	0.00	25.06	25.06	
														1608.64	Cumecs

FLOOD HYDROGRAPH FOR PAVANA RIVER BY SCS METHOD



ANNEXURE VI

FLOOD ESTIMATION BY SYNTHETIC UNIT HYDROGRAPH (SCS METHOD)
MULA MUTHA RIVERFRONT DEVELOPMENT

Project:	**Mula Mutha Riverfront Development**		
River:	Mula	longitude	73^0 75' 08"
City	Pune	latitude	18^0 55' 91"

Table for Computation of Equivalent slope(S)

C.A. **730** km^2

'Datum =Reduced level of river bed = **483** m

TABLE-1

Sr No.	Reduced distance starting (km)	Reduced levels of river bed (m)	Length of each segment Li (km)	Height above datum(Di)= difference between the datum & its R.L. (m)	Di-1 + Di (m)	Li * (Di-1 + Di) (km * m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	483	0.00	0	0	0
2	11.65	485	11.65	2	2	23.302
3	21.02	490	9.37	7	9	84.348
4	30.56	495	9.541	12	19	181.279
5	44.27	500	13.708	17	29	397.532
6	45.94	520	1.667	37	54	90.018
7	65.40	540	19.456	57	94	1828.864
8	67.74	560	2.349	77	134	314.766
9	69.01	580	1.262	97	174	219.588
10	69.97	600	0.959	117	214	205.226
11	70.42	620	0.455	137	254	115.57
12	70.71	640	0.288	157	294	84.672
13	71.24	660	0.53	177	334	177.02
Total			**71.24**			**3722.185**

$$\text{Eq. Slope} = \frac{\text{sum of}(Li*(Di\text{-}1+Di)}{L^2}$$

= **0.73** m/km

Design return period:		**100**	years
From plate no 11 , 100 yr point rainfall from sub zone 3h manual =		**20**	cms

i) Name of Project **Mula Mutha Riverfront**

ii) Name of Tributary/River **Mula**

Estimation of flood using SCS method

Data

C.A. (A)	(Catchment Area up to the project site in km^2)	**730**	km^2	
Length(L)	(Length of Main Stream from farthest point to dam site)	**71238**	m	
Slope Sg	(Equivalent stream slope of main stream in m/km)	**0.73**	m/km	0.07%
C.G. (Lc)	(Length of Longest stream from a point opposite to C.G)	**27.30**	km	
CN	**(** Run off Curver Number)	**98**	(From SCS Manual)	

(1) Determination of synthetic 1 hr U.G.Parameters

$$tc = \frac{L^{0.8}((1000/CN)-9)^{0.7}}{(4407\,(Sg)^{0.5})}$$

= 7.3 hrs

tp = D/2 +0.6tc

where tp = time of peak in hrs

D = Duration of excess rainfall in cm

tp = 5 hrs

Say **5** hrs

Peak flow rate (m3/sec) per unit of rainfall q = (2.08 x A)/tp

= 303.68 m3/sec

(2) Estimation of storm duration

The design storm duration T_D = 2.67 x tp = 13.35 hrs

Say 14 hrs

(3) Estimation of Design Base Flow

Q_B = A x q_b (Base Flow)

= 730x0.05

= 36.5 cumecs

(4) Estimation of Point rainfall and Areal Rainfall from C.W.C.Report-Sub Zone-3(h)

(I) Point Rainfall

The catchment was located on Plate-10 (Ref C.W.C.Report-Sub Zone-3(h))
showing 100 yr point rainfall = **20** cms
Conversion factor of 100 yr 24 hr point rainfall to 100 yr 14 hr point rainfall
is read from fig-10 section 4.2 = **0.870**
100 yr 5 hrs point rainfall = 20 x 0.87 = **17.4** cm

(ii) Areal Rainfall

Areal reduction factor for TD= 5 hrs corresponding to catchment
area 730 km2 was interpolated from Annexure 4.4 = **0.7803**
100 yr 5 hrs areal rainfall = 17.4x0.7803 = **13.58** cms

Recharge capacity of watershed

$$S = \frac{25400}{CN} - 254$$

$$S = 5.18$$

Now Runoff depth

$$Q = \frac{(P-0.2\,S)^{2}}{(P+0.8S)}$$

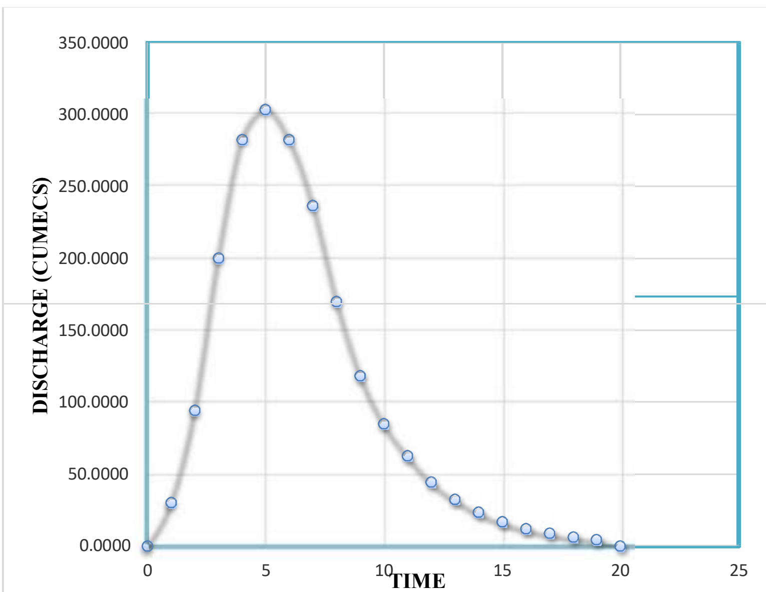
Where

P = Rainfall in cm = 135.77 mm

Therefore

Q = 12.975 **Cm**

(5) Drawing of synthetic unit hydrograph



Hourly Rainfall Increment				
Sr. No.	Duration t (hrs)	Distributio n n Coefficient	Storm Rainfall (cm)	1-hr rainfall increment (cm)
1	1	0.32	4.15	4.15
2	2	0.43	5.58	1.43
3	3	0.52	6.75	1.17
4	4	0.61	7.91	1.16
5	5	0.68	8.82	0.91
6	6	0.74	9.60	0.78
7	7	0.79	10.25	0.65
8	8	0.84	10.90	0.65
9	9	0.87	11.29	0.39
10	10	0.91	11.81	0.52
11	11	0.94	12.20	0.39
12	12	0.96	12.46	0.26
13	13	0.98	12.72	0.26
14	14	1.00	12.98	0.26

Computation of 1 in 100yr flood: (Peak only)			
Time (hrs)	U.G (m^3/sec)	R.F excess in design order	Direct Runoff (cumecs)
1	30.4	0.26	7.90
2	94.1	0.65	61.19
3	200.4	0.91	182.39
4	282.4	1.17	330.43
5	303.7	4.15	1260.27
6	282.4	1.43	403.86
7	236.9	1.16	274.77
8	170.1	0.78	132.65
9	118.4	0.65	76.98
10	85.0	0.52	44.22
11	62.9	0.39	24.52
12	44.6	0.39	17.41
13	32.5	0.26	8.45
14	23.4	0.26	6.08
Sum=			**2831.12**

1 in 100 yr flood.

= Sum of direct runoff + Base flow

= 2831.12 + 36.5

= **2867.62 cumecs** **Say 2868 cumecs**

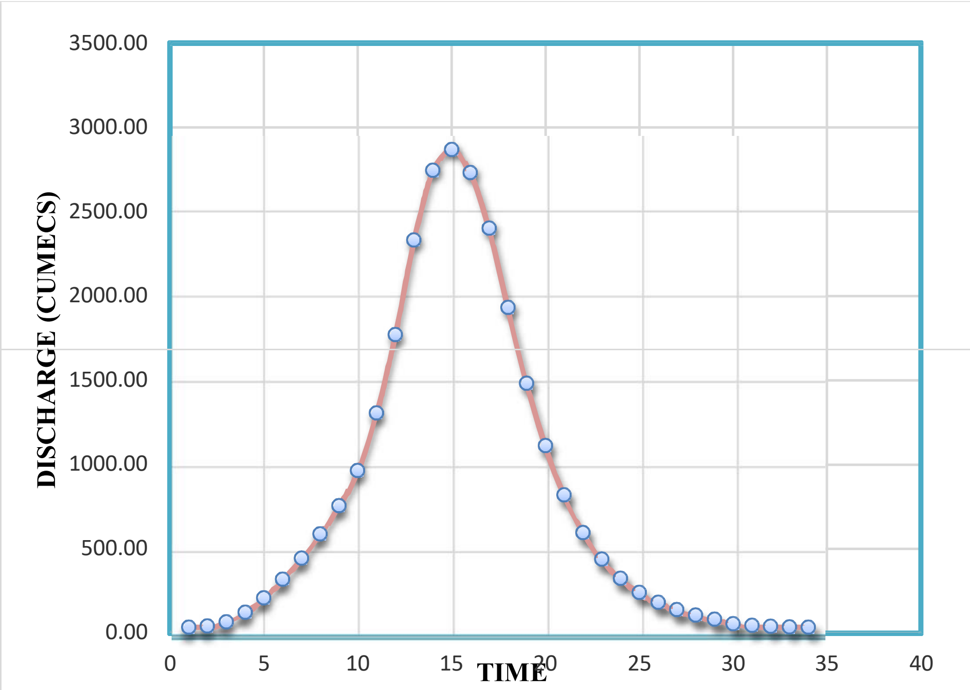
= **101284 cusecs**

Computation of Design Flood Peak hydrograph (1 in 100 Year)

Calculated Peak Flood 2867.62 cumecs

Synthetic	Hourly rainfall excess in cm														Total	Base	Total	Remarks
U.G.	0.26	0.26	0.39	0.39	0.52	0.65	0.78	1.16	1.43	4.15	1.17	0.91	0.65	0.26		Flow		
Ordinates	1	2	3	4	5	6	7	8	9	10	11	12	13	14	(Cumecs)	(Cumecs)	(Cumecs)	
0.0	0.00														0.00	36.50	36.50	
30.4	7.90	0.00													7.90	36.50	44.40	
94.1	24.48	7.90	0.00												32.38	36.50	68.88	
200.4	52.11	24.48	11.84	0.00											88.43	36.50	124.93	
282.4	73.43	52.11	36.71	11.84	0.00										174.09	36.50	210.59	
303.7	78.96	73.43	78.17	36.71	15.79	0.00									283.06	36.50	319.56	
282.4	73.43	78.96	110.14	78.17	48.95	19.74	0.00								409.39	36.50	445.89	
236.9	61.59	73.43	118.44	110.14	104.22	61.19	23.69	0.00							552.70	36.50	589.20	
170.1	44.22	61.59	110.14	118.44	146.86	130.28	73.43	35.23	0.00						720.19	36.50	756.69	
118.4	30.79	44.22	92.38	110.14	157.91	183.57	156.33	109.20	43.43	0.00					927.97	36.50	964.47	
85.0	22.11	30.79	66.32	92.38	146.86	197.39	220.29	232.50	134.62	126.03	0.00				1269.29	36.50	1305.79	
62.9	16.34	22.11	46.19	66.32	123.17	183.57	236.87	327.61	286.61	390.68	35.53	0.00			1735.00	36.50	1771.50	
44.6	11.61	16.34	33.16	46.19	88.43	153.97	220.29	352.27	403.86	831.78	110.14	27.63	0.00		2295.67	36.50	2332.17	
32.5	8.45	11.61	24.52	33.16	61.59	110.54	184.76	327.61	434.26	1172.05	234.50	85.67	19.74	0.00	2708.46	36.50	2744.96	
23.4	6.08	8.45	17.41	24.52	44.22	76.98	132.65	274.77	403.86	1260.27	330.43	182.39	61.19	7.90	2831.12	36.50	2867.62	**Peak Flood**
16.7	4.34	6.08	12.67	17.41	32.69	55.27	92.38	197.27	338.72	1172.05	355.31	257.00	130.28	24.48	2695.95	36.50	2732.45	
12.1	3.16	4.34	9.12	12.67	23.21	40.86	66.32	137.38	243.19	983.01	330.43	276.35	183.57	52.11	2365.72	36.50	2402.22	
8.8	2.29	3.16	6.51	9.12	16.90	29.02	49.03	98.64	169.36	705.75	277.14	257.00	197.39	73.43	1894.74	36.50	1931.24	
6.4	1.66	2.29	4.74	6.51	12.16	21.12	34.82	72.92	121.59	491.51	198.97	215.55	183.57	78.96	1446.37	36.50	1482.87	
4.6	1.18	1.66	3.43	4.74	8.69	15.20	25.35	51.78	89.89	352.88	138.57	154.76	153.97	73.43	1075.53	36.50	1112.03	
0.0	0.00	1.18	2.49	3.43	6.32	10.86	18.24	37.69	63.84	260.88	99.49	107.78	110.54	61.59	784.33	36.50	820.83	
		0.00	1.78	2.49	4.58	7.90	13.03	27.12	46.47	185.26	73.55	77.38	76.98	44.22	560.76	36.50	597.26	
			0.00	1.78	3.32	5.72	9.47	19.37	33.44	134.85	52.23	57.20	55.27	30.79	403.44	36.50	439.94	
				0.00	2.37	4.15	6.87	14.09	23.88	97.04	38.02	40.62	40.86	22.11	290.01	36.50	326.51	
					0.00	2.96	4.97	10.22	17.37	69.31	27.36	29.57	29.02	16.34	207.12	36.50	243.62	
						0.00	3.55	7.40	12.59	50.41	19.54	21.28	21.12	11.61	147.50	36.50	184.00	
							0.00	5.28	9.12	36.55	14.21	15.20	15.20	8.45	104.01	36.50	140.51	
								0.00	6.51	26.47	10.30	11.05	10.86	6.08	71.27	36.50	107.77	
									0.00	18.90	7.46	8.01	7.90	4.34	46.61	36.50	83.11	
										0.00	5.33	5.80	5.72	3.16	20.01	36.50	56.51	
											0.00	4.15	4.15	2.29	10.59	36.50	47.09	
												0.00	2.96	1.66	4.62	36.50	41.12	
													0.00	1.18	1.18	36.50	37.68	
														0.00	0.00	36.50	36.50	
																	2867.62	Cumecs

FLOOD HYDROGRAPH FOR MULA RIVER BY SCS METHOD



ANNEXURE VII

FLOOD ESTIMATION BY SYNTHETIC UNIT HYDROGRAPH (SCS METHOD)
MULA MUTHA RIVERFRONT DEVELOPMENT

Project:	**Mula Mutha Riverfront Development**
River:	Mula Mutha River
City	Pune

Table for Computation of Equivalent slope(S)

C.A. **2096** km^2

'Datum =Reduced level of river bed = **464** m

TABLE-1

Sr No.	Reduced distance starting (km)	Reduced levels of river bed (m)	Length of each segment Li (km)	Height above datum(Di)= difference between the datum & its R.L. (m)	Di-1 + Di (m)	Li * (Di-1 + Di) (km * m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	464	0.00	0	0	0
2	26.65	466	26.65	2	2	53.3
3	31.50	485	4.85	21	23	111.55
4	36.55	490	5.05	26	47	237.303
5	45.66	495	9.11	31	57	519.27
6	57.14	500	11.48	36	67	769.16
7	81.62	520	24.48	56	92	2252.16
8	92.22	540	10.60	76	132	1399.332
9	93.45	560	1.23	96	172	211.216
10	95.02	580	1.57	116	212	333.476
11	95.80	600	0.78	136	252	196.056
Total			**95.80**			**6082.823**

Eq. Slope= $\frac{\text{sum of}(Li*(Di-1+Di)}{L^2}$

= **0.66** m/km

Design return period:		**100**	years
From plate no 11 , 100 yr point rainfall from sub zone 3h manual =		**20**	cms

i) Name of Project **Mula Mutha Riverfront**

ii) Name of Tributary/River **Mutha**

Estimation of flood using SCS method

Data

C.A. (A)	(Catchment Area up to the project site in km^2)	**2096**	km^2	
Length(L)	(Length of Main Stream from farthest point to dam site)	**95799**	m	
Slope Sg	(Equivalent stream slope of main stream in m/km)	**0.66**	m/km	0.07%
CN	**(** Run off Curver Number)	**98**	(From SCS Manual)	

(1) Determination of synthetic 1 hr U.G.Parameters

$$tc = \frac{L^{0.8}((1000/CN)-9)^{0.7}}{(4407\,(Sg)^{0.5})}$$

= 9.7 hrs

tp = D/2 +0.6tc

where tp = time of peak in hrs

D = Duration of excess rainfall in cm

tp = 7 hrs

Say **7** hrs

Peak flow rate (m3/sec) per unit of rainfall q = (2.08 x A)/tp

= 622.81 m3/sec

(2) Estimation of storm duration

The design storm duration T_D = 2.67 x tp = 18.69 hrs

Say 19 hrs

(3) Estimation of Design Base Flow

Q_B = A x q_b (Base Flow)

= 2096x0.05

= 36.5 cumecs

(4) Estimation of Point rainfall and Areal Rainfall from C.W.C.Report-Sub Zone-3(h)

(I) Point Rainfall

The catchment was located on Plate-10 (Ref C.W.C.Report-Sub Zone-3(h))

showing 100 yr point rainfall = **20** cms

Conversion factor of 100 yr 24 hr point rainfall to 100 yr 19 hr point rainfall

is read from fig-10 section 4.2 = **0.950**

100 yr 7 hrs point rainfall = 20 x 0.95 = **19** cm

(ii) Areal Rainfall

Areal reduction factor for TD= 19 hrs corresponding to catchment

area 2,096 km2 was interpolated from Annexure 4.4 = **0.7800**

100 yr 19 hrs areal rainfall = 19x0.78 = **14.82** cms

Recharge capacity of watershed

$$S = \frac{25400}{254\ CN} -$$

S = 5.18

Now Runoff depth

$$Q = \frac{(P-0.2\ S)^{2}}{(P+0.8S)}$$

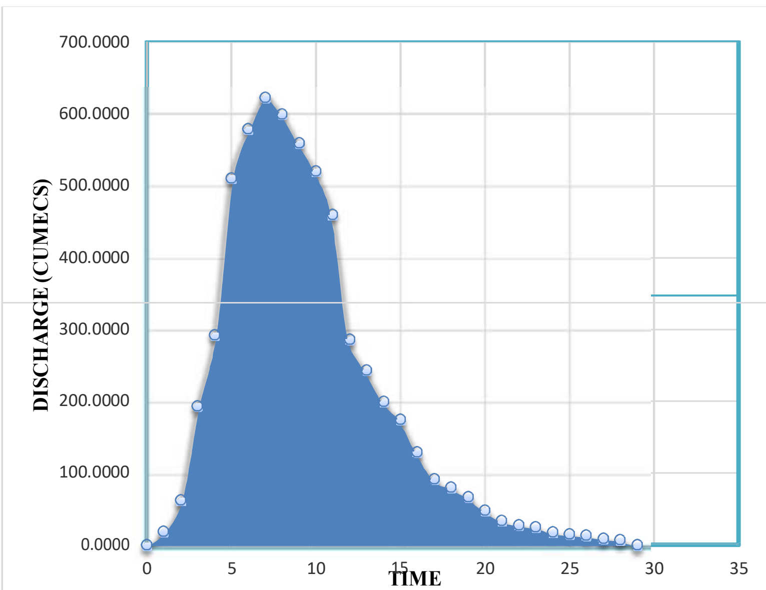
Where

P = Rainfall in cm = 148.20 mm

Therefore

Q = 14.216 **Cm**

(5) Drawing of synthetic unit hydrograph



Hourly Rainfall Increment				
Sr. No.	Duration t (hrs)	Distribution Coefficient	Storm Rainfall (cm)	1-hr rainfall increment (cm)
1	1	0.20	2.84	2.84
2	2	0.35	4.98	2.14
3	3	0.42	5.97	0.99
4	4	0.49	6.97	1.00
5	5	0.56	7.96	0.99
6	6	0.62	8.81	0.85
7	7	0.66	9.38	0.57
8	8	0.70	9.95	0.57
9	9	0.73	10.38	0.43
10	10	0.77	10.95	0.57
11	11	0.80	11.37	0.42
12	12	0.82	11.66	0.29
13	13	0.85	12.08	0.42
14	14	0.89	12.65	0.57
15	15	0.93	13.22	0.57
16	16	0.95	13.51	0.29
17	17	0.97	13.79	0.28
18	18	0.99	14.07	0.28
19	19	1.00	14.22	0.15

Computation of 1 in 100yr flood: (Peak only)			
Time (hrs)	U.G (m^3/sec)	R.F excess in design order	Direct Runoff (cumecs)
1	62.3	0.28	17.44
2	193.1	0.43	83.02
3	292.7	0.57	166.85
4	510.7	0.85	434.10
5	579.2	1.00	579.21
6	622.8	2.84	1768.78
7	600.0	2.14	1284.00
8	560.0	0.99	554.40
9	520.0	0.99	514.80
10	460.0	0.57	262.20
11	286.5	0.57	163.30
12	242.9	0.57	138.45
13	200.0	0.57	114.00
14	174.4	0.42	73.24
15	128.9	0.42	54.15
16	91.6	0.29	26.55
17	80.0	0.29	23.20
18	66.6	0.28	18.66
19	48.0	0.15	7.19
Sum=			**6283.54**

1 in 100 yr flood.

= Sum of direct runoff + Base flow

= 6283.54 + 36.5

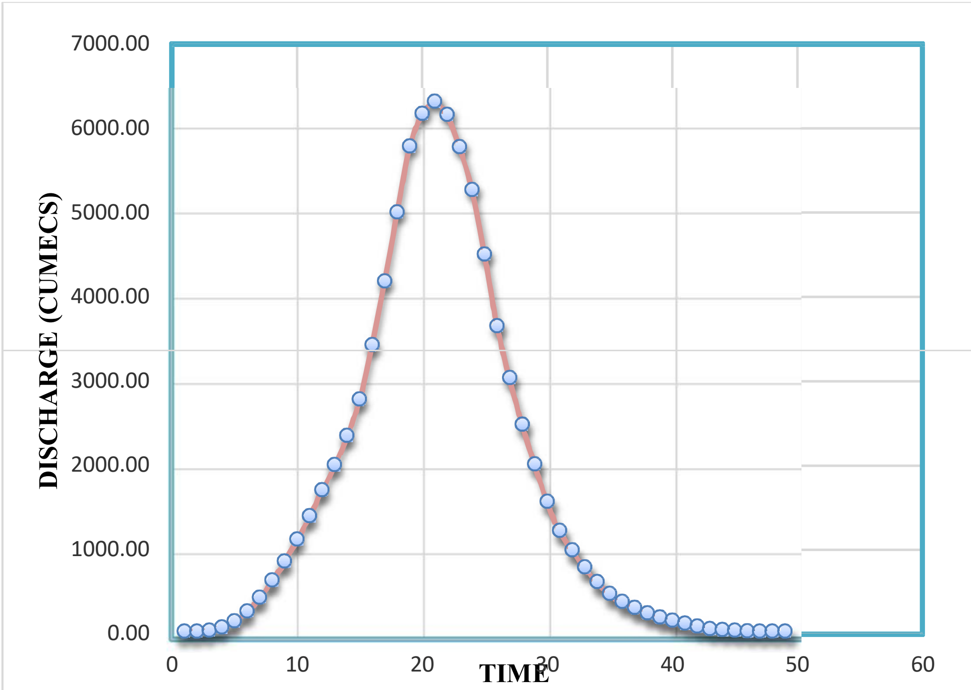
= **6320.04 cumecs** **Say** **6321** **cumecs**

Computation of Design Flood Peak hydrograph (1 in 100 Year)

Calculated Peak Flood 6320.04 cumecs

Synthetic	Hourly rainfall excess in cm																			Total	Base	Total	Remarks
U.G.	0.15	0.28	0.29	0.29	0.42	0.42	0.57	0.57	0.57	0.57	0.99	0.99	2.14	2.84	1.00	0.85	0.57	0.43	0.28		Flow		
Ordinates	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	(Cumecs)	(Cumecs)	(Cumecs)	
0.0	0.00																			0.00	36.50	36.50	
18.7	2.80	0.00																		2.80	36.50	39.30	
62.3	9.34	5.23	0.00																	14.57	36.50	51.07	
193.1	28.96	17.44	5.42	0.00																51.82	36.50	88.32	
292.7	43.91	54.06	18.06	5.42	0.00															121.45	36.50	157.95	
510.7	76.61	81.96	55.99	18.06	7.85	0.00														240.47	36.50	276.97	
579.2	86.88	143.00	84.89	55.99	26.16	7.85	0.00													404.77	36.50	441.27	
622.8	93.42	162.18	148.10	84.89	81.09	26.16	10.65	0.00												606.49	36.50	642.99	
600.0	90.00	174.39	167.97	148.10	122.94	81.09	35.50	10.65	0.00											830.64	36.50	867.14	
560.0	84.00	168.00	180.61	167.97	214.50	122.94	110.05	35.50	10.65	0.00										1094.22	36.50	1130.72	
520.0	78.00	156.80	174.00	180.61	243.27	214.50	166.85	110.05	35.50	10.65	0.00									1370.23	36.50	1406.73	
460.0	69.00	145.60	162.40	174.00	261.58	243.27	291.10	166.85	110.05	35.50	18.50	0.00								1677.85	36.50	1714.35	
286.5	42.97	128.80	150.80	162.40	252.00	261.58	330.15	291.10	166.85	110.05	61.66	18.50	0.00							1976.86	36.50	2013.36	
242.9	36.43	80.22	133.40	150.80	235.20	252.00	355.00	330.15	291.10	166.85	191.14	61.66	39.98	0.00						2323.93	36.50	2360.43	
200.0	30.00	68.01	83.08	133.40	218.40	235.20	342.00	355.00	330.15	291.10	289.79	191.14	133.28	53.06	0.00					2753.61	36.50	2790.11	
174.4	26.16	56.00	70.44	83.08	193.20	218.40	319.20	342.00	355.00	330.15	505.60	289.79	413.17	176.88	18.68	0.00				3397.75	36.50	3434.25	
128.9	19.34	48.83	58.00	70.44	120.33	193.20	296.40	319.20	342.00	355.00	573.42	505.60	626.42	548.32	62.28	15.88	0.00			4154.66	36.50	4191.16	
91.6	13.73	36.10	50.57	58.00	102.02	120.33	262.20	296.40	319.20	342.00	616.58	573.42	1092.91	831.33	193.07	52.94	10.65	0.00		4971.45	36.50	5007.95	
80.0	12.00	25.63	37.39	50.57	84.00	102.02	163.30	262.20	296.40	319.20	594.00	616.58	1239.52	1450.40	292.72	164.11	35.50	8.03	0.00	5753.57	36.50	5790.07	
66.6	10.00	22.40	26.55	37.39	73.24	84.00	138.45	163.30	262.20	296.40	554.40	594.00	1332.81	1644.97	510.70	248.81	110.05	26.78	5.23	6141.68	36.50	6178.18	
48.0	7.19	18.66	23.20	26.55	54.15	73.24	114.00	138.45	163.30	262.20	514.80	554.40	1284.00	1768.78	579.21	434.10	166.85	83.02	17.44	6283.54	36.50	6320.04	Peak Flood
34.3	5.14	13.43	19.33	23.20	38.45	54.15	99.40	114.00	138.45	163.30	455.40	514.80	1198.40	1704.00	622.81	492.33	291.10	125.87	54.06	6127.62	36.50	6164.12	
28.0	4.20	9.59	13.91	19.33	33.60	38.45	73.49	99.40	114.00	138.45	283.63	455.40	1112.80	1590.40	600.00	529.39	330.15	219.60	81.96	5747.75	36.50	5784.25	
24.9	3.74	7.84	9.93	13.91	27.99	33.60	52.19	73.49	99.40	114.00	240.47	283.63	984.40	1476.80	560.00	510.00	355.00	249.06	143.00	5238.45	36.50	5274.95	
18.1	2.71	6.98	8.12	9.93	20.14	27.99	45.60	52.19	73.49	99.40	198.00	240.47	613.09	1306.40	520.00	476.00	342.00	267.81	162.18	4472.50	36.50	4509.00	
15.0	2.25	5.06	7.22	8.12	14.39	20.14	37.99	45.60	52.19	73.49	172.64	198.00	519.80	813.64	460.00	442.00	319.20	258.00	174.39	3624.12	36.50	3660.62	
13.1	1.96	4.20	5.24	7.22	11.76	14.39	27.34	37.99	45.60	52.19	127.63	172.64	428.00	689.82	286.49	391.00	296.40	240.80	168.00	3008.67	36.50	3045.17	
9.3	1.40	3.66	4.35	5.24	10.46	11.76	19.53	27.34	37.99	45.60	90.64	127.63	373.19	568.00	242.90	243.52	262.20	223.60	156.80	2455.81	36.50	2492.31	
6.9	1.03	2.62	3.79	4.35	7.59	10.46	15.96	19.53	27.34	37.99	79.20	90.64	275.89	495.26	200.00	206.46	163.30	197.80	145.60	1984.81	36.50	2021.31	
0.0	0.00	1.92	2.71	3.79	6.30	7.59	14.20	15.96	19.53	27.34	65.97	79.20	195.92	366.14	174.39	170.00	138.45	123.19	128.80	1541.40	36.50	1577.90	
		0.00	1.99	2.71	5.49	6.30	10.30	14.20	15.96	19.53	47.48	65.97	171.20	260.01	128.92	148.23	114.00	104.45	80.22	1196.96	36.50	1233.46	
			0.00	1.99	3.92	5.49	8.55	10.30	14.20	15.96	33.91	47.48	142.61	227.20	91.55	109.58	99.40	86.00	68.01	966.15	36.50	1002.65	
				0.00	2.88	3.92	7.46	8.55	10.30	14.20	27.72	33.91	102.63	189.26	80.00	77.82	73.49	74.99	56.00	763.13	36.50	799.63	
					0.00	2.88	5.33	7.46	8.55	10.30	24.66	27.72	73.30	136.20	66.64	68.00	52.19	55.44	48.83	587.50	36.50	624.00	
						0.00	3.91	5.33	7.46	8.55	17.88	24.66	59.92	97.28	47.96	56.64	45.60	39.37	36.10	450.66	36.50	487.16	
							0.00	3.91	5.33	7.46	14.85	17.88	53.31	79.52	34.25	40.76	37.99	34.40	25.63	355.29	36.50	391.79	
								0.00	3.91	5.33	12.95	14.85	38.65	70.75	28.00	29.12	27.34	28.66	22.40	281.96	36.50	318.46	
									0.00	3.91	9.25	12.95	32.10	51.29	24.91	23.80	19.53	20.62	18.66	217.02	36.50	253.52	
										0.00	6.78	9.25	27.99	42.60	18.06	21.18	15.96	14.73	13.43	169.98	36.50	206.48	
											0.00	6.78	19.99	37.14	15.00	15.35	14.20	12.04	9.59	130.09	36.50	166.59	
												0.00	14.66	26.53	13.08	12.75	10.30	10.71	7.84	95.87	36.50	132.37	
													0.00	19.46	9.34	11.12	8.55	7.77	6.98	63.22	36.50	99.72	
														0.00	6.85	7.94	7.46	6.45	5.06	33.76	36.50	70.26	
															0.00	5.82	5.33	5.62	4.20	20.97	36.50	57.47	
																0.00	3.91	4.02	3.66	11.59	36.50	48.09	
																	0.00	2.95	2.62	5.57	36.50	42.07	
																		0.00	1.92	1.92	36.50	38.42	
																			0.00	0.00	36.50	36.50	
																				0.00	36.50	36.50	
																						6320.04	Cumecs

FLOOD HYDROGRAPH FOR MULA MUTHA RIVER BY SCS METHOD



ANNEXURE VIII

FLOOD ESTIMATION BY SYNTHETIC UNIT HYDROGRAPH (SCS METHOD)
MULA MUTHA RIVERFRONT DEVELOPMENT

Project:	**Mula Mutha Riverfront Development**		
River:	Mutha	longitude	73^0 86' 07"
City	Pune	latitude	18^0 52' 84"

Table for Computation of Equivalent slope(S)

C.A. **738.5** km^2

'Datum =Reduced level of river bed = **473** m

TABLE-1

Sr No.	Reduced distance starting (km)	Reduced levels of river bed (m)	Length of each segment Li (km)	Height above datum(Di)= difference between the datum & its R.L. (m)	Di-1 + Di (m)	Li * (Di-1 + Di) (km * m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	473	0.00	0	0	0
2	3.07	475	3.07	2	2	6.13
3	6.44	475	3.38	2	4	13.5
4	9.09	480	2.653	7	9	23.877
5	13.74	485	4.65	12	19	88.35
6	15.82	500	2.075	27	39	80.925
7	36.66	520	20.837	47	74	1541.938
8	36.83	540	0.178	67	114	20.292
9	54.81	560	17.98	87	154	2768.92
10	58.20	580	3.384	107	194	656.496
11	59.39	600	1.192	127	234	278.928
12	59.98	620	0.587	147	274	160.838
13	60.57	640	0.592	167	314	185.888
Total			**60.57**			**5826.082**

$$\text{Eq. Slope} = \frac{\text{sum of}(Li^*(Di\text{-}1+Di))}{L^2}$$

$$= \mathbf{1.59}\ \text{m/km}$$

Design return period:		**100**	years
From plate no 11 , 100 yr point rainfall from sub zone 3h manual =		**20**	cms

i) Name of Project **Mula Mutha Riverfront**

ii) Name of Tributary/River **Mutha**

Estimation of flood using SCS method

Data

C.A. (A)	(Catchment Area up to the project site in km^2)	**738.5**	km^2	
Length(L)	(Length of Main Stream from farthest point to dam site)	**60568**	m	
Slope Sg	(Equivalent stream slope of main stream in m/km)	**1.59**	m/km	0.16%
C.G. (Lc)	(Length of Longest stream from a point opposite to C.G)	**26.10**	km	
CN	(Run off Curver Number)	**98**	(From SCS Manual)	

(1) Determination of synthetic 1 hr U.G.Parameters

$$tc = \frac{L^{0.8}((1000/CN)-9)^{0.7}}{(4407\ (Sg)^{0.5})}$$

= 4.3 hrs

tp = D/2 +0.6tc

where tp = time of peak in hrs

D = Duration of excess rainfall in cm

tp = 4 hrs

Say **4** hrs

Peak flow rate (m3/sec) per unit of rainfall q = (2.08 x A)/tp

= 384.02 m3/sec

(2) Estimation of storm duration

The design storm duration T_D = 2.67 x tp = 10.68 hrs

Say 11 hrs

(3) Estimation of Design Base Flow

Q_B = A x q_b (Base Flow)

= 738.5x0.05

= 36.5 cumecs

(4) Estimation of Point rainfall and Areal Rainfall from C.W.C.Report-Sub Zone-3(h)

(I) Point Rainfall

The catchment was located on Plate-10 (Ref C.W.C.Report-Sub Zone-3(h))
showing 100 yr point rainfall = **20** cms
Conversion factor of 100 yr 24 hr point rainfall to 100 yr 11 hr point rainfall
is read from fig-10 section 4.2 = **0.820**
100 yr 11 hrs point rainfall = 20 x 0.82 = **16.4** cm

(ii) Areal Rainfall

Areal reduction factor for catchment
area 739 km2 was interpolated from Annexure 4.4 = **0.7712**
100 yr 11 hrs areal rainfall = 16.4x0.77115 = **12.65** cms

Recharge capacity of watershed

$$S = \frac{25400}{254\ CN} -$$

$$S = 5.18$$

Now Runoff depth

$$Q = \frac{(P-0.2\ S)^{2}}{(P+0.8S)}$$

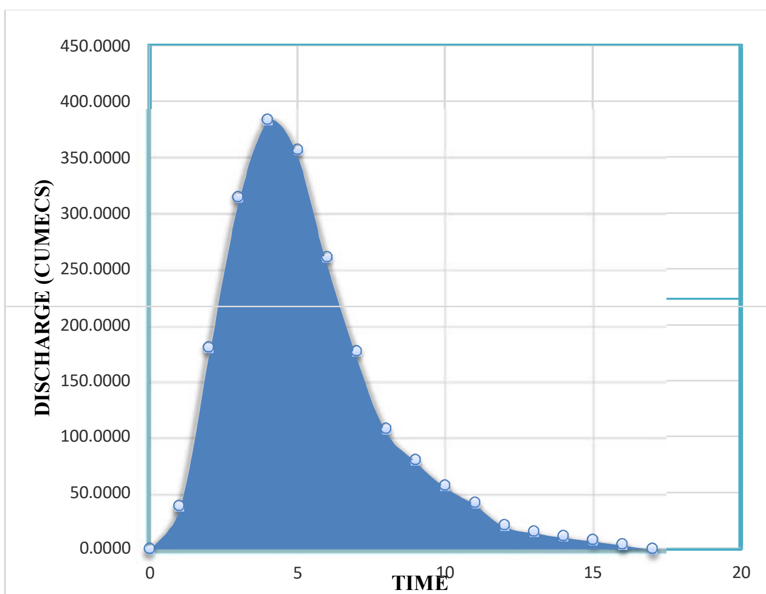
Where

P = Rainfall in cm = 126.47 mm

Therefore

Q = 12.046 **Cm**

(5) Drawing of synthetic unit hydrograph



Hourly Rainfall Increment				
Sr. No.	Duration t (hrs)	Distributio n n Coefficient	Storm Rainfall (cm)	1-hr rainfall increment (cm)
1	1	0.35	4.22	4.22
2	2	0.52	6.26	2.04
3	3	0.62	7.47	1.21
4	4	0.72	8.67	1.20
5	5	0.78	9.40	0.73
6	6	0.83	10.00	0.60
7	7	0.87	10.48	0.48
8	8	0.94	11.32	0.84
9	9	0.96	11.56	0.24
10	10	0.98	11.81	0.25
11	11	1.00	12.05	0.24

Computation of 1 in 100yr flood: (Peak only)			
Time (hrs)	U.G (m^3/sec)	R.F excess in design order	Direct Runoff (cumecs)
1	38.4	0.24	9.22
2	180.5	0.84	151.61
3	314.9	1.21	381.02
4	384.0	4.22	1620.56
5	357.1	2.04	728.56
6	261.1	1.20	313.36
7	176.6	0.73	128.95
8	107.5	0.60	64.52
9	79.5	0.48	38.16
10	56.5	0.25	14.11
11	41.1	0.24	9.86
Sum=			**3459.93**

1 in 100 yr flood.

= Sum of direct runoff + Base flow

= 3459.93 + 36.5

= **3496.43 cumecs** **Say** **3497** **cumecs**

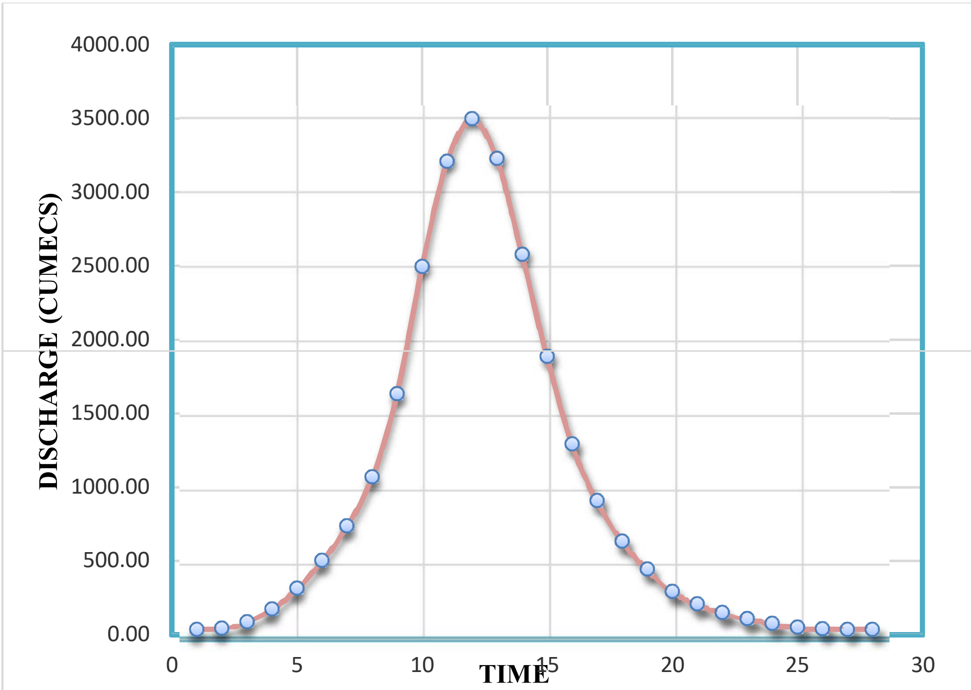
= **123497** **cusecs**

Computation of Design Flood Peak hydrograph (1 in 100 Year)

Calculated Peak Flood 3496.43 cumecs

Synthetic U.G. Ordinates	Hourly rainfall excess in cm											Total (Cumecs)	Base Flow (Cumecs)	Total (Cumecs)	Remarks
	0.24	0.25	0.48	0.60	0.73	1.20	2.04	4.22	1.21	0.84	0.24				
	1	2	3	4	5	6	7	8	9	10	11				
0.0	0.00											0.00	36.50	36.50	
38.4	9.22	0.00										9.22	36.50	45.72	
180.5	43.32	9.60	0.00									52.92	36.50	89.42	
314.9	75.58	45.12	18.43	0.00								139.13	36.50	175.63	
384.0	92.16	78.72	86.63	23.04	0.00							280.55	36.50	317.05	
357.1	85.71	96.01	151.15	108.29	28.03	0.00						469.19	36.50	505.69	
261.1	62.67	89.28	184.33	188.94	131.76	46.08	0.00					703.06	36.50	739.56	
176.6	42.40	65.28	171.43	230.41	229.87	216.59	78.34	0.00				1034.32	36.50	1070.82	
107.5	25.81	44.16	125.34	214.28	280.33	377.88	368.20	162.06	0.00			1598.06	36.50	1634.56	
79.5	19.08	26.88	84.79	156.68	260.71	460.82	642.39	761.67	46.47	0.00		2459.49	36.50	2495.99	
56.5	13.55	19.87	51.61	105.99	190.63	428.57	783.40	1328.86	218.39	32.26	0.00	3173.13	36.50	3209.63	
41.1	9.86	14.11	38.16	64.52	128.95	313.36	728.56	1620.56	381.02	151.61	9.22	3459.93	36.50	3496.43	Peak Flood
21.1	5.07	10.27	27.10	47.70	78.49	211.98	532.71	1507.12	464.66	264.51	43.32	3192.93	36.50	3229.43	
15.4	3.69	5.28	19.72	33.87	58.03	129.03	360.36	1101.98	432.14	322.58	75.58	2542.26	36.50	2578.76	
11.1	2.67	3.84	10.14	24.65	41.21	95.39	219.35	745.46	315.97	300.00	92.16	1850.84	36.50	1887.34	
8.1	1.94	2.78	7.37	12.67	30.00	67.74	162.16	453.76	213.75	219.35	85.71	1257.23	36.50	1293.73	
4.2	1.01	2.02	5.35	9.22	15.42	49.31	115.16	335.46	130.11	148.39	62.67	874.12	36.50	910.62	
0.0	0.00	1.06	3.87	6.68	11.21	25.35	83.82	238.22	96.19	90.32	42.40	599.12	36.50	635.62	
		0.00	2.03	4.84	8.13	18.43	43.09	173.40	68.31	66.77	25.81	410.81	36.50	447.31	
			0.00	2.53	5.89	13.36	31.34	89.13	49.72	47.42	19.08	258.47	36.50	294.97	
				0.00	3.08	9.68	22.72	64.82	25.56	34.52	13.55	173.93	36.50	210.43	
					0.00	5.07	16.45	47.00	18.59	17.74	9.86	114.71	36.50	151.21	
						0.00	8.62	34.03	13.48	12.90	5.07	74.10	36.50	110.60	
							0.00	17.83	9.76	9.35	3.69	40.63	36.50	77.13	
								0.00	5.11	6.77	2.67	14.55	36.50	51.05	
									0.00	3.55	1.94	5.49	36.50	41.99	
										0.00	1.01	1.01	36.50	37.51	
											0.00	0.00	36.50	36.50	
														3496.43	Cumecs

FLOOD HYDROGRAPH FOR MUTHA RIVER BY SCS METHOD



ANNEXURE IX

FLOOD ESTIMATION BY SYNTHETIC UNIT HYDROGRAPH (SCS METHOD)
MULA MUTHA RIVERFRONT DEVELOPMENT

Project:	**Mula Mutha Riverfront Development**		
River:	Pawana	longitude	73^0 83' 33"
City	Pune	latitude	18^0 56' 66"

Table for Computation of Equivalent slope(S)

C.A. **501.2** km^2

'Datum =Reduced level of river bed = **484** m

TABLE-1

Sr No.	Reduced distance starting (km)	Reduced levels of river bed (m)	Length of each segment Li (km)	Height above datum(Di)= difference between the datum & its R.L. (m)	Di-1 + Di (m)	Li * (Di-1 + Di) (km * m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	484	0.00	0	0	0
2	4.85	485	4.85	1	1	4.85
3	9.90	490	5.05	6	7	35.343
4	19.01	495	9.11	11	17	154.87
5	30.49	500	11.48	16	27	309.96
6	54.97	520	24.48	36	52	1272.96
7	65.57	540	10.601	56	92	975.292
8	66.80	560	1.228	76	132	162.096
9	68.37	580	1.573	96	172	270.556
10	69.15	600	0.778	116	212	164.936
Total			**69.15**			**3350.863**

$$\text{Eq. Slope} = \frac{\text{sum of}(Li*(Di\text{-}1+Di))}{L^2}$$

$$= \mathbf{0.70} \text{ m/km}$$

Design return period:	**100**	years
From plate no 11 , 100 yr point rainfall from sub zone 3h manual =	**20**	cms

i) Name of Project **Mula Mutha Riverfront**

ii) Name of Tributary/River **Mutha**

Estimation of flood using SCS method

Data

C.A. (A)	(Catchment Area up to the project site in km^2)	**501.2**	km^2	
Length(L)	(Length of Main Stream from farthest point to dam site)	**69149**	m	
Slope Sg	(Equivalent stream slope of main stream in m/km)	**0.70**	m/km	0.07%
C.G. (Lc)	(Length of Longest stream from a point opposite to C.G)	**25.20**	km	
CN	**(** Run off Curver Number)	**98**	(From SCS Manual)	

(1) Determination of synthetic 1 hr U.G.Parameters

$$\mathbf{tc} = \frac{L^{0.8}((1000/CN)-9)^{0.7}}{(4407\,(Sg)^{0.5})}$$

= 7.3 hrs

tp = D/2 +0.6tc

where tp = time of peak in hrs

D = Duration of excess rainfall in cm

tp = 5 hrs

Say **5** hrs

Peak flow rate (m3/sec) per unit of rainfall q = (2.08 x A)/tp

= 208.4992 m3/sec

(2) Estimation of storm duration

The design storm duration T_D = 2.67 x tp = 13.35 hrs

Say 14 hrs

(3) Estimation of Design Base Flow

$\mathbf{Q_B}$ **=** A x q_b (Base Flow)

= 501.2x0.05

= 36.5 cumecs

(4) Estimation of Point rainfall and Areal Rainfall from C.W.C. Report-Sub Zone-3(h)

(I) Point Rainfall

The catchment was located on Plate-10 (Ref C.W.C.Report-Sub Zone-3(h))
showing 100 yr point rainfall = **20** cms
Conversion factor of 100 yr 24 hr point rainfall to 100 yr 14 hr point rainfall
is read from fig-10 section 4.2 = **0.870**
100 yr 14 hrs point rainfall = 20 x 0.87 = **17.4** cm

(ii) Areal Rainfall

Areal reduction factor for TD= 14 hrs corresponding to catchment
area 501 km2 was interpolated from Annexure 4.4 = **0.8123**
100 yr 14 hrs areal rainfall = 17.4x0.8122996 = **14.13** cms

Recharge capacity of watershed

$$S = \frac{25400}{254\ CN} -$$

$$S = 5.18$$

Now Runoff depth

$$Q = \frac{(P-0.2\ S)^{2}}{(P+0.8S)}$$

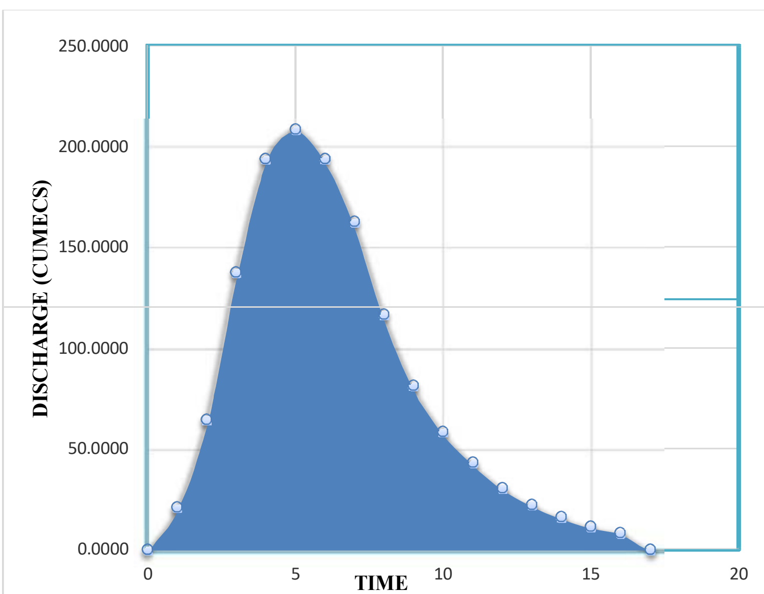
Where

P = Rainfall in cm = 141.34 mm

Therefore

Q = 13.531 **Cm**

(5) Drawing of synthetic unit hydrograph



Hourly Rainfall Increment				
Sr. No.	Duration t (hrs)	Distributio n n Coefficient	Storm Rainfall (cm)	1-hr rainfall increment (cm)
1	1	0.32	4.33	4.33
2	2	0.43	5.82	1.49
3	3	0.52	7.04	1.22
4	4	0.61	8.25	1.21
5	5	0.68	9.20	0.95
6	6	0.74	10.01	0.81
7	7	0.79	10.69	0.68
8	8	0.84	11.37	0.68
9	9	0.87	11.77	0.40
10	10	0.91	12.31	0.54
11	11	0.94	12.72	0.41
12	12	0.96	12.99	0.27
13	13	0.98	13.26	0.27
14	14	1.00	13.53	0.27

Computation of 1 in 100yr flood: (Peak only)			
Time (hrs)	U.G (m^3/sec)	R.F excess in design order	Direct Runoff (cumecs)
1	20.8	0.27	5.63
2	64.6	0.68	43.95
3	137.6	0.95	130.73
4	193.9	1.22	236.56
5	208.5	4.33	902.80
6	193.9	1.49	288.92
7	162.6	1.21	196.78
8	116.8	0.81	94.58
9	81.3	0.68	55.29
10	58.4	0.54	31.53
11	43.2	0.41	17.70
12	30.6	0.40	12.26
13	22.3	0.27	6.02
14	16.1	0.27	4.33
Sum=			**2027.08**

1 in 100 yr flood.

= Sum of direct runoff + Base flow

= 2027.08 + 36.5

= **2063.58 cumecs** **Say 2064 cumecs**

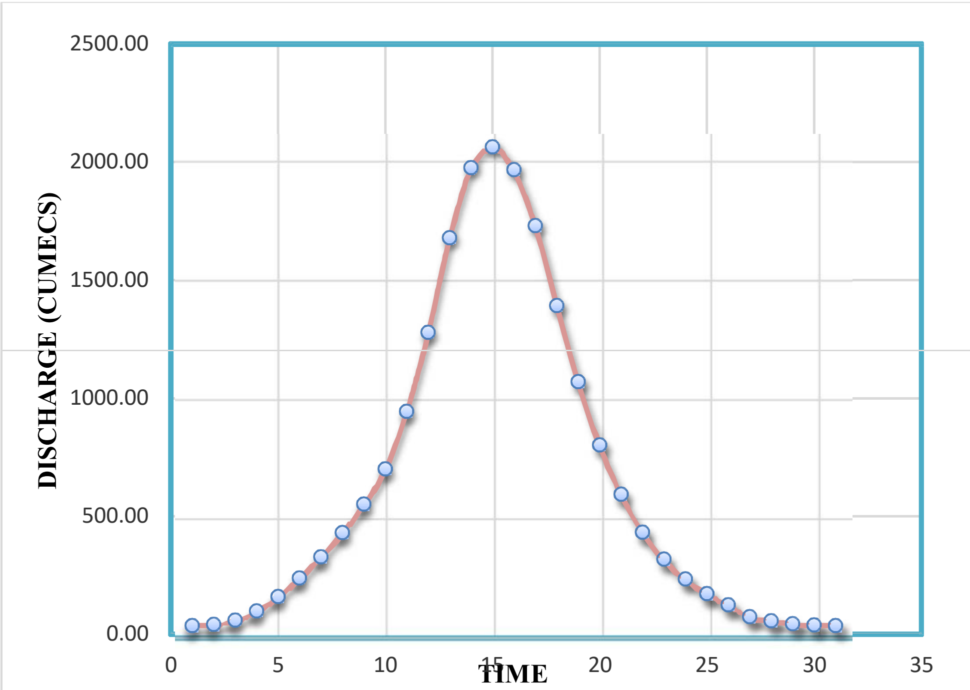
= **72891 cusecs**

Computation of Design Flood Peak hydrograph (1 in 100 Year)

Calculated Peak Flood 2063.58 cumecs

Synthetic	Hourly rainfall excess in cm														Total	Base	Total	Remarks
U.G.	0.27	0.27	0.40	0.41	0.54	0.68	0.81	1.21	1.49	4.33	1.22	0.95	0.68	0.27		Flow		
Ordinates	1	2	3	4	5	6	7	8	9	10	11	12	13	14	(Cumecs)	(Cumecs)	(Cumecs)	
0.0	0.00														0.00	36.50	36.50	
20.8	5.63	0.00													5.63	36.50	42.13	
64.6	17.45	5.63	0.00												23.08	36.50	59.58	
137.6	37.15	17.45	8.34	0.00											62.94	36.50	99.44	
193.9	52.35	37.15	25.85	8.55	0.00										123.90	36.50	160.40	
208.5	56.29	52.35	55.04	26.50	11.26	0.00									201.44	36.50	237.94	
193.9	52.35	56.29	77.56	56.42	34.90	14.18	0.00								291.70	36.50	328.20	
162.6	43.91	52.35	83.40	79.50	74.31	43.95	16.89	0.00							394.31	36.50	430.81	
116.8	31.53	43.91	77.56	85.48	104.71	93.57	52.35	25.23	0.00						514.34	36.50	550.84	
81.3	21.95	31.53	65.05	79.50	112.59	131.85	111.46	78.21	31.07	0.00					663.21	36.50	699.71	
58.4	15.76	21.95	46.70	66.68	104.71	141.78	157.06	166.51	96.31	90.28	0.00				907.74	36.50	944.24	
43.2	11.65	15.76	32.53	47.87	87.82	131.85	168.88	234.62	205.04	279.87	25.44	0.00			1241.33	36.50	1277.83	
30.6	8.28	11.65	23.35	33.34	63.05	110.59	157.06	252.28	288.92	595.85	78.85	19.81	0.00		1643.03	36.50	1679.53	
22.3	6.02	8.28	17.26	23.94	43.91	79.40	131.73	234.62	310.66	839.61	167.88	61.40	14.18	0.00	1938.89	36.50	1975.39	
16.1	4.33	6.02	12.26	17.70	31.53	55.29	94.58	196.78	288.92	902.80	236.56	130.73	43.95	5.63	2027.08	36.50	2063.58	Peak Flood
11.5	3.10	4.33	8.92	12.57	23.31	39.70	65.86	141.28	242.32	839.61	254.37	184.21	93.57	17.45	1930.60	36.50	1967.10	
8.3	2.25	3.10	6.42	9.15	16.55	29.35	47.29	98.39	173.97	704.19	236.56	198.07	131.85	37.15	1694.29	36.50	1730.79	
0.0	0.00	2.25	4.59	6.58	12.05	20.84	34.96	70.64	121.16	505.57	198.41	184.21	141.78	52.35	1355.39	36.50	1391.89	
		0.00	3.34	4.70	8.67	15.17	24.83	52.22	86.99	352.09	142.45	154.50	131.85	56.29	1033.10	36.50	1069.60	
			0.00	3.42	6.19	10.92	18.07	37.09	64.31	252.78	99.20	110.92	110.59	52.35	765.84	36.50	802.34	
				0.00	4.50	7.80	13.00	26.99	45.67	186.88	71.22	77.25	79.40	43.91	556.62	36.50	593.12	
					0.00	5.67	9.29	19.43	33.24	132.71	52.65	55.46	55.29	31.53	395.27	36.50	431.77	
						0.00	6.76	13.88	23.92	96.60	37.39	41.00	39.70	21.95	281.20	36.50	317.70	
							0.00	10.09	17.09	69.52	27.22	29.12	29.35	15.76	198.15	36.50	234.65	
								0.00	12.43	49.65	19.59	21.19	20.84	11.65	135.35	36.50	171.85	
									0.00	36.11	13.99	15.25	15.17	8.28	88.80	36.50	125.30	
										0.00	10.17	10.89	10.92	6.02	38.00	36.50	74.50	
											0.00	7.92	7.80	4.33	20.05	36.50	56.55	
												0.00	5.67	3.10	8.77	36.50	45.27	
													0.00	2.25	2.25	36.50	38.75	
														0.00	0.00	36.50	36.50	
																	2063.58	Cumecs

FLOOD HYDROGRAPH FOR PAVANA RIVER BY SCS METHOD



4. HYDRAULIC STUDY

4.1 INTRODUCTION

The velocities and depths of the free surface flow in a channel - either natural or artificial, conform to the principle of the conservation of energy expressed by the well-known Bernoulli's theorem. After the enunciation of the principle of conservation of energy; a formula for flow velocity of water from consideration of the resistance to flow by river topography is developed by the well known Engineer Manning. This hydraulic principle is followed in estimating water surface profiles for the given flood peaks.

4.2 WATER SURFACE ELEVATION (WSEL)/HFL COMPUTATION USING HEC-RAS

The basis for the hydraulic analysis was the development of an existing conditions as well as channelized sections in worldwide used HEC RAS Software developed by the Hydrologic Engineering Center, U.S. Army Corps of Engineers designed for interactive use in a multi-tasking environment and used to perform one-dimensional water surface calculations. HEC-RAS system is comprised of a graphical user interface, separate hydraulic analysis components, data storage and management capabilities, and graphing and reporting facilities (USACE, 2002 b). HEC-RAS is currently capable of performing one–dimensional water surface profile calculations for steady gradually varied flow in natural or constructed channels. It can handle a full network of channels or single river reach. Within steady flow it can be model subcritical, supercritical or mixed flow regime.

Computation engine of HEC-RAS is based on the solution of the one-dimensional energy equation. Energy losses are evaluated by friction (Manning’s formula), contraction, and expansion. In cases where the water surface profile is rapidly varied, use of the momentum equitation is necessary. HEC-RAS is capable of calculating effects of bridges, culverts, dam’s weirs, and other structures in the river and floodplain. Existing bridges in our project area will also create afflux, which also needs to be assessed for deriving the water levels.

It is first required to estimate the flood profile for the existing natural river regime and to re estimate it under the channelized river regime condition for a given value of selected design flood. The lowering/rising in the backwater profile would indicate the measure of effect that would be experienced on account of channelization of the river. The hydraulic structures are required to be designed accordingly for the revised profile. The afflux at the bridge structures involved needs also to be estimated

The brief introduction of main concept and equations used in HEC RAS are as follows.

Steady and Unsteady Flow

Flow in an open channel is steady if the depth, discharge, and mean velocity of flow at a particular location does not change with time, or if it can be assumed constant during the time period under consideration. If the depth, discharge and velocity of flow at some point changes with time, the flow is unsteady. A time factor is taken into account explicitly in the case of unsteady flow analysis, while steady flow analysis neglect time factors altogether.

Uniform and Non Uniform Flow

We say that channel flow is uniform if the depth, the discharge and the mean velocity do not change in space. This implies that the energy grade line, water surface elevation and channel bottom are all parallel for uniform flow. This type of flow rarely occurs in reality. Non-uniform flow is sometimes designated as varied flow and can be further classified as gradually varied and rapidly varied. The flow is rapidly varied if the spatial changes to the flow occur rapidly and the pressure distribution is not hydrostatic, otherwise it is gradually varied. Based on these classifications the steady flow can be uniform or varied. The unsteady flow is usually varied, as the unsteady uniform flow is practically impossible, because it would require that the water surface fluctuates from time to time while remaining parallel to the channel bottom (Chow, 1959). The basic assumption of the gradually varied flow computation is that the streamlines are practically parallel and hydrostatic pressure distribution prevails over the channel section. The head loss at a section is the same as with a uniform flow that has the same hydraulic radius of the section. Accordingly, the uniform flow equation may be used to evaluate the energy slope of a gradually varied flow, while the corresponding coefficient of roughness developed primarily for uniform flow is applicable to the gradually varied flow (Chow, 1959).

Subcritical and Supercritical Flow

The effect of gravity upon the state of flow is defined by a ratio of inertial force to gravitational force as the dimensionless Froude Number.

$$F = \frac{V}{\sqrt{gL}} \quad \text{.........(1)}$$

where,
F = Froude number (dimensionless)
V = mean channel flow velocity (m/s)
g = acceleration due to gravity (m/s2) and
L = characteristic length (m).

In open channel flow, the characteristic length is often taken as the hydraulic depth D, which is defined as the cross sectional area channel normal to the direction of flow divided by the width of the free surface. The flow is classified as subcritical, critical or supercritical, depending on the Froude number. When the Froude number is less than 1, the effect of gravitational force is less than the inertial force and the state of flow is referred to as subcritical flow

When inertial and the gravitational forces are equal, the Froude number is equal to unity and the flow is said to be at the critical stage. When the inertial forces exceed the gravitational force, the Froude number is greater than 1, and the flow is referred to as supercritical flow. The flow regime is an important criterion for the calculation of water surface profiles. When the state of flow is subcritical, the state of flow is controlled by channel characteristics at the downstream end of the river reach. In the case of supercritical flow, the flow is governed by the upstream end of the river reach.

Continuity Equation.

In the steady open channel flow analysis, the continuity equation states that flow remain constant between adjacent cross-sections.

$$Q = A_1 V_1 = A_2 V_2 \quad \text{..........(2)}$$

Where

Q = flow rate/discharge (m^3/s)

V_1, V_2 = mean flow velocity (m/s) and

A_1, A_2 = cross-sectional flow area (m^2).

Energy Equation.

Gradually varied water surface profiles are based on the principle of the conservation of energy, which states that the sum of the kinetic energy and potential energy at a particular cross section is equal to the sum of the potential and kinetic energy at any other cross section plus or minus energy loss or gains between the sections . Water surface is calculated from one cross section to the next by solving the energy equation written as:

$$Y_2 + Z_2 + \frac{\alpha_2 V_2^2}{2g} = Y_1 + Z_1 + \frac{\alpha_1 V_1^2}{2g} + h_e \quad \text{..........(3)}$$

where,

Y_1 , Y_2 = depth of water at cross sections (m)

Z_1 ,Z_2 = elevation of main channel inverts (m)

V_1, V_2 = average velocities (total discharge/total flow area)

g = gravitational acceleration

α_1, α_2 = velocity weighting coefficients (dimensionless) and

h_e= energy head loss (m).

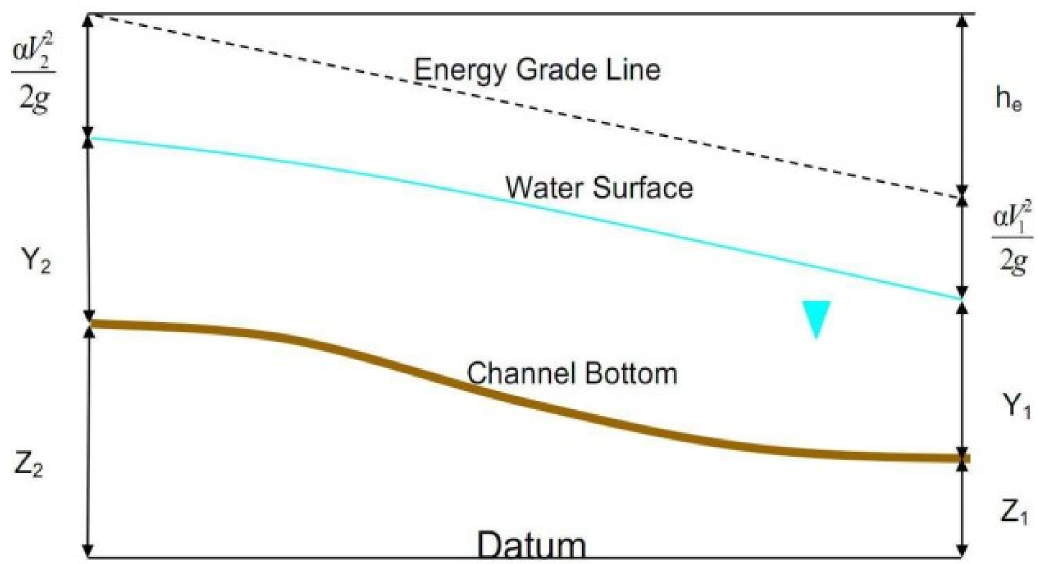


Figure 12: Representation of Terms in the Energy Equation

Based on the energy equation, the energy head loss is the sum of friction losses and expansion, or contraction of coefficient.

$$h_e = L\bar{S_f} + C\left|\frac{\alpha_2 V_2^2}{2g} - \frac{\alpha_1 V_1^2}{2g}\right| \qquad \text{...(4)}$$

where,

L = reach length between the adjacent cross sections
Sf = friction slope between the two sections and
C = expansion or contraction loss coefficient (dimensionless).

Manning's Loss Coefficient:

The energy losses due to the roughness of the river bed are usually evaluated in terms of Manning's Equation:

$$Q = KS_f^{1/2}$$

$$K = \frac{1}{n}AR^{2/3} \qquad \text{...(5)}$$

K = conveyance of the section (m3s-1)
n = Manning's roughness coefficient (m-1/3s) and
R = hydraulic radius (m).

Selecting the appropriate Manning's n value is very important for accurate computation of water surface profiles. The value of Manning's n is highly variable and depends upon a number of factors including: surface roughness, channel irregularities, channel alignment, size and shape of channel, scour and deposition, vegetation, obstructions, stage and discharge, seasonal change, temperature, suspended materials and bed load). The n value decreases with increases in stage and discharge. When the water depth is shallow, irregularities of the channel bottom are exposed and their effect may become pronounced. However, the n value may be large at high stages if the banks are rough and grassy (Chow, 1959)

If there is observed water surface data (high water marks, gagged data), Manning's n values should be calibrated. If there is no observed data (like in this study), then values of n obtained from another stream with similar conditions should be used.

Expansion and Contraction Coefficients.

The coefficient of expansion and the coefficient of contraction are introduced to take into account losses due to the expansion or contraction of flow caused by changes in the cross.

Friction Loss Evaluation.

Manning's equation is used for the calculation of energy slope as follows:

$$S_f = \left(\frac{Q}{K}\right)^2 \quad \text{..........}(6)$$

There are also a few other alternative expressions for the representation of reach friction slope in HEC-RAS computer program.

4.2.1 Computation method for Water Surface Elevation Generation in HEC RAS

The method of computation of water surface profiles for gradually varied flow is based on the assumption that the slope of the energy grade line at a section is equal to the energy slope for a uniform flow with the velocity and hydraulic radius of the section (Chow, 1959). Some of the basic steps in the computation of water surface profiles in HEC-RAS are explained below

Mean Kinetic Energy Head Calculation.

Mean kinetic energy head for each cross section is obtained by computing the flow weighted kinetic energy heads for three subsections of the cross sections (main channel, right and left overbank) Figure 12 illustrates the mean kinetic energy calculation process for the cross section with the main channel and the right overbank

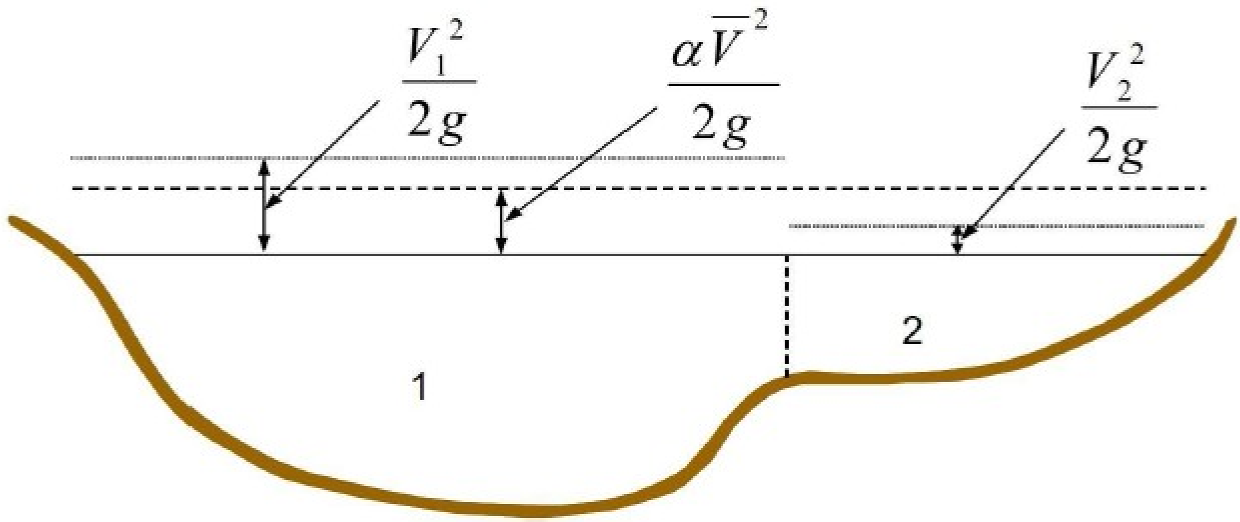


Figure 13 Example of Mean Energy Calculation

V1 is mean velocity for the main channel and V2 is mean velocity for the right overbank. The calculation of the mean energy head requires the velocity weighing coefficient alpha . The following equation, which is written in terms of conveyance and area, shows the calculation of coefficient alpha.

$$\alpha = \frac{(A_t)^2\left[\frac{K_{lob}^3}{A_{lob}^2} + \frac{K_{ch}^3}{A_{ch}^2} + \frac{K_{rob}^3}{A_{rob}^2}\right]}{K_t^3}$$

where:
$A_t =$ total flow area of the cross section
$A_{lob}, A_{ch}, A_{rob,} =$ flow areas of left overbank, main channel, and right overbank, respectively
$K_t =$ total conveyance of the cross section and
$K_{lob}, K_{ch}, K_{rob,} =$ conveyance of left overbank, main channel and right overbank respectively.

Standard Step Method.

The Standard Step Method can be used for both prismatic and non-prismatic channels, including the adjacent floodplain. This method can be applied to compute steady, gradually varied flow, and can also be used for both subcritical and supercritical flow. The computation for this method is based on the energy Equation (4) by steps from station to station. Depending upon the conditions of flow (subcritical or supercritical), the computations must be made in different directions. For subcritical flow that is under downstream control, the computation starts from downstream and proceeds upstream. For supercritical flow that is under upstream control, the computation starts from upstream and proceeds downstream. The computation steps used in this procedure for the subcritical flow are as follows

1. Assume the water surface elevation at the upstream cross section.

2. Based on the assumed water surface elevation, determine the corresponding total conveyance and velocity head.

3. With values from step 2, calculate the frictional slope Sf and solve Equation (4) for energy head loss (he)

4. With values from steps 2 and 3, solve Equation (3) for water surface elevation WS.

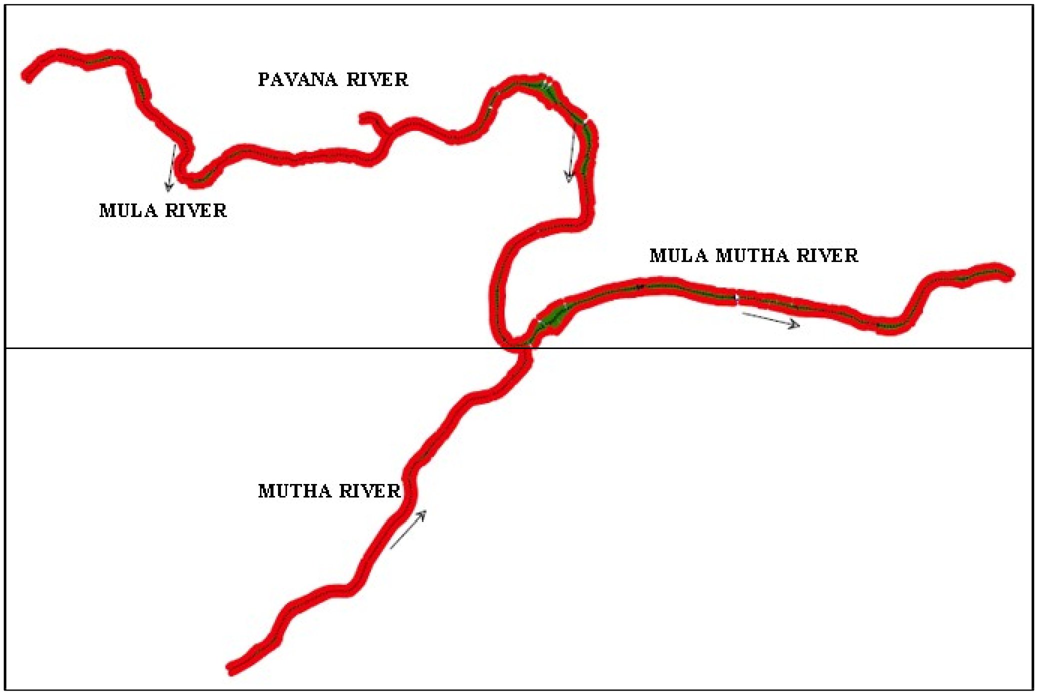
5. The computed value of WS is compared with the assumed value in step 1.

4.3 STEP BY STEP MODELLING OF GEOMETRY FILE USING HEC-RAS

The following section presents brief manual for use of HEC-RAS program for computation of water surface profiles

4.3.1 Creating HEC-RAS Project and Importing Geometry For Natural River Section

The first step in creating HEC- RAS geometry was to convert the surveyed elevation points of river bed and banks of project reach into CSV format and importing the same in AutoCAD 3D. Next step was to assign the flow path of the river stream within projected area in AutoCAD 3D and assigning cross section at every 50m interval well extending up to the available banks distance. geometry file consisting of stream line and cross section created in AutoCAD 3D were then exported to HEC RAS. First, the imported cross-sections in HEC RAS are compared with cross-sections with survey data at the same locations and if some cross-sections may have duplicate points cross Section Points Filter is used for editing.



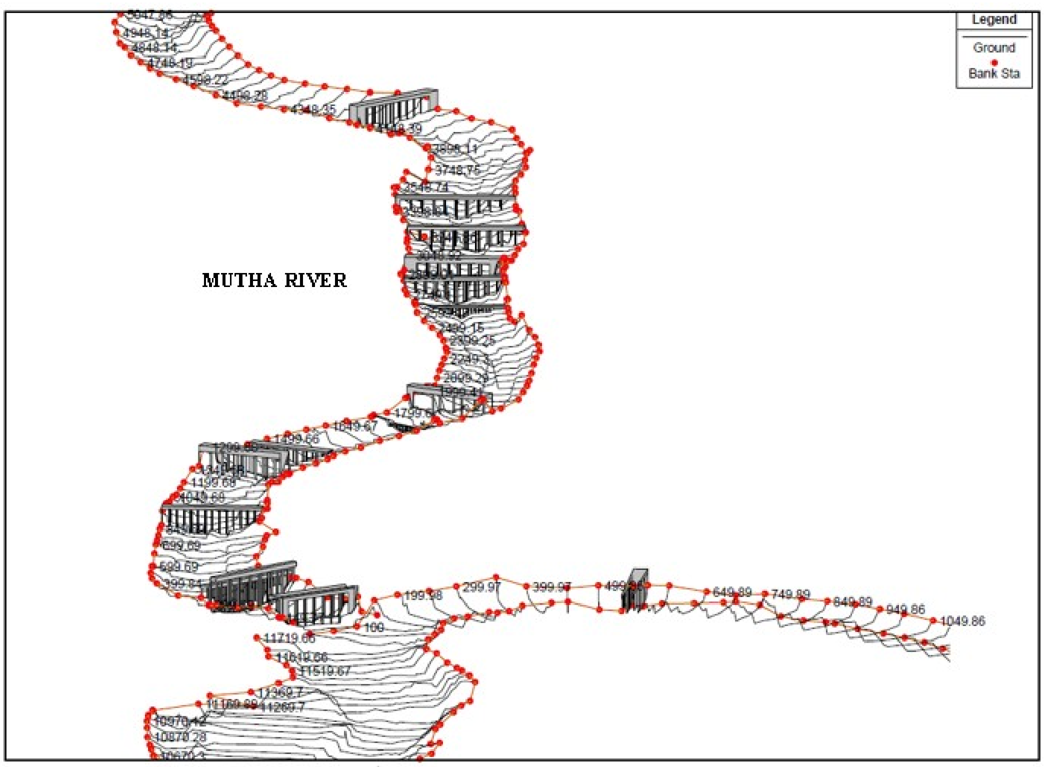


Figure 14 : 1D Geometry File as Generated in HEC-RAS

Manning’s n values.

Manning’s n values are part of the Geometry data required for HECRAS modeling. As there are no authentic observed water surface data (high water marks, gagged data), Manning’s n values is not calibrated. For natural river section Manning’s n values adopted as 0.03.

Bridge and Inline Structures (Check Dam, Barrage) data.

The data for bridges i.e. soffit Lvl, Top of Bridge Lvl , Spanning of Bridges, Pier Width are obtained from the Survey and are imported into HEC RAS model. The appropriate placing of bridge cross-sections for each bridge is taken into account while importing into HEC RAS model. The bridge bounding cross-sections 2 and 3 are shown in below figure

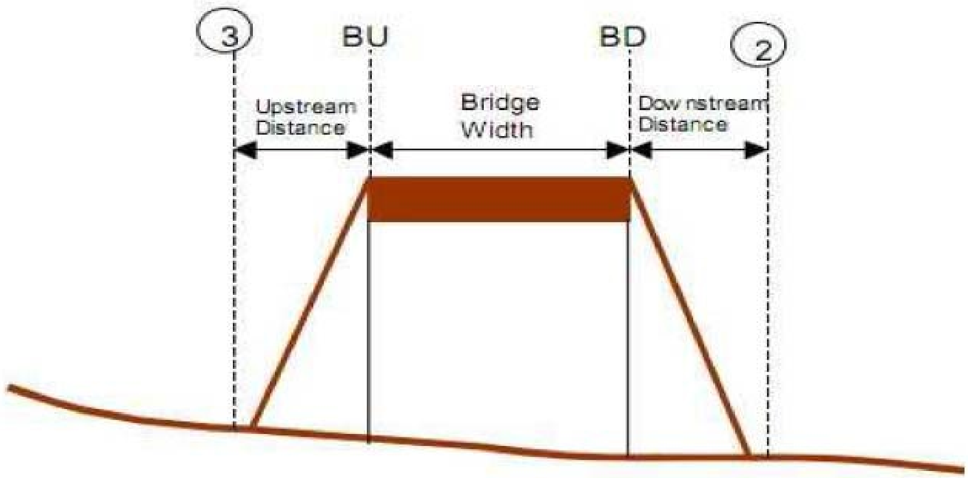


Figure 15 : Bridge Bounding Cross Sections

HEC-RAS automatically adds two more cross sections, immediately inside the upstream (BU for bridge upstream) and downstream (BD for bridge downstream) bridge faces. These two new cross sections appear in the Bridge/Culvert Data Editor window. The bridge deck editor is used to describe the area that is blocked out by the bridge deck and road embankment. Flowing bridges on the river are assigned to the model

Mutha River

- Wellesley Bridge
- Sangam Bridge
- Railway Bridge
- Sangam Arch Bridge
- Dengale Bridge
- Shivaji Bridge
- Tilak Bridge
- Causeway
- Shinde Bridge
- Baba Bhide Bridge
- Kakasaheb Z Bridge
- Sambhaji Bridge
- Chavan Bridge
- Joshi Bridge
- Mhatre Bridge
- Rajaram Bridge
- NH-4 Bridge

Mula River

- Mumbai Pune Bypass Bridge
- Wakad Bridge
- Bridge
- K Shakuntlal Bridge
- Shivaji Maharaj Bridge
- Old Aundh Bridge
- Aundh Bridge
- Sangvi Bridge
- Dapodi Bridge
- Dapodi Railway Bridge
- Old Harris Bridge
- New Harris Bridge
- Shanti Bridge
- Old Holkar Bridge
- New Holkar Bridge
- Sangam bridge
- Check dam 2 nos

Mula Mutha River

- Yerwada old and new Bridge,
- KT Weir
- Bund Garden
- H H Aga Khan Bridge
- Mundhwa Bridge

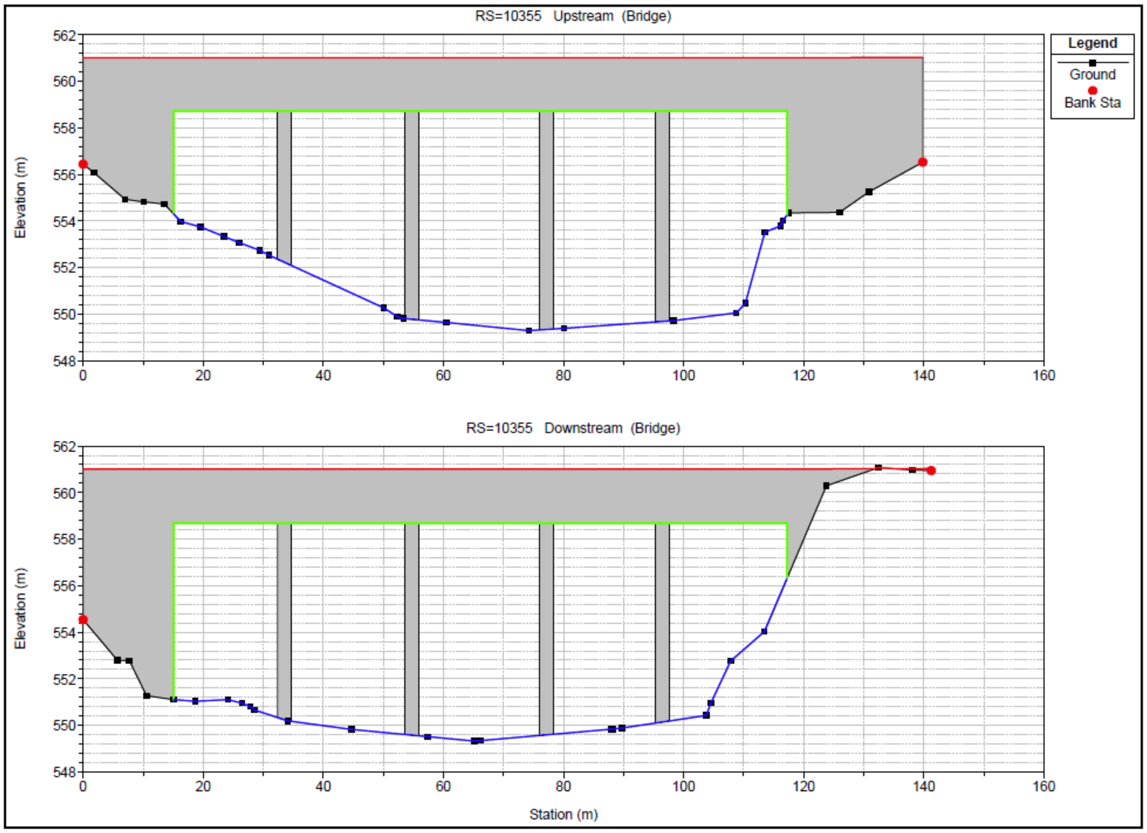


Figure 16: Cross Section of Balewadi Mumbai Pune Bypass Bridge on River Mula as generated in HEC-RAS

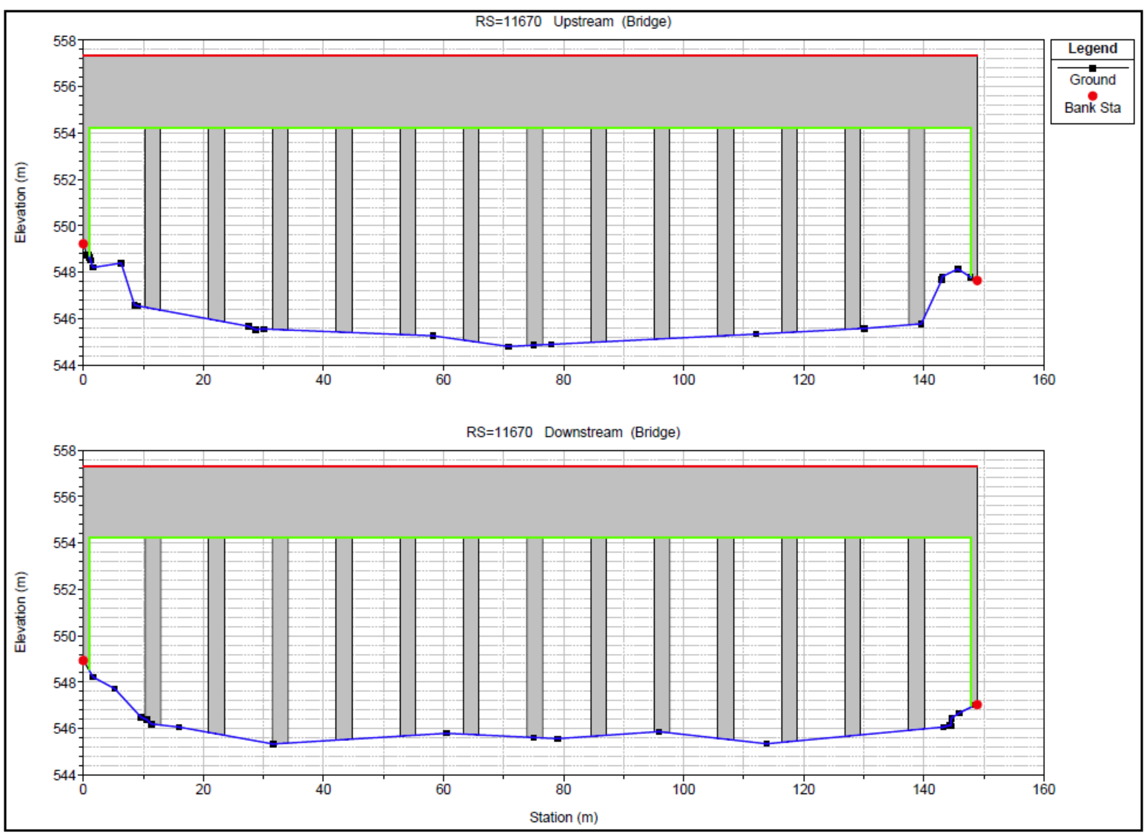


Figure 17: Cross Section of Dapodi Railway Bridge on River Mula as generated in HEC-RAS

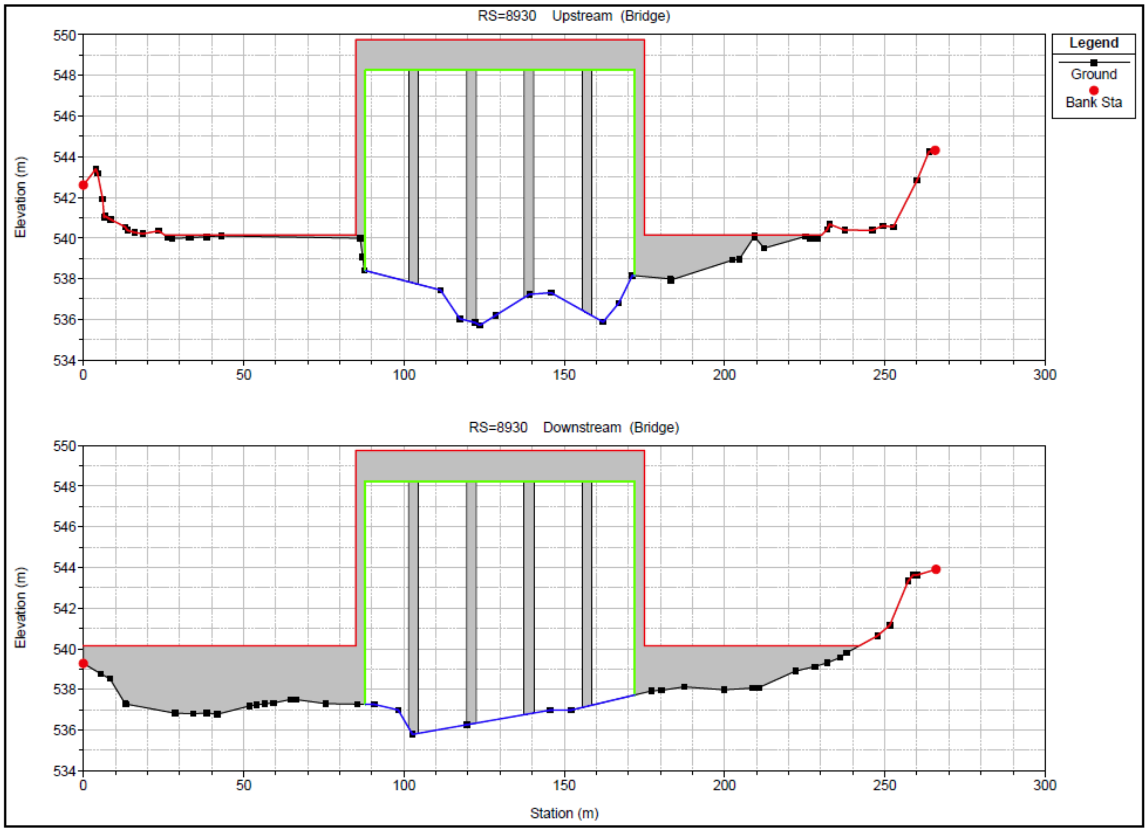


Figure 18: Bund Garden Barrage on River Mula- Mutha as generated in HEC-RAS

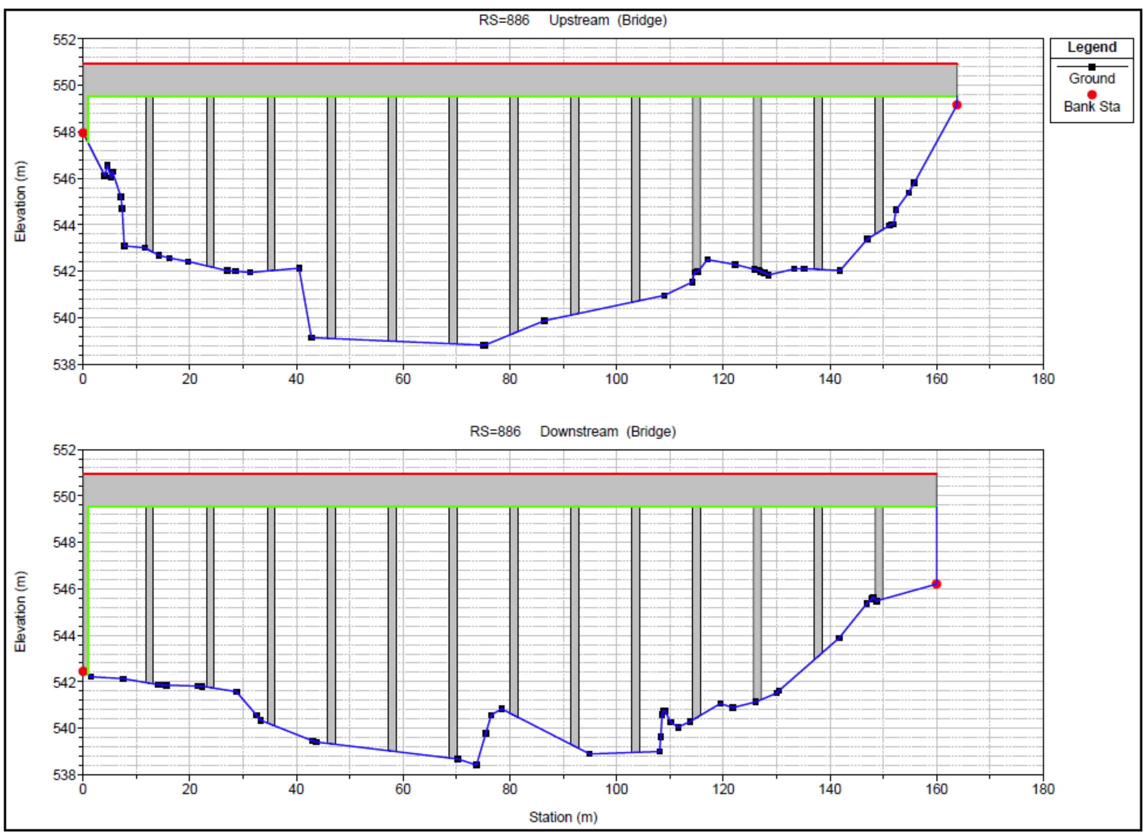


Figure 19: Dengale Bridge on River Mutha as generated in HEC-RAS

Flow data and Gradient.

The flood adopted for Mula Mutha river at Sangam i.e. at the confluence of Mula and Mutha river is 4758 Cumecs. Considering that simultaneous flood will not occur in both the river, the flood distribution is carried out in such a way that alternatively maximum discharge is passed through each river to match adopted flood discharge of Mula Mutha river. The flood discharge and gradient adopted for computing water surface elevation (WSEL) in HEC-RAS for 1 in 25,100 year return period flood for Mula ,Mutha and Mula Mutha river natural section is tabulated in Table 8.

Sr. No.	Particulars	Flood Discharge (Cumecs) 100 Year Return Period	Flood Discharge (Cumecs) 25 Year Return Period	Gradient
1	Mula River Up to Confluence Of Pawana River	1232 (Up to Babashaheb Ambedkar Bridge)	1206	1 In 2777
		1670 (Up to Confluence Point with Pawana River)	1536	
2	Mula River After Confluence Up To Sangam	3971	2875	1 In 1630
3	Mutha River	2835	1700	1 In1650
4	Mula - Mutha River Up To Project End Reach I.E. Kt Weir.	4762	3345	1 In1350

Table 8 :Flood Discharge and Gradient Adopted in HEC RAS for Natural River Section.

4.4 ANALYSIS AND RESULT

Water surface elevations/HFL are estimated in HEC-RAS for Mula , Mutha, Mula Mutha river within project reach as per flood tabulated in Table 8.Longitudinal section of water surface elevation at various flood discharges as generated in HEC RAS is shown in figure 9.Red line and Blue line marked in Longitudinal section are water surface elevation/HFL corresponding to 100 year and 25 year return period flood.

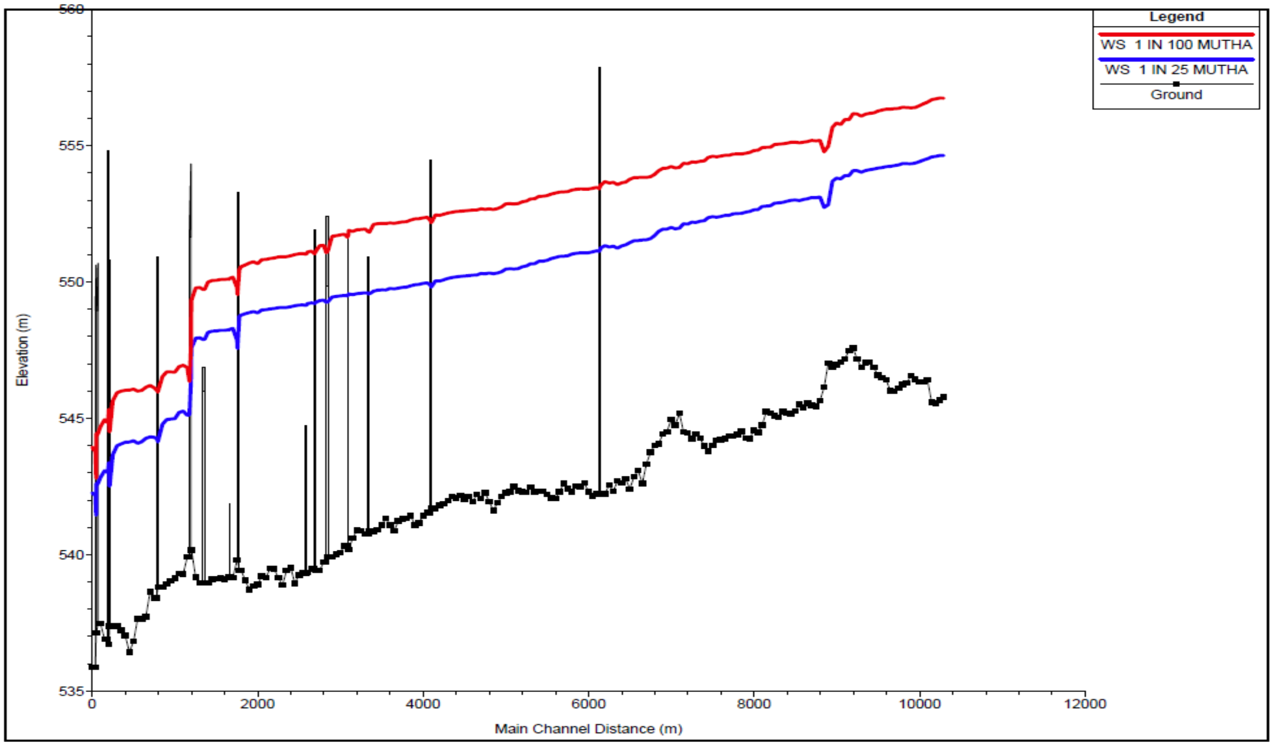


Figure 20 : Longitudinal Section of Water Surface Elevation/ HFL for Mutha River in Natural River Condition

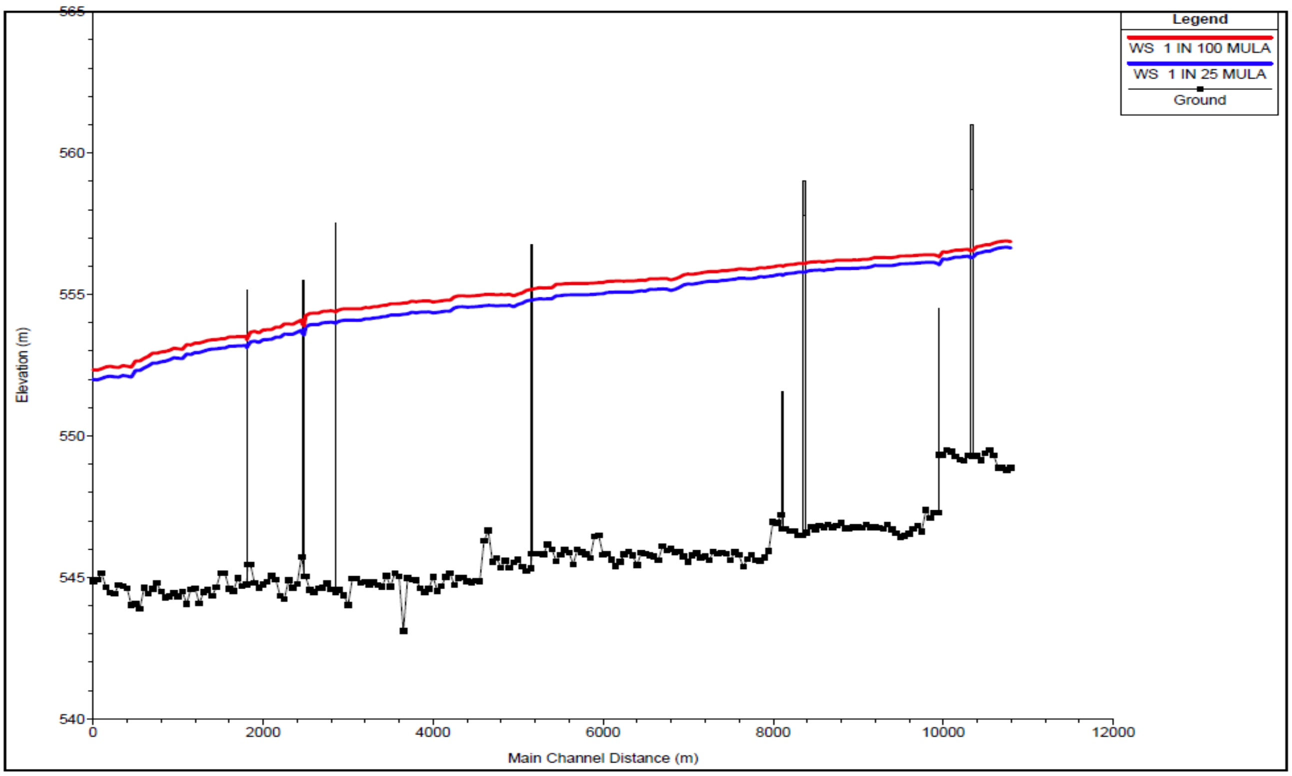


Figure 21 : Longitudinal Section of Water Surface Elevation/ HFL for Mula River in Natural River Condition from Balewadi Bridge to Confluence of Pawana River

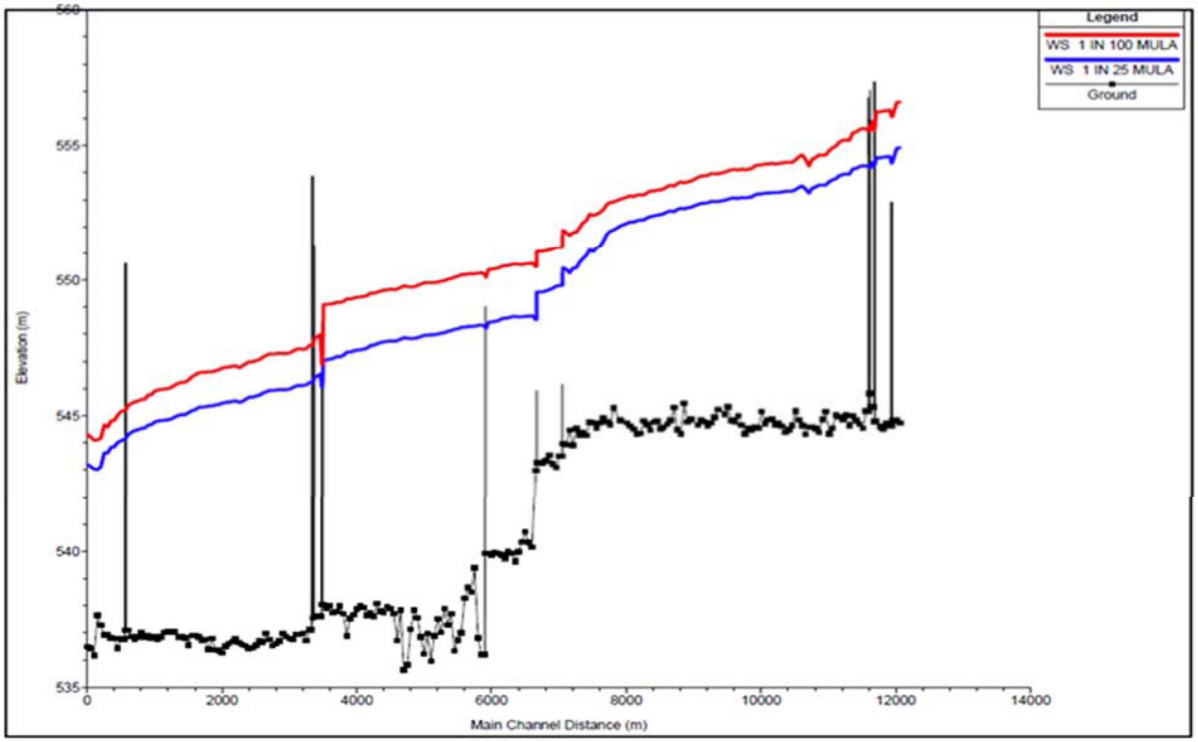


Figure 22 : Longitudinal Section of Water Surface Elevation/HFL for Mula River In Natural River Condition from confluence Of Pawana River to Sangam

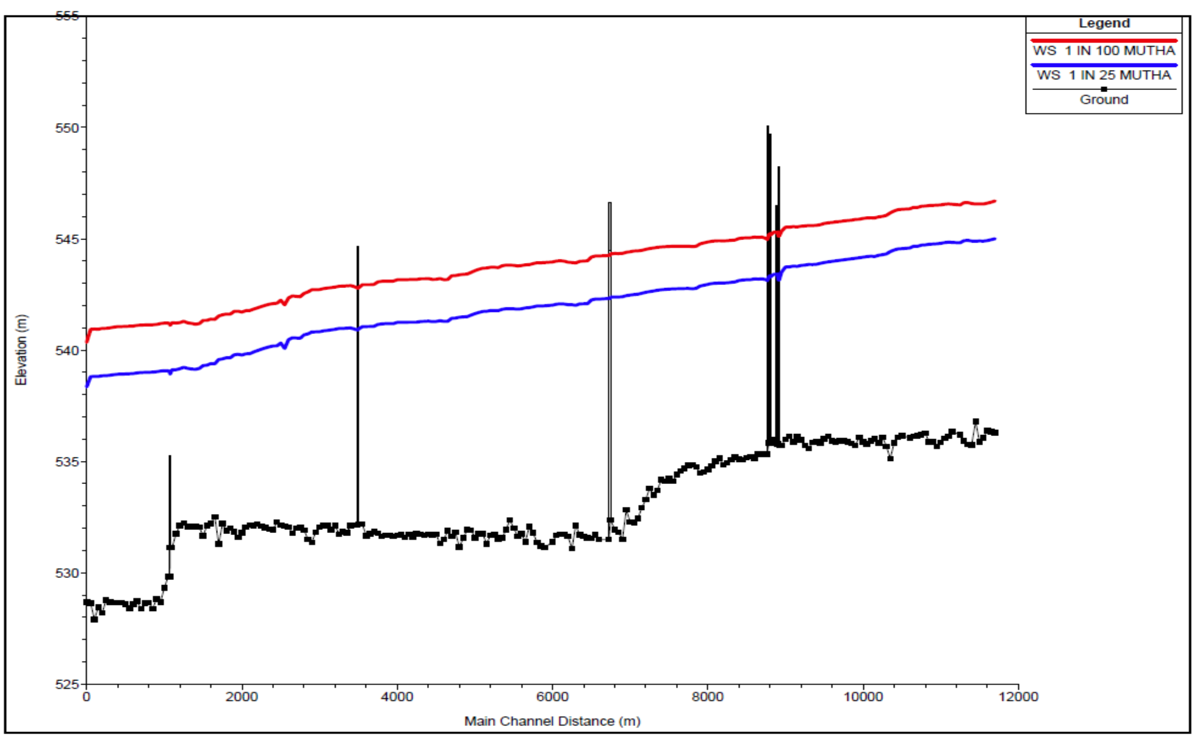


Figure 23 : Longitudinal Section of Water Surface Elevation/HFL for Mula Mutha River in Natural River Condition up to KT Weir

4.4.1 HFL AT BRIDGE LOCATIONS

The HFL at each Bridge location within the project reach for Mula river up to confluence of Pawana river and up to Sangam point, Mutha river and Mula Mutha river in natural condition is tabulated in Table 9 to 12 respectively.

S. No.	Ch.	Bridge Name	Top of Bridge	Bottom of Bridge/ Soffit of Bridge	Natural HFL in Meter for Discharge of 1 in 25 year return period	Natural HFL in Meter for Discharge of 1 In 100 year return period
1	10355	Mumbai Pune Bypass Bridge	561.01	558.71	556.31	556.56
2	9972	Wakad Bridge	554.52	554.1	556.08	556.36
3	8389	Bridge	559	557.81	555.79	556.10
4	8131	K Shakuntlal Baban Shadhe	551.57	551.34	555.70	556.01
5	5175	Shivaji Maharaj Bridge	556.78	555.06	554.81	555.19
6	2884	Old Aundh Bridge	557.51	555.05	554.00	554.40
7	2495	Aundh Bridge	555.49	553.37	553.64	553.97
8	1838	Sangvi Bridge	555.16	552.54	553.19	553.48

Table 9 Detail of HFL at various bridges on Mula River up to Confluence of Pawana River for Natural Waterway

From table 9 it is observed that flood discharge of 100 and 25 year period rises over the soffits of Shivaji Maharaj Bridge and Aundh Bridge respectively and overtops the deck slab of Wakad Bridge and K Shakuntlal Baban Shadhe Bridge .

S. No.	Ch.	Bridge Name	Top of Bridge	Bottom of Bridge/ Soffit of Bridge	Natural HFL in Meter for Discharge of 1 in 25 year return period	Natural HFL in Meter for Discharge of 1 In 100 year return period
1	11945	Dapodi Bridge	552.9	550.95	554.40	556.07
2	11670	Dapodi Railway Bridge	557.32	554.22	554.31	555.64
3	11610	Old Harris Bridge	557.04	555.35	554.19	555.58
4	11575	New Harris Bridge	554.68	556.78	554.26	555.60
5	5903	Shanti Bridge	549.01	547.42	548.30	550.20
6	3479	Old Holkar Bridge	547.55	545.26	546.06	546.91
7	3379	Holkar Bridge Low	551.31	549.21	546.40	547.84
8	3337	Holkar Bridge	553.88	551.49	546.22	547.39
9	569	Sangam Bridge	550.66	548.93	544.13	545.20
10	7045	Check Dam 1	546.15		550.46	551.87
11	6659	Check Dam 2	545.93		549.56	551.07

Table 10: Detail of HFL at various bridges on Mula River from Confluence of Pawana River up to Sangam for Natural Waterway

From table 10 it is observed that flood discharge of 25 year return period rises over the soffits of Dapodi Railway Bridge, Shanti Bridge, Old Holkar Bridge and overtops the deck slab of Dapodi Bridge. The Flood discharge of 100 year return period rises over the soffits of Old Harris Bridge and New Harris Bridge and overtops the deck slab of Shanti Bridge.

S. No.	Ch.	Bridge Name	Top of Bridge	Bottom of Bridge/ Soffit of Bridge	Natural HFL in Meter for Discharge of 1 in 25 year return period	Natural HFL in Meter for Discharge of 1 In 100 year return period
1	8930	Barrage	549.75	548.25	545.12	543.16
2	8905	Yerwada New	549.99	546.49	543.40	545.29
3	8830	Yerwada Old	549.68	547.68	543.30	545.19
4	8807	Yerwada Old	550.06	548.06	543.28	545.16
5	6755	H H Aga Khan Bridge	546.61	544.47	542.33	544.28
6	3512	Mundhwa	544.64	543.1	540.94	542.78
7	1093	KT Weir	535.22	534.86	539.01	541.17

Table 11: Detail of HFL at various bridges on Mula Mutha River From Sangam to KT Weir for Natural Waterway

From table 11 it is observed that flood discharges overtops the deck slab of KT WEIR only and flood discharge passes safely through bridges.

S. No.	Ch.	Bridge Name	Top of Bridge	Bottom of Bridge/ Soffit of Bridge	Natural HFL in Meter for Discharge of 1 in 25 year return period	Natural HFL in Meter for Discharge of 1 In 100 year return period
1	6237	Rajaram Bridge	557.87	555.87	551.25	553.56
2	4189	Mhatre Bridge	554.48	552.8	549.91	552.28
3	3440	Joshi Bridge	550.96	549.51	549.59	551.86

4	3190	Chavan Bridge	551.8	550.27	549.54	551.73
5	2938	Sambhaji Bridge	552.39	549.85	549.28	551.14
6	2793	Kakasaheb Z Bridge	551.9	550.24	549.25	551.11
7	2685	Baba Bhide Bridge	544.74	543.93	549.16	551.04
8	1867	Shinde Bridge	553.29	550.92	548.73	550.45
9	1757	Causeway	541.83	541.5	548.27	550.14
10	1449	Tilak Bridge	546.86	545.98	547.91	549.74
11	1284	Shivaji Bridge	554.33	551.46	546.38	547.65
12	886	Dengale Bridge	550.92	549.55	544.26	546.04
13	340	Sangam Arch Bridge	550.82	549	543.29	545.20
14	291	Railway Bridge	554.8	552.8	543.28	545.18
15	159	Sangam Bridge	550.69	548.95	542.62	544.45
16	141	Wellesley Bridge	550.61	548.97	542.18	543.78

Table 12: Detail of HFL at various bridges on Mutha River From Upstream of Rajaram Bridge to Sangam for Natural Waterway

From table 12 it is observed that flood discharges of 25 year return period rises considerably over the soffits of Joshi Bridge, Tilak Bridge and over tops the deck slab of Baba Bhide Bridge, Causeway between Shinde Bridge and Tilak Bridge. While flood discharge of 100 year return period rises considerably over the soffits of Chavan Bridge, Sambhaji Bridge and Kakasaheb Z bridge and over tops the deck slab of Joshi Bridge.

4.4.2 VARIOUS OTHER OUTPUT OF HEC RAS

The output of HEC RAS such as Velocity, Water Depth, Flow area, Bed Level and Water Surface elevation corresponding to various flood discharge within projected reach is appended vide Annexure 10 to 17.

4.4.2.1 VELOCITY OF WATER

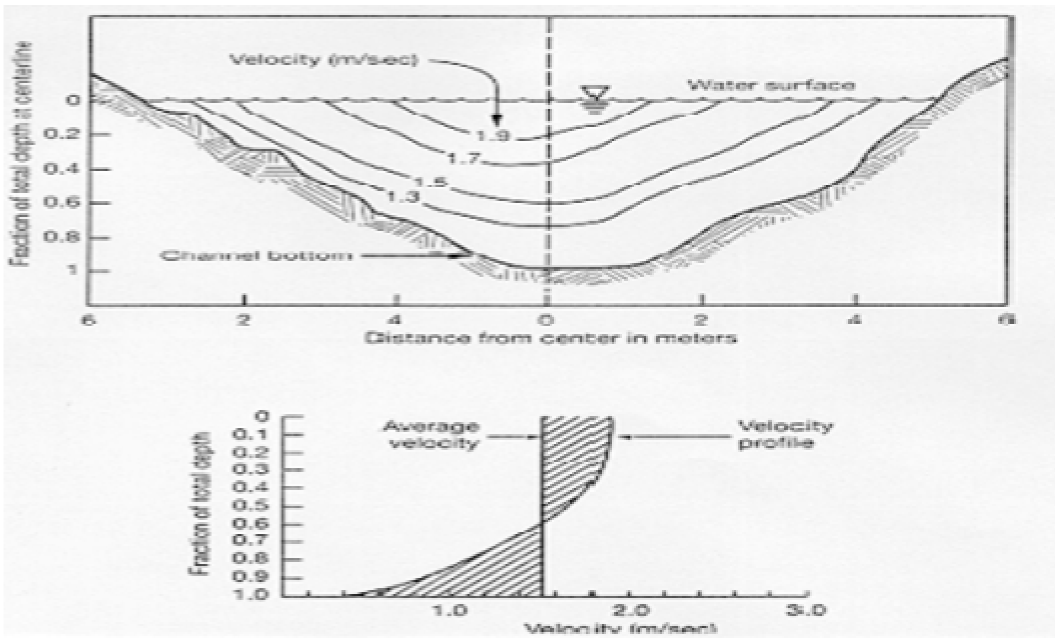


Figure 24(a) & 27(b) : Velocity In Stream

Figure 23a is an example of how the velocity of a stream can vary in the cross stream direction and with depth. Stream velocity is typically faster at the surface and toward the middle of the channel, and slower along the sides and bottom of the channel due to differences in friction. The velocity profile in Figure 23b shows how the average velocity is usually at 0.6 times the total depth from the water surface, or 0.4 times the total depth from the bottom of the channel. This is why, in shallow channels(< 0.75 m), current meter measurements are made at four tenths of the total depth (from the bottom). In larger streams two velocity measurements are made at each vertical and averaged; one at two tenths of the total depth and one at eight tenths of the total depth. From these diagrams you can see why the float method could give velocities that are higher than the average stream velocity. You can also see how the volume-area method, which involves more detailed measurements of the velocity distribution, could give a more accurate representation of the discharge

ANNEXURE X

OUTPUTOF MUTHA RIVER FROM HEC RAS FOR FLOOD DISCHARGE OF 25 YEAR RETURN PERIOD

Sr No	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Vel Chnl (m/s)	Water Depth (m)	Flow Area (m2)
1	10389.1	1700	545.78	554.64	1.58	8.86	1079.15
2	10344.02	1700	545.67	554.64	1.53	8.97	1113.29
3	10294.04	1700	545.56	554.61	1.64	9.05	1038.88
4	10244.15	1700	545.6	554.59	1.69	8.99	1003
5	10194.1	1700	546.41	554.52	1.97	8.11	862.57
6	10144.11	1700	546.33	554.47	2.11	8.14	805.37
7	10094.11	1700	546.33	554.42	2.23	8.09	762.43
8	10044.13	1700	546.43	554.36	2.36	7.93	721.2
9	9994.18	1700	546.57	554.34	2.3	7.77	740.56
10	9944.18	1700	546.3	554.34	2.15	8.04	791.62
11	9894.14	1700	546.24	554.35	1.98	8.11	860.37
12	9844.58	1700	546.1	554.3	2.11	8.2	803.81
13	9794.45	1700	546	554.27	2.1	8.27	810.28
14	9744.45	1700	546.02	554.24	2.11	8.22	806.98
15	9694.45	1700	546.41	554.23	1.99	7.82	853.47
16	9644.4	1700	546.49	554.2	2.03	7.71	835.52
17	9594.6	1700	546.58	554.18	2.02	7.6	839.87
18	9544.84	1700	546.87	554.14	2.09	7.27	812.62
19	9494.84	1700	547.07	554.12	2.1	7.05	809.09
20	9444.84	1700	547.04	554.09	2.13	7.05	798.46
21	9394.88	1700	546.87	554.03	2.28	7.16	744.54
22	9344.86	1700	547.17	554.09	1.74	6.92	977.98
23	9295.03	1700	547.58	554.09	1.63	6.51	1044.86
24	9245.03	1700	547.49	553.91	2.35	6.42	722.97
25	9194.98	1700	547.17	553.9	2.2	6.73	771.88
26	9145.14	1700	547.07	553.78	2.53	6.71	672.52
27	9095.25	1700	546.97	553.81	2.19	6.84	775.9
28	9045.35	1700	546.89	553.7	2.51	6.81	676.65
29	8995.41	1700	547.03	552.84	4.53	5.81	375.1
30	8945.4	1700	546.14	552.74	4.34	6.6	391.9
31	8895.42	1700	545.65	553.12	2.52	7.47	674.39
32	8845.42	1700	545.44	553.09	2.51	7.65	676.68
33	8795.42	1700	545.47	553.1	2.28	7.63	747.18
34	8745.42	1700	545.56	553.05	2.35	7.49	724.06
35	8695.42	1700	545.4	553.03	2.34	7.63	727.44
36	8645.42	1700	545.51	552.99	2.38	7.48	715.5
37	8595.42	1700	545.26	553.01	2.07	7.75	820.44
38	8545.37	1700	545.17	553	2.02	7.83	842.8
39	8495.66	1700	545.2	552.96	2.07	7.76	821.64
40	8445.78	1700	545.25	552.92	2.14	7.67	793.99
41	8396.01	1700	545.04	552.91	2.08	7.87	815.62
42	8346	1700	545.09	552.89	2.02	7.8	840.72
43	8296.02	1700	545.2	552.8	2.3	7.6	738.54
44	8246.02	1700	545.24	552.79	2.21	7.55	769.12
45	8196.02	1700	544.76	552.77	2.12	8.01	801.74

46	8146.02	1700	544.49	552.66	2.43	8.17	698.89
47	8096.02	1700	544.56	552.65	2.3	8.09	740.19
48	8046.02	1700	544.26	552.59	2.39	8.33	710.31
49	7996.02	1700	544.28	552.56	2.37	8.28	718.1
50	7946.02	1700	544.52	552.52	2.41	8	703.98
51	7896.15	1700	544.41	552.52	2.23	8.11	761.14
52	7846.13	1700	544.36	552.5	2.14	8.14	794.08
53	7796.11	1700	544.36	552.45	2.24	8.09	757.31
54	7746.09	1700	544.25	552.44	2.11	8.19	805.15
55	7696.47	1700	544.21	552.41	2.16	8.2	786.78
56	7646.58	1700	544.19	552.38	2.17	8.19	784.77
57	7596.57	1700	544.01	552.4	1.87	8.39	909.63
58	7546.56	1700	543.8	552.36	1.95	8.56	871.6
59	7496.56	1700	543.98	552.25	2.32	8.27	731.3
60	7446.69	1700	544.27	552.23	2.28	7.96	744.04
61	7396.74	1700	544.43	552.19	2.35	7.76	724.78
62	7346.74	1700	544.26	552.2	2.12	7.94	802.57
63	7296.75	1700	544.46	552.13	2.3	7.67	739.39
64	7246.73	1700	544.5	552.14	2.05	7.64	828.3
65	7196.81	1700	545.19	551.98	2.56	6.79	664.03
66	7146.81	1700	544.75	551.95	2.49	7.2	683.65
67	7096.84	1700	544.96	552.01	2	7.05	851.69
68	7046.84	1700	544.51	551.95	2.16	7.44	786.03
69	6996.83	1700	544.43	551.94	2.05	7.51	829.21
70	6946.84	1700	544.07	551.86	2.28	7.79	745.83
71	6896.98	1700	544.01	551.71	2.71	7.7	628
72	6847.1	1700	543.76	551.6	2.9	7.84	585.96
73	6797.1	1700	543.32	551.55	2.84	8.23	597.6
74	6747.19	1700	542.61	551.55	2.64	8.94	644.21
75	6697.22	1700	543.1	551.53	2.53	8.43	671.66
76	6647.24	1700	542.86	551.52	2.38	8.66	715.34
77	6597.24	1700	542.41	551.45	2.5	9.04	679.15
78	6547.23	1700	542.78	551.37	2.66	8.59	639.81
79	6497.2	1700	542.63	551.33	2.66	8.7	638.76
80	6447.16	1700	542.7	551.25	2.79	8.55	609.18
81	6397.36	1700	542.32	551.32	2.2	9	771.17
82	6347.36	1700	542.56	551.29	2.23	8.73	760.81
83	6297.64	1700	542.24	551.34	1.75	9.1	972.78
84	6237	RAJARAM BRIDGE					
85	6197.7	1700	542.24	551.15	2.29	8.91	741.99
86	6147.69	1700	542.15	551.11	2.33	8.96	728.18
87	6097.69	1700	542.31	551.07	2.36	8.76	720.65
88	6047.69	1700	542.63	551.07	2.22	8.44	764.16
89	5997.69	1700	542.5	551.07	2.05	8.57	828.62
90	5947.68	1700	542.51	551.05	2.04	8.54	834.45
91	5897.68	1700	542.3	551.03	2.08	8.73	818.78
92	5847.69	1700	542.42	550.97	2.23	8.55	761.86
93	5797.69	1700	542.61	550.95	2.17	8.34	783.37
94	5747.69	1700	542.3	550.94	2.09	8.64	815.06
95	5697.74	1700	542.05	550.9	2.16	8.85	787.9
96	5647.74	1700	542.08	550.86	2.22	8.78	765.63
97	5597.74	1700	542.21	550.8	2.36	8.59	719.84

98	5547.74	1700	542.32	550.77	2.35	8.45	722.24
99	5497.74	1700	542.32	550.76	2.23	8.44	761.72
100	5447.74	1700	542.3	550.68	2.46	8.38	690.89
101	5397.74	1700	542.49	550.67	2.33	8.18	728.66
102	5347.87	1700	542.29	550.59	2.52	8.3	674.01
103	5297.86	1700	542.3	550.56	2.52	8.26	674.32
104	5247.86	1700	542.34	550.49	2.64	8.15	644.88
105	5197.87	1700	542.5	550.48	2.52	7.98	674.41
106	5147.88	1700	542.31	550.49	2.28	8.18	744.22
107	5097.88	1700	542.27	550.48	2.23	8.21	763.66
108	5047.86	1700	542.13	550.38	2.49	8.25	682.92
109	4997.99	1700	541.9	550.33	2.56	8.43	665.02
110	4948.14	1700	541.62	550.31	2.51	8.69	678.17
111	4898.11	1700	541.95	550.33	2.23	8.38	763.84
112	4848.14	1700	542.27	550.31	2.25	8.04	756.52
113	4798.14	1700	542.06	550.32	2.05	8.26	829.29
114	4748.19	1700	542.22	550.26	2.2	8.04	773.56
115	4698.21	1700	541.94	550.26	2.08	8.32	817.16
116	4648.2	1700	542.13	550.24	2.06	8.11	824.39
117	4598.22	1700	542.04	550.22	2.02	8.18	840.14
118	4548.24	1700	542.17	550.21	2.01	8.04	846.38
119	4498.28	1700	542.08	550.19	1.97	8.11	863.52
120	4448.25	1700	542.14	550.17	2.01	8.03	844.43
121	4398.38	1700	541.98	550.13	2.06	8.15	824.76
122	4348.35	1700	541.87	550.08	2.17	8.21	781.63
123	4298.35	1700	541.81	550.04	2.26	8.23	751.19
124	4248.35	1700	541.69	550.05	2.05	8.36	830.12
125	4189	MHATRE BRIDGE					
126	4148.39	1700	541.54	549.97	1.59	8.43	1066.6
127	4098.39	1700	541.43	549.95	1.62	8.52	1052.59
128	4048.52	1700	541.17	549.92	1.74	8.75	977.55
129	3998.6	1700	541.09	549.9	1.73	8.81	984.55
130	3949.13	1700	541.42	549.87	1.84	8.45	925.07
131	3898.11	1700	541.34	549.82	1.97	8.48	861.11
132	3848.85	1700	541.31	549.81	1.91	8.5	889.27
133	3798.75	1700	541.23	549.78	1.96	8.55	868.37
134	3748.75	1700	540.87	549.75	2	8.88	852.1
135	3698.75	1700	541.09	549.77	1.77	8.68	962.95
136	3648.75	1700	541.33	549.71	1.96	8.38	868.14
137	3598.75	1700	541.09	549.71	1.8	8.62	942.22
138	3548.74	1700	540.91	549.71	1.74	8.8	976.06
139	3498.74	1700	540.85	549.67	1.85	8.82	918.74
140	3440	JOSHI BRIDGE					
141	3398.84	1700	540.77	549.61	1.57	8.84	1086.07
142	3348.85	1700	540.88	549.59	1.59	8.71	1066.16
143	3298.84	1700	540.89	549.58	1.6	8.69	1060.03
144	3248.86	1700	540.61	549.54	1.72	8.93	986.55
145	3198.93	1700	540.19	549.57	1.4	9.38	1214.83
146	3190	CHAVAN BRIDGE					
147	3148.92	1700	540.33	549.51	1.55	9.18	1095.35
148	3098.92	1700	540.08	549.5	1.58	9.42	1077.29
149	3048.92	1700	540.02	549.48	1.64	9.46	1038.66

150	2998.9	1700	539.92	549.46	1.68	9.54	1013.37
151	2938	SAMBHAJI BRIDGE					
152	2899.01	1700	539.73	549.34	1.76	9.61	965.22
153	2849.09	1700	539.43	549.32	1.76	9.89	966.95
154	2793	KAKASAHEB Z BRIDGE					
155	2749.1	1700	539.48	549.24	1.84	9.76	921.65
156	2699.1	1700	539.35	549.21	1.91	9.86	892.36
157	2685	BABA BHIDE BRIDGE					
158	2649.09	1700	539.32	549.16	1.84	9.84	924.82
159	2599.17	1700	539.26	549.16	1.79	9.9	947.78
160	2549.16	1700	538.95	549.13	1.85	10.18	920.44
161	2499.15	1700	539.52	549.1	1.93	9.58	882.8
162	2449.14	1700	539.42	549.07	1.98	9.65	859.99
163	2399.25	1700	538.89	549.07	1.86	10.18	912.08
164	2349.27	1700	539.15	549.06	1.82	9.91	933.12
165	2299.3	1700	539.48	549.03	1.89	9.55	899.41
166	2249.3	1700	539.49	549.01	1.9	9.52	896.27
167	2199.3	1700	539.16	548.99	1.94	9.83	876.58
168	2149.3	1700	539.21	548.98	1.9	9.77	896.28
169	2099.29	1700	538.91	548.87	2.27	9.96	749.93
170	2049.28	1700	538.85	548.92	1.79	10.07	948.51
171	1999.41	1700	538.72	548.88	1.9	10.16	895.33
172	1949.36	1700	539.06	548.84	2.02	9.78	841.46
173	1899.5	1700	539.43	548.79	2.16	9.36	785.51
174	1867	SHINDE BRIDGE					
175	1849.6	1700	539.8	547.86	4.05	8.06	419.85
176	1799.6	1700	539.15	548.3	1.81	9.15	938.52
177	1757	CAUSEWAY					
178	1749.64	1700	539.2	548.25	1.92	9.05	883.75
179	1699.65	1700	539.1	548.23	1.91	9.13	888.72
180	1649.67	1700	539.13	548.23	1.81	9.1	938.52
181	1599.67	1700	539.11	548.21	1.86	9.1	915.59
182	1549.67	1700	539.1	548.2	1.79	9.1	948.59
183	1499.66	1700	538.97	548.15	1.94	9.18	874.17
184	1449	TILAK BRIDGE					
185	1399.67	1700	538.97	547.96	1.84	8.99	923.92
186	1349.68	1700	539.17	547.94	1.84	8.77	924.05
187	1299.68	1700	540.17	547.58	3.06	7.41	555.63
188	1284	SHIVAJI BRIDGE					
189	1249.68	1700	539.92	545.11	4.05	5.19	419.84
190	1199.68	1700	539.29	545.27	2.97	5.98	572.49
191	1149.68	1700	539.31	545.21	2.91	5.9	584.63
192	1099.68	1700	539.14	544.99	3.32	5.85	511.9
193	1049.68	1700	539.04	544.97	3.03	5.93	560.18
194	999.68	1700	538.92	544.96	2.8	6.04	606.49
195	949.68	1700	538.82	544.78	3.11	5.96	546
196	886	DENGALE BRIDGE					
197	849.69	1700	538.41	544.31	3.09	5.9	550.51
198	799.69	1700	538.65	544.32	2.67	5.67	636.69
199	749.69	1700	537.73	544.27	2.64	6.54	643.75
200	699.69	1700	537.65	544.15	2.85	6.5	597.23
201	649.69	1700	537.65	544.09	2.83	6.44	600.68

202	599.69	1700	536.82	544.18	2.06	7.36	823.48
203	549.69	1700	536.43	544.13	2.15	7.7	789.95
204	499.69	1700	537.03	544.13	2.04	7.1	832.32
205	449.67	1700	537.22	544.07	2.17	6.85	781.99
206	399.84	1700	537.38	544	2.31	6.62	737.45
207	349.69	1700	537.38	543.67	3.19	6.29	532.94
208	340			SANGAM ARCH BRIDGE			
209	299.69	1700	536.71	543.37	1.92	6.66	886.47
210	291			RAILWAY BRIDGE			
211	249.69	1700	536.91	543.08	2.58	6.17	658.32
212	199.69	1700	537.47	542.83	3.19	5.36	533.3
213	159			SANGAM BRIDGE			
214	149.77	1700	537.14	542.61	3.35	5.47	507.23
215	141			WELESLY BRIDGE			
216	99.95	1700	535.88	542.26	2.41	6.38	704.02

ANNEXURE XI

OUTPUT OF MUTHA RIVER FROM HEC RAS FOR FLOOD DISCHARGE OF 100 YEAR RETURN PERIOD

Sr No	River Sta	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Difference in Depth	Flow Area
		(m3/s)	(m)	(m)	(m/s)	(m)	(m2)
1	10389.1	2835	545.78	556.75	2.04	10.97	1387.99
2	10344.02	2835	545.67	556.75	1.95	11.08	1453.03
3	10294.04	2835	545.56	556.72	2.05	11.16	1380.85
4	10244.15	2835	545.6	556.69	2.13	11.09	1330.33
5	10194.1	2835	546.41	556.6	2.42	10.19	1173.39
6	10144.11	2835	546.33	556.54	2.57	10.21	1104.73
7	10094.11	2835	546.33	556.46	2.73	10.13	1039.19
8	10044.13	2835	546.43	556.4	2.85	9.97	993.81
9	9994.18	2835	546.57	556.39	2.77	9.82	1022.56
10	9944.18	2835	546.3	556.4	2.59	10.1	1095.17
11	9894.14	2835	546.24	556.41	2.42	10.17	1172.75
12	9844.58	2835	546.1	556.37	2.5	10.27	1134.96
13	9794.45	2835	546	556.36	2.43	10.36	1168.57
14	9744.45	2835	546.02	556.34	2.39	10.32	1184.92
15	9694.45	2835	546.41	556.34	2.27	9.93	1249.81
16	9644.4	2835	546.49	556.31	2.32	9.82	1224.56
17	9594.6	2835	546.58	556.27	2.37	9.69	1194.05
18	9544.84	2835	546.87	556.21	2.53	9.34	1119.5
19	9494.84	2835	547.07	556.19	2.51	9.12	1130.67
20	9444.84	2835	547.04	556.16	2.54	9.12	1116.12
21	9394.88	2835	546.87	556.08	2.7	9.21	1048.93
22	9344.86	2835	547.17	556.16	2.12	8.99	1334.61
23	9295.03	2835	547.58	556.18	1.94	8.6	1458.32
24	9245.03	2835	547.49	555.95	2.73	8.46	1038.22
25	9194.98	2835	547.17	555.96	2.57	8.79	1103.31
26	9145.14	2835	547.07	555.78	3.05	8.71	928.52
27	9095.25	2835	546.97	555.84	2.63	8.87	1079.54
28	9045.35	2835	546.89	555.68	3.04	8.79	932.87
29	8995.41	2835	547.03	554.98	4.54	7.95	623.86
30	8945.4	2835	546.14	554.78	4.71	8.64	601.31
31	8895.42	2835	545.65	555.2	3	9.55	946.39
32	8845.42	2835	545.44	555.18	2.94	9.74	964.75
33	8795.42	2835	545.47	555.19	2.72	9.72	1041.38
34	8745.42	2835	545.56	555.15	2.77	9.59	1024.13
35	8695.42	2835	545.4	555.13	2.75	9.73	1030.76
36	8645.42	2835	545.51	555.11	2.73	9.6	1040.11
37	8595.42	2835	545.26	555.13	2.47	9.87	1146.66
38	8545.37	2835	545.17	555.13	2.37	9.96	1194.74
39	8495.66	2835	545.2	555.09	2.43	9.89	1167.31
40	8445.78	2835	545.25	555.07	2.42	9.82	1172.13
41	8396.01	2835	545.04	555.06	2.39	10.02	1187.54
42	8346	2835	545.09	555.04	2.34	9.95	1212.3
43	8296.02	2835	545.2	554.95	2.61	9.75	1087.22
44	8246.02	2835	545.24	554.94	2.49	9.7	1140.03
45	8196.02	2835	544.76	554.93	2.41	10.17	1177.48

46	8146.02	2835	544.49	554.83	2.66	10.34	1063.94
47	8096.02	2835	544.56	554.82	2.58	10.26	1098.2
48	8046.02	2835	544.26	554.75	2.72	10.49	1043.2
49	7996.02	2835	544.28	554.72	2.73	10.44	1037.58
50	7946.02	2835	544.52	554.7	2.72	10.18	1042.03
51	7896.15	2835	544.41	554.7	2.56	10.29	1106.06
52	7846.13	2835	544.36	554.69	2.48	10.33	1144.49
53	7796.11	2835	544.36	554.65	2.54	10.29	1117.78
54	7746.09	2835	544.25	554.65	2.42	10.4	1169.11
55	7696.47	2835	544.21	554.62	2.45	10.41	1156.97
56	7646.58	2835	544.19	554.59	2.46	10.4	1150.64
57	7596.57	2835	544.01	554.61	2.24	10.6	1267.11
58	7546.56	2835	543.8	554.57	2.33	10.77	1214.53
59	7496.56	2835	543.98	554.45	2.7	10.47	1049.01
60	7446.69	2835	544.27	554.43	2.67	10.16	1063.09
61	7396.74	2835	544.43	554.39	2.69	9.96	1053.39
62	7346.74	2835	544.26	554.4	2.51	10.14	1131.39
63	7296.75	2835	544.46	554.34	2.65	9.88	1069.04
64	7246.73	2835	544.5	554.36	2.45	9.86	1158.15
65	7196.81	2835	545.19	554.21	2.86	9.02	990.37
66	7146.81	2835	544.75	554.19	2.8	9.44	1013.14
67	7096.84	2835	544.96	554.24	2.39	9.28	1183.89
68	7046.84	2835	544.51	554.18	2.53	9.67	1118.67
69	6996.83	2835	544.43	554.17	2.47	9.74	1148.13
70	6946.84	2835	544.07	554.08	2.69	10.01	1053.17
71	6896.98	2835	544.01	553.95	3.03	9.94	936.1
72	6847.1	2835	543.76	553.86	3.16	10.1	897.68
73	6797.1	2835	543.32	553.84	3.11	10.52	912.8
74	6747.19	2835	542.61	553.84	2.91	11.23	974.2
75	6697.22	2835	543.1	553.83	2.81	10.73	1007.31
76	6647.24	2835	542.86	553.83	2.69	10.97	1053.34
77	6597.24	2835	542.41	553.77	2.8	11.36	1011.55
78	6547.23	2835	542.78	553.67	3.02	10.89	939.72
79	6497.2	2835	542.63	553.64	3.01	11.01	940.89
80	6447.16	2835	542.7	553.58	3.09	10.88	917.37
81	6397.36	2835	542.32	553.66	2.55	11.34	1112.07
82	6347.36	2835	542.56	553.63	2.56	11.07	1105.29
83	6297.64	2835	542.24	553.69	2.14	11.45	1322.24
84	6237	RAJARAM BRIDGE					
85	6197.7	2835	542.24	553.47	2.62	11.23	1081.15
86	6147.69	2835	542.15	553.44	2.66	11.29	1067.78
87	6097.69	2835	542.31	553.41	2.67	11.1	1063.74
88	6047.69	2835	542.63	553.41	2.55	10.78	1112.96
89	5997.69	2835	542.5	553.42	2.41	10.92	1177.12
90	5947.68	2835	542.51	553.4	2.4	10.89	1182.91
91	5897.68	2835	542.3	553.37	2.43	11.07	1167.93
92	5847.69	2835	542.42	553.32	2.55	10.9	1111.8
93	5797.69	2835	542.61	553.31	2.5	10.7	1133.16
94	5747.69	2835	542.3	553.3	2.43	11	1164.39
95	5697.74	2835	542.05	553.26	2.49	11.21	1136.9
96	5647.74	2835	542.08	553.23	2.54	11.15	1114.62
97	5597.74	2835	542.21	553.17	2.65	10.96	1069.39

98	5547.74	2835	542.32	553.15	2.65	10.83	1070.59
99	5497.74	2835	542.32	553.14	2.57	10.82	1104.61
100	5447.74	2835	542.3	553.05	2.76	10.75	1026.13
101	5397.74	2835	542.49	553.05	2.66	10.56	1067.67
102	5347.87	2835	542.29	552.97	2.82	10.68	1003.92
103	5297.86	2835	542.3	552.94	2.8	10.64	1012.59
104	5247.86	2835	542.34	552.88	2.91	10.54	974.36
105	5197.87	2835	542.5	552.86	2.82	10.36	1005.58
106	5147.88	2835	542.31	552.88	2.62	10.57	1083.85
107	5097.88	2835	542.27	552.87	2.54	10.6	1113.97
108	5047.86	2835	542.13	552.76	2.82	10.63	1006
109	4997.99	2835	541.9	552.69	2.92	10.79	970.01
110	4948.14	2835	541.62	552.66	2.92	11.04	971.71
111	4898.11	2835	541.95	552.68	2.68	10.73	1059.69
112	4848.14	2835	542.27	552.66	2.66	10.39	1064
113	4798.14	2835	542.06	552.68	2.44	10.62	1162.88
114	4748.19	2835	542.22	552.64	2.52	10.42	1124.22
115	4698.21	2835	541.94	552.64	2.42	10.7	1171.99
116	4648.2	2835	542.13	552.62	2.4	10.49	1179.6
117	4598.22	2835	542.04	552.61	2.37	10.57	1195.69
118	4548.24	2835	542.17	552.6	2.36	10.43	1202.23
119	4498.28	2835	542.08	552.59	2.32	10.51	1219.63
120	4448.25	2835	542.14	552.56	2.36	10.42	1200.86
121	4398.38	2835	541.98	552.53	2.4	10.55	1181.64
122	4348.35	2835	541.87	552.49	2.49	10.62	1139.42
123	4298.35	2835	541.81	552.45	2.55	10.64	1110.24
124	4248.35	2835	541.69	552.46	2.35	10.77	1208.52
125	4189			MHATRE BRIDGE			
126	4148.39	2835	541.54	552.38	1.87	10.84	1519.37
127	4098.39	2835	541.43	552.35	1.93	10.92	1471.92
128	4048.52	2835	541.17	552.32	2.01	11.15	1407.89
129	3998.6	2835	541.09	552.32	1.98	11.23	1434.13
130	3949.13	2835	541.42	552.27	2.1	10.85	1348.61
131	3898.11	2835	541.34	552.21	2.29	10.87	1237.82
132	3848.85	2835	541.31	552.21	2.23	10.9	1269.45
133	3798.75	2835	541.23	552.18	2.27	10.95	1246.19
134	3748.75	2835	540.87	552.15	2.31	11.28	1226.97
135	3698.75	2835	541.09	552.17	2.12	11.08	1338.07
136	3648.75	2835	541.33	552.14	2.16	10.81	1310.62
137	3598.75	2835	541.09	552.15	2.04	11.06	1391.88
138	3548.74	2835	540.91	552.14	1.98	11.23	1434.45
139	3498.74	2835	540.85	552.11	2.06	11.26	1377.5
140	3440			JOSHI BRIDGE			
141	3398.84	2835	540.77	551.94	1.85	11.17	1535.23
142	3348.85	2835	540.88	551.93	1.87	11.05	1516.98
143	3298.84	2835	540.89	551.91	1.88	11.02	1508.99
144	3248.86	2835	540.61	551.86	2.09	11.25	1358.42
145	3198.93	2835	540.19	551.9	1.71	11.71	1655.23
146	3190			CHAVAN BRIDGE			
147	3148.92	2835	540.33	551.75	1.89	11.42	1496.49
148	3098.92	2835	540.08	551.73	1.94	11.65	1460.4
149	3048.92	2835	540.02	551.7	2.02	11.68	1403.84

150	2998.9	2835	539.92	551.68	2.07	11.76	1370.09
151	2938	SAMBHAJI BRIDGE					
152	2899.01	2835	539.73	551.34	2.23	11.61	1272.88
153	2849.09	2835	539.43	551.33	2.19	11.9	1295.04
154	2793	KAKASAHEB Z BRIDGE					
155	2749.1	2835	539.48	551.14	2.33	11.66	1215.28
156	2699.1	2835	539.35	551.1	2.42	11.75	1173.16
157	2685	BABA BHIDE BRIDGE					
158	2649.09	2835	539.32	551.04	2.35	11.72	1204.82
159	2599.17	2835	539.26	551.03	2.31	11.77	1227.6
160	2549.16	2835	538.95	551	2.36	12.05	1199.35
161	2499.15	2835	539.52	550.96	2.44	11.44	1159.57
162	2449.14	2835	539.42	550.93	2.49	11.51	1137.01
163	2399.25	2835	538.89	550.93	2.38	12.04	1189.25
164	2349.27	2835	539.15	550.92	2.34	11.77	1210.05
165	2299.3	2835	539.48	550.88	2.41	11.4	1175.29
166	2249.3	2835	539.49	550.86	2.42	11.37	1171.66
167	2199.3	2835	539.16	550.83	2.46	11.67	1151.17
168	2149.3	2835	539.21	550.82	2.42	11.61	1170.65
169	2099.29	2835	538.91	550.67	2.84	11.76	997.94
170	2049.28	2835	538.85	550.74	2.32	11.89	1220.23
171	1999.41	2835	538.72	550.7	2.43	11.98	1165.53
172	1949.36	2835	539.06	550.62	2.62	11.56	1084.1
173	1899.5	2835	539.43	550.56	2.73	11.13	1038.14
174	1867	SHINDE BRIDGE					
175	1849.6	2835	539.8	549.8	4.13	10	686.91
176	1799.6	2835	539.15	550.18	2.33	11.03	1217.98
177	1757	CAUSEWAY					
178	1749.64	2835	539.2	550.11	2.44	10.91	1161.43
179	1699.65	2835	539.1	550.09	2.43	10.99	1166.03
180	1649.67	2835	539.13	550.09	2.33	10.96	1215.92
181	1599.67	2835	539.11	550.06	2.38	10.95	1192.1
182	1549.67	2835	539.1	550.06	2.31	10.96	1225.02
183	1499.66	2835	538.97	550	2.47	11.03	1148.8
184	1449	TILAK BRIDGE					
185	1399.67	2835	538.97	549.8	2.37	10.83	1198.53
186	1349.68	2835	539.17	549.78	2.37	10.61	1197.07
187	1299.68	2835	540.17	549.33	3.64	9.16	779.79
188	1284	SHIVAJI BRIDGE					
189	1249.68	2835	539.92	546.86	4.05	6.94	699.46
190	1199.68	2835	539.29	546.95	3.42	7.66	829.47
191	1149.68	2835	539.31	546.9	3.41	7.59	831.98
192	1099.68	2835	539.14	546.69	3.75	7.55	756.55
193	1049.68	2835	539.04	546.7	3.44	7.66	823.08
194	999.68	2835	538.92	546.7	3.21	7.78	882.38
195	949.68	2835	538.82	546.53	3.51	7.71	807.2
196	886	DENGALE BRIDGE					
197	849.69	2835	538.41	546.12	3.46	7.71	819.42
198	799.69	2835	538.65	546.2	2.86	7.55	991.89
199	749.69	2835	537.73	546.14	2.92	8.41	970.62
200	699.69	2835	537.65	546.03	3.12	8.38	907.71
201	649.69	2835	537.65	546	3.04	8.35	933.46

202	599.69	2835	536.82	546.07	2.5	9.25	1135.58
203	549.69	2835	536.43	546.03	2.54	9.6	1114.39
204	499.69	2835	537.03	546.03	2.41	9	1174.82
205	449.67	2835	537.22	546	2.46	8.78	1154.3
206	399.84	2835	537.38	545.94	2.56	8.56	1106.52
207	349.69	2835	537.38	545.65	3.32	8.27	853.65
208	340	SANGAM ARCH BRIDGE					
209	299.69	2835	536.71	545.32	2.32	8.61	1222.49
210	291	RAILWAY BRIDGE					
211	249.69	2835	536.91	544.95	3.04	8.04	931.34
212	199.69	2835	537.47	544.69	3.62	7.22	783.82
213	159	SANGAM BRIDGE					
214	149.77	2835	537.14	544.44	3.8	7.3	746.32
215	141	WELESLY BRIDGE					
216	99.95	2835	535.88	543.94	2.89	8.06	980.62

ANNEXURE XII							
OUTPUT OF MULA MUTHA RIVER FROM HEC RAS FOR FLOOD DISCHARGE OF 25 YEAR RETURN PERIOD							
Sr No	River Sta	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Difference in Depth	Flow Area
		(m3/s)	(m)	(m)	(m/s)		(m2)
1	11719.66	3345	536.29	545	1.9	8.71	1764.83
2	11669.66	3345	536.33	544.96	2.02	8.63	1659.63
3	11619.66	3345	536.39	544.92	2.11	8.53	1584.18
4	11569.67	3345	536.07	544.9	2.14	8.83	1561.58
5	11519.67	3345	535.88	544.9	1.99	9.02	1678.21
6	11469.67	3345	536.8	544.89	2	8.09	1673.18
7	11419.67	3345	535.75	544.9	1.83	9.15	1831.57
8	11369.7	3345	535.76	544.93	1.45	9.17	2302.58
9	11319.7	3345	535.93	544.92	1.49	8.99	2239.06
10	11269.7	3345	536.19	544.82	1.92	8.63	1741.07
11	11169.89	3345	536.34	544.84	1.55	8.5	2157.9
12	11119.88	3345	536.12	544.85	1.33	8.73	2520.09
13	11070.23	3345	536.04	544.83	1.39	8.79	2403.72
14	11020.11	3345	535.86	544.79	1.54	8.93	2175.29
15	10970.12	3345	535.68	544.77	1.56	9.09	2141.5
16	10920.05	3345	535.88	544.76	1.54	8.88	2174.65
17	10870.28	3345	535.88	544.75	1.5	8.87	2235.46
18	10820.25	3345	536.27	544.73	1.57	8.46	2128.76
19	10770.32	3345	536.2	544.71	1.57	8.51	2128.68
20	10720.31	3345	536.16	544.66	1.77	8.5	1895.18
21	10670.3	3345	536.12	544.66	1.62	8.54	2062.25
22	10620.3	3345	536.07	544.58	1.93	8.51	1733.04
23	10520.3	3345	536.15	544.56	1.83	8.41	1832.14
24	10470.3	3345	536.09	544.54	1.79	8.45	1867.77
25	10420.3	3345	535.84	544.5	1.94	8.66	1721.73
26	10370.32	3345	535.13	544.43	2.16	9.3	1545.4
27	10320.31	3345	535.68	544.32	2.48	8.64	1348.75
28	10270.36	3345	536.09	544.29	2.5	8.2	1336.04
29	10220.36	3345	535.84	544.26	2.51	8.42	1333.14
30	10170.36	3345	536.01	544.21	2.6	8.2	1287.41
31	10120.37	3345	535.92	544.21	2.4	8.29	1393.64
32	10070.37	3345	535.79	544.2	2.35	8.41	1423.29
33	10020.37	3345	535.88	544.17	2.37	8.29	1413.52
34	9970.37	3345	536.08	544.14	2.41	8.06	1388.52
35	9920.37	3345	535.73	544.13	2.34	8.4	1428.75
36	9870.37	3345	535.82	544.1	2.38	8.28	1404.97
37	9820.37	3345	535.89	544.08	2.38	8.19	1403.4
38	9770.37	3345	535.92	544.06	2.35	8.14	1423.03
39	9720.37	3345	535.92	544.03	2.39	8.11	1399.42
40	9670.44	3345	535.89	544.01	2.34	8.12	1428.42
41	9620.42	3345	535.92	543.98	2.36	8.06	1415.9
42	9570.42	3345	536.12	543.96	2.37	7.84	1412.99
43	9520.13	3345	536.02	543.93	2.39	7.91	1399.16
44	9470.43	3345	535.82	543.9	2.45	8.08	1367.81
45	9420.43	3345	535.87	543.86	2.5	7.99	1338.03

46	9370.43	3345	535.86	543.84	2.44	7.98	1369.68
47	9320.55	3345	535.59	543.85	2.3	8.26	1455.05
48	9270.5	3345	535.73	543.82	2.33	8.09	1434.03
49	9220.5	3345	535.97	543.8	2.31	7.83	1445.75
50	9170.5	3345	536.14	543.76	2.39	7.62	1401
51	9120.5	3345	535.87	543.77	2.18	7.9	1536.45
52	9070.49	3345	536.12	543.73	2.25	7.61	1485.22
53	9020.5	3345	535.99	543.73	2.12	7.74	1576.28
54	8970.5	3345	535.71	543.5	2.85	7.79	1172.81
55	8930	BARRAGE					
56	8920.5	3345	535.79	543.41	2.27	7.62	1472.8
57	8905	YERWADA NEW BRIDGE					
58	8870.5	3345	535.99	543.41	2.1	7.42	1594.73
59	8830	YERWADA OLD BRIDGE 1					
60	8820.5	3345	535.84	543.33	2.14	7.49	1561.77
61	8807	YERWADA OLD BRIDGE 2					
62	8770.54	3345	535.32	543.16	2.55	7.84	1309.47
63	8720.54	3345	535.32	543.2	2.18	7.88	1532.62
64	8670.6	3345	535.33	543.19	2.14	7.86	1561.13
65	8620.6	3345	535.12	543.2	1.97	8.08	1696.56
66	8570.6	3345	535.22	543.16	2.05	7.94	1635.61
67	8520.6	3345	535.17	543.16	1.98	7.99	1687.04
68	8470.64	3345	535.08	543.15	1.95	8.07	1714.65
69	8420.64	3345	535.11	543.12	2	8.01	1676.22
70	8370.64	3345	535.19	543.06	2.19	7.87	1524.65
71	8320.64	3345	535.07	543.04	2.18	7.97	1535.9
72	8270.64	3345	534.95	543.03	2.16	8.08	1546.77
73	8220.64	3345	534.84	543.01	2.16	8.17	1546.08
74	8170.71	3345	535.14	543.01	2.02	7.87	1653.49
75	8120.71	3345	535.01	543	1.99	7.99	1682.75
76	8070.71	3345	534.81	542.99	1.96	8.18	1705.08
77	8020.71	3345	534.64	542.95	2.07	8.31	1619.62
78	7970.71	3345	534.53	542.91	2.15	8.38	1555.21
79	7920.71	3345	534.47	542.88	2.23	8.41	1502.94
80	7870.71	3345	534.75	542.77	2.53	8.02	1324.69
81	7820.71	3345	534.84	542.75	2.5	7.91	1337.95
82	7770.71	3345	534.83	542.77	2.27	7.94	1473.03
83	7720.71	3345	534.69	542.76	2.2	8.07	1521.2
84	7670.73	3345	534.56	542.76	2.08	8.2	1608.14
85	7620.73	3345	534.42	542.76	2.01	8.34	1667.61
86	7570.72	3345	534.12	542.75	1.99	8.63	1681.32
87	7520.74	3345	534.26	542.73	1.98	8.47	1693.18
88	7470.74	3345	534.12	542.73	1.92	8.61	1740.41
89	7420.74	3345	534.18	542.71	1.92	8.53	1738.34
90	7370.74	3345	533.71	542.69	1.97	8.98	1695.81
91	7320.74	3345	533.5	542.65	2.04	9.15	1636.29
92	7270.76	3345	533.78	542.62	2.1	8.84	1595.8
93	7220.76	3345	533.28	542.6	2.14	9.32	1564.67
94	7170.76	3345	532.91	542.55	2.24	9.64	1491.08
95	7120.76	3345	532.45	542.51	2.32	10.06	1439.27
96	7070.76	3345	532.26	542.49	2.28	10.23	1466.54
97	7020.76	3345	532.29	542.47	2.29	10.18	1460.71

98	6970.83	3345	532.83	542.45	2.28	9.62	1464.34
99	6920.85	3345	531.51	542.39	2.4	10.88	1393.79
100	6870.85	3345	531.81	542.38	2.34	10.57	1429.68
101	6820.85	3345	531.94	542.39	2.18	10.45	1534.77
102	6770.86	3345	532.36	542.37	2.16	10.01	1551.77
103	6755	H H AGA KHAN BRIDGE					
104	6620.86	3345	531.49	542.29	2.17	10.8	1538.74
105	6570.9	3345	531.7	542.29	2.09	10.59	1601.36
106	6520.9	3345	531.54	542.25	2.18	10.71	1532.14
107	6470.9	3345	531.56	542.08	2.72	10.52	1228.96
108	6420.9	3345	531.65	542.08	2.63	10.43	1272.87
109	6370.9	3345	531.71	542.08	2.52	10.37	1326.55
110	6320.9	3345	532.13	542.01	2.68	9.88	1250.29
111	6270.9	3345	531.09	542.04	2.42	10.95	1383.62
112	6220.91	3345	531.63	542.04	2.31	10.41	1446.81
113	6170.91	3345	531.73	542.06	2.05	10.33	1634.66
114	6120.91	3345	531.74	542.08	1.87	10.34	1790.83
115	6071.49	3345	531.68	542.06	1.9	10.38	1758.43
116	6020.74	3345	531.39	542.01	2.04	10.62	1638.03
117	5920.78	3345	531.13	541.99	2.02	10.86	1656.13
118	5871.41	3345	531.2	541.98	2.01	10.78	1662.01
119	5821.15	3345	531.36	541.98	1.9	10.62	1762.32
120	5771.22	3345	531.79	541.94	2.02	10.15	1657.78
121	5721.47	3345	532.07	541.9	2.11	9.83	1585.36
122	5671.31	3345	531.39	541.89	2.09	10.5	1602.27
123	5621.43	3345	531.75	541.85	2.19	10.1	1525.61
124	5571.42	3345	531.64	541.83	2.2	10.19	1523.21
125	5521.43	3345	532.01	541.85	1.96	9.84	1709.88
126	5471.43	3345	532.36	541.86	1.84	9.5	1818.47
127	5421.46	3345	531.93	541.85	1.77	9.92	1893.77
128	5371.46	3345	531.56	541.83	1.84	10.27	1815.58
129	5321.62	3345	531.51	541.77	2.04	10.26	1635.96
130	5271.48	3345	531.71	541.77	1.93	10.06	1729.56
131	5221.48	3345	531.69	541.77	1.85	10.08	1805.43
132	5171.49	3345	531.3	541.74	1.94	10.44	1725.75
133	5121.49	3345	531.76	541.73	1.92	9.97	1745.99
134	5071.48	3345	531.75	541.69	2.06	9.94	1626.82
135	5021.53	3345	531.58	541.64	2.22	10.06	1508.86
136	4971.53	3345	531.92	541.57	2.41	9.65	1388.12
137	4921.53	3345	531.93	541.5	2.58	9.57	1297.63
138	4871.53	3345	531.56	541.49	2.5	9.93	1339.55
139	4821.53	3345	531.15	541.48	2.48	10.33	1351.11
140	4771.53	3345	531.81	541.44	2.54	9.63	1314.71
141	4721.53	3345	531.63	541.43	2.49	9.8	1345.87
142	4671.53	3345	531.9	541.29	2.86	9.39	1171.06
143	4621.49	3345	531.49	541.29	2.75	9.8	1216.08
144	4571.53	3345	531.31	541.32	2.5	10.01	1340.64
145	4521.55	3345	531.74	541.29	2.53	9.55	1320.84
146	4471.55	3345	531.69	541.28	2.46	9.59	1359.82
147	4421.55	3345	531.73	541.3	2.21	9.57	1510.42
148	4371.55	3345	531.69	541.29	2.19	9.6	1525.01
149	4321.55	3345	531.72	541.28	2.15	9.56	1557.18

150	4271.56	3345	531.75	541.25	2.21	9.5	1516.6
151	4221.56	3345	531.6	541.25	2.09	9.65	1598.98
152	4171.56	3345	531.72	541.25	2.02	9.53	1658.31
153	4121.57	3345	531.59	541.24	1.98	9.65	1685.52
154	4071.57	3345	531.7	541.25	1.89	9.55	1767.73
155	4021.57	3345	531.69	541.24	1.84	9.55	1818.94
156	3971.57	3345	531.65	541.19	2.04	9.54	1640.31
157	3921.57	3345	531.69	541.19	1.97	9.5	1695.12
158	3871.57	3345	531.68	541.19	1.9	9.51	1763.37
159	3821.57	3345	531.63	541.18	1.89	9.55	1766.62
160	3771.57	3345	531.78	541.15	1.96	9.37	1704.81
161	3721.57	3345	531.84	541.07	2.25	9.23	1484.66
162	3671.57	3345	531.75	541.06	2.23	9.31	1501.58
163	3621.57	3345	531.67	541.06	2.16	9.39	1549.31
164	3571.57	3345	532.18	541.05	2.09	8.87	1601.37
165	3512	MUNDHWA BRIDGE					
166	3471.57	3345	532.14	540.95	2.13	8.81	1567.06
167	3421.57	3345	532.12	540.99	1.69	8.87	1983.34
168	3371.57	3345	531.8	540.99	1.68	9.19	1987.96
169	3321.57	3345	531.84	540.97	1.73	9.13	1936.36
170	3271.57	3345	531.74	540.97	1.67	9.23	2000.87
171	3221.57	3345	532.12	540.93	1.81	8.81	1846.87
172	3171.57	3345	531.94	540.91	1.87	8.97	1784.41
173	3121.57	3345	532.11	540.88	1.92	8.77	1746.56
174	3071.57	3345	532.12	540.86	1.96	8.74	1705.43
175	3021.57	3345	532.04	540.83	2.05	8.79	1630.57
176	2971.57	3345	531.83	540.82	2.03	8.99	1647.67
177	2921.57	3345	531.37	540.81	1.94	9.44	1720.18
178	2871.57	3345	531.49	540.73	2.25	9.24	1484.15
179	2821.86	3345	531.92	540.69	2.34	8.77	1427.75
180	2771.57	3345	532.02	540.53	2.79	8.51	1198.21
181	2721.58	3345	532	540.54	2.62	8.54	1275.01
182	2671.58	3345	531.78	540.55	2.42	8.77	1381.14
183	2621.58	3345	532.06	540.47	2.64	8.41	1268.56
184	2571.59	3345	532.1	540.07	3.64	7.97	917.92
185	2521.59	3345	532.15	540.32	2.35	8.17	1426.23
186	2471.59	3345	532.27	540.19	2.71	7.92	1234.98
187	2421.59	3345	531.94	540.19	2.58	8.25	1295
188	2371.59	3345	531.96	540.14	2.64	8.18	1267.71
189	2321.59	3345	532.02	540.09	2.73	8.07	1223.8
190	2271.59	3345	532.1	540.04	2.78	7.94	1201.93
191	2221.59	3345	532.19	539.97	2.91	7.78	1150.61
192	2171.59	3345	532.12	539.91	2.98	7.79	1123.85
193	2121.6	3345	532.15	539.84	3.09	7.69	1081.54
194	2071.59	3345	532.04	539.83	2.95	7.79	1135.46
195	2021.59	3345	531.79	539.78	3	7.99	1116.35
196	1971.59	3345	531.59	539.81	2.69	8.22	1243.53
197	1921.59	3345	531.84	539.79	2.66	7.95	1255.58
198	1871.59	3345	532	539.66	2.98	7.66	1123.41
199	1821.59	3345	531.88	539.65	2.82	7.77	1187.7
200	1771.69	3345	532.21	539.6	2.87	7.39	1166.8
201	1721.66	3345	531.29	539.57	2.87	8.28	1166.05

202	1671.66	3345	532.52	539.38	3.3	6.86	1013.32
203	1621.66	3345	532.22	539.4	3.05	7.18	1098.3
204	1571.66	3345	532.13	539.32	3.15	7.19	1062.38
205	1521.66	3345	531.66	539.3	3.04	7.64	1100.83
206	1471.66	3345	532.05	539.17	3.28	7.12	1019.25
207	1421.66	3345	532.07	539.13	3.26	7.06	1027.33
208	1371.66	3345	532.07	539.15	3	7.08	1113.29
209	1321.66	3345	532.07	539.17	2.72	7.1	1231.8
210	1271.66	3345	532.24	539.23	2.29	6.99	1461.12
211	1221.66	3345	532.12	539.16	2.45	7.04	1365.77
212	1171.66	3345	531.75	539.11	2.52	7.36	1328.46
213	1121.68	3345	531.13	539.12	2.35	7.99	1424.13
214	1093	KT WEIR					
215	1071.68	3345	529.84	539.07	1.83	9.23	1830.88
216	1021.68	3345	529.32	539.07	1.73	9.75	1934.87
217	971.68	3345	528.67	539.06	1.76	10.39	1900.13
218	921.68	3345	528.83	539.02	1.87	10.19	1789.38
219	871.68	3345	528.39	539.01	1.89	10.62	1771.5
220	821.68	3345	528.66	539	1.9	10.34	1761.21
221	771.68	3345	528.63	538.99	1.87	10.36	1785.42
222	721.69	3345	528.38	538.99	1.8	10.61	1855.64
223	671.69	3345	528.72	538.97	1.86	10.25	1799.91
224	621.69	3345	528.59	538.94	1.94	10.35	1723.78
225	571.69	3345	528.4	538.93	1.91	10.53	1753.84
226	521.69	3345	528.58	538.93	1.89	10.35	1772.95
227	471.69	3345	528.65	538.92	1.86	10.27	1795.72
228	421.71	3345	528.66	538.91	1.82	10.25	1836.33
229	371.71	3345	528.66	538.89	1.87	10.23	1791.42
230	321.71	3345	528.67	538.87	1.94	10.2	1726.58
231	271.71	3345	528.77	538.85	1.97	10.08	1693.74
232	221.71	3345	528.21	538.84	1.92	10.63	1745.81
233	171.71	3345	528.46	538.81	2.01	10.35	1668.05
234	121.71	3345	527.91	538.82	1.9	10.91	1758.22
235	71.71	3345	528.64	538.8	1.92	10.16	1743.22
236	21.71	3345	528.68	538.35	3.39	9.67	986.43

ANNEXURE XIII

OUTPUT OF MULA MUTHA RIVER FROM HEC RAS FOR FLOOD DISCHARGE OF 100 YEAR RETURN PERIOD

Sr No	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Vel Chnl (m/s)	Difference in Depth	Flow Area (m2)
1	11719.66	4762	536.29	546.7	2.11	10.41	2259.98
2	11669.66	4762	536.33	546.64	2.26	10.31	2105.77
3	11619.66	4762	536.39	546.6	2.37	10.21	2008.58
4	11569.67	4762	536.07	546.56	2.46	10.49	1939.33
5	11519.67	4762	535.88	546.57	2.31	10.69	2064.61
6	11469.67	4762	536.8	546.56	2.27	9.76	2093.3
7	11419.67	4762	535.75	546.58	2.05	10.83	2318.32
8	11369.7	4762	535.76	546.63	1.65	10.87	2894.75
9	11319.7	4762	535.93	546.62	1.62	10.69	2940.12
10	11269.7	4762	536.19	546.52	2.06	10.33	2316.13
11	11169.89	4762	536.34	546.55	1.65	10.21	2887.45
12	11119.88	4762	536.12	546.57	1.42	10.45	3351.34
13	11070.23	4762	536.04	546.55	1.47	10.51	3229.18
14	11020.11	4762	535.86	546.52	1.59	10.66	2995.02
15	10970.12	4762	535.68	546.51	1.61	10.83	2958.16
16	10920.05	4762	535.88	546.5	1.59	10.62	2995.65
17	10870.28	4762	535.88	546.49	1.56	10.61	3058.77
18	10820.25	4762	536.27	546.47	1.62	10.2	2931.06
19	10770.32	4762	536.2	546.46	1.64	10.26	2904.76
20	10720.31	4762	536.16	546.41	1.84	10.25	2585.3
21	10670.3	4762	536.12	546.41	1.71	10.29	2785.31
22	10620.3	4762	536.07	546.34	1.98	10.27	2409.26
23	10520.3	4762	536.15	546.33	1.9	10.18	2511.48
24	10470.3	4762	536.09	546.31	1.92	10.22	2479.33
25	10420.3	4762	535.84	546.25	2.11	10.41	2255.33
26	10370.32	4762	535.13	546.16	2.4	11.03	1985.14
27	10320.31	4762	535.68	546.05	2.71	10.37	1756.83
28	10270.36	4762	536.09	546.01	2.77	9.92	1717.15
29	10220.36	4762	535.84	545.98	2.78	10.14	1711.55
30	10170.36	4762	536.01	545.94	2.85	9.93	1672.58
31	10120.37	4762	535.92	545.94	2.69	10.02	1769.93
32	10070.37	4762	535.79	545.94	2.62	10.15	1817.01
33	10020.37	4762	535.88	545.91	2.63	10.03	1807.45
34	9970.37	4762	536.08	545.87	2.69	9.79	1770.75
35	9920.37	4762	535.73	545.87	2.62	10.14	1815.53
36	9870.37	4762	535.82	545.84	2.66	10.02	1790.52
37	9820.37	4762	535.89	545.82	2.65	9.93	1796.88
38	9770.37	4762	535.92	545.8	2.62	9.88	1816.61
39	9720.37	4762	535.92	545.77	2.65	9.85	1794.44
40	9670.44	4762	535.89	545.76	2.61	9.87	1824.63
41	9620.42	4762	535.92	545.73	2.63	9.81	1810.34
42	9570.42	4762	536.12	545.72	2.62	9.6	1819.56
43	9520.13	4762	536.02	545.69	2.65	9.67	1796.4
44	9470.43	4762	535.82	545.64	2.75	9.82	1733.22
45	9420.43	4762	535.87	545.61	2.77	9.74	1716.85

46	9370.43	4762	535.86	545.59	2.73	9.73	1742.05
47	9320.55	4762	535.59	545.6	2.59	10.01	1839.94
48	9270.5	4762	535.73	545.58	2.6	9.85	1833.74
49	9220.5	4762	535.97	545.56	2.57	9.59	1852.32
50	9170.5	4762	536.14	545.53	2.61	9.39	1823.22
51	9120.5	4762	535.87	545.55	2.41	9.68	1972.84
52	9070.49	4762	536.12	545.52	2.45	9.4	1945.5
53	9020.5	4762	535.99	545.52	2.32	9.53	2050.77
54	8970.5	4762	535.71	545.34	2.87	9.63	1659.53
55	8930	BARRAGE					
56	8920.5	4762	535.79	545.31	2.41	9.52	1973.51
57	8905	YERWADA NEW BRIDGE					
58	8870.5	4762	535.99	545.3	2.26	9.31	2108.52
59	8830	YERWADA OLD BRIDGE 1					
60	8820.5	4762	535.84	545.22	2.31	9.38	2060.97
61	8807	YERWADA OLD BRIDGE 2					
62	8770.54	4762	535.32	545.01	2.82	9.69	1688.07
63	8720.54	4762	535.32	545.07	2.38	9.75	1997.34
64	8670.6	4762	535.33	545.06	2.35	9.73	2026.45
65	8620.6	4762	535.12	545.07	2.18	9.95	2188.43
66	8570.6	4762	535.22	545.05	2.24	9.83	2128.44
67	8520.6	4762	535.17	545.04	2.18	9.87	2179.42
68	8470.64	4762	535.08	545.03	2.16	9.95	2207.46
69	8420.64	4762	535.11	545.01	2.19	9.9	2172.28
70	8370.64	4762	535.19	544.94	2.4	9.75	1986.96
71	8320.64	4762	535.07	544.93	2.38	9.86	2001.64
72	8270.64	4762	534.95	544.92	2.36	9.97	2016.38
73	8220.64	4762	534.84	544.9	2.35	10.06	2028.01
74	8170.71	4762	535.14	544.91	2.21	9.77	2151.97
75	8120.71	4762	535.01	544.9	2.18	9.89	2182.11
76	8070.71	4762	534.81	544.89	2.17	10.08	2191.13
77	8020.71	4762	534.64	544.85	2.27	10.21	2098.09
78	7970.71	4762	534.53	544.81	2.36	10.28	2020.94
79	7920.71	4762	534.47	544.77	2.46	10.3	1938.23
80	7870.71	4762	534.75	544.66	2.76	9.91	1725.47
81	7820.71	4762	534.84	544.65	2.73	9.81	1745.85
82	7770.71	4762	534.83	544.67	2.5	9.84	1901.16
83	7720.71	4762	534.69	544.66	2.43	9.97	1962.53
84	7670.73	4762	534.56	544.67	2.31	10.11	2065.1
85	7620.73	4762	534.42	544.67	2.23	10.25	2133.92
86	7570.72	4762	534.12	544.66	2.21	10.54	2155.93
87	7520.74	4762	534.26	544.65	2.18	10.39	2186.15
88	7470.74	4762	534.12	544.65	2.12	10.53	2241.42
89	7420.74	4762	534.18	544.63	2.12	10.45	2250.24
90	7370.74	4762	533.71	544.61	2.16	10.9	2208.64
91	7320.74	4762	533.5	544.58	2.21	11.08	2152.45
92	7270.76	4762	533.78	544.56	2.26	10.78	2110.9
93	7220.76	4762	533.28	544.52	2.34	11.24	2038.71
94	7170.76	4762	532.91	544.48	2.44	11.57	1947.88
95	7120.76	4762	532.45	544.46	2.46	12.01	1937.44
96	7070.76	4762	532.26	544.45	2.39	12.19	1993.36
97	7020.76	4762	532.29	544.42	2.43	12.13	1955.95

98	6970.83	4762	532.83	544.39	2.46	11.56	1935.12
99	6920.85	4762	531.51	544.34	2.57	12.83	1853.08
100	6870.85	4762	531.81	544.33	2.51	12.52	1895.35
101	6820.85	4762	531.94	544.34	2.39	12.4	1993.3
102	6770.86	4762	532.36	544.33	2.36	11.97	2013.78
103	6755	H H AGA KHAN BRIDGE					
104	6620.86	4762	531.49	544.23	2.43	12.74	1961.01
105	6570.9	4762	531.7	544.22	2.38	12.52	2002.92
106	6520.9	4762	531.54	544.18	2.48	12.64	1918.4
107	6470.9	4762	531.56	544.01	2.98	12.45	1599.57
108	6420.9	4762	531.65	544	2.91	12.35	1633.62
109	6370.9	4762	531.71	543.98	2.86	12.27	1666.37
110	6320.9	4762	532.13	543.92	3	11.79	1587.85
111	6270.9	4762	531.09	543.93	2.82	12.84	1687.92
112	6220.91	4762	531.63	543.95	2.66	12.32	1791.47
113	6170.91	4762	531.73	543.99	2.32	12.26	2050.46
114	6120.91	4762	531.74	544.02	2.11	12.28	2256.94
115	6071.49	4762	531.68	544	2.15	12.32	2216.08
116	6020.74	4762	531.39	543.95	2.26	12.56	2103.92
117	5920.78	4762	531.13	543.93	2.25	12.8	2119.84
118	5871.41	4762	531.2	543.92	2.24	12.72	2129.46
119	5821.15	4762	531.36	543.92	2.13	12.56	2236.96
120	5771.22	4762	531.79	543.88	2.26	12.09	2110.15
121	5721.47	4762	532.07	543.84	2.37	11.77	2010.78
122	5671.31	4762	531.39	543.83	2.35	12.44	2026.86
123	5621.43	4762	531.75	543.79	2.42	12.04	1965.79
124	5571.42	4762	531.64	543.78	2.41	12.14	1978.59
125	5521.43	4762	532.01	543.8	2.18	11.79	2184.82
126	5471.43	4762	532.36	543.82	2.02	11.46	2352
127	5421.46	4762	531.93	543.82	1.95	11.89	2443.83
128	5371.46	4762	531.56	543.78	2.05	12.22	2318.61
129	5321.62	4762	531.51	543.7	2.34	12.19	2034.6
130	5271.48	4762	531.71	543.72	2.12	12.01	2241
131	5221.48	4762	531.69	543.72	2.06	12.03	2307.5
132	5171.49	4762	531.3	543.69	2.16	12.39	2208.64
133	5121.49	4762	531.76	543.67	2.16	11.91	2208.96
134	5071.48	4762	531.75	543.63	2.3	11.88	2073.39
135	5021.53	4762	531.58	543.57	2.48	11.99	1923.27
136	4971.53	4762	531.92	543.49	2.69	11.57	1773.31
137	4921.53	4762	531.93	543.41	2.86	11.48	1667.68
138	4871.53	4762	531.56	543.4	2.82	11.84	1690.02
139	4821.53	4762	531.15	543.38	2.81	12.23	1694.69
140	4771.53	4762	531.81	543.35	2.86	11.54	1664.58
141	4721.53	4762	531.63	543.34	2.82	11.71	1689.18
142	4671.53	4762	531.9	543.17	3.24	11.27	1467.59
143	4621.49	4762	531.49	543.16	3.14	11.67	1514.79
144	4571.53	4762	531.31	543.21	2.83	11.9	1685.44
145	4521.55	4762	531.74	543.18	2.85	11.44	1668.06
146	4471.55	4762	531.69	543.17	2.79	11.48	1703.85
147	4421.55	4762	531.73	543.21	2.5	11.48	1905.87
148	4371.55	4762	531.69	543.2	2.47	11.51	1924.85
149	4321.55	4762	531.72	543.2	2.39	11.48	1995.94

150	4271.56	4762	531.75	543.17	2.44	11.42	1952.05
151	4221.56	4762	531.6	543.17	2.34	11.57	2030.86
152	4171.56	4762	531.72	543.17	2.3	11.45	2074.46
153	4121.57	4762	531.59	543.16	2.27	11.57	2102.13
154	4071.57	4762	531.7	543.16	2.19	11.46	2172.78
155	4021.57	4762	531.69	543.16	2.14	11.47	2228.74
156	3971.57	4762	531.65	543.1	2.35	11.45	2029.68
157	3921.57	4762	531.69	543.1	2.28	11.41	2089.39
158	3871.57	4762	531.68	543.1	2.18	11.42	2182.24
159	3821.57	4762	531.63	543.09	2.18	11.46	2185.32
160	3771.57	4762	531.78	543.06	2.26	11.28	2111.51
161	3721.57	4762	531.84	542.95	2.61	11.11	1824.18
162	3671.57	4762	531.75	542.94	2.6	11.19	1834.49
163	3621.57	4762	531.67	542.94	2.52	11.27	1890.76
164	3571.57	4762	532.18	542.94	2.43	10.76	1956.97
165	3512	MUNDHWA BRIDGE					
166	3471.57	4762	532.14	542.85	2.31	10.71	2062.19
167	3421.57	4762	532.12	542.89	1.93	10.77	2473.4
168	3371.57	4762	531.8	542.89	1.93	11.09	2469.86
169	3321.57	4762	531.84	542.87	1.96	11.03	2430.5
170	3271.57	4762	531.74	542.87	1.91	11.13	2499.7
171	3221.57	4762	532.12	542.83	2.03	10.71	2341.71
172	3171.57	4762	531.94	542.81	2.09	10.87	2273.15
173	3121.57	4762	532.11	542.79	2.13	10.68	2235.4
174	3071.57	4762	532.12	542.76	2.18	10.64	2186.03
175	3021.57	4762	532.04	542.72	2.29	10.68	2075.46
176	2971.57	4762	531.83	542.71	2.27	10.88	2094.02
177	2921.57	4762	531.37	542.71	2.19	11.34	2170.56
178	2871.57	4762	531.49	542.61	2.5	11.12	1901.69
179	2821.86	4762	531.92	542.55	2.67	10.63	1784.23
180	2771.57	4762	532.02	542.39	3.08	10.37	1546.92
181	2721.58	4762	532	542.41	2.87	10.41	1661.12
182	2671.58	4762	531.78	542.43	2.66	10.65	1789.35
183	2621.58	4762	532.06	542.34	2.88	10.28	1655.22
184	2571.59	4762	532.1	542.03	3.62	9.93	1313.82
185	2521.59	4762	532.15	542.24	2.55	10.09	1866.8
186	2471.59	4762	532.27	542.1	2.93	9.83	1627.22
187	2421.59	4762	531.94	542.09	2.88	10.15	1655.87
188	2371.59	4762	531.96	542.06	2.9	10.1	1640.45
189	2321.59	4762	532.02	542	2.99	9.98	1591.36
190	2271.59	4762	532.1	541.96	3.05	9.86	1562.42
191	2221.59	4762	532.19	541.89	3.16	9.7	1508.83
192	2171.59	4762	532.12	541.84	3.22	9.72	1478.62
193	2121.6	4762	532.15	541.77	3.32	9.62	1434.33
194	2071.59	4762	532.04	541.77	3.19	9.73	1490.84
195	2021.59	4762	531.79	541.71	3.29	9.92	1448.39
196	1971.59	4762	531.59	541.74	2.99	10.15	1591.01
197	1921.59	4762	531.84	541.74	2.91	9.9	1635.16
198	1871.59	4762	532	541.62	3.19	9.62	1492.7
199	1821.59	4762	531.88	541.62	3.05	9.74	1562.99
200	1771.69	4762	532.21	541.58	3.07	9.37	1553.62
201	1721.66	4762	531.29	541.53	3.15	10.24	1513.79

202	1671.66	4762	532.52	541.38	3.47	8.86	1374.1
203	1621.66	4762	532.22	541.39	3.26	9.17	1461.81
204	1571.66	4762	532.13	541.34	3.32	9.21	1432.51
205	1521.66	4762	531.66	541.33	3.21	9.67	1484.06
206	1471.66	4762	532.05	541.19	3.5	9.14	1362.03
207	1421.66	4762	532.07	541.16	3.46	9.09	1377.79
208	1371.66	4762	532.07	541.2	3.15	9.13	1510.14
209	1321.66	4762	532.07	541.22	2.9	9.15	1641.42
210	1271.66	4762	532.24	541.29	2.44	9.05	1949.42
211	1221.66	4762	532.12	541.23	2.59	9.11	1840.09
212	1171.66	4762	531.75	541.22	2.56	9.47	1857.02
213	1121.68	4762	531.13	541.23	2.37	10.1	2005.09
214	1093	KT WEIR					
215	1071.68	4762	529.84	541.22	1.97	11.38	2422.43
216	1021.68	4762	529.32	541.21	1.93	11.89	2469.06
217	971.68	4762	528.67	541.19	1.99	12.52	2397.77
218	921.68	4762	528.83	541.15	2.12	12.32	2247.65
219	871.68	4762	528.39	541.14	2.14	12.75	2229.73
220	821.68	4762	528.66	541.13	2.12	12.47	2248.96
221	771.68	4762	528.63	541.13	2.08	12.5	2289.34
222	721.69	4762	528.38	541.13	2.01	12.75	2374.23
223	671.69	4762	528.72	541.1	2.07	12.38	2302.61
224	621.69	4762	528.59	541.07	2.15	12.48	2214.12
225	571.69	4762	528.4	541.07	2.1	12.67	2269.38
226	521.69	4762	528.58	541.06	2.09	12.48	2276.26
227	471.69	4762	528.65	541.05	2.08	12.4	2294.43
228	421.71	4762	528.66	541.05	2.03	12.39	2345.99
229	371.71	4762	528.66	541.03	2.08	12.37	2294.65
230	321.71	4762	528.67	541	2.17	12.33	2198.52
231	271.71	4762	528.77	540.98	2.21	12.21	2150.09
232	221.71	4762	528.21	540.97	2.18	12.76	2183.14
233	171.71	4762	528.46	540.94	2.28	12.48	2092.34
234	121.71	4762	527.91	540.95	2.16	13.04	2204.28
235	71.71	4762	528.64	540.93	2.17	12.29	2191.68
236	21.71	4762	528.68	540.34	3.86	11.66	1233.46

ANNEXURE XIV

OUTPUT OF MULA RIVER UPTO CONFLUENCE WITH PAWANA RIVER FROM HEC RAS FOR FLOOD DISCHARGE OF 25 YEAR RETURN PERIOD

Sr No	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Vel Chnl (m/s)	Difference in Depth	Flow Area (m2)
1	10820.69	1206	548.87	556.65	1.5	7.78	804.16
2	10770.05	1206	548.8	556.68	1.14	7.88	1060.78
3	10720.05	1206	548.87	556.66	1.22	7.79	991.89
4	10670.05	1206	548.87	556.64	1.31	7.77	918.12
5	10620.05	1206	549.32	556.59	1.56	7.27	771.22
6	10570.05	1206	549.5	556.53	1.82	7.03	664.19
7	10520.06	1206	549.39	556.53	1.72	7.14	701.43
8	10470.06	1206	549.15	556.48	1.86	7.33	647.34
9	10420.06	1206	549.29	556.45	1.91	7.16	630.71
10	10355	MUMBAI PUNE BYPASS BRIDGE					
11	10320.07	1206	549.32	556.36	1.82	7.04	662.91
12	10270.28	1206	549.12	556.34	1.79	7.22	672.65
13	10220.28	1206	549.17	556.32	1.84	7.15	655.37
14	10170.28	1206	549.27	556.33	1.65	7.06	729.45
15	10120.29	1206	549.44	556.28	1.81	6.84	664.91
16	10070.29	1206	549.5	556.24	1.91	6.74	631.07
17	10020.28	1206	549.34	556.26	1.65	6.92	729.95
18	9972	WAKAD BRIDGE					
19	9920.43	1206	547.29	556.13	1.46	8.84	825.63
20	9870.41	1206	547.1	556.14	1.28	9.04	940.32
21	9820.57	1206	547.38	556.13	1.29	8.75	938.06
22	9770.58	1206	546.62	556.12	1.3	9.5	928.84
23	9720.61	1206	546.84	556.12	1.29	9.28	937.12
24	9670.61	1206	546.71	556.1	1.35	9.39	895.91
25	9620.61	1206	546.54	556.1	1.28	9.56	943.07
26	9570.59	1206	546.47	556.09	1.29	9.62	936.76
27	9520.65	1206	546.43	556.09	1.21	9.66	999.11
28	9470.72	1206	546.56	556.05	1.42	9.49	849.74
29	9420.72	1206	546.69	556.02	1.5	9.33	801.62
30	9370.71	1206	546.86	556.02	1.39	9.16	864.65
31	9320.72	1206	546.71	556.03	1.28	9.32	940.45
32	9270.92	1206	546.76	556.02	1.21	9.26	993.58
33	9220.72	1206	546.77	556.03	1.05	9.26	1145.56
34	9170.77	1206	546.78	555.98	1.39	9.2	867.88
35	9120.77	1206	546.87	555.95	1.49	9.08	809.34
36	9070.9	1206	546.76	555.95	1.36	9.19	890.01
37	9020.89	1206	546.77	555.93	1.45	9.16	831.22
38	8970.89	1206	546.77	555.93	1.32	9.16	914.38
39	8920.89	1206	546.73	555.92	1.34	9.19	896.68
40	8870.89	1206	546.73	555.92	1.23	9.19	983.28
41	8820.89	1206	546.93	555.92	1.13	8.99	1062.78
42	8770.89	1206	546.82	555.92	1.03	9.1	1166.56
43	8720.89	1206	546.77	555.89	1.27	9.12	948.47
44	8671.1	1206	546.87	555.88	1.21	9.01	996.98

45	8621.18	1206	546.77	555.85	1.39	9.08	870.61
46	8570.97	1206	546.83	555.87	1.11	9.04	1091.07
47	8521.05	1206	546.68	555.86	1.14	9.18	1060.01
48	8471.01	1206	546.8	555.85	1.16	9.05	1039.01
49	8421.45	1206	546.58	555.82	1.3	9.24	926.73
50	8389	Bridge					
51	8321.33	1206	546.48	555.79	1.28	9.31	941
52	8271.33	1206	546.64	555.76	1.45	9.12	829.35
53	8221.33	1206	546.63	555.75	1.46	9.12	825.97
54	8171.07	1206	546.72	555.73	1.5	9.01	804.2
55	8131	K SHAKUNTLAL BABAN SHADHE					
56	8121.42	1206	547.21	555.72	1.25	8.51	961.34
57	8071.42	1206	546.93	555.7	1.34	8.77	900.25
58	8021.52	1206	546.96	555.66	1.53	8.7	788.5
59	7971.42	1206	545.93	555.64	1.54	9.71	781.24
60	7921.59	1206	545.71	555.62	1.62	9.91	746.1
61	7871.58	1206	545.59	555.63	1.39	10.04	870.32
62	7821.58	1206	545.61	555.58	1.61	9.97	748.57
63	7771.58	1206	545.81	555.57	1.63	9.76	740.09
64	7721.58	1206	545.64	555.56	1.52	9.92	791.28
65	7671.62	1206	545.38	555.57	1.31	10.19	922.27
66	7621.62	1206	545.79	555.58	1.13	9.79	1066.23
67	7571.58	1206	545.9	555.54	1.34	9.64	903
68	7521.67	1206	545.6	555.53	1.35	9.93	892.57
69	7471.67	1206	545.84	555.5	1.44	9.66	838.49
70	7421.67	1206	545.87	555.5	1.33	9.63	905.55
71	7371.68	1206	545.84	555.47	1.46	9.63	827.05
72	7321.65	1206	545.92	555.47	1.36	9.55	885.87
73	7271.71	1206	545.61	555.47	1.29	9.86	935.97
74	7221.76	1206	545.74	555.45	1.38	9.71	876.28
75	7171.89	1206	545.7	555.41	1.54	9.71	785.63
76	7122.08	1206	545.85	555.39	1.61	9.54	748.54
77	7072.06	1206	545.78	555.36	1.7	9.58	709.76
78	7022.08	1206	545.56	555.37	1.5	9.81	801.8
79	6972.08	1206	545.75	555.34	1.64	9.59	737.4
80	6922.08	1206	545.92	555.25	1.98	9.33	607.75
81	6872.08	1206	545.89	555.18	2.21	9.29	545.98
82	6822.08	1206	546.01	555.14	2.27	9.13	531.16
83	6772.08	1206	545.96	555.19	1.78	9.23	675.97
84	6722.08	1206	546.1	555.2	1.64	9.1	737.25
85	6672.08	1206	545.61	555.19	1.59	9.58	756.98
86	6622.08	1206	545.74	555.18	1.58	9.44	764.14
87	6572.1	1206	545.78	555.18	1.42	9.4	847.69
88	6522.09	1206	545.84	555.12	1.69	9.28	712.43
89	6472.09	1206	545.87	555.13	1.47	9.26	819.71
90	6422.1	1206	545.43	555.11	1.52	9.68	791.03
91	6372.1	1206	545.78	555.09	1.58	9.31	765.15
92	6322.1	1206	545.92	555.09	1.43	9.17	843.53
93	6272.11	1206	545.82	555.08	1.37	9.26	882.12
94	6222.11	1206	545.55	555.09	1.25	9.54	961.11
95	6171.99	1206	545.39	555.09	1.15	9.7	1046.55
96	6122.29	1206	545.63	555.08	1.17	9.45	1033.51

97	6072.27	1206	545.84	555.07	1.16	9.23	1041.39
98	6022.27	1206	545.81	555.03	1.42	9.22	850.45
99	5972.15	1206	546.48	555.02	1.36	8.54	887.89
100	5922.27	1206	546.45	555.01	1.39	8.56	866.4
101	5871.84	1206	545.69	555	1.38	9.31	870.97
102	5822.27	1206	545.82	554.99	1.4	9.17	862.22
103	5772.25	1206	545.9	554.99	1.3	9.09	928.87
104	5721.82	1206	546	554.99	1.27	8.99	952.13
105	5672.25	1206	545.46	554.99	1.19	9.53	1013.04
106	5622.25	1206	545.88	554.99	1.16	9.11	1042.2
107	5572.25	1206	545.98	554.98	1.15	9	1046.8
108	5522.31	1206	545.8	554.96	1.29	9.16	932.37
109	5472.55	1206	545.58	554.96	1.24	9.38	975.14
110	5422.55	1536	545.99	554.85	1.8	8.86	851.22
111	5372.55	1536	546.17	554.85	1.75	8.68	875.46
112	5322.55	1536	545.82	554.84	1.7	9.02	904.9
113	5272.66	1536	545.83	554.85	1.57	9.02	978.39
114	5175	SHIVAJI MAHARAJ BRIDGE					
115	5172.59	1536	545.33	554.81	1.64	9.48	939.37
116	5119.41	1536	545.22	554.77	1.77	9.55	869.82
117	5072.72	1536	545.38	554.69	2.08	9.31	737.69
118	5022.73	1536	545.63	554.65	2.19	9.02	701.23
119	4972.73	1536	545.53	554.57	2.41	9.04	637.05
120	4922.72	1536	545.34	554.62	1.88	9.28	818.36
121	4872.76	1536	545.59	554.61	1.83	9.02	840.22
122	4822.75	1536	545.35	554.61	1.67	9.26	921.78
123	4772.81	1536	545.68	554.6	1.64	8.92	936.61
124	4722.97	1536	545.55	554.61	1.38	9.06	1115.47
125	4672.71	1536	546.65	554.62	1.24	7.97	1242.81
126	4623.45	1536	546.29	554.6	1.27	8.31	1210.22
127	4573.47	1536	544.87	554.58	1.36	9.71	1128.88
128	4523.6	1536	544.88	554.57	1.39	9.69	1107.13
129	4473.68	1536	544.82	554.56	1.41	9.74	1089.74
130	4423.73	1536	544.87	554.55	1.39	9.68	1104.9
131	4373.73	1536	545	554.57	1.17	9.57	1307.62
132	4323.71	1536	544.97	554.56	1.14	9.59	1342
133	4273.9	1536	544.72	554.53	1.37	9.81	1121.16
134	4223.98	1536	545.15	554.41	1.94	9.26	793.52
135	4173.98	1536	545.02	554.41	1.81	9.39	850
136	4123.95	1536	544.69	554.39	1.85	9.7	832.32
137	4073.9	1536	544.53	554.37	1.9	9.84	808.78
138	4024.22	1536	545.02	554.35	1.9	9.33	808.75
139	3974.22	1536	544.6	554.39	1.52	9.79	1009.72
140	3924.22	1536	544.48	554.38	1.5	9.9	1021.91
141	3874.23	1536	544.62	554.38	1.42	9.76	1078.55
142	3824.23	1536	544.9	554.35	1.51	9.45	1015.25
143	3774.23	1536	544.92	554.38	1.17	9.46	1307.87
144	3724.23	1536	544.97	554.31	1.52	9.34	1007.28
145	3674.23	1536	543.1	554.3	1.5	11.2	1021.03
146	3624.22	1536	545.03	554.28	1.58	9.25	970.39
147	3574.29	1536	545.15	554.27	1.49	9.12	1030.24
148	3524.29	1536	544.68	554.27	1.39	9.59	1104.1

149	3474.29	1536	545.05	554.23	1.62	9.18	948.31
150	3424.29	1536	544.67	554.21	1.6	9.54	957.01
151	3374.29	1536	544.72	554.18	1.73	9.46	888.68
152	3324.04	1536	544.83	554.17	1.67	9.34	919.46
153	3274.51	1536	544.73	554.14	1.77	9.41	867.92
154	3224.5	1536	544.84	554.14	1.62	9.3	949.56
155	3174.5	1536	544.81	554.09	1.8	9.28	852.91
156	3124.51	1536	544.96	554.09	1.7	9.13	905.47
157	3074.51	1536	544.96	554.09	1.59	9.13	964.07
158	3024.51	1536	544.03	554.1	1.38	10.07	1112.19
159	2974.51	1536	544.37	554.09	1.42	9.72	1078.05
160	2924.51	1536	544.56	554.06	1.54	9.5	997.51
161	2884	OLD AUNDH BRIDGE					
162	2874.51	1536	544.47	554	1.7	9.53	905.71
163	2824.51	1536	544.57	554.02	1.36	9.45	1125.77
164	2774.57	1536	544.79	554.01	1.41	9.22	1089.82
165	2724.57	1536	544.64	554	1.42	9.36	1079.37
166	2674.57	1536	544.61	553.94	1.7	9.33	902.67
167	2624.57	1536	544.48	553.94	1.59	9.46	965.91
168	2574.57	1536	544.56	553.93	1.58	9.37	970.91
169	2524.57	1536	545.03	553.85	1.93	8.82	795.83
170	2495	AUNDH BRIDGE					
171	2474.62	1536	545.72	553.74	1.63	8.02	942.16
172	2424.62	1536	544.76	553.67	1.92	8.91	802.08
173	2374.62	1536	544.64	553.6	2.16	8.96	711.09
174	2324.7	1536	544.91	553.6	2.02	8.69	761.63
175	2274.74	1536	544.24	553.6	1.87	9.36	823.18
176	2224.73	1536	544.35	553.49	2.27	9.14	675.89
177	2174.74	1536	544.92	553.49	2.1	8.57	731.15
178	2124.74	1536	545.05	553.42	2.32	8.37	661.51
179	2074.74	1536	544.85	553.41	2.26	8.56	678.63
180	2024.74	1536	544.75	553.4	2.18	8.65	704.27
181	1974.77	1536	544.63	553.3	2.47	8.67	622.05
182	1924.77	1536	544.8	553.35	2.03	8.55	755.83
183	1874.75	1536	545.46	553.32	2.1	7.86	730.67
184	1838	SANGVI BRIDGE					
185	1824.79	1536	544.75	553.2	2.19	8.45	700.83
186	1774.78	1536	544.7	553.19	2.12	8.49	724.16
187	1724.72	1536	544.97	553.19	1.99	8.22	772.21
188	1674.78	1536	544.51	553.17	1.92	8.66	801.43
189	1624.78	1536	544.6	553.17	1.77	8.57	867.03
190	1574.78	1536	545.15	553.11	1.97	7.96	780.17
191	1524.78	1536	545.15	553.1	1.86	7.95	824.45
192	1474.78	1536	544.66	553.08	1.88	8.42	817.21
193	1424.77	1536	544.34	553.07	1.81	8.73	848.65
194	1374.8	1536	544.55	553.05	1.85	8.5	831.78
195	1324.8	1536	544.48	553	1.98	8.52	776.99
196	1274.79	1536	544.08	552.95	2.07	8.87	740.71
197	1224.82	1536	544.62	552.95	1.91	8.33	804.85
198	1174.82	1536	544.58	552.88	2.12	8.3	723.96
199	1124.84	1536	544.07	552.9	1.82	8.83	844.84
200	1074.84	1536	544.49	552.73	2.42	8.24	634.6

201	1024.84	1536	544.32	552.75	2.18	8.43	705.81
202	974.86	1536	544.44	552.77	1.87	8.33	820.26
203	924.86	1536	544.33	552.69	2.12	8.36	725.09
204	874.86	1536	544.3	552.64	2.19	8.34	699.91
205	824.86	1536	544.49	552.62	2.13	8.13	721.25
206	774.86	1536	544.8	552.58	2.19	7.78	702.3
207	724.86	1536	544.6	552.58	1.99	7.98	771.16
208	674.86	1536	544.42	552.48	2.3	8.06	666.68
209	624.83	1536	544.63	552.41	2.47	7.78	621.07
210	574.83	1536	543.9	552.32	2.68	8.42	573.75
211	524.87	1536	544.06	552.31	2.52	8.25	610.36
212	474.87	1536	544.03	552.08	3.13	8.05	491.4
213	424.97	1536	544.61	552.12	2.68	7.51	572.66
214	374.97	1536	544.69	552.14	2.37	7.45	648.6
215	325	1536	544.73	552.08	2.48	7.35	620.34
216	275	1536	544.42	552.09	2.27	7.67	677.77
217	225.01	1536	544.46	552.11	1.98	7.65	777
218	175.01	1536	544.65	552.09	2	7.44	767.26
219	125.01	1536	545.15	552.03	2.18	6.88	705.75
220	75.01	1536	544.93	551.98	2.27	7.05	676.22
221	25.01	1536	544.87	551.99	2.08	7.12	738.87

ANNEXURE XV

OUTPUT OF MULA RIVER UPTO CONFLUENCE WITH PAWANA RIVER FROM HEC RAS FOR FLOOD DISCHARGE OF 100 YEAR RETURN PERIOD

Sr No	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Vel Chnl (m/s)	Difference in Depth	Flow Area (m2)
MULA CL1	10820.69	1232	548.87	556.87	1.48	8	830.52
MULA CL1	10770.05	1232	548.8	556.9	1.12	8.1	1095.45
MULA CL1	10720.05	1232	548.87	556.88	1.2	8.01	1025.71
MULA CL1	10670.05	1232	548.87	556.86	1.3	7.99	950.22
MULA CL1	10620.05	1232	549.32	556.82	1.54	7.5	802.41
MULA CL1	10570.05	1232	549.5	556.76	1.77	7.26	694.62
MULA CL1	10520.06	1232	549.39	556.76	1.69	7.37	729.59
MULA CL1	10470.06	1232	549.15	556.72	1.82	7.57	677.42
MULA CL1	10420.06	1232	549.29	556.69	1.85	7.4	664.16
MULA CL1	10355	MUMBAI PUNE BYPASS BRIDGE					
MULA CL1	10320.07	1232	549.32	556.6	1.78	7.28	691.43
MULA CL1	10270.28	1232	549.12	556.59	1.75	7.47	705.17
MULA CL1	10220.28	1232	549.17	556.56	1.79	7.39	686.73
MULA CL1	10170.28	1232	549.27	556.57	1.62	7.3	758.85
MULA CL1	10120.29	1232	549.44	556.53	1.77	7.09	697.11
MULA CL1	10070.29	1232	549.5	556.5	1.85	7	664.47
MULA CL1	10020.28	1232	549.34	556.51	1.61	7.17	764.61
MULA CL1	9972	WAKAD BRIDGE					
MULA CL1	9920.43	1232	547.29	556.4	1.43	9.11	861.49
MULA CL1	9870.41	1232	547.1	556.41	1.25	9.31	985.38
MULA CL1	9820.57	1232	547.38	556.4	1.25	9.02	983.89
MULA CL1	9770.58	1232	546.62	556.39	1.26	9.77	975.17
MULA CL1	9720.61	1232	546.84	556.39	1.25	9.55	984.75
MULA CL1	9670.61	1232	546.71	556.37	1.3	9.66	947.45
MULA CL1	9620.61	1232	546.54	556.37	1.24	9.83	989.92
MULA CL1	9570.59	1232	546.47	556.36	1.25	9.89	984.78
MULA CL1	9520.65	1232	546.43	556.36	1.17	9.93	1048.6
MULA CL1	9470.72	1232	546.56	556.33	1.38	9.77	891.29
MULA CL1	9420.72	1232	546.69	556.3	1.46	9.61	843.56
MULA CL1	9370.71	1232	546.86	556.3	1.36	9.44	906.59
MULA CL1	9320.72	1232	546.71	556.31	1.25	9.6	983.66
MULA CL1	9270.92	1232	546.76	556.31	1.17	9.55	1053.49
MULA CL1	9220.72	1232	546.77	556.31	1.02	9.54	1212.07
MULA CL1	9170.77	1232	546.78	556.26	1.34	9.48	919.99
MULA CL1	9120.77	1232	546.87	556.24	1.44	9.37	857.68
MULA CL1	9070.9	1232	546.76	556.24	1.31	9.48	937.81
MULA CL1	9020.89	1232	546.77	556.22	1.4	9.45	879.87
MULA CL1	8970.89	1232	546.77	556.22	1.28	9.45	965.38
MULA CL1	8920.89	1232	546.73	556.21	1.29	9.48	951.68
MULA CL1	8870.89	1232	546.73	556.21	1.19	9.48	1036.26
MULA CL1	8820.89	1232	546.93	556.21	1.1	9.28	1118.32
MULA CL1	8770.89	1232	546.82	556.22	1.01	9.4	1225.34
MULA CL1	8720.89	1232	546.77	556.18	1.23	9.41	1003.54
MULA CL1	8671.1	1232	546.87	556.18	1.18	9.31	1047.03
MULA CL1	8621.18	1232	546.77	556.15	1.34	9.38	917.83

MULA CL1	8570.97	1232	546.83	556.17	1.07	9.34	1146.23
MULA CL1	8521.05	1232	546.68	556.16	1.11	9.48	1110.89
MULA CL1	8471.01	1232	546.8	556.15	1.12	9.35	1095.64
MULA CL1	8421.45	1232	546.58	556.13	1.26	9.55	978.03
MULA CL1	8389	Bridge					
MULA CL1	8321.33	1232	546.48	556.1	1.25	9.62	989.14
MULA CL1	8271.33	1232	546.64	556.07	1.41	9.43	875.16
MULA CL1	8221.33	1232	546.63	556.06	1.41	9.43	871.98
MULA CL1	8171.07	1232	546.72	556.04	1.46	9.32	841.65
MULA CL1	8131	K SHAKUNTLAL BABAN SHADHE					
MULA CL1	8121.42	1232	547.21	556.03	1.22	8.82	1007.74
MULA CL1	8071.42	1232	546.93	556.01	1.29	9.08	951.92
MULA CL1	8021.52	1232	546.96	555.97	1.47	9.01	839.66
MULA CL1	7971.42	1232	545.93	555.96	1.49	10.03	824.89
MULA CL1	7921.59	1232	545.71	555.94	1.56	10.23	789.4
MULA CL1	7871.58	1232	545.59	555.95	1.34	10.36	922.09
MULA CL1	7821.58	1232	545.61	555.91	1.55	10.3	796.83
MULA CL1	7771.58	1232	545.81	555.89	1.56	10.08	789.66
MULA CL1	7721.58	1232	545.64	555.89	1.46	10.25	844.4
MULA CL1	7671.62	1232	545.38	555.9	1.23	10.52	999.23
MULA CL1	7621.62	1232	545.79	555.91	1.07	10.12	1146.46
MULA CL1	7571.58	1232	545.9	555.87	1.26	9.97	975.4
MULA CL1	7521.67	1232	545.6	555.86	1.28	10.26	959.4
MULA CL1	7471.67	1232	545.84	555.84	1.37	10	897.96
MULA CL1	7421.67	1232	545.87	555.84	1.27	9.97	969.87
MULA CL1	7371.68	1232	545.84	555.81	1.39	9.97	883.44
MULA CL1	7321.65	1232	545.92	555.81	1.31	9.89	943.68
MULA CL1	7271.71	1232	545.61	555.81	1.24	10.2	990.42
MULA CL1	7221.76	1232	545.74	555.79	1.33	10.05	923.94
MULA CL1	7171.89	1232	545.7	555.76	1.49	10.06	827.26
MULA CL1	7122.08	1232	545.85	555.74	1.57	9.89	784.39
MULA CL1	7072.06	1232	545.78	555.71	1.64	9.93	750.56
MULA CL1	7022.08	1232	545.56	555.73	1.45	10.17	852.21
MULA CL1	6972.08	1232	545.75	555.7	1.56	9.95	789.33
MULA CL1	6922.08	1232	545.92	555.61	1.93	9.69	638.6
MULA CL1	6872.08	1232	545.89	555.55	2.11	9.66	583.66
MULA CL1	6822.08	1232	546.01	555.52	2.18	9.51	565.06
MULA CL1	6772.08	1232	545.96	555.56	1.69	9.6	727.73
MULA CL1	6722.08	1232	546.1	555.57	1.56	9.47	790.56
MULA CL1	6672.08	1232	545.61	555.56	1.52	9.95	811.9
MULA CL1	6622.08	1232	545.74	555.55	1.49	9.81	827.47
MULA CL1	6572.1	1232	545.78	555.55	1.35	9.77	911.07
MULA CL1	6522.09	1232	545.84	555.5	1.61	9.66	765.01
MULA CL1	6472.09	1232	545.87	555.51	1.39	9.64	884.33
MULA CL1	6422.1	1232	545.43	555.49	1.44	10.06	855.3
MULA CL1	6372.1	1232	545.78	555.47	1.48	9.69	830.2
MULA CL1	6322.1	1232	545.92	555.48	1.34	9.56	918.13
MULA CL1	6272.11	1232	545.82	555.47	1.3	9.65	950.39
MULA CL1	6222.11	1232	545.55	555.47	1.19	9.92	1037.31
MULA CL1	6171.99	1232	545.39	555.48	1.1	10.09	1122.23
MULA CL1	6122.29	1232	545.63	555.47	1.11	9.84	1109.16
MULA CL1	6072.27	1232	545.84	555.46	1.11	9.62	1107.9

MULA CL1	6022.27	1232	545.81	555.42	1.34	9.61	916.95
MULA CL1	5972.15	1232	546.48	555.42	1.29	8.94	958.28
MULA CL1	5922.27	1232	546.45	555.41	1.32	8.96	934.75
MULA CL1	5871.84	1232	545.69	555.4	1.32	9.71	935.54
MULA CL1	5822.27	1232	545.82	555.39	1.35	9.57	914.09
MULA CL1	5772.25	1232	545.9	555.39	1.25	9.49	985.58
MULA CL1	5721.82	1232	546	555.39	1.22	9.39	1010.3
MULA CL1	5672.25	1232	545.46	555.39	1.15	9.93	1072.58
MULA CL1	5622.25	1232	545.88	555.39	1.12	9.51	1101.92
MULA CL1	5572.25	1232	545.98	555.38	1.11	9.4	1106.6
MULA CL1	5522.31	1232	545.8	555.36	1.24	9.56	992.66
MULA CL1	5472.55	1232	545.58	555.36	1.19	9.78	1035.46
MULA CL1	5422.55	1670	545.99	555.24	1.86	9.25	898.72
MULA CL1	5372.55	1670	546.17	555.23	1.8	9.06	926.63
MULA CL1	5322.55	1670	545.82	555.23	1.75	9.41	952.06
MULA CL1	5272.66	1670	545.83	555.24	1.62	9.41	1033.46
MULA CL1	5175	SHIVAJI MAHARAJ BRIDGE					
MULA CL1	5172.59	1670	545.33	555.18	1.7	9.85	984.91
MULA CL1	5119.41	1670	545.22	555.14	1.83	9.92	911.28
MULA CL1	5072.72	1670	545.38	555.06	2.16	9.68	773.42
MULA CL1	5022.73	1670	545.63	555.01	2.27	9.38	735.17
MULA CL1	4972.73	1670	545.53	554.95	2.42	9.42	690.03
MULA CL1	4922.72	1670	545.34	555.01	1.86	9.67	896.54
MULA CL1	4872.76	1670	545.59	554.99	1.84	9.4	906.44
MULA CL1	4822.75	1670	545.35	555	1.68	9.65	996.26
MULA CL1	4772.81	1670	545.68	554.99	1.64	9.31	1021.26
MULA CL1	4722.97	1670	545.55	555	1.39	9.45	1203.29
MULA CL1	4672.71	1670	546.65	555.01	1.26	8.36	1326.61
MULA CL1	4623.45	1670	546.29	555	1.28	8.71	1309.08
MULA CL1	4573.47	1670	544.87	554.97	1.38	10.1	1209.03
MULA CL1	4523.6	1670	544.88	554.96	1.43	10.08	1171.55
MULA CL1	4473.68	1670	544.82	554.95	1.45	10.13	1154.55
MULA CL1	4423.73	1670	544.87	554.94	1.43	10.07	1166.89
MULA CL1	4373.73	1670	545	554.96	1.21	9.96	1380.88
MULA CL1	4323.71	1670	544.97	554.95	1.17	9.98	1424.27
MULA CL1	4273.9	1670	544.72	554.92	1.41	10.2	1188.39
MULA CL1	4223.98	1670	545.15	554.8	1.97	9.65	849.47
MULA CL1	4173.98	1670	545.02	554.8	1.86	9.78	899.26
MULA CL1	4123.95	1670	544.69	554.78	1.9	10.09	881.26
MULA CL1	4073.9	1670	544.53	554.75	1.95	10.22	856.56
MULA CL1	4024.22	1670	545.02	554.73	1.97	9.71	849.6
MULA CL1	3974.22	1670	544.6	554.78	1.55	10.18	1074.35
MULA CL1	3924.22	1670	544.48	554.77	1.52	10.29	1095.74
MULA CL1	3874.23	1670	544.62	554.77	1.44	10.15	1157.46
MULA CL1	3824.23	1670	544.9	554.74	1.53	9.84	1092.82
MULA CL1	3774.23	1670	544.92	554.77	1.2	9.85	1389.35
MULA CL1	3724.23	1670	544.97	554.71	1.52	9.74	1097.46
MULA CL1	3674.23	1670	543.1	554.7	1.52	11.6	1098.4
MULA CL1	3624.22	1670	545.03	554.67	1.6	9.64	1046.4
MULA CL1	3574.29	1670	545.15	554.67	1.51	9.52	1105.84
MULA CL1	3524.29	1670	544.68	554.67	1.42	9.99	1179.5
MULA CL1	3474.29	1670	545.05	554.62	1.63	9.57	1021.46

MULA CL1	3424.29	1670	544.67	554.61	1.62	9.94	1031.31
MULA CL1	3374.29	1670	544.72	554.58	1.74	9.86	958.01
MULA CL1	3324.04	1670	544.83	554.57	1.69	9.74	988.51
MULA CL1	3274.51	1670	544.73	554.54	1.79	9.81	935.52
MULA CL1	3224.5	1670	544.84	554.54	1.64	9.7	1015.3
MULA CL1	3174.5	1670	544.81	554.49	1.82	9.68	917.77
MULA CL1	3124.51	1670	544.96	554.49	1.71	9.53	973.99
MULA CL1	3074.51	1670	544.96	554.49	1.61	9.53	1036.5
MULA CL1	3024.51	1670	544.03	554.5	1.41	10.47	1183.98
MULA CL1	2974.51	1670	544.37	554.49	1.45	10.12	1149.43
MULA CL1	2924.51	1670	544.56	554.46	1.56	9.9	1068.93
MULA CL1	2884	OLD AUNDH BRIDGE					
MULA CL1	2874.51	1670	544.47	554.4	1.72	9.93	971.6
MULA CL1	2824.51	1670	544.57	554.43	1.39	9.86	1200.08
MULA CL1	2774.57	1670	544.79	554.41	1.44	9.62	1161.44
MULA CL1	2724.57	1670	544.64	554.4	1.45	9.76	1152.69
MULA CL1	2674.57	1670	544.61	554.34	1.73	9.73	965.16
MULA CL1	2624.57	1670	544.48	554.34	1.63	9.86	1026.06
MULA CL1	2574.57	1670	544.56	554.33	1.62	9.77	1029.16
MULA CL1	2524.57	1670	545.03	554.25	1.99	9.22	839.97
MULA CL1	2495	AUNDH BRIDGE					
MULA CL1	2474.62	1670	545.72	554.1	1.68	8.38	996.23
MULA CL1	2424.62	1670	544.76	554.03	1.97	9.27	846.77
MULA CL1	2374.62	1670	544.64	553.95	2.24	9.31	744.33
MULA CL1	2324.7	1670	544.91	553.96	2.07	9.05	806.81
MULA CL1	2274.74	1670	544.24	553.96	1.9	9.72	876.66
MULA CL1	2224.73	1670	544.35	553.84	2.33	9.49	716.63
MULA CL1	2174.74	1670	544.92	553.85	2.15	8.93	775.94
MULA CL1	2124.74	1670	545.05	553.76	2.4	8.71	694.46
MULA CL1	2074.74	1670	544.85	553.75	2.32	8.9	718.32
MULA CL1	2024.74	1670	544.75	553.75	2.26	9	738.93
MULA CL1	1974.77	1670	544.63	553.64	2.56	9.01	651.78
MULA CL1	1924.77	1670	544.8	553.7	2.09	8.9	798.55
MULA CL1	1874.75	1670	545.46	553.67	2.17	8.21	769.55
MULA CL1	1838	SANGVI BRIDGE					
MULA CL1	1824.79	1670	544.75	553.52	2.24	8.77	745.85
MULA CL1	1774.78	1670	544.7	553.51	2.19	8.81	764.13
MULA CL1	1724.72	1670	544.97	553.51	2.02	8.54	827.97
MULA CL1	1674.78	1670	544.51	553.5	1.95	8.99	858.14
MULA CL1	1624.78	1670	544.6	553.5	1.81	8.9	925.03
MULA CL1	1574.78	1670	545.15	553.44	1.99	8.29	838.9
MULA CL1	1524.78	1670	545.15	553.43	1.89	8.28	884.22
MULA CL1	1474.78	1670	544.66	553.41	1.92	8.75	867.66
MULA CL1	1424.77	1670	544.34	553.4	1.85	9.06	901.49
MULA CL1	1374.8	1670	544.55	553.38	1.88	8.83	886.06
MULA CL1	1324.8	1670	544.48	553.33	2.01	8.85	831.09
MULA CL1	1274.79	1670	544.08	553.28	2.1	9.2	794.88
MULA CL1	1224.82	1670	544.62	553.28	1.95	8.66	858.44
MULA CL1	1174.82	1670	544.58	553.21	2.15	8.63	778.43
MULA CL1	1124.84	1670	544.07	553.23	1.87	9.16	894.76
MULA CL1	1074.84	1670	544.49	553.06	2.48	8.57	672.37
MULA CL1	1024.84	1670	544.32	553.08	2.21	8.76	755

MULA CL1	974.86	1670	544.44	553.1	1.91	8.66	875.05
MULA CL1	924.86	1670	544.33	553.03	2.15	8.7	778.43
MULA CL1	874.86	1670	544.3	552.99	2.21	8.69	755.6
MULA CL1	824.86	1670	544.49	552.97	2.14	8.48	779.95
MULA CL1	774.86	1670	544.8	552.92	2.2	8.12	760.2
MULA CL1	724.86	1670	544.6	552.93	2.01	8.33	831.53
MULA CL1	674.86	1670	544.42	552.82	2.37	8.4	705.48
MULA CL1	624.83	1670	544.63	552.74	2.54	8.11	657.88
MULA CL1	574.83	1670	543.9	552.65	2.74	8.75	608.74
MULA CL1	524.87	1670	544.06	552.65	2.58	8.59	647.43
MULA CL1	474.87	1670	544.03	552.43	3.12	8.4	534.85
MULA CL1	424.97	1670	544.61	552.47	2.7	7.86	618.25
MULA CL1	374.97	1670	544.69	552.49	2.41	7.8	692.56
MULA CL1	325	1670	544.73	552.42	2.54	7.69	658.46
MULA CL1	275	1670	544.42	552.43	2.33	8.01	715.45
MULA CL1	225.01	1670	544.46	552.46	2.03	8	822.07
MULA CL1	175.01	1670	544.65	552.44	2.06	7.79	811.91
MULA CL1	125.01	1670	545.15	552.38	2.23	7.23	747.56
MULA CL1	75.01	1670	544.93	552.33	2.33	7.4	716.94
MULA CL1	25.01	1670	544.87	552.34	2.14	7.47	778.8

ANNEXURE XVI

OUTPUT OF MULA RIVER UPTO SANGAM FROM HEC RAS FOR FLOOD DISCHARGE OF 25 YEAR RETURN PERIOD

Sr No	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Vel Chnl (m/s)	Difference in Depth	Flow Area (m2)
MULA CL 2	12047.05	2875	544.73	554.92	2.23	10.19	1288.05
MULA CL 2	11997.19	2875	544.83	554.9	2.28	10.07	1261.36
MULA CL 2	11945	DAPODI BRIDGE					
MULA CL 2	11897.23	2875	544.64	554.61	2.26	9.97	1274.93
MULA CL 2	11847.23	2875	544.74	554.59	2.28	9.85	1259.31
MULA CL 2	11797.23	2875	544.53	554.57	2.27	10.04	1265.31
MULA CL 2	11747.23	2875	544.6	554.55	2.31	9.95	1245.31
MULA CL 2	11697.23	2875	544.8	554.56	2.18	9.76	1321.2
MULA CL 2	11670	DAPODI RAILWAY BRIDGE					
MULA CL 2	11647.23	2875	545.33	554.4	2.26	9.07	1273.93
MULA CL 2	11610	OLD HARRIS BRIDGE					
MULA CL 2	11597	2875	545.83	554.29	2.22	8.46	1296.28
MULA CL 2	11575	NEW HARRIS BRIDGE					
MULA CL 2	11547.23	2875	545.17	554.25	2.26	9.08	1271.97
MULA CL 2	11497.23	2875	544.55	554.26	2.14	9.71	1344.5
MULA CL 2	11447.23	2875	544.7	554.23	2.2	9.53	1304.69
MULA CL 2	11397.23	2875	544.82	554.16	2.41	9.34	1192.4
MULA CL 2	11347.23	2875	544.99	554.14	2.4	9.15	1197.65
MULA CL 2	11297.23	2875	544.64	553.95	2.98	9.31	964.89
MULA CL 2	11247.23	2875	545.01	553.95	2.83	8.94	1017.53
MULA CL 2	11197.22	2875	544.86	553.93	2.8	9.07	1025.09
MULA CL 2	11147.23	2875	544.96	553.89	2.86	8.93	1006.07
MULA CL 2	11097.23	2875	545.01	553.78	3.1	8.77	928.49
MULA CL 2	11047.23	2875	544.54	553.74	3.11	9.2	923.49
MULA CL 2	10997.23	2875	544.34	553.67	3.23	9.33	889.88
MULA CL 2	10947.2	2875	545.16	553.55	3.45	8.39	834.35
MULA CL 2	10897.3	2875	544.86	553.54	3.33	8.68	864.18
MULA CL 2	10847.3	2875	544.4	553.55	3.14	9.15	914.27
MULA CL 2	10797.3	2875	544.53	553.47	3.26	8.94	882.78
MULA CL 2	10747.3	2875	544.58	553.44	3.27	8.86	879.93
MULA CL 2	10697.36	2875	544.58	553.25	3.64	8.67	789.05
MULA CL 2	10647.36	2875	544.32	553.4	2.83	9.08	1014.31
MULA CL 2	10597.36	2875	544.64	553.51	2.05	8.87	1401.83
MULA CL 2	10546.93	2875	544.84	553.46	2.22	8.62	1295.97
MULA CL 2	10497.36	2875	545.17	553.38	2.45	8.21	1174.57
MULA CL 2	10447.36	2875	544.64	553.32	2.58	8.68	1112.71
MULA CL 2	10397.36	2875	544.48	553.32	2.45	8.84	1174.49
MULA CL 2	10347.35	2875	544.39	553.32	2.36	8.93	1217.04
MULA CL 2	10297.33	2875	544.61	553.29	2.39	8.68	1205.4
MULA CL 2	10247.31	2875	544.74	553.27	2.36	8.53	1219.43
MULA CL 2	10197.78	2875	544.68	553.26	2.32	8.58	1237.87
MULA CL 2	10147.78	2875	544.87	553.27	2.14	8.4	1345.2
MULA CL 2	10097.78	2875	544.84	553.25	2.16	8.41	1331.88
MULA CL 2	10047.78	2875	544.72	553.25	2.06	8.53	1397.49
MULA CL 2	9997.78	2875	545.16	553.23	2.08	8.07	1381.31
MULA CL 2	9947.78	2875	544.55	553.22	2.01	8.67	1426.82

MULA CL 2	9897.78	2875	544.59	553.19	2.1	8.6	1365.89
MULA CL 2	9847.77	2875	544.47	553.11	2.34	8.64	1228.17
MULA CL 2	9797.81	2875	544.53	553.09	2.31	8.56	1246.67
MULA CL 2	9747.81	2875	544.34	553.08	2.27	8.74	1264.38
MULA CL 2	9697.8	2875	544.66	553.08	2.11	8.42	1364.14
MULA CL 2	9647.8	2875	544.99	553.05	2.15	8.06	1335.91
MULA CL 2	9597.8	2875	544.8	553.07	1.95	8.27	1476.16
MULA CL 2	9547.8	2875	544.83	553.06	1.9	8.23	1512.25
MULA CL 2	9497.8	2875	545.32	553.02	2.01	7.7	1430.06
MULA CL 2	9447.8	2875	545.05	552.99	2.08	7.94	1379.91
MULA CL 2	9347.9	2875	545.22	552.94	2.13	7.72	1351.72
MULA CL 2	9297.9	2875	544.94	552.94	2.02	8	1425
MULA CL 2	9247.9	2875	544.73	552.94	1.88	8.21	1526.18
MULA CL 2	9197.9	2875	544.63	552.89	2.03	8.26	1419.64
MULA CL 2	9147.9	2875	544.78	552.88	2.01	8.1	1432.59
MULA CL 2	9097.9	2875	544.85	552.87	1.98	8.02	1449.19
MULA CL 2	9047.9	2875	544.66	552.83	2.08	8.17	1384.24
MULA CL 2	8947.9	2875	544.86	552.73	2.32	7.87	1237.14
MULA CL 2	8897.9	2875	544.77	552.7	2.31	7.93	1242.28
MULA CL 2	8847.9	2875	545.45	552.67	2.35	7.22	1223.07
MULA CL 2	8797.9	2875	544.34	552.69	2.1	8.35	1370.81
MULA CL 2	8747.94	2875	544.48	552.65	2.18	8.17	1316.9
MULA CL 2	8697.94	2875	545.3	552.57	2.39	7.27	1201.98
MULA CL 2	8647.94	2875	544.83	552.59	2.11	7.76	1364.93
MULA CL 2	8597.94	2875	544.69	552.55	2.18	7.86	1320.21
MULA CL 2	8547.94	2875	544.58	552.5	2.31	7.92	1241.99
MULA CL 2	8497.94	2875	544.52	552.45	2.39	7.93	1202.34
MULA CL 2	8447.94	2875	544.8	552.44	2.29	7.64	1255.73
MULA CL 2	8397.94	2875	544.77	552.4	2.32	7.63	1240.99
MULA CL 2	8347.94	2875	544.47	552.39	2.22	7.92	1294.3
MULA CL 2	8297.94	2875	544.67	552.33	2.3	7.66	1248.32
MULA CL 2	8247.93	2875	544.81	552.25	2.47	7.44	1163.36
MULA CL 2	8197.93	2875	544.35	552.25	2.23	7.9	1287.12
MULA CL 2	8147.93	2875	544.34	552.23	2.15	7.89	1337.32
MULA CL 2	8097.93	2875	544.51	552.17	2.26	7.66	1272.5
MULA CL 2	8047.93	2875	544.62	552.18	1.96	7.56	1467.75
MULA CL 2	7997.93	2875	544.73	552.13	2.05	7.4	1401.53
MULA CL 2	7898.19	2875	544.83	552.03	2.14	7.2	1340.47
MULA CL 2	7798.73	2875	545.28	551.88	2.34	6.6	1229.9
MULA CL 2	7748.73	2875	544.67	551.83	2.26	7.16	1272.83
MULA CL 2	7698.78	2875	544.77	551.71	2.47	6.94	1165.5
MULA CL 2	7648.78	2875	544.93	551.46	3.03	6.53	949.9
MULA CL 2	7598.78	2875	544.74	551.27	3.25	6.53	885.08
MULA CL 2	7548.77	2875	544.56	551.21	3.03	6.65	948.17
MULA CL 2	7498.78	2875	544.73	551.06	3.17	6.33	908.08
MULA CL 2	7448.78	2875	544.75	551.14	2.39	6.39	1200.72
MULA CL 2	7398.38	2875	544.27	550.92	2.95	6.65	975.9
MULA CL 2	7349.36	2875	544.38	550.81	3.07	6.43	937.3
MULA CL 2	7298.85	2875	544.3	550.68	3.24	6.38	886.22
MULA CL 2	7248.85	2875	544.52	550.46	3.62	5.94	794.77
MULA CL 2	7198.82	2875	543.92	550.45	3.34	6.53	859.74
MULA CL 2	7148.9	2875	544.46	550.27	3.61	5.81	796.93

MULA CL 2	7098.9	2875	543.94	550.4	2.74	6.46	1049.2
MULA CL 2	7048.9	2875	543.96	550.46	2.24	6.5	1283.6
MULA CL 2	7045	CHECK DAM 1					
MULA CL 2	6998.9	2875	543.52	549.8	2.34	6.28	1228.41
MULA CL 2	6948.9	2875	543.09	549.78	2.25	6.69	1276.34
MULA CL 2	6898.9	2875	543.23	549.7	2.42	6.47	1186.45
MULA CL 2	6848.91	2875	543.55	549.64	2.46	6.09	1166.96
MULA CL 2	6798.91	2875	543.33	549.6	2.44	6.27	1179.07
MULA CL 2	6749.15	2875	543.26	549.56	2.41	6.3	1192.42
MULA CL 2	6659	CHEKC DAM 2					
MULA CL 2	6649.15	2875	542.98	548.53	3.18	5.55	904.89
MULA CL 2	6599.21	2875	540.15	548.69	2.1	8.54	1366.14
MULA CL 2	6549.21	2875	540.32	548.67	2.01	8.35	1429.06
MULA CL 2	6499.21	2875	540.72	548.66	1.93	7.94	1491.83
MULA CL 2	6449.21	2875	540.34	548.65	1.9	8.31	1512.37
MULA CL 2	6399.2	2875	539.97	548.65	1.79	8.68	1603.82
MULA CL 2	6349.24	2875	539.64	548.66	1.62	9.02	1777.26
MULA CL 2	6299.24	2875	539.92	548.65	1.55	8.73	1853.86
MULA CL 2	6249.22	2875	539.97	548.61	1.73	8.64	1658.32
MULA CL 2	6199.26	2875	539.75	548.6	1.73	8.85	1663.85
MULA CL 2	6149.22	2875	539.86	548.58	1.76	8.72	1637.91
MULA CL 2	6099.25	2875	539.93	548.51	2.02	8.58	1425.93
MULA CL 2	6049.25	2875	539.96	548.48	2.06	8.52	1394.05
MULA CL 2	5999.27	2875	539.86	548.46	2.09	8.6	1375.75
MULA CL 2	5949.28	2875	539.93	548.46	1.98	8.53	1451.89
MULA CL 2	5903	SHANTI BRIDGE					
MULA CL 2	5849.28	2875	536.19	548.34	1.68	12.15	1709.32
MULA CL 2	5799.28	2875	536.81	548.33	1.68	11.52	1706.32
MULA CL 2	5749.28	2875	539.4	548.3	1.79	8.9	1602.12
MULA CL 2	5699.29	2875	538.51	548.29	1.71	9.78	1679.07
MULA CL 2	5649.29	2875	538.68	548.29	1.66	9.61	1737.15
MULA CL 2	5599.29	2875	538.27	548.27	1.72	10	1673.59
MULA CL 2	5549.32	2875	537	548.27	1.59	11.27	1808.22
MULA CL 2	5499.32	2875	536.74	548.2	1.87	11.46	1540.32
MULA CL 2	5449.34	2875	536.33	548.19	1.87	11.86	1540.88
MULA CL 2	5399.34	2875	537.71	548.14	2.03	10.43	1414.29
MULA CL 2	5349.34	2875	537.29	548.12	2.06	10.83	1395.03
MULA CL 2	5299.34	2875	537.9	548.06	2.22	10.16	1294.92
MULA CL 2	5249.34	2875	537.01	548.05	2.2	11.04	1305.87
MULA CL 2	5199.34	2875	537.52	548.01	2.3	10.49	1252.32
MULA CL 2	5149.35	2875	536.88	547.99	2.28	11.11	1262.55
MULA CL 2	5099.35	2875	535.94	547.98	2.24	12.04	1284.61
MULA CL 2	5049.53	2875	536.98	547.97	2.2	10.99	1307.74
MULA CL 2	4999.35	2875	536.22	547.97	2.08	11.75	1381.96
MULA CL 2	4949.35	2875	536.85	547.92	2.22	11.07	1293.24
MULA CL 2	4899.35	2875	537.56	547.88	2.31	10.32	1244.39
MULA CL 2	4849.35	2875	537.83	547.85	2.35	10.02	1223.19
MULA CL 2	4799.35	2875	537.13	547.85	2.3	10.72	1250.45
MULA CL 2	4749.35	2875	535.82	547.85	2.16	12.03	1333.73
MULA CL 2	4699.35	2875	535.62	547.88	1.9	12.26	1515.16
MULA CL 2	4649.35	2875	537.84	547.83	2.09	9.99	1374.87
MULA CL 2	4599.34	2875	536.72	547.78	2.24	11.06	1284.31

MULA CL 2	4549.34	2875	537.7	547.74	2.32	10.04	1238.06
MULA CL 2	4499.34	2875	537.89	547.76	2.1	9.87	1365.96
MULA CL 2	4449.54	2875	537.98	547.74	2.14	9.76	1345.21
MULA CL 2	4399.54	2875	537.74	547.73	2.11	9.99	1363.71
MULA CL 2	4349.54	2875	537.8	547.7	2.19	9.9	1314.76
MULA CL 2	4299.52	2875	538.09	547.66	2.27	9.57	1264.61
MULA CL 2	4249.5	2875	537.62	547.61	2.41	9.99	1192.19
MULA CL 2	4199.53	2875	537.74	547.6	2.35	9.86	1224.8
MULA CL 2	4149.53	2875	537.65	547.49	2.62	9.84	1096.85
MULA CL 2	4099.53	2875	537.94	547.46	2.65	9.52	1085.79
MULA CL 2	4049.53	2875	538	547.43	2.63	9.43	1091.79
MULA CL 2	3999.58	2875	537.88	547.42	2.54	9.54	1133.79
MULA CL 2	3949.58	2875	537.66	547.39	2.55	9.73	1128.8
MULA CL 2	3899.58	2875	537.53	547.34	2.63	9.81	1093.51
MULA CL 2	3849.58	2875	536.88	547.35	2.45	10.47	1173.07
MULA CL 2	3799.64	2875	537.71	547.24	2.75	9.53	1046.21
MULA CL 2	3749.64	2875	538	547.17	2.85	9.17	1009.65
MULA CL 2	3699.64	2875	537.78	547.18	2.63	9.4	1094.18
MULA CL 2	3649.64	2875	537.74	547.12	2.73	9.38	1051.46
MULA CL 2	3599.65	2875	537.99	547.09	2.73	9.1	1052.75
MULA CL 2	3549.65	2875	537.92	547.07	2.68	9.15	1072.6
MULA CL 2	3499.59	2875	538.05	547.05	2.6	9	1104.75
MULA CL 2	3479	OLD HOLKAR BRIDGE					
MULA CL 2	3449.64	2875	537.6	546.53	2.51	8.93	1147.65
MULA CL 2	3379	HOLKAR BRIDGE LOW					
MULA CL 2	3349.62	2875	537.55	546.27	3.02	8.72	951.26
MULA CL 2	3337	HOLKAR BRIDGE					
MULA CL 2	3299.67	2875	537.11	546.23	2.9	9.12	991.16
MULA CL 2	3249.66	2875	536.71	546.14	3.08	9.43	934.43
MULA CL 2	3199.66	2875	536.98	546.12	3.03	9.14	948.09
MULA CL 2	3149.65	2875	536.94	546.12	2.9	9.18	993.09
MULA CL 2	3099.73	2875	536.95	546.1	2.82	9.15	1020
MULA CL 2	3049.71	2875	536.75	546.05	2.9	9.3	990.89
MULA CL 2	2999.69	2875	536.78	545.98	2.99	9.2	960.14
MULA CL 2	2949.81	2875	536.87	545.96	2.92	9.09	983.67
MULA CL 2	2899.81	2875	536.99	545.95	2.82	8.96	1019.22
MULA CL 2	2849.8	2875	536.7	545.97	2.63	9.27	1092.63
MULA CL 2	2799.83	2875	536.59	545.95	2.6	9.36	1105.15
MULA CL 2	2749.83	2875	536.52	545.93	2.58	9.41	1112.19
MULA CL 2	2699.83	2875	536.75	545.93	2.44	9.18	1179.17
MULA CL 2	2649.83	2875	536.98	545.88	2.55	8.9	1129.15
MULA CL 2	2599.82	2875	536.65	545.84	2.61	9.19	1102.83
MULA CL 2	2549.82	2875	536.71	545.75	2.79	9.04	1029.89
MULA CL 2	2499.82	2875	536.54	545.73	2.79	9.19	1029.81
MULA CL 2	2449.83	2875	536.45	545.68	2.83	9.23	1015.74
MULA CL 2	2399.83	2875	536.42	545.68	2.68	9.26	1070.78
MULA CL 2	2349.83	2875	536.53	545.61	2.81	9.08	1022.13
MULA CL 2	2299.83	2875	536.56	545.53	2.96	8.97	971.69
MULA CL 2	2249.83	2875	536.64	545.5	2.95	8.86	976.12
MULA CL 2	2199.83	2875	536.77	545.55	2.54	8.78	1129.93
MULA CL 2	2149.83	2875	536.68	545.52	2.53	8.84	1134.78
MULA CL 2	2099.83	2875	536.59	545.5	2.5	8.91	1150.5

MULA CL 2	2049.83	2875	536.5	545.49	2.45	8.99	1171.85
MULA CL 2	1999.83	2875	536.25	545.47	2.45	9.22	1175.5
MULA CL 2	1949.83	2875	536.35	545.42	2.54	9.07	1133.29
MULA CL 2	1899.83	2875	536.37	545.4	2.5	9.03	1147.91
MULA CL 2	1849.83	2875	536.79	545.36	2.55	8.57	1126.94
MULA CL 2	1799.83	2875	536.38	545.36	2.44	8.98	1176.05
MULA CL 2	1749.83	2875	536.75	545.33	2.47	8.58	1162.58
MULA CL 2	1699.83	2875	536.72	545.32	2.35	8.6	1221.9
MULA CL 2	1649.83	2875	536.85	545.31	2.3	8.46	1249.63
MULA CL 2	1599.83	2875	536.91	545.22	2.51	8.31	1146.36
MULA CL 2	1549.83	2875	536.91	545.19	2.54	8.28	1132.6
MULA CL 2	1499.83	2875	536.54	545.11	2.7	8.57	1066.28
MULA CL 2	1449.83	2875	536.8	545.04	2.84	8.24	1011.45
MULA CL 2	1399.83	2875	536.86	545.04	2.67	8.18	1075.11
MULA CL 2	1349.82	2875	536.85	545.01	2.68	8.16	1072.12
MULA CL 2	1299.84	2875	537.05	544.96	2.76	7.91	1042.09
MULA CL 2	1249.84	2875	537.03	544.89	2.87	7.86	1001.77
MULA CL 2	1199.84	2875	537.06	544.85	2.9	7.79	993.06
MULA CL 2	1149.84	2875	537.02	544.84	2.81	7.82	1022.89
MULA CL 2	1099.86	2875	536.84	544.83	2.72	7.99	1058.56
MULA CL 2	1049.86	2875	536.77	544.81	2.68	8.04	1071.85
MULA CL 2	999.86	2875	536.85	544.77	2.7	7.92	1064.64
MULA CL 2	949.86	2875	536.79	544.68	2.91	7.89	986.46
MULA CL 2	899.84	2875	536.89	544.65	2.89	7.76	994.29
MULA CL 2	849.89	2875	536.84	544.55	3.09	7.71	930.57
MULA CL 2	799.89	2875	537	544.53	2.99	7.53	963.1
MULA CL 2	749.89	2875	536.84	544.48	3.02	7.64	953.46
MULA CL 2	699.89	2875	536.76	544.45	2.99	7.69	960.76
MULA CL 2	649.89	2875	536.87	544.38	3.07	7.51	937.7
MULA CL 2	599.89	2875	537.1	544.3	3.15	7.2	912.3
MULA CL 2	569	SANGAM BRIDGE					
MULA CL 2	499.85	2875	536.77	544.08	3.2	7.31	897.13
MULA CL 2	449.85	2875	536.42	544.02	3.21	7.6	895.11
MULA CL 2	399.97	2875	536.79	543.86	3.5	7.07	822.32
MULA CL 2	349.97	2875	536.81	543.84	3.32	7.03	866.92
MULA CL 2	299.97	2875	536.92	543.63	3.69	6.71	778.69
MULA CL 2	249.97	2875	536.93	543.64	3.32	6.71	865.67
MULA CL 2	199.98	2875	537.28	543.12	4.27	5.84	673.1
MULA CL 2	149.98	2875	537.65	543.01	4.14	5.36	694.56
MULA CL 2	100	2875	536.15	543.03	3.64	6.88	790.17
MULA CL 2	50	2875	536.42	543.12	3	6.7	957.92
MULA CL 2	0	2875	536.48	543.2	2.37	6.72	1214.66

ANNEXURE XVII

OUTPUT OF MULA RIVER UPTO SANGAM FROM HEC RAS FOR FLOOD DISCHARGE OF 100 YEAR RETURN PERIOD

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Difference in	Flow Area
		(m3/s)	(m)	(m)	(m/s)	Depth	(m2)
MULA CL 2	12047.05	3971	544.73	556.61	2.62	11.88	1516.23
MULA CL 2	11997.19	3971	544.83	556.58	2.67	11.75	1490.05
MULA CL 2	11945	DAPODI BRIDGE					
MULA CL 2	11897.23	3971	544.64	556.31	2.6	11.67	1528.15
MULA CL 2	11847.23	3971	544.74	556.29	2.63	11.55	1512.25
MULA CL 2	11797.23	3971	544.53	556.27	2.62	11.74	1518.12
MULA CL 2	11747.23	3971	544.6	556.25	2.65	11.65	1497.82
MULA CL 2	11697.23	3971	544.8	556.25	2.52	11.45	1573.9
MULA CL 2	11670	DAPODI RAILWAY BRIDGE					
MULA CL 2	11647.23	3971	545.33	555.91	2.65	10.58	1499.65
MULA CL 2	11610	OLD HARRIS BRIDGE					
MULA CL 2	11597	3971	545.83	555.74	2.6	9.91	1527.98
MULA CL 2	11575	NEW HARRIS BRIDGE					
MULA CL 2	11547.23	3971	545.17	555.62	2.69	10.45	1475.45
MULA CL 2	11497.23	3971	544.55	555.63	2.56	11.08	1553.32
MULA CL 2	11447.23	3971	544.7	555.59	2.62	10.89	1515.28
MULA CL 2	11397.23	3971	544.82	555.5	2.87	10.68	1383.48
MULA CL 2	11347.23	3971	544.99	555.48	2.86	10.49	1389.95
MULA CL 2	11297.23	3971	544.64	555.19	3.59	10.55	1106.9
MULA CL 2	11247.23	3971	545.01	555.21	3.36	10.2	1180.88
MULA CL 2	11197.22	3971	544.86	555.19	3.34	10.33	1190.15
MULA CL 2	11147.23	3971	544.96	555.13	3.41	10.17	1164.98
MULA CL 2	11097.23	3971	545.01	554.98	3.7	9.97	1073.94
MULA CL 2	11047.23	3971	544.54	554.92	3.76	10.38	1057.25
MULA CL 2	10997.23	3971	544.34	554.82	3.9	10.48	1018.52
MULA CL 2	10947.2	3971	545.16	554.65	4.15	9.49	956.37
MULA CL 2	10897.3	3971	544.86	554.64	4.02	9.78	987.84
MULA CL 2	10847.3	3971	544.4	554.66	3.83	10.26	1037.97
MULA CL 2	10797.3	3971	544.53	554.56	3.95	10.03	1004.17
MULA CL 2	10747.3	3971	544.58	554.5	3.98	9.92	996.95
MULA CL 2	10697.36	3971	544.58	554.25	4.41	9.67	899.99
MULA CL 2	10647.36	3971	544.32	554.49	3.37	10.17	1176.79
MULA CL 2	10597.36	3971	544.64	554.66	2.44	10.02	1625.93
MULA CL 2	10546.93	3971	544.84	554.59	2.63	9.75	1510.63
MULA CL 2	10497.36	3971	545.17	554.47	2.93	9.3	1356.51
MULA CL 2	10447.36	3971	544.64	554.38	3.13	9.74	1270.23
MULA CL 2	10397.36	3971	544.48	554.38	2.96	9.9	1342.03
MULA CL 2	10347.35	3971	544.39	554.38	2.85	9.99	1391.58
MULA CL 2	10297.33	3971	544.61	554.36	2.86	9.75	1388.78
MULA CL 2	10247.31	3971	544.74	554.34	2.82	9.6	1408.8
MULA CL 2	10197.78	3971	544.68	554.32	2.78	9.64	1427.04
MULA CL 2	10147.78	3971	544.87	554.35	2.54	9.48	1565.3
MULA CL 2	10097.78	3971	544.84	554.32	2.57	9.48	1546.97
MULA CL 2	10047.78	3971	544.72	554.32	2.45	9.6	1619.96
MULA CL 2	9997.78	3971	545.16	554.3	2.47	9.14	1606.91
MULA CL 2	9947.78	3971	544.55	554.28	2.45	9.73	1618.07

MULA CL 2	9897.78	3971	544.59	554.25	2.5	9.66	1587.26
MULA CL 2	9847.77	3971	544.47	554.16	2.74	9.69	1448.36
MULA CL 2	9797.81	3971	544.53	554.13	2.76	9.6	1441.27
MULA CL 2	9747.81	3971	544.34	554.11	2.74	9.77	1449.91
MULA CL 2	9697.8	3971	544.66	554.13	2.5	9.47	1586.21
MULA CL 2	9647.8	3971	544.99	554.1	2.53	9.11	1566.63
MULA CL 2	9597.8	3971	544.8	554.12	2.31	9.32	1717.08
MULA CL 2	9547.8	3971	544.83	554.11	2.26	9.28	1755.12
MULA CL 2	9497.8	3971	545.32	554.06	2.37	8.74	1673.94
MULA CL 2	9447.8	3971	545.05	554.02	2.45	8.97	1620.58
MULA CL 2	9347.9	3971	545.22	553.96	2.52	8.74	1575.26
MULA CL 2	9297.9	3971	544.94	553.96	2.38	9.02	1665.58
MULA CL 2	9247.9	3971	544.73	553.97	2.24	9.24	1773.37
MULA CL 2	9197.9	3971	544.63	553.9	2.43	9.27	1634.8
MULA CL 2	9147.9	3971	544.78	553.89	2.38	9.11	1665.75
MULA CL 2	9097.9	3971	544.85	553.87	2.36	9.02	1686.07
MULA CL 2	9047.9	3971	544.66	553.82	2.47	9.16	1609.58
MULA CL 2	8947.9	3971	544.86	553.69	2.77	8.83	1435.42
MULA CL 2	8897.9	3971	544.77	553.66	2.77	8.89	1435.17
MULA CL 2	8847.9	3971	545.45	553.63	2.77	8.18	1433.75
MULA CL 2	8797.9	3971	544.34	553.66	2.47	9.32	1608.66
MULA CL 2	8747.94	3971	544.48	553.6	2.59	9.12	1535.51
MULA CL 2	8697.94	3971	545.3	553.51	2.8	8.21	1416.05
MULA CL 2	8647.94	3971	544.83	553.54	2.5	8.71	1588.21
MULA CL 2	8597.94	3971	544.69	553.49	2.59	8.8	1531.91
MULA CL 2	8547.94	3971	544.58	553.41	2.77	8.83	1435.4
MULA CL 2	8497.94	3971	544.52	553.37	2.81	8.85	1410.86
MULA CL 2	8447.94	3971	544.8	553.36	2.69	8.56	1475.18
MULA CL 2	8397.94	3971	544.77	553.33	2.67	8.56	1484.66
MULA CL 2	8347.94	3971	544.47	553.32	2.54	8.85	1566.39
MULA CL 2	8297.94	3971	544.67	553.26	2.64	8.59	1505.06
MULA CL 2	8247.93	3971	544.81	553.18	2.79	8.37	1423.48
MULA CL 2	8197.93	3971	544.35	553.19	2.53	8.84	1569.8
MULA CL 2	8147.93	3971	544.34	553.18	2.42	8.84	1642.69
MULA CL 2	8097.93	3971	544.51	553.12	2.49	8.61	1592.31
MULA CL 2	8047.93	3971	544.62	553.15	2.13	8.53	1860.38
MULA CL 2	7997.93	3971	544.73	553.1	2.21	8.37	1794.22
MULA CL 2	7898.19	3971	544.83	553.02	2.29	8.19	1736.38
MULA CL 2	7798.73	3971	545.28	552.92	2.38	7.64	1669.95
MULA CL 2	7748.73	3971	544.67	552.9	2.25	8.23	1763.19
MULA CL 2	7698.78	3971	544.77	552.82	2.42	8.05	1641.26
MULA CL 2	7648.78	3971	544.93	552.64	2.84	7.71	1399.11
MULA CL 2	7598.78	3971	544.74	552.53	2.96	7.79	1341.6
MULA CL 2	7548.77	3971	544.56	552.47	2.96	7.91	1343.14
MULA CL 2	7498.78	3971	544.73	552.42	2.9	7.69	1370.37
MULA CL 2	7448.78	3971	544.75	552.47	2.4	7.72	1651.5
MULA CL 2	7398.38	3971	544.27	552.24	3.04	7.97	1306.44
MULA CL 2	7349.36	3971	544.38	552.16	3.13	7.78	1269.69
MULA CL 2	7298.85	3971	544.3	551.98	3.47	7.68	1143.64
MULA CL 2	7248.85	3971	544.52	551.8	3.75	7.28	1060.31
MULA CL 2	7198.82	3971	543.92	551.79	3.56	7.87	1116.19
MULA CL 2	7148.9	3971	544.46	551.68	3.67	7.22	1082.16

MULA CL 2	7098.9	3971	543.94	551.79	2.99	7.85	1328.02
MULA CL 2	7048.9	3971	543.96	551.87	2.43	7.91	1634.48
MULA CL 2	7045	Check Dam 1					
MULA CL 2	6998.9	3971	543.52	551.22	2.46	7.7	1614.97
MULA CL 2	6948.9	3971	543.09	551.21	2.35	8.12	1687.13
MULA CL 2	6898.9	3971	543.23	551.16	2.45	7.93	1620.83
MULA CL 2	6848.91	3971	543.55	551.12	2.47	7.57	1609.13
MULA CL 2	6798.91	3971	543.33	551.1	2.42	7.77	1640.03
MULA CL 2	6749.15	3971	543.26	551.07	2.43	7.81	1635.05
MULA CL 2	6659	Check Dam 2					
MULA CL 2	6649.15	3971	542.98	550.5	2.85	7.52	1394.2
MULA CL 2	6599.21	3971	540.15	550.63	1.94	10.48	2042.88
MULA CL 2	6549.21	3971	540.32	550.62	1.94	10.3	2047.67
MULA CL 2	6499.21	3971	540.72	550.61	1.91	9.89	2080.74
MULA CL 2	6449.21	3971	540.34	550.58	1.95	10.24	2038.83
MULA CL 2	6399.2	3971	539.97	550.59	1.82	10.62	2180.67
MULA CL 2	6349.24	3971	539.64	550.59	1.7	10.95	2342.72
MULA CL 2	6299.24	3971	539.92	550.59	1.64	10.67	2416.97
MULA CL 2	6249.22	3971	539.97	550.55	1.84	10.58	2162.45
MULA CL 2	6199.26	3971	539.75	550.54	1.82	10.79	2182.48
MULA CL 2	6149.22	3971	539.86	550.53	1.84	10.67	2157.69
MULA CL 2	6099.25	3971	539.93	550.46	2.1	10.53	1886.81
MULA CL 2	6049.25	3971	539.96	550.43	2.15	10.47	1845.13
MULA CL 2	5999.27	3971	539.86	550.41	2.17	10.55	1827.64
MULA CL 2	5949.28	3971	539.93	550.42	2.06	10.49	1932.25
MULA CL 2	5903	SHANTI BRIDGE					
MULA CL 2	5849.28	3971	536.19	550.28	1.77	14.09	2246.68
MULA CL 2	5799.28	3971	536.81	550.26	1.79	13.45	2222.28
MULA CL 2	5749.28	3971	539.4	550.24	1.85	10.84	2148.63
MULA CL 2	5699.29	3971	538.51	550.24	1.78	11.73	2230.56
MULA CL 2	5649.29	3971	538.68	550.24	1.71	11.56	2324.17
MULA CL 2	5599.29	3971	538.27	550.2	1.83	11.93	2169.74
MULA CL 2	5549.32	3971	537	550.22	1.65	13.22	2407.15
MULA CL 2	5499.32	3971	536.74	550.15	1.96	13.41	2023.8
MULA CL 2	5449.34	3971	536.33	550.12	2.03	13.79	1956.21
MULA CL 2	5399.34	3971	537.71	550.06	2.21	12.35	1800.43
MULA CL 2	5349.34	3971	537.29	550.04	2.25	12.75	1766.53
MULA CL 2	5299.34	3971	537.9	549.99	2.4	12.09	1655.43
MULA CL 2	5249.34	3971	537.01	549.97	2.41	12.96	1646.91
MULA CL 2	5199.34	3971	537.52	549.93	2.51	12.41	1583.69
MULA CL 2	5149.35	3971	536.88	549.92	2.48	13.04	1602.81
MULA CL 2	5099.35	3971	535.94	549.91	2.42	13.97	1640.26
MULA CL 2	5049.53	3971	536.98	549.9	2.38	12.92	1671.76
MULA CL 2	4999.35	3971	536.22	549.91	2.26	13.69	1754.97
MULA CL 2	4949.35	3971	536.85	549.86	2.4	13.01	1656
MULA CL 2	4899.35	3971	537.56	549.82	2.48	12.26	1598.16
MULA CL 2	4849.35	3971	537.83	549.75	2.64	11.92	1506.41
MULA CL 2	4799.35	3971	537.13	549.75	2.59	12.62	1533.71
MULA CL 2	4749.35	3971	535.82	549.76	2.45	13.94	1623.73
MULA CL 2	4699.35	3971	535.62	549.79	2.17	14.17	1833.18
MULA CL 2	4649.35	3971	537.84	549.74	2.35	11.9	1690.72
MULA CL 2	4599.34	3971	536.72	549.68	2.51	12.96	1583.84

MULA CL 2	4549.34	3971	537.7	549.64	2.58	11.94	1537.44
MULA CL 2	4499.34	3971	537.89	549.67	2.33	11.78	1707.52
MULA CL 2	4449.54	3971	537.98	549.64	2.4	11.66	1653.57
MULA CL 2	4399.54	3971	537.74	549.63	2.37	11.89	1673.24
MULA CL 2	4349.54	3971	537.8	549.6	2.45	11.8	1618.97
MULA CL 2	4299.52	3971	538.09	549.56	2.54	11.47	1564.94
MULA CL 2	4249.5	3971	537.62	549.52	2.62	11.9	1515.86
MULA CL 2	4199.53	3971	537.74	549.52	2.5	11.78	1585.49
MULA CL 2	4149.53	3971	537.65	549.43	2.73	11.78	1453.97
MULA CL 2	4099.53	3971	537.94	549.4	2.76	11.46	1439.75
MULA CL 2	4049.53	3971	538	549.38	2.75	11.38	1442.27
MULA CL 2	3999.58	3971	537.88	549.37	2.68	11.49	1479.79
MULA CL 2	3949.58	3971	537.66	549.34	2.72	11.68	1460.63
MULA CL 2	3899.58	3971	537.53	549.3	2.78	11.77	1429.34
MULA CL 2	3849.58	3971	536.88	549.31	2.61	12.43	1519.82
MULA CL 2	3799.64	3971	537.71	549.22	2.84	11.51	1398.95
MULA CL 2	3749.64	3971	538	549.18	2.9	11.18	1367.78
MULA CL 2	3699.64	3971	537.78	549.18	2.75	11.4	1443.67
MULA CL 2	3649.64	3971	537.74	549.14	2.82	11.4	1406.25
MULA CL 2	3599.65	3971	537.99	549.12	2.79	11.13	1422.24
MULA CL 2	3549.65	3971	537.92	549.11	2.74	11.19	1451.24
MULA CL 2	3499.59	3971	538.05	549.1	2.65	11.05	1496.92
MULA CL 2	3479	OLD HOLKAR BRIDGE					
MULA CL 2	3449.64	3971	537.6	547.99	2.8	10.39	1416.87
MULA CL 2	3379	HOLKAR BRIDGE LOW					
MULA CL 2	3349.62	3971	537.55	547.66	3.43	10.11	1157.66
MULA CL 2	3337	HOLKAR BRIDGE					
MULA CL 2	3299.67	3971	537.11	547.61	3.32	10.5	1196.23
MULA CL 2	3249.66	3971	536.71	547.48	3.57	10.77	1112.65
MULA CL 2	3199.66	3971	536.98	547.45	3.54	10.47	1122.74
MULA CL 2	3149.65	3971	536.94	547.46	3.33	10.52	1193.53
MULA CL 2	3099.73	3971	536.95	547.45	3.25	10.5	1220.38
MULA CL 2	3049.71	3971	536.75	547.38	3.34	10.63	1188.05
MULA CL 2	2999.69	3971	536.78	547.31	3.43	10.53	1158.62
MULA CL 2	2949.81	3971	536.87	547.3	3.36	10.43	1181.28
MULA CL 2	2899.81	3971	536.99	547.29	3.26	10.3	1217.53
MULA CL 2	2849.8	3971	536.7	547.31	3.05	10.61	1301.63
MULA CL 2	2799.83	3971	536.59	547.28	3.03	10.69	1311.54
MULA CL 2	2749.83	3971	536.52	547.26	3	10.74	1322.33
MULA CL 2	2699.83	3971	536.75	547.28	2.8	10.53	1415.96
MULA CL 2	2649.83	3971	536.98	547.22	2.92	10.24	1359.85
MULA CL 2	2599.82	3971	536.65	547.16	3.02	10.51	1314.49
MULA CL 2	2549.82	3971	536.71	547.06	3.21	10.35	1237.51
MULA CL 2	2499.82	3971	536.54	547.03	3.19	10.49	1245.7
MULA CL 2	2449.83	3971	536.45	546.99	3.22	10.54	1231.89
MULA CL 2	2399.83	3971	536.42	546.99	3.08	10.57	1290.33
MULA CL 2	2349.83	3971	536.53	546.92	3.18	10.39	1249.42
MULA CL 2	2299.83	3971	536.56	546.84	3.29	10.28	1208.09
MULA CL 2	2249.83	3971	536.64	546.76	3.4	10.12	1167.19
MULA CL 2	2199.83	3971	536.77	546.84	2.89	10.07	1372.84
MULA CL 2	2149.83	3971	536.68	546.82	2.87	10.14	1381.94
MULA CL 2	2099.83	3971	536.59	546.79	2.86	10.2	1389.7

MULA CL 2	2049.83	3971	536.5	546.78	2.79	10.28	1421.86
MULA CL 2	1999.83	3971	536.25	546.76	2.78	10.51	1427.53
MULA CL 2	1949.83	3971	536.35	546.69	2.91	10.34	1363.2
MULA CL 2	1899.83	3971	536.37	546.66	2.92	10.29	1361.41
MULA CL 2	1849.83	3971	536.79	546.62	2.95	9.83	1348.34
MULA CL 2	1799.83	3971	536.38	546.62	2.8	10.24	1419.65
MULA CL 2	1749.83	3971	536.75	546.6	2.77	9.85	1436.05
MULA CL 2	1699.83	3971	536.72	546.6	2.64	9.88	1502.09
MULA CL 2	1649.83	3971	536.85	546.58	2.58	9.73	1536.78
MULA CL 2	1599.83	3971	536.91	546.5	2.76	9.59	1438.26
MULA CL 2	1549.83	3971	536.91	546.44	2.86	9.53	1389.42
MULA CL 2	1499.83	3971	536.54	546.32	3.11	9.78	1277.84
MULA CL 2	1449.83	3971	536.8	546.23	3.26	9.43	1218.4
MULA CL 2	1399.83	3971	536.86	546.23	3.11	9.37	1275.63
MULA CL 2	1349.82	3971	536.85	546.2	3.12	9.35	1272.77
MULA CL 2	1299.84	3971	537.05	546.14	3.21	9.09	1238.96
MULA CL 2	1249.84	3971	537.03	546.05	3.33	9.02	1192.36
MULA CL 2	1199.84	3971	537.06	546	3.37	8.94	1178.14
MULA CL 2	1149.84	3971	537.02	545.99	3.29	8.97	1206.85
MULA CL 2	1099.86	3971	536.84	545.98	3.19	9.14	1245.62
MULA CL 2	1049.86	3971	536.77	545.95	3.18	9.18	1250.1
MULA CL 2	999.86	3971	536.85	545.91	3.19	9.06	1244.93
MULA CL 2	949.86	3971	536.79	545.78	3.46	8.99	1148.76
MULA CL 2	899.84	3971	536.89	545.76	3.37	8.87	1179.62
MULA CL 2	849.89	3971	536.84	545.6	3.66	8.76	1084.7
MULA CL 2	799.89	3971	537	545.6	3.5	8.6	1133.16
MULA CL 2	749.89	3971	536.84	545.54	3.54	8.7	1123.04
MULA CL 2	699.89	3971	536.76	545.51	3.5	8.75	1134.37
MULA CL 2	649.89	3971	536.87	545.45	3.53	8.58	1125.4
MULA CL 2	599.89	3971	537.1	545.38	3.56	8.28	1115.12
MULA CL 2	569	SANGAM BRIDGE					
MULA CL 2	499.85	3971	536.77	545.16	3.55	8.39	1119.24
MULA CL 2	449.85	3971	536.42	545.02	3.74	8.6	1061.2
MULA CL 2	399.97	3971	536.79	544.83	4.05	8.04	979.52
MULA CL 2	349.97	3971	536.81	544.82	3.85	8.01	1030.7
MULA CL 2	299.97	3971	536.92	544.58	4.21	7.66	942.52
MULA CL 2	249.97	3971	536.93	544.66	3.64	7.73	1089.9
MULA CL 2	199.98	3971	537.28	544.17	4.51	6.89	879.86
MULA CL 2	149.98	3971	537.65	544.11	4.32	6.46	919.22
MULA CL 2	100	3971	536.15	544.1	4.03	7.95	985.76
MULA CL 2	50	3971	536.42	544.2	3.38	7.78	1175.1
MULA CL 2	0	3971	536.48	544.32	2.67	7.84	1489.99

4.5 2D FLOOD PLAIN MAPPING

Floodplain mapping is performed using the water surface elevations on the XS cut lines, within the limits of the bounding polygon. Floodplain mapping is completed in following steps

The first step is to create a water surface TIN from the Survey data. The TIN is created using the ArcGIS triangulation method .All water surface profiles of flood discharges are selected from the window of HEC RAS. The water surface TIN is converted into a grid based on the rasterization cell size. Then, it is compared with the TIN terrain model, which is also in grid format, allowing the elevation difference to be calculated within the bounding polygon. The areas with positive results (where water surface is higher than the terrain elevation) are included in the floodplain area (inundation depth grid). The inundation depth grid is represented with different hues of color. By using the “identify tool” button, water depth at any point can be easily identified. water surface elevation and extents of submergence within project area is shown in figure 24 to 31.

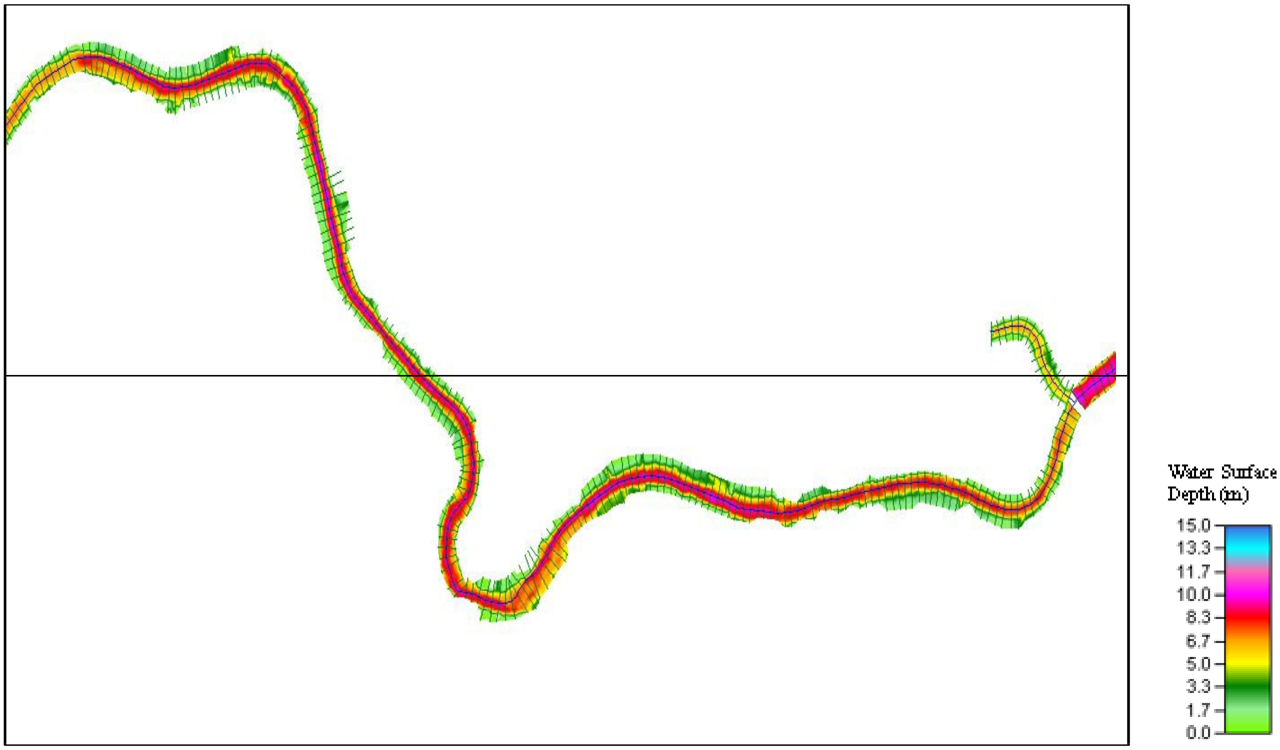


Figure 25 : Water Depth Contours i n Mula River from Balewadi Bridge up to Confluence of Pawana River for 25 Year Return Period Flood Discharge

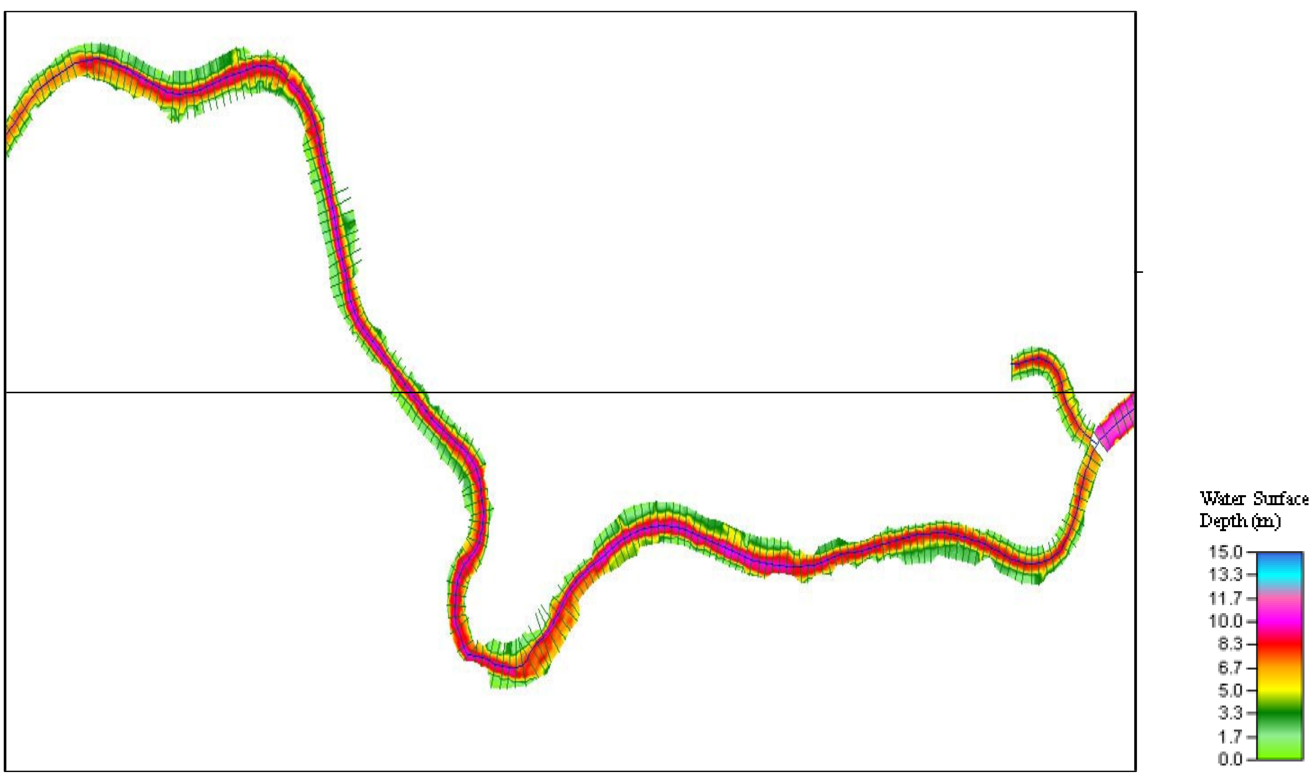


Figure 26 : Water Depth Contours in Mula River from Balewadi Bridge up to Confluence of Pawana River f or 100 Year Return Period Flood Discharge

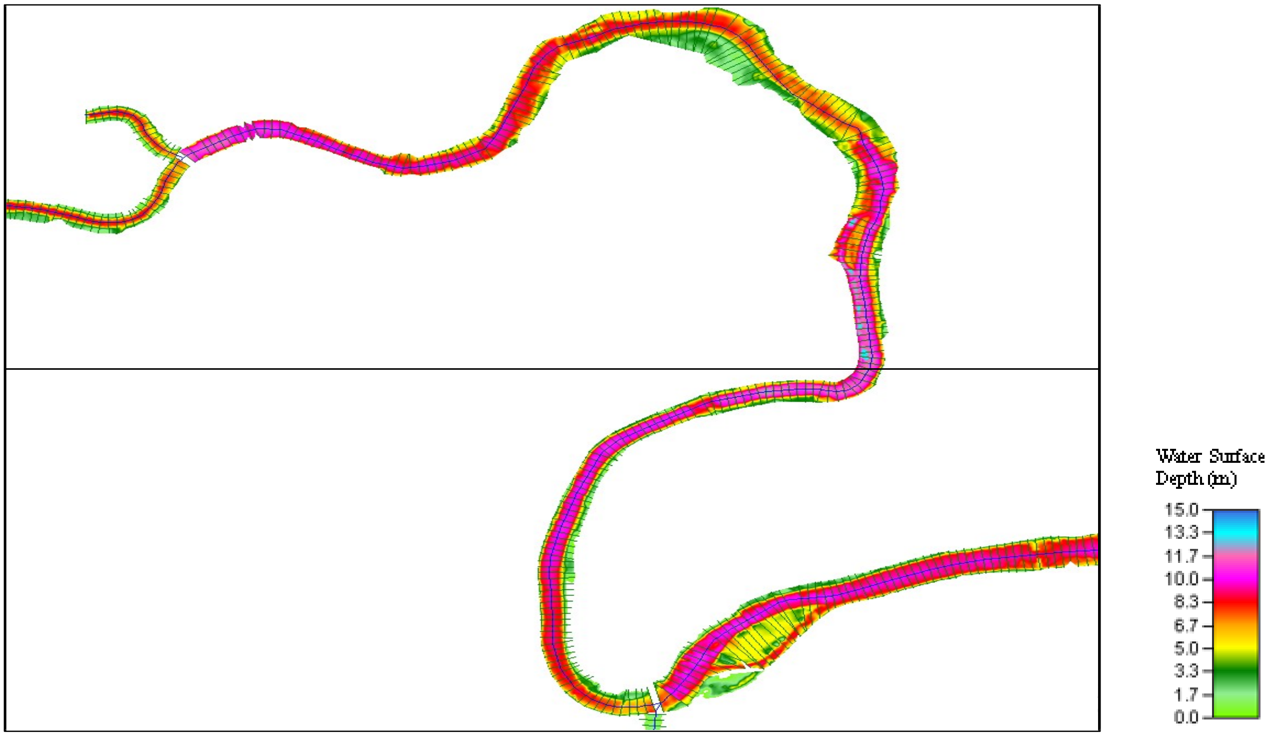


Figure 27: Water Depth Contours in Mula River from Confluence of Pawana River up to Sangam of Mutha River for 25 Year Return Period Flood Discharge

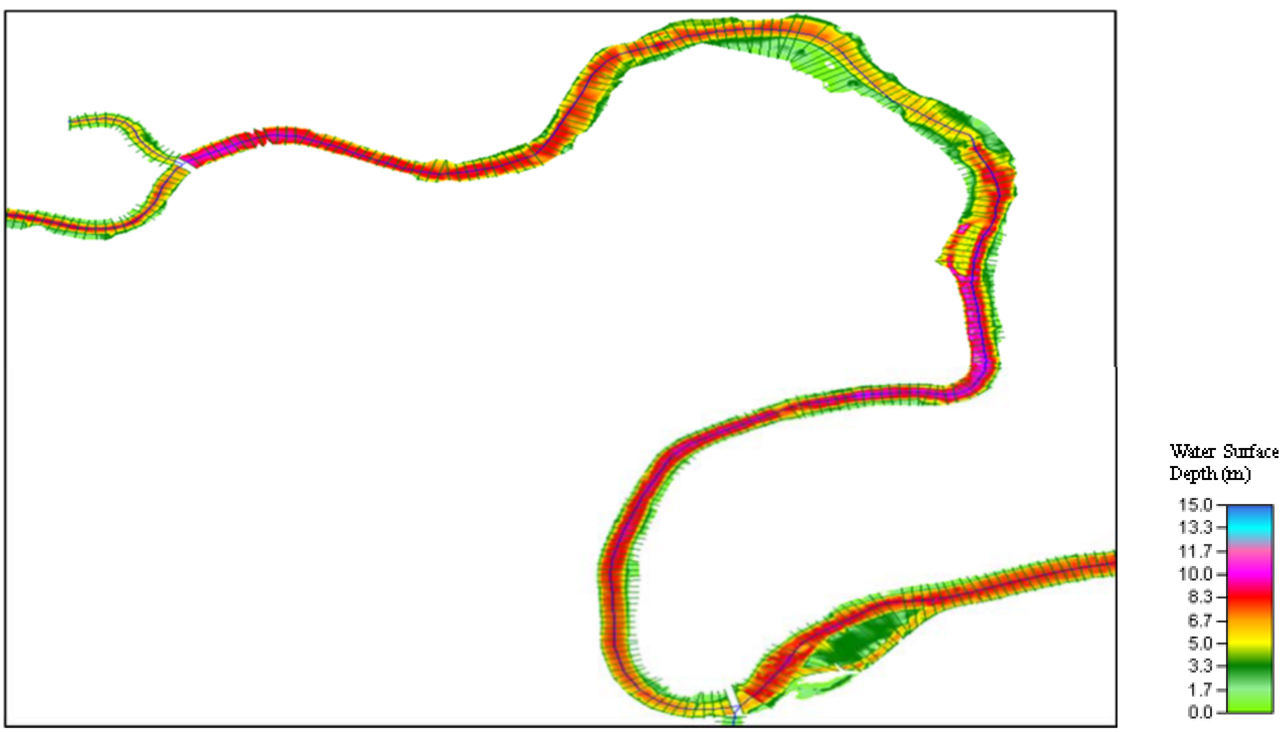


Figure 28: Water Depth Contours in Mula River from Confluence of Pawana River up to Sangam of Mutha River for 100 Year Return Period Flood Discharge

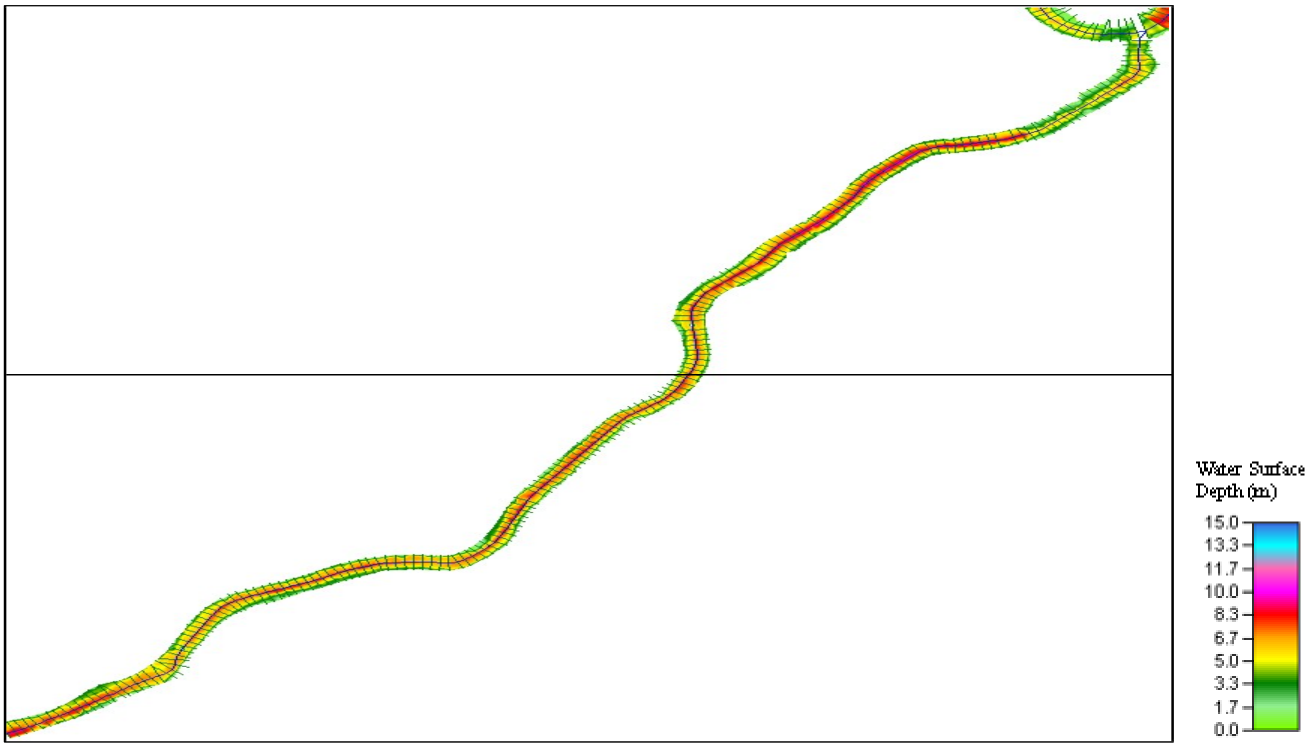


Figure 29: Water Depth Contours i n Mutha River up to Sangam of Mula River for 25 Year Return Period Flood Discharge

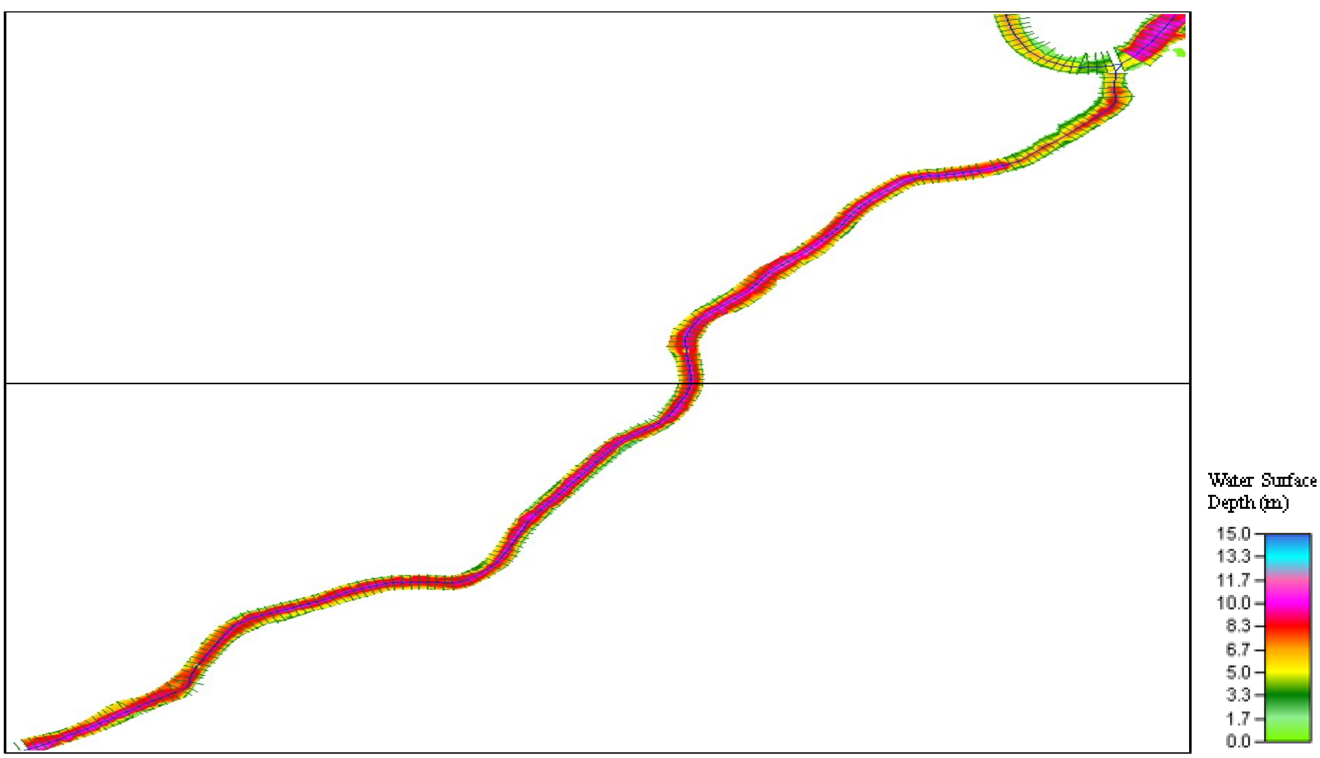


Figure 30: Water Depth Contours in Mutha River up to Sangam of Mula River for 100 Year Return Period Flood Discharge

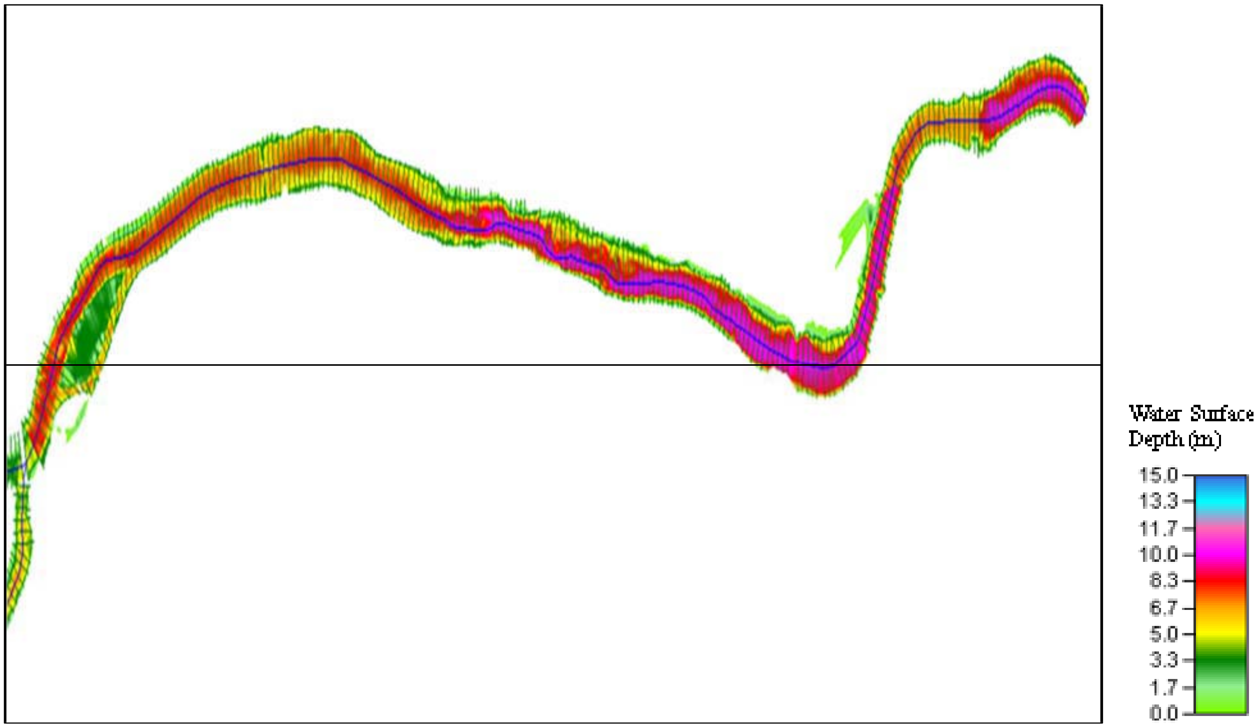


Figure 31: Water Depth Contours in Mula Mutha River from Sangam to KT Weir for 25 Year Return Period Flood Discharge

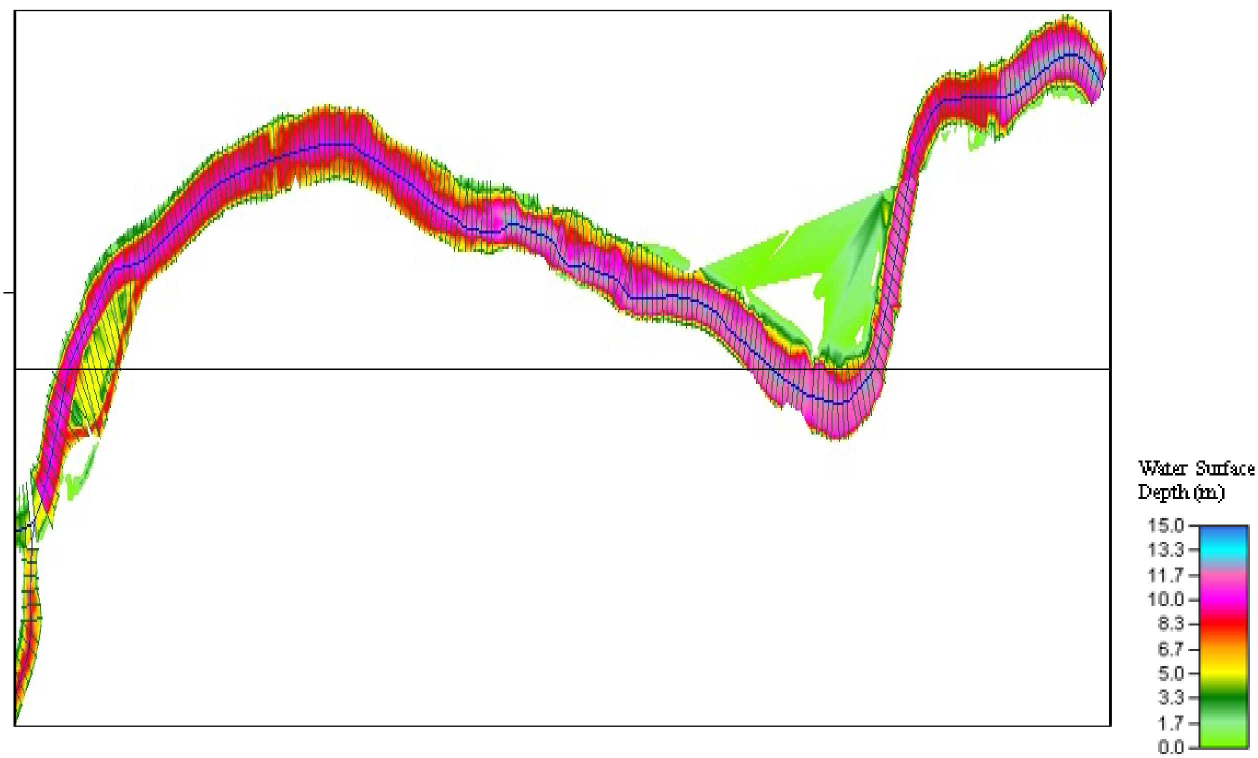


Figure 32: Water Depth Contours in Mula Mutha River from Sangam to KT Weir for 100 Year Return Period Flood Discharge

4.6 CHANNELIZED CONDITION

The alignment and the dimensions of the new channel which will protect the city against flooding and bank erosion have been determined with the following criteria.

- A stream line flow pattern allowing the river to negotiate the bends with minimum turbulence and cross currents.

- Minimum impact on water levels.

- Improving Rugosity coefficient Manning's (n).

The side walls of river front will be constructed in RCC or sloping banks with side slope of 2:1 with pitching and river bed free from bushes, vegetation, rock protruding's and other obstructing structures like manholes, temples etc. This will enhance the conveyance carrying capacity of the river & which will result into reduction in water surface elevation & result into higher velocity.

4.6.1 CHANNELIZED FLOW IN HEC-RAS

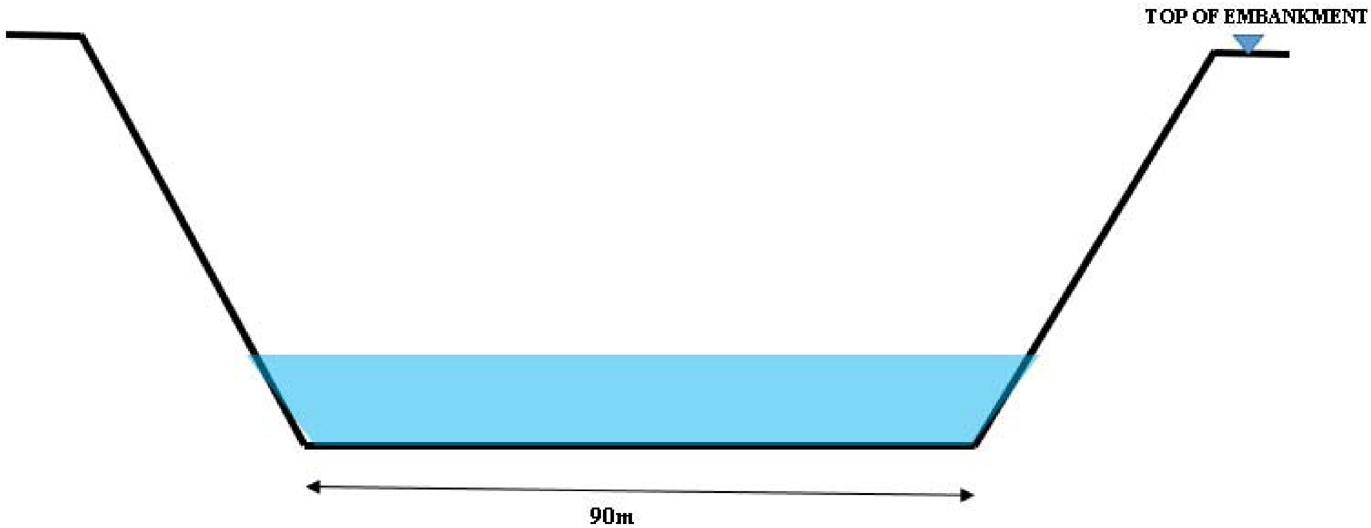
Geometry file of Mula, Mutha, Mula Mutha river was channelized by using channelization tool in HEC RAS. The channelized cross section is selected on following parameters.

- The channelized and cross section is accommodated within the available river gorge
- The conveyance carrying capacity of Proposed channelized cross section is in line with the existing natural river cross section.
- The channelized cross section HFL corresponds to HFL of natural river.
- Flood is contained within the proposed Channelized cross section.
- Creating minimum afflux at Bridge location and flood can pass clear off the soffit of the Bridge deck.
- Different channelized cross sections are adopted keeping in view the existing profile of Bank level and existing surrounding development level.

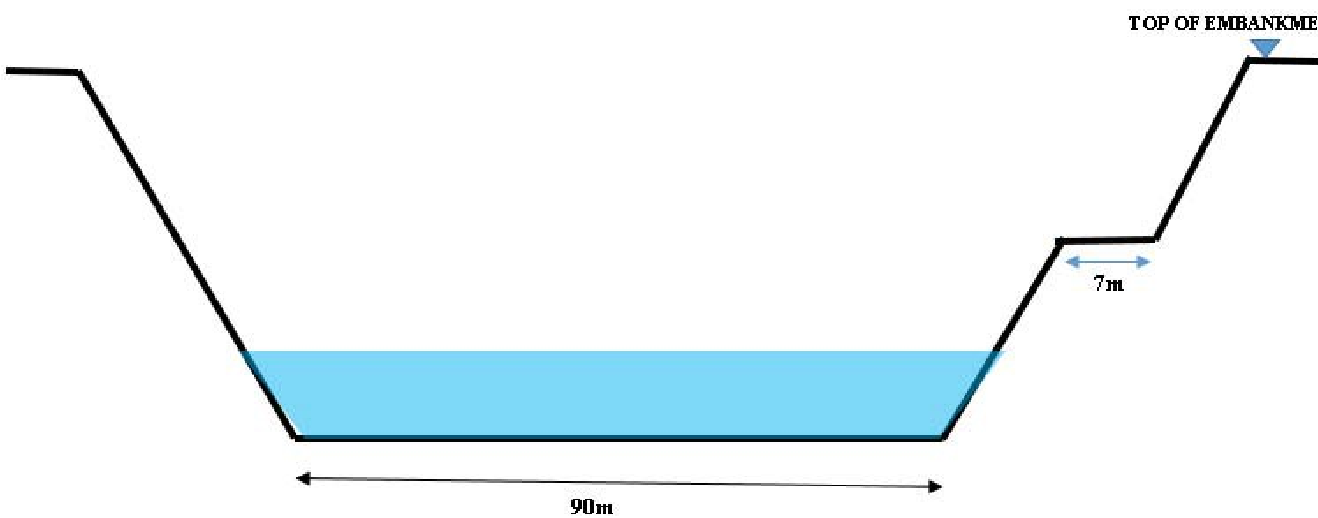
MULA RIVER UPTO CONFULENCE OF PAWANA RIVER

Two type of sections are proposed within projected reach

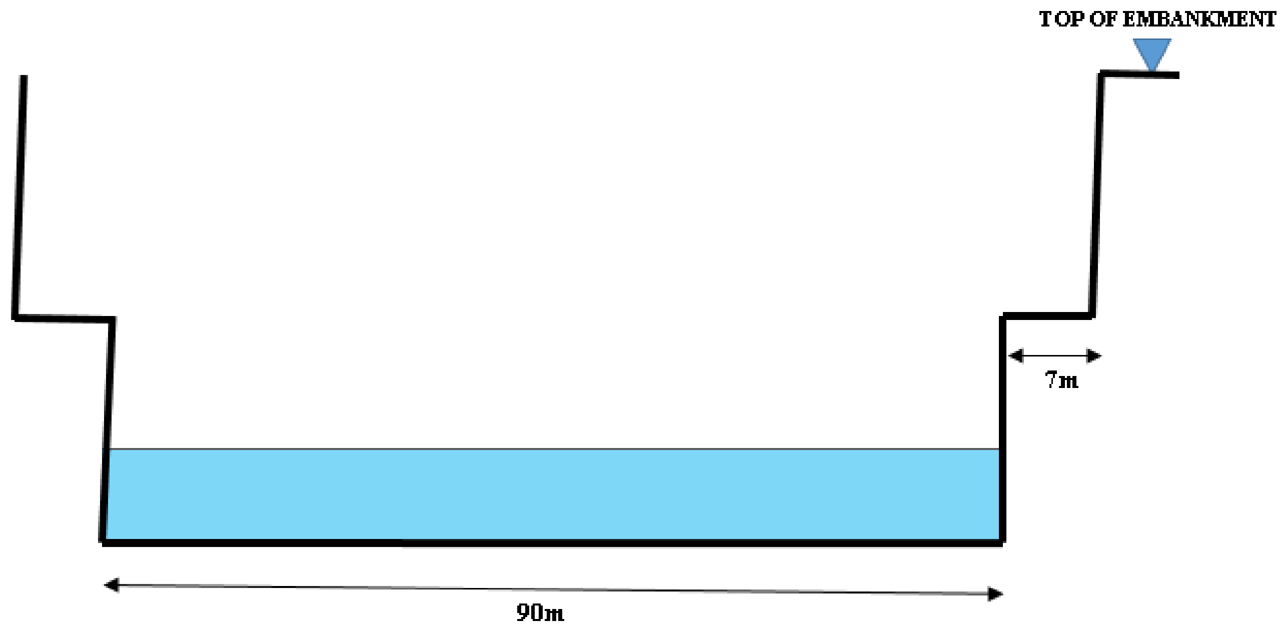
1) Trapezoidal Section having bed width of 90 m with stable side slope.



2) Trapezoidal Section having bed width of 90 m with stable side slope on one side and intermediate berm 7m wide acting as lower promenade/walkway.



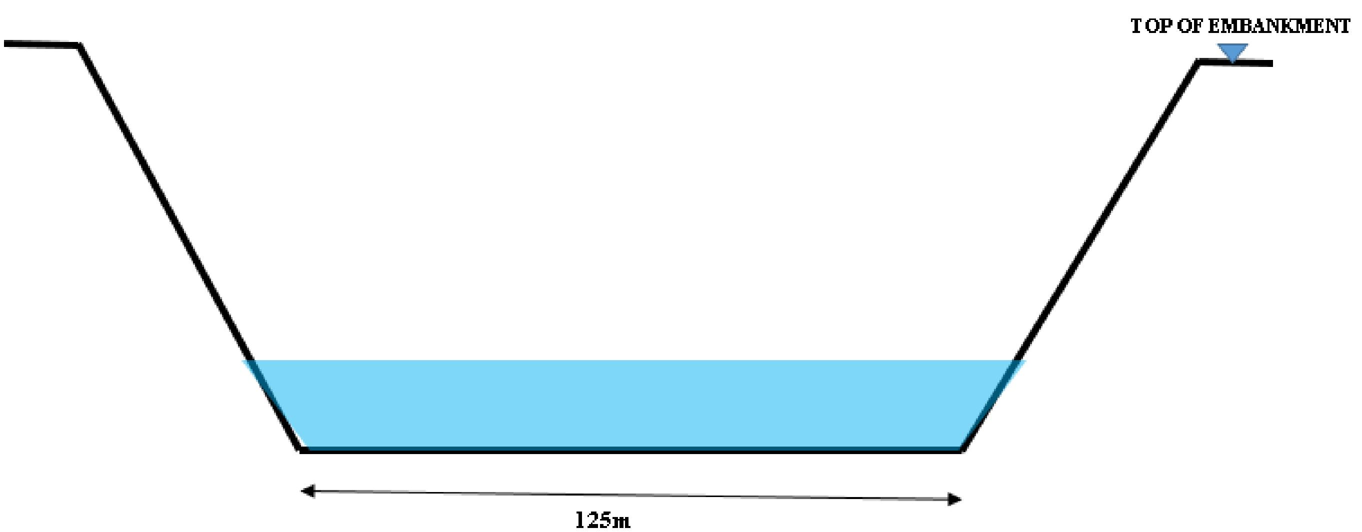
3) Rectangular section having bed width of 90 m and intermediate berm 7m wide acting as lower promenade/walkway.



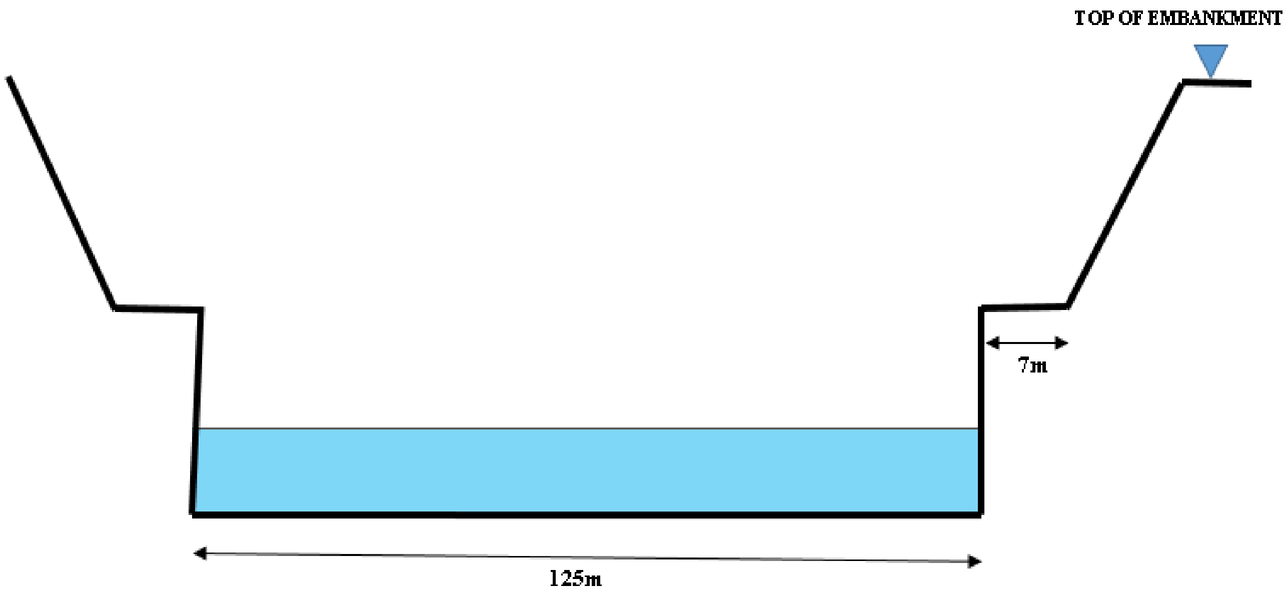
MULA RIVER UPTO CONFULENCE OF SANGAM RIVER

Two type of sections are proposed within projected reach

1) Trapezoidal Section having bed width of 125 m with stable side slope.



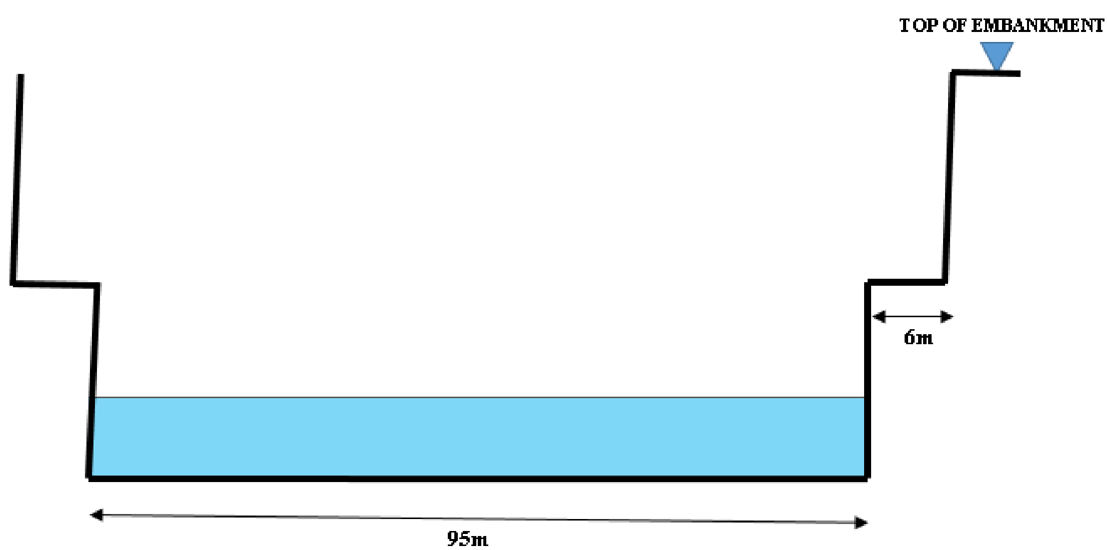
2) Rectangular Section having bed width of 125 m with intermediate berm 7m wide acting as lower promenade/walkway on both side.



MUTHA RIVER UPTO SANGAM

Type of sections proposed within projected reach

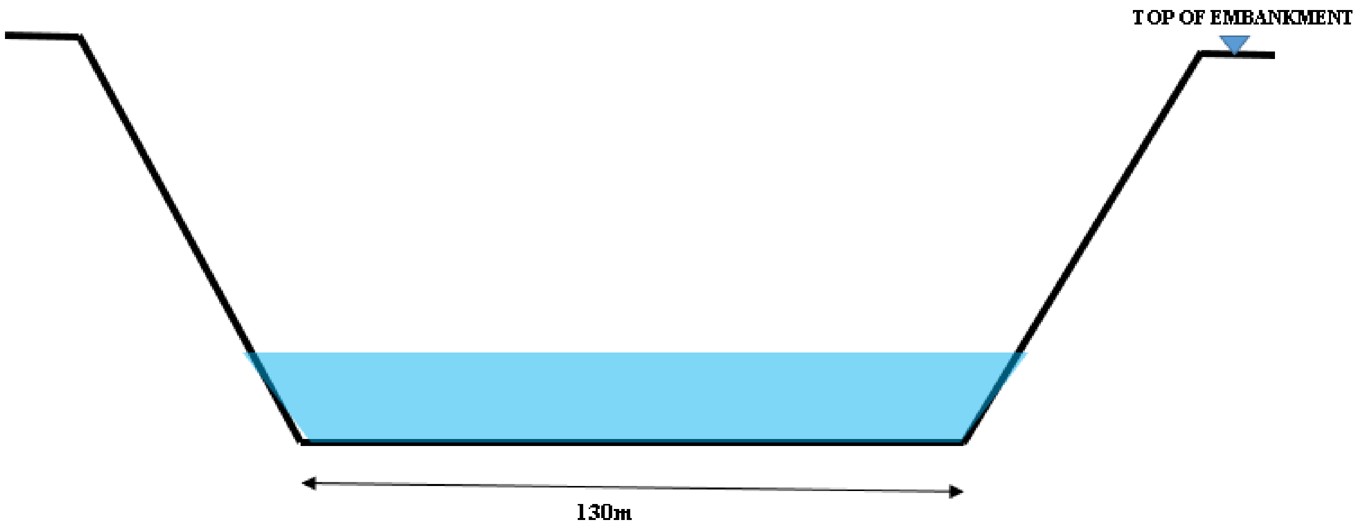
1) Rectangular Section having bed width of 125 m with intermediate berm 7m wide acting as lower promenade/walkway on both side and bank with RCC retaining wall.



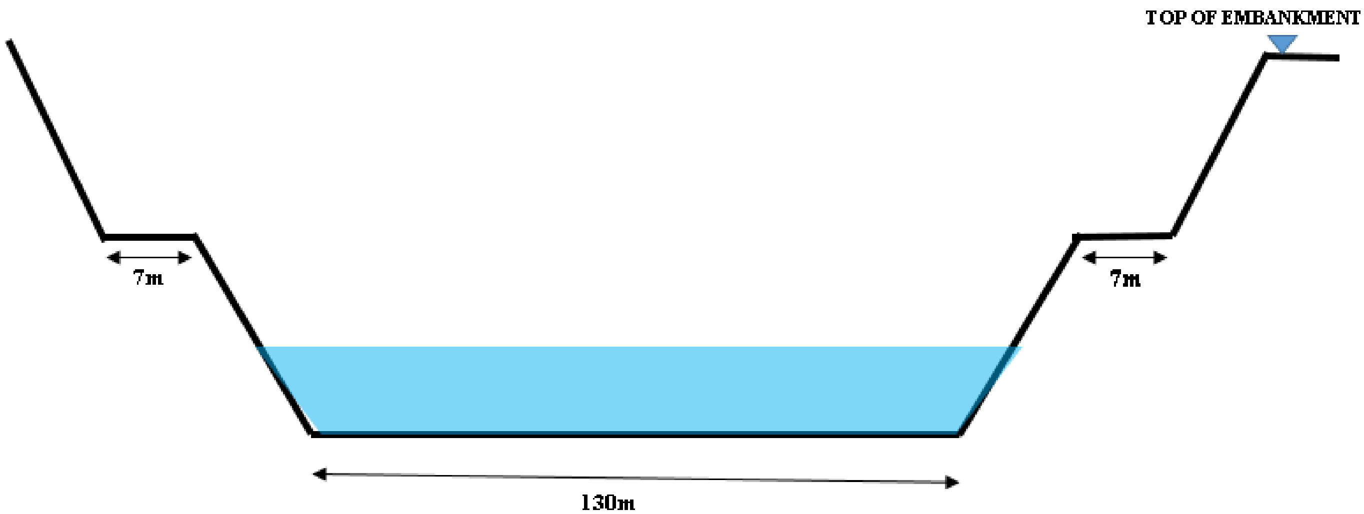
MULA MUTHA RIVER FROM SANGAM UPTO KT WEIR

Two type of sections are proposed within projected reach

1) Trapezoidal Section having bed width of 130 m with stable side slope.



2) Trapezoidal Section having bed width of 130 m with intermediate berm 7m wide acting as lower promenade/walkway on both side.



4.6.2 FLOW DATA AND GRADIENT

The flood discharge and gradient adopted for computing water surface elevation (WSEL) in HEC-RAS for 25 and 100 year return period flood for Mula ,Mutha and Mula Mutha river channelized section is tabulated in Table 13.

Sr No	Particulars	Flood Discharge (Cumecs) 100 Year Return Period	Flood Discharge (Cumecs) 25 Year Return Period
1	Mula River up to confluence of Pawana River	1232 (Up to Babashaheb Ambedkar Bridge)	1206
		1670 (Up to Confluence Point With Pawana River)	1536
2	Mula River after confluence up to Sangam with Mutha	3971	2875
3	Mutha River	2835	1700
4	Mula - Mutha River up to project end reach i.e. KT weir.	4762	3345

Table 13 :Flood Discharge Adopted in HEC RAS for Channelized River Section.

4.6.2.1 MANNING'S N VALUES.

Due to streamlining the flow, removing rock protruding from the river bed, bank protection with RCC Retaining wall or constructing embankment with pitching will reduce the Rugosity coefficient i.e. Manning's (n) value and corresponding increase in conveyance carrying capacity of channelized section .However the adopted roughness coefficient of channelized cross section is adopted same as natural cross section i.e. 0.03.

4.6.2.2 BRIDGE AND INLINE STRUCTURES (CHECK DAM, BARRAGE) DATA.

There are number of low lying Bridges, Causeway, Check Dams, Weirs with restricted opening located in the project reach causing obstruction to the flow and correspondingly creating afflux or rise in water level in u/s of project reach. Water surface elevation in HEC RAS for Proposed channelized cross section is worked out by removing such obstruction to the flow. Proposed bridges to be dismantled in channelized section are tabulated in Table 14 for Mula Mutha River front development.

Sr No	River	Chainage	Name
1	Mula Mutha River	1093	KT Weir
2	Mutha River	2685	Baba Bhide Bridge
3	Mutha River	1757	Causeway

4	Mula River	9972	Wakad Bridge
5	Mula River	8131	K Shakuntlal Baban Shadhe
6	Mula River After Sangam	7045	Check Dam 1
7	Mula River After Sangam	6659	Check Dam 2

Table 14 : Proposed Bridges to be Dismantled in Channelized River Section

4.6.3 ANALYSIS AND RESULT

Water surface elevations/HFL are estimated in HEC-RAS for Mula , Mutha, Mula Mutha river for channelized section within project reach as per flood discharge of 25 and 100 year return period flood are compared with the natural river section. Longitudinal section of water surface elevation/HFL of channelized section with respect to natural river section for Mula ,Mutha and Mula Mutha river is shown in plate 3 to6.

Typical cross section of proposed channelized section and natural section with respect to Water surface elevation /HFL at Chainage 9444 and 4971 of Mutha and Mula Mutha River respectively is shown in figure 31 and figure 32.

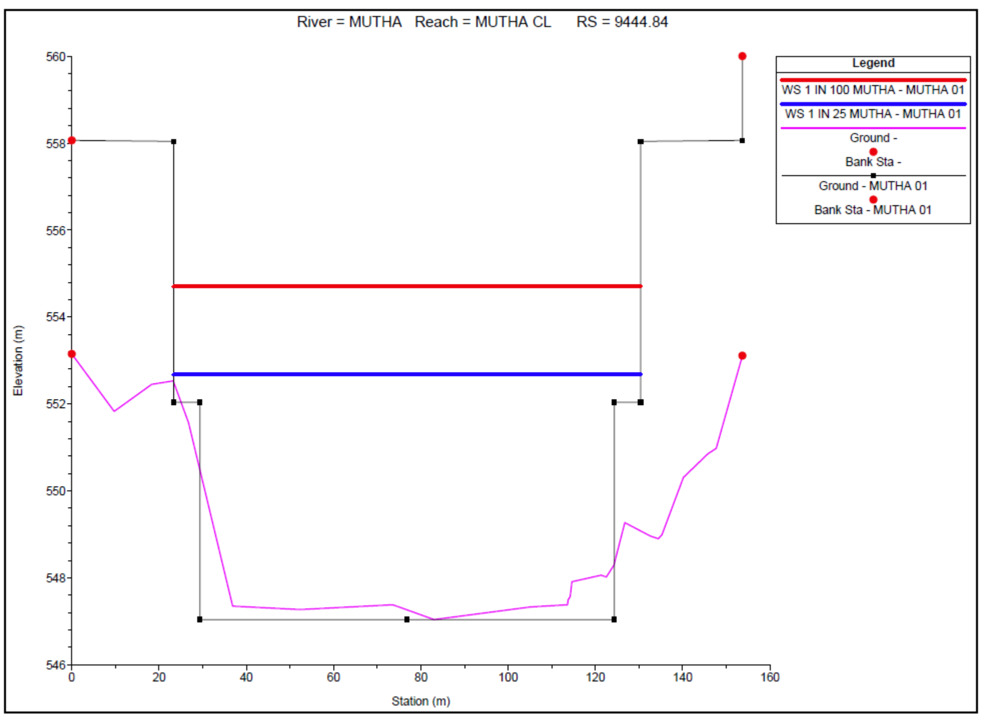


Figure 33: WSEL/HFL at Ch 9444 in Mutha River for proposed Channelized Section

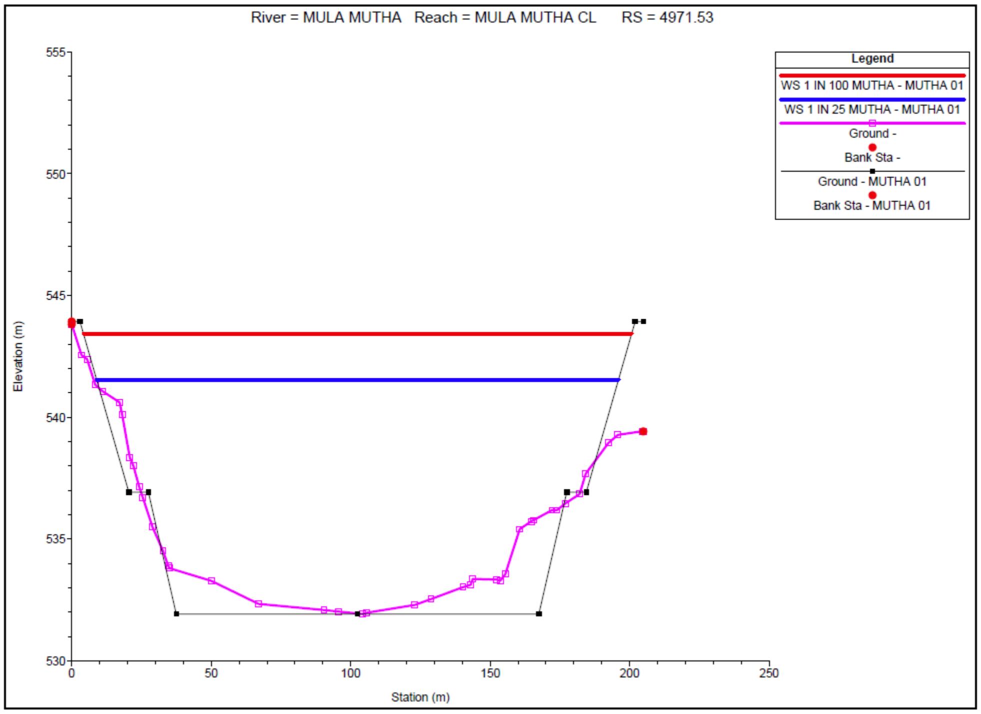


Figure 34: WSEL/HFL at Ch 4971 in Mula Mutha River for Proposed Channelized Section

4.6.3.1 HFL AT BRIDGE LOCATION

HEC RAS analysis shows that flood discharge passes clear off through most of the bridges in channelized condition. The following bridges as mentioned in Table 14, the flood level is above the soffit of the bridge and in some cases it overtops the deck slab of Bridge. Raising of the bridge is required at such location to minimize the afflux.

Sr No	River	Chainage	Name	Remarks
1	Mutha River	3440	Joshi Bridge	Flood Discharge of 100 Year Return Period Raises Above The Soffit of the Bridge
2	Mutha River	1449	Tilak Bridge	Flood Discharge of 25year Return Period Raises Above The Soffit of the Bridge and for 100 Year Return Period it overtops the Deck Slab of Bridge
3	Mula River Up to	1838	Sangvi Bridge	Flood Discharge of 25 and 100 Year

	Confluence Point with Pawana River			Return Period Raises Above The Soffit Of The Bridge
4	Mula River Up to Sangam Point	11945	Dapodi Bridge	Flood Discharge of 25 and 100 Year Overtops the Deck Slab of Bridge
5	Mula River Up to Sangam Point	11610	Old Harris Bridge	Flood Discharge of 100 Year Return Period Raises above the Soffit of the Bridge
6	Mula River Up to Sangam Point	11575	New Harris Bridge	Flood Discharge of 100 Year Return Period Raises above the Soffit of the Bridge
7	Mula River Up to Sangam Point	5903	Shanti Bridge	Flood Discharge Of 25year Return Period Raises Above The Soffit of the Bridge and for 100 Year Return Period it overtops the Deck Slab of Bridge

Table 15 : Proposed Bridges to Be Raised in Channelized Section for Mula Mutha Riverfront Development

4.6.3.2 VARIOUS OTHER OUTPUT OF HEC RAS

The output of HEC RAS for channelized sections such as Velocity, Water Depth, Flow area, Bed Level and Water Surface elevation corresponding to flood discharge within projected reach is appended vide Annexure 18 to 25.

4.6.3.3 TOP OF EMBANKMNET LEVEL

Minimum 1.0 m of free board as per Indian Standard Code of Practice 12094-2000 (Guideline for planning and design of river embankment) over the back water levels in channelized condition is considered for proposed embankment level of Mula Mutha Riverfront development. Leaving a minimum 1.0 m of free board, the top of embankment/retaining walls are Estimated and indicated on the Drawing. To Safeguard against unforeseen nature of flood intensities the design flood discharge shall be enhanced by some factor, same is considered as 20% of design flood discharge which shall be contained within the provided freeboard.

4.7 SCOUR DEPTH

For assessing the probable scour, well known time tested mathematical formulae are available. Scours are involved in bridge construction, foundations of hydraulic structures etc. The normal and maximum scour depths can be accessed from the field geotechnical data and the time tested formulae. It should therefore, be appropriate if the foundations of the retaining walls etc. are designed based on mathematically assessed scour depths with a reasonable safety factor. If necessary, the design flood for assessing such scour depth can be somewhat higher, as compared to the normal design flood, to ensure the safety of the foundations for the probable higher floods.

It has to be appreciated that due to channelization, the velocities for the same discharge would be higher which would tend to scour the bed. But as in our case river Bed consist of weathered Rock at shallow depth ,the Scour will reach up to rock level in the entire project reach. Hence all the foundation shall be rested on rock.

ANNEXURE XVIII

OUTPUT OF MUTHA RIVER UPTO SANGAM FROM HEC RAS FOR FLOOD DISCHARGE OF 25 YEAR RETURN PERIOD IN CHANNELIZED SECTION

Sr No	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Top of Embankment Level From Bed Level(m)	Vel Chnl (m/s)
1	10389.1	1700	545.78	553.5	8.72	2.22
2	10344.02	1700	545.67	553.49	8.82	2.19
3	10294.04	1700	545.56	553.48	8.92	2.16
4	10244.15	1700	545.6	553.46	8.86	2.18
5	10194.1	1700	546.41	553.36	7.95	2.49
6	10144.11	1700	546.33	553.34	8.01	2.47
7	10094.11	1700	546.33	553.31	7.98	2.48
8	10044.13	1700	546.43	553.27	7.84	2.53
9	9994.18	1700	546.57	553.22	7.65	2.61
10	9944.18	1700	546.3	553.21	7.91	2.5
11	9894.14	1700	546.24	553.19	7.95	2.49
12	9844.58	1700	546.1	553.17	8.07	2.44
13	9794.45	1700	546	553.15	8.15	2.41
14	9744.45	1700	546.02	553.12	8.1	2.43
15	9694.45	1700	546.41	553.05	7.64	2.62
16	9644.4	1700	546.49	553	7.51	2.67
17	9594.6	1700	546.58	552.95	7.37	2.74
18	9544.84	1700	546.87	552.84	6.97	2.94
19	9494.84	1700	547.07	552.74	6.67	3.11
20	9444.84	1700	547.04	552.68	6.64	3.13
21	9394.88	1700	546.87	552.65	6.78	3.05
22	9344.86	1700	547.17	552.48	6.31	3.34
23	9295.03	1700	547.58	552.18	5.6	3.89
24	9245.03	1700	547.49	552.07	5.58	3.9
25	9194.98	1700	547.17	552.04	5.87	3.67
26	9145.14	1700	547.07	551.96	5.89	3.66
27	9095.25	1700	546.97	551.89	5.92	3.64
28	9045.35	1700	546.89	551.81	5.92	3.64
29	8995.41	1700	547.03	551.6	5.57	3.92
30	8945.4	1700	546.14	551.71	6.57	3.17
31	8895.42	1700	545.65	551.73	7.08	2.88
32	8845.42	1700	545.44	551.71	7.27	2.78
33	8795.42	1700	545.47	551.66	7.19	2.82
34	8745.42	1700	545.56	551.59	7.03	2.9
35	8695.42	1700	545.4	551.57	7.17	2.83
36	8645.42	1700	545.51	551.5	6.99	2.93
37	8595.42	1700	545.26	551.48	7.22	2.81

38	8545.37	1700	545.17	551.45	7.28	2.78
39	8495.66	1700	545.2	551.4	7.2	2.82
40	8445.78	1700	545.25	551.35	7.1	2.87
41	8396.01	1700	545.04	551.33	7.29	2.77
42	8346	1700	545.09	551.27	7.18	2.83
43	8296.02	1700	545.2	551.2	7	2.92
44	8246.02	1700	545.24	551.14	6.9	2.97
45	8196.02	1700	544.76	551.15	7.39	2.72
46	8146.02	1700	544.49	551.14	7.65	2.61
47	8096.02	1700	544.56	551.1	7.54	2.66
48	8046.02	1700	544.26	551.09	7.83	2.53
49	7996.02	1700	544.28	551.06	7.78	2.55
50	7946.02	1700	544.52	550.99	7.47	2.69
51	7896.15	1700	544.41	550.97	7.56	2.65
52	7846.13	1700	544.36	550.94	7.58	2.64
53	7796.11	1700	544.36	550.9	7.54	2.66
54	7746.09	1700	544.25	550.88	7.63	2.62
55	7696.47	1700	544.21	550.85	7.64	2.61
56	7646.58	1700	544.19	550.82	7.63	2.62
57	7596.57	1700	544.01	550.81	7.8	2.55
58	7546.56	1700	543.8	550.79	7.99	2.47
59	7496.56	1700	543.98	550.74	7.76	2.56
60	7446.69	1700	544.27	550.66	7.39	2.72
61	7396.74	1700	544.43	550.59	7.16	2.84
62	7346.74	1700	544.26	550.57	7.31	2.76
63	7296.75	1700	544.46	550.49	7.03	2.91
64	7246.73	1700	544.5	550.43	6.93	2.96
65	7196.81	1700	545.19	550.12	5.93	3.63
66	7146.81	1700	544.75	550.13	6.38	3.29
67	7096.84	1700	544.96	549.95	5.99	3.59
68	7046.84	1700	544.51	549.97	6.46	3.25
69	6996.83	1700	544.43	549.91	6.48	3.23
70	6946.84	1700	544.07	549.91	6.84	3.01
71	6896.98	1700	544.01	549.86	6.85	3
72	6847.1	1700	543.76	549.84	7.08	2.88
73	6797.1	1700	543.32	549.85	7.53	2.66
74	6747.19	1700	542.61	549.88	8.27	2.37
75	6697.22	1700	543.1	549.79	7.69	2.59
76	6647.24	1700	542.86	549.78	7.92	2.5
77	6597.24	1700	542.41	549.79	8.38	2.33
78	6547.23	1700	542.78	549.72	7.94	2.49
79	6497.2	1700	542.63	549.71	8.08	2.44
80	6447.16	1700	542.7	549.67	7.97	2.48
81	6397.36	1700	542.32	549.67	8.35	2.34
82	6347.36	1700	542.56	549.62	8.06	2.44
83	6297.64	1700	542.24	549.62	8.38	2.33
84	6237	RAJARAM BRIDGE				

85	6197.7	1700	542.24	549.53	8.29	2.36
86	6147.69	1700	542.15	549.51	8.36	2.34
87	6097.69	1700	542.31	549.47	8.16	2.41
88	6047.69	1700	542.63	549.41	7.78	2.56
89	5997.69	1700	542.5	549.39	7.89	2.51
90	5947.68	1700	542.51	549.36	7.85	2.53
91	5897.68	1700	542.3	549.35	8.05	2.45
92	5847.69	1700	542.42	549.31	7.89	2.51
93	5797.69	1700	542.61	549.25	7.64	2.61
94	5747.69	1700	542.3	549.24	7.94	2.49
95	5697.74	1700	542.05	549.24	8.19	2.4
96	5647.74	1700	542.08	549.21	8.13	2.42
97	5597.74	1700	542.21	549.17	7.96	2.48
98	5547.74	1700	542.32	549.12	7.8	2.55
99	5497.74	1700	542.32	549.09	7.77	2.56
100	5447.74	1700	542.3	549.06	7.76	2.56
101	5397.74	1700	542.49	549	7.51	2.67
102	5347.87	1700	542.29	548.99	7.7	2.59
103	5297.86	1700	542.3	548.95	7.65	2.61
104	5247.86	1700	542.34	548.91	7.57	2.64
105	5197.87	1700	542.5	548.85	7.35	2.74
106	5147.88	1700	542.31	548.83	7.52	2.66
107	5097.88	1700	542.27	548.8	7.53	2.66
108	5047.86	1700	542.13	548.78	7.65	2.61
109	4997.99	1700	541.9	548.77	7.87	2.52
110	4948.14	1700	541.62	548.77	8.15	2.41
111	4898.11	1700	541.95	548.7	7.75	2.57
112	4848.14	1700	542.27	548.61	7.34	2.75
113	4798.14	1700	542.06	548.6	7.54	2.66
114	4748.19	1700	542.22	548.53	7.31	2.76
115	4698.21	1700	541.94	548.52	7.58	2.64
116	4648.2	1700	542.13	548.46	7.33	2.76
117	4598.22	1700	542.04	548.43	7.39	2.73
118	4548.24	1700	542.17	548.36	7.19	2.82
119	4498.28	1700	542.08	548.33	7.25	2.79
120	4448.25	1700	542.14	548.27	7.13	2.85
121	4398.38	1700	541.98	548.25	7.27	2.78
122	4348.35	1700	541.87	548.22	7.35	2.74
123	4298.35	1700	541.81	548.19	7.38	2.73
124	4248.35	1700	541.69	548.17	7.48	2.69
125	4189	MHATRE BRIDGE				
126	4148.39	1700	541.54	547.98	7.44	2.7
127	4098.39	1700	541.43	547.95	7.52	2.67
128	4048.52	1700	541.17	547.94	7.77	2.56
129	3998.6	1700	541.09	547.92	7.83	2.54
130	3949.13	1700	541.42	547.84	7.42	2.71
131	3898.11	1700	541.34	547.81	7.47	2.69

132	3848.85	1700	541.31	547.78	7.47	2.69
133	3798.75	1700	541.23	547.75	7.52	2.67
134	3748.75	1700	540.87	547.75	7.88	2.52
135	3698.75	1700	541.09	547.69	7.6	2.63
136	3648.75	1700	541.33	547.61	7.28	2.78
137	3598.75	1700	541.09	547.59	7.5	2.67
138	3548.74	1700	540.91	547.58	7.67	2.6
139	3498.74	1700	540.85	547.55	7.7	2.59
140	3440	JOSHI BRIDGE				
141	3398.84	1700	540.77	547.39	7.62	2.62
142	3348.85	1700	540.88	547.34	7.46	2.69
143	3298.84	1700	540.89	547.3	7.41	2.72
144	3248.86	1700	540.61	547.29	7.68	2.6
145	3198.93	1700	540.19	547.3	8.11	2.43
146	3190	CHAVAN BRIDGE				
147	3148.92	1700	540.33	547.19	7.86	2.52
148	3098.92	1700	540.08	547.18	8.1	2.43
149	3048.92	1700	540.02	547.16	8.14	2.42
150	2998.9	1700	539.92	547.14	8.22	2.39
151	2938	SAMBHAJI BRIDGE				
152	2899.01	1700	539.73	547.01	8.28	2.36
153	2849.09	1700	539.43	547.01	8.58	2.26
154	2793	KAKASAHEB Z BRIDGE				
155	2749.1	1700	539.48	546.89	8.41	2.32
156	2699.1	1700	539.35	546.88	8.53	2.28
157	2649.09	1700	539.32	546.86	8.54	2.28
158	2599.17	1700	539.26	546.84	8.58	2.26
159	2549.16	1700	538.95	546.84	8.89	2.17
160	2499.15	1700	539.52	546.77	8.25	2.38
161	2449.14	1700	539.42	546.75	8.33	2.35
162	2399.25	1700	538.89	546.76	8.87	2.17
163	2349.27	1700	539.15	546.72	8.57	2.27
164	2299.3	1700	539.48	546.67	8.19	2.4
165	2249.3	1700	539.49	546.64	8.15	2.41
166	2199.3	1700	539.16	546.64	8.48	2.3
167	2149.3	1700	539.21	546.61	8.4	2.32
168	2099.29	1700	538.91	546.61	8.7	2.23
169	2049.28	1700	538.85	546.6	8.75	2.21
170	1999.41	1700	538.72	546.59	8.87	2.18
171	1949.36	1700	539.06	546.54	8.48	2.3
172	1899.5	1700	539.43	546.47	8.04	2.45
173	1867	SHINDE BRIDGE				
174	1849.6	1700	539.8	546.36	7.56	2.65
175	1799.6	1700	539.15	546.38	8.23	2.38
176	1749.64	1700	539.2	546.35	8.15	2.41
177	1699.65	1700	539.1	546.34	8.24	2.38
178	1649.67	1700	539.13	546.31	8.18	2.4

179	1599.67	1700	539.11	546.29	8.18	2.4
180	1549.67	1700	539.1	546.26	8.16	2.41
181	1499.66	1700	538.97	546.25	8.28	2.37
182	1449	TILAK BRIDGE				
183	1399.67	1700	538.97	546.08	8.11	2.43
184	1349.68	1700	539.17	546.03	7.86	2.52
185	1299.68	1700	540.17	545.8	6.63	3.14
186	1284	SHIVAJI BRIDGE				
187	1249.68	1700	539.92	542.18	3.26	7.92
188	1199.68	1700	539.29	544.47	6.18	3.44
189	1149.68	1700	539.31	544.36	6.05	3.54
190	1099.68	1700	539.14	544.3	6.16	3.45
191	1049.68	1700	539.04	544.23	6.19	3.43
192	999.68	1700	538.92	544.18	6.26	3.38
193	949.68	1700	538.82	544.11	6.29	3.36
194	886	DENGALE BRIDGE				
195	849.69	1700	538.41	543.66	6.25	3.39
196	799.69	1700	538.65	543.45	5.8	3.73
197	749.69	1700	537.73	543.56	6.83	3.02
198	699.69	1700	537.65	543.52	6.87	2.99
199	649.69	1700	537.65	543.46	6.81	3.03
200	599.69	1700	536.82	543.51	7.69	2.59
201	549.69	1700	536.43	543.51	8.08	2.44
202	499.69	1700	537.03	543.4	7.37	2.74
203	449.67	1700	537.22	543.32	7.1	2.87
204	399.84	1700	537.38	543.23	6.85	3
205	349.69	1700	537.38	543.17	6.79	3.04
206	340	SANGAM ARCH BRIDGE				
207	299.69	1700	536.71	542.92	7.21	2.81
208	291	RAILWAY BRIDGE				
209	249.69	1700	536.91	542.69	6.78	3.05
210	199.69	1700	537.47	542.41	5.94	3.62
211	159	SANGAM BRIDGE				
212	149.77	1700	537.14	542.23	6.09	3.51
213	141	WELESLY BRIDGE				
214	99.95	1700	535.88	542.04	7.16	2.84

ANNEXURE XIX

OUTPUT OF MUTHA RIVER UPTO SANGAM FROM HEC RAS FOR FLOOD DISCHARGE OF 100 YEAR RETURN PERIOD IN CHANNELIZED SECTION

Sr No	River Sta	Q Total	Min Ch El	W.S. Elev	Top of Embankment Level From Bed Lvl(m)	Vel Chnl
		(m3/s)	(m)	(m)		(m/s)
1	10389.1	2835	545.78	555.61	10.83	2.86
2	10344.02	2835	545.67	555.6	10.93	2.83
3	10294.04	2835	545.56	555.59	11.03	2.8
4	10244.15	2835	545.6	555.56	10.96	2.82
5	10194.1	2835	546.41	555.43	10.02	3.13
6	10144.11	2835	546.33	555.41	10.08	3.11
7	10094.11	2835	546.33	555.38	10.05	3.12
8	10044.13	2835	546.43	555.33	9.9	3.18
9	9994.18	2835	546.57	555.27	9.7	3.25
10	9944.18	2835	546.3	555.27	9.97	3.15
11	9894.14	2835	546.24	555.24	10	3.14
12	9844.58	2835	546.1	555.22	10.12	3.09
13	9794.45	2835	546	555.2	10.2	3.07
14	9744.45	2835	546.02	555.17	10.15	3.08
15	9694.45	2835	546.41	555.08	9.67	3.27
16	9644.4	2835	546.49	555.02	9.53	3.32
17	9594.6	2835	546.58	554.96	9.38	3.39
18	9544.84	2835	546.87	554.85	8.98	3.57
19	9494.84	2835	547.07	554.74	8.67	3.73
20	9444.84	2835	547.04	554.69	8.65	3.74
21	9394.88	2835	546.87	554.66	8.79	3.66
22	9344.86	2835	547.17	554.5	8.33	3.91
23	9295.03	2835	547.58	554.23	7.65	4.35
24	9245.03	2835	547.49	554.15	7.66	4.34
25	9194.98	2835	547.17	554.14	7.97	4.13
26	9145.14	2835	547.07	554.08	8.01	4.11
27	9095.25	2835	546.97	554.02	8.05	4.08
28	9045.35	2835	546.89	553.96	8.07	4.07
29	8995.41	2835	547.03	553.8	7.77	4.27
30	8945.4	2835	546.14	553.91	8.77	3.68
31	8895.42	2835	545.65	553.92	9.27	3.43
32	8845.42	2835	545.44	553.91	9.47	3.35
33	8795.42	2835	545.47	553.86	9.39	3.38
34	8745.42	2835	545.56	553.8	9.24	3.45
35	8695.42	2835	545.4	553.78	9.38	3.39
36	8645.42	2835	545.51	553.71	9.2	3.47
37	8595.42	2835	545.26	553.7	9.44	3.36

38	8545.37	2835	545.17	553.67	9.5	3.34
39	8495.66	2835	545.2	553.62	9.42	3.37
40	8445.78	2835	545.25	553.57	9.32	3.42
41	8396.01	2835	545.04	553.55	9.51	3.33
42	8346	2835	545.09	553.5	9.41	3.38
43	8296.02	2835	545.2	553.43	9.23	3.45
44	8246.02	2835	545.24	553.38	9.14	3.5
45	8196.02	2835	544.76	553.39	9.63	3.28
46	8146.02	2835	544.49	553.39	9.9	3.18
47	8096.02	2835	544.56	553.34	9.78	3.22
48	8046.02	2835	544.26	553.34	10.08	3.11
49	7996.02	2835	544.28	553.3	10.02	3.13
50	7946.02	2835	544.52	553.23	9.71	3.25
51	7896.15	2835	544.41	553.21	9.8	3.22
52	7846.13	2835	544.36	553.18	9.82	3.21
53	7796.11	2835	544.36	553.14	9.78	3.22
54	7746.09	2835	544.25	553.12	9.87	3.19
55	7696.47	2835	544.21	553.09	9.88	3.18
56	7646.58	2835	544.19	553.06	9.87	3.19
57	7596.57	2835	544.01	553.05	10.04	3.13
58	7546.56	2835	543.8	553.04	10.24	3.05
59	7496.56	2835	543.98	552.98	10	3.14
60	7446.69	2835	544.27	552.9	9.63	3.29
61	7396.74	2835	544.43	552.83	9.4	3.38
62	7346.74	2835	544.26	552.81	9.55	3.32
63	7296.75	2835	544.46	552.72	9.26	3.44
64	7246.73	2835	544.5	552.67	9.17	3.48
65	7196.81	2835	545.19	552.42	8.23	3.98
66	7146.81	2835	544.75	552.43	8.68	3.72
67	7096.84	2835	544.96	552.3	8.34	3.91
68	7046.84	2835	544.51	552.31	8.8	3.66
69	6996.83	2835	544.43	552.27	8.84	3.64
70	6946.84	2835	544.07	552.27	9.2	3.47
71	6896.98	2835	544.01	552.24	9.23	3.46
72	6847.1	2835	543.76	552.23	9.47	3.35
73	6797.1	2835	543.32	552.24	9.92	3.17
74	6747.19	2835	542.61	552.27	10.66	2.91
75	6697.22	2835	543.1	552.17	10.07	3.11
76	6647.24	2835	542.86	552.17	10.31	3.03
77	6597.24	2835	542.41	552.18	10.77	2.88
78	6547.23	2835	542.78	552.1	10.32	3.02
79	6497.2	2835	542.63	552.09	10.46	2.98
80	6447.16	2835	542.7	552.05	10.35	3.01
81	6397.36	2835	542.32	552.06	10.74	2.89
82	6347.36	2835	542.56	552	10.44	2.98
83	6297.64	2835	542.24	552	10.76	2.88
84	6237	RAJARAM BRIDGE				

85	6197.7	2835	542.24	551.89	10.65	2.91
86	6147.69	2835	542.15	551.87	10.72	2.89
87	6097.69	2835	542.31	551.83	10.52	2.96
88	6047.69	2835	542.63	551.76	10.13	3.09
89	5997.69	2835	542.5	551.74	10.24	3.05
90	5947.68	2835	542.51	551.71	10.2	3.07
91	5897.68	2835	542.3	551.7	10.4	3
92	5847.69	2835	542.42	551.66	10.24	3.05
93	5797.69	2835	542.61	551.6	9.99	3.14
94	5747.69	2835	542.3	551.6	10.3	3.03
95	5697.74	2835	542.05	551.59	10.54	2.95
96	5647.74	2835	542.08	551.56	10.48	2.97
97	5597.74	2835	542.21	551.52	10.31	3.03
98	5547.74	2835	542.32	551.47	10.15	3.08
99	5497.74	2835	542.32	551.44	10.12	3.1
100	5447.74	2835	542.3	551.41	10.11	3.1
101	5397.74	2835	542.49	551.35	9.86	3.19
102	5347.87	2835	542.29	551.34	10.05	3.12
103	5297.86	2835	542.3	551.31	10.01	3.14
104	5247.86	2835	542.34	551.27	9.93	3.17
105	5197.87	2835	542.5	551.2	9.7	3.25
106	5147.88	2835	542.31	551.19	9.88	3.18
107	5097.88	2835	542.27	551.16	9.89	3.18
108	5047.86	2835	542.13	551.14	10.01	3.13
109	4997.99	2835	541.9	551.13	10.23	3.05
110	4948.14	2835	541.62	551.13	10.51	2.96
111	4898.11	2835	541.95	551.06	10.11	3.1
112	4848.14	2835	542.27	550.97	9.7	3.25
113	4798.14	2835	542.06	550.96	9.9	3.18
114	4748.19	2835	542.22	550.9	9.68	3.26
115	4698.21	2835	541.94	550.89	9.95	3.16
116	4648.2	2835	542.13	550.83	9.7	3.26
117	4598.22	2835	542.04	550.8	9.76	3.23
118	4548.24	2835	542.17	550.74	9.57	3.31
119	4498.28	2835	542.08	550.71	9.63	3.28
120	4448.25	2835	542.14	550.66	9.52	3.33
121	4398.38	2835	541.98	550.64	9.66	3.27
122	4348.35	2835	541.87	550.62	9.75	3.23
123	4298.35	2835	541.81	550.59	9.78	3.22
124	4248.35	2835	541.69	550.57	9.88	3.18
125	4189	MHATRE BRIDGE				
126	4148.39	2835	541.54	550.35	9.81	3.21
127	4098.39	2835	541.43	550.33	9.9	3.18
128	4048.52	2835	541.17	550.32	10.15	3.08
129	3998.6	2835	541.09	550.3	10.21	3.06
130	3949.13	2835	541.42	550.22	9.8	3.22
131	3898.11	2835	541.34	550.19	9.85	3.19

132	3848.85	2835	541.31	550.16	9.85	3.19
133	3798.75	2835	541.23	550.14	9.91	3.17
134	3748.75	2835	540.87	550.14	10.27	3.04
135	3698.75	2835	541.09	550.08	9.99	3.14
136	3648.75	2835	541.33	550.01	9.68	3.26
137	3598.75	2835	541.09	550	9.91	3.18
138	3548.74	2835	540.91	549.98	10.07	3.11
139	3498.74	2835	540.85	549.96	10.11	3.1
140	3440	JOSHI BRIDGE				
141	3398.84	2835	540.77	549.71	9.94	3.16
142	3348.85	2835	540.88	549.66	9.78	3.23
143	3298.84	2835	540.89	549.62	9.73	3.24
144	3248.86	2835	540.61	549.61	10	3.14
145	3198.93	2835	540.19	549.62	10.43	2.99
146	3190	CHAVAN BRIDGE				
147	3148.92	2835	540.33	549.48	10.15	3.09
148	3098.92	2835	540.08	549.47	10.39	3
149	3048.92	2835	540.02	549.45	10.43	2.99
150	2998.9	2835	539.92	549.43	10.51	2.96
151	2938	SAMBHAJI BRIDGE				
152	2899.01	2835	539.73	549.27	10.54	2.88
153	2849.09	2835	539.43	549.25	10.82	2.86
154	2793	KAKASAHEB Z BRIDGE				
155	2749.1	2835	539.48	549.09	10.61	2.93
156	2699.1	2835	539.35	549.07	10.72	2.89
157	2649.09	2835	539.32	549.05	10.73	2.89
158	2599.17	2835	539.26	549.03	10.77	2.88
159	2549.16	2835	538.95	549.03	11.08	2.78
160	2499.15	2835	539.52	548.94	10.42	2.99
161	2449.14	2835	539.42	548.92	10.5	2.96
162	2399.25	2835	538.89	548.94	11.05	2.79
163	2349.27	2835	539.15	548.89	10.74	2.89
164	2299.3	2835	539.48	548.82	10.34	3.02
165	2249.3	2835	539.49	548.79	10.3	3.03
166	2199.3	2835	539.16	548.79	10.63	2.92
167	2149.3	2835	539.21	548.76	10.55	2.95
168	2099.29	2835	538.91	548.76	10.85	2.85
169	2049.28	2835	538.85	548.74	10.89	2.84
170	1999.41	2835	538.72	548.73	11.01	2.8
171	1949.36	2835	539.06	548.67	10.61	2.93
172	1899.5	2835	539.43	548.59	10.16	3.08
173	1867	SHINDE BRIDGE				
174	1849.6	2835	539.8	548.45	9.65	3.28
175	1799.6	2835	539.15	548.48	10.33	3.02
176	1749.64	2835	539.2	548.44	10.24	3.05
177	1699.65	2835	539.1	548.42	10.32	3.02
178	1649.67	2835	539.13	548.39	10.26	3.05

179	1599.67	2835	539.11	548.36	10.25	3.05
180	1549.67	2835	539.1	548.33	10.23	3.05
181	1499.66	2835	538.97	548.32	10.35	3.02
182	1449	TILAK BRIDGE				
183	1399.67	2835	538.97	547.93	9.96	3.15
184	1349.68	2835	539.17	547.86	9.69	3.26
185	1299.68	2835	540.17	547.58	8.41	3.87
186	1284	SHIVAJI BRIDGE				
187	1249.68	2835	539.92	543.08	4.16	9.44
188	1199.68	2835	539.29	546.52	8.23	3.97
189	1149.68	2835	539.31	546.47	8.16	3.94
190	1099.68	2835	539.14	546.4	8.26	3.96
191	1049.68	2835	539.04	546.35	8.31	3.93
192	999.68	2835	538.92	546.3	8.38	3.88
193	949.68	2835	538.82	546.26	8.44	3.85
194	886	DENGALE BRIDGE				
195	849.69	2835	538.41	545.83	8.42	3.86
196	799.69	2835	538.65	545.66	8.01	4.11
197	749.69	2835	537.73	545.76	9.03	3.55
198	699.69	2835	537.65	545.72	9.07	3.53
199	649.69	2835	537.65	545.67	9.02	3.55
200	599.69	2835	536.82	545.73	9.91	3.17
201	549.69	2835	536.43	545.73	10.3	3.03
202	499.69	2835	537.03	545.6	9.57	3.31
203	449.67	2835	537.22	545.53	9.31	3.42
204	399.84	2835	537.38	545.44	9.06	3.53
205	349.69	2835	537.38	545.39	9.01	3.56
206	340	SANGAM ARCH BRIDGE				
207	299.69	2835	536.71	545.08	9.37	3.39
208	291	RAILWAY BRIDGE				
209	249.69	2835	536.91	544.79	8.88	3.62
210	199.69	2835	537.47	544.54	8.07	4.07
211	159	SANGAM BRIDGE				
212	149.77	2835	537.14	544.35	8.21	3.99
213	141	WELESLY BRIDGE				
214	99.95	2835	535.88	544.1	9.22	3.46

ANNEXURE XX						
OUTPUTOF MULA MUTHA RIVER FROM HEC RAS FOR FLOOD DISCHARGE OF 25 YEAR RETURN PERIOD IN CHANNELIZED SECTION						
Sr No	**River Sta**	**Q Total (m3/s)**	**Min Ch El (m)**	**W.S. Elev (m)**	**Top of Embankment t Level From Bed Lvl(m)**	**Vel Chnl (m/s)**
1	11719.66	3345	536.29	544.94	9.65	2.48
2	11669.66	3345	536.33	544.91	9.58	2.5
3	11619.66	3345	536.39	544.89	9.5	2.53
4	11569.67	3345	536.07	544.89	9.82	2.42
5	11519.67	3345	535.88	544.89	10.01	2.37
6	11469.67	3345	536.8	544.76	8.96	2.73
7	11419.67	3345	535.75	544.82	10.07	2.35
8	11369.7	3345	535.76	544.8	10.04	2.36
9	11319.7	3345	535.93	544.77	9.84	2.42
10	11269.7	3345	536.19	544.72	9.53	2.52
11	11169.89	3345	536.34	544.67	9.33	2.59
12	11119.88	3345	536.12	544.66	9.54	2.52
13	11070.23	3345	536.04	544.65	9.61	2.49
14	11020.11	3345	535.86	544.64	9.78	2.44
15	10970.12	3345	535.68	544.64	9.96	2.38
16	10920.05	3345	535.88	544.6	9.72	2.46
17	10870.28	3345	535.88	544.58	9.7	2.46
18	10820.25	3345	536.27	544.52	9.25	2.62
19	10770.32	3345	536.2	544.51	9.31	2.6
20	10720.31	3345	536.16	544.49	9.33	2.59
21	10670.3	3345	536.12	544.47	9.35	2.58
22	10620.3	3345	536.07	544.45	9.38	2.57
23	10520.3	3345	536.15	544.4	9.25	2.62
24	10470.3	3345	536.09	544.39	9.3	2.6
25	10420.3	3345	535.84	544.38	9.54	2.52
26	10370.32	3345	535.13	544.41	10.28	2.28
27	10320.31	3345	535.68	544.34	9.66	2.48
28	10270.36	3345	536.09	544.28	9.19	2.64
29	10220.36	3345	535.84	544.27	9.43	2.55
30	10170.36	3345	536.01	544.23	9.22	2.63
31	10120.37	3345	535.92	544.22	9.3	2.6
32	10070.37	3345	535.79	544.21	9.42	2.56
33	10020.37	3345	535.88	544.18	9.3	2.6
34	9970.37	3345	536.08	544.13	9.05	2.7
35	9920.37	3345	535.73	544.13	9.4	2.57
36	9870.37	3345	535.82	544.1	9.28	2.61
37	9820.37	3345	535.89	544.07	9.18	2.65
38	9770.37	3345	535.92	544.04	9.12	2.67

39	9720.37	3345	535.92	544.02	9.1	2.68
40	9670.44	3345	535.89	544	9.11	2.67
41	9620.42	3345	535.92	543.97	9.05	2.7
42	9570.42	3345	536.12	543.92	8.8	2.8
43	9520.13	3345	536.02	543.9	8.88	2.76
44	9470.43	3345	535.82	543.89	9.07	2.69
45	9420.43	3345	535.87	543.86	8.99	2.72
46	9370.43	3345	535.86	543.83	8.97	2.72
47	9320.55	3345	535.59	543.83	9.24	2.62
48	9270.5	3345	535.73	543.79	9.06	2.69
49	9220.5	3345	535.97	543.73	8.76	2.81
50	9170.5	3345	536.14	543.67	8.53	2.91
51	9120.5	3345	535.87	543.67	8.8	2.8
52	9070.49	3345	536.12	543.6	8.48	2.94
53	9020.5	3345	535.99	543.6	8.61	2.8
54	8970.5	3345	535.71	543.58	8.87	2.77
55	8930	BARRAGE				
56	8920.5	3345	535.79	543.02	8.23	3.05
57	8905	YERWADA NEW BRIDGE				
58	8870.5	3345	535.99	542.9	7.91	3.21
59	8830	YERWADA OLD BRIDGE 1				
60	8820.5	3345	535.84	542.74	7.9	3.22
61	8807	YERWADA OLD BRIDGE 2				
62	8770.54	3345	535.32	542.68	8.36	2.99
63	8720.54	3345	535.32	542.65	8.33	3
64	8670.6	3345	535.33	542.61	8.28	3.03
65	8620.6	3345	535.12	542.6	8.48	2.93
66	8570.6	3345	535.22	542.53	8.31	3.06
67	8520.6	3345	535.17	542.49	8.32	3.06
68	8470.64	3345	535.08	542.47	8.39	3.02
69	8420.64	3345	535.11	542.42	8.31	3.06
70	8370.64	3345	535.19	542.36	8.17	3.13
71	8320.64	3345	535.07	542.34	8.27	3.08
72	8270.64	3345	534.95	542.32	8.37	3.04
73	8220.64	3345	534.84	542.29	8.45	2.99
74	8120.71	3345	535.01	542.18	8.17	3.13
75	8070.71	3345	534.81	542.16	8.35	3.04
76	8020.71	3345	534.64	542.15	8.51	2.97
77	7970.71	3345	534.53	542.13	8.6	2.93
78	7920.71	3345	534.47	542.1	8.63	2.91
79	7870.71	3345	534.75	542.01	8.26	3.09
80	7820.71	3345	534.84	541.94	8.1	3.17
81	7770.71	3345	534.83	541.9	8.07	3.18
82	7720.71	3345	534.69	541.88	8.19	3.12
83	7670.73	3345	534.56	541.85	8.29	3.07
84	7620.73	3345	534.42	541.83	8.41	3.01
85	7570.72	3345	534.12	541.83	8.71	2.88

86	7520.74	3345	534.26	541.78	8.52	2.96
87	7470.74	3345	534.12	541.76	8.64	2.91
88	7420.74	3345	534.18	541.71	8.53	2.96
89	7370.74	3345	533.71	541.73	9.02	2.75
90	7320.74	3345	533.5	541.72	9.22	2.67
91	7270.76	3345	533.78	541.65	8.87	2.81
92	7220.76	3345	533.28	541.67	9.39	2.6
93	7170.76	3345	532.91	541.68	9.77	2.47
94	7120.76	3345	532.45	541.69	10.24	2.32
95	7070.76	3345	532.26	541.68	10.42	2.27
96	7020.76	3345	532.29	541.66	10.37	2.28
97	6970.83	3345	532.83	541.6	9.77	2.47
98	6920.85	3345	531.51	541.65	11.14	2.08
99	6870.85	3345	531.81	541.62	10.81	2.16
100	6820.85	3345	531.94	541.6	10.66	2.2
101	6770.86	3345	532.36	541.5	10.14	2.52
102	6755	H H AGA KHAN BRIDGE				
103	6620.86	3345	531.49	541.46	10.97	2.27
104	6570.9	3345	531.7	541.46	10.76	2.18
105	6520.9	3345	531.54	541.46	10.92	2.14
106	6470.9	3345	531.56	541.44	10.88	2.14
107	6420.9	3345	531.65	541.42	10.77	2.17
108	6370.9	3345	531.71	541.41	10.7	2.19
109	6320.9	3345	532.13	541.36	10.23	2.33
110	6270.9	3345	531.09	541.38	11.29	2.16
111	6220.91	3345	531.63	541.36	10.73	2.19
112	6170.91	3345	531.73	541.34	10.61	2.22
113	6120.91	3345	531.74	541.33	10.59	2.22
114	6071.49	3345	531.68	541.32	10.64	2.21
115	6020.74	3345	531.39	541.32	10.93	2.13
116	5920.78	3345	531.13	541.31	11.18	2.07
117	5871.41	3345	531.2	541.29	11.09	2.09
118	5821.15	3345	531.36	541.27	10.91	2.14
119	5771.22	3345	531.79	541.23	10.44	2.27
120	5721.47	3345	532.07	541.19	10.12	2.36
121	5671.31	3345	531.39	541.21	10.82	2.16
122	5621.43	3345	531.75	541.17	10.42	2.27
123	5571.42	3345	531.64	541.16	10.52	2.24
124	5521.43	3345	532.01	541.11	10.1	2.36
125	5471.43	3345	532.36	541.06	9.7	2.49
126	5421.46	3345	531.93	541.07	10.14	2.35
127	5371.46	3345	531.56	541.07	10.51	2.24
128	5321.62	3345	531.51	541.06	10.55	2.23
129	5271.48	3345	531.71	541.03	10.32	2.3
130	5221.48	3345	531.69	541.02	10.33	2.3
131	5171.49	3345	531.3	541.03	10.73	2.19
132	5121.49	3345	531.76	540.98	10.22	2.33

133	5071.48	3345	531.75	540.96	10.21	2.33
134	5021.53	3345	531.58	540.96	10.38	2.28
135	4971.53	3345	531.92	540.91	9.99	2.4
136	4921.53	3345	531.93	540.89	9.96	2.41
137	4871.53	3345	531.56	540.9	10.34	2.29
138	4821.53	3345	531.15	540.9	10.75	2.18
139	4771.53	3345	531.81	540.84	10.03	2.39
140	4721.53	3345	531.63	540.83	10.2	2.34
141	4671.53	3345	531.9	540.76	9.86	2.54
142	4621.49	3345	531.49	540.77	10.28	2.41
143	4571.53	3345	531.31	540.78	10.47	2.26
144	4521.55	3345	531.74	540.73	9.99	2.4
145	4471.55	3345	531.69	540.72	10.03	2.39
146	4421.55	3345	531.73	540.7	9.97	2.41
147	4371.55	3345	531.69	540.68	9.99	2.4
148	4321.55	3345	531.72	540.66	9.94	2.41
149	4271.56	3345	531.75	540.64	9.89	2.43
150	4221.56	3345	531.6	540.63	10.03	2.39
151	4171.56	3345	531.72	540.6	9.88	2.43
152	4121.57	3345	531.59	540.59	10	2.39
153	4071.57	3345	531.7	540.57	9.87	2.44
154	4021.57	3345	531.69	540.55	9.86	2.44
155	3971.57	3345	531.65	540.53	9.88	2.43
156	3921.57	3345	531.69	540.51	9.82	2.45
157	3871.57	3345	531.68	540.49	9.81	2.46
158	3821.57	3345	531.63	540.48	9.85	2.45
159	3771.57	3345	531.78	540.44	9.66	2.51
160	3721.57	3345	531.84	540.41	9.57	2.54
161	3671.57	3345	531.75	540.4	9.65	2.52
162	3621.57	3345	531.67	540.39	9.72	2.49
163	3571.57	3345	532.18	540.3	9.12	2.71
164	3512	MUNDHWA BRIDGE				
165	3471.57	3345	532.14	540.12	8.98	2.76
166	3421.57	3345	532.12	540.09	8.97	2.77
167	3371.57	3345	531.8	540.09	9.29	2.64
168	3321.57	3345	531.84	540.06	9.22	2.67
169	3271.57	3345	531.74	540.05	9.31	2.63
170	3221.57	3345	532.12	539.97	8.85	2.82
171	3171.57	3345	531.94	539.96	9.02	2.75
172	3121.57	3345	532.11	539.9	8.79	2.84
173	3071.57	3345	532.12	539.87	8.75	2.86
174	3021.57	3345	532.04	539.85	8.81	2.83
175	2971.57	3345	531.83	539.84	9.01	2.75
176	2921.57	3345	531.37	539.85	9.48	2.57
177	2871.57	3345	531.49	539.82	9.33	2.63
178	2821.86	3345	531.92	539.73	8.81	2.83
179	2771.57	3345	532.02	539.68	8.66	2.9

180	2721.58	3345	532	539.65	8.65	2.9
181	2671.58	3345	531.78	539.64	8.86	2.81
182	2621.58	3345	532.06	539.56	8.5	2.97
183	2571.59	3345	532.1	539.52	8.42	3.01
184	2521.59	3345	532.15	539.47	8.32	3.06
185	2471.59	3345	532.27	539.4	8.13	3.16
186	2421.59	3345	531.94	539.4	8.46	2.99
187	2371.59	3345	531.96	539.36	8.4	3.02
188	2321.59	3345	532.02	539.3	8.28	3.08
189	2271.59	3345	532.1	539.24	8.14	3.15
190	2221.59	3345	532.19	539.17	7.98	3.23
191	2171.59	3345	532.12	539.13	8.01	3.22
192	2121.6	3345	532.15	539.07	7.92	3.26
193	2071.59	3345	532.04	539.04	8	3.22
194	2021.59	3345	531.79	539.03	8.24	3.1
195	1971.59	3345	531.59	539.02	8.43	3.01
196	1921.59	3345	531.84	538.92	8.08	3.18
197	1871.59	3345	532	538.83	7.83	3.32
198	1821.59	3345	531.88	538.8	7.92	3.27
199	1771.69	3345	532.21	538.63	7.42	3.56
200	1721.66	3345	531.29	538.72	8.43	3
201	1671.66	3345	532.52	538.24	6.72	4.08
202	1621.66	3345	532.22	538.23	7.01	3.86
203	1571.66	3345	532.13	538.16	7.03	3.84
204	1521.66	3345	531.66	538.19	7.53	3.5
205	1471.66	3345	532.05	537.93	6.88	3.95
206	1421.66	3345	532.07	537.79	6.72	4.08
207	1371.66	3345	532.07	537.64	6.57	4.21
208	1321.66	3345	532.07	537.45	6.38	4.38
209	1271.66	3345	532.24	536.93	5.69	5.12
210	1221.66	3345	532.12	536.1	4.98	6.09
211	1171.66	3345	531.75	535.5	4.75	6.49
212	1121.68	3345	531.13	535.84	5.71	5.1
213	1071.68	3345	529.84	536.24	7.4	3.5
214	1021.68	3345	529.32	536.28	7.96	3.19
215	971.68	3345	528.67	536.32	8.65	2.86
216	921.68	3345	528.83	536.26	8.43	2.96
217	871.68	3345	528.39	536.27	8.88	2.76
218	821.68	3345	528.66	536.2	8.54	2.91
219	771.68	3345	528.63	536.17	8.54	2.9
220	721.69	3345	528.38	536.17	8.79	2.8
221	671.69	3345	528.72	536.08	8.36	2.99
222	621.69	3345	528.59	536.06	8.47	2.94
223	571.69	3345	528.4	536.05	8.65	2.86
224	521.69	3345	528.58	535.99	8.41	2.96
225	471.69	3345	528.65	535.94	8.29	3.02
226	421.71	3345	528.66	535.9	8.24	3.04

227	371.71	3345	528.66	535.87	8.21	3.06
228	321.71	3345	528.67	535.83	8.16	3.09
229	271.71	3345	528.77	535.76	7.99	3.17
230	221.71	3345	528.21	535.79	8.58	2.89
231	171.71	3345	528.46	535.7	8.24	3.08
232	121.71	3345	527.91	535.73	8.82	2.79
233	71.71	3345	528.64	535.56	7.92	3.2

ANNEXURE XXI						
OUTPUTOF MULA MUTHA RIVER FROM HEC RAS FOR FLOOD DISCHARGE OF 100 YEAR RETURN PERIOD IN CHANNELIZED SECTION						
Sr No	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Top of Embankment t Level From Bed Lvl(m)	Vel Chnl (m/s)
1	11719.66	4762	536.29	546.65	11.36	2.85
2	11669.66	4762	536.33	546.62	11.29	2.88
3	11619.66	4762	536.39	546.6	11.21	2.9
4	11569.67	4762	536.07	546.6	11.53	2.8
5	11519.67	4762	535.88	546.6	11.72	2.74
6	11469.67	4762	536.8	546.46	10.66	3.1
7	11419.67	4762	535.75	546.52	11.77	2.72
8	11369.7	4762	535.76	546.5	11.74	2.73
9	11319.7	4762	535.93	546.47	11.54	2.8
10	11269.7	4762	536.19	546.42	11.23	2.9
11	11169.89	4762	536.34	546.36	11.02	2.97
12	11119.88	4762	536.12	546.35	11.23	2.9
13	11070.23	4762	536.04	546.34	11.3	2.87
14	11020.11	4762	535.86	546.33	11.47	2.82
15	10970.12	4762	535.68	546.33	11.65	2.76
16	10920.05	4762	535.88	546.29	11.41	2.84
17	10870.28	4762	535.88	546.27	11.39	2.84
18	10820.25	4762	536.27	546.2	10.93	3
19	10770.32	4762	536.2	546.18	10.98	2.98
20	10720.31	4762	536.16	546.17	11.01	2.97
21	10670.3	4762	536.12	546.15	11.03	2.97
22	10620.3	4762	536.07	546.13	11.06	2.96
23	10520.3	4762	536.15	546.07	10.92	3
24	10470.3	4762	536.09	546.06	10.97	2.99
25	10420.3	4762	535.84	546.06	11.22	2.9
26	10370.32	4762	535.13	546.09	11.96	2.67
27	10320.31	4762	535.68	546.01	11.33	2.86
28	10270.36	4762	536.09	545.94	10.85	3.03
29	10220.36	4762	535.84	545.93	11.09	2.94
30	10170.36	4762	536.01	545.89	10.88	3.02
31	10120.37	4762	535.92	545.87	10.95	2.99
32	10070.37	4762	535.79	545.86	11.07	2.95
33	10020.37	4762	535.88	545.83	10.95	2.99
34	9970.37	4762	536.08	545.78	10.7	3.09
35	9920.37	4762	535.73	545.78	11.05	2.96
36	9870.37	4762	535.82	545.75	10.93	3
37	9820.37	4762	535.89	545.71	10.82	3.04

38	9770.37	4762	535.92	545.68	10.76	3.06
39	9720.37	4762	535.92	545.66	10.74	3.07
40	9670.44	4762	535.89	545.64	10.75	3.07
41	9620.42	4762	535.92	545.61	10.69	3.09
42	9570.42	4762	536.12	545.55	10.43	3.19
43	9520.13	4762	536.02	545.53	10.51	3.16
44	9470.43	4762	535.82	545.53	10.71	3.08
45	9420.43	4762	535.87	545.49	10.62	3.11
46	9370.43	4762	535.86	545.47	10.61	3.12
47	9320.55	4762	535.59	545.46	10.87	3.02
48	9270.5	4762	535.73	545.41	10.68	3.09
49	9220.5	4762	535.97	545.35	10.38	3.21
50	9170.5	4762	536.14	545.29	10.15	3.31
51	9120.5	4762	535.87	545.29	10.42	3.2
52	9070.49	4762	536.12	545.21	10.09	3.33
53	9020.5	4762	535.99	545.22	10.23	3.17
54	8970.5	4762	535.71	545.2	10.49	3.17
55	8930	BARRAGE				
56	8920.5	4762	535.79	544.72	9.93	3.4
57	8905	YERWADA NEW BRIDGE				
58	8870.5	4762	535.99	544.59	9.6	3.55
59	8830	YERWADA OLD BRIDGE 1				
60	8820.5	4762	535.84	544.42	9.58	3.57
61	8807	YERWADA OLD BRIDGE 2				
62	8770.54	4762	535.32	544.35	10.03	3.36
63	8720.54	4762	535.32	544.31	9.99	3.37
64	8670.6	4762	535.33	544.27	9.94	3.39
65	8620.6	4762	535.12	544.27	10.15	3.31
66	8570.6	4762	535.22	544.19	9.97	3.42
67	8520.6	4762	535.17	544.16	9.99	3.41
68	8470.64	4762	535.08	544.14	10.06	3.38
69	8420.64	4762	535.11	544.1	9.99	3.42
70	8370.64	4762	535.19	544.04	9.85	3.48
71	8320.64	4762	535.07	544.02	9.95	3.44
72	8270.64	4762	534.95	544	10.05	3.39
73	8220.64	4762	534.84	543.98	10.14	3.35
74	8120.71	4762	535.01	543.86	9.85	3.48
75	8070.71	4762	534.81	543.85	10.04	3.39
76	8020.71	4762	534.64	543.84	10.2	3.32
77	7970.71	4762	534.53	543.82	10.29	3.29
78	7920.71	4762	534.47	543.79	10.32	3.27
79	7870.71	4762	534.75	543.7	9.95	3.43
80	7820.71	4762	534.84	543.64	9.8	3.5
81	7770.71	4762	534.83	543.6	9.77	3.52
82	7720.71	4762	534.69	543.58	9.89	3.46
83	7670.73	4762	534.56	543.56	10	3.41
84	7620.73	4762	534.42	543.54	10.12	3.36

85	7570.72	4762	534.12	543.55	10.43	3.23
86	7520.74	4762	534.26	543.49	10.23	3.31
87	7470.74	4762	534.12	543.47	10.35	3.26
88	7420.74	4762	534.18	543.43	10.25	3.3
89	7370.74	4762	533.71	543.45	10.74	3.11
90	7320.74	4762	533.5	543.44	10.94	3.03
91	7270.76	4762	533.78	543.37	10.59	3.16
92	7220.76	4762	533.28	543.39	11.11	2.97
93	7170.76	4762	532.91	543.4	11.49	2.84
94	7120.76	4762	532.45	543.41	11.96	2.7
95	7070.76	4762	532.26	543.41	12.15	2.64
96	7020.76	4762	532.29	543.39	12.1	2.66
97	6970.83	4762	532.83	543.32	11.49	2.83
98	6920.85	4762	531.51	543.37	12.86	2.45
99	6870.85	4762	531.81	543.34	12.53	2.54
100	6820.85	4762	531.94	543.31	12.37	2.58
101	6770.86	4762	532.36	543.19	11.83	2.93
102	6755	H H AGA KHAN BRIDGE				
103	6620.86	4762	531.49	543.14	12.65	2.68
104	6570.9	4762	531.7	543.15	12.45	2.56
105	6520.9	4762	531.54	543.14	12.6	2.52
106	6470.9	4762	531.56	543.12	12.56	2.53
107	6420.9	4762	531.65	543.1	12.45	2.56
108	6370.9	4762	531.71	543.08	12.37	2.58
109	6320.9	4762	532.13	543.03	11.9	2.71
110	6270.9	4762	531.09	543.03	12.94	2.63
111	6220.91	4762	531.63	543.02	12.39	2.61
112	6170.91	4762	531.73	543.01	12.28	2.6
113	6120.91	4762	531.74	543	12.26	2.61
114	6071.49	4762	531.68	542.98	12.3	2.6
115	6020.74	4762	531.39	542.99	12.6	2.52
116	5920.78	4762	531.13	542.97	12.84	2.46
117	5871.41	4762	531.2	542.96	12.76	2.48
118	5821.15	4762	531.36	542.93	12.57	2.53
119	5771.22	4762	531.79	542.88	12.09	2.66
120	5721.47	4762	532.07	542.83	11.76	2.76
121	5671.31	4762	531.39	542.86	12.47	2.55
122	5621.43	4762	531.75	542.81	12.06	2.67
123	5571.42	4762	531.64	542.8	12.16	2.64
124	5521.43	4762	532.01	542.75	11.74	2.76
125	5471.43	4762	532.36	542.69	11.33	2.89
126	5421.46	4762	531.93	542.7	11.77	2.75
127	5371.46	4762	531.56	542.71	12.15	2.64
128	5321.62	4762	531.51	542.69	12.18	2.63
129	5271.48	4762	531.71	542.66	11.95	2.7
130	5221.48	4762	531.69	542.64	11.95	2.7
131	5171.49	4762	531.3	542.65	12.35	2.58

132	5121.49	4762	531.76	542.59	11.83	2.73
133	5071.48	4762	531.75	542.57	11.82	2.74
134	5021.53	4762	531.58	542.57	11.99	2.69
135	4971.53	4762	531.92	542.52	11.6	2.81
136	4921.53	4762	531.93	542.49	11.56	2.82
137	4871.53	4762	531.56	542.5	11.94	2.71
138	4821.53	4762	531.15	542.51	12.36	2.61
139	4771.53	4762	531.81	542.43	11.62	2.81
140	4721.53	4762	531.63	542.42	11.79	2.77
141	4671.53	4762	531.9	542.32	11.42	3.04
142	4621.49	4762	531.49	542.33	11.84	2.91
143	4571.53	4762	531.31	542.36	12.05	2.69
144	4521.55	4762	531.74	542.3	11.56	2.83
145	4471.55	4762	531.69	542.28	11.59	2.83
146	4421.55	4762	531.73	542.26	11.53	2.83
147	4371.55	4762	531.69	542.25	11.56	2.82
148	4321.55	4762	531.72	542.23	11.51	2.84
149	4271.56	4762	531.75	542.2	11.45	2.85
150	4221.56	4762	531.6	542.19	11.59	2.81
151	4171.56	4762	531.72	542.16	11.44	2.86
152	4121.57	4762	531.59	542.15	11.56	2.82
153	4071.57	4762	531.7	542.12	11.42	2.87
154	4021.57	4762	531.69	542.1	11.41	2.87
155	3971.57	4762	531.65	542.08	11.43	2.86
156	3921.57	4762	531.69	542.05	11.36	2.88
157	3871.57	4762	531.68	542.03	11.35	2.89
158	3821.57	4762	531.63	542.01	11.38	2.88
159	3771.57	4762	531.78	541.97	11.19	2.94
160	3721.57	4762	531.84	541.94	11.1	2.99
161	3671.57	4762	531.75	541.92	11.17	2.98
162	3621.57	4762	531.67	541.91	11.24	2.94
163	3571.57	4762	532.18	541.81	10.63	3.15
164	3512	MUNDHWA BRIDGE				
165	3471.57	4762	532.14	541.58	10.44	3.22
166	3421.57	4762	532.12	541.55	10.43	3.23
167	3371.57	4762	531.8	541.55	10.75	3.1
168	3321.57	4762	531.84	541.52	10.68	3.13
169	3271.57	4762	531.74	541.5	10.76	3.1
170	3221.57	4762	532.12	541.41	10.29	3.28
171	3171.57	4762	531.94	541.4	10.46	3.21
172	3121.57	4762	532.11	541.34	10.23	3.31
173	3071.57	4762	532.12	541.3	10.18	3.33
174	3021.57	4762	532.04	541.28	10.24	3.31
175	2971.57	4762	531.83	541.27	10.44	3.22
176	2921.57	4762	531.37	541.29	10.92	3.04
177	2871.57	4762	531.49	541.24	10.75	3.1
178	2821.86	4762	531.92	541.14	10.22	3.31

179	2771.57	4762	532.02	541.08	10.06	3.38
180	2721.58	4762	532	541.05	10.05	3.39
181	2671.58	4762	531.78	541.04	10.26	3.3
182	2621.58	4762	532.06	540.95	9.89	3.46
183	2571.59	4762	532.1	540.9	9.8	3.5
184	2521.59	4762	532.15	540.84	9.69	3.56
185	2471.59	4762	532.27	540.76	9.49	3.65
186	2421.59	4762	531.94	540.77	9.83	3.49
187	2371.59	4762	531.96	540.72	9.76	3.52
188	2321.59	4762	532.02	540.66	9.64	3.58
189	2271.59	4762	532.1	540.59	9.49	3.66
190	2221.59	4762	532.19	540.51	9.32	3.74
191	2171.59	4762	532.12	540.47	9.35	3.73
192	2121.6	4762	532.15	540.4	9.25	3.78
193	2071.59	4762	532.04	540.37	9.33	3.74
194	2021.59	4762	531.79	540.36	9.57	3.64
195	1971.59	4762	531.59	540.35	9.76	3.53
196	1921.59	4762	531.84	540.24	9.4	3.7
197	1871.59	4762	532	540.13	9.13	3.85
198	1821.59	4762	531.88	540.1	9.22	3.8
199	1771.69	4762	532.21	539.91	8.7	4.1
200	1721.66	4762	531.29	540.02	9.73	3.54
201	1671.66	4762	532.52	539.47	7.95	4.63
202	1621.66	4762	532.22	539.46	8.24	4.41
203	1571.66	4762	532.13	539.39	8.26	4.39
204	1521.66	4762	531.66	539.43	8.77	4.06
205	1471.66	4762	532.05	539.14	8.09	4.52
206	1421.66	4762	532.07	538.99	7.92	4.65
207	1371.66	4762	532.07	538.83	7.76	4.78
208	1321.66	4762	532.07	538.64	7.57	4.94
209	1271.66	4762	532.24	538.09	6.85	5.67
210	1221.66	4762	532.12	537.25	6.13	6.6
211	1171.66	4762	531.75	536.46	5.71	7.25
212	1121.68	4762	531.13	537.46	7.33	5.16
213	1071.68	4762	529.84	537.8	8.96	3.88
214	1021.68	4762	529.32	537.84	9.52	3.59
215	971.68	4762	528.67	537.89	10.22	3.28
216	921.68	4762	528.83	537.83	10	3.37
217	871.68	4762	528.39	537.84	10.45	3.18
218	821.68	4762	528.66	537.77	10.11	3.32
219	771.68	4762	528.63	537.74	10.11	3.32
220	721.69	4762	528.38	537.74	10.36	3.22
221	671.69	4762	528.72	537.64	9.92	3.41
222	621.69	4762	528.59	537.62	10.03	3.36
223	571.69	4762	528.4	537.61	10.21	3.28
224	521.69	4762	528.58	537.54	9.96	3.39
225	471.69	4762	528.65	537.49	9.84	3.44

226	421.71	4762	528.66	537.45	9.79	3.46
227	371.71	4762	528.66	537.41	9.75	3.48
228	321.71	4762	528.67	537.37	9.7	3.51
229	271.71	4762	528.77	537.3	9.53	3.59
230	221.71	4762	528.21	537.33	10.12	3.32
231	171.71	4762	528.46	537.21	9.75	3.58
232	121.71	4762	527.91	537.27	10.36	3.22
233	71.71	4762	528.64	537.08	9.44	3.63

ANNEXURE XXII

OUTPUTOF MULA RIVER UPTO CONFLUENCE WITH PAWANA RIVER FROM HEC RAS FOR FLOOD DISCHARGE OF 25 YEAR RETURN PERIOD IN CHANNELIZED SECTION

Sr No	River Sta	Q Total	Min Ch El	W.S. Elev	Top of Embankment Level From Bed Lvl(m)	Vel Chnl
		(m3/s)	(m)	(m)		(m/s)
1	10820.69	1206	548.87	555.04	7.17	1.82
2	10770.05	1206	548.8	555.03	7.23	1.78
3	10720.05	1206	548.87	555.01	7.14	1.81
4	10670.05	1206	548.87	554.99	7.12	1.82
5	10620.05	1206	549.32	554.93	6.61	2.01
6	10570.05	1206	549.5	554.88	6.38	2.11
7	10520.06	1206	549.39	554.86	6.47	2.07
8	10470.06	1206	549.15	554.85	6.7	1.97
9	10420.06	1206	549.29	554.82	6.53	2.05
10	10355	MUMBAI PUNE BYPASS BRIDGE				
11	10320.07	1206	549.32	554.64	6.32	2.14
12	10270.28	1206	549.12	554.63	6.51	2.06
13	10170.28	1206	549.27	554.55	6.28	2.16
14	10120.29	1206	549.44	554.5	6.06	2.27
15	10070.29	1206	549.5	554.45	5.95	2.33
16	10020.28	1206	549.34	554.43	6.09	2.25
17	9920.43	1206	547.29	554.49	8.2	1.5
18	9870.41	1206	547.1	554.49	8.39	1.45
19	9820.57	1206	547.38	554.47	8.09	1.53
20	9770.58	1206	546.62	554.48	8.86	1.35
21	9720.61	1206	546.84	554.46	8.62	1.4
22	9670.61	1206	546.71	554.46	8.75	1.37
23	9620.61	1206	546.54	554.46	8.92	1.34
24	9570.59	1206	546.47	554.45	8.98	1.33
25	9520.65	1206	546.43	554.44	9.01	1.32
26	9470.72	1206	546.56	554.43	8.87	1.35
27	9420.72	1206	546.69	554.42	8.73	1.38
28	9370.71	1206	546.86	554.41	8.55	1.42
29	9320.72	1206	546.71	554.4	8.69	1.39
30	9270.92	1206	546.76	554.39	8.63	1.4
31	9220.72	1206	546.77	554.38	8.61	1.4
32	9170.77	1206	546.78	554.38	8.6	1.41
33	9120.77	1206	546.87	554.36	8.49	1.43
34	9070.9	1206	546.76	554.36	8.6	1.41
35	9020.89	1206	546.77	554.35	8.58	1.41
36	8970.89	1206	546.77	554.34	8.57	1.41
37	8920.89	1206	546.73	554.34	8.61	1.41

38	8870.89	1206	546.73	554.33	8.6	1.41
39	8820.89	1206	546.93	554.31	8.38	1.46
40	8770.89	1206	546.82	554.31	8.49	1.43
41	8720.89	1206	546.77	554.3	8.53	1.42
42	8671.1	1206	546.87	554.29	8.42	1.45
43	8621.18	1206	546.77	554.28	8.51	1.43
44	8570.97	1206	546.83	554.27	8.44	1.44
45	8521.05	1206	546.68	554.26	8.58	1.41
46	8471.01	1206	546.8	554.25	8.45	1.44
47	8421.45	1206	546.58	554.25	8.67	1.39
48	8389	BRIDGE				
49	8321.33	1206	546.48	554.22	8.74	1.38
50	8271.33	1206	546.64	554.21	8.57	1.41
51	8221.33	1206	546.63	554.2	8.57	1.41
52	8121.42	1206	547.21	554.16	7.95	1.57
53	8071.42	1206	546.93	554.15	8.22	1.49
54	8021.52	1206	546.96	554.14	8.18	1.51
55	7971.42	1206	545.93	554.16	9.23	1.28
56	7921.59	1206	545.71	554.16	9.45	1.24
57	7871.58	1206	545.59	554.15	9.56	1.22
58	7821.58	1206	545.61	554.15	9.54	1.22
59	7771.58	1206	545.81	554.14	9.33	1.26
60	7721.58	1206	545.64	554.13	9.49	1.23
61	7671.62	1206	545.38	554.13	9.75	1.19
62	7621.62	1206	545.79	554.12	9.33	1.26
63	7571.58	1206	545.9	554.11	9.21	1.28
64	7521.67	1206	545.6	554.11	9.51	1.23
65	7471.67	1206	545.84	554.1	9.26	1.27
66	7421.67	1206	545.87	554.09	9.22	1.28
67	7371.68	1206	545.84	554.08	9.24	1.28
68	7321.65	1206	545.92	554.08	9.16	1.29
69	7271.71	1206	545.61	554.08	9.47	1.23
70	7221.76	1206	545.74	554.07	9.33	1.26
71	7171.89	1206	545.7	554.06	9.36	1.26
72	7122.08	1206	545.85	554.05	9.2	1.29
73	7072.06	1206	545.78	554.05	9.27	1.29
74	7022.08	1206	545.56	554.04	9.48	1.23
75	6972.08	1206	545.75	554.03	9.28	1.27
76	6922.08	1206	545.92	553.97	9.05	1.59
77	6872.08	1206	545.89	553.99	9.1	1.37
78	6822.08	1206	546.01	553.98	8.97	1.4
79	6772.08	1206	545.96	553.98	9.02	1.32
80	6722.08	1206	546.1	553.97	8.87	1.35
81	6672.08	1206	545.61	553.97	9.36	1.25
82	6622.08	1206	545.74	553.96	9.22	1.28
83	6572.1	1206	545.78	553.96	9.18	1.29
84	6522.09	1206	545.84	553.95	9.11	1.3

85	6472.09	1206	545.87	553.94	9.07	1.31
86	6422.1	1206	545.43	553.94	9.51	1.23
87	6372.1	1206	545.78	553.93	9.15	1.29
88	6322.1	1206	545.92	553.92	9	1.32
89	6272.11	1206	545.82	553.91	9.09	1.3
90	6222.11	1206	545.55	553.91	9.36	1.25
91	6171.99	1206	545.39	553.91	9.52	1.23
92	6122.29	1206	545.63	553.9	9.27	1.27
93	6072.27	1206	545.84	553.88	9.04	1.31
94	6022.27	1206	545.81	553.88	9.07	1.31
95	5972.15	1206	546.48	553.85	8.37	1.46
96	5922.27	1206	546.45	553.84	8.39	1.46
97	5871.84	1206	545.69	553.85	9.16	1.29
98	5822.27	1206	545.82	553.84	9.02	1.32
99	5772.25	1206	545.9	553.83	8.93	1.34
100	5721.82	1206	546	553.82	8.82	1.36
101	5672.25	1206	545.46	553.82	9.36	1.25
102	5622.25	1206	545.88	553.8	8.92	1.34
103	5572.25	1206	545.98	553.79	8.81	1.36
104	5522.31	1206	545.8	553.79	8.99	1.32
105	5472.55	1206	545.58	553.79	9.21	1.28
106	5422.55	1536	545.99	553.7	8.71	1.76
107	5372.55	1536	546.17	553.67	8.5	1.82
108	5322.55	1536	545.82	553.67	8.85	1.79
109	5272.66	1536	545.83	553.66	8.83	1.75
110	5175	SHIVAJI MAHARAJ BRIDGE				
111	5172.59	1536	545.33	553.63	9.3	1.67
112	5119.41	1536	545.22	553.6	9.38	1.73
113	5072.72	1536	545.38	553.55	9.17	1.95
114	5022.73	1536	545.63	553.5	8.87	2.1
115	4972.73	1536	545.53	553.54	9.01	1.7
116	4922.72	1536	545.34	553.54	9.2	1.65
117	4872.76	1536	545.59	553.51	8.92	1.72
118	4822.75	1536	545.35	553.51	9.16	1.66
119	4772.81	1536	545.68	553.48	8.8	1.75
120	4722.97	1536	545.55	553.47	8.92	1.72
121	4672.71	1536	546.65	553.38	7.73	2.1
122	4623.45	1536	546.29	553.38	8.09	1.97
123	4573.47	1536	544.87	553.42	9.55	1.57
124	4523.6	1536	544.88	553.41	9.53	1.57
125	4473.68	1536	544.82	553.4	9.58	1.56
126	4423.73	1536	544.87	553.39	9.52	1.57
127	4373.73	1536	545	553.38	9.38	1.61
128	4323.71	1536	544.97	553.37	9.4	1.6
129	4273.9	1536	544.72	553.36	9.64	1.55
130	4223.98	1536	545.15	553.34	9.19	1.65
131	4173.98	1536	545.02	553.33	9.31	1.65

132	4073.9	1536	544.53	553.32	9.79	1.56
133	4024.22	1536	545.02	553.27	9.25	1.8
134	3974.22	1536	544.6	553.29	9.69	1.54
135	3924.22	1536	544.48	553.28	9.8	1.51
136	3874.23	1536	544.62	553.27	9.65	1.54
137	3824.23	1536	544.9	553.25	9.35	1.61
138	3774.23	1536	544.92	553.24	9.32	1.62
139	3724.23	1536	544.97	553.23	9.26	1.64
140	3674.23	1536	543.1	553.26	11.16	1.26
141	3624.22	1536	545.03	553.19	9.16	1.66
142	3574.29	1536	545.15	553.17	9.02	1.7
143	3524.29	1536	544.68	553.17	9.49	1.58
144	3474.29	1536	545.05	553.15	9.1	1.68
145	3424.29	1536	544.67	553.15	9.48	1.58
146	3374.29	1536	544.72	553.13	9.41	1.6
147	3324.04	1536	544.83	553.12	9.29	1.63
148	3274.51	1536	544.73	553.11	9.38	1.61
149	3224.5	1536	544.84	553.1	9.26	1.64
150	3174.5	1536	544.81	553.09	9.28	1.63
151	3124.51	1536	544.96	553.07	9.11	1.67
152	3074.51	1536	544.96	553.06	9.1	1.67
153	3024.51	1536	544.03	553.08	10.05	1.46
154	2974.51	1536	544.37	553.06	9.69	1.54
155	2924.51	1536	544.56	553.04	9.48	1.58
156	2884	OLD AUNDH BRIDGE				
157	2874.51	1536	544.47	553.02	9.55	1.57
158	2824.51	1536	544.57	553.01	9.44	1.59
159	2774.57	1536	544.79	552.99	9.2	1.65
160	2724.57	1536	544.64	552.98	9.34	1.62
161	2674.57	1536	544.61	552.97	9.36	1.61
162	2624.57	1536	544.48	552.97	9.49	1.58
163	2574.57	1536	544.56	552.96	9.4	1.6
164	2524.57	1536	545.03	552.9	8.87	1.85
165	2495	AUNDH BRIDGE				
166	2474.62	1536	545.72	552.79	8.07	1.98
167	2424.62	1536	544.76	552.81	9.05	1.72
168	2374.62	1536	544.64	552.74	9.1	2.01
169	2324.7	1536	544.91	552.76	8.85	1.76
170	2274.74	1536	544.24	552.77	9.53	1.57
171	2224.73	1536	544.35	552.74	9.39	1.7
172	2174.74	1536	544.92	552.71	8.79	1.78
173	2124.74	1536	545.05	552.62	8.57	2.14
174	2074.74	1536	544.85	552.65	8.8	1.83
175	2024.74	1536	544.75	552.6	8.85	1.98
176	1974.77	1536	544.63	552.53	8.9	2.22
177	1924.77	1536	544.8	552.58	8.78	1.8
178	1874.75	1536	545.46	552.52	8.06	2

179	1838	SANGVI BRIDGE				
180	1824.79	1536	544.75	552.51	8.76	1.77
181	1774.78	1536	544.7	552.49	8.79	1.78
182	1724.72	1536	544.97	552.47	8.5	1.84
183	1674.78	1536	544.51	552.47	8.96	1.71
184	1624.78	1536	544.6	552.46	8.86	1.74
185	1524.78	1536	545.15	552.39	8.24	1.92
186	1474.78	1536	544.66	552.4	8.74	1.77
187	1424.77	1536	544.34	552.4	9.06	1.69
188	1374.8	1536	544.55	552.37	8.82	1.75
189	1324.8	1536	544.48	552.36	8.88	1.73
190	1274.79	1536	544.08	552.36	9.28	1.63
191	1224.82	1536	544.62	552.32	8.7	1.78
192	1174.82	1536	544.58	552.31	8.73	1.77
193	1124.84	1536	544.07	552.32	9.25	1.64
194	1074.84	1536	544.49	552.27	8.78	1.85
195	1024.84	1536	544.32	552.27	8.95	1.71
196	974.86	1536	544.44	552.25	8.81	1.75
197	924.86	1536	544.33	552.25	8.92	1.72
198	874.86	1536	544.3	552.23	8.93	1.72
199	824.86	1536	544.49	552.21	8.72	1.78
200	774.86	1536	544.8	552.18	8.38	1.88
201	724.86	1536	544.6	552.17	8.57	1.82
202	674.86	1536	544.42	552.16	8.74	1.77
203	624.83	1536	544.63	552.14	8.51	1.84
204	574.83	1536	543.9	552.15	9.25	1.64
205	524.87	1536	544.06	552.13	9.07	1.69
206	474.87	1536	544.03	552.12	9.09	1.68
207	424.97	1536	544.61	552.07	8.46	1.87
208	374.97	1536	544.69	552.04	8.35	1.93
209	325	1536	544.73	552	8.27	2.04
210	275	1536	544.42	552	8.58	1.95
211	225.01	1536	544.46	552	8.54	1.86
212	175.01	1536	544.65	551.97	8.32	1.93
213	125.01	1536	545.15	551.9	7.75	2.16
214	75.01	1536	544.93	551.89	7.96	2.1
215	25.01	1536	544.87	551.87	8	2.1

ANNEXURE XXIII

OUTPUTOF MULA RIVER UPTO CONFLUENCE WITH PAWANA RIVER FROM HEC RAS FOR FLOOD DISCHARGE OF 100 YEAR RETURN PERIOD IN CHANNELIZED SECTION

Sr No	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Top of Embankment Level From Bed Lvl(m)	Vel Chnl (m/s)
1	10820.69	1232	548.87	555.3	7.43	1.77
2	10770.05	1232	548.8	555.29	7.49	1.73
3	10720.05	1232	548.87	555.27	7.4	1.76
4	10670.05	1232	548.87	555.26	7.39	1.77
5	10620.05	1232	549.32	555.2	6.88	1.95
6	10570.05	1232	549.5	555.16	6.66	2.03
7	10520.06	1232	549.39	555.15	6.76	2
8	10470.06	1232	549.15	555.14	6.99	1.91
9	10420.06	1232	549.29	555.1	6.81	1.97
10	10355	MUMBAI PUNE BYPASS BRIDGE				
11	10320.07	1232	549.32	554.95	6.63	2.05
12	10270.28	1232	549.12	554.94	6.82	1.97
13	10170.28	1232	549.27	554.87	6.6	2.06
14	10120.29	1232	549.44	554.83	6.39	2.15
15	10070.29	1232	549.5	554.79	6.29	2.2
16	10020.28	1232	549.34	554.77	6.43	2.14
17	9920.43	1232	547.29	554.83	8.54	1.45
18	9870.41	1232	547.1	554.82	8.72	1.41
19	9820.57	1232	547.38	554.81	8.43	1.48
20	9770.58	1232	546.62	554.81	9.19	1.31
21	9720.61	1232	546.84	554.8	8.96	1.36
22	9670.61	1232	546.71	554.8	9.09	1.33
23	9620.61	1232	546.54	554.79	9.25	1.3
24	9570.59	1232	546.47	554.79	9.32	1.29
25	9520.65	1232	546.43	554.78	9.35	1.28
26	9470.72	1232	546.56	554.77	9.21	1.31
27	9420.72	1232	546.69	554.76	9.07	1.34
28	9370.71	1232	546.86	554.75	8.89	1.37
29	9320.72	1232	546.71	554.75	9.04	1.34
30	9270.92	1232	546.76	554.74	8.98	1.36
31	9220.72	1232	546.77	554.73	8.96	1.36
32	9170.77	1232	546.78	554.72	8.94	1.36
33	9120.77	1232	546.87	554.71	8.84	1.38
34	9070.9	1232	546.76	554.71	8.95	1.36
35	9020.89	1232	546.77	554.7	8.93	1.37
36	8970.89	1232	546.77	554.69	8.92	1.37
37	8920.89	1232	546.73	554.69	8.96	1.36
38	8870.89	1232	546.73	554.68	8.95	1.36

39	8820.89	1232	546.93	554.67	8.74	1.41
40	8770.89	1232	546.82	554.66	8.84	1.38
41	8720.89	1232	546.77	554.65	8.88	1.37
42	8671.1	1232	546.87	554.64	8.77	1.4
43	8621.18	1232	546.77	554.64	8.87	1.38
44	8570.97	1232	546.83	554.63	8.8	1.39
45	8521.05	1232	546.68	554.62	8.94	1.36
46	8471.01	1232	546.8	554.61	8.81	1.39
47	8421.45	1232	546.58	554.61	9.03	1.34
48	8389	Bridge				
49	8321.33	1232	546.48	554.59	9.11	1.33
50	8271.33	1232	546.64	554.57	8.93	1.36
51	8221.33	1232	546.63	554.57	8.94	1.36
52	8121.42	1232	547.21	554.53	8.32	1.5
53	8071.42	1232	546.93	554.53	8.6	1.44
54	8021.52	1232	546.96	554.52	8.56	1.45
55	7971.42	1232	545.93	554.53	9.6	1.24
56	7921.59	1232	545.71	554.53	9.82	1.2
57	7871.58	1232	545.59	554.53	9.94	1.18
58	7821.58	1232	545.61	554.52	9.91	1.18
59	7771.58	1232	545.81	554.51	9.7	1.22
60	7721.58	1232	545.64	554.51	9.87	1.19
61	7671.62	1232	545.38	554.51	10.13	1.15
62	7621.62	1232	545.79	554.49	9.7	1.22
63	7571.58	1232	545.9	554.49	9.59	1.24
64	7521.67	1232	545.6	554.49	9.89	1.19
65	7471.67	1232	545.84	554.48	9.64	1.23
66	7421.67	1232	545.87	554.47	9.6	1.24
67	7371.68	1232	545.84	554.46	9.62	1.23
68	7321.65	1232	545.92	554.46	9.54	1.25
69	7271.71	1232	545.61	554.46	9.85	1.19
70	7221.76	1232	545.74	554.45	9.71	1.22
71	7171.89	1232	545.7	554.44	9.74	1.22
72	7122.08	1232	545.85	554.43	9.58	1.25
73	7072.06	1232	545.78	554.43	9.65	1.25
74	7022.08	1232	545.56	554.43	9.87	1.19
75	6972.08	1232	545.75	554.42	9.67	1.22
76	6922.08	1232	545.92	554.36	9.44	1.55
77	6872.08	1232	545.89	554.38	9.49	1.33
78	6822.08	1232	546.01	554.37	9.36	1.36
79	6772.08	1232	545.96	554.37	9.41	1.27
80	6722.08	1232	546.1	554.36	9.26	1.3
81	6672.08	1232	545.61	554.36	9.75	1.21
82	6622.08	1232	545.74	554.36	9.62	1.23
83	6572.1	1232	545.78	554.35	9.57	1.24
84	6522.09	1232	545.84	554.34	9.5	1.25
85	6472.09	1232	545.87	554.34	9.47	1.26

86	6422.1	1232	545.43	554.34	9.91	1.18
87	6372.1	1232	545.78	554.32	9.54	1.25
88	6322.1	1232	545.92	554.31	9.39	1.27
89	6272.11	1232	545.82	554.31	9.49	1.26
90	6222.11	1232	545.55	554.31	9.76	1.21
91	6171.99	1232	545.39	554.31	9.92	1.18
92	6122.29	1232	545.63	554.3	9.67	1.23
93	6072.27	1232	545.84	554.29	9.45	1.26
94	6022.27	1232	545.81	554.28	9.47	1.26
95	5972.15	1232	546.48	554.25	8.77	1.4
96	5922.27	1232	546.45	554.25	8.8	1.39
97	5871.84	1232	545.69	554.25	9.56	1.24
98	5822.27	1232	545.82	554.25	9.43	1.27
99	5772.25	1232	545.9	554.24	9.34	1.28
100	5721.82	1232	546	554.23	9.23	1.31
101	5672.25	1232	545.46	554.23	9.77	1.21
102	5622.25	1232	545.88	554.22	9.34	1.29
103	5572.25	1232	545.98	554.21	9.23	1.31
104	5522.31	1232	545.8	554.2	9.4	1.27
105	5472.55	1232	545.58	554.2	9.62	1.23
106	5422.55	1670	545.99	554.1	9.11	1.81
107	5372.55	1670	546.17	554.07	8.9	1.86
108	5322.55	1670	545.82	554.06	9.24	1.84
109	5272.66	1670	545.83	554.06	9.23	1.79
110	5175	SHIVAJI MAHARAJ BRIDGE				
111	5172.59	1670	545.33	554.03	9.7	1.73
112	5119.41	1670	545.22	554	9.78	1.8
113	5072.72	1670	545.38	553.94	9.56	2.02
114	5022.73	1670	545.63	553.89	9.26	2.18
115	4972.73	1670	545.53	553.94	9.41	1.74
116	4922.72	1670	545.34	553.94	9.6	1.69
117	4872.76	1670	545.59	553.91	9.32	1.76
118	4822.75	1670	545.35	553.91	9.56	1.7
119	4772.81	1670	545.68	553.88	9.2	1.79
120	4722.97	1670	545.55	553.87	9.32	1.76
121	4672.71	1670	546.65	553.78	8.13	2.13
122	4623.45	1670	546.29	553.78	8.49	2
123	4573.47	1670	544.87	553.82	9.95	1.61
124	4523.6	1670	544.88	553.81	9.93	1.61
125	4473.68	1670	544.82	553.8	9.98	1.6
126	4423.73	1670	544.87	553.79	9.92	1.62
127	4373.73	1670	545	553.77	9.77	1.65
128	4323.71	1670	544.97	553.77	9.8	1.65
129	4273.9	1670	544.72	553.76	10.04	1.59
130	4223.98	1670	545.15	553.73	9.58	1.7
131	4173.98	1670	545.02	553.72	9.7	1.7
132	4073.9	1670	544.53	553.72	10.19	1.62

133	4024.22	1670	545.02	553.66	9.64	1.87
134	3974.22	1670	544.6	553.69	10.09	1.58
135	3924.22	1670	544.48	553.68	10.2	1.56
136	3874.23	1670	544.62	553.67	10.05	1.59
137	3824.23	1670	544.9	553.65	9.75	1.66
138	3774.23	1670	544.92	553.63	9.71	1.66
139	3724.23	1670	544.97	553.62	9.65	1.68
140	3674.23	1670	543.1	553.65	11.55	1.31
141	3624.22	1670	545.03	553.58	9.55	1.7
142	3574.29	1670	545.15	553.56	9.41	1.74
143	3524.29	1670	544.68	553.57	9.89	1.62
144	3474.29	1670	545.05	553.54	9.49	1.72
145	3424.29	1670	544.67	553.54	9.87	1.63
146	3374.29	1670	544.72	553.53	9.81	1.64
147	3324.04	1670	544.83	553.52	9.69	1.67
148	3274.51	1670	544.73	553.51	9.78	1.65
149	3224.5	1670	544.84	553.49	9.65	1.68
150	3174.5	1670	544.81	553.49	9.68	1.67
151	3124.51	1670	544.96	553.47	9.51	1.71
152	3074.51	1670	544.96	553.46	9.5	1.72
153	3024.51	1670	544.03	553.47	10.44	1.51
154	2974.51	1670	544.37	553.45	10.08	1.58
155	2924.51	1670	544.56	553.44	9.88	1.63
156	2884	OLD AUNDH BRIDGE				
157	2874.51	1670	544.47	553.42	9.95	1.61
158	2824.51	1670	544.57	553.4	9.83	1.64
159	2774.57	1670	544.79	553.38	9.59	1.69
160	2724.57	1670	544.64	553.38	9.74	1.66
161	2674.57	1670	544.61	553.37	9.76	1.65
162	2624.57	1670	544.48	553.36	9.88	1.62
163	2574.57	1670	544.56	553.35	9.79	1.65
164	2524.57	1670	545.03	553.29	9.26	1.91
165	2495	AUNDH BRIDGE				
166	2474.62	1670	545.72	553.18	8.46	2.02
167	2424.62	1670	544.76	553.2	9.44	1.78
168	2374.62	1670	544.64	553.12	9.48	2.09
169	2324.7	1670	544.91	553.14	9.23	1.82
170	2274.74	1670	544.24	553.16	9.92	1.62
171	2224.73	1670	544.35	553.12	9.77	1.76
172	2174.74	1670	544.92	553.09	9.17	1.83
173	2124.74	1670	545.05	552.99	8.94	2.21
174	2074.74	1670	544.85	553.03	9.18	1.89
175	2024.74	1670	544.75	552.98	9.23	2.05
176	1974.77	1670	544.63	552.9	9.27	2.3
177	1924.77	1670	544.8	552.95	9.15	1.86
178	1874.75	1670	545.46	552.9	8.44	2.05
179	1838	SANGVI BRIDGE				

180	1824.79	1670	544.75	552.86	9.11	1.82
181	1774.78	1670	544.7	552.84	9.14	1.84
182	1724.72	1670	544.97	552.82	8.85	1.89
183	1674.78	1670	544.51	552.82	9.31	1.76
184	1624.78	1670	544.6	552.81	9.21	1.79
185	1524.78	1670	545.15	552.74	8.59	1.97
186	1474.78	1670	544.66	552.75	9.09	1.82
187	1424.77	1670	544.34	552.75	9.41	1.74
188	1374.8	1670	544.55	552.72	9.17	1.8
189	1324.8	1670	544.48	552.71	9.23	1.78
190	1274.79	1670	544.08	552.72	9.64	1.68
191	1224.82	1670	544.62	552.67	9.05	1.83
192	1174.82	1670	544.58	552.66	9.08	1.83
193	1124.84	1670	544.07	552.67	9.6	1.69
194	1074.84	1670	544.49	552.61	9.12	1.92
195	1024.84	1670	544.32	552.62	9.3	1.77
196	974.86	1670	544.44	552.6	9.16	1.8
197	924.86	1670	544.33	552.59	9.26	1.78
198	874.86	1670	544.3	552.58	9.28	1.77
199	824.86	1670	544.49	552.56	9.07	1.83
200	774.86	1670	544.8	552.52	8.72	1.93
201	724.86	1670	544.6	552.52	8.92	1.87
202	674.86	1670	544.42	552.51	9.09	1.82
203	624.83	1670	544.63	552.48	8.85	1.89
204	574.83	1670	543.9	552.5	9.6	1.7
205	524.87	1670	544.06	552.48	9.42	1.75
206	474.87	1670	544.03	552.47	9.44	1.73
207	424.97	1670	544.61	552.42	8.81	1.92
208	374.97	1670	544.69	552.39	8.7	1.99
209	325	1670	544.73	552.34	8.61	2.11
210	275	1670	544.42	552.34	8.92	2.02
211	225.01	1670	544.46	552.34	8.88	1.92
212	175.01	1670	544.65	552.31	8.66	1.98
213	125.01	1670	545.15	552.24	8.09	2.22
214	75.01	1670	544.93	552.23	8.3	2.17
215	25.01	1670	544.87	552.21	8.34	2.17

ANNEXURE XXIV

OUTPUTOF MULA RIVER UPTO SANGAM FROM HEC RAS FOR FLOOD DISCHARGE OF 25 YEAR RETURN PERIOD IN CHANELLIZED SECTION

Sr No	River Sta	Q Total	Min Ch El	W.S. Elev	Top of Embankment Level From Bed Lvl(m)	Vel Chnl
		(m3/s)	(m)	(m)		(m/s)
1	12047.05	2875	544.73	554.4	10.67	2.22
2	11997.19	2875	544.83	554.38	10.55	2.24
3	11945	DAPODI BRIDGE				
4	11897.23	2875	544.64	554.06	10.42	2.14
5	11847.23	2875	544.74	554.05	10.31	2.17
6	11797.23	2875	544.53	554.04	10.51	2.12
7	11747.23	2875	544.6	554.02	10.42	2.14
8	11697.23	2875	544.8	554	10.2	2.19
9	11670	DAPODI RAILWAY BRIDGE				
10	11647.23	2875	545.33	553.81	9.48	2.39
11	11610	OLD HARRIS BRIDGE				
12	11597	2875	545.83	553.64	8.81	2.53
13	11575	NEW HARRIS BRIDGE				
14	11547.23	2875	545.17	553.62	9.45	2.4
15	11497.23	2875	544.55	553.65	10.1	2.17
16	11447.23	2875	544.7	553.62	9.92	2.2
17	11397.23	2875	544.82	553.57	9.75	2.35
18	11347.23	2875	544.99	553.54	9.55	2.39
19	11297.23	2875	544.64	553.38	9.74	2.88
20	11247.23	2875	545.01	553.4	9.39	2.65
21	11197.22	2875	544.86	553.4	9.54	2.57
22	11147.23	2875	544.96	553.34	9.38	2.68
23	11097.23	2875	545.01	553.26	9.25	2.88
24	11047.23	2875	544.54	553.22	9.68	2.91
25	10997.23	2875	544.34	553.2	9.86	2.9
26	10947.2	2875	545.16	553.02	8.86	3.31
27	10897.3	2875	544.86	553.03	9.17	3.15
28	10847.3	2875	544.4	553.03	9.63	2.98
29	10797.3	2875	544.53	552.99	9.46	3.03
30	10747.3	2875	544.58	552.92	9.34	3.14
31	10697.36	2875	544.58	552.9	9.32	3.11
32	10647.36	2875	544.32	553.03	9.71	2.3
33	10597.36	2875	544.64	553.02	9.38	2.29
34	10546.93	2875	544.84	552.98	9.14	2.36
35	10497.36	2875	545.17	552.92	8.75	2.51
36	10447.36	2875	544.64	552.91	9.27	2.43
37	10397.36	2875	544.48	552.92	9.44	2.3
38	10347.35	2875	544.39	552.91	9.52	2.26
39	10297.33	2875	544.61	552.88	9.27	2.32
40	10247.31	2875	544.74	552.84	9.1	2.38
41	10197.78	2875	544.68	552.83	9.15	2.36
42	10147.78	2875	544.87	552.78	8.91	2.44

43	10097.78	2875	544.84	552.76	8.92	2.44
44	10047.78	2875	544.72	552.75	9.03	2.4
45	9997.78	2875	545.16	552.67	8.51	2.59
46	9947.78	2875	544.55	552.69	9.14	2.36
47	9897.78	2875	544.59	552.67	9.08	2.39
48	9847.77	2875	544.47	552.65	9.18	2.35
49	9797.81	2875	544.53	552.63	9.1	2.38
50	9747.81	2875	544.34	552.62	9.28	2.32
51	9697.8	2875	544.66	552.56	8.9	2.45
52	9647.8	2875	544.99	552.5	8.51	2.6
53	9597.8	2875	544.8	552.49	8.69	2.53
54	9547.8	2875	544.83	552.46	8.63	2.55
55	9497.8	2875	545.32	552.36	8.04	2.8
56	9447.8	2875	545.05	552.35	8.3	2.68
57	9347.9	2875	545.22	552.25	8.03	2.8
58	9297.9	2875	544.94	552.25	8.31	2.68
59	9247.9	2875	544.73	552.24	8.51	2.6
60	9197.9	2875	544.63	552.22	8.59	2.56
61	9147.9	2875	544.78	552.17	8.39	2.64
62	9097.9	2875	544.85	552.13	8.28	2.69
63	9047.9	2875	544.66	552.11	8.45	2.62
64	8947.9	2875	544.86	552.02	8.16	2.74
65	8897.9	2875	544.77	552	8.23	2.71
66	8847.9	2875	545.45	551.82	7.37	3.13
67	8797.9	2875	544.34	551.9	8.56	2.57
68	8747.94	2875	544.48	551.86	8.38	2.65
69	8697.94	2875	545.3	551.66	7.36	3.14
70	8647.94	2875	544.83	551.68	7.85	2.88
71	8597.94	2875	544.69	551.66	7.97	2.83
72	8547.94	2875	544.58	551.63	8.05	2.79
73	8497.94	2875	544.52	551.6	8.08	2.78
74	8447.94	2875	544.8	551.51	7.71	2.95
75	8397.94	2875	544.77	551.47	7.7	2.96
76	8347.94	2875	544.47	551.47	8	2.81
77	8297.94	2875	544.67	551.39	7.72	2.95
78	8247.93	2875	544.81	551.31	7.5	3.06
79	8197.93	2875	544.35	551.33	7.98	2.82
80	8147.93	2875	544.34	551.29	7.95	2.84
81	8097.93	2875	544.51	551.21	7.7	2.95
82	8047.93	2875	544.62	551.14	7.52	3.05
83	7997.93	2875	544.73	551.06	7.33	3.15
84	7898.19	2875	544.83	550.91	7.08	3.3
85	7798.73	2875	545.28	550.55	6.27	3.87
86	7748.73	2875	544.67	550.61	6.94	3.39
87	7698.78	2875	544.77	550.49	6.72	3.54
88	7648.78	2875	544.93	550.32	6.39	3.78
89	7598.78	2875	544.74	550.27	6.53	3.67
90	7548.77	2875	544.56	550.22	6.66	3.57
91	7498.78	2875	544.73	550.04	6.31	3.84
92	7448.78	2875	544.75	549.88	6.13	3.99
93	7398.38	2875	544.27	549.91	6.64	3.59
94	7349.36	2875	544.38	549.76	6.38	3.79

95	7298.85	2875	544.3	549.68	6.38	3.79
96	7248.85	2875	544.52	549.38	5.86	4.24
97	7198.82	2875	543.92	549.45	6.53	3.67
98	7148.9	2875	544.46	548.82	5.36	4.77
99	7098.9	2875	543.94	548.89	5.95	4.16
100	7048.9	2875	543.96	548.65	5.69	4.41
101	6998.9	2875	543.52	548.67	6.15	3.98
102	6948.9	2875	543.09	548.68	6.59	3.63
103	6898.9	2875	543.23	548.5	6.27	3.88
104	6848.91	2875	543.55	548.02	5.47	4.65
105	6798.91	2875	543.33	547.91	5.58	4.52
106	6749.15	2875	543.26	547.65	5.39	4.74
107	6649.15	2875	542.98	547.16	5.18	5
108	6599.21	2875	540.15	547.77	8.62	2.55
109	6549.21	2875	540.32	547.71	8.39	2.64
110	6499.21	2875	540.72	547.62	7.9	2.86
111	6449.21	2875	540.34	547.62	8.28	2.69
112	6399.2	2875	539.97	547.62	8.65	2.54
113	6349.24	2875	539.64	547.62	8.98	2.42
114	6299.24	2875	539.92	547.56	8.64	2.54
115	6249.22	2875	539.97	547.53	8.56	2.57
116	6199.26	2875	539.75	547.52	8.77	2.49
117	6149.22	2875	539.86	547.48	8.62	2.55
118	6099.25	2875	539.93	547.45	8.52	2.59
119	6049.25	2875	539.96	547.41	8.45	2.62
120	5999.27	2875	539.86	547.39	8.53	2.59
121	5949.28	2875	539.93	547.35	8.42	2.63
122	5903	SHANTI BRIDGE				
123	5849.28	2875	536.19	547.41	12.22	1.62
124	5799.28	2875	536.81	547.38	11.57	1.74
125	5749.28	2875	539.4	547.19	8.79	2.49
126	5699.29	2875	538.51	547.22	9.71	2.18
127	5649.29	2875	538.68	547.19	9.51	2.24
128	5599.29	2875	538.27	547.2	9.93	2.12
129	5549.32	2875	537	547.23	11.23	1.81
130	5499.32	2875	536.74	547.23	11.49	1.75
131	5449.34	2875	536.33	547.23	11.9	1.67
132	5399.34	2875	537.71	547.16	10.45	1.98
133	5349.34	2875	537.29	547.16	10.87	1.88
134	5299.34	2875	537.9	547.11	10.21	2.04
135	5249.34	2875	537.01	547.13	11.12	1.83
136	5199.34	2875	537.52	547.1	10.58	1.96
137	5149.35	2875	536.88	547.11	11.23	1.81
138	5099.35	2875	535.94	547.12	12.18	1.63
139	5049.53	2875	536.98	547.08	11.1	1.83
140	4999.35	2875	536.22	547.09	11.87	1.68
141	4949.35	2875	536.85	547.05	11.2	1.81
142	4899.35	2875	537.56	547.01	10.45	1.98
143	4849.35	2875	537.83	546.94	10.11	2.2
144	4799.35	2875	537.13	546.96	10.83	2.03
145	4749.35	2875	535.82	546.99	12.17	1.76
146	4699.35	2875	535.62	546.99	12.37	1.64

147	4649.35	2875	537.84	546.89	10.05	2.11
148	4599.34	2875	536.72	546.91	11.19	1.89
149	4549.34	2875	537.7	546.85	10.15	2.13
150	4499.34	2875	537.89	546.83	9.94	2.12
151	4449.54	2875	537.98	546.8	9.82	2.19
152	4399.54	2875	537.74	546.8	10.06	2.12
153	4349.54	2875	537.8	546.78	9.98	2.15
154	4299.52	2875	538.09	546.74	9.65	2.25
155	4249.5	2875	537.62	546.75	10.13	2.09
156	4199.53	2875	537.74	546.74	10	2.1
157	4149.53	2875	537.65	546.73	10.08	2.08
158	4099.53	2875	537.94	546.69	9.75	2.17
159	4049.53	2875	538	546.67	9.67	2.2
160	3999.58	2875	537.88	546.66	9.78	2.16
161	3949.58	2875	537.66	546.65	9.99	2.12
162	3899.58	2875	537.53	546.65	10.12	2.08
163	3849.58	2875	536.88	546.66	10.78	1.91
164	3799.64	2875	537.71	546.6	9.89	2.13
165	3749.64	2875	538	546.56	9.56	2.23
166	3699.64	2875	537.78	546.55	9.77	2.17
167	3649.64	2875	537.74	546.54	9.8	2.16
168	3599.65	2875	537.99	546.5	9.51	2.24
169	3549.65	2875	537.92	546.49	9.57	2.23
170	3499.59	2875	538.05	546.46	9.41	2.28
171	3479	OLD HOLKAR BRIDGE				
172	3449.64	2875	537.6	546.18	9.58	2.22
173	3379	HOLKAR BRIDGE LOW				
174	3349.62	2875	537.55	546.09	9.54	2.35
175	3337	HOLKAR BRIDGE				
176	3299.67	2875	537.11	546.08	9.97	2.23
177	3249.66	2875	536.71	546.08	10.37	2.13
178	3199.66	2875	536.98	546.05	10.07	2.21
179	3149.65	2875	536.94	546.04	10.1	2.2
180	3099.73	2875	536.95	546.02	10.07	2.21
181	3049.71	2875	536.75	546.02	10.27	2.16
182	2999.69	2875	536.78	546	10.22	2.17
183	2949.81	2875	536.87	545.98	10.11	2.2
184	2899.81	2875	536.99	545.96	9.97	2.23
185	2849.8	2875	536.7	545.96	10.26	2.11
186	2799.83	2875	536.59	545.96	10.37	2.07
187	2749.83	2875	536.52	545.96	10.44	1.99
188	2699.83	2875	536.75	545.93	10.18	2.05
189	2649.83	2875	536.98	545.9	9.92	2.12
190	2599.82	2875	536.65	545.9	10.25	2.03
191	2549.82	2875	536.71	545.88	10.17	2.06
192	2499.82	2875	536.54	545.88	10.34	2.04
193	2449.83	2875	536.45	545.87	10.42	2.02
194	2399.83	2875	536.42	545.86	10.44	2.01
195	2349.83	2875	536.53	545.84	10.31	2.02
196	2299.83	2875	536.56	545.83	10.27	2.03
197	2249.83	2875	536.64	545.81	10.17	2.06
198	2199.83	2875	536.77	545.79	10.02	2.1

199	2149.83	2875	536.68	545.78	10.1	2.07
200	2099.83	2875	536.59	545.77	10.18	2.05
201	2049.83	2875	536.5	545.76	10.26	2.03
202	1999.83	2875	536.25	545.76	10.51	1.97
203	1949.83	2875	536.35	545.74	10.39	2
204	1899.83	2875	536.37	545.73	10.36	2.01
205	1849.83	2875	536.79	545.68	9.89	2.13
206	1799.83	2875	536.38	545.69	10.31	2.02
207	1749.83	2875	536.75	545.65	9.9	2.13
208	1699.83	2875	536.72	545.64	9.92	2.12
209	1649.83	2875	536.85	545.61	9.76	2.17
210	1599.83	2875	536.91	545.59	9.68	2.19
211	1549.83	2875	536.91	545.57	9.66	2.2
212	1499.83	2875	536.54	545.58	10.04	2.09
213	1449.83	2875	536.8	545.54	9.74	2.17
214	1399.83	2875	536.86	545.52	9.66	2.2
215	1349.82	2875	536.85	545.42	9.57	2.53
216	1299.84	2875	537.05	545.37	9.32	2.62
217	1249.84	2875	537.03	545.34	9.31	2.62
218	1199.84	2875	537.06	545.31	9.25	2.64
219	1149.84	2875	537.02	545.29	9.27	2.64
220	1099.86	2875	536.84	545.27	9.43	2.58
221	1049.86	2875	536.77	545.25	9.48	2.56
222	999.86	2875	536.85	545.22	9.37	2.6
223	949.86	2875	536.79	545.2	9.41	2.58
224	899.84	2875	536.89	545.16	9.27	2.63
225	849.89	2875	536.84	545.14	9.3	2.62
226	799.89	2875	537	545.09	9.09	2.7
227	749.89	2875	536.84	545.07	9.23	2.65
228	699.89	2875	536.76	545.05	9.29	2.63
229	649.89	2875	536.87	545.01	9.14	2.68
230	599.89	2875	537.1	544.79	8.69	3.24
231	569	SANGAM BRIDGE				
232	499.85	2875	536.77	544.64	8.87	3.16
233	449.85	2875	536.42	544.72	9.3	2.62
234	399.97	2875	536.79	544.64	8.85	2.81
235	349.97	2875	536.81	544.6	8.79	2.82
236	299.97	2875	536.92	544.55	8.63	2.89
237	249.97	2875	536.93	544.51	8.58	2.91
238	199.98	2875	537.28	544.4	8.12	3.13
239	149.98	2875	537.65	544.25	7.6	3.41
240	100	2875	536.15	544.38	9.23	2.65
241	50	2875	536.42	544.31	8.89	2.78
242	0	2875	536.48	544.27	8.79	2.82

ANNEXURE XXV

OUTPUTOF MULA RIVER UPTO SANGAM FROM HEC RAS FOR FLOOD DISCHARGE OF 100 YEAR RETURN PERIOD IN CHANELLIZED SECTION

Sr NO	River Sta	Q Total	Min Ch El	W.S. Elev	Top of Embankment Level From Bed Lvl(m)	Vel Chnl
		(m3/s)	(m)	(m)		(m/s)
1	12047.05	3971	544.73	556.16	12.43	2.59
2	11997.19	3971	544.83	556.14	12.31	2.6
3	11945	DAPODI BRIDGE				
4	11897.23	3971	544.64	555.86	12.22	2.46
5	11847.23	3971	544.74	555.84	12.1	2.49
6	11797.23	3971	544.53	555.83	12.3	2.44
7	11747.23	3971	544.6	555.82	12.22	2.46
8	11697.23	3971	544.8	555.79	11.99	2.52
9	11670	DAPODI RAILWAY BRIDGE				
10	11647.23	3971	545.33	555.44	11.11	2.74
11	11610	OLD HARRIS BRIDGE				
12	11597	3971	545.83	555.24	10.41	2.85
13	11575	NEW HARRIS BRIDGE				
14	11547.23	3971	545.17	555.17	11	2.77
15	11497.23	3971	544.55	555.2	11.65	2.54
16	11447.23	3971	544.7	555.18	11.48	2.57
17	11397.23	3971	544.82	555.11	11.29	2.75
18	11347.23	3971	544.99	555.08	11.09	2.79
19	11297.23	3971	544.64	554.84	11.2	3.41
20	11247.23	3971	545.01	554.88	10.87	3.11
21	11197.22	3971	544.86	554.88	11.02	3.03
22	11147.23	3971	544.96	554.81	10.85	3.15
23	11097.23	3971	545.01	554.7	10.69	3.38
24	11047.23	3971	544.54	554.64	11.1	3.45
25	10997.23	3971	544.34	554.61	11.27	3.45
26	10947.2	3971	545.16	554.39	10.23	3.89
27	10897.3	3971	544.86	554.4	10.54	3.72
28	10847.3	3971	544.4	554.41	11.01	3.56
29	10797.3	3971	544.53	554.35	10.82	3.61
30	10747.3	3971	544.58	554.26	10.68	3.73
31	10697.36	3971	544.58	554.24	10.66	3.7
32	10647.36	3971	544.32	554.43	11.11	2.72
33	10597.36	3971	544.64	554.43	10.79	2.63
34	10546.93	3971	544.84	554.39	10.55	2.71
35	10497.36	3971	545.17	554.31	10.14	2.88
36	10447.36	3971	544.64	554.3	10.66	2.86
37	10397.36	3971	544.48	554.31	10.83	2.7

38	10347.35	3971	544.39	554.3	10.91	2.65
39	10297.33	3971	544.61	554.27	10.66	2.69
40	10247.31	3971	544.74	554.24	10.5	2.73
41	10197.78	3971	544.68	554.22	10.54	2.71
42	10147.78	3971	544.87	554.17	10.3	2.79
43	10097.78	3971	544.84	554.15	10.31	2.79
44	10047.78	3971	544.72	554.14	10.42	2.75
45	9997.78	3971	545.16	554.05	9.89	2.94
46	9947.78	3971	544.55	554.07	10.52	2.72
47	9897.78	3971	544.59	554.05	10.46	2.74
48	9847.77	3971	544.47	554.03	10.56	2.7
49	9797.81	3971	544.53	554	10.47	2.73
50	9747.81	3971	544.34	553.99	10.65	2.67
51	9697.8	3971	544.66	553.93	10.27	2.8
52	9647.8	3971	544.99	553.86	9.87	2.95
53	9597.8	3971	544.8	553.85	10.05	2.89
54	9547.8	3971	544.83	553.81	9.98	2.91
55	9497.8	3971	545.32	553.7	9.38	3.16
56	9447.8	3971	545.05	553.69	9.64	3.04
57	9347.9	3971	545.22	553.59	9.37	3.16
58	9297.9	3971	544.94	553.58	9.64	3.04
59	9247.9	3971	544.73	553.57	9.84	2.96
60	9197.9	3971	544.63	553.55	9.92	2.93
61	9147.9	3971	544.78	553.5	9.72	3.01
62	9097.9	3971	544.85	553.45	9.6	3.06
63	9047.9	3971	544.66	553.44	9.78	2.99
64	8947.9	3971	544.86	553.34	9.48	3.11
65	8897.9	3971	544.77	553.31	9.54	3.09
66	8847.9	3971	545.45	553.12	8.67	3.5
67	8797.9	3971	544.34	553.21	9.87	2.95
68	8747.94	3971	544.48	553.16	9.68	3.03
69	8697.94	3971	545.3	552.95	8.65	3.51
70	8647.94	3971	544.83	552.96	9.13	3.27
71	8597.94	3971	544.69	552.94	9.25	3.21
72	8547.94	3971	544.58	552.92	9.34	3.18
73	8497.94	3971	544.52	552.88	9.36	3.16
74	8447.94	3971	544.8	552.78	8.98	3.34
75	8397.94	3971	544.77	552.74	8.97	3.34
76	8347.94	3971	544.47	552.74	9.27	3.21
77	8297.94	3971	544.67	552.65	8.98	3.34
78	8247.93	3971	544.81	552.57	8.76	3.45
79	8197.93	3971	544.35	552.59	9.24	3.22
80	8147.93	3971	544.34	552.55	9.21	3.23
81	8097.93	3971	544.51	552.46	8.95	3.35
82	8047.93	3971	544.62	552.39	8.77	3.45
83	7997.93	3971	544.73	552.3	8.57	3.55
84	7898.19	3971	544.83	552.14	8.31	3.7

85	7798.73	3971	545.28	551.78	7.5	4.23
86	7748.73	3971	544.67	551.84	8.17	3.78
87	7698.78	3971	544.77	551.72	7.95	3.92
88	7648.78	3971	544.93	551.55	7.62	4.14
89	7598.78	3971	544.74	551.51	7.77	4.04
90	7548.77	3971	544.56	551.47	7.91	3.95
91	7498.78	3971	544.73	551.29	7.56	4.19
92	7448.78	3971	544.75	551.15	7.4	4.3
93	7398.38	3971	544.27	551.18	7.91	3.94
94	7349.36	3971	544.38	551.04	7.66	4.12
95	7298.85	3971	544.3	550.96	7.66	4.11
96	7248.85	3971	544.52	550.71	7.19	4.47
97	7198.82	3971	543.92	550.78	7.86	3.98
98	7148.9	3971	544.46	550.3	6.84	4.77
99	7098.9	3971	543.94	550.36	7.42	4.29
100	7048.9	3971	543.96	550.21	7.25	4.42
101	6998.9	3971	543.52	550.23	7.71	4.08
102	6948.9	3971	543.09	550.25	8.16	3.79
103	6898.9	3971	543.23	550.11	7.88	3.96
104	6848.91	3971	543.55	549.83	7.28	4.39
105	6798.91	3971	543.33	549.79	7.46	4.26
106	6749.15	3971	543.26	549.7	7.44	4.27
107	6649.15	3971	542.98	549.58	7.6	4.15
108	6599.21	3971	540.15	549.91	10.76	2.64
109	6549.21	3971	540.32	549.87	10.55	2.7
110	6499.21	3971	540.72	549.8	10.08	2.87
111	6449.21	3971	540.34	549.8	10.46	2.74
112	6399.2	3971	539.97	549.81	10.84	2.61
113	6349.24	3971	539.64	549.81	11.17	2.51
114	6299.24	3971	539.92	549.76	10.84	2.61
115	6249.22	3971	539.97	549.73	10.76	2.64
116	6199.26	3971	539.75	549.73	10.98	2.57
117	6149.22	3971	539.86	549.7	10.84	2.61
118	6099.25	3971	539.93	549.67	10.74	2.64
119	6049.25	3971	539.96	549.64	10.68	2.66
120	5999.27	3971	539.86	549.63	10.77	2.63
121	5949.28	3971	539.93	549.6	10.67	2.67
122	5903	SHANTI BRIDGE				
123	5849.28	3971	536.19	549.47	14.28	1.73
124	5799.28	3971	536.81	549.43	13.62	1.89
125	5749.28	3971	539.4	549.24	10.84	2.61
126	5699.29	3971	538.51	549.27	11.76	2.35
127	5649.29	3971	538.68	549.24	11.56	2.4
128	5599.29	3971	538.27	549.24	11.97	2.29
129	5549.32	3971	537	549.28	13.28	1.97
130	5499.32	3971	536.74	549.27	13.53	1.92
131	5449.34	3971	536.33	549.27	13.94	1.86

132	5399.34	3971	537.71	549.19	12.48	2.17
133	5349.34	3971	537.29	549.2	12.91	2.08
134	5299.34	3971	537.9	549.15	12.25	2.23
135	5249.34	3971	537.01	549.17	13.16	2.06
136	5199.34	3971	537.52	549.13	12.61	2.19
137	5149.35	3971	536.88	549.14	13.26	2.04
138	5099.35	3971	535.94	549.16	14.22	1.85
139	5049.53	3971	536.98	549.11	13.13	2.04
140	4999.35	3971	536.22	549.12	13.9	1.89
141	4949.35	3971	536.85	549.09	13.24	2.01
142	4899.35	3971	537.56	549.04	12.48	2.17
143	4849.35	3971	537.83	548.95	12.12	2.47
144	4799.35	3971	537.13	548.97	12.84	2.32
145	4749.35	3971	535.82	549	14.18	2.04
146	4699.35	3971	535.62	549.01	14.39	1.9
147	4649.35	3971	537.84	548.9	12.06	2.35
148	4599.34	3971	536.72	548.92	13.2	2.16
149	4549.34	3971	537.7	548.85	12.15	2.38
150	4499.34	3971	537.89	548.85	11.96	2.31
151	4449.54	3971	537.98	548.81	11.83	2.42
152	4399.54	3971	537.74	548.81	12.07	2.36
153	4349.54	3971	537.8	548.79	11.99	2.4
154	4299.52	3971	538.09	548.75	11.66	2.49
155	4249.5	3971	537.62	548.77	12.15	2.31
156	4199.53	3971	537.74	548.76	12.02	2.28
157	4149.53	3971	537.65	548.75	12.1	2.27
158	4099.53	3971	537.94	548.71	11.77	2.35
159	4049.53	3971	538	548.69	11.69	2.37
160	3999.58	3971	537.88	548.68	11.8	2.35
161	3949.58	3971	537.66	548.68	12.02	2.33
162	3899.58	3971	537.53	548.67	12.14	2.29
163	3849.58	3971	536.88	548.69	12.81	2.13
164	3799.64	3971	537.71	548.63	11.92	2.32
165	3749.64	3971	538	548.59	11.59	2.4
166	3699.64	3971	537.78	548.59	11.81	2.36
167	3649.64	3971	537.74	548.58	11.84	2.35
168	3599.65	3971	537.99	548.55	11.56	2.41
169	3549.65	3971	537.92	548.54	11.62	2.39
170	3499.59	3971	538.05	548.51	11.46	2.43
171	3479	OLD HOLKAR BRIDGE				
172	3449.64	3971	537.6	547.91	11.31	2.47
173	3379	HOLKAR BRIDGE LOW				
174	3349.62	3971	537.55	547.77	11.22	2.69
175	3337	HOLKAR BRIDGE				
176	3299.67	3971	537.11	547.76	11.65	2.58
177	3249.66	3971	536.71	547.76	12.05	2.49
178	3199.66	3971	536.98	547.73	11.75	2.56

179	3149.65	3971	536.94	547.71	11.77	2.55
180	3099.73	3971	536.95	547.7	11.75	2.56
181	3049.71	3971	536.75	547.69	11.94	2.51
182	2999.69	3971	536.78	547.67	11.89	2.52
183	2949.81	3971	536.87	547.65	11.78	2.55
184	2899.81	3971	536.99	547.63	11.64	2.58
185	2849.8	3971	536.7	547.64	11.94	2.44
186	2799.83	3971	536.59	547.63	12.04	2.4
187	2749.83	3971	536.52	547.64	12.12	2.27
188	2699.83	3971	536.75	547.62	11.87	2.32
189	2649.83	3971	536.98	547.58	11.6	2.39
190	2599.82	3971	536.65	547.58	11.93	2.31
191	2549.82	3971	536.71	547.56	11.85	2.36
192	2499.82	3971	536.54	547.55	12.01	2.35
193	2449.83	3971	536.45	547.54	12.09	2.34
194	2399.83	3971	536.42	547.53	12.11	2.32
195	2349.83	3971	536.53	547.52	11.99	2.32
196	2299.83	3971	536.56	547.51	11.95	2.3
197	2249.83	3971	536.64	547.49	11.85	2.32
198	2199.83	3971	536.77	547.46	11.69	2.36
199	2149.83	3971	536.68	547.45	11.77	2.34
200	2099.83	3971	536.59	547.44	11.85	2.32
201	2049.83	3971	536.5	547.43	11.93	2.3
202	1999.83	3971	536.25	547.43	12.18	2.24
203	1949.83	3971	536.35	547.41	12.06	2.27
204	1899.83	3971	536.37	547.4	12.03	2.28
205	1849.83	3971	536.79	547.35	11.56	2.4
206	1799.83	3971	536.38	547.36	11.98	2.29
207	1749.83	3971	536.75	547.32	11.57	2.4
208	1699.83	3971	536.72	547.3	11.58	2.39
209	1649.83	3971	536.85	547.27	11.42	2.44
210	1599.83	3971	536.91	547.25	11.34	2.46
211	1549.83	3971	536.91	547.24	11.33	2.47
212	1499.83	3971	536.54	547.24	11.7	2.36
213	1449.83	3971	536.8	547.2	11.4	2.44
214	1399.83	3971	536.86	547.18	11.32	2.47
215	1349.82	3971	536.85	547.05	11.2	2.85
216	1299.84	3971	537.05	547	10.95	2.93
217	1249.84	3971	537.03	546.97	10.94	2.93
218	1199.84	3971	537.06	546.94	10.88	2.96
219	1149.84	3971	537.02	546.91	10.89	2.95
220	1099.86	3971	536.84	546.9	11.06	2.89
221	1049.86	3971	536.77	546.88	11.11	2.88
222	999.86	3971	536.85	546.85	11	2.92
223	949.86	3971	536.79	546.82	11.03	2.9
224	899.84	3971	536.89	546.78	10.89	2.95
225	849.89	3971	536.84	546.76	10.92	2.94

226	799.89	3971	537	546.71	10.71	3.02
227	749.89	3971	536.84	546.69	10.85	2.97
228	699.89	3971	536.76	546.67	10.91	2.94
229	649.89	3971	536.87	546.63	10.76	3
230	599.89	3971	537.1	546.37	10.27	3.61
231	569	SANGAM BRIDGE				
232	499.85	3971	536.77	546.2	10.43	3.54
233	449.85	3971	536.42	546.31	10.89	2.95
234	399.97	3971	536.79	546.21	10.42	3.16
235	349.97	3971	536.81	546.18	10.37	3.15
236	299.97	3971	536.92	546.12	10.2	3.21
237	249.97	3971	536.93	546.08	10.15	3.23
238	199.98	3971	537.28	545.97	9.69	3.43
239	149.98	3971	537.65	545.83	9.18	3.69
240	100	3971	536.15	545.96	10.81	2.98
241	50	3971	536.42	545.89	10.47	3.11
242	0	3971	536.48	545.85	10.37	3.15

5. WATER RETENTION AND REPLENISH OF WATER

Water retention in Mula Mutha riverfront is proposed by construction of Barrages at various location along Mula, Mutha and Mula-Mutha river. The retention of water in Barrages are through gates and flood modernization can be easily controlled by barrage structure and also obstruction due to control structure is bare minimum compare to other type of controlled structures.

5.1 BARRAGE

A Barrage is a type of low-head, diversion dam which consists of a number of large gates that can be opened or closed to control the amount of water passing through the structure, and thus regulate and stabilize river water elevation upstream for use in irrigation and other systems. The gates are set between flanking piers which are responsible for supporting the water load of the pool created.

Figure 35 : Typical Barrage Photograph

Looking to the bed gradient of the river ,water depth to be retained in Barrage and entire riverfront having water pool depth of at least 1 m planning of barrages have been carried out. Mula-Mutha Riverfront is divided in to 5 pools which is shown in figure 34 .

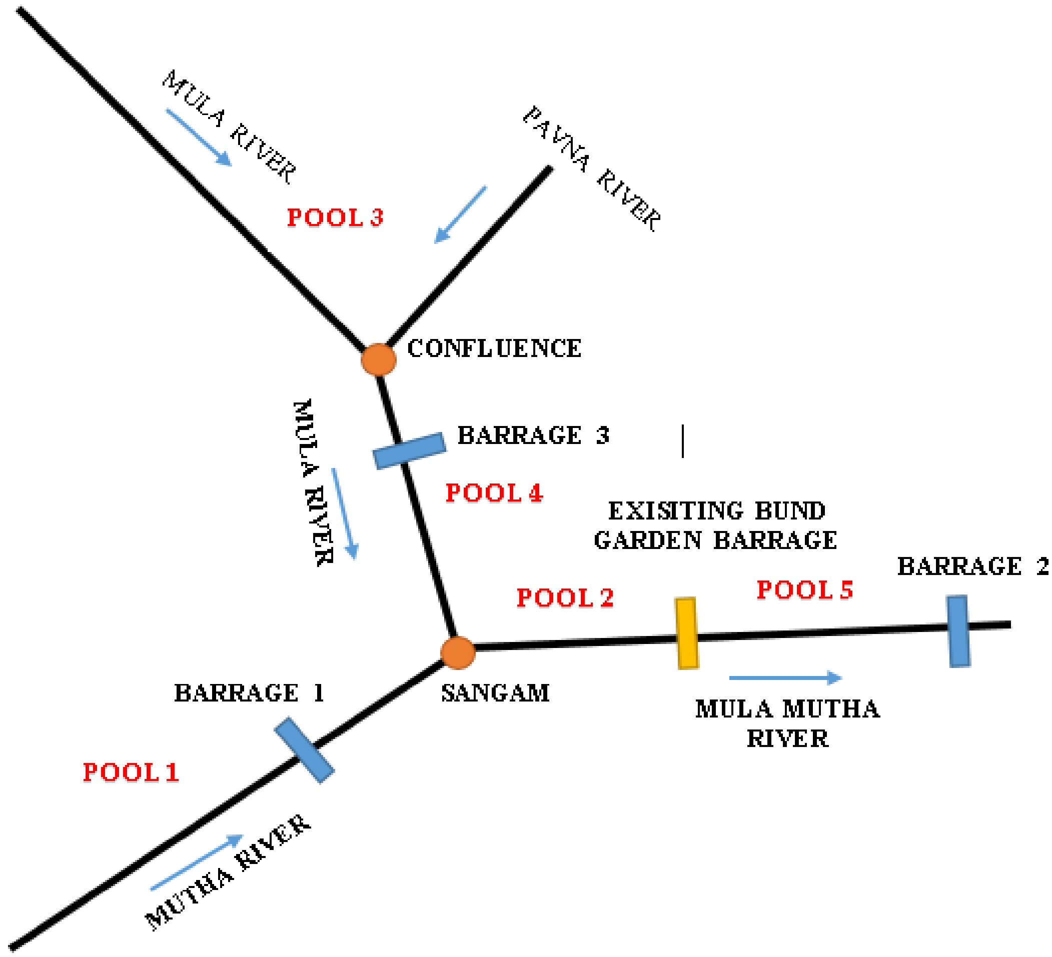


Figure 36 : Location Plan of Proposed Barrage

- **POOL 1 :** Mutha River ,starting of project Reach to proposed Barrage-1 (Ch 8995m to 3398m)
- **POOL 2 :** Mutha River ,from proposed Barrage-1 to Bund Garden Barrage (Ch 3398m to 0m)
- **POOL 3:** Mula River, from starting of project to proposed Barrage-3 (Ch 10020m to 6649m)
- **POOL 4:** Mula River ,from proposed Barrage-3 to Confluence of Mula- Mutha (Ch 6649m to 0m)
- **POOL 5:** Mula Mutha River, from proposed Barrage-2 to Bund Garden (Ch 1093m to 8930m)

Salient Features of Proposed Barrage have been designed as per IS 6966 Hydraulic design of

Barrages and Weirs for Mula-Mutha Riverfront are proposed Below.

BARRAGE 1			
1	F.R.L	**546.77**	m
2	DISCHARGE	**2835**	m^3/sec
3	NO. OF GATE	**9**	Nos.
4	SIZE OF GATE	**10 x 5**	m
5	LENGTH OF STRUCUTRE	**105**	m
6	CREST LEVEL	**541.85**	m

Table 16 : Salient Features of Barrage 1

BARRAGE 2			
1	F.R.L	537.13	m
2	DISCHARGE	4762	m3/sec
3	NO. OF GATE	20	Nos.
4	SIZE OF GATE	10 x 5	m
5	LENGTH OF STRUCUTRE	231.5	m
6	CREST LEVEL	532.65	m

Table 17: Salient Features of Barrage 2

BARRAGE 3			
1	F.R.L	**549.00**	m
2	DISCHARGE	**3971**	m^3/sec
3	NO. OF GATE	**17**	Nos.
4	SIZE OF GATE	**10 x 5**	m
5	LENGTH OF STRUCUTRE	**197**	m
6	CREST LEVEL	**543.76**	m

Table 17 : Salient Features of Barrage 3

5.2 SEEPAGE & EVAPORATION LOSSES THROUGH RIVERFRONT

The evaporation of water from, channel or similar - depends on the temperature of the water, actual humidity and the velocity of the air above the surface. The river course is topographically surveyed and according to it seepage and evaporation losses for Pool 1 to 5 are worked out and appended at Annexure 26 and generalized in Table . Evaporation looses of 12 mm/day are considered for the month of May for Pune as per Indian agriculture map and same has been adopted for entire year.

Sr No	Particulars	Total Storage of water in (m3)	Losses			Discharge Required (m^3/sec)
			Evaporation Losses (m^3/day) B	Seepage Losses (m^3/day) C	Total Losses (m3/day) B+C	
1	**POOL 1 :** Mutha River, starting of project Reach to proposed Barrage-1.	4948740	6910	1730	8640	0.1
2	**POOL 2 :** Mutha River, from proposed Barrage-1 to Bund Garden Barrage.	8636136	8986	2246	11232	0.13
3	**POOL 3:** Mula River, from starting of project to proposed Barrage-3.	16707168	4147	1037	5184	0.06
4	**POOL 4:** Mula River, from proposed Barrage-3 to Confluence of Mula Mutha.	11995146	11059	2765	13824	0.16
5	**POOL 5:** Mula Mutha River, from proposed Barrage-2 to Bund Garden	14835288	13824	3456	17280	0.2

Table 19 : Summary of Total Looses, Storage of Water, Discharge Required for Replenishing Losses in Proposed Pools for Mula Mutha Riverfront Development

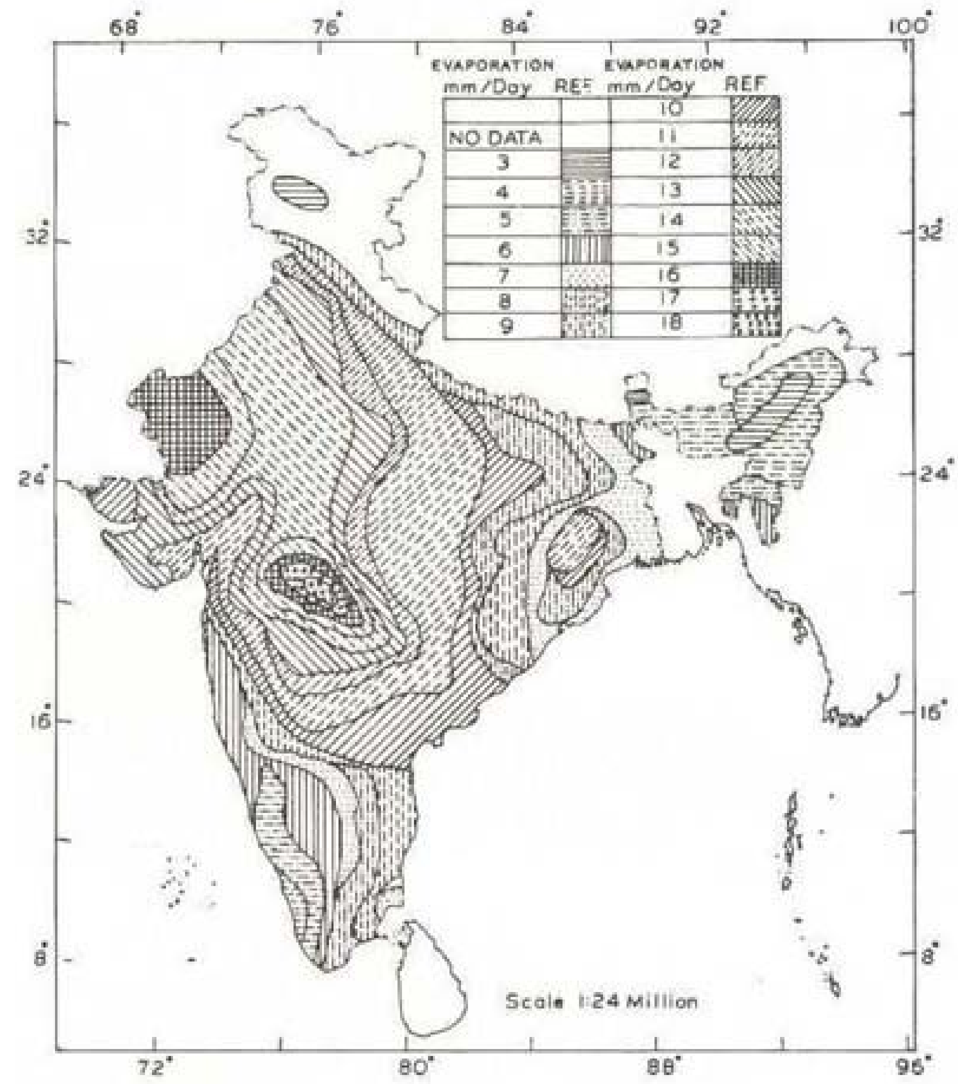


Figure 37 : Mean Daily Evaporation for May Month (Mm/Day) (Source : Agriculture Department)

Total discharge required for replenish of Water for Evaporation Losses and Seepage Losses is 0.65 m^3/sec i.e. 56160 m^3/day. There are number of STP located on either bank of Mula Mutha river which will replenish the water losses for Mula Mutha Riverfront. The tertiary treatment of STP should be odorless and colorless.

5.3 DRAINAGE OUTLET CONTROLLING

Numbers of drainage outlets discharging effluent, industrial wastes are located all along the projected reach in Pune City and present highly polluted stagnant water requires to be diverted to sewage treatment plant and only rain/storm water shall be discharged in river.

Trunk sewer line shall be planed parallel to existing river on east and west bank intercepting all the outlets and collecting and conveying the same to sewage treatment plant.

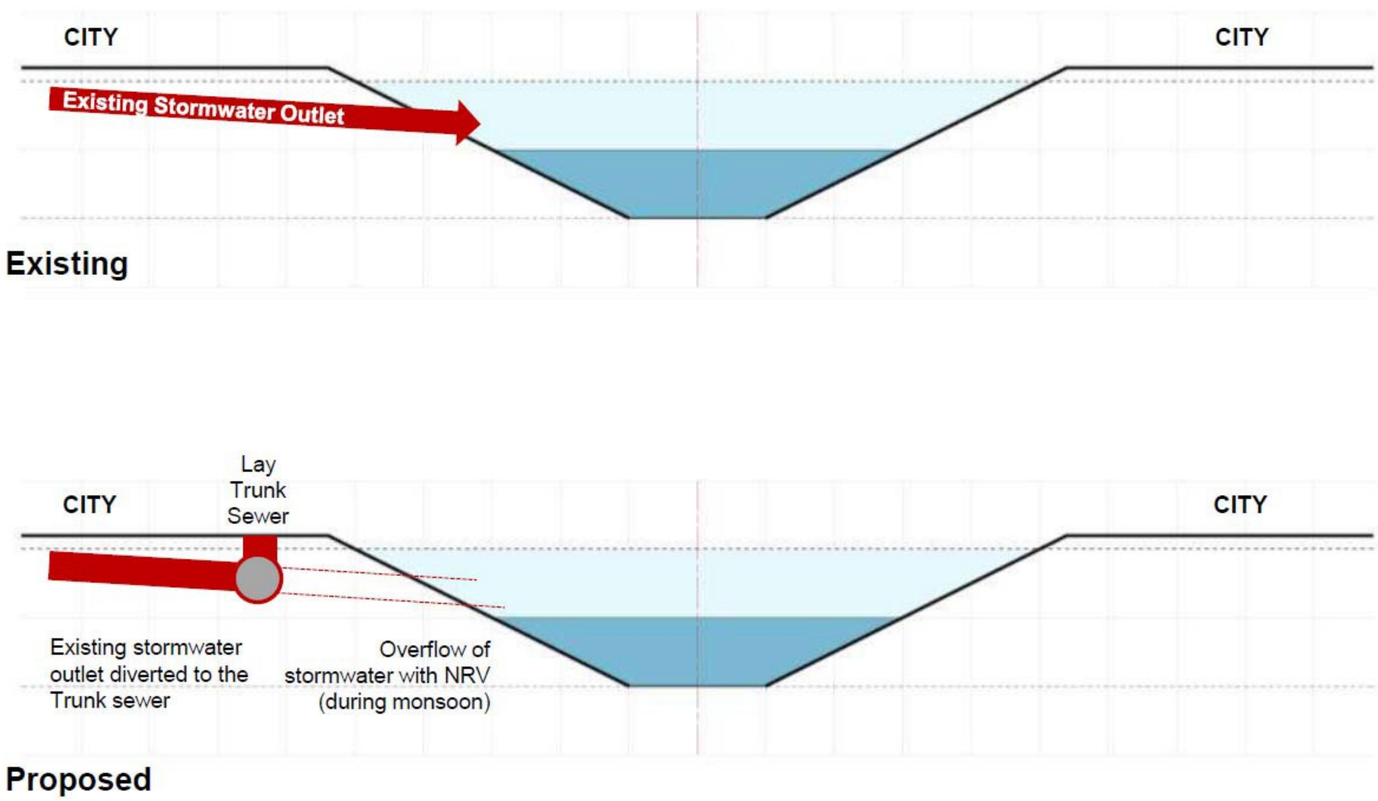


Figure 38 : Proposed Interceptor for Sewage Diversion

The specially designed Manholes with over flowing weir type allowing storm water to discharge in river in rainy season and diverting in to trunk sewer in rest of the season shall be constructed at each outlet junction.

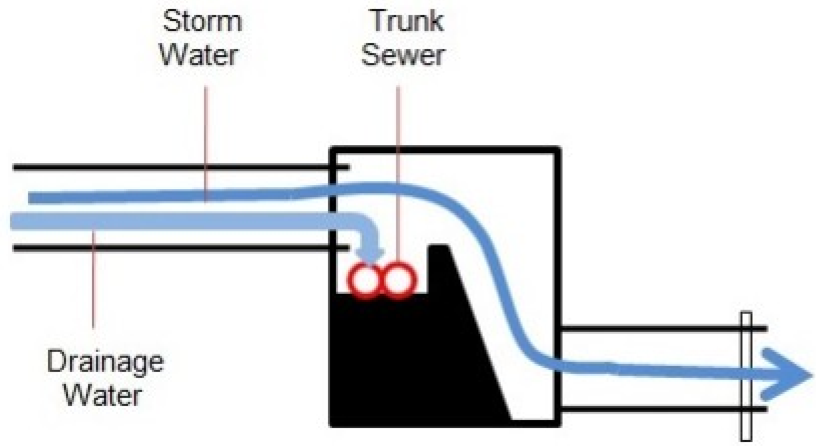


Figure 39 : Typical Outfall Manhole Intercepting Fair Weather Flow Consisting of Sewage Water and Allowing Storm Water to Over Flow in River.

Pune Municipal corporation have already undertaken the work of Interceptor drain to intercept all the outlets discharging sewage water in the river on left and right bank. New STP have also been proposed for treating this sewage up to tertiary level. The interceptor drains shall be planned in conjunction with the proposed Mula-Mutha Riverfront development to prevent subsequent changes in the alignment of interceptor.

CONCLUSIONS

From the foregoing studies and discussions, the following conclusions can be drawn:

- The flood discharge of Mutha and Mula-Mutha river adopted by irrigation department i.e. 2833 and 4758 cumecs respectively is in conformity with computed flood discharge by sub zone 3h and SCS method.

- Variation in flood discharge is observed for Mula and Pawana river as computed by SCS & Sub Zone method and as adopted by irrigation department. However the total discharge after confluence of Mula and Pawana is in conformity with the computed discharge .Mulshi and Pawana dams are located in u/s of Mula and Pawana river respectively. Therefore only controlled outflow will be discharged and through real time flood management the flood discharge adopted by irrigation department can be achieved.

- The flood discharge adopted for Mula Mutha Riverfront is shown below sides.

Sr No	Particulars	Flood Discharge (Cumecs) 100 Year Return Period	Flood Discharge (Cumecs) 25 Year Return Period
1	Mula River Upto Confluence Of Pawana River	1232 (Upto Babashaheb Ambedkar Bridge)	1206
		1670 (Upto Confluence Point with Pawana River)	1536
2	Mula River After Confluence Up To Sangam	3971	3345
3	Mutha River	2835	1700
4	Mula - Mutha River Up To Project End Reach i.e. KT Weir.	4762	3345

- In the light of aforesaid considerations it would be fair to plan the channelized cross section of the river and the side embankments/walls such that they can contain a design flood discharge without any overflow or outflanking and with adequate free board.

- A flood is a natural phenomenon and therefore occurrence of a higher flood cannot be ruled out. In such a case adequate top and downstream protection can be provided to minimize the resulting damage. Such overflows would occur even otherwise in the existing conditions and would not be the result of new constructions. In fact, in the existing conditions a design flood discharge would have caused overflows at certain locations which would now be prevented as this flood would be fully contained within the entire

Channelized cross section. To this extent it can be considered as a distinct improvement.

- Careful backwater studies using internationally accepted HEC-RAS software with “Special Bridge Options" and adopting design flood discharge have yielded flood profiles in the natural and channelized river cross section which have been shown on Plate-3 to 6. The top profiles of side embankments/walls with minimum 1.0m free-board have also been shown.

- Different channelized bed width adopted in Mula, Mutha, Mula Mutha river are as per below-

Sr No	River Name	Section Adopted
1	Mula River Up to Confluence of Pawana River	Trapezoidal Section having bed width of 90 m with stable side slope.
		Trapezoidal Section having bed width of 90 m with stable side slope on one side and intermediate berm 7m wide acting as lower promenade/walkway.
		Rectangular section having bed width of 90 m and intermediate berm 7m wide acting as lower promenade/walkway
2	Mula River Up to Confluence Of Sangam River	Trapezoidal Section having bed width of 125 m with stable side slope.
		Rectangular Section having bed width of 125 m with intermediate berm 7m wide acting as lower promenade/walkway on both side.
3	Mutha River Up to Sangam	Rectangular Section having bed width of 125 m with intermediate berm 7m wide acting as lower promenade/walkway on both side and bank with RCC retaining wall.
4	Mula Mutha River from Sangam Up to KT Weir	Trapezoidal Section having bed width of 130 m with stable side slope.
		Trapezoidal Section having bed width of 130 m with intermediate berm 7m wide acting as lower promenade/walkway on both side.

- Different bridges to be dismantled in channelized river section for Mula Mutha riverfront development are

Sr No	River	Chainage	Name
1	Mula Mutha River	1093	Kt Weir
2	Mutha River	2685	Baba Bhide Bridge
3	Mutha River	1757	Causeway
4	Mula River	9972	Wakad Bridge
5	Mula River	8131	K Shakuntlal Baban Shadhe
6	Mula River After Sangam	7045	Check Dam 1
7	Mula River After Sangam	6659	Check Dam 2

- Different bridges to be raised in channelized river section for Mula Mutha riverfront development are

Sr No	River	Chainage	Name
1	Mutha River	3440	Joshi Bridge
2	Mutha River	1449	Tilak Bridge
3	Mula River Up to Confluence Point With Pawana River	1838	Sangvi Bridge
4	Mula River Up to Sangam Point	11945	Dapodi Bridge
5	Mula River Up to Sangam Point	11610	Old Harris Bridge
6	Mula River Up to Sangam Point	11575	New Harris Bridge
7	Mula River Up to Sangam Point	5903	Shanti Bridge

- Water retention in Mula Mutha riverfront is proposed by construction of Barrages at various location along Mula, Mutha and Mula Mutha river

- The post-project flood profiles thus do not aggravate the existing conditions and as exposed rock is met with in river bed question of scour or foundation protection does not arise. There is likelihood of somewhat greater velocity which can be taken care during the detailed engineering stage.

- There is an apprehension expressed by some that a prolonged period of low floods would cause silting of the bed. It is however believed that constriction of the section would increase the specific discharge and velocities which will prevent silting of the bed. The existing upstream dams would entrap the sediment appreciably and the downstream flows with relatively less silt load would tend to pick up sediments rather than depositing them. In any case, this phenomenon can always be monitored through careful post project surveys.

RECCOMENDATIONS

- The proposed works may be planned and designed for a design flood as per Para 3 of conclusion.

- Suitable top and downstream protection may be provided to the embankments/walls against possible overflows during higher floods.

- As Foundation is rested on the rock only minimum anchorage in rock as specified in IS and IRC shall be provided for various structural arrangement planned for Mula Mutha Riverfront development.

- Due to channelization the velocities will increase and hence adequate surface protection to embankments/walls will have to be provided against damage due to surface erosion.

- A system of periodical river channel surveys, gauge and discharge observations at suitable locations and regular safety inspections will be designed and implemented for monitoring the hydraulic and safe performance of the river and project components. Specifically a gauge and discharge site should be established at bridges at strategic location where the river channel is straight and stable. At all other bridges, gauges should be fixed and the observations should be correlated with the gauge and discharge site pending next monsoon onwards.

- Low Lying Bridges shall be raised in channelized section so that afflux/Rise in water level can be substantially reduced.

- Any activities affecting the river regime will have to be vigilantly monitored and checked. No encroachments, dumping of refuse etc. should be allowed. The existing shrubs, rock protruding and other obstructions in the river channel should be cleared and not to allowed to grow again.

- One of the objectives of Barrages to be constructed is to provide a waterfront to the city. However, this pond will have to be so regulated during monsoon that it does not cause sedimentation or accentuate the afflux. The gates should be so operated that they negotiate the flood without causing significant afflux. For this an advance flood warning system as well as representative rain gauge stations in the downstream catchments, will have to be designed so that advance depletion of the pond can be done in the event of occurrence of floods.

- Three barrages / ground bar type having sill level of barrage almost at river bed level and full height gated operation are proposed in Pune city whose location is shown in Plate 3 to 6.

- The water will be lost due to seepage and evaporation from the pooled water of barrages constructed for retaining water in River Front in such case replenishing of water in riverfront will be carried out by treated water of sewage treatment.

- Numbers of drainage outlets discharging effluent, industrial wastes are located all along the River in Pune City and present highly polluted stagnant water requires to be diverted to sewage treatment plant and only rain/storm water shall be discharged in river.

- Trunk sewer line shall be planed parallel to existing river on east and west bank intercepting all the outlets and collecting and conveying the same to sewage treatment plant.

- The specially designed Manholes with over flowing weir type allowing storm water to discharge in river in rainy season and diverting in to trunk sewer in rest of the season shall be constructed at each outlet junction.

- From the post-project topographical, hydraulic and hydrological data observed from year to year, the flood analysis, the hydraulic parameters etc. should be periodically reviewed and suitable remedial or other measures should be taken, if warranted.

- For taking up construction of additional bridges etc. across the river the implications of such constructions on the river regime and flood profiles should be carefully got studied and suitable precautionary measures taken Longer spans and slimmer piers may be adopted to reduce the afflux to the minimum. There should be proper co-ordination between the bridge-construction authority and the PMC for such and other purposes.

- Suitable River Regulation Authority should be set up to monitor the river affecting activities and also to co-ordinate the functions of various organizations involved as well as to liaise with the concerned Government Authorities.

CWPRS SUGGESTIONS AND SUBSEQUENT SUBMISSION OF REPORT

Subject: FW: REVISED ADDITIONAL HYDROLOGY REPORT WITH CATCHMENT AREA PLAN ^_PUNE^_ RIVER FRONT

From: pradip@hcp.co.in
To: physics.cwprs@gmail.com; rsrgp@rediffmail.com
Cc: puneriverprojects@gmail.com; riverfront@punecorporation.org; archana.kothari@hcp.co.in; aesha.shah@hcp.co.in; ganesh@hcp.co.in; advanceengconsultant@yahoo.co.in; advanceeng@outlook.com
Date: Tuesday 14 March 2017, 3:19:41 PM IST

Project : Riverfront Development Plan for Mula, Mutha & Mula Mutha Rivers in Pune

Our Ref: 15091/A1/PJ

Dear Sirs,

This is with reference to our meeting on 13th February & 9th March, 2017 with CWPRS team regarding Hydrology and Hydraulics for Pune Riverfront Project. Our compliance to your observations during discussions is as follows;

A. Hydrology

1. Estimation of Flood

Observation:-

The flood for Pune Riverfront project should be alternatively calculated considering maximum outflow from dams plus flood from balance catchment downstream of the dam for 25, 50 &100 years return period flood.

Compliance:-

The Hydrology report submitted by us considering complete catchment area of that tributary and based on CWC sub zone 3(h) method 100 years return period flood is worked out. Subsequently as per discussion with CWPRS team, the peak discharge release from the respective dam plus flood calculated based on sub zone 3(h) method for balance catchment for 100, 50, 25 & maximum rainfall mentioned in Pune as per sub zone 3(h) report is considered in design and same is attached herewith.

The simultaneous occurrence of peak discharge released from dam and 100 years return period flood from the balance catchment cannot be possible therefore peak discharge from the dam and reasonable rainfall occurring simultaneously from the balance catchment will give realistic flood discharge.

Real time management for releasing water from dams can modernized the flood to great extend and occurrence of peak flood discharge in the river can be minimized.

B. Hydraulics

1. Manning's 'n' value

Comment: -

To keep same value for natural and trained section.

Compliance:-

We have considered same value for Manning's 'n'. Refer 4.6.2.1 on page no. 169 of draft report.

2. Afflux

Comment:-
Afflux should not be more than 1% of the normal depth.
Compliance:-
In channelized section water surface elevation is lower than the river cross section as removal of causeway, low level bridges, nos of weir located in river is proposed to be removed and corresponding overall reduction in afflux.

3. Impact of removing rock protruding from river bed
Comment:-
Foundation of existing bridge should not be disturbed
Compliance:-
All the bridges are founded on hard rock and therefore foundation will not be affected.

Kind Regards,

Pradip Jadav
Sr. Project Manager

For and on behalf of

HCP

Design, Planning and Management Pvt. Ltd.,

Paritosh, Usmanpura, Ahmedabad - 380013, India

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(Ext. No. – 411)

From: Pradip [mailto:pradip@hcp.co.in]
Sent: 08 March 2017 18:57
To: 'physics.cwprs@gmail.com'; 'rsgp@rediffmail.com'
Cc: 'puneriverprojects@gmail.com'; 'riverfront@punecorporation.org'; 'Archana Kothari'; 'Aesha Shah'; 'Ganesh Ahire'; 'Rajendra Parikh - Advance Engineering'; 'advanceeng@outlook.com'
Subject: FW: REVISED ADDITIONAL HYDROLOGY REPORT WITH CATCHMENT AREA PLAN PUNE RIVER FRONT

Dear Sir,

ANNEXURE 1

PAWNA CATCHMENT AREA AFTER DEDUCTING PAWNA DAM CATCHMENT

FLOOD ESTIMATION REPORT FOR KRISHNA AND PENNAR (SUB-ZONE-3h) BY CWC
MULA MUTHA RIVERFRONT DEVELOPMENT

Project:	**Mula Mutha Riverfront Development**		
River:	Pawna	longitude	73^0 83' 33"
City	Pune	latitide	18^0 56' 66"

Table for Computation of Eqivalent slope(S)

C.A. **384.5** km^2

'Datum =Reduced level of river bed = **484** m

TABLE-1

Sr No.	Reduced distance starting (km)	Reduced levels of river bed (m)	Length of each segment Li (km)	Height above datum(Di)= difference between the datum & its R.L. (m)	Di-1 + Di (m)	Li * (Di-1 + Di) (km * m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	484	0.00	0	0	0
2	4.85	485	4.85	1	1	4.85
3	9.90	490	5.05	6	7	35.343
4	19.01	495	9.11	11	17	154.87
5	30.49	500	11.48	16	27	309.96
6	54.97	520	24.48	36	52	1272.96
Total			**54.97**			**1777.983**

$$\text{Eq. Slope} = \frac{\text{sum of } (Li*(Di\text{-}1 + Di)}{L^2}$$

= **0.59** m/km

Design return period:	**100**	years
From plate no 11 , 100 yr point rainfall from sub zone 3h manual =	**20**	cms

I) Name & number of subzone — **Lower Ganga Sub Zone -3(h).**

ii) Name of Project — **MulaMutha RiverFront**

iii) Name of Tributary/River — **PAWNA**

iv) Site location — longitude 730 83' 33"
latitide 180 56' 66"

Estimation of flood using procedure as recommended in flood estimation report for Krishna & Pennar(SubZone- 3 h) published by Director of 'Hydrology(Small Catchment) CWC New Delhi (September-2000).

Data

C.A. (A)	(Catchment Area up to the project site in km^2)	**384.5**	km^2	
Length(L)	(Length of Main Stream from farthest point to dam site)	**54.969**	km	
Slope S	(Equivalent stream slope of main stream in m/km)	**0.59**	m/km	(Table - 1)
C.G. (Lc)	(Length of Longest stream from a point oppposite to C.G)	**20.20**	km	

(1) Determination of synthetic 1 hr U.G.Parameters

(i) tp= $0.325(LLc/Sqrt(s))^{-0.447}$ (Time to peak less half of unit duration)

= $0.325 \times (54.97 \times 20.20 / sqrt(0.59))^{0.447}$ = **8.4** hrs

tp adopted= **8.5** hrs

(ii) $q_{p} = 0.996(t_P)^{-0.497}$ (Peak discharge per km^2)

= $0.996 \times (8.50)^{-0.497}$

= 0.344 cumecs/km^2

(iii) $T_B = 7.392(t_p)^{0.524}$ (Base period of hydrograph)

= $7.392 * (8.500)^{0.524}$

= 22.687

= 23 hrs

(iv) $\mathbf{Q_p} =$ q_p x A (Peak Discharge of Unit Hydrograph in cumecs)

= 0.344x384.5

= 132.268 cumecs

(v) $\mathbf{W_{50}} =$ $2.389(q_p)^{-1.065}$ (Width of U.G. measured at 50% of maximum Discharge)

= $2.389 \times (0.344)^{-1.065}$

= 7.44 hrs Ordinate(Qp) in hrs)

(vi) $\mathbf{W_{75}} =$ $1.415\ (q_p)^{-1.067}$ (Width of U.G. measured at 75%of maximum Discharge

= $1.415 \times (0.344)^{-1.067}$

= 4.42 hrs Ordinate (Qp) in hrs)

(vii)$\mathbf{W_{R50}} =$ $0.753 \times (q_p)^{-1.229}$ (Width of rising side of U.G. measured at 50% of maximum

= $0.753 \times (0.344)^{-1.229}$ Discharge (Qp) in hrs)

= 2.79 hrs

(viii)$\mathbf{W_{R75}} =$ $0.558 \times (q_p)^{-1.088}$

= $0.558 \times (0.344)^{-1.088}$ (Width of rising side of U.G. measured at 75% of maximum

= 1.78 hrs Discharge (Qp) in hours)

(ix) Computation of Design base flow:

$\mathbf{Q_B} =$ A x q_b (Base Flow)

= 384.5x0.05

19.23 cumecs

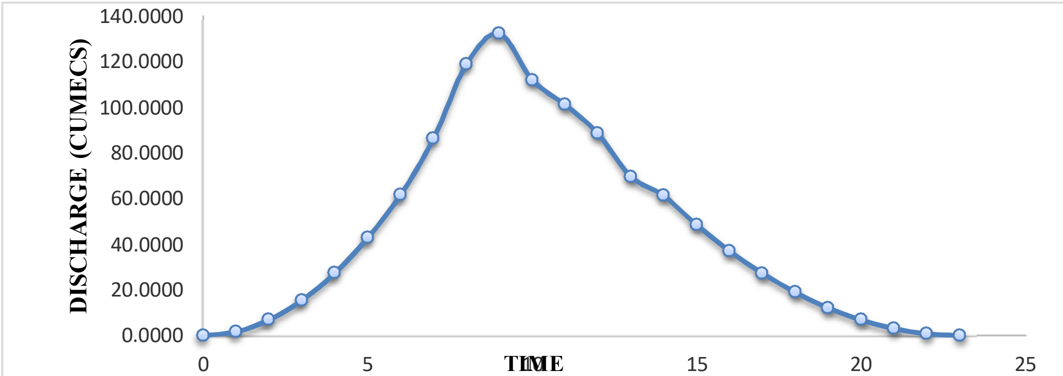
(x) $\mathbf{T_m}$ = t_p + tr/2

= 8.50+1/2

= 9.00 hrs

(2) Drawing of synthatic unit hydrograph

Estimated parameters of U.G.at Plate No.I are plotted to scale on Graph paper as shown in figure and smoothened



(3) Estimaton of design storm duration

The design storm duration $T_{DS}= T_m$ hrs = **9** hrs

(4) Estimation of Point rainfall and Areal Rainfall

(I) Point Rainfall

The catchment was located on Plate-10 (Ref C.W.C.Report-Sub Zone-3(h))
showing 100 yr point rainfall = **20** cms
Conversion factor of 100 yr 24 hr point rainfall to 100 yr 9 hr point rainfall
is read from fig-10 section 4.2 = **0.750**
100 yr 9 hrs point rainfall = 20 x 0.75 = **15** cm

(ii) Areal Rainfall

Areal reduction factor for TD= 9 hrs corresponding to catchment
area 385 km2 was interpotated from Annexure 4.4 = **0.7914**
100 yr 9 hrs areal rainfall = 15x0.791375 = **11.87** cms

(5) Time distribution of Areal Rainfall

Loss rate considered = **0.10** cm/hr

For 1 in 100 yr return period flood

100 yr 9 hrs areal rainfall = 11.87 cms was distributed with the distribution coefficient corresponding to 9

Hourly Rainfall Increment

Sr.No.	Duration t (hrs)	Distribution Coefficient	Storm Rainfall (cm)	1-hr rainfall increment (cm)	1-hr rainfall excess (deducting loss of 0.10 cm/hr (cm)
1	1	0.39	4.63	4.63	4.53
2	2	0.57	6.77	2.14	2.04
3	3	0.70	8.31	1.54	1.44
4	4	0.78	9.26	0.95	0.85
5	5	0.84	9.97	0.71	0.61
6	6	0.89	10.56	0.59	0.49
7	7	0.94	11.16	0.60	0.50
8	8	0.97	11.51	0.35	0.25
9	9	1.00	11.87	0.36	0.26

Computation of 1 in 100yr flood: (Peak only)

Time (hrs)	U.G (m^3/sec)	R.F excess in design order	Direct Runoff (cumecs)
6	61.7	0.26	16.05
7	86.4	0.49	42.32
8	118.9	2.04	242.60
9	132.3	4.53	599.17
10	112.0	1.44	161.22
11	101.1	0.85	85.97
12	88.4	0.50	44.21
13	69.6	0.50	34.80
14	61.3	0.25	15.32
Sum=	**831.7**		**1241.66**

1 in 100 yr flood.

= Sum of direct runoff + Base flow

= 1241.66 + 19.23

= **1260.89 cumecs** **Say 1261 cumecs**

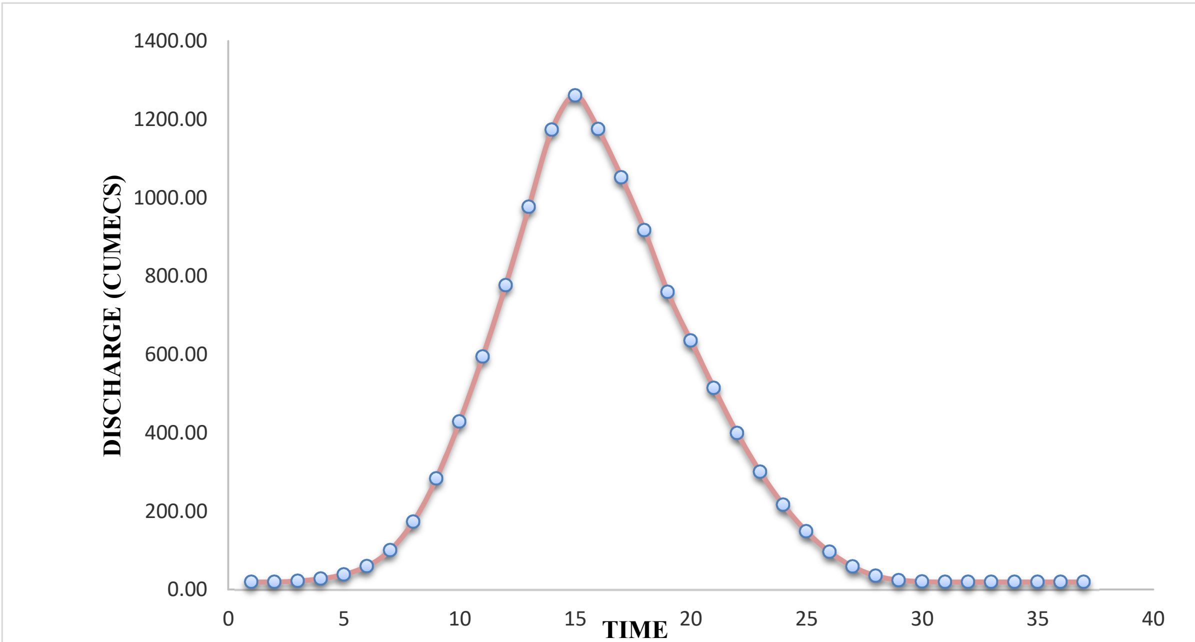
= 44533 cusecs

Computation of Design Flood Peak hydrograph (1 in 100 Year)

Calculated Peak Flood

Synthetic										Total	Base	Total	Remarks
U.G.	**0.25**	**0.50**	**0.50**	**0.85**	**1.44**	**4.53**	**2.04**	**0.49**	**0.26**		Flow		
Ordinates	4	5	6	7	8	9	10	11	12	(Cumecs)	(Cumecs)	(Cumecs)	
0.0	0.00									0.00	19.23	19.23	
1.7	0.43	0.00								0.43	19.23	19.66	
6.9	1.71	0.86	0.00							2.57	19.23	21.80	
15.4	3.86	3.43	0.86	0.00						8.15	19.23	27.38	
27.4	6.86	7.72	3.43	1.46	0.00					19.47	19.23	38.70	
42.9	10.72	13.72	7.72	5.83	2.47	0.00				40.46	19.23	59.69	
61.7	15.43	21.44	13.72	13.12	9.88	7.77	0.00			81.36	19.23	100.59	
86.4	21.59	30.87	21.44	23.32	22.23	31.07	3.50	0.00		154.02	19.23	173.25	
118.9	29.73	43.18	30.87	36.44	39.51	69.92	13.99	0.84	0.00	264.48	19.23	283.71	
132.3	33.07	59.46	43.18	52.48	61.74	124.30	31.49	3.36	0.45	409.53	19.23	428.76	
112.0	27.99	66.13	59.46	73.41	88.90	194.21	55.97	7.56	1.78	575.41	19.23	594.64	
101.1	25.29	55.98	66.13	101.08	124.36	279.67	87.46	13.44	4.01	757.42	19.23	776.65	
88.4	22.10	50.57	55.98	112.43	171.25	391.23	125.94	21.01	7.13	957.64	19.23	976.87	
69.6	17.40	44.21	50.57	95.17	190.47	538.72	176.18	30.25	11.15	1154.12	19.23	1173.35	
61.3	15.32	34.80	44.21	85.97	161.22	599.17	242.60	42.32	16.05	1241.66	19.23	1260.89	**Peak Flood**
48.4	12.10	30.64	34.80	75.15	145.65	507.19	269.83	58.27	22.45	1156.08	19.23	1175.31	
37.1	9.27	24.21	30.64	59.15	127.32	458.18	228.40	64.81	30.92	1032.90	19.23	1052.13	
27.2	6.81	18.53	24.21	52.08	100.21	400.53	206.33	54.86	34.39	897.95	19.23	917.18	
18.9	4.73	13.62	18.53	41.15	88.24	315.25	180.37	49.56	29.11	740.56	19.23	759.79	
12.1	3.03	9.46	13.62	31.51	69.72	277.58	141.97	43.32	26.30	616.51	19.23	635.74	
6.8	1.70	6.05	9.46	23.15	53.38	219.32	125.00	34.10	22.99	495.15	19.23	514.38	
3.0	0.76	3.40	6.05	16.08	39.22	167.92	98.77	30.02	18.09	380.31	19.23	399.54	
0.8	0.19	1.51	3.40	10.29	27.23	123.37	75.62	23.72	15.93	281.26	19.23	300.49	
0.0	0.00	0.38	1.51	5.79	17.43	85.67	55.56	18.16	12.59	197.09	19.23	216.32	
		0.00	0.38	2.57	9.80	54.83	38.58	13.34	9.64	129.14	19.23	148.37	
		0.00	0.00	0.64	4.36	30.84	24.69	9.27	7.08	76.88	19.23	96.11	
		0.00	0.00	0.00	1.09	13.71	13.89	5.93	4.92	39.54	19.23	58.77	
			0.00	0.00	0.00	3.43	6.17	3.34	3.15	16.09	19.23	35.32	
				0.00	0.00	0.00	1.54	1.48	1.77	4.79	19.23	24.02	
					0.00	0.00	0.00	0.37	0.79	1.16	19.23	20.39	
						0.00	0.00	0.00	0.20	0.20	19.23	19.43	
							0.00	0.00	0.00	0.00	19.23	19.23	
								0.00	0.00	0.00	19.23	19.23	
									0.00	0.00	19.23	19.23	
										0.00	19.23	19.23	
										0.00	19.23	19.23	
										0.00	19.23	19.23	
												1260.89	Cumecs

FLOOD HYDROGRAPH FOR PAWNA RIVER



ANNEXURE II

MULA CATCHMENT AREA UPTO CONFLUENCE OF PAWNA RIVER AFTER DEDUCTING MULSHI DAM CATCHMENT

FLOOD ESTIMATION REPORT FOR KRISHNA AND PENNAR (SUB-ZONE-3h) BY CWC

MULA MUTHA RIVERFRONT DEVELOPMENT

Project:	**Mula Mutha Riverfront Development**		
River:	Mula	longitude	73^0 75' 08"
City	Pune	latitide	18^0 55' 91"

Table for Computation of Eqivalent slope(S)

C.A. **480.85** km^2

'Datum =Reduced level of river bed = **483** m

TABLE-1

Sr No.	Reduced distance starting (km)	Reduced levels of river bed (m)	Length of each segment Li (km)	Height above datum(Di)= difference between the datum & its R.L. (m)	Di-1 + Di (m)	Li * (Di-1 + Di) (km * m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	483	0.00	0	0	0
2	11.65	485	11.65	2	2	23.302
3	21.02	490	9.37	7	9	84.348
4	30.56	495	9.541	12	19	181.279
5	44.27	500	13.708	17	29	397.532
6	45.94	520	1.667	37	54	90.018
Total			**45.94**			**776.479**

$$\text{Eq. Slope} = \frac{\text{sum of (Li*(Di-1 + Di)}}{L^2}$$

= **0.37** m/km

Design return period: **100** years

From plate no 11 , 100 yr point rainfall from sub zone 3h manual = **20** cms

i) Name & number of subzone	**Lower Ganga Sub Zone -3(h).**
ii) Name of Project	**MulaMutha RiverFront**
iii) Name of Tributary/River	**Mula**
iv) Site location	longitude 730 75' 08" latitide 180 55' 91"

Estimation of flood using procedure as recommended in flood estimation report for Krishna & Pennar(SubZone- 3 h) published by Director of 'Hydrology(Small Catchment) CWC New Delhi (September-2000).

Data

C.A. (A)	(Catchment Area up to the project site in km^2)	**480.85**	km^2	
Length(L)	(Length of Main Stream from farthest point to dam site)	**45.939**	km	
Slope S	(Equivalent stream slope of main stream in m/km)	**0.37**	m/km	(Table - 1)
C.G. (Lc)	(Length of Longest stream from a point oppposite to C.G)	**27.48**	km	

(1) Determination of synthetic 1 hr U.G.Parameters

(i) tp= $0.325(LLc/Sqrt(s))^{-0.447}$ (Time to peak less half of unit duration)

= $0.325 \times (45.94 \times 27.48 / sqrt(0.37))^{0.447}$ = **9.8** hrs

tp adopted= **9.5** hrs

(ii) $q_{p} = 0.996(t_P)^{-0.497}$ (Peak discharge per km^2)

$= 0.996 \times (9.50)^{-0.497}$

= 0.325 cumecs/km^2

(iii) $T_B = 7.392(t_p)^{0.524}$ (Base period of hydrograph)

= $7.392 * (9.500)^{0.524}$

= 24.049

= 24 hrs

(iv) Q_p= q_p x A (Peak Discharge of Unit Hydrograph in cumecs)

= 0.325x480.85

= 156.276 cumecs

(v) W_{50} = $2.389(q_p)^{\wedge -1.065}$ (Width of U.G. measured at 50% of maximum Discharge)

= $2.389 \times (0.325)^{-1.065}$

= 7.91 hrs Ordinate(Qp) in hrs)

(vi) W_{75} = $1.415\ (q_p)^{-1.067}$ (Width of U.G. measured at 75%of maximum Discharge

= $1.415 \times (0.325)^{-1.067}$

= 4.69 hrs Ordinate (Qp) in hrs)

(vii)W_{R50} = $0.753 \times (q_p)^{-1.229}$ (Width of rising side of U.G. measured at 50% of maximum Discharge (Qp) in hrs)

= $0.753 \times (0.325)^{-1.229}$

= 3 hrs

(viii)W_{R75} = $0.558x(q_p)^{-1.088}$

= $0.558 \times (0.325)^{-1.088}$ (Width of rising side of U.G. measured at 75% of maximum Discharge (Qp) in hours)

= 1.90 hrs

(ix) Computation of Design base flow:

Q_B = A x q_b (Base Flow)

= 480.85x0.05

24.04 cumecs

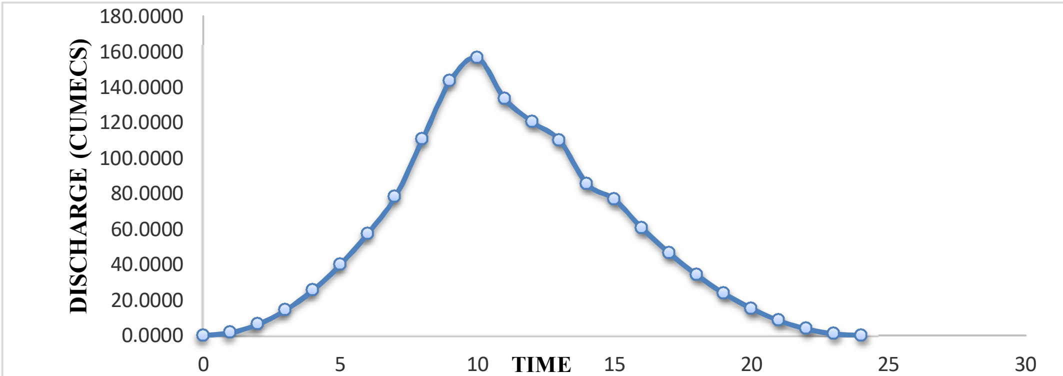
(x) T_m = t_p + tr/2

= 9.50+1/2

= 10.00 hrs

(2) Drawing of synthatic unit hydrograph

Estimated parameters of U.G.at Plate No.I are plotted to scale on Graph paper as shown in figure and smoothened



(3) Estimaton of design storm duration

The design storm duration T_{DS}= T_m hrs = **10** hrs

(4) Estimation of Point rainfall and Areal Rainfall

(I) Point Rainfall

The catchment was located on Plate-10 (Ref C.W.C.Report-Sub Zone-3(h))
showing 100 yr point rainfall = **20** cms
Conversion factor of 100 yr 24 hr point rainfall to 100 yr 10 hr point rainfall
is read from fig-10 section 4.2 = **0.810**
100 yr 10 hrs point rainfall = 20 x 0.81 = **16.2** cm

(ii) Areal Rainfall

Areal reduction factor for TD= 10 hrs corresponding to catchment
area 481 km2 was interpotated from Annexure 4.4 = **0.7816**
100 yr 10 hrs areal rainfall = 16.2x0.7816364 = **12.66** cms

(5) Time distribution of Areal Rainfall

Loss rate considered = **0.10** cm/hr

For 1 in 100 yr return period flood

100 yr 10 hrs areal rainfall = 12.66 cms was distributed with the distribution coefficient corresponding to 10

Hourly Rainfall Increment

Sr.No.	Duration t (hrs)	Distribution Coefficient	Storm Rainfall (cm)	1-hr rainfall increment (cm)	1-hr rainfall excess (deducting loss of 0.10 cm/hr (cm)
1	1	0.37	4.69	4.69	4.59
2	2	0.55	6.96	2.27	2.17
3	3	0.67	8.48	1.52	1.42
4	4	0.75	9.50	1.02	0.92
5	5	0.81	10.26	0.76	0.66
6	6	0.86	10.89	0.63	0.53
7	7	0.91	11.52	0.63	0.53
8	8	0.95	12.03	0.51	0.41
9	9	0.98	12.41	0.38	0.28
10	10	1.00	12.66	0.25	0.15

Computation of 1 in 100yr flood: (Peak only)

Time (hrs)	U.G (m^3/sec)	R.F excess in design order	Direct Runoff (cumecs)
7	78.1	0.41	32.04
8	110.4	0.66	72.88
9	143.4	2.17	311.09
10	156.3	4.59	717.31
11	133.3	1.42	189.27
12	120.3	0.92	110.71
13	109.9	0.53	58.22
14	85.3	0.53	45.23
15	76.6	0.28	21.45
16	60.5	0.15	9.08
Sum=	**1074.1**		**1567.28**

1 in 100 yr flood.

= Sum of direct runoff + Base flow

= 1567.28 + 24.04

= **1591.32 cumecs** **Say** **1592** **cumecs**

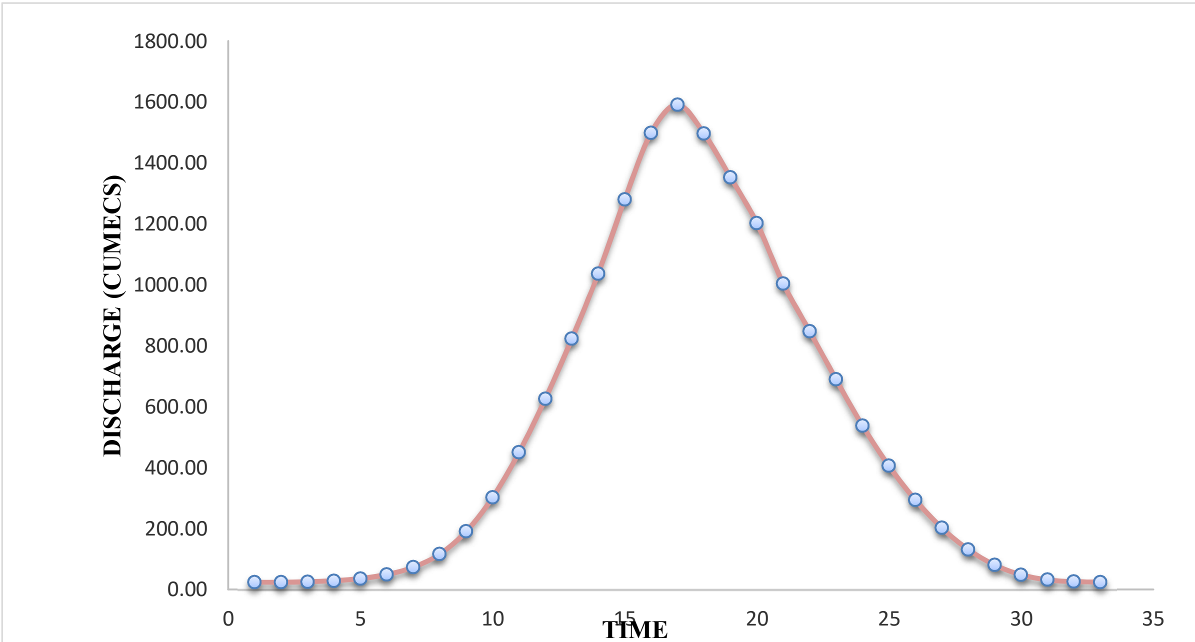
= **56222** **cusecs**

Computation of Design Flood Peak hydrograph (1 in 100 Year)

alculated Peak Floc 1591.32 cumecs

Synthetic U.G. Ordinates	0.15	0.28	0.53	0.53	0.92	1.42	4.59	2.17	0.66	0.41	Total	Base Flow	Total	Remarks
	1	2	3	4	5	6	7	8	9	10	(Cumecs)	(Cumecs)	(Cumecs)	
0.0	0.00										0.00	24.04	24.04	
1.6	0.24	0.00									0.24	24.04	24.28	
6.4	0.96	0.45	0.00								1.41	24.04	25.45	
14.4	2.15	1.79	0.85	0.00							4.79	24.04	28.83	
25.5	3.83	4.02	3.38	0.85	0.00						12.08	24.04	36.12	
39.9	5.98	7.14	7.61	3.38	1.47	0.00					25.58	24.04	49.62	
57.4	8.61	11.16	13.52	7.61	5.87	2.26	0.00				49.03	24.04	73.07	
78.1	11.72	16.07	21.13	13.52	13.20	9.06	7.32	0.00			92.02	24.04	116.06	
110.4	16.56	21.88	30.43	21.13	23.47	20.38	29.28	3.46	0.00		166.59	24.04	190.63	
143.4	21.50	30.92	41.41	30.43	36.68	36.23	65.88	13.84	1.05	0.00	277.94	24.04	301.98	
156.3	23.44	40.14	58.53	41.41	52.81	56.61	117.11	31.14	4.21	0.65	426.05	24.04	450.09	
133.3	19.99	43.76	75.98	58.53	71.89	81.52	182.99	55.37	9.47	2.62	602.12	24.04	626.16	
120.3	18.05	37.32	82.83	75.98	101.59	110.96	263.50	86.51	16.84	5.88	799.46	24.04	823.50	
109.9	16.48	33.70	70.64	82.83	131.89	156.81	358.65	124.57	26.31	10.46	1012.34	24.04	1036.38	
85.3	12.80	30.76	63.78	70.64	143.77	203.57	506.86	169.56	37.89	16.35	1255.98	24.04	1280.02	
76.6	11.49	23.89	58.22	63.78	122.63	221.91	658.03	239.63	51.57	23.54	1474.69	24.04	1498.73	
60.5	9.08	21.45	45.23	58.22	110.71	189.27	717.31	311.09	72.88	32.04	1567.28	24.04	1591.32	**Peak Flood**
46.3	6.95	16.95	40.60	45.23	101.06	170.88	611.79	339.12	94.62	45.27	1472.47	24.04	1496.51	
34.0	5.11	12.97	32.08	40.60	78.51	155.99	552.36	289.24	103.14	58.78	1328.78	24.04	1352.82	
23.6	3.55	9.53	24.56	32.08	70.47	121.18	504.21	261.14	87.97	64.07	1178.76	24.04	1202.80	
15.1	2.27	6.62	18.04	24.56	55.68	108.77	391.69	238.38	79.42	54.65	980.08	24.04	1004.12	
8.5	1.28	4.24	12.53	18.04	42.63	85.94	351.59	185.18	72.50	49.34	823.27	24.04	847.31	
3.8	0.57	2.38	8.02	12.53	31.32	65.80	277.80	166.22	56.32	45.04	666.00	24.04	690.04	
0.9	0.14	1.06	4.51	8.02	21.75	48.34	212.69	131.33	50.55	34.99	513.38	24.04	537.42	
0.0	0.00	0.26	2.00	4.51	13.92	33.57	156.26	100.55	39.94	31.41	382.42	24.04	406.46	
		0.00	0.50	2.00	7.83	21.49	108.51	73.87	30.58	24.81	269.59	24.04	293.63	
			0.00	0.50	3.48	12.09	69.45	51.30	22.47	19.00	178.29	24.04	202.33	
				0.00	0.87	5.37	39.07	32.83	15.60	13.96	107.70	24.04	131.74	
				0.00	0.00	1.34	17.36	18.47	9.99	9.69	56.85	24.04	80.89	
						0.00	4.34	8.21	5.62	6.20	24.37	24.04	48.41	
							0.00	2.05	2.50	3.49	8.04	24.04	32.08	
								0.00	0.62	1.55	2.17	24.04	26.21	
									0.00	0.39	0.39	24.04	24.43	
										0.00	0.00	24.04	24.04	
													1591.32	Cumecs

FLOOD HYDROGRAPH FOR MULA RIVER BY SUBZONE METHOD



ANNEXURE III

MULA CATCHMENT AREA FROM CONFLUENCE OF PAWNA RIVER TO MUTHA RIVER SANGAM

FLOOD ESTIMATION REPORT FOR KRISHNA AND PENNAR (SUB-ZONE-3h) BY CWC

MULA MUTHA RIVERFRONT DEVELOPMENT

Project:	**Mula Mutha Riverfront Development**		
River:	Mula	longitude	73^0 75' 08"
City	Pune	latitide	18^0 55' 91"

Table for Computation of Eqivalent slope(S)

C.A. **67.5** km^2

'Datum =Reduced level of river bed = **483** m

TABLE-1

Sr No.	Reduced distance starting (km)	Reduced levels of river bed (m)	Length of each segment Li (km)	Height above datum(Di)= difference between the datum & its R.L. (m)	Di-1 + Di (m)	Li * (Di-1 + Di) (km * m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	483	0.00	0	0	0
2	11.10	485	11.10	2	2	22.2
Total			**11.10**			**22.2**

$$\text{Eq. Slope} = \frac{\text{sum of }(Li*(Di\text{-}1 + Di)}{L^2}$$

= **0.18** m/km

Design return period:	**100**	years
From plate no 11 , 100 yr point rainfall from sub zone 3h manual =	**20**	cms

i) Name & number of subzone	**Lower Ganga Sub Zone -3(h).**
ii) Name of Project	**MulaMutha RiverFront**
iii) Name of Tributary/River	**Mula**
iv) Site location	longitude 730 75' 08" latitide 180 55' 91"

Estimation of flood using procedure as recommended in flood estimation report for Krishna & Pennar(SubZone- 3 h) published by Director of 'Hydrology(Small Catchment) CWC New Delhi (September-2000).

Data

C.A. (A)	(Catchment Area up to the project site in km^2)	**67.5** km^2	
Length(L)	(Length of Main Stream from farthest point to dam site)	**11.1** km	
Slope S	(Equivalent stream slope of main stream in m/km)	**0.18** m/km	(Table - 1)
C.G. (Lc)	(Length of Longest stream from a point oppposite to C.G)	**6.20** km	

(1) Determination of synthetic 1 hr U.G.Parameters

(i) tp= $0.325(LLc/Sqrt(s))^{-0.447}$ (Time to peak less half of unit duration)

$= 0.325 \times (11.10 \times 6.20 / sqrt(0.18))^{0.447}$ = **3.1** hrs

tp adopted= **3.5** hrs

(ii) $q_{p} = 0.996(t_P)^{-0.497}$ (Peak discharge per km^2)

$= 0.996 \times (3.50)^{-0.497}$

= 0.534 cumecs/km^2

(iii) $T_B = 7.392(t_p)^{0.524}$ (Base period of hydrograph)

$= 7.392 * (3.500)^{0.524}$

= 14.251

= 14 hrs

(iv) Q_p= q_p x A (Peak Discharge of Unit Hydrograph in cumecs)

= 0.534x67.5

= 36.045 cumecs

(v) W_{50} = $2.389(q_p)^{\wedge -1.065}$ (Width of U.G. measured at 50% of maximum Discharge)

= $2.389 \times (0.534)^{-1.065}$

= 4.66 hrs Ordinate(Qp) in hrs)

(vi) W_{75} = $1.415\ (q_p)^{-1.067}$ (Width of U.G. measured at 75%of maximum Discharge

= $1.415 \times (0.534)^{-1.067}$

= 2.76 hrs Ordinate (Qp) in hrs)

(vii)W_{R50} = $0.753 \times (q_p)^{-1.229}$ (Width of rising side of U.G. measured at 50% of maximum

= $0.753 \times (0.534)^{-1.229}$ Discharge (Qp) in hrs)

= 1.63 hrs

(viii)W_{R75} = $0.558x(q_p)^{-1.088}$

= $0.558 \times (0.534)^{-1.088}$ (Width of rising side of U.G. measured at 75% of maximum

= 1.10 hrs Discharge (Qp) in hours)

(ix) Computation of Design base flow:

Q_B = A x q_b (Base Flow)

= 67.5x0.05

3.38 cumecs

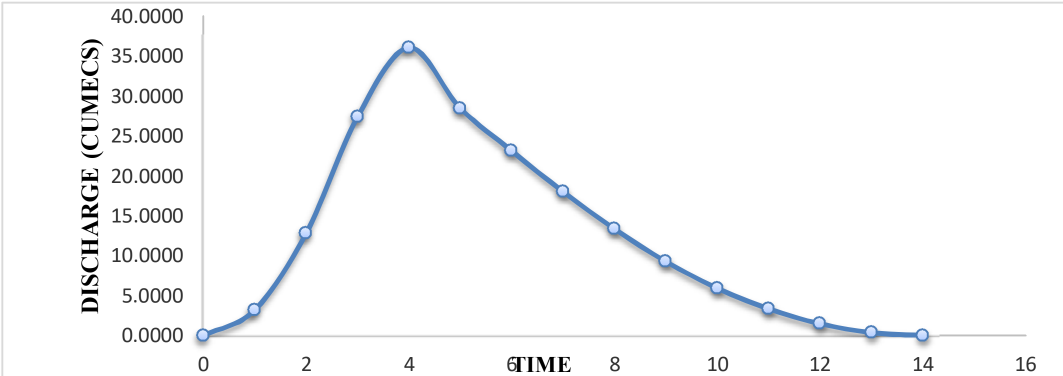
(x) T_m = t_p + tr/2

= 3.50+1/2

= 4.00 hrs

(2) Drawing of synthatic unit hydrograph

Estimated parameters of U.G.at Plate No.I are plotted to scale on Graph paper as shown in figure and smoothened



(3) Estimaton of design storm duration

The design storm duration T_{DS}= T_m hrs = **4** hrs

(4) Estimation of Point rainfall and Areal Rainfall

(I) Point Rainfall

The catchment was located on Plate-10 (Ref C.W.C.Report-Sub Zone-3(h))
showing 100 yr point rainfall = **20** cms
Conversion factor of 100 yr 24 hr point rainfall to 100 yr 4 hr point rainfall
is read from fig-10 section 4.2 = **0.680**
100 yr 4 hrs point rainfall = 20 x 0.68 = **13.6** cm

(ii) Areal Rainfall

Areal reduction factor for TD= 4 hrs corresponding to catchment
area 68 km2 was interpotated from Annexure 4.4 = **0.9062**
100 yr 4 hrs areal rainfall = 13.6x0.906155 = **12.32** cms

(5) Time distribution of Areal Rainfall

Loss rate considered = **0.10** cm/hr

For 1 in 100 yr return period flood

100 yr 4 hrs areal rainfall = 12.32 cms was distributed with the distribution coefficient corresponding to 4

Hourly Rainfall Increment

Sr.No.	Duration t (hrs)	Distribution Coefficient	Storm Rainfall (cm)	1-hr rainfall increment (cm)	1-hr rainfall excess (deducting loss of 0.10 cm/hr (cm)
1	1	0.67	8.26	8.26	8.16
2	2	0.86	10.60	2.34	2.24
3	3	0.96	11.83	1.23	1.13
4	4	1.00	12.32	0.49	0.39

Computation of 1 in 100yr flood: (Peak only)

Time (hrs)	U.G (m^3/sec)	R.F excess in design order	Direct Runoff (cumecs)
3	27.4	1.13	30.91
4	36.0	8.16	294.13
5	28.5	2.24	63.75
6	23.1	0.39	9.02
Sum=	**115.0**		**397.81**

1 in 100 yr flood.

= Sum of direct runoff + Base flow

= 397.81 + 3.38

= **401.19 cumecs** **Say** **402** **cumecs**

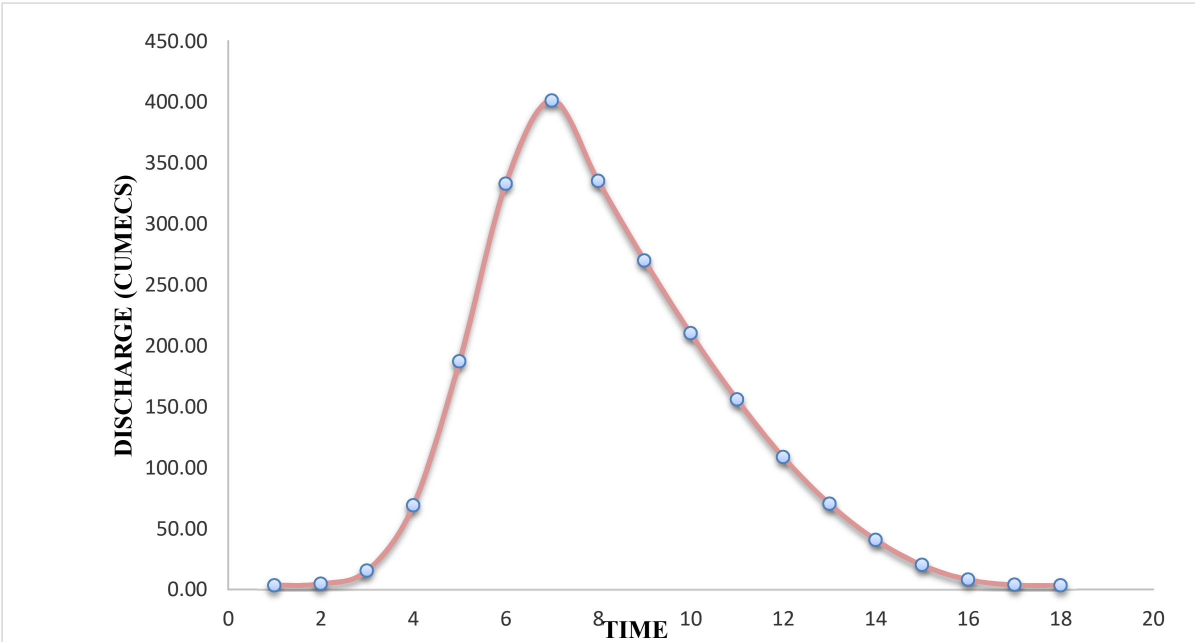
= **14197** **cusecs**

Computation of Design Flood Peak hydrograph (1 in 100 Year)

ated Peak Flood

Synthetic U.G. Ordinates	0.39 7	2.24 8	8.16 9	1.13 10	Total (Cumecs)	Base Flow (Cumecs)	Total (Cumecs)	Remarks
0.0	0.00				0.00	3.38	3.38	
3.2	1.25	0.00			1.25	3.38	4.63	
12.8	5.01	7.19	0.00		12.20	3.38	15.58	
27.4	10.67	28.75	26.18	0.00	65.60	3.38	68.98	
36.0	14.06	61.27	104.73	3.63	183.69	3.38	187.07	
28.5	11.10	80.74	223.21	14.50	329.55	3.38	332.93	
23.1	9.02	63.75	294.13	30.91	397.81	3.38	401.19	**Peak Flood**
18.0	7.03	51.78	232.22	40.73	331.76	3.38	335.14	
13.4	5.21	40.38	188.63	32.16	266.38	3.38	269.76	
9.3	3.62	29.92	147.10	26.12	206.76	3.38	210.14	
5.9	2.31	20.77	108.98	20.37	152.43	3.38	155.81	
3.3	1.30	13.30	75.68	15.09	105.37	3.38	108.75	
1.5	0.58	7.48	48.44	10.48	66.98	3.38	70.36	
0.4	0.14	3.32	27.24	6.71	37.41	3.38	40.79	
0.0	0.00	0.83	12.11	3.77	16.71	3.38	20.09	
		0.00	3.03	1.68	4.71	3.38	8.09	
			0.00	0.42	0.42	3.38	3.80	
				0.00	0.00	3.38	3.38	
							401.19	Cumecs

FLOOD HYDROGRAPH FOR MULA RIVER BY SUBZONE METHOD



ANNEXURE IV

MUTHA CATCHMENT AREA AFTER DEDUCTING KHADAKWASLA DAM CATCHMENT UPTO SANGAM WITH MULA RIVER

FLOOD ESTIMATION REPORT FOR KRISHNA AND PENNAR (SUB-ZONE-3h) BY CWC

MULA MUTHA RIVERFRONT DEVELOPMENT

Project:	**Mula Mutha Riverfront Development**		
River:	Mutha	longitude	73^0 86' 07"
City	Pune	latitide	18^0 52' 84"

Table for Computation of Eqivalent slope(S)

C.A. **188** km^2

'Datum =Reduced level of river bed = **473** m

TABLE-1

Sr No.	Reduced distance starting (km)	Reduced levels of river bed (m)	Length of each segment Li (km)	Height above datum(Di)= difference between the datum & its R.L. (m)	Di-1 + Di (m)	Li * (Di-1 + Di) (km * m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	473	0.00	0	0	0
2	3.07	475	3.07	2	2	6.13
3	6.44	475	3.38	2	4	13.5
4	9.09	480	2.653	7	9	23.877
5	13.74	485	4.65	12	19	88.35
6	15.82	500	2.075	27	39	80.925
Total			**15.82**			**212.782**

$$\text{Eq. Slope} = \frac{\text{sum of (Li*(Di-1 + Di)}}{L^2}$$

= **0.85** m/km

Design return period: **100** years
From plate no 11 , 100 yr point rainfall from sub zone 3h manual = **20** cms

I) Name & number of subzone **Lower Ganga Sub Zone -3(h).**

ii) Name of Project **MulaMutha RiverFront**

iii) Name of Tributary/River **Mutha**

iv) Site location longitude 730 86' 07"
latitide 180 52' 84"

Estimation of flood using procedure as recommended in flood estimation report for Krishna & Pennar(SubZone- 3 h) published by Director of 'Hydrology(Small Catchment) CWC New Delhi (September-2000).

Data

C.A. (A)	(Catchment Area up to the project site in km^2)	**188** km^2	
Length(L)	(Length of Main Stream from farthest point to dam site)	**15.818** km	
Slope S	(Equivalent stream slope of main stream in m/km)	**0.85** m/km	(Table - 1)
C.G. (Lc)	(Length of Longest stream from a point oppposite to C.G)	**9.83** km	

(1) Determination of synthetic 1 hr U.G.Parameters

(i) tp= $0.325(LLc/Sqrt(s))^{-0.447}$ (Time to peak less half of unit duration)

= $0.325 \times (15.82 \times 9.83 / sqrt(0.85))^{0.447}$ = **3.2** hrs

tp adopted= **3.5** hrs

(ii) $q_{p} = 0.996(t_{P})^{-0.497}$ (Peak discharge per km^2)

$= 0.996 \times (3.50)^{-0.497}$

= 0.534 cumecs/km^2

(iii) $T_B = 7.392(t_p)^{0.524}$ (Base period of hydrograph)

$= 7.392 * (3.500)^{0.524}$

= 14.251

= 14 hrs

(iv) $Q_p = q_p \times A$ (Peak Discharge of Unit Hydrograph in cumecs)

= 0.534x188

= 100.392 cumecs

(v) $W_{50} = 2.389(q_p)^{-1.065}$ (Width of U.G. measured at 50% of maximum Discharge)

= $2.389 \times (0.534)^{-1.065}$

= 4.66 hrs Ordinate(Qp) in hrs)

(vi) $W_{75} = 1.415\,(q_p)^{-1.067}$ (Width of U.G. measured at 75%of maximum Discharge

= $1.415 \times (0.534)^{-1.067}$

= 2.76 hrs Ordinate (Qp) in hrs)

(vii) $W_{R50} = 0.753 \times (q_p)^{-1.229}$ (Width of rising side of U.G. measured at 50% of maximum

= $0.753 \times (0.534)^{-1.229}$ Discharge (Qp) in hrs)

= 1.63 hrs

(viii) $W_{R75} = 0.558 \times (q_p)^{-1.088}$

= $0.558 \times (0.534)^{-1.088}$ (Width of rising side of U.G. measured at 75% of maximum

= 1.10 hrs Discharge (Qp) in hours)

(ix) Computation of Design base flow:

$Q_B = A \times q_b$ (Base Flow)

= 188x0.05

9.4 cumecs

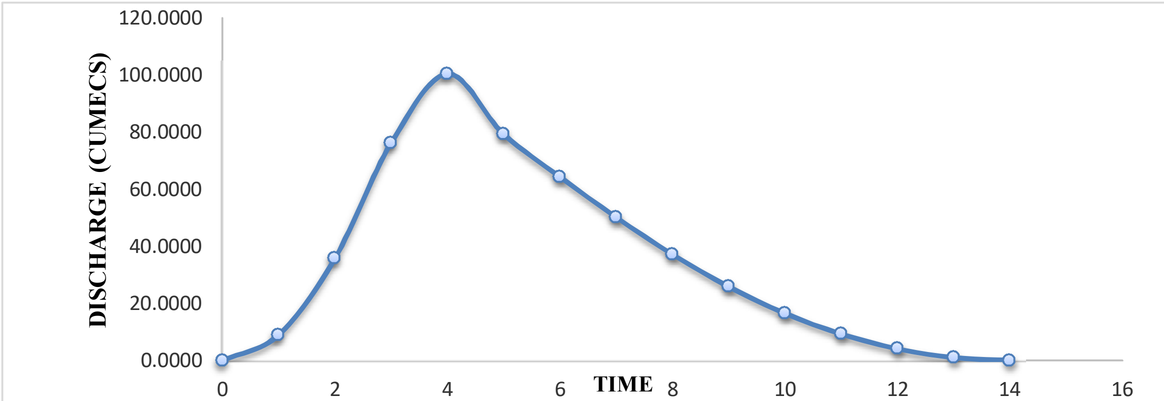
(x) $T_m = t_p + tr/2$

= 3.50+1/2

= 4.00 hrs

(2) Drawing of synthatic unit hydrograph

Estimated parameters of U.G.at Plate No.I are plotted to scale on Graph paper as shown in figure and smoothened



(3) Estimaton of design storm duration

The design storm duration T_{DS}= T_m hrs = **4** hrs

(4) Estimation of Point rainfall and Areal Rainfall

(I) Point Rainfall

The catchment was located on Plate-10 (Ref C.W.C.Report-Sub Zone-3(h))
showing 100 yr point rainfall = **20** cms
Conversion factor of 100 yr 24 hr point rainfall to 100 yr 4 hr point rainfall
is read from fig-10 section 4.2 = **0.680**
100 yr 4 hrs point rainfall = 20 x 0.68 = **13.6** cm

(ii) Areal Rainfall

Areal reduction factor for TD= 4 hrs corresponding to catchment
area 188 km2 was interpotated from Annexure 4.4 = **0.8065**
100 yr 4 hrs areal rainfall = 13.6x0.806508 = **10.97** cms

(5) Time distribution of Areal Rainfall

Loss rate considered = **0.10** cm/hr

For 1 in 100 yr return period flood

100 yr 4 hrs areal rainfall = 10.97 cms was distributed with the distribution coefficient corresponding to 4

Hourly Rainfall Increment

Sr.No.	Duration t (hrs)	Distribution Coefficient	Storm Rainfall (cm)	1-hr rainfall increment (cm)	1-hr rainfall excess (deducting loss of 0.10 cm/hr (cm)
1	1	0.67	7.35	7.35	7.25
2	2	0.86	9.43	2.08	1.98
3	3	0.96	10.53	1.10	1.00
4	4	1.00	10.97	0.44	0.34

Computation of 1 in 100yr flood: (Peak only)

Time (hrs)	U.G (m^3/sec)	R.F excess in design order	Direct Runoff (cumecs)
3	76.2	1.00	76.19
4	100.4	7.25	727.84
5	79.3	1.98	156.94
6	64.4	0.34	21.89
Sum=	**320.2**		**982.86**

1 in 100 yr flood.

= Sum of direct runoff + Base flow

= 982.86 + 9.4

= **992.26 cumecs** **Say 993 cumecs**

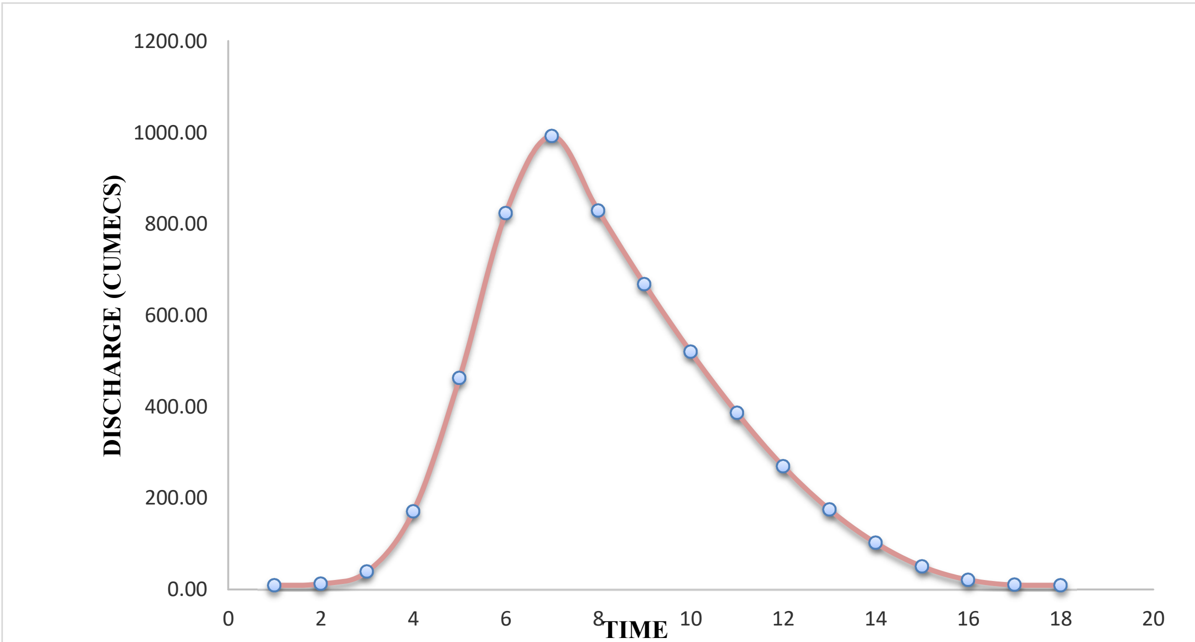
= **35068 cusecs**

Computation of Design Flood Peak hydrograph (1 in 100 Year)

ated Peak

Synthetic U.G. Ordinates	Hourly rainfall excess in cm				Total (Cumecs)	Base Flow (Cumecs)	Total (Cumecs)	Remarks
	0.34	**1.98**	**7.25**	**1.00**				
	9	**10**	**11**	**12**				
0.0	0.00				0.00	9.40	9.40	
8.9	3.04	0.00			3.04	9.40	12.44	
35.7	12.15	17.69	0.00		29.84	9.40	39.24	
76.2	25.90	70.78	64.79	0.00	161.47	9.40	170.87	
100.4	34.13	150.85	259.16	8.94	453.08	9.40	462.48	
79.3	26.95	198.78	552.36	35.75	813.84	9.40	823.24	
64.4	21.89	156.94	727.84	76.19	982.86	9.40	992.26	**Peak Flood**
50.2	17.07	127.48	574.65	100.39	819.59	9.40	828.99	
37.2	12.65	99.41	466.77	79.26	658.09	9.40	667.49	
25.8	8.78	73.65	364.01	64.38	510.82	9.40	520.22	
16.5	5.62	51.15	269.68	50.21	376.66	9.40	386.06	
9.3	3.16	32.73	187.28	37.20	260.37	9.40	269.77	
4.1	1.41	18.41	119.86	25.83	165.51	9.40	174.91	
1.0	0.35	8.18	67.42	16.53	92.48	9.40	101.88	
0.0	0.00	2.05	29.96	9.30	41.31	9.40	50.71	
		0.00	7.49	4.13	11.62	9.40	21.02	
			0.00	1.03	1.03	9.40	10.43	
				0.00	0.00	9.40	9.40	
							992.26	Cumecs

FLOOD HYDROGRAPH FOR MUTHA RIVER



MULA CATCHMENT AREA FROM CONFLUENCE OF PAWNA RIVER TO MUTHA RIVER SANGAM ISOHYTE OF 107mm

FLOOD ESTIMATION REPORT FOR KRISHNA AND PENNAR (SUB-ZONE-3h) BY CWC

MULA MUTHA RIVERFRONT DEVELOPMENT

Project:	**Mula Mutha Riverfront Development**		
River:	Mula	longitude	73^0 75' 08"
City	Pune	latitide	18^0 55' 91"

Table for Computation of Eqivalent slope(S)

C.A. **67.5** km^2

'Datum =Reduced level of river bed = **483** m

TABLE-1

Sr No.	Reduced distance starting (km)	Reduced levels of river bed (m)	Length of each segment Li (km)	Height above datum(Di)= difference between the datum & its R.L. (m)	Di-1 + Di (m)	Li * (Di-1 + Di) (km * m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	483	0.00	0	0	0
2	11.10	485	11.10	2	2	22.2
Total			**11.10**			**22.2**

$$\text{Eq. Slope} = \frac{\text{sum of (Li*(Di-1 + Di)}}{L^2}$$

= **0.18** m/km

From plate no 11 , 100 yr point rainfall from sub zone 3h manual = **10.7** cms

i) Name & number of subzone	**Lower Ganga Sub Zone -3(h).**
ii) Name of Project	**MulaMutha RiverFront**
iii) Name of Tributary/River	**Mula**
iv) Site location	longitude 730 75' 08" latitide 180 55' 91"

Estimation of flood using procedure as recommended in flood estimation report for Krishna & Pennar(SubZone- 3 h) published by Director of 'Hydrology(Small Catchment) CWC New Delhi (September-2000).

Data

C.A. (A)	(Catchment Area up to the project site in km^2)	**67.5** km^2	
Length(L)	(Length of Main Stream from farthest point to dam site)	**11.1** km	
Slope S	(Equivalent stream slope of main stream in m/km)	**0.18** m/km	(Table - 1)
C.G. (Lc)	(Length of Longest stream from a point oppposite to C.G)	**6.20** km	

(1) Determination of synthetic 1 hr U.G.Parameters

(i) tp= $0.325(LLc/Sqrt(s))^{-0.447}$ (Time to peak less half of unit duration)

$= 0.325 \times (11.10 \times 6.20 / sqrt(0.18))^{0.447}$ = **3.1** hrs

tp adopted= **3.5** hrs

(ii) $q_P = 0.996(t_P)^{-0.497}$ (Peak discharge per km^2)

$= 0.996 \times (3.50)^{-0.497}$

= 0.534 cumecs/km^2

(iii) $T_B = 7.392(t_p)^{0.524}$ (Base period of hydrograph)

$= 7.392^* (3.500)^{0.524}$

= 14.251

= 14 hrs

(iv) Q_p = $q_p \times A$ (Peak Discharge of Unit Hydrograph in cumecs)

= 0.534x67.5

= 36.045 cumecs

(v) W_{50} = $2.389(q_p)^{-1.065}$ (Width of U.G. measured at 50% of maximum Discharge)

= $2.389 \times (0.534)^{-1.065}$

= 4.66 hrs Ordinate(Qp) in hrs)

(vi) W_{75} = $1.415\ (q_p)^{-1.067}$ (Width of U.G. measured at 75%of maximum Discharge

= $1.415 \times (0.534)^{-1.067}$

= 2.76 hrs Ordinate (Qp) in hrs)

(vii) W_{R50} = $0.753 \times (q_p)^{-1.229}$ (Width of rising side of U.G. measured at 50% of maximum

= $0.753 \times (0.534)^{-1.229}$ Discharge (Qp) in hrs)

= 1.63 hrs

(viii) W_{R75} = $0.558 \times (q_p)^{-1.088}$

= $0.558 \times (0.534)^{-1.088}$ (Width of rising side of U.G. measured at 75% of maximum

= 1.10 hrs Discharge (Qp) in hours)

(ix) Computation of Design base flow:

Q_B = $A \times q_b$ (Base Flow)

= 67.5x0.05

3.38 cumecs

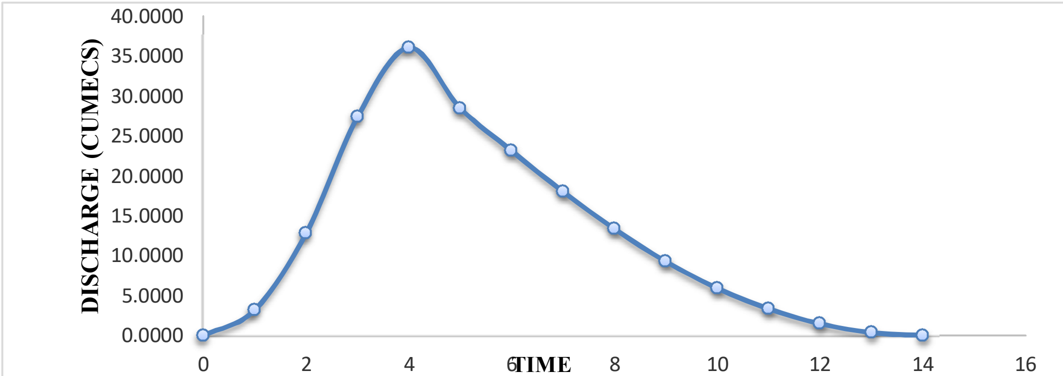
(x) T_m = $t_p + tr/2$

= 3.50+1/2

= 4.00 hrs

(2) Drawing of synthatic unit hydrograph

Estimated parameters of U.G.at Plate No.I are plotted to scale on Graph paper as shown in figure and smoothened



(3) Estimaton of design storm duration

The design storm duration $T_{DS}= T_m$ hrs = **4** hrs

(4) Estimation of Point rainfall and Areal Rainfall

(I) Point Rainfall

The catchment was located on Plate-10 (Ref C.W.C.Report-Sub Zone-3(h))
showing 100 yr point rainfall = **10.7** cms
Conversion factor of 100 yr 24 hr point rainfall to 100 yr 4 hr point rainfall
is read from fig-10 section 4.2 = **0.680**
100 yr 4 hrs point rainfall = 10.7 x 0.68 = **7.276** cm

(ii) Areal Rainfall

Areal reduction factor for TD= 4 hrs corresponding to catchment
area 68 km2 was interpotated from Annexure 4.4 = **0.9062**
100 yr 4 hrs areal rainfall = 7.276x0.906155 = **6.59** cms

(5) Time distribution of Areal Rainfall

Loss rate considered = **0.10** cm/hr

For 1 in 100 yr return period flood

100 yr 4 hrs areal rainfall = 6.59 cms was distributed with the distribution coefficient corresponding to 4

Hourly Rainfall Increment

Sr.No.	Duration t (hrs)	Distribution Coefficient	Storm Rainfall (cm)	1-hr rainfall increment (cm)	1-hr rainfall excess (deducting loss of 0.10 cm/hr (cm)
1	1	0.67	4.42	4.42	4.32
2	2	0.86	5.67	1.25	1.15
3	3	0.96	6.33	0.66	0.56
4	4	1.00	6.59	0.26	0.16

Computation of 1 in 100yr flood: (Peak only)

Time (hrs)	U.G (m^3/sec)	R.F excess in design order	Direct Runoff (cumecs)
3	27.4	0.56	15.32
4	36.0	4.32	155.71
5	28.5	1.15	32.73
6	23.1	0.16	3.70
Sum=	**115.0**		**207.46**

1 in 100 yr flood.

= Sum of direct runoff + Base flow

= 207.46 + 3.38

= **210.84 cumecs** **Say** **211** **cumecs**

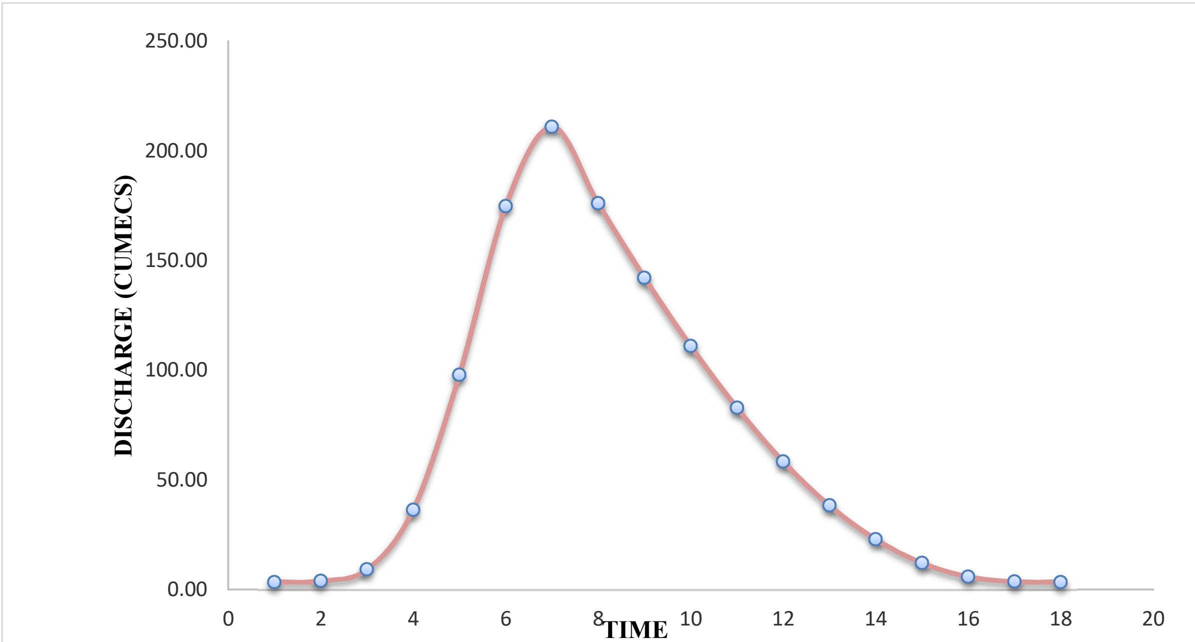
= **7452** **cusecs**

Computation of Design Flood Peak hydrograph

ated Peak Flood

Synthetic U.G. Ordinates	0.16	1.15	4.32	0.56	Total (Cumecs)	Base Flow (Cumecs)	Total (Cumecs)	Remarks
	7	8	9	10				
0.0	0.00				0.00	3.38	3.38	
3.2	0.51	0.00			0.51	3.38	3.89	
12.8	2.05	3.69	0.00		5.74	3.38	9.12	
27.4	4.38	14.76	13.86	0.00	33.00	3.38	36.38	
36.0	5.77	31.46	55.44	1.80	94.47	3.38	97.85	
28.5	4.55	41.45	118.17	7.19	171.36	3.38	174.74	
23.1	3.70	32.73	155.71	15.32	207.46	3.38	210.84	**Peak Flood**
18.0	2.88	26.58	122.94	20.19	172.59	3.38	175.97	
13.4	2.14	20.73	99.86	15.94	138.67	3.38	142.05	
9.3	1.48	15.36	77.88	12.94	107.66	3.38	111.04	
5.9	0.95	10.67	57.69	10.10	79.41	3.38	82.79	
3.3	0.53	6.83	40.07	7.48	54.91	3.38	58.29	
1.5	0.24	3.84	25.64	5.19	34.91	3.38	38.29	
0.4	0.06	1.71	14.42	3.32	19.51	3.38	22.89	
0.0	0.00	0.43	6.41	1.87	8.71	3.38	12.09	
		0.00	1.60	0.83	2.43	3.38	5.81	
			0.00	0.21	0.21	3.38	3.59	
				0.00	0.00	3.38	3.38	
							210.84	Cumecs

FLOOD HYDROGRAPH OF MULA RIVER FOR SUBZONE METHOD



MULA CATCHMENT AREA UPTO CONFLUENCE OF PAWNA RIVER AFTER DEDUCTING MULSHI DAM CATCHMENT ISOHYTE OF 107mm

FLOOD ESTIMATION REPORT FOR KRISHNA AND PENNAR (SUB-ZONE-3h) BY CWC

MULA MUTHA RIVERFRONT DEVELOPMENT

Project:	**Mula Mutha Riverfront Development**		
River:	Mula	longitude	73^0 75' 08"
City	Pune	latitide	18^0 55' 91"

Table for Computation of Eqivalent slope(S)

C.A. **480.85** km^2

'Datum =Reduced level of river bed = **483** m

TABLE-1

Sr No.	Reduced distance starting (km)	Reduced levels of river bed (m)	Length of each segment Li (km)	Height above datum(Di)= difference between the datum & its R.L. (m)	Di-1 + Di (m)	Li * (Di-1 + Di) (km * m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	483	0.00	0	0	0
2	11.65	485	11.65	2	2	23.302
3	21.02	490	9.37	7	9	84.348
4	30.56	495	9.541	12	19	181.279
5	44.27	500	13.708	17	29	397.532
6	45.94	520	1.667	37	54	90.018
Total			**45.94**			**776.479**

$$\text{Eq. Slope} = \frac{\text{sum of (Li*(Di-1 + Di)}}{L^2}$$

= **0.37** m/km

From plate no 11 , 100 yr point rainfall from sub zone 3h manual = **10.7** cms

i) Name & number of subzone	**Lower Ganga Sub Zone -3(h).**
ii) Name of Project	**MulaMutha RiverFront**
iii) Name of Tributary/River	**Mula**
iv) Site location	longitude 730 75' 08" latitide 180 55' 91"

Estimation of flood using procedure as recommended in flood estimation report for Krishna & Pennar(SubZone- 3 h) published by Director of 'Hydrology(Small Catchment) CWC New Delhi (September-2000).

Data

C.A. (A)	(Catchment Area up to the project site in km^2)	**480.85**	km^2	
Length(L)	(Length of Main Stream from farthest point to dam site)	**45.939**	km	
Slope S	(Equivalent stream slope of main stream in m/km)	**0.37**	m/km	(Table - 1)
C.G. (Lc)	(Length of Longest stream from a point oppposite to C.G)	**27.48**	km	

(1) Determination of synthetic 1 hr U.G.Parameters

(i) tp= $0.325(LLc/Sqrt(s))^{-0.447}$ (Time to peak less half of unit duration)

= $0.325 \times (45.94 \times 27.48 / sqrt(0.37))^{0.447}$ = **9.8** hrs

tp adopted= **9.5** hrs

(ii) $q_{P} = 0.996(t_P)^{-0.497}$ (Peak discharge per km^2)

= $0.996 \times (9.50)^{-0.497}$

= 0.325 cumecs/km^2

(iii) $T_B = 7.392(t_p)^{0.524}$ (Base period of hydrograph)

= $7.392^* (9.500)^{0.524}$

= 24.049

= 24 hrs

(iv) Q_p= $q_p \times A$ (Peak Discharge of Unit Hydrograph in cumecs)

= 0.325x480.85

= 156.276 cumecs

(v) W_{50} = $2.389(q_p)^{-1.065}$ (Width of U.G. measured at 50% of maximum Discharge)

= $2.389 \times (0.325)^{-1.065}$

= 7.91 hrs Ordinate(Qp) in hrs)

(vi) W_{75} = $1.415\ (q_p)^{-1.067}$ (Width of U.G. measured at 75%of maximum Discharge

= $1.415 \times (0.325)^{-1.067}$

= 4.69 hrs Ordinate (Qp) in hrs)

(vii)W_{R50} = $0.753 \times (q_p)^{-1.229}$ (Width of rising side of U.G. measured at 50% of maximum Discharge (Qp) in hrs)

= $0.753 \times (0.325)^{-1.229}$

= 3 hrs

(viii)W_{R75} = $0.558 \times (q_p)^{-1.088}$

= $0.558 \times (0.325)^{-1.088}$ (Width of rising side of U.G. measured at 75% of maximum Discharge (Qp) in hours)

= 1.90 hrs

(ix) Computation of Design base flow:

Q_B = $A \times q_b$ (Base Flow)

= 480.85x0.05

24.04 cumecs

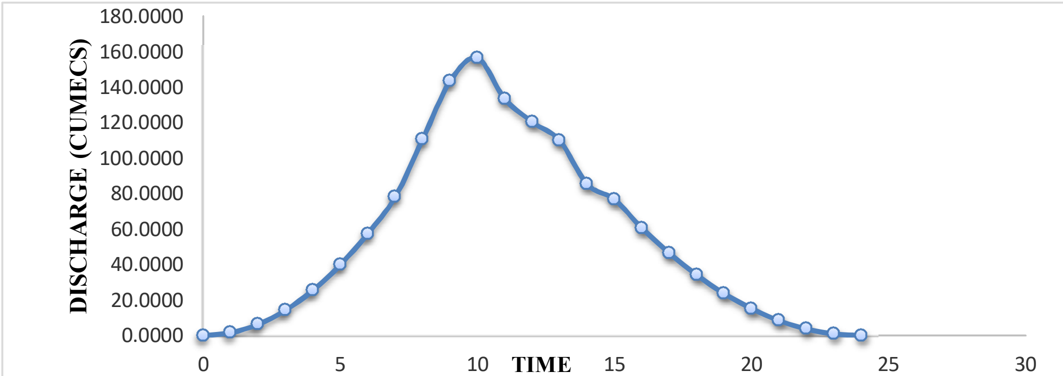
(x) T_m = $t_p + tr/2$

= 9.50+1/2

= 10.00 hrs

(2) Drawing of synthatic unit hydrograph

Estimated parameters of U.G.at Plate No.I are plotted to scale on Graph paper as shown in figure and smoothened



(3) Estimaton of design storm duration

The design storm duration T_{DS}= T_m hrs = **10** hrs

(4) Estimation of Point rainfall and Areal Rainfall

(I) Point Rainfall

The catchment was located on Plate-10 (Ref C.W.C.Report-Sub Zone-3(h))
showing 100 yr point rainfall = **10.7** cms
Conversion factor of 100 yr 24 hr point rainfall to 100 yr 10 hr point rainfall
is read from fig-10 section 4.2 = **0.810**
100 yr 10 hrs point rainfall = 10.7 x 0.81 = **8.667** cm

(ii) Areal Rainfall

Areal reduction factor for TD= 10 hrs corresponding to catchment
area 481 km2 was interpotated from Annexure 4.4 = **0.7816**
100 yr 10 hrs areal rainfall = 8.667x0.7816364 = **6.77** cms

(5) Time distribution of Areal Rainfall

Loss rate considered = **0.10** cm/hr

For 1 in 100 yr return period flood

100 yr 10 hrs areal rainfall = 6.77 cms was distributed with the distribution coefficient corresponding to 10

Hourly Rainfall Increment

Sr.No.	Duration t (hrs)	Distribution Coefficient	Storm Rainfall (cm)	1-hr rainfall increment (cm)	1-hr rainfall excess (deducting loss of 0.10 cm/hr (cm)
1	1	0.37	2.51	2.51	2.41
2	2	0.55	3.73	1.22	1.12
3	3	0.67	4.54	0.81	0.71
4	4	0.75	5.08	0.54	0.44
5	5	0.81	5.49	0.41	0.31
6	6	0.86	5.83	0.34	0.24
7	7	0.91	6.16	0.33	0.23
8	8	0.95	6.44	0.28	0.18
9	9	0.98	6.64	0.20	0.10
10	10	1.00	6.77	0.13	0.03

Computation of 1 in 100yr flood: (Peak only)

Time (hrs)	U.G (m^3/sec)	R.F excess in design order	Direct Runoff (cumecs)
7	78.1	0.18	14.06
8	110.4	0.31	34.23
9	143.4	1.12	160.56
10	156.3	2.41	376.63
11	133.3	0.71	94.63
12	120.3	0.44	52.95
13	109.9	0.24	26.36
14	85.3	0.23	19.63
15	76.6	0.10	7.66
16	60.5	0.03	1.82
Sum=	**1074.1**		**788.53**

1 in 100 yr flood.

= Sum of direct runoff + Base flow

= 788.53 + 24.04

= **812.57 cumecs** **Say 813 cumecs**

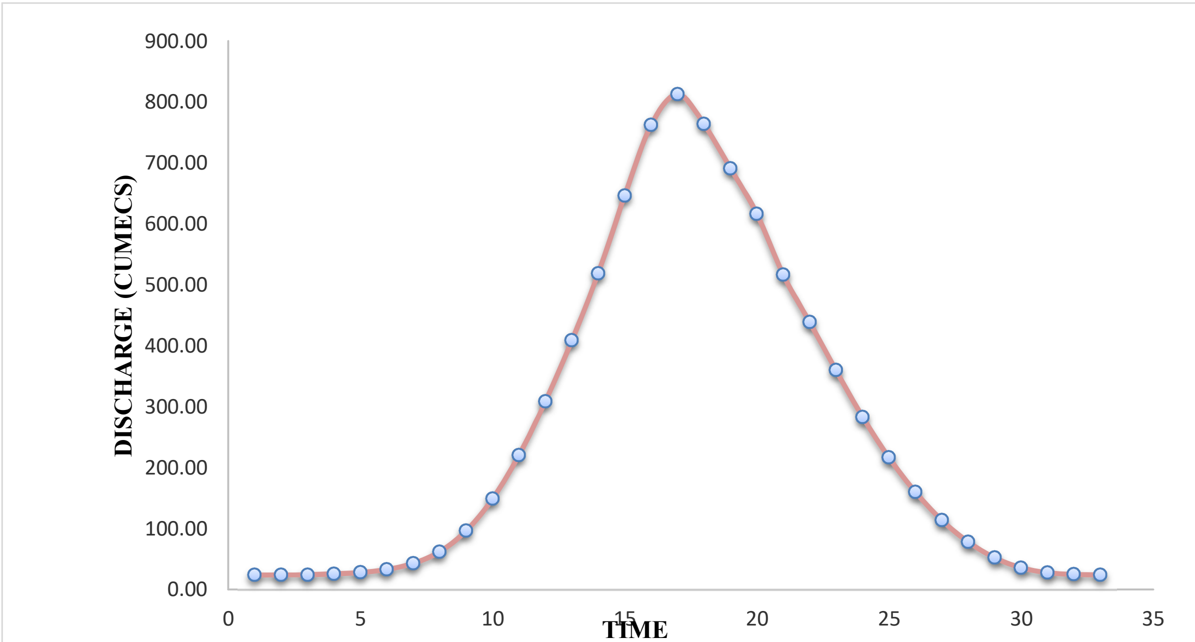
= **28712 cusecs**

Computation of Design Flood Peak hydrograph

alculated Peak Floc 812.57 cumecs

Synthetic											Total	Base	Total	Remarks
U.G.	0.03	0.10	0.23	0.24	0.44	0.71	2.41	1.12	0.31	0.18		Flow		
Ordinates	1	2	3	4	5	6	7	8	9	10	(Cumecs)	(Cumecs)	(Cumecs)	
0.0	0.00										0.00	24.04	24.04	
1.6	0.05	0.00									0.05	24.04	24.09	
6.4	0.19	0.16	0.00								0.35	24.04	24.39	
14.4	0.43	0.64	0.37	0.00							1.44	24.04	25.48	
25.5	0.77	1.44	1.47	0.38	0.00						4.06	24.04	28.10	
39.9	1.20	2.55	3.30	1.53	0.70	0.00					9.28	24.04	33.32	
57.4	1.72	3.99	5.87	3.44	2.81	1.13	0.00				18.96	24.04	43.00	
78.1	2.34	5.74	9.17	6.12	6.31	4.53	3.84	0.00			38.05	24.04	62.09	
110.4	3.31	7.81	13.20	9.57	11.23	10.19	15.37	1.79	0.00		72.47	24.04	96.51	
143.4	4.30	11.04	17.97	13.78	17.54	18.12	34.59	7.14	0.49	0.00	124.97	24.04	149.01	
156.3	4.69	14.34	25.40	18.75	25.26	28.31	61.49	16.07	1.98	0.29	196.58	24.04	220.62	
133.3	4.00	15.63	32.97	26.50	34.38	40.76	96.08	28.58	4.45	1.15	284.50	24.04	308.54	
120.3	3.61	13.33	35.94	34.41	48.59	55.48	138.35	44.65	7.91	2.58	384.85	24.04	408.89	
109.9	3.30	12.03	30.66	37.51	63.08	78.40	188.31	64.30	12.36	4.59	494.54	24.04	518.58	
85.3	2.56	10.99	27.68	31.99	68.76	101.79	266.13	87.51	17.80	7.18	622.39	24.04	646.43	
76.6	2.30	8.53	25.27	28.88	58.65	110.96	345.50	123.68	24.22	10.33	738.32	24.04	762.36	
60.5	1.82	7.66	19.63	26.36	52.95	94.63	376.63	160.56	34.23	14.06	788.53	24.04	812.57	**Peak Flood**
46.3	1.39	6.05	17.62	20.48	48.33	85.44	321.23	175.03	44.44	19.88	739.89	24.04	763.93	
34.0	1.02	4.63	13.92	18.38	37.55	77.99	290.02	149.28	48.45	25.80	667.04	24.04	691.08	
23.6	0.71	3.40	10.66	14.53	33.70	60.59	264.74	134.78	41.32	28.13	592.56	24.04	616.60	
15.1	0.45	2.36	7.83	11.12	26.63	54.38	205.66	123.03	37.31	23.99	492.76	24.04	516.80	
8.5	0.26	1.51	5.44	8.17	20.39	42.97	184.60	95.58	34.05	21.66	414.63	24.04	438.67	
3.8	0.11	0.85	3.48	5.67	14.98	32.90	145.86	85.79	26.45	19.77	335.86	24.04	359.90	
0.9	0.03	0.38	1.96	3.63	10.40	24.17	111.67	67.78	23.75	15.36	259.13	24.04	283.17	
0.0	0.00	0.09	0.87	2.04	6.66	16.79	82.05	51.90	18.76	13.79	192.95	24.04	216.99	
		0.00	0.22	0.91	3.74	10.74	56.98	38.13	14.36	10.89	135.97	24.04	160.01	
			0.00	0.23	1.66	6.04	36.46	26.48	10.55	8.34	89.76	24.04	113.80	
				0.00	0.42	2.69	20.51	16.95	7.33	6.13	54.03	24.04	78.07	
				0.00	0.00	0.67	9.12	9.53	4.69	4.26	28.27	24.04	52.31	
						0.00	2.28	4.24	2.64	2.72	11.88	24.04	35.92	
							0.00	1.06	1.17	1.53	3.76	24.04	27.80	
								0.00	0.29	0.68	0.97	24.04	25.01	
									0.00	0.17	0.17	24.04	24.21	
										0.00	0.00	24.04	24.04	
													812.57	Cumecs

FLOOD HYDROGRAPH FOR MULA RIVER FOR SUBZONE METHOD



PAWNA CATCHMENT AREA AFTER DEDUCTING PAWNA DAM CATCHMENT ISOHYTE OF 107mm

FLOOD ESTIMATION REPORT FOR KRISHNA AND PENNAR (SUB-ZONE-3h) BY CWC
MULA MUTHA RIVERFRONT DEVELOPMENT

Project:	**Mula Mutha Riverfront Development**		
River:	Pawna	longitude	73^0 83' 33"
City	Pune	latitide	18^0 56' 66"

Table for Computation of Eqivalent slope(S)

C.A. **384.5** km^2

'Datum =Reduced level of river bed = **484** m

TABLE-1

Sr No.	Reduced distance starting (km)	Reduced levels of river bed (m)	Length of each segment Li (km)	Height above datum(Di)= difference between the datum & its R.L. (m)	Di-1 + Di (m)	Li * (Di-1 + Di) (km * m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.00	484	0.00	0	0	0
2	4.85	485	4.85	1	1	4.85
3	9.90	490	5.05	6	7	35.343
4	19.01	495	9.11	11	17	154.87
5	30.49	500	11.48	16	27	309.96
6	54.97	520	24.48	36	52	1272.96
Total			**54.97**			**1777.983**

$$\text{Eq. Slope} = \frac{\text{sum of } (Li*(Di\text{-}1 + Di)}{L^2}$$

= **0.59** m/km

From plate no 11 , 100 yr point rainfall from sub zone 3h manual = **10.7** cms

I) Name & number of subzone	**Lower Ganga Sub Zone -3(h).**
ii) Name of Project	**MulaMutha RiverFront**
iii) Name of Tributary/River	**PAWNA**
iv) Site location	longitude 730 83' 33"
	latitide 180 56' 66"

Estimation of flood using procedure as recommended in flood estimation report for Krishna & Pennar(SubZone- 3 h) published by Director of 'Hydrology(Small Catchment) CWC New Delhi (September-2000).

Data

C.A. (A)	(Catchment Area up to the project site in km^2)	**384.5** km^2	
Length(L)	(Length of Main Stream from farthest point to dam site)	**54.969** km	
Slope S	(Equivalent stream slope of main stream in m/km)	**0.59** m/km	(Table - 1)
C.G. (Lc)	(Length of Longest stream from a point oppposite to C.G)	**20.20** km	

(1) Determination of synthetic 1 hr U.G.Parameters

(i) tp= $0.325(LLc/Sqrt(s))^{-0.447}$ (Time to peak less half of unit duration)

$= 0.325 \times (54.97 \times 20.20 / sqrt(0.59))^{0.447}$ = **8.4** hrs

tp adopted= **8.5** hrs

(ii) $q_{p} = 0.996(t_P)^{-0.497}$ (Peak discharge per km^2)

$= 0.996 \times (8.50)^{-0.497}$

= 0.344 $cumecs/km^2$

(iii) $T_B = 7.392(t_p)^{0.524}$ (Base period of hydrograph)

$= 7.392 * (8.500)^{0.524}$

= 22.687

= 23 hrs

(iv) Q_p= q_p x A (Peak Discharge of Unit Hydrograph in cumecs)

= 0.344x384.5

= 132.268 cumecs

(v) W_{50} = $2.389(q_p)^{\wedge -1.065}$ (Width of U.G. measured at 50% of maximum Discharge)

= $2.389 \times (0.344)^{-1.065}$

= 7.44 hrs Ordinate(Qp) in hrs)

(vi) W_{75} = $1.415\ (q_p)^{-1.067}$ (Width of U.G. measured at 75%of maximum Discharge

= $1.415 \times (0.344)^{-1.067}$

= 4.42 hrs Ordinate (Qp) in hrs)

(vii)W_{R50} = $0.753 \times (q_p)^{-1.229}$ (Width of rising side of U.G. measured at 50% of maximum

= $0.753 \times (0.344)^{-1.229}$ Discharge (Qp) in hrs)

= 2.79 hrs

(viii)W_{R75} = $0.558 \times (q_p)^{-1.088}$

= $0.558 \times (0.344)^{-1.088}$ (Width of rising side of U.G. measured at 75% of maximum

= 1.78 hrs Discharge (Qp) in hours)

(ix) Computation of Design base flow:

Q_B = A x q_b (Base Flow)

= 384.5x0.05

19.23 cumecs

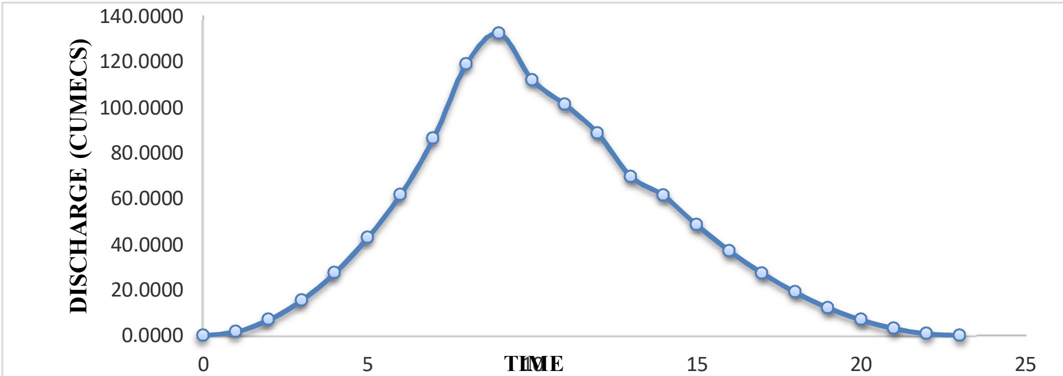
(x) T_m = t_p + tr/2

= 8.50+1/2

= 9.00 hrs

(2) Drawing of synthatic unit hydrograph

Estimated parameters of U.G.at Plate No.I are plotted to scale on Graph paper as shown in figure and smoothened



(3) Estimaton of design storm duration

The design storm duration T_{DS}= T_m hrs = **9** hrs

(4) Estimation of Point rainfall and Areal Rainfall

(I) Point Rainfall

The catchment was located on Plate-10 (Ref C.W.C.Report-Sub Zone-3(h))
showing 100 yr point rainfall = **10.7** cms
Conversion factor of 100 yr 24 hr point rainfall to 100 yr 9 hr point rainfall
is read from fig-10 section 4.2 = **0.750**
100 yr 9 hrs point rainfall = 10.7 x 0.75 = **8.025** cm

(ii) Areal Rainfall

Areal reduction factor for TD= 9 hrs corresponding to catchment
area 385 km2 was interpotated from Annexure 4.4 = **0.7914**
100 yr 9 hrs areal rainfall = 8.025x0.791375 = **6.35** cms

(5) Time distribution of Areal Rainfall

Loss rate considered = **0.10** cm/hr

For 1 in 100 yr return period flood

100 yr 9 hrs areal rainfall = 6.35 cms was distributed with the distribution coefficient corresponding to 9

Hourly Rainfall Increment

Sr.No.	Duration t (hrs)	Distribution Coefficient	Storm Rainfall (cm)	1-hr rainfall increment (cm)	1-hr rainfall excess (deducting loss of 0.10 cm/hr (cm)
1	1	0.39	2.48	2.48	2.38
2	2	0.57	3.62	1.14	1.04
3	3	0.70	4.45	0.83	0.73
4	4	0.78	4.95	0.50	0.40
5	5	0.84	5.33	0.38	0.28
6	6	0.89	5.65	0.32	0.22
7	7	0.94	5.97	0.32	0.22
8	8	0.97	6.16	0.19	0.09
9	9	1.00	6.35	0.19	0.09

Computation of 1 in 100yr flood: (Peak only)

Time (hrs)	U.G (m^3/sec)	R.F excess in design order	Direct Runoff (cumecs)
6	61.7	0.09	5.56
7	86.4	0.22	19.00
8	118.9	1.04	123.68
9	132.3	2.38	314.80
10	112.0	0.73	81.73
11	101.1	0.40	40.46
12	88.4	0.22	19.45
13	69.6	0.22	15.31
14	61.3	0.09	5.51
Sum=	**831.7**		**625.50**

1 in 100 yr flood.

= Sum of direct runoff + Base flow

= 625.5 + 19.23

= **644.73 cumecs** **Say** **645** **cumecs**

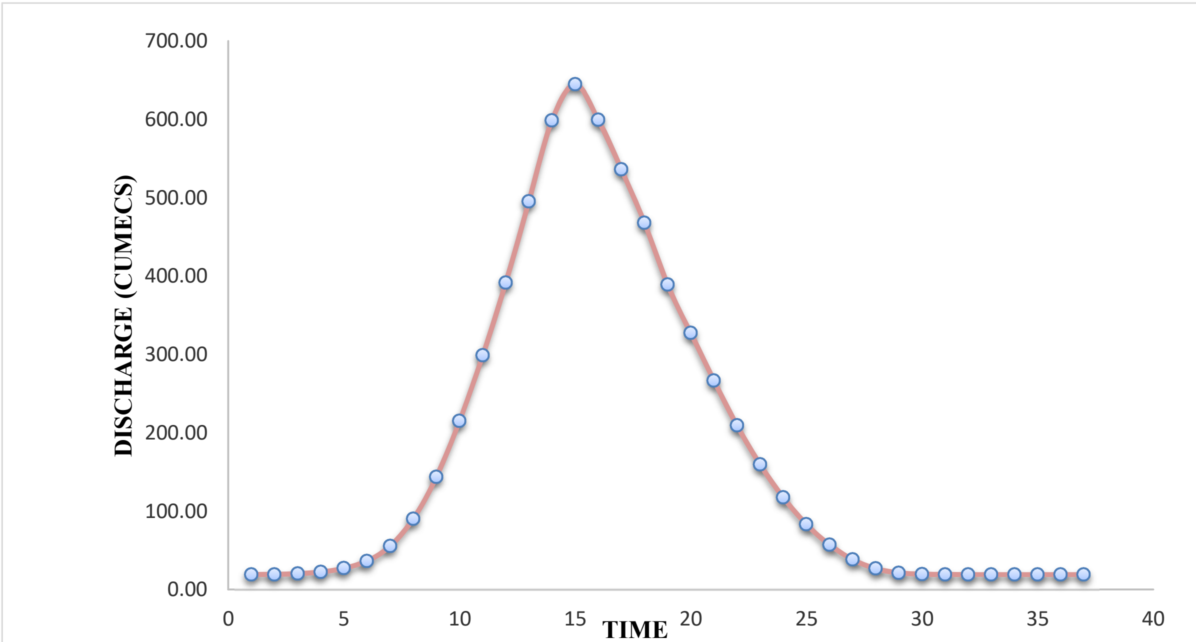
= **22779** **cusecs**

Computation of Design Flood Peak hydrograph

Calculated Peak Flood

Synthetic U.G. Ordinates	0.09	0.22	0.22	0.40	0.73	2.38	1.04	0.22	0.09	Total (Cumecs)	Base Flow (Cumecs)	Total (Cumecs)	Remarks
	4	5	6	7	8	9	10	11	12				
0.0	0.00									0.00	19.23	19.23	
1.7	0.15	0.00								0.15	19.23	19.38	
6.9	0.62	0.38	0.00							1.00	19.23	20.23	
15.4	1.39	1.51	0.38	0.00						3.28	19.23	22.51	
27.4	2.47	3.40	1.51	0.69	0.00					8.07	19.23	27.30	
42.9	3.86	6.04	3.40	2.74	1.25	0.00				17.29	19.23	36.52	
61.7	5.56	9.43	6.04	6.17	5.01	4.08	0.00			36.29	19.23	55.52	
86.4	7.77	13.58	9.43	10.98	11.27	16.33	1.78	0.00		71.14	19.23	90.37	
118.9	10.70	19.00	13.58	17.15	20.03	36.73	7.13	0.38	0.00	124.70	19.23	143.93	
132.3	11.90	26.16	19.00	24.69	31.30	65.30	16.05	1.51	0.15	196.06	19.23	215.29	
112.0	10.08	29.10	26.16	34.55	45.07	102.04	28.54	3.40	0.62	279.56	19.23	298.79	
101.1	9.10	24.63	29.10	47.57	63.05	146.93	44.59	6.04	1.39	372.40	19.23	391.63	
88.4	7.96	22.25	24.63	52.91	86.81	205.55	64.21	9.43	2.47	476.22	19.23	495.45	
69.6	6.26	19.45	22.25	44.78	96.56	283.04	89.82	13.58	3.86	579.60	19.23	598.83	
61.3	5.51	15.31	19.45	40.46	81.73	314.80	123.68	19.00	5.56	625.50	19.23	644.73	**Peak Flood**
48.4	4.36	13.48	15.31	35.37	73.84	266.47	137.56	26.16	7.77	580.32	19.23	599.55	
37.1	3.34	10.65	13.48	27.84	64.54	240.72	116.44	29.10	10.70	516.81	19.23	536.04	
27.2	2.45	8.15	10.65	24.51	50.80	210.43	105.19	24.63	11.90	448.71	19.23	467.94	
18.9	1.70	5.99	8.15	19.37	44.73	165.63	91.95	22.25	10.08	369.85	19.23	389.08	
12.1	1.09	4.16	5.99	14.83	35.34	145.84	72.38	19.45	9.10	308.18	19.23	327.41	
6.8	0.61	2.66	4.16	10.89	27.06	115.23	63.73	15.31	7.96	247.61	19.23	266.84	
3.0	0.27	1.50	2.66	7.56	19.88	88.22	50.35	13.48	6.26	190.18	19.23	209.41	
0.8	0.07	0.67	1.50	4.84	13.81	64.82	38.55	10.65	5.51	140.42	19.23	159.65	
0.0	0.00	0.17	0.67	2.72	8.84	45.01	28.32	8.15	4.36	98.24	19.23	117.47	
		0.00	0.17	1.21	4.97	28.81	19.67	5.99	3.34	64.16	19.23	83.39	
		0.00	0.00	0.30	2.21	16.20	12.59	4.16	2.45	37.91	19.23	57.14	
		0.00	0.00	0.00	0.55	7.20	7.08	2.66	1.70	19.19	19.23	38.42	
			0.00	0.00	0.00	1.80	3.15	1.50	1.09	7.54	19.23	26.77	
				0.00	0.00	0.00	0.79	0.67	0.61	2.07	19.23	21.30	
					0.00	0.00	0.00	0.17	0.27	0.44	19.23	19.67	
						0.00	0.00	0.00	0.07	0.07	19.23	19.30	
							0.00	0.00	0.00	0.00	19.23	19.23	
								0.00	0.00	0.00	19.23	19.23	
									0.00	0.00	19.23	19.23	
										0.00	19.23	19.23	
										0.00	19.23	19.23	
										0.00	19.23	19.23	
												644.73	Cumecs

FLOOD HYDROGRAPH FOR PAUNA RIVER



ANNEXURE V

MAXIMUM SPILLWAY DISCHARGE FROM PAWNA DAM				
Year	DATA 1		DATA 2	
	Maximum Spillway in cusecs	Maximum Spillway in cumecs	Maximum Spillway in cusecs	Maximum Spillway in cumecs
1990	4800	136.05		
1991	2760	78.23		
1992	Nill			
1993	1436	40.70		
1994	3393	96.17		
1995	Nill			
1996	2430	68.88		
1997	1306	37.02		
1998	Nill			
1999	842	23.87		
2000	1400	39.68		
2001	1400	39.68		
2002	1398	39.63		
2003	3358	95.18		
2004	15101	428.03		
2005	19058	540.19	15280	433.11
2006	18572	526.42	13488	382.31
2007	11676	330.95	4326	122.62
2008	16325	462.73	14529	411.82
2009	Nill		0	
2010	1400	39.68	1444	40.93
2011	13694	388.15	8532	241.84
2012	Nill			
2013	8897	252.18		
2014	6020	170.63		
2015	Nill			
MAXIMUM	**19058**	**541**	**15280**	**434**

ANNEXURE VI

MAXIMUM SPILLWAY DISCHARGE FROM MULSHI DAM					
Year	**DATA 1**		**DATA 2**		
	Maximum Spillway in cusecs	**Maximum Spillway in cumecs**	**Maximum Spillway in cusecs**	**Maximum Spillway in cumecs**	**REMARKS**
1987	Nill				
1988	3677	104.22			
1989	Nill				
1990	42706	1,210.49			
1991	17171	486.71			
1992	15603				
1993	10542	298.81			
1994	36961	1,047.65			
1995	Nill				
1996	Nill				
1997	130146	3,688.95			SPILLWAY CAPACITY 1892 CUMECS
1998	Nill				
1999	Nill				
2000	Nill				
2001	Nill				
2002	Nill				
2003	Nill				
2004	25359.700	718.81			
2005	38420.600	1,089.02	38500	1,091.27	
2006	35844.7	1,016.01	20000	566.89	
2007	15388.5	436.18	3602	102.10	
2008	40605.1	1,150.94	35000	992.06	
2009	Nill		0		
2010	Nill		0		
2011	Nill		20000		
2012	10259.008	290.79	10000	283.45	
2013					
2014					
2015					
MAXIMUM	**130146**	**1090**	**38500**	**1092**	

ANNEXURE VII

MAXIMUM SPILLWAY DISCHARGE FROM KHADAKWASLA DAM				
Year	DATA 1		DATA 2	
	Maximum Spillway in cusecs	Maximum Spillway in cumecs	Maximum Spillway in cusecs	Maximum Spillway in cumecs
1996				
1997				
1998				
1999				
2000				
2001				
2002				
2003				
2004				
2005			46591	1,320.61
2006			47872	1,356.92
2007			21292	603.51
2008			18746	531.35
2009			11396	323.02
2010			2544	72.11
2011			26229	743.45
2012			3424	97.05
2013				
2014				
2015				
MAXIMUM			**47872**	**1357**

ANNEXURE VIII

COMPARITIVE STATEMENT OF VARIOUS FLOOD DISCHARGE CALCULATED FOR 100,50,25 YEAR RETURN PERIOD FLOOD

SR NO	PARTICULARS	SUB ZONE METHOD (CUMECS)	SCS METHOD (CUMECS)	FREQUENCY ANALYSIS BY GUMBLES METHOD (CUMECS)	IRRIGATION DEPARTMENT PUNE (CUMECS)	MAXIMUM FLOOD DISCHARGE FROM DAM AS PER AVAILABLE DATA (CUMECS)	FLOOD DISCHARGE OF BALANCE CATCHEMENT AFTER DEDUCTING DAM CATCHMENT (CUMECS) FOR 100 YEAR RETURN PERIOD FLOOD(CUMECS)	FLOOD DISCHARGE OF BALANCE CATCHEMENT AFTER DEDUCTING DAM CATCHMENT (CUMECS) FOR 25YEAR RETURN PERIOD FLOOD(CUMECS)	FLOOD DISCHARGE OF BALANCE CATCHEMENT AFTER DEDUCTING DAM CATCHMENT (CUMECS) FOR 50 YEAR RETURN PERIOD FLOOD(CUMECS)	TOTAL FLOOD DISCHARGE OF SPILLWAY OVERFLOW AND BALANCD CATCHMENT FOR 100 YEAR RETURN PERIOD FLOOD(CUMECS)	TOTAL FLOOD DISCHARGE OF SPILLWAY OVERFLOW AND BALANCD CATCHMENT FOR 25 YEAR RETURN PERIOD FLOOD(CUMECS)	TOTAL FLOOD DISCHARGE OF SPILLWAY OVERFLOW AND BALANCD CATCHMENT FOR 50 YEAR RETURN PERIOD FLOOD(CUMECS)
1	MULA RIVER UPTO CONFLUENCE OF PAWANA RIVER	2221	2868	-	1232 (UPTO BABASHAHEB AMBEDKAR BRIDGE) 1670 (UPTO CONFLUENC POINT WITH PAWANA RIVER)	1092 (FLOOD DISCHARGE OF YEAR 1997 IS NOT CONSIDERED AS ITS MORE THAN ACTUAL SPILLWAY CAPACITY OF MULSHI DAM)	1592	1173	1341	2684	2265	2433
2	PAWANA RIVER	1609	2064	-	2738	541	1261	929	1061	1802	1470	1602
3	MULA RIVER FROM CONFLUENCE OF PAWNA RIVER UPTO SANGAM WITH MUTHA RIVER						402	299	340			
4	MUTHA RIVER	2537	3497	-	2833	1357	993	739	840	2350	2096	2197
5	MULA - MUTHA RIVER UPTO PROJECT END REACH i.e. KT WEIR.	5073	6321	4872	4758							

ANNEXURE IX

FLOOD DISCHARGE CONSIDERED IN VARIOUS REACHES OF MULA MUTHA RIVERFRONT DEVELOPMENT

Sr No	PARTICULARS	MULA RIVER (CUMECS)	MUTHA RIVER (CUMECS)
1	FROM MULSHI DAM TO BABA SAHEB AMBEDKAR BRIDGE (MULA RIVER)	1232	1232
2	AMBEDKAR BRIDGE ON MULA RIVER TO CONFLUENCE OF PAWNA RIVER	1670	1670
3	PAWNA RIVER	2301	257
4	MULA RIVER FROM CONFLUENCE OF PAWNA RIVER UPTO SANGAM WITH MUTHA RIVER	3971	1927
5	MULA MUTHA RIVER	4762	4762
6	Mutha river upto confluence with sangam of Mula river	352	2835

ANNEXURE V

MAXIMUM SPILLWAY DISCHARGE FROM PAWNA DAM				
Year	**DATA 1**		**DATA 2**	
	Maximum Spillway in cusecs	**Maximum Spillway in cumecs**	**Maximum Spillway in cusecs**	**Maximum Spillway in cumecs**
1990	4800	136.05		
1991	2760	78.23		
1992	Nill			
1993	1436	40.70		
1994	3393	96.17		
1995	Nill			
1996	2430	68.88		
1997	1306	37.02		
1998	Nill			
1999	842	23.87		
2000	1400	39.68		
2001	1400	39.68		
2002	1398	39.63		
2003	3358	95.18		
2004	15101	428.03		
2005	19058	540.19	15280	433.11
2006	18572	526.42	13488	382.31
2007	11676	330.95	4326	122.62
2008	16325	462.73	14529	411.82
2009	Nill		0	
2010	1400	39.68	1444	40.93
2011	13694	388.15	8532	241.84
2012	Nill			
2013	8897	252.18		
2014	6020	170.63		
2015	Nill			
MAXIMUM	**19058**	**541**	**15280**	**434**

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Ministry of Water Resources, River Development & Ganga Rejuvenation
Central Water and Power Research Station
PO: Khadakwasla, Pune-411024

No. 520/RFD-PMC/2017/HMET/213/748

Dated: 06/04/2017
10 APR 2017

The Chief Engineer (Projects)
Pune Municipal Corporation
Savarkar Bhavan
Shivajinagar, Pune 411005

Sub: River Front Development of Mula, Mutha and Mula-Mutha River, Pune – reg.

Sir,

Please refer to PMC letter No. 4404 dated 08.12.2016 forwarding therewith the report on 'Riverfront Development of Mula, Mutha and Mula-Mutha River, Pune'. The matter was discussed with the PMC Officers along with the consultant M/s HCP Design, Planning and Management Pvt. Ltd, Ahmedabad on 15.03.17 and 30.03.17. It is noted that the consultant has proposed five barrages to create cascade of reservoirs/pools on Mula, Mutha and Mula-Mutha river stretches with provision of replenishment of evaporation and seepage losses by treated water from STPs. Such an arrangement would raise many environmental and health issues, and therefore, it is suggested to have wider stakeholder consultation on the proposal.

The consultant has adopted CWC Flood Estimation Reports (which were evolved primarily for ungauged catchments) for the fully regulated catchments of Pune due to existence of 4 dams on Mutha limb, 1 dam on Pavna and 1 dam on Mulshi (in addition to some water harvesting structures), which is not appropriate. Design floods and/or the releases from the dams subject to flood frequency analysis need to be accounted for along with in-between catchment flows in Flood Routing (FR) model. Further, occurrence of severe floods in the two limbs, i.e., Mula and Mutha needs to be studied with joint probability approach.

More than hydrology, broad parameters of the Project, such as river front development through cascade of reservoirs/pools, possibility of untreated sewage entering into such pool of water and their remediation, environmental and health effects, possible objection from downstream regions from diversion of sewage through interceptors, storm water drainage into river, effectiveness of STPs and availability of treated water to replenish reservoirs/pools, etc., are more vital and need to be frozen before checking hydrological calculations. It is, therefore, suggested that a Workshop with all stakeholders may be organized to finalize these broad parameters.

This issues with the approval of Director, CWPRS.

Yours faithfully,

C. Ramesh

(Dr. C. Ramesh)
Scientist-C

मुख्य अभियंता (प्रकल्प) कार्यालय
पुणे महानगरपालिका
आवक क्र. 3307 दिनांक 11/4/17

अ.नि.
Pl. discuss & SO

मुख्य अभियंता (प्रकल्प)
पुणे महानगरपालिका

HCP DESIGN, PLANNING & MANAGEMENT PVT. LTD.

PARITOSH, USMANPURA, AHMEDABAD 380 013, INDIA, PHONE: +91 79 27550875, 27552442, 27552563
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Our Ref: 15091/A1/23
Date: 12/05/2017

Mr. Srinivas Bonala
Chief Engineer (Projects),
Pune Municipal Corporation,
Third Floor,
Savarkar Udyog Bhavan,
Pune.

Sub: Hydrology and Hydraulics of Mula, Mutha & Mula - Mutha River, Pune for Riverfront Development Project.

Ref: 1) Submission of Hydrology and Draft Hydraulics Report with our letter no. 15091/A1/16 dated 12-09-2016

2) Meeting with CWPRS on 9 Jan, 2017.

3) Meeting with CPWRS on 13 Feb, 2017.

4) Email from HCPDPM to PMC/CWPRS.

5) Meeting with CPWRS on 9 March, 2017.

6) CWPRS letter No. 520/RFD-PMC/2017/HMET/213/748 received on 18 April, 2017.

Dear Sir,

This is regarding Hydrology and Hydraulics for Pune Riverfront and subsequent discussions and letter from CWPRS. Our para wise compliances to the CWPRS letter is as follows:-

1) Design Flood –

We would like to bring to your notice that we have already worked out peak discharge considering maximum overflow from the respective spillway dam plus balance catchment between dam and our proposed project reach and the same was in discussed the meeting on 13 Feb, 2017. An Additional Report incorporating dam discharge and balance catchment along with the calculations was also submitted on 8 March, 2017 and discussed on 9 March, 2017. The design flood adapted includes gauged discharge from the dams and ungauged discharge from the balance catchments. A copy of the email with additional report is attached herewith for your ready reference.

2) Untreated Sewage entering in the river –

We are hereby attaching our note the same for your review and further needful action.

Yours faithfully,

Pradip Kumar

Pradip Jadav
Senior Project Manager
For and on behalf of
HCP Design, Planning and Management Pvt. Ltd

Encl: 1) Copy of Email along with additional report
2) A note on untreated sewage entering in the river

Pune Riverfront Development Project

Brief note on Untreated Sewage entering in the river

Project Background

Pune lies on the western margin of the Deccan plateau, on the leeward side of the Sahyadri mountain range. The city is blessed with Mula and Mutha Rivers that originate in the Sahyadri ranges and traverse across Pune. The total length of the three rivers Mula, Mutha and Mula-Mutha traversing through Pune Municipal Corporation is approximately 44km. In order to cope up with these current issues and create a meaningful public realm along the river, the Pune Municipal Corporation has taken up the Riverfront Development Plan for all three rivers in entire Pune Municipal Corporation area along with Pimpri-Chinchwad Municipal Corporation.

Existing Conditions of River

Currently rivers in the Pune city are victims of neglect and disregard. With the fast pace of urbanization the quality of water in the rivers have also deteriorated drastically. The Pune Municipal Corporation has commenced work on comprehensive design of the Pune Riverfront Development Project. This project will prevent the environmental degradation of Pune’s Rivers, protect them from being choked by development, reduce the threat of flooding, create a public realm along the river and provide Pune with a vital riverfront that enriches life in the city.

Various Proposals

At present, the existing sewage treatment facility within the Pune city limit is insufficient and is not working effectively. Some of the Sewage Treatment Plants and trunk sewer mains have been proposed under NRCP & JICA project. Under the present proposal by NRCP, it is proposed to augment the existing sewage treatment capacity by constructing 11 new STP’s of 396 MLD treatment capacity to cater to the sewage generation upto the year 2027. Once these projects are completed the outfall parameters/ discharge from the STP will get improved.

Proposals under Pune Riverfront Project

Heavy urbanization in PMC and PCMC areas along the river over the past few decades and numerous piped outfalls and nallas discharging untreated sewage directly have converted the rivers into a polluted ‘drain’. Also, the outfalls from STP are directly discharged into the Nallas and the river which may cause many environmental and health issues. The outlet parameters/ quality of water discharged from the STP’s do not match with standard parameters mentioned in CPHEEO Manual and MoEFCC draft notification, dated 25th Nov. 2015.

To prevent the possibility of untreated sewage entering into the river and its consequent environmental and health effects, the Riverfront Development project proposes the following remediation measures –

- It has been observed that the river water parameters especially of Mutha River are comparatively beyond the acceptable limit. Other than the existing trunk lines along the river, a few trunk lines have also been proposed under the JICA project. Additionally, under the Pune Riverfront Development Project, a sewage collection trunk line has been proposed, wherever required to curb the piped outfalls. This will also result into the reduction of the river water pollution.

- Additionally, Sewage Treatment Plants have been proposed on the upstream side of Mutha River at 2 locations (at Shivane & Ram Nagar) with tertiary treatment facility having a capacity of 30 MLD each which will improve the water quality. Similarly, recommendations have been suggested to ensure the quality of water as per required standards for the upstream discharge coming from Mula and Pawana river.

- For using STP treated water for replenishment, it is essential that treated water should meet the CPCB waste water discharge standards defined in MoEFCC draft notification, dated 25th Nov. 2015. The waste water discharge standards mentioned in the CPHEEO Manual (shown below) were also referred. It can be observed clearly that the treated water from the existing STP's does not comply with the stated discharge parameters.

	STANDARD OF WATER QUALITY TO BE ACHIEVED AS PER MoEFCC (draft notification dated 25/11/2015)	STANDARD OF WATER QUALITY TO BE ACHIEVED AS PER CPHEEO	TREATMENT IN STP Screening and biological treatments
PH	6.5-9.0	5.5- 9.0	7.2- 7.4
BOD	10 mg/l	10 mg/l	6-13 mg/l
COD	50 mg/l	50 mg/l	30-60 mg/l
TSS	20 mg/l	20 mg/l	3-11 mg/l
NH4-N	5 mg/l	5 mg/l	NH4: 1.5- 18 mg/l
T-N	10 mg/l	10 mg/l	6.13- 8.05 mg/l
COLIFORMS	<100	100	140-860

To obtain treated effluent from STP as per the above standard, free from any foul smell and color after secondary treatment, tertiary treatment should also be provided.

- Tertiary treatment has been proposed at the outfalls of existing STP. The goal of providing tertiary treatment is to remove non-biodegradable toxic organic pollutants, disable disease causing organisms, and viruses, and other synthetic pollutants. They are removed by activated carbon filters

Phosphate is removed by precipitation as calcium phosphate, and nitrogen is removed by volatilisation as ammonia. The above mentioned treatment can maintain outlet parameters up to standard level, which will reduce health and hygiene issues.

After the Primary, secondary and tertiary treatment the treated water will be free from any kind of contamination which can affect environment and human health, hence it is suggested that in existing STP plants, tertiary treatment plant should be installed, after biological secondary plant, which will include addition of secondary settling tank, sand filter and carbon filter at existing STP.

- It is also essential to ensure that all the sources, which will cause contamination of river water, are prohibited / prevented. Such sources may include possible untreated sewage, diversion of sewage through interceptor, storm water drainage etc.

- Apart from this, significant number of nallas like Ambill Odha, etc. brings untreated sewage into the rivers. Hence, phytorid basin near Nalla has also been proposed to reduce the water contamination. Phytorid technology Treatment efficiencies for the removal of faecal coliforms, BOD, COD, nutrients are up to 95%, which is greater than the traditional chemical methods. It is a very cost effective technology when compared with the traditional wastewater treatment methods. Since it utilizes natural vegetation and rhizosphere microorganisms, it is eco-friendly method of treating sewage. An important factor to be considered is the aesthetic improvement that is provided by this methodology. No mosquitoes and odor nuisance. The quality of treated water is comparable to irrigation standards. To reduce pollution through untreated sewage being discharged by nallas, it is suggested that trunk lines should be laid along them and connected to sewage treatment facility.

- Revolving aerators /aeration fountains have also been proposed to get revolving movement to the water. Aeration systems induce circulation and add dissolved oxygen throughout the water body, helping to mitigate the damage caused by excessive nutrient loading. Floating fountain aerators will be used as aeration system. Submersed aeration systems release oxygen directly into the water column at precise locations, and work extremely well for circulating large areas of water and increasing oxygen levels in deeper water bodies. Other advantages of providing revolving aerators/ aeration fountains include improving water quality, reducing algae growth, removal of foul odor, enhancing habitat for aquatic organism, reduction of viable mosquito breeding habitat and reducing accumulation of bottom sediment.

Regarding the replenishment of evaporation and seepage losses, use of effectively treated STP water to the prescribed standards, will not have adverse affect on environment and human health.
The total amount of water required for replenishing the losses due to evaporation and seepage during the peak days is not more than 56160m3/day (56MLD) approximately which is only 6.6% of water that will be treated from the STPs after successful implementation of JICA project. As per the proposal, 910 MLD amount of treated water will be available after tertiary treatment from existing and proposed STPs for replenishment thus, ensuring flowing water in the river.

Conclusion

At present, the condition of the rivers is very critical and needs immediate attention for rejuvenation. As iterated above, it is clear that the project proposes a wide spectrum of proposals that will not only curb the pouring of sewage effluent into the river but also ensure the replenishment of flowing water as per expected standards, thus, rejuvenating the rivers, thereby benefitting the environment and the health of the citizens. The Pune Riverfront development Project poses a great opportunity to transform the river and reintegrate it with its surrounding areas, thus turning the rivers into an asset for the city.

भारत सरकार/ Government of India
जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय
Ministry of Water Resources, River Development & Ganga Rejuvenation
केन्द्रीय जल तथा विद्युत अनुसंधान शाला
Central Water and Power Research Station
खड़कवासला, पुणे – 411024 / Khadakwasla, Pune 411024
Tel.: +91 20 2410 3282, 2410 3200, Fax: +91 20 2438 1004
E-mail: physics.cwprs@gmail.com, Website: www.cwprs.gov.in

संख्या: 520/Riverfront/PMC/HMET/2017/ दिनांक: July, 2017

सेवा में,

The Chief Engineer (Projects)
Pune Municipal Corporation
Sawarkar Bhavan, Shivajinagar
Pune - 411 052

विषय: Subject: Riverfront Development of Mula, Mutha and Mula-Mutha rivers, Pune - Reg. CWPRS Comments

Ref.: e-mail of Shri Mangesh Dighe, Environment Officer, PMC dated 24th May 2017

Sir,

PMC requested CWPRS to vet the hydrology report by M/s HCP consultants on Riverfront Development for Mutha, Mula and Mula-Mutha river. CWPRS had conveyed its observations on hydrology-hydraulics of the study on Riverfront development carried out by M/s HCP consultants for PMC. Subsequent to CWPRS letter of 06.04.2017, M/s HCP consultants have made efforts in remedying the components of hydrology and hydraulics of Mula-Mutha system as suggested by CWPRS. Though hydrology is required for flood estimations for any catchment, it is not vital in front development aspects of a river system wherein the concern is more for lean flow component.

In the present proposal by PMC, Riverfront development of Mula-Mutha river system is envisaged through creating five pools with-in Mula-Mutha river in and around Pune city. It is advocated by the consultants to PMC that Pune city riverfront would be on the lines of Sabarmati which is in the downstream reaches where-in replenishing the pools could be managed with upstream dam releases. However, it is cautioned that Pune is in headwater region and frequent replenishments of these pools during lean flow periods is questionable. Moreover, Pune city in the recent past has witnessed water shortages for drinking purposes also. Thus, only the option of tapping of treated water from the STPs as proposed would be the viable option. However, this needs to be critically reviewed as the treated water from STPs also has already been allocated in the water plans by PMC. To address this issue and also not to end-up in future problems, a river ecology study incorporating the bio-remediation is essential. M/s HCP (PMC) have provided a Brief note on Untreated Sewage entering in the river in which it is quoted that

The total amount of water required for replenishing the losses due to evaporation and seepage during the peak days is not more than 56160m^3/day (56MLD) approximately which is only 6.6% of water that will be treated from the STPs after successful implementation of JICA project. As per the proposal, 910 MLD amount of treated water will be available after tertiary treatment from existing and proposed STPs for replenishment thus, ensuring flowing water in the river.

A meticulous study of the existing STPs on the Mula-Mutha river system along with the proposed STPs and their futuristic issues need to be taken into account for a stable proposal with assured quantum of replenishable water to the pools to avert the risks of stagnation in pools.

It is once again re-iterated to conduct a workshop on these issues with all the stake holders of the river system for arriving at a workable solution. CWPRS would extend its cooperation in all these endeavors of PMC.

This issues with the approval of Director, CWPRS.

Thanking you

Yours faithfully

C. Ramesh
27/07/2017

(Dr. C. Ramesh)
Scientist-C (HMET)

CC: The Director, CWPRS for kind information

HCP DESIGN, PLANNING & MANAGEMENT PVT. LTD.
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Our Ref: 15091/A1/27
Date: 12/09/2017

Mr. Srinivas Bonala
Chief Engineer (Projects),
Pune Municipal Corporation,
Third Floor,
Savarkar Udyog Bhavan,
Pune.

Sub: Hydrology and Hydraulics of Mula, Mutha & Mula - Mutha River, Pune for Riverfront Development Project.

Ref:
1) **Submission of Hydrology and Draft Hydraulics Report with our letter no. 15091/A1/16 dated 12 Sept, 2016.**
2) **Meeting with CWPRS on 9 Jan, 2017 & 13 Feb, 2017.**
3) **Email from HCPDPM to PMC/CWPRS on 8 March, 2017.**
4) **Meeting with CPWRS on 9 March, 2017.**
5) **CWPRS letter No. 520/RFD-PMC/2017/HMET/213/748 received on 18 April, 2017.**
6) **Compliance for CWPRS letter sent to PMC/CWPRS via email and letter no. 15091/A1/23 on 12th May, 2017**
7) **CWPRS letter No. 520/Riverfront/PMC/HMET/2017/ received on 28 July, 2017**
8) **Meeting with CWPRS on 7 Sep, 2017.**

Dear Sir,

This is regarding Hydrology and Hydraulics for Pune Riverfront and subsequent discussions and letter from CWPRS. Our para wise compliances to the CWPRS letter is as follows:-

Through detailed review of various components and features of the Mula, Mutha and Mula-Mutha, it is clearly understood that the Master Plan for Mula, Mutha and Mula-Mutha shall be very different from any other river including Sabarmati River. It is also understood that no two rivers are alike and therefore unique solution for the specific river is required to be worked out.

As observed, the Master Plan looks to ensure that there is clean and adequate water available in majority stretch of the 44km length. However, it is not envisaged that this length shall be seen as 5 pools. Whatever methods are put for at the detail design stage shall ensure that there is no stagnation of water and adequate measures are put in place to ensure that the quality of water in the river stretch is as per stipulated norms. At the time of detailing the structures to make water available, we shall be happy to seek suggestions from CWPRS to ensure the above.

We also understand the periodic flooding and, in contradiction, the periodic water scarcity of the city of Pune. Therefore, the water replenishment is anticipated only from STPs which are also upgraded to ensure that water quality released into river after treatment is well above the stipulated limits. For this a meticulous study of existing STPs, including JICA project, looks at futuristic scenario in comprehensive manner.

For arriving at the Master Plan that addresses all key concerns of the project, stakeholder meetings at periodic intervals have been held with various groups including citizens, NGOs, political representatives, PCMC and cantonment as well as elected representatives and standing committee. A list of key stakeholder meetings held is attached for your reference. The stakeholders will be continuously consulted periodically going forward also. CWPRS had suggested for a 1 day workshop wherein all the stakeholders could deliberate on the proceeds of DPR of River Rejuvenation Project including river ecology. Accordingly PMC has planned to organize the outcome of workshop in the final DPR.

We trust the above addresses the key concerns from your end and the project can now be taken up for DPR stage.

Yours faithfully,

Pradip Kumar

Pradip Jadav
Senior Project Manager
For and on behalf of
HCP Design, Planning and Management Pvt. Ltd
Encl: As above

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PH.: +91 79 27550875, 27552442, 27552563 fax : + 91 79 27552924. e-mail : hcpahd@hcp.co.in. web : www.hcp.co.in

List of key stakeholder meetings for Mula, Mutha, and Mula-Mutha River Development Project, Pune		
Date	**Action**	**Details**
3-Feb-16	Kick off meeting with PMC, Irrigation department, PCPMC	Regarding brief of project, project timeline and deliverables
29-Feb-16	Meeting with PCMC	Regarding brief of project, project timeline and deliverables, regarding permission letter in PCMC area
9-Mar-16	Meeting with Superintending Engineer (WRD), Irrigation Department	Regarding brief of project and data needed for feasibility study
21-Mar-16	Meeting with Commandant, KCB - Bombay Engineer Group	Regarding brief of project, project timeline and deliverables
12-Apr-16	Meeting with PMC-Mr. Srinivas Bonala along with EIA consultant	Regarding submission of forms-1,1A for review
27-Apr-16	Meeting with Commissioner, Collector Office, Irrigation Department, CWPRS and PCMC officials	To get a status update, discuss regarding the topographic surveys and approvals for environment.
11-Jun-16	Meeting with Members of Parliament and Members of Legislative Assembly and Commissioner	To discuss the Concept Master Plan and get suggestions
11-Jun-16	Meeting with Press Media	To discuss the Concept Master Plan and get suggestions
15-Jun-16	Meeting with CWPRS and CEO, Irrigation Department	To discuss and review the methodology adopted for preparation of hydrology and hydraulics scenario
18-Aug-16	Meeting with NGO representatives and HCPDPM	To discuss the project brief, its need and the objectives
1-Sep-16	Meeting with Municipal Commissioner, PMC and Settlement Commissioner, Land Records Dept	Regarding preparation of base map and land records with Geographis
14-Sep-16	Meeting with Slum Rehabilitation Authority (SRA)	Regarding data collection and to understand the process of rehabilitation of the slums in Maharahta
5-Dec-16	Meeting with Irrigation Department	For discussion of Hydrology and Draft Hydraulics Report
7-Dec-16	Meeting with Municipal Commissioner, PMC and Settlement Commissioner, Land Records Dept	To discuss the draft preliminary base map and further process for finalization of the base map.
9-Jan-17	Meeting of CWPRS, PMC and HCPDPM	For discussion of Hydrology and Draft Hydraulics Report and their inputs
1-Feb-17	Meeting of Director, CWPRS, PMC and HCPDPM	For technical vetting to be carried out by CWPRS
13-Feb-17	Meeting of CWPRS, PMC and HCPDPM	Regarding their observations and issues about the study of the Hydrology and Draft Hydraulics
1-Mar-17	Meeting with PMC, Deputy Director Land Records	Regarding further steps for Mojani Procedure
8-Mar-17	Meeting with Hon. Municipal Commissioner, PMC	Regarding Cost of Project, Priority Projects, Implementation strategies, Funding mechanism for the project
9-Mar-17	Meeting with CWPRS	Regarding discussion of observations and issues about the study of the Hydrology and Draft Hydraulics for the Pune Riverfront Project
17-Mar-17	Meeting with PMC, Hon. Municipal Commissioner, DP Cell	Regarding status update, revenue generation, further steps for ground truthing, finance mechanism
29-Jun-17	Meeting with Expert Appraisal Committee, MOEFCC	A presentation to committee for seeking Terms of Reference (TOR) for EIA procedure
4-Jul-17	Meeting with Members of Standing Committee of PMC and PCMC	To give a discuss the Draft Master Plan and get suggestions
5-Jul-17	Meeting with Mayor, PMC and PCMC and the Members of Legislative Assembly	To discuss the Draft Master Plan and get suggestions

List of key stakeholder meetings for Mula, Mutha, and Mula-Mutha River Development Project, Pune		
Date	**Action**	**Details**
31-Jul-17	Meeting with Parineeta Dandekar, NGO representative	To discuss the Draft Master Plan and get suggestions
1-Aug-17	Meeting with PMC,	Regarding Project status, EIA tor presentation, Finance mechanism
29-Aug-17	Meeting with DILR, Land Records dept	Regarding the status of Final base map
7-Sep-17	Meeting with Director, CWPRS	For the approval of the draft hydrology and hydraulics report

भारत सरकार/ Government of India
जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय
Ministry of Water Resources, River Development & Ganga Rejuvenation
केन्द्रीय जल तथा विद्युत अनुसंधान शाला
Central Water and Power Research Station
खड़कवासला, पुणे – 411024 / Khadakwasla, Pune 411024
Tel.: +91 20 2410 3378, 2410 3200, Fax: +91 20 2438 1004
E-mail: cro_tc@cwprs.gov.in, Website: www.cwprs.gov.in

संख्या: 520/Mula-Mutha-RFD/HMET/2017/725 दिनांक: December, 2017
26.12.17

सेवा में,

Shri Srinivas Bonala
Chief Engineer
Pune Municipal Corporation
Sawarkar Bhavan
Shivajinagar, Pune – 411 005

विषय: Vetting of Studies on Hydrology and Hydraulics of Mula-Mutha River for River Front Development Project of PMC at Pune

Ref.:
1. PMC letter No.: Nil dated 29.09.2017
2. Letter from PMC No. PMC/2399 dated 05 December 2017

Sir,

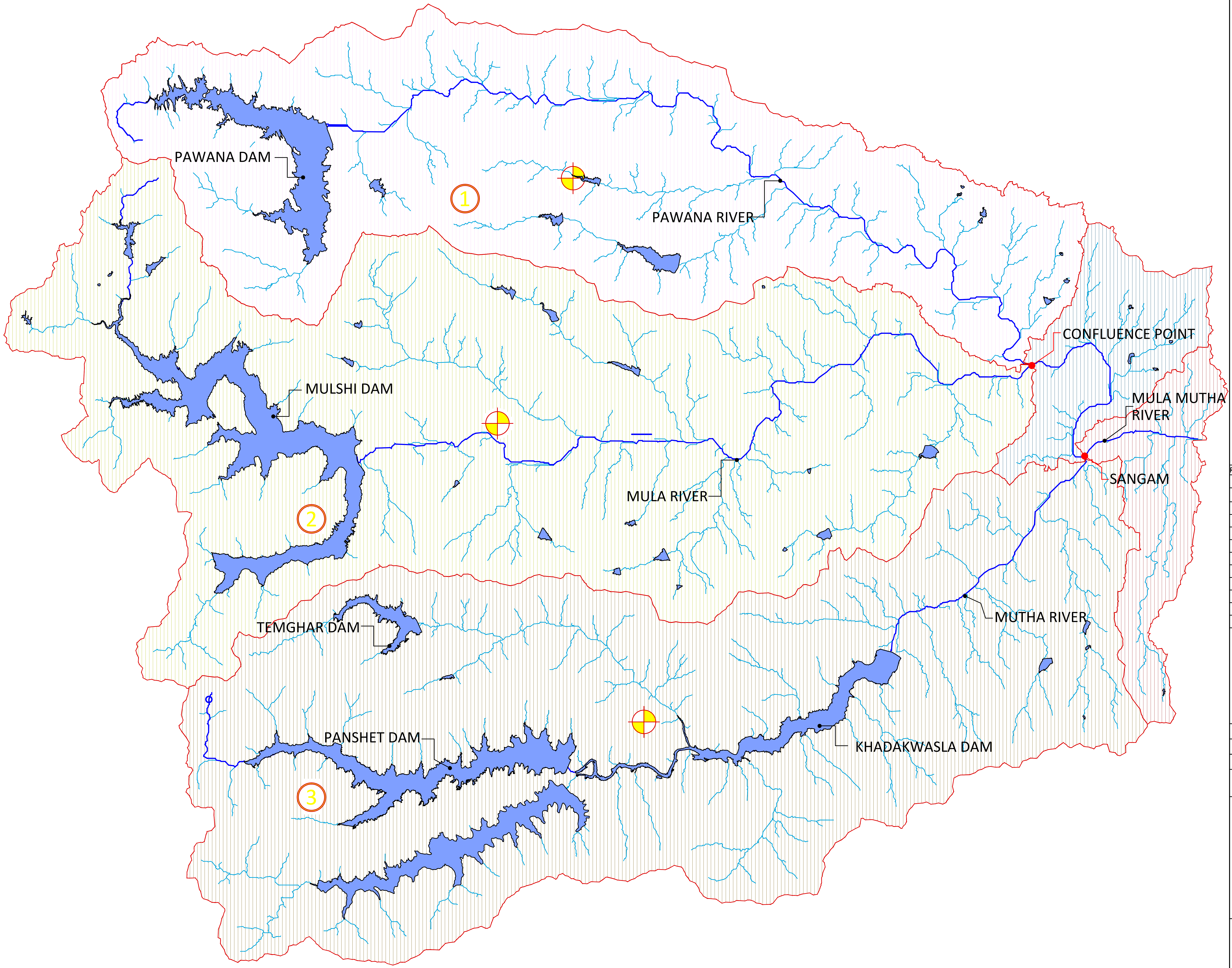
CWPRS have examined the hydrology and hydraulics report on Mula-Mutha river in context of River Front Development (RFD) planning as requested by PMC. The observations and suggestions of CWPRS during the course of interaction in this regard were addressed by the consultants of PMC. In principle, the report has taken into consideration the requisite aspects. CWPRS being the premier research institute in hydraulics and conducting research in water resources development and water borne transport has also made an observation on the river ecology as the issue to be tackled for the post RFD scenario and the same was communicated to PMC. It appears that, this issue is also being addressed by PMC in a comprehensive manner under the umbrella of JICA report on Mula-Mutha.

In light of the above facts, CWPRS clears the report on hydrology and hydraulics of Mula-Mutha as regards RFD project.

This issues with the approval of Director, CWPRS.

भवदीय,
सी.र मेश 26/12/2017
डॉ. सी. रमेश
साइंटिस्ट-C (ज.मौ.वि.)

PLATE -01



LEGEND:-

1. PAWANA RIVER CATCHMENT
2. MULA RIVER CATCHMENT
3. MUTHA RIVER CATCHMENT

MAIN STREAM

STREAM

CENTROID

BOUNDARY

REVISIONS

REF.	DATE	DESCRIPTION

ADVANCE ENGINEERING & CONSULTANT
601, 6th FLOOR,ABHISHEK BUILDING,
SECTOR-11, GANDHINAGAR-382011.

DRAWN BY : PATIL C.G.
CHECKED BY : R.R.PARIKH
ISSUED BY :

MULA MUTHA RIVER FRONT RIVER FRONT DEVELOPMENT PROJECT
AT PUNE PROJECT NO:

CATCHMENT AREA PLAN OF MULA MUTHA RIVER

DRG. NO. :AEC/MULA MUTHA RIVER FRONT/001/16
DATE : 07/09/2016
SCALE : 1:150
PLOT SIZE : A2

HCP DESIGN , PLANNING AND MANAGEMENT PVT LTD
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601, 6th Floor, ABHISHEK BUILDING, Sector - 11 Gandhinagar-382 011, Gujarat, INDIA
Phone no.- 079-23243608 advanceengconsultant@yahoo.co.in

TOP OF BANK	0.00		545.10	545.35	545.54	545.79	546.08	546.39	546.45	546.53	546.61	546.73	546.73	546.67	546.72	546.76	546.66	[illegible]
WATER SURFACE ELEVATION / HFL IN NATURAL RIVER CROSS SECTION DURING FLOOD OF 2835 CUMECS (RED LINE)	0.00		543.94	544.44	544.69	544.95	545.32	545.65	545.94	546.00	546.03	546.03	546.07	546.00	546.03	546.14	546.21	[illegible]
WATER SURFACE ELEVATION / HFL IN NATURAL RIVER CROSS SECTION DURING FLOOD OF 1700 CUMECS (BLUE LINE)	0.00		542.26	542.60	542.83	543.08	543.37	543.67	544.00	544.06	544.12	544.13	544.18	544.08	544.14	544.27	544.32	[illegible]
WATER SURFACE ELEVATION / HFL IN CANALIZED SECTION DURING FLOOD OF 1700 CUMECS	0.00	539.00	542.04	542.23	542.41	542.69	542.92	543.17	543.23	543.32	543.40	543.51	543.51	543.46	543.52	543.56	543.45	[illegible]
WATER SURFACE ELEVATION / HFL IN CANALIZED SECTION DURING FLOOD OF 2835 CUMECS	0.00		544.10	544.35	544.54	544.79	545.08	545.39	545.45	545.53	545.61	545.73	545.73	545.67	545.72	545.76	545.66	[illegible]
MINIMUM RIVER BED LVL(m)	0.00		535.88	537.14	537.47	536.91	536.71	537.38	537.38	537.22	537.03	536.43	536.82	537.65	537.65	537.73	538.65	[illegible]
CHAINAGE	0.00		99.95	141.00 149.77 159.00	199.69	249.69	291.00 299.69	340.00 349.69	399.84	449.67	499.69	549.69	599.69	649.69	699.69	749.69	799.69	[illegible]

NOTES / LEGEND

- TOP OF BANK
- WATER SURFACE ELEVATION / HFL IN NATURAL RIVER CROSS SECTION DURING FLOOD OF 2835 CUMECS (RED LINE)
- WATER SURFACE ELEVATION / HFL IN NATURAL RIVER CROSS SECTION DURING FLOOD OF 1700 CUMECS (BLUE LINE)
- WATER SURFACE ELEVATION / HFL IN CANALIZED SECTION DURING FLOOD OF 1700 CUMECS
- WATER SURFACE ELEVATION / HFL IN CANALIZED SECTION DURING FLOOD OF 2835 CUMECS
- MINIMUM RIVER BED LVL(m)

REVISIONS		
REV.	DATE	DESCRIPTION

ADVANCE ENGINEERING & CONSULTANT
601, 6th FLOOR, ABHISHEK BUILDING,
SECTOR-11, GANDHINAGAR-382011.

DRAWN BY : PATIL C.G.
CHECKED BY : R.R.PARIKH
ISSUED BY :

PUNE RIVER FRONT DEVELOPMENT PROJECT

LONGITUDINAL SECTION OF MUTHA RIVER FROM STARTING OF PROJECT REACH TO SANGAM AT MULA MUTHA

DATE : 25/06/2016
SCALE : N.T.S.

HCP DESIGN, PLANNING AND MANAGEMENT PVT LTD.

ADVANCE ENGINEERING & CONSULTANT

TOP OF BANK	[illegible]
WATER SURFACE ELEVATION / HFL IN NATURAL RIVER CROSS SECTION DURING FLOOD OF 4762 CUMECS (RED LINE)	[illegible]
WATER SURFACE ELEVATION / HFL IN NATURAL RIVER CROSS SECTION DURING FLOOD OF 2043 CUMECS (BLUE LINE)	[illegible]
WATER SURFACE ELEVATION / HFL IN CANALIZED SECTION DURING FLOOD OF 2043 CUMECS	[illegible]
MINIMUM RIVER BED LVL(m)	[illegible]
WATER SURFACE ELEVATION / HFL IN CANALIZED SECTION DURING FLOOD OF 4762 CUMECS	[illegible]
CHAINAGE	[illegible]

NOTES / LEGEND

- TOP OF BANK
- WATER SURFACE ELEVATION / HFL IN NATURAL RIVER CROSS SECTION DURING FLOOD OF 4762 CUMECS (RED LINE)
- WATER SURFACE ELEVATION / HFL IN NATURAL RIVER CROSS SECTION DURING FLOOD OF 2043 CUMECS (BLUE LINE)
- WATER SURFACE ELEVATION / HFL IN CANALIZED SECTION DURING FLOOD OF 2043 CUMECS
- MINIMUM RIVER BED LVL(m)
- WATER SURFACE ELEVATION / HFL IN CANALIZED SECTION DURING FLOOD OF 4762 CUMECS
- SOFFIT / BRIDGE
- * TO BE DISMANTLE DURING CHANALISATION

ADVANCE ENGINEERING & CONSULTANT
601, 6th FLOOR, ABHISHEK BUILDING, SECTOR-11, GANDHINAGAR-382011.

DRAWN BY : PATIL C.C.
CHECKED BY : R.R.PARIKH
ISSUED BY :

PUNE RIVER FRONT DEVELOPMENT PROJECT

LONGITUDINAL SECTION OF MULA MUTHA RIVER FROM SANGAM TO END OF THE PROJECT REACH (K.T WEIR)

DATE : 25/08/2016
SCALE : N.T.S.

HCP DESIGN, PLANNING AND MANAGEMENT PVT LTD.

CHAINAGE	TOP OF BANK	WATER SURFACE ELEVATION / HFL IN NATURAL RIVER CROSS SECTION (BLUE LINE)	WATER SURFACE ELEVATION / HFL IN NATURAL RIVER CROSS SECTION (RED LINE)	WATER SURFACE ELEVATION / HFL IN CANALIZED RIVER SECTION	MINIMUM RIVER BED LVL (m)	WATER SURFACE ELEVATION / HFL IN CANALIZED RIVER SECTION
0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.01	553.21	551.99	552.34	552.21	544.87	551.87
75.01	553.23	551.98	552.33	552.23	544.93	551.89
125.01	553.24	552.03	552.38	552.24	545.15	551.90
175.01	553.31	552.09	552.44	552.31	544.65	551.97
225.01	553.34	552.11	552.46	552.34	544.46	552.00
275.00	553.34	552.09	552.43	552.34	544.42	552.00
325.00	553.34	552.08	552.42	552.34	544.73	552.00
374.97	553.39	552.14	552.49	552.39	544.69	552.04
424.97	553.41	552.12	552.47	552.41	544.61	552.07
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2024.74	553.98	553.40	553.75	552.98	544.75	552.60
2074.74	554.03	553.41	553.76	553.03	544.85	552.65
2124.74	553.99	553.42	553.76	552.99	545.05	552.62
2174.74	554.09	553.49	553.85	553.09	544.92	552.71
2224.73	554.12	553.49	553.84	553.12	544.35	552.74
2274.74	554.15	553.61	553.96	553.15	544.24	552.77
2324.70	554.14	553.60	553.96	553.14	544.91	552.76
2374.62	554.11	553.60	553.95	553.11	544.64	552.74
2424.62	554.19	553.67	554.03	553.19	544.76	552.81
2474.62	554.17	553.74	554.10	553.17	545.72	552.79
2524.57	554.28	553.85	554.25	553.28	545.03	552.90
2574.57	554.35	553.93	554.33	553.35	544.56	552.95
2624.57	554.36	553.94	554.34	553.36	544.48	552.97
2674.57	554.37	553.94	554.34	553.37	544.61	552.97
2724.57	554.38	554.00	554.40	553.38	544.64	552.98
2774.57	554.38	554.01	554.41	553.38	544.79	552.99
2824.51	554.40	554.03	554.43	553.40	544.57	553.01
2874.51	554.41	554.00	554.40	553.41	544.47	553.02
2924.51	554.43	554.06	554.46	553.43	544.56	553.04
2974.51	554.45	554.09	554.49	553.45	544.37	553.05
3024.51	554.47	554.10	554.50	553.47	544.03	553.07
3074.51	554.45	554.09	554.49	553.45	544.96	553.06
3124.51	554.46	554.09	554.49	553.46	544.96	553.07
3174.50	554.48	554.09	554.49	553.48	544.81	553.09
3224.50	554.49	554.14	554.54	553.49	544.84	553.10
3274.51	554.51	554.14	554.54	553.51	544.73	553.11
3324.04	554.51	554.17	554.57	553.51	544.83	553.12
3374.29	554.53	554.18	554.58	553.53	544.72	553.13
3424.29	554.54	554.21	554.61	553.54	544.67	553.14
3474.29	554.54	554.23	554.62	553.54	545.05	553.14
3524.29	554.56	554.28	554.67	553.56	544.68	553.17
3574.29	554.56	554.28	554.67	553.56	545.15	553.17
3624.22	554.58	554.28	554.67	553.58	545.03	553.18
3674.23	554.65	554.30	554.70	553.65	543.10	553.26
3724.23	554.62	554.31	554.71	553.62	544.97	553.22
3774.23	554.63	554.38	554.77	553.63	544.92	553.24
3824.23	554.64	554.35	554.74	553.64	544.90	553.25
3874.23	554.66	554.38	554.77	553.66	544.62	553.27
3924.22	554.68	554.38	554.77	553.68	544.48	553.28
3974.22	554.68	554.39	554.78	553.68	544.60	553.29
4024.22	554.66	554.35	554.74	553.66	545.02	553.26
4073.90	554.71	554.37	554.75	553.71	544.53	553.32
		554.39	554.78			
4173.98	554.72	554.41	554.80	553.72	545.02	553.32
4223.98	554.73	554.41	554.80	553.73	545.15	553.33
4273.90	554.76	554.53	554.92	553.76	544.72	553.36
4323.71	554.76	554.56	554.96	553.76	544.97	553.36
4373.73	554.77	554.57	554.96	553.77	545.00	553.37
4423.73	554.79	554.55	554.94	553.79	544.87	553.39
4473.68	554.80	554.56	554.95	553.80	544.82	553.40
4523.60	554.80	554.57	554.96	553.80	544.88	553.41
4573.47	554.81	554.58	554.97	553.81	544.87	553.42
4623.45	554.77	554.60	555.00	553.77	546.29	553.38
4672.71	554.77	554.62	555.01	553.77	546.65	553.38
4722.97	554.87	554.61	555.00	553.87	545.55	553.47
4772.81	554.88	554.60	554.99	553.88	545.68	553.48
4822.75	554.90	554.61	555.00	553.90	545.35	553.51
4872.76	554.91	554.61	554.99	553.91	545.59	553.51
4922.72	554.93	554.62	555.01	553.93	545.34	553.54
4972.73	554.94	554.57	554.95	553.94	545.53	553.54
5022.73	554.89	554.65	555.01	553.89	545.63	553.50
5072.72	554.94	554.69	555.06	553.94	545.38	553.55
5119.41	555.00	554.77	555.14	554.00	545.22	553.60
5172.59	555.02	554.81	555.18	554.02	545.33	553.62
5272.66	555.06	554.85	555.24	554.06	545.83	553.66
5322.55	555.06	554.84	555.23	554.06	545.82	553.66
5372.55	555.07	554.85	555.23	554.07	546.17	553.67
5422.55	555.09	554.85	555.24	554.09	545.99	553.69
5472.55	555.20	554.96	555.36	554.20	545.58	553.79
5522.31	555.20	554.96	555.36	554.20	545.80	553.79
5572.25	555.20	554.98	555.38	554.20	545.98	553.79
5622.25	555.21	554.99	555.39	554.21	545.88	553.80
5672.25	555.23	554.99	555.39	554.23	545.46	553.82
5721.82	555.22	554.99	555.39	554.22	546.00	553.82
5772.25	555.23	554.99	555.39	554.23	545.90	553.83
5822.27	555.24	554.99	555.39	554.24	545.82	553.84
5871.84	555.25	555.00	555.40	554.25	545.69	553.85
5922.27	555.24	555.01	555.41	554.24	546.45	553.84
5972.15	555.25	555.02	555.42	554.25	546.48	553.84
6022.27	555.28	555.03	555.42	554.28	545.81	553.88
6072.27	555.28	555.07	555.46	554.28	545.84	553.88
6122.29	555.29	555.08	555.47	554.29	545.63	553.89
6171.99	555.30	555.09	555.48	554.30	545.39	553.91
6222.11	555.31	555.09	555.47	554.31	545.55	553.91
6272.11	555.31	555.08	555.47	554.31	545.82	553.91
6322.10	555.31	555.09	555.48	554.31	545.92	553.91
6372.10	555.32	555.09	555.47	554.32	545.78	553.92
6422.10	555.33	555.11	555.49	554.33	545.43	553.94
6472.09	555.33	555.13	555.51	554.33	545.87	553.94
6522.09	555.34	555.12	555.50	554.34	545.84	553.95
6572.10	555.35	555.18	555.55	554.35	545.78	553.95
6622.08	555.35	555.18	555.55	554.35	545.74	553.96
6672.08	555.36	555.19	555.56	554.36	545.61	553.97
6722.08	555.36	555.20	555.57	554.36	546.10	553.97
6772.08	555.37	555.20	555.57	554.37	545.96	553.98
6822.08	555.36	555.14	555.52	554.36	546.01	553.98
6872.08	555.37	555.18	555.55	554.37	545.89	553.99
6922.08	555.36	555.25	555.61	554.36	545.92	553.97
6972.08	555.42	555.34	555.69	554.42	545.75	554.03
7022.08	555.43	555.37	555.72	554.43	545.56	554.04
7072.06	555.43	555.36	555.71	554.43	545.78	554.04
7122.08	555.43	555.39	555.74	554.43	545.85	554.05
7171.89	555.44	555.41	555.76	554.44	545.70	554.06
7221.76	555.44	555.45	555.79	554.44	545.74	554.06
7271.71	555.45	555.47	555.81	554.45	545.61	554.07
7321.65	555.45	555.47	555.81	554.45	545.92	554.07
7371.68	555.46	555.47	555.81	554.46	545.84	554.08
7421.67	555.47	555.50	555.84	554.47	545.87	554.09
7471.67	555.47	555.50	555.84	554.47	545.84	554.09
7521.67	555.48	555.53	555.86	554.48	545.60	554.10
7571.58	555.48	555.54	555.87	554.48	545.90	554.11
7621.62	555.49	555.58	555.91	554.49	545.79	554.11
7671.62	555.50	555.57	555.90	554.50	545.38	554.13
7721.58	555.50	555.56	555.89	554.50	545.64	554.13
7771.58	555.51	555.57	555.89	554.51	545.81	554.13
7821.58	555.52	555.58	555.91	554.52	545.61	554.14
7871.58	555.52	555.63	555.95	554.52	545.59	554.15
7921.59	555.53	555.62	555.94	554.53	545.71	554.15
7971.42	555.53	555.64	555.96	554.53	545.93	554.16
8021.52	555.51	555.66	555.97	554.51	546.96	554.14
8071.42	555.52	555.70	556.01	554.52	546.93	554.15
8121.42	555.52	555.72	556.03	554.52	547.21	554.15
		555.73	556.04			
8221.33	555.56	555.75	556.06	554.56	546.63	554.20
8271.33	555.57	555.76	556.06	554.57	546.64	554.20
8321.33	555.58	555.79	556.10	554.58	546.48	554.22
8421.45	555.61	555.82	556.12	554.61	546.58	554.24
8471.01	555.61	555.85	556.15	554.61	546.80	554.25
8521.05	555.62	555.86	556.16	554.62	546.68	554.26
8570.97	555.62	555.87	556.16	554.62	546.83	554.27
8621.18	555.63	555.85	556.15	554.63	546.77	554.28
8671.10	555.64	555.88	556.18	554.64	546.87	554.28
8720.89	555.65	555.88	556.18	554.65	546.77	554.29
8770.89	555.66	555.92	556.21	554.66	546.82	554.30
8820.89	555.66	555.92	556.21	554.66	546.93	554.31
8870.89	555.68	555.92	556.21	554.68	546.73	554.32
8920.89	555.68	555.92	556.21	554.68	546.73	554.33
8970.89	555.69	555.93	556.22	554.69	546.77	554.34
9020.89	555.70	555.93	556.22	554.70	546.77	554.35
9070.90	555.70	555.95	556.24	554.70	546.76	554.36
9120.77	555.71	555.95	556.24	554.71	546.87	554.36
9170.77	555.72	555.98	556.26	554.72	546.78	554.37
9220.72	555.73	556.03	556.31	554.73	546.77	554.38
9270.92	555.73	556.02	556.31	554.73	546.76	554.39
9320.72	555.74	556.03	556.31	554.74	546.71	554.40
9370.71	555.75	556.02	556.30	554.75	546.86	554.40
9420.72	555.76	556.02	556.30	554.76	546.69	554.42
9470.72	555.77	556.05	556.32	554.77	546.56	554.43
9520.65	555.78	556.09	556.36	554.78	546.43	554.44
9570.59	555.78	556.09	556.36	554.78	546.47	554.45
9620.61	555.79	556.09	556.37	554.79	546.54	554.45
9670.61	555.79	556.10	556.37	554.79	546.71	554.45
9720.61	555.80	556.12	556.39	554.80	546.84	554.46
9770.58	555.81	556.12	556.39	554.81	546.62	554.47
9820.57	555.80	556.13	556.40	554.80	547.38	554.46
9870.41	555.82	556.14	556.41	554.82	547.10	554.49
9920.43	555.82	556.13	556.40	554.82	547.29	554.49
10020.28	555.76	556.26	556.51	554.76	549.34	554.42
10070.29	555.78	556.24	556.50	554.78	549.50	554.44
10120.29	555.82	556.28	556.53	554.82	549.44	554.49
10170.28	555.87	556.32	556.57	554.87	549.27	554.55
		556.32	556.56			
10270.28	555.93	556.34	556.59	554.93	549.12	554.62
10320.07	555.94	556.36	556.60	554.94	549.32	554.64
10420.06		556.45	556.69	555.10	549.29	554.81
10470.06		556.48	556.71	555.13	549.15	554.85
10520.06	556.14	556.52	556.75	555.14	549.39	554.86
10570.05	556.16	556.53	556.76	555.16	549.50	554.88
10620.05	556.20	556.59	556.82	555.20	549.32	554.92
10670.05	556.25	556.64	556.86	555.25	548.87	554.99
10720.05	556.27	556.66	556.88	555.27	548.87	555.00
10770.05	556.29	556.67	556.90	555.29	548.80	555.03
10820.69	556.30	556.65	556.87	555.30	548.87	555.04

NOTES / LEGEND

- TOP OF BANK
- WATER SURFACE ELEVATION / HFL IN NATURAL RIVER CROSS SECTION (BLUE LINE)
- WATER SURFACE ELEVATION / HFL IN NATURAL RIVER CROSS SECTION (RED LINE)
- WATER SURFACE ELEVATION / HFL IN CANALIZED RIVER SECTION
- MINIMUM RIVER BED LVL(m)
- WATER SURFACE ELEVATION / HFL IN CANALIZED RIVER SECTION

REVISIONS

REF.	DATE	DESCRIPTION

ADVANCE ENGINEERING & CONSULTANT
601, 6th FLOOR,ABHISHEK BUILDING,
SECTOR-11, GANDHINAGAR-382011.

DRAWN BY : PATIL C.G.
CHECKED BY : R.R.PARIKH
ISSUED BY :

PUNE RIVER FRONT DEVELOPMENT PROJECT
AT PUNE PROJECT NO:

LONGITUDINAL SECTION OF MULA RIVER FROM STARTING OF PROJECT REACH TO PAVNA RIVER CONFLUENCE

DRG. NO. :AEC/PUNE RIVER FRONT/002/16
DATE : 25/06/2016
SCALE : N.T.S.

HCP DESIGN , PLANNING AND MANAGEMENT PVT LTD
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ADVANCE ENGINEERING & CONSULTANT
601, 6th FLOOR, ABHISHEK BUILDING,
SECTOR-11, GANDHINAGAR-382011.

DRAWN BY : PATIL C.G.
CHECKED BY : R.R.PARIKH
ISSUED BY :

PUNE RIVER FRONT DEVELOPMENT PROJECT
AT PUNE PROJECT NO:

LONGITUDINAL SECTION OF MULA RIVER FROM PAUNA RIVER CONFLUENCE TO MULA MUTHA SANGAM

DRG. NO. : AEC/PUNE RIVER FRONT/002/16
DATE : 25/06/2016
SCALE : N.T.S.

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