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1. Introduction

1.1 General

Mumbai has a drainage system, which in many places, are more than 100 years old, consisting of 2,000 km of open drains, 440 km of closed drains, 186 outfalls and more than 30,000 water entrances. The capacity of most of the drains is around 25 mm of rain per hour during low tide, which is exceeded routinely during the monsoon season in Mumbai, which witness more than 1400 mm during June and July. The drain system works with the aid of gravity, with no pumping stations to speed up the drainage. Most of the storm water drains are also choked due to the dumping of garbage by citizens. Portions of Mumbai like Bombay Central and Tardeo remain below sea level. Reclamation of ponds and obstructions in drains due to cables and gas pipe exacerbate the problem.

Hydrology and cross drainage are important consideration in the design of highway projects. The term drainage is defined in several different ways, including the process of removing surplus groundwater or surface waters by artificial means, the manner in which the waters of an area are removed, and the area from which waters are drained. A project may alter the existing drainage. When this occurs, drainage features should be provided which protect the highway, adjacent landowners, and the travelling public from floods, while maintaining water quality and protecting other environmental resources.

1.2 Objectives

This report is part of Volume II of Detailed Project Report for the project. This report has been prepared to meet the following objectives:

- To study the hydrology of the project area.
- To determine the design discharge of the cross drainage structures along the proposed alignment.
- To provide adequate cross drainage works for the flood protection measures along the proposed alignment.

Following **Figure 1-1** shows the location map of Mumbai.

Figure 1-1 Location Map of Coastal Road Project

1.3 Project Background

Mumbai City and Suburbs have an area of 437.71 Sq.kms. The City receives seasonal rainfall for four months i.e. from June to September. Mumbai city and Suburbs receive average rainfall of 2000mm out of which major rainfall generally occurs in the month of June-July-August.

The present Storm Water Drainage (SWD) system in the city is more than 100 years old and is about 480 km long. This network consists of underground drains, laterals roadside open drains, minor and major nallas built on the basis of population and weather conditions at that time. The old SWD system is capable of handling rain intensity of 25 mm per hour at low tide. If the rain intensity is more than 25 mm per hour and high tide occurs, there is always a possibility of flooding. There are 107 major outfalls in city, which drain to Arabian Sea directly, 4 at Mahim Creek and 4 at Mahul Creek. There are 29 outfalls in Western Suburbs draining directly into sea while 14 drain into Mithi River, which ultimately joins Mahim Creek. In Eastern Suburbs 14 outfalls discharge in Thane Creek while 6 discharges in Mahul Creek and 8 discharges into Mithi River in suburbs and extended Suburban area, open SWD are constructed on both sides of roads.

1.4 Project Description

The South part of the proposed road starts at Princess Flyover with proposed chainage of 2+448 km to Worli Sea Link with proposed chainage of 12+400 km, and North part of proposed road starts at Bandra Worli sea link with proposed chainage of 0+00 km to Kandivali with proposed chainage of 19+300 km. Following **Table 1-1** shows the Type of the Road structure along the proposed alignment.

Table 1-1 Details of Type of Road Structure and Chainages

Type of Road Structure	South Section	North Section	Remarks
	Princes Flyover to BWSL	BWSL to Kandivali	
	Chainage(km)		
Land Filled road/ Land filled Road Mangroves/surface road	5.90 -7.496	0.00 -1.40	Provide adequate cross drainage structures and extension of existing outfall
	9.60 - 9.72	-	
	9.87- 11.68	-	
Land filled Road without obstructing Mangroves	-	1.40 - 2.53	-
		3.37 - 4.325	-
Tunnel	3.23-5.27	5.2-9.525	-
Bridge on sea/Creek	7. 95-9.38	2.53 - 3.37	-
	9.72 - 9.87	13.35-13.8	
	11.68 -12.43	15.1-15.60	
	-	16.20 - 16.80	
	-	18.20-19.27	
Bridge (VUP)	-	14.076 - 14.106	-
	-	14.296 - 14.326	-
Road on stilts	-	15.60 -16.20	-
		16.80 - 18. 20	-
Elevated Road	-	10.10 -13.35	-

For our project work we have considered Cross Drainage Structures. Necessity of providing cross drainage and extension to existing outfalls occurs only for Land filled road, Land filled Road Mangroves, surface road.

Figure 1-2 represents the Indicative alignment of Mumbai Coastal road Project.

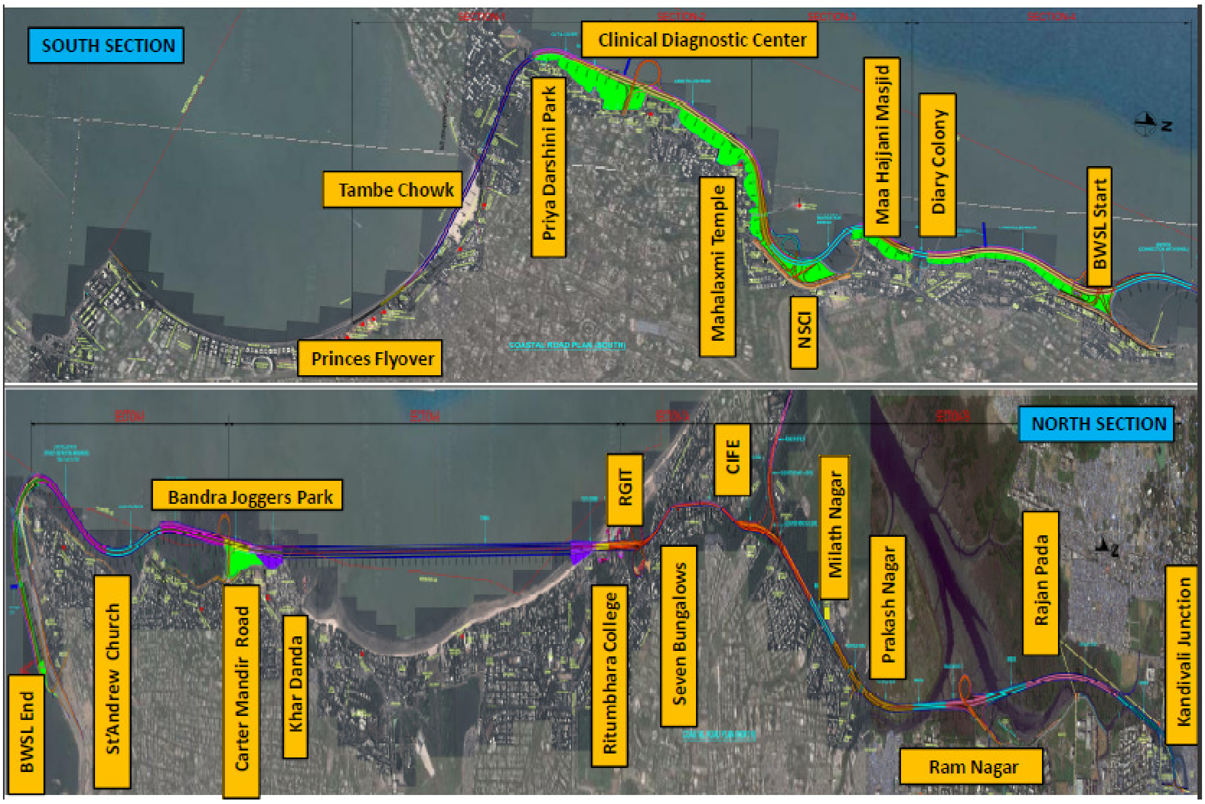


Figure 1-2 Indicative Alignment of Mumbai Coastal Road Project

1.5 Report Structure

This report is organized into 5 Chapters and the contents of each chapter are described below

Chapter 1	Serves as an Introduction to the background and objectives of this report.
Chapter 2	Provides the Socio-Economic profile of project Influence area.
Chapter 3	Provides the Design data details required for the storm water runoff analysis.
Chapter 4	Provides the steps for the estimation of Storm water design.
Chapter 5	Contains the detail analysis of Storm water runoff and summary of the results using Rational Method.

2. Socio-Economic Profile of the project influence area

2.1 Mumbai Metro City

2.1.1. Introduction

Looking to growth of Mumbai Metro City Govt of Maharashtra in addition to existing authorities like MCGM established Mumbai Metropolitan Region Development Authority (MMRDA) under the MMRDA Act 1974 primarily as planning and development authority for Mumbai Metropolitan Region (MMR) whose boundaries are defined by the said Act and its subsequent amendment. The present boundaries of MMR encompass a total area of 4,355 sq. km. MMR consists of the following revenue units:

- Mumbai City District
- Mumbai Suburban District
- Part of Thane District (comprising Thane, Kalyan, Bhiwandi and Ambernath Tehsils)
- Part of Vasai Tehsil
- Part of Raigad District
- Uran Tehsil; and
- Part of Panvel, Karjat, Khalapur, Pen and Alibaug Tehsils

2.1.2. Climate

The Climate of Mumbai is a tropical wet and dry climate. Mumbai's climate can be best described as moderately hot with high level of humidity. Its coastal nature and tropical location ensures temperatures won't fluctuate much throughout the year.

The mean average is 27.2 °C and average precipitation is 242.2 cm (95.35 inches). The mean maximum average temperatures in about 32 °C (90 °F) in summer and 30 °C (86 °F) in winter, while the average minimums are 25 °C (77 °F) in summer and 20.5 °C (68.9 °F) in winter. Mumbai experiences four distinct seasons: Winter (December–Feb); Summer (March–May); Monsoon (June–Sep); and Post-Monsoon (Oct–Dec). The mean annual temperature varies from 20 °C to 27 °C. Figure 2-1 shows the Normal Annual Temperature of Konkan coast.

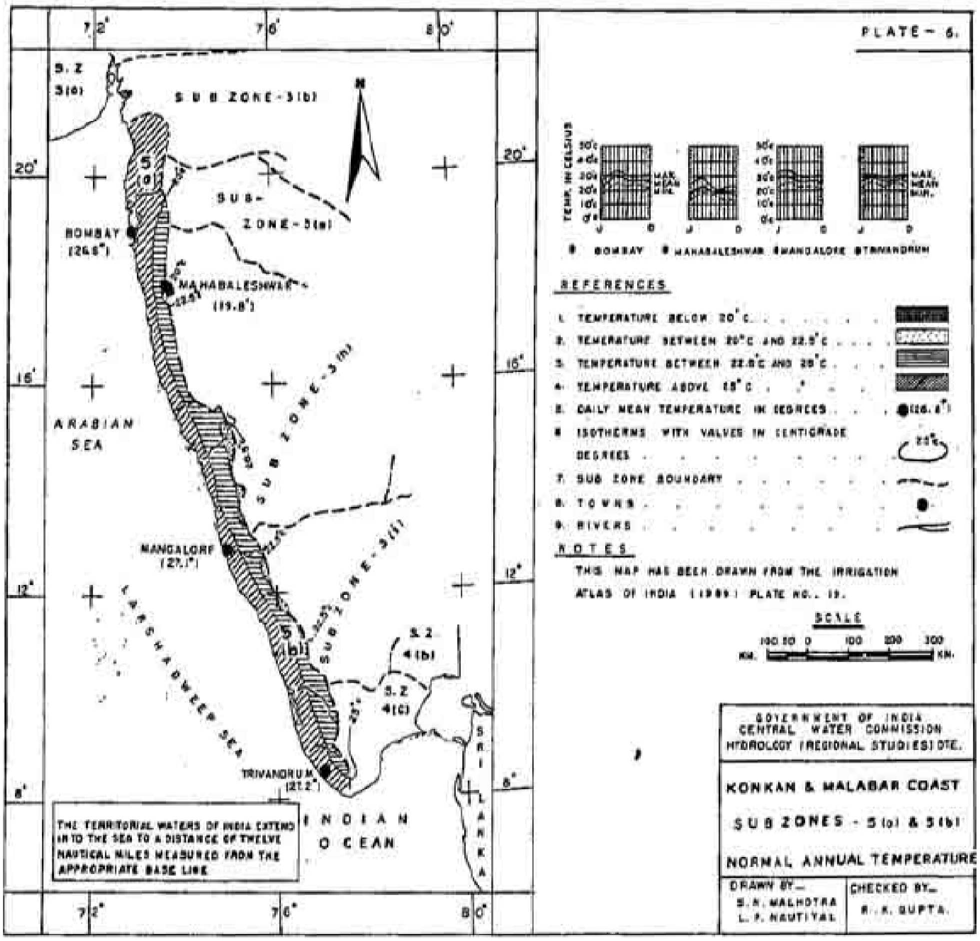


Figure 2-1 Normal Annual Temperature of konkan Coast

[Central water commission report]

2.1.3. Average Rainfall in Mumbai

The maximum annual rainfall ever recorded was 3,452 mm (136 in) for 1954. The highest rainfall recorded in a single day was 944 mm (37 in) on 26 July 2005. The average total annual rainfall is 2,146.6 mm (85 in) for the Island City, and 2,457 mm (97 in) for the suburbs. The normal Annual rainfall varies from 1000mm to 4000mm.

Figure 2-2 gives the 100 year 24- hour Rainfall of Konkan Coast.

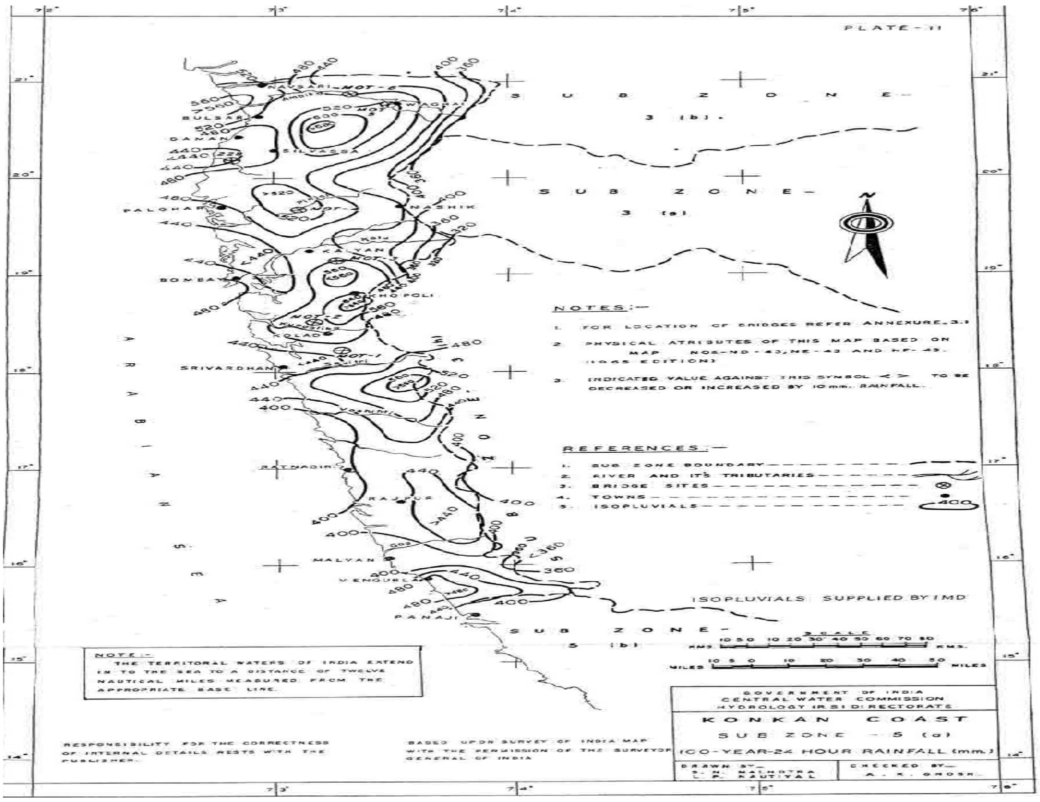


Figure 2-2 100 year 24 hour Rainfall of Konkan Coast

[Central water commission report]

Note: The data for charts above are taken from year 2000 to 2012.

2.1.4. Geography

Mumbai is located on Salsette Island which lies at the mouth of Ulhas River off the western coast of India in the coastal region known as the Konkan. Most of Mumbai is at sea level and the average elevation ranges from 10 to 15 metres. The northern part of Mumbai is hilly and the highest point of the city is at 450 metres (1,450 feet). Mumbai spans a total area of 468 km^2.

Three lakes are located within the metropolitan limits the Tulsi Lake, Vihar Lake and the Powai Lake. The first two are located within the Borivali National Park and supply part of the city's drinking water. Mumbai also has three small rivers within the city limits originating in the National Park. The coastline of the city is indented with numerous creeks and bays. On the eastern seaboard, large mangrove swamps rich in biodiversity occupy most of the region. Soil cover in the city region is predominantly sandy due to its proximity to the sea. In the suburbs the soil cover is largely alluvial and loamy. The underlying rock of the region is composed of black Deccan basalt flows and their acid and basic variants dating back to the late Cretaceous and early Eocene geological eras. Mumbai sits on a seismically active zone owing to the presence of three fault lines in the vicinity. The area is classified as a Zone III region, which means an earthquake of magnitude up to 6.5 can be expected.

Mumbai is classified as a metropolis of India, under the jurisdiction of the Brihan Mumbai Municipal Corporation. It consists of two discrete regions the City and the Suburbs, which also form two districts of Maharashtra. The city region is also commonly referred to as the Island City by most media publications.

2.1.5. Geology

The entire Greater Mumbai area is occupied by Deccan basalt flows and their acid and basic variants, poured out between the late Cretaceous and early Eocene times. The basaltic flows are horizontally bedded and are more or less uniform in character over wide areas. Certain extrusive and intrusive mafic types are associated with basalt's and are found in the Mumbai Islands and it's vicinity. This is in contrast to the monotonous uniformity displayed by the Deccan basalt's in general. Further, some fossiliferous sediment, mainly of tufaceous origin and partly of fresh water origin, rich in fauna are also found in Mumbai area.

Mumbai Island has ridges along its western and eastern side. The city of Mumbai is built on the central low-lying part of the island. The western ridge comprises stratified ash beds overlain by hard, massive andesitic lava flows, both formations showing gentle tilt towards the west. The stratified ashed which display variegated colors and variable textures attain a total thickness of about 45m.

The ash beds are capped by massive lava flows which attain a thickness of about 16 m. The rocks are aphanitic, have a conchoidal fracture and exhibit conspicuous hexagonal columnar jointing. They are exposed on the Malabar, Cumballa, Worli hills and extend on to the Salsette Island. Dark colored fossiliferous shales attaining a thickness of about 2m are exposed at the foot of the Worli hills. Being deposited during a period of quiescence and overlain by a later flow, these beds are known as Intertrapean Beds.

The eastern ridge represents a different suite of rocks. The geology of the intervening low lands is more or less obscured by the development of the city of Mumbai. Some of the recent excavations near Flora Fountain, Old Custom House and Dadar have revealed the presence of

Municipal Corporation of Greater Mumbai

2.1.6. Population

Mumbai's 2013 population is estimated at 19 million, but its total metropolitan area is home to more than 20.5 million. As with other metropolitan areas in India, Mumbai's population has grown very rapidly over the past two decades, and much of its population are migrants from other regions in the country who came seeking better employment opportunities.

Mumbai's population has nearly doubled since 1991, when its population was just 12.5 million. This rapid expansion has led to serious health-related issues, and a large percentage of the population lives in slums.

The number of people living in slums is estimated at 9 million, which is up from 6 million just a decade ago. That means about 62% of all Mumbaikers live in slums. Dharavi, the second largest slum in Asia, is located in central Mumbai and is home to 800,000 to 1 million people in just 2.39 square kilometers (or 0.92 square miles). This makes it one of the most densely populated areas on the planet with a density of a minimum of 334,728 people per square kilometer. It's also the most literate slum in India with a literacy rate of 69%.

Because land is at such a premium, residents of Mumbai frequently live in cheap, cramped housing far from work, so there are usually long commutes necessary on its busy mass transit system

2.1.7. Demographics

Mumbai is a real melting pot as people from all over the region move here in search of jobs. Mumbai, like most metropolitan areas of India, has a large polyglot population and 16 major languages of India are spoken here, including Gujarati, Hindi and Marathi, along with a colloquial form of Hindi called Bambaiya.

Mumbai's sex ratio is skewed, and a ward-level analysis of the last Census in 2013 found that 20 of the city's 24 municipal wards had a decline in child sex ratio in the past decade. The Worli-Prabhadevi region had the highest drop in child sex ratio. For every 1,000 boys, there are just 899 girls. This gender imbalance is visible throughout Mumbai and it's blamed on sex-selective abortions.

2.1.8. Socio Economic profile of MMR

MMR is highly urbanized area with more than 90% of the total population of 11.9 million as per 2001 census and 12.4 million as per 2011 census is concentrated in cities and towns. The urban population is however confined to 8 Municipal Corporations, 11 Municipal Councils and 10 Non Municipal Towns. Total area under these urban units is about 1,500 sq. km. In the rest of the region, about 1 million population is spread over 950 village settlements. The demographic census gives population and worker details according to 88 census sections in Greater Mumbai, for suitably defined wards in other urban centres and for village as a whole in MMR.

3. Design Data

3.1 Rainfall Intensity

The rainfall intensity (Ic) is the average rainfall rate in mm/hr for a selected return period that is based on a duration equal to the time of concentration (t_c). The return period is typically stated by local authorities depending on the impact of the development.

For the present study Rainfall Intensity of 66 mm/hr, 85 mm/hr and 93 mm/hr for culverts, minor bridges and major bridges is adopted. Based on one hour duration this figure approximately represents 1 in 10, 1 in 50, 1 in 100 return periods.

Table 3-1 shows the maximum rainfall intensities for various return periods.

Once a particular return period has been selected for design and a time of concentration has been calculated for the drainage area, the rainfall intensity can be determined from rainfall-intensity-duration relationship which is expressed in the form of a formula or in the form of a graphic curve. Calculation of I_c and t_c is discussed in the next chapter.

Table 3-1 Maximum rainfall Intensities

Duration in Hrs	Return Periods						
	1	10	25	50	100	500	1500
1	29.911	65.861	76.770	84.862	92.894	111.456	124.103
2	23.594	48.452	55.995	61.590	67.144	79.979	88.723
3	17.968	41.291	48.367	53.617	58.828	70.870	79.074
4	15.336	36.285	42.641	47.356	52.037	62.853	70.222
6	12.894	30.971	36.456	40.524	44.563	53.897	60.255

[Source: Fact finding committee on Mumbai floods]

3.2 Runoff Coefficient

The runoff coefficient 'P' is expressed as a dimensionless decimal that represents the ratio of runoff to rainfall. It is a larger value for area with low infiltration and high runoff (pavement, steep gradient) and lower for permeable well vegetated area (forest, flat land).

In urban hydrology, the percentage of pervious and impervious land is important. The percentage of impervious area increases when urbanization occurs and Rainfall-Runoff relationships significantly.

Before the development of Mumbai, the runoff coefficient was considered as 0.5. As per international standard handbook by Mr. Haestad, the runoff coefficient for paved surface is considered as 0.95. Therefore, Mumbai city being the fast developed and commercialized, the runoff coefficient is considered as 1 for the design.

3.3 Catchment Area

The area 'A', draining to any point under consideration in a storm water management system must be determined accurately. Drainage area information should include:

- Land Use - present and predicted future - as it affects degree of protection to be provided and percentage of imperviousness.
- Character of soil and ground cover as they may affect the runoff coefficient.
- General magnitude of ground slopes which, with previous items above and shape of drainage area, will affect the time of concentration.

Following **Table 3-2** shows Catchment area details along the proposed alignment of the project and **Figure 3-1** and **Figure 3-2** shows the Catchment areas of the proposed alignment.

Table 3-2 Catchment Area details along the Proposed Alignment

Sl. No.	Proposed Chainage	Catchment No.	CA "Ha"	L"Km"	H"m"
A	Princes Flyover to Bandra Worli Sea Link				
1	05+350	134	59	1.1	27
	05+700		59	0.9	27
	05+800		59	0.7	27
	05+900		59	0.6	25
	06+050		59	0.9	40
	06+350		59	1.3	38
	06+700		59	0.5	21
2	07+120	133	15	0.2	11
	07+210		18	0.3	21
3	08+000	130-132	109	3.5	4
	08+000		42	1.4	29
	8+150		130	0.9	7
4	11+150	131	22	1.0	15
B	Bandra Worli Sea Link to Kandivali				
5	04+500	238	37	1.1	39
	04+700		27	0.4	6

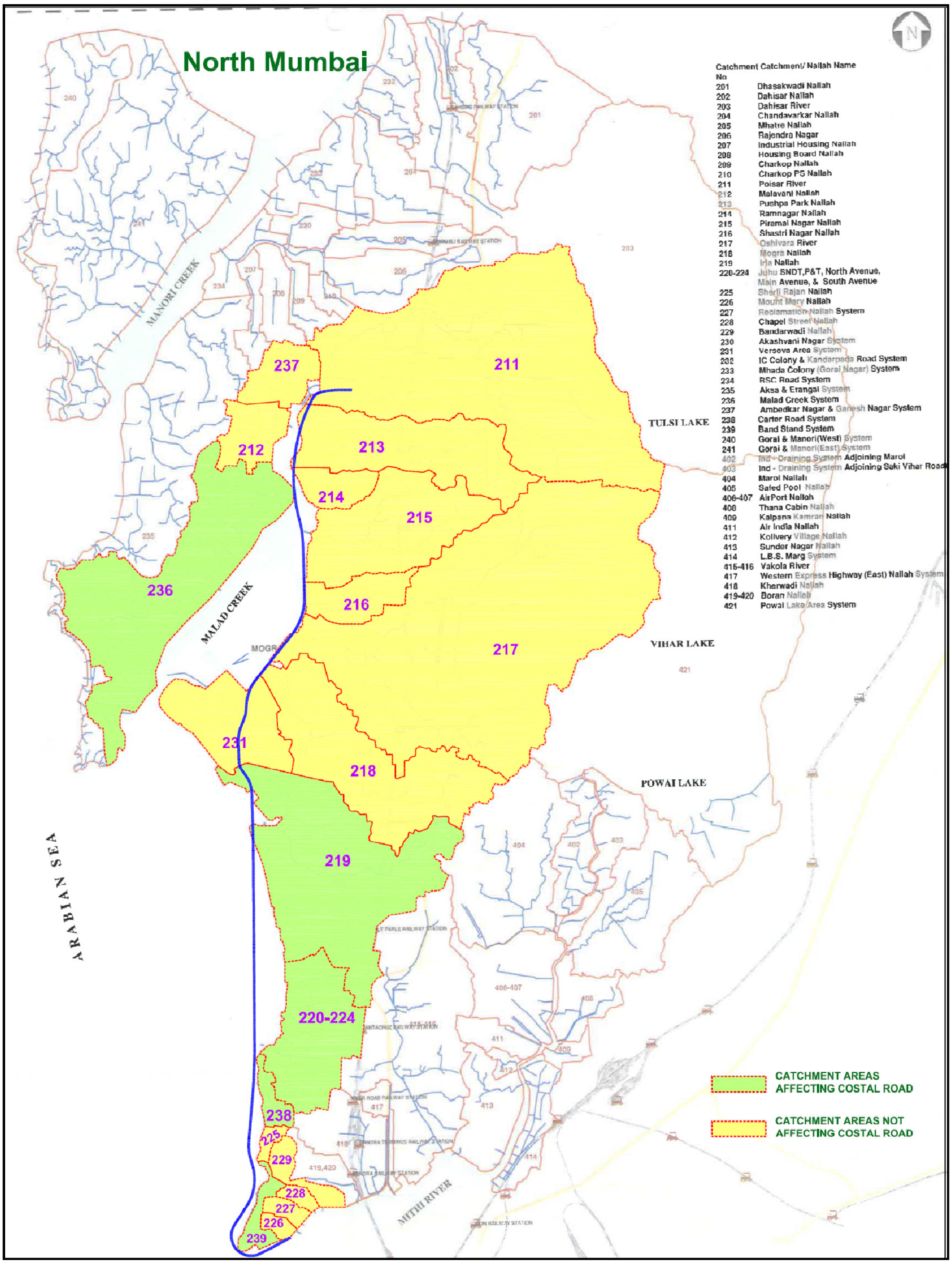


Figure 3-1 Catchment area of the proposed alignment (NORTH)

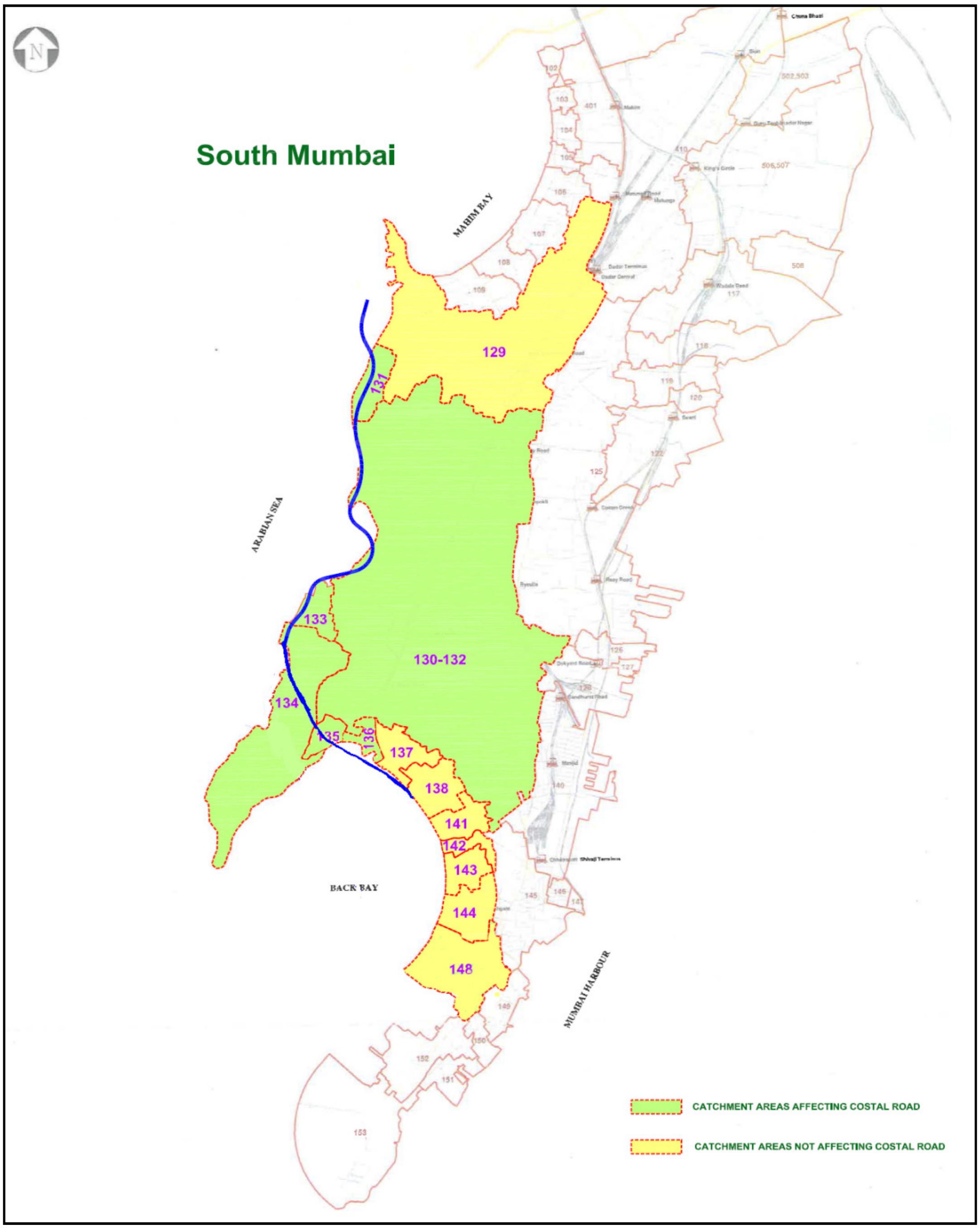


Figure 3-2 Catchment area of the proposed alignment (SOUTH)

4. Estimation of Storm Water Runoff

Calculation of the rate of storm water runoff is important in determining the size of inlets, drains, sewers, etc. All portions of the storm water system must be designed to handle the peak flow anticipated under certain design conditions. The most widely used method for estimating peak storm water runoff is Rational Formula Method.

This formula assumes:

- The rate of storm-water run-off from an area is a direct function of the average rainfall rate during the time that it takes the runoff to travel from the most remote point of the tributary area to the inlet or drain.
- The average frequency of occurrence of the peak runoff equals the average frequency of occurrence of the rainfall rate.
- The quantity of storm water lost due to evaporation, infiltration, and surface depressions remains constant throughout the rainfall.
- The coefficient of runoff is a coefficient which accounts for storm-water losses attributed to evaporation, infiltration, and surface depressions. The peak value of the flow rate Q of storm-water runoff is estimated using the following equation,

$Q = 0.028\ PAI_c\ m^3/s$

Where, A- Catchment Area in "Ha"

P- Runoff Coefficient

I_c- Intensity of Rainfall "mm/Hr"

$I_c = I_o\ (2/\ (t_c+1))$

$t_c = (0.87xL^3/H)^{0.385}$

Where, t_c Time of Concentration in "hrs"

L- The distance from the critical point to the structure in km

I_o – One hour Rainfall

$Q = V*A\ m^3/s$

Where, A- Culvert Area "m^2"

V- Velocity "m/sec"

$V=1/n\ (R^{2/3} *S^{1/2})$

In the present study we have considered catchment areas form BRIMSTOWD manual and required discharge and design discharges are calculated.

An example with reference to catchment area no. 131 is worked out for illustrating the calculated discharge and design discharge procedure. The particulars of the catchment under the study are as follows.

Catchment No. 131

Catchment Area = 22 Ha

Outfall location = Khan Abdul Gaffar Khan Marg / A52
L= 1.0 km

H=15m

I_o=65.861 mm/hr

P= 1.0

1. $t_c= (0.87xL^3/H)^{0.385}$

   $t_c= (0.87x1^3/15)^{0.385}$

   t_c= 0.3 hr

2. $I_c = I_o\ (2/\ (t_c+1))$

   I_c = 65.861(2/(0.3+1))

   I_c=100 mm/hr

3. Q = 0.028 PAI_c m^3/s

   Q = 0.028x1x22x100

   $\boxed{Q = 6.00\ m^3/s}$

4. Q_{design} = V*A m^3/s

   $V=1/n\ (R^{2/3}*S^{1/2})$

   n=0.020

   w=4m; h=3m

   A= wxh = 12m^2

   P= h+w+h = 3+4+3 =12m

   R = A/P = 12/12= 1.00

   S = 1/200

   $V=1/0.02\ (1.00)^{2/3}*(1/200)^{1/2})$

V = 3.99 m/sec

Q_{design} = 3.99*12

$\boxed{Q_{design} = 47.88\ m^3/s}$

Following **Table 4-1** shows the existing culvert discharge runoff details.

Table 4-2 represent calculated discharge details of the existing culverts along the alignment. **Table 4-3** represent calculated discharge details of proposed new culverts along the alignment.

Table 4-1 Existing Outfall Discharge Details

Sl. No.	Proposed Chainage	Catchment No.	CA 'Ha"	Outfall Location/ Ref Outfall No.	Details of Outfall				L "Km"	H "m"	Tc "Hr"	Io "mm/Hr"	Ic "mm/Hr"	P	Q_{cal} m^3/s
					Invert Level w.r.t THD(m)	Width	Height	Type							
A	**2+449 to 12+400**	**Prince Flyover to Bandra Worli Sea Link**													
2	05+450	134	59	PWD Office Outfall / A12	24.43	1200	-	Circular	1.1	27	0.3	66	102	1	17
	05+700		59	Sitalwad Lane Outfall / A13	25.44	450	-	Circular	0.9	27	0.2	66	107	1	18
	05+800		59	Kashinath Compound Outfall / A14	25.624	1200	-	Circular	0.7	27	0.2	66	112	1	18
	05+900		59	Darabshaw Lane Outfall / A15	28.1	300	-	Circular	0.6	25	0.2	66	114	1	19
	06+050		59	Breach Candy Garden Outfall,Bhulabhai Desai Road / A16	24.43	1200	-	Circular	0.9	40	0.2	66	110	1	18
	06+350		59	Vaibhav Apartments Outfall / A17	26.48	900	-	Circular	0.5	21	0.1	66	116	1	19
	06+700		59	Breach	26.5	900	-	Circular	0.5	21	0.1	66	116	1	19

Sl. No.	Proposed Chainage	Catchment No.	CA 'Ha"	Outfall Location/ Ref Outfall No.	Details of Outfall				L "Km"	H "m"	Tc "Hr"	Io "mm/Hr"	Ic "mm/Hr"	P	Q_{cal} m^3/s
					Invert Level w.r.t THD(m)	Width	Height	Type							
				Candy/A18											
3	07+120	133	15	Breach Candy Hospital Outfall / A19	24.6	600	-	Circular	0.2	10.5	0.1	66	124	1	5
	07+210		18	Mafatalal Park Outfall / A20	24.69	900	-	Circular	0.3	21	0.1	66	123	1	6
4	08+000	130-132	109	Haji Ali Juice Centre Outfall / A21	22.79	2700	1800	Arch	3.5	4	2.4	66	39	1	12
	08+00		42	Haji Ali Pumping Station / A22	26.3	900	-	Circular	1.4	29	0.4	67	97	2	22
	08+150		130.8	Haji Ali Bypass A23	22.79	1400	1900	Rectangular	0.9	7	0.4	66	94	1	34
5	11+150	131	22	Khan Abdul Gaffar Khan Marg / A52	26.5	900	-	Circular	1.0	15	0.3	66	100	1	6
B	**0+00 to19+220**	**Bandra Worli Sea Link to Lalji Malad**													
8	04+500	238	37	/ B15	24.5	1800	100	Box Drain	1.1	39.0	0.3	66	105	1	11
	04+700		27	/ B16	23	1800	1800	Box Drain	0.4	6.0	0.2	66	113	1	9

Table 4-2: Reconstruction of Existing Outfalls and Discharge Details

Sl. No.	Catchment No.	Outfall Location/ No	Existing Qcal m3/s	Type	Width	Height	V m/s	Q design m3/s
A	Princes Fly Over to Bandra Worli Sea Link							
1	134	PWD Office Outfall / A12	17	Box Culvert	6.00	4.00	5.06	121.54
		Sitalwad Lane Outfall / A13	18	Box Drain	3.00	2.00	3.19	19.14
		Kashinath Compound Outfall / A14	18	Box Drain	3.00	2.00	3.19	19.14
		Darabshaw Lane Outfall / A15	19	Box Drain	3.00	2.00	3.19	19.14
		Breach Candy Garden Outfall,Bhulabhai Desai Road / A16	18	Box Culvert	6.00	3.00	4.63	83.39
		Vaibhav Apartments Outfall / A17	19	Box Culvert	5.00	3.00	4.35	65.21
		Breach Candy/A18	19	Box Culvert	4.00	3.00	3.99	47.91
2	133	Breach Candy Hospital Outfall / A19	5	Box Drain	2.00	1.50	2.52	7.55
		Mafatalal Park Outfall / A20	6	Box Culvert	4.00	3.00	3.99	47.91
3	130-132	Haji Ali Juice Centre Outfall / A21	12	Box Drain	3.00	3.50	3.65	38.35
		Haji Ali Juice Centre Outfall / A22	22	Box Drain				
		Haji Ali Bypass/ A23	34	Box Culvert	5.00	4.00	4.71	94.23
4	131	Khan Abdul Gaffar Khan Marg / A52	6	Box Culvert	4.00	3.00	3.99	47.91
B	Bandra Worli Sea Link to Lalji Malad							
5	238	/ B15	11	Box Drain	2.00	2.50	2.83	14.3
		/ B16	9	Box Drain	2.00	2.00	2.70	10.79

Table 4-3: Proposed New Culverts along the Alignment

Chainage	Designation	Breadth (m)	Height (m)	Culvert discharge Capacity m^3/s
South Section				
7+940	CP-A 05	3.00	3.00	31.82
10+260	CP-A 06	3.00	3.00	31.82
10+920	CP-A 07	3.00	3.00	31.82
North Section				
00+000	CP -B 01	3.00	3.00	31.82
01+020	CP B 02	2.00	3.00	17.51
14+780	CP B 03	3.00	3.00	31.82

5. Drainage Design

5.1 Introduction

Drainage assumes paramount importance in all new developments including highways. Proposed Coastal road shall be constructed on sea ward side of the existing coast. The new road is proposed by carrying out reclamation inside intertidal zone. Such reclamation shall not only affect the existing storm water discharges, it also requires to adequately drain out new areas along with highway.

Extension of existing drains inside sea has already been discussed in chapter 4 of this report. Characteristics of precipitation, surface runoff and other parameters are presented in chapter 2.

5.2 Design of drains

Drains have been designed based on catchment area characteristics associated with each drain. Considering large four lane highway it is essential that carriageway surfaces are drained adequately. Drains are proposed on either side of the carriageway to cater for its drainage. Whereas, median drains has been proposed at the center of median to cater for large landscaped area of the median.

Both drains towards carriageway shall be provided with additional capacity to store flood as per guidelines provided in IRC.

5.3 Design Calculations

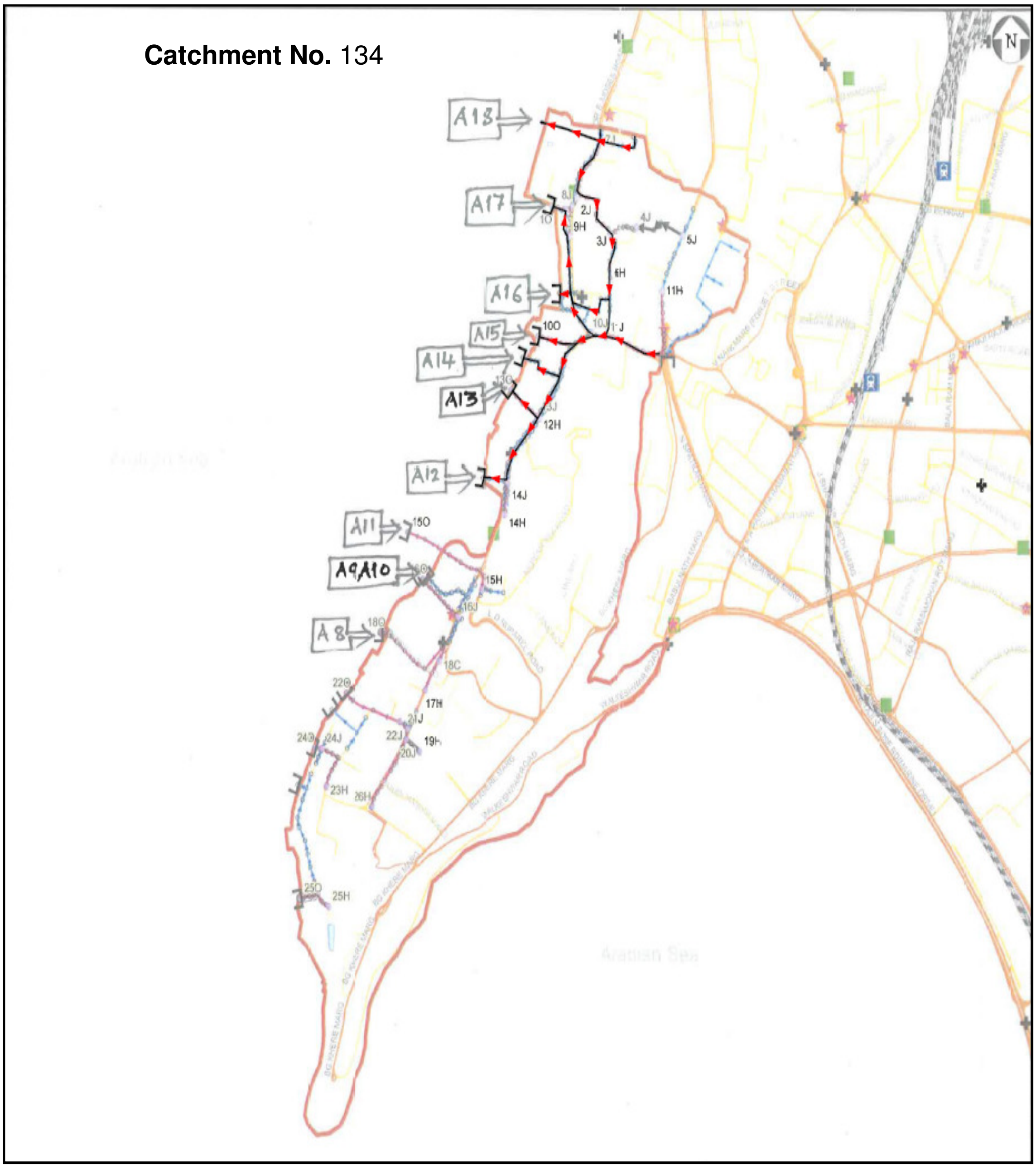
Catchment areas along the alignment, its associated characteristics, and design calculations are presented in the following Appendix's as given below

APPENDIX A	shows the Catchment areas along the Mumbai Coastal Road
APPENDIX B	shows the Details of Discharge Calculations of Proposed Drains
APPENDIX C	shows the Drain Schedule
APPENDIX D	Layout of Drain along the Proposed Alignment

Appendix A

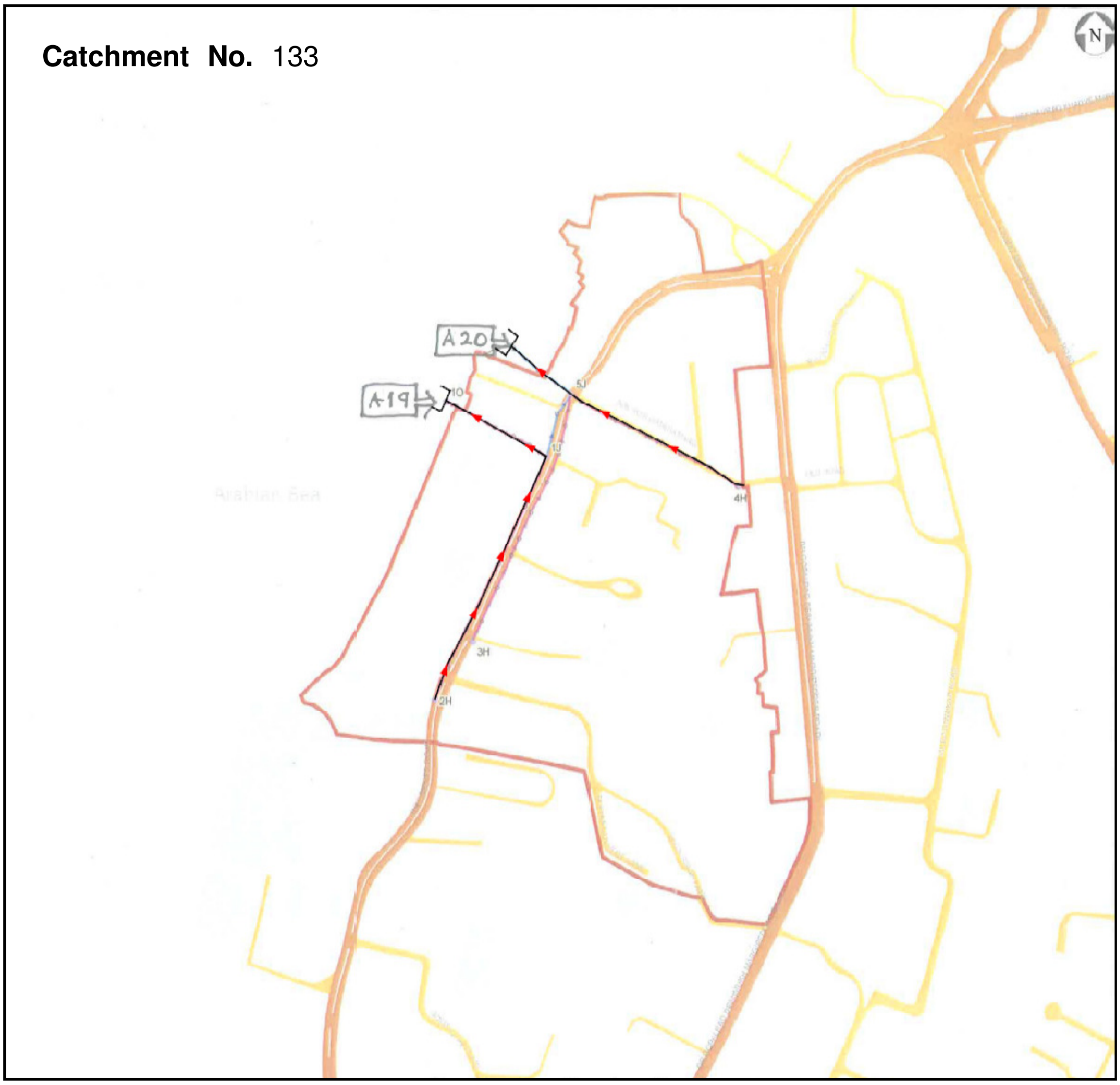
Catchment areas along the Mumbai Coastal Road

(i) SOUTH



Catchment No. 134

No. of Outfalls along the alignment - 7 - A12, A13, A14, A15, A16, A17, A18



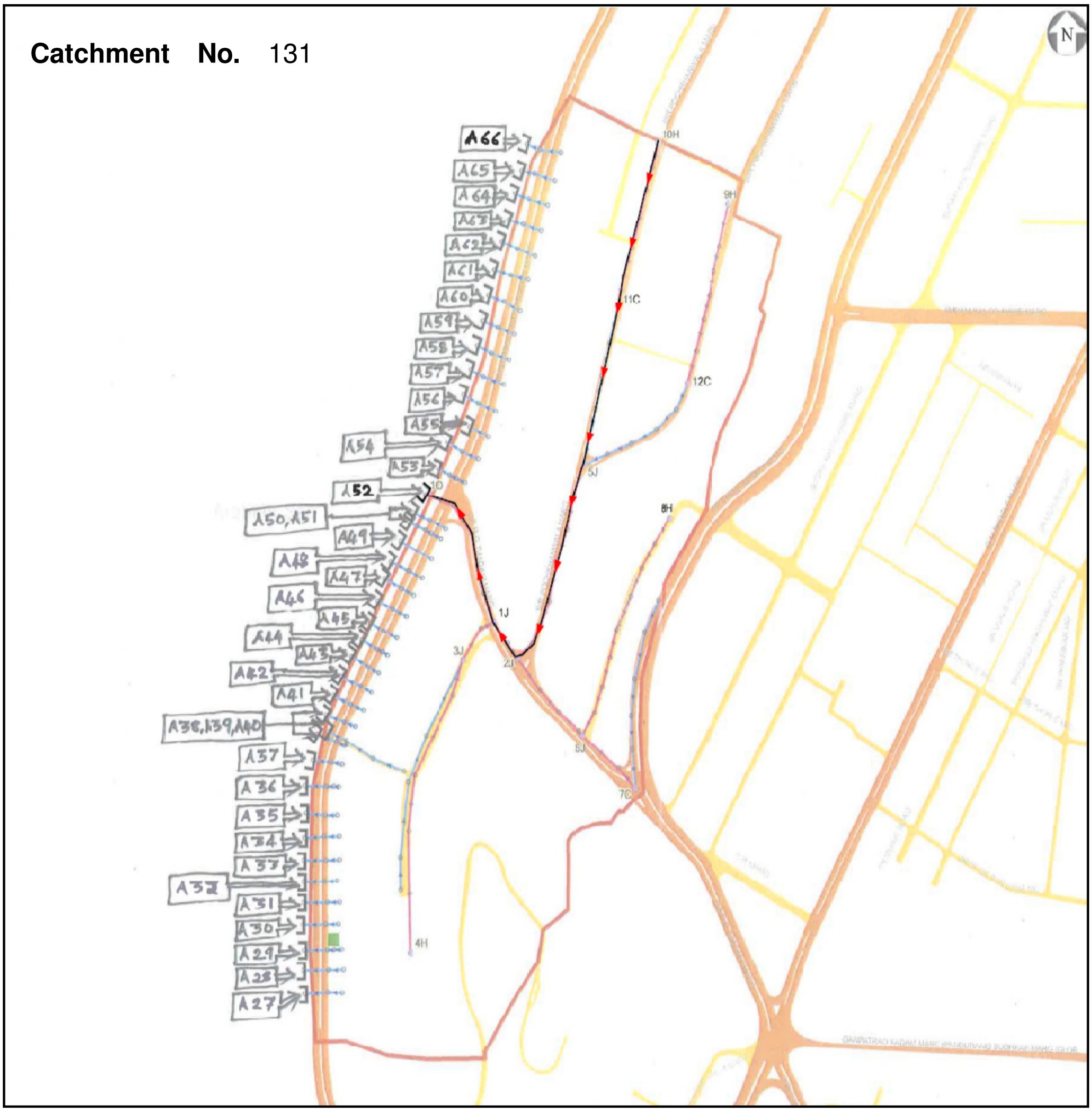
Catchment No. 133

No. of Outfalls along the alignment - 2 - A19, A20

Catchment No. 130-132

No. of Outfalls along the alignment - 4 - A21, A22, (A23-A25), A26

No of outfall affecting the alignment – A21, A22, A23



Catchment No. 131

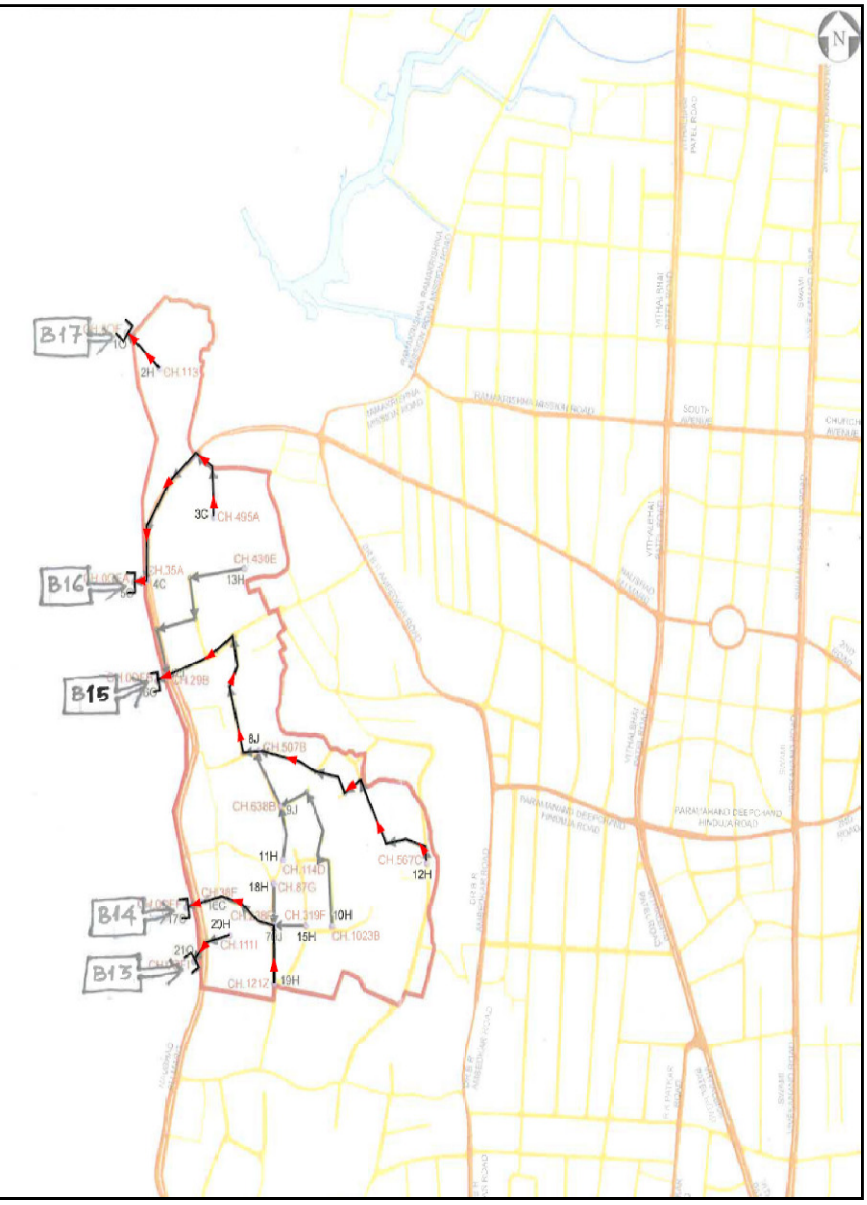
No. of Outfalls along the alignment - 1 - A52

[Note: Outfalls other than A52 do affect the alignment; these are considered in connecting with the proposed drains flows along the alignment]

(ii) NORTH

Since the North Section alignment mainly consists of land filled road over mangroves with arch type opening, bridge on sea/creek, elevated roads, road on stilts and Tunnels existing outfall locations are not affected. Also, new cross drainage structures are not necessary at such locations as water will be diverted directly to sea/ nallas through longitudinal drain sections.

Catchment No.
238



Catchment No. 238

No. of Outfalls - 2 - B15, B16.

Appendix B

SOUTH SECTION - Discharge Calculations

<table>
<tr><th colspan="9">PROPOSED DRAIN DETAILS</th><th colspan="6">PROPOSED CULVERT DETAILS</th></tr>
<tr><th>Sr. No.</th><th>Drain No.</th><th>Catchment area (Ha)</th><th>Q_{cal} m^3/s</th><th>B (m)</th><th>D (m)</th><th>V</th><th>Q_{prov} m^3/s</th><th>Total Q_{cal} m^3/s</th><th>Outfall Location</th><th>Culvert No</th><th>Width (m)</th><th>Height (m)</th><th>Culvert discharge Capacity m^3/s</th><th>Culvert discharge+Catchment area Discharge m^3/s</th></tr>
<tr><td>1</td><td>DA 06</td><td>2.89</td><td>7.29</td><td>2.00</td><td>2.00</td><td>2.70</td><td>10.79</td><td>7.29</td><td rowspan="5">6+050</td><td rowspan="5">A 16</td><td rowspan="5">6.00</td><td rowspan="5">3.00</td><td rowspan="5">83.39</td><td rowspan="5">62.21</td></tr>
<tr><td>2</td><td>DA 05 A</td><td>0.36</td><td>0.90</td><td>1.00</td><td>1.00</td><td>1.70</td><td>1.70</td><td>0.90</td></tr>
<tr><td>3</td><td>DA 06A</td><td>2.89</td><td>7.29</td><td>2.00</td><td>2.00</td><td>2.70</td><td>10.79</td><td>7.29</td></tr>
<tr><td>4</td><td>A15</td><td>-</td><td>-</td><td>3.00</td><td>2.00</td><td>3.19</td><td>19.14</td><td>18.89</td></tr>
<tr><td>5</td><td>DA 05 B</td><td>0.51</td><td>1.29</td><td>1.00</td><td>1.00</td><td>1.70</td><td>1.70</td><td>1.29</td></tr>
<tr><td colspan="15"></td></tr>
<tr><td>6</td><td>DA 06B</td><td>2.00</td><td>5.03</td><td>2.00</td><td>1.50</td><td>2.52</td><td>7.55</td><td>5.03</td><td rowspan="8">5+450</td><td rowspan="8">A 12</td><td rowspan="8">6.00</td><td rowspan="8">4.00</td><td rowspan="8">121.54</td><td rowspan="8">92.75</td></tr>
<tr><td>7</td><td>A14</td><td>-</td><td>-</td><td>3.00</td><td>2.00</td><td>3.19</td><td>19.14</td><td>18.50</td></tr>
<tr><td>8</td><td>DA 06C</td><td>1.64</td><td>4.14</td><td>3.00</td><td>3.00</td><td>3.54</td><td>31.82</td><td>30.83</td></tr>
<tr><td>9</td><td>A13</td><td>-</td><td>-</td><td>3.00</td><td>2.00</td><td>3.19</td><td>19.14</td><td>17.61</td></tr>
<tr><td>10</td><td>DA 06D</td><td>2.34</td><td>5.90</td><td>4.00</td><td>3.50</td><td>4.15</td><td>58.13</td><td>56.86</td></tr>
<tr><td>11</td><td>DA 06E</td><td>0.73</td><td>1.83</td><td>2.00</td><td>1.50</td><td>2.52</td><td>7.55</td><td>1.83</td></tr>
<tr><td>12</td><td>DA 05C</td><td>1.89</td><td>4.77</td><td>2.00</td><td>1.50</td><td>2.52</td><td>7.55</td><td>4.77</td></tr>
<tr><td>13</td><td>DA 05 D</td><td>0.41</td><td>1.02</td><td>1.00</td><td>1.50</td><td>1.84</td><td>2.76</td><td>1.02</td></tr>
<tr><td colspan="15"></td></tr>
<tr><td>14</td><td>DA 07</td><td>0.94</td><td>2.38</td><td>2.00</td><td>1.00</td><td>2.23</td><td>4.45</td><td>2.38</td><td rowspan="3">06+346</td><td rowspan="3">A 17</td><td rowspan="3">5.00</td><td rowspan="3">3.00</td><td rowspan="3">65.21</td><td rowspan="3">50.03</td></tr>
<tr><td>15</td><td>DA 08</td><td>5.89</td><td>14.83</td><td>3.00</td><td>2.00</td><td>3.19</td><td>19.14</td><td>14.83</td></tr>
<tr><td>16</td><td>DA 09</td><td>1.04</td><td>2.61</td><td>2.00</td><td>1.00</td><td>2.23</td><td>4.45</td><td>2.61</td></tr>
</table>

PROPOSED DRAIN DETAILS									PROPOSED CULVERT DETAILS					
Sr. No.	Drain No.	Catchment area (Ha)	Q_{cal} m^3/s	B (m)	D (m)	V	Q_{prov} m^3/s	Total Q_{cal} m^3/s	Outfall Location	Culvert No	Width (m)	Height (m)	Culvert discharge Capacity m^3/s	Culvert discharge+Catchment area Discharge m^3/s
17	DA 10	0.85	2.15	1.00	1.50	1.84	2.76	2.15						
18	DA 11	0.38	0.95	1.00	1.00	1.70	1.70	0.95	6+700	A 18	4.00	3.00	48.00	37.23
19	DA 12	0.43	1.08	1.00	1.50	1.84	2.76	1.08						
20	DA 13	3.52	8.88	2.00	2.00	2.70	10.79	8.88						
21	DA 14	1.01	2.55	1.00	1.50	1.84	2.76	2.55						
22	DA 15	0.75	1.89	1.00	1.50	1.84	2.76	1.89	07+210	A 20	4.00	3.00	47.94	42.04
23	DA 16	1.67	4.21	2.00	1.50	2.52	7.55	4.21						
24	DA 16 A	1.30	3.27	2.00	1.50	2.52	7.55	3.27						
25	DA 17	0.92	2.33	1.00	1.50	1.84	2.76	2.33						
26	DA 18	4.12	10.39	2.00	2.00	2.70	10.79	10.39						
27	A19	0.00	0.00	2.00	1.50	2.52	7.55	5.22						
28	DA 19	1.89	4.76	2.00	1.50	2.52	7.55	4.76	7+940	CP-A 05	3.00	3.00	31.82	21.67
29	DA 20	4.62	11.63	2.00	2.50	2.83	14.13	11.63						
30	A 21-22	0.00	0.00	3.00	3.50	3.65	38.35	34.38	8+150	A 23	5.00	4.00	94.23	82.01
31	DA 22 A	2.26	5.69	3.00	4.00	3.75	44.96	44.05						
32	DA 21 A	0.67	1.69	1.00	1.50	1.84	2.76	1.690						
33	DA 22	6.07	15.30	2.00	3.00	2.92	17.51	15.30	-	-	-	-	-	-
34	DA 21	1.33	3.34	1.00	2.00	1.92	3.84	3.34	-	-	-	-	-	-

PROPOSED DRAIN DETAILS									PROPOSED CULVERT DETAILS					
Sr. No.	Drain No.	Catchment area (Ha)	Q_{cal} m^3/s	B (m)	D (m)	V	Q_{prov} m^3/s	Total Q_{cal} m^3/s	Outfall Location	Culvert No	Width (m)	Height (m)	Culvert discharge Capacity m^3/s	Culvert discharge+Catchment area Discharge m^3/s
35	DA 23	0.93	2.36	1.00	1.50	1.84	2.76	2.36	-	-	-	-	-	-
36	DA 24	2.74	6.91	2.00	1.50	2.52	7.55	6.91	-	-	-	-	-	-
37	DA 25	0.87	2.18	1.00	1.50	1.84	2.76	2.18	-	-	-	-	-	-
38	DA 26	2.46	6.19	2.00	1.50	2.52	7.55	6.19	-	-	-	-	-	-
39	DA 27	0.50	1.25	1.00	1.00	1.70	1.70	1.25	-	-	-	-	-	-
40	DA 28	0.74	1.86	1.00	1.50	1.84	2.76	1.86	-	-	-	-	-	-
41	DA 29	0.89	2.25	2.00	1.00	2.23	4.45	2.25	10+260	CP-A 06	3.00	3.00	31.82	24.00
42	DA 30	1.66	4.18	2.00	1.50	2.52	7.55	4.18						
43	DA 31	1.41	3.56	2.00	1.00	2.23	4.45	3.56						
44	DA 32	2.12	5.33	2.00	1.50	2.52	7.55	5.33						
45	DA 33	1.07	2.71	2.00	1.00	2.23	4.45	2.71	10+920	CP-A 07	3.00	3.00	31.82	25.70
46	DA 34	1.57	3.95	2.00	1.50	2.52	7.55	3.95						
47	DA 35	0.11	0.28	1.00	1.00	1.70	1.70	0.28						
48	DA 36	0.21	0.52	1.00	1.00	1.70	1.70	0.52						
49	DA 37	0.71	1.79	1.00	1.50	1.84	2.76	1.79	11+150	A52	4.00	3.00	47.91	31.54
50	DA 38	1.53	3.86	2.00	1.50	2.52	7.55	3.86						
51	DA 39	0.35	0.87	2.00	1.50	2.52	7.55	0.87						
52	DA 40	0.91	2.30	2.00	1.50	2.52	7.55	2.30						

PROPOSED DRAIN DETAILS									PROPOSED CULVERT DETAILS					
Sr. No.	**Drain No.**	**Catchment area (Ha)**	**Q_{cal} m^3/s**	**B (m)**	**D (m)**	**V**	**Q_{prov} m^3/s**	**Total Q_{cal} m^3/s**	**Outfall Location**	**Culvert No**	**Width (m)**	**Height (m)**	**Culvert discharge Capacity m^3/s**	**Culvert discharge+Catchment area Discharge m^3/s**
53	DA 41	1.53	3.86	2.00	1.50	2.52	7.55	3.86	-	-	-	-	-	-
54	DA 42	5.54	13.96	2.00	2.50	2.83	14.13	13.96	-	-	-	-	-	-

- DA * Proposed South Drain No.
- CP A* Proposed Culvert No. South
- A * South Side Outfall No.

NORTH SECTION - Discharge Calculations

Proposed Drain Details									Proposed Culvert Details					
Sr. No.	**Catchment area**	**Drain No.**	**Catchment area (Ha)**	**Q_{cal} m^3/s**	**B (m)**	**D (m)**	**Q_{prov} m^3/s**	**Total $Q_{cal,}$ m^3/s**	**Outfall Location**	**Culvert No**	**Width (m)**	**Height (m)**	**Culvert discharge Capacity m^3/s**	**Culvert discharge +Catchment area Discharge m^3/s**
1	36152	DB 01	3.62	9.11	2.00	2.00	10.79	9.11	00+000	CP -B 01	3	3	31.82	21.58
2	21532	DB 02	2.15	5.43	2.00	2.00	10.79	5.43						
3	14958	DB 03	1.50	3.77	1.00	2.00	3.84	3.77	01+020	CP B 02	2.00	3.00	17.51	12.11
4	6934	DB 04	0.69	1.75	1.00	1.50	2.76	1.75						
5	7946	DB 05	0.79	2.00	1.00	1.50	2.76	2.00						
6	3864	DB 06	0.39	0.97	1.00	1.50	2.76	0.97						
7	48124	DB 07	4.81	12.13	2.00	2.50	14.13	12.13	-	-	-		-	-
8	28319	DB 08	2.83	7.14	2.00	1.50	7.55	7.14	-	-	-		-	-
9	21425	DB 09	2.14	5.40	2.00	1.50	7.55	5.40	-	-	-		-	-
10	9386	DB 10	0.94	2.37	2.00	1.00	4.45	2.37	-	-	-		-	-
11	6617	DB 11	0.66	1.67	2.00	1.00	4.45	1.67	-	-	-		-	-
12	0	B 16	0.00	0.00	2.00	2.00	10.79	8.55	-	-	-		-	-
13	33564	DB 13	3.36	8.46	3.00	2.50	25.40	19.25	-	-	-		-	-
14	0	B 15	0.00	0.00	2.00	2.50	14.13	10.85	-	-	-		-	-
15	30155	D B 12	3.02	7.60	4.00	3.00	47.91	39.53	-	-	-		-	-
16	9773	DB014	0.98	2.46	1.00	1.50	2.76	2.46	-	-	-		-	-
17	10106	DB015	1.01	2.55	1.00	1.50	2.76	2.55	-	-	-		-	-
18	1594	DB016	0.16	0.40	1.00	1.50	2.76	0.40	-	-	-		-	-

Proposed Drain Details									Proposed Culvert Details					
Sr. No.	**Catchment area**	**Drain No.**	**Catchment area (Ha)**	**Q_{cal} m^3/s**	**B (m)**	**D (m)**	**Q_{prov} m^3/s**	**Total $Q_{cal,}$ m^3/s**	**Outfall Location**	**Culvert No**	**Width (m)**	**Height (m)**	**Culvert discharge Capacity m^3/s**	**Culvert discharge +Catchment area Discharge m^3/s**
19	1594	DB017	0.16	0.40	1.00	1.50	2.76	0.40	-	-	-		-	-
20	1072	DB 18	0.11	0.27	1.00	1.00	1.70	0.27	14+780	CP B 03	3.00	3.00	31.82	21.22
21	1072	DB 19	0.11	0.27	1.00	1.00	1.70	0.27						
22	12655	DB 20	1.27	3.19	2.00	1.00	4.45	3.19						
23	13333	DB 21	1.33	3.36	2.00	1.00	4.45	3.36						
24	4794	DB22	0.48	1.21	2.00	1.00	4.45	1.21						
25	4737	DB23	0.47	1.19	2.00	1.00	4.45	1.19						

- DB * Proposed North Drain No. CP B * Proposed Culvert No. North B * North Side Outfall No.

Appendix C

Drain Schedule

SCHEDULE OF DRAIN/CULVERT (SOUTH)								
Sr. No	Drain No.	Culvert No.	Start Chainage	End Chainage	Length of Drain l (m)	Length of Drain l (km)	Size	
1	DA 05 D		5+250	5+450	200	0.200	1.00	1.50
2	DA 05 C		5+900	5+450	450	0.450	2.00	1.50
3	DA 06 E		5+450	5+250	200	0.200	2.00	1.50
4	DA 06 D		5+700	5+450	327	0.327	4.00	3.50
5	A 13		5+700		123	0.123	3.00	2.00
6	DA 06 C		5+800	5+700	100	0.100	3.00	3.00
7	A 14		5+800		154	0.154	3.00	2.00
8	DA 06 B		5+900	5+800	100	0.100	2.00	1.50
9		A12	5+450		93	0.093	6.00	4.00
10	A 15		5+900		149	0.149	3.00	2.00
11	DA 05 B		5+900	6+050	150	0.150	1.00	1.00
12	DA 06 A		5+900	6+050	150	0.150	2.00	1.50
13	DA 06		6+150	6+050	100	0.100	2.00	2.00
14	DA 05 A		6+150	6+050	100	0.100	1.00	1.00
15		A 16	6+050		325	0.325	5.00	3.00
16	DA 07		6+150	6+346	196	0.196	2.00	1.00
17	DA 08		6+150	6+346	196	0.196	3.00	2.00
18	DA 09		6+600	6+346	254	0.254	2.00	1.00
19	DA 10		6+600	6+346	254	0.254	1.00	1.50
20		A17	6+346		306	0.306	5.00	3.00
21	DA 11		6+600	6+700	100	0.100	1.00	1.00
22	DA 12		6+600	6+700	100	0.100	1.00	1.50
23	DA 13		7+000	6+700	300	0.300	2.00	2.00
24	DA 14		7+000	6+700	300	0.300	1.00	1.50
25		A 18	6+700		99	0.099	4.00	3.00
26	DA 15		7+000	7+210	210	0.210	1.00	1.50
27	DA 16		7+000	7+120	120	0.120	2.00	1.50
28	DA 16 A		7+120	7+210	90	0.090	2.00	1.50
29	A 19		7+120		103	0.103	2.00	1.50
30	DA 17		7+470	7+210	260	0.260	1.00	1.50
31	DA 18		7+470	7+210	260	0.260	2.00	2.00
32		A 20	7+210		264	0.264	4.00	3.00

SCHEDULE OF DRAIN/CULVERT (SOUTH)								
Sr. No	Drain No.	Culvert No.	Start Chainage	End Chainage	Length of Drain l (m)	Length of Drain l (km)	Size	
33	DA 19		7+470	7+940	470	0.450	2.00	1.50
34	DA 20		7+470	7+940	470	0.450	2.00	2.50
35		CP A 05	7+940		77	0.077	3.00	3.00
36	DA 21 A		7+940	8+150	210	0.150	1.00	1.50
37	DA 22 A		7+940	8+150	210	0.150	3.00	4.00
	A21 - A23		8+000		97	0.097	3.00	3.50
38		A 23	8+150		193	0.193	5.00	4.00
39	DA 21		8+150	8+700	600	0.600	1.00	2.00
40	DA 22		8+150	8+700	600	0.600	2.00	3.00
41	DA 23		9+500	9+100	400	0.400	1.00	1.50
42	DA 24		9+500	9+100	400	0.400	2.00	1.50
43	DA 25		9+500	9+750	250	0.250	1.00	1.50
44	DA 26		9+500	9+750	250	0.250	2.00	1.50
45	DA 27		10+000	9+860	140	0.140	1.00	1.00
46	DA 28		10+000	9+860	140	0.140	1.00	1.50
47	DA 29		10+000	10+260	260	0.260	2.00	1.00
48	DA 30		10+000	10+260	260	0.260	2.00	1.50
49	DA 31		10+650	10+260	390	0.390	2.00	1.00
50	DA 32		10+650	10+260	390	0.390	2.00	1.50
51		CP A 06	10+260		112	0.112	3.00	3.00
52	DA 33		10+650	10+920	270	0.270	2.00	1.00
53	DA 34		10+650	10+920	270	0.270	2.00	1.50
54	DA 35		10+950	10+920	30	0.030	1.00	1.00
55	DA 36		10+950	10+920	30	0.030	1.00	1.00
56		CP A 07	10+920		118	0.118	3.00	3.00
57	DA 37		11+150	10+950	200	0.200	1.00	1.50
58	DA 38		11+150	10+950	200	0.200	2.00	1.00
59	DA 39		11+290	11+150	140	0.140	2.00	1.50
60	DA 40		11+290	11+150	140	0.140	2.00	1.50
61	DA 41		11+290	11+690	400	0.400	2.00	1.50
62	DA 42		11+290	11+690	400	0.400	2.00	2.50

- DA* Proposed South Drain No.
- CP A * Proposed Culvert No. South
- A * South Side Outfall No.

SCHEDULE OF DRAIN/CULVERT (NORTH)								
Sr. No	Drain No.	Culvert No.	Start chainage	End Chainage	Length of Drain l (m)	Length of Drain l (km)	Size	
							B (m)	D(m)
1	DB - 01	-	0+550	0+000	513.00	0.513	2.00	2.00
2	DB - 02	-	0+550	0+000	511.00	0.511	2.00	2.00
3	-	CP B -01	0+000		117.00	0.117	3.00	3.00
4	DB - 03	-	0+650	1+020	432.00	0.432	1.00	2.00
5	DB - 04	-	0+650	1+020	349.00	0.349	1.00	1.50
6	DB - 05	-	1+210	1+020	181.78	0.182	1.00	1.50
7	DB - 06	-	1+210	1+020	173.00	0.173	1.00	1.50
8		CP B -02	1+020		81.00	0.081	2.00	3.00
9	DB - 07	-	1+210	2+560	1334.00	1.334	2.00	2.50
10	DB - 08	-	1+211	2+560	1291.00	1.291	2.00	1.50
11	DB - 09	-	4+720	3+360	1360.00	1.360	2.00	1.50
12	DB - 10	-	3+800	3+360	436.00	0.436	1.00	2.00
13	DB - 11	-	3+800	3+980	160.00	0.160	2.00	1.00
14	DB - 12	-	4+500	4+320	178.00	0.178	4.00	3.00
15	B15	-	4+500		148.00	0.148	2.00	2.50
16	B16	-	4+700		77.00	0.077	2.00	2.00
17	DB - 13	-	4+800	4+500	317.00	0.317	3.00	2.50
18	DB - 14	-	14+200	13+800	400.00	0.40	1.00	1.50
19	DB - 15	-	14+201	13+800	400.00	0.40	1.00	1.50
20	DB - 16	-	14+200	14+100	137	0.14	1.00	1.50
21	DB - 17	-	14+200	14+100	137	0.14	1.00	1.50
22	DB - 18	-	14+200	14+310	105	0.11	1.00	1.00
23	DB - 19	-	14+200	14+310	105	0.11	1.00	1.00
24	DB - 20	-	14+200	14+780	570	0.57	2.00	1.00
25	DB - 21	-	14+200	14+780	570	0.57	2.00	1.00
26	DB - 22	-	15+100	14+780	335	0.34	2.00	1.00
27	DB - 23	-	15+100	14+780	335	0.34	2.00	1.00
28	-	CP B -03	14+780		63	0.06	3.00	3.00

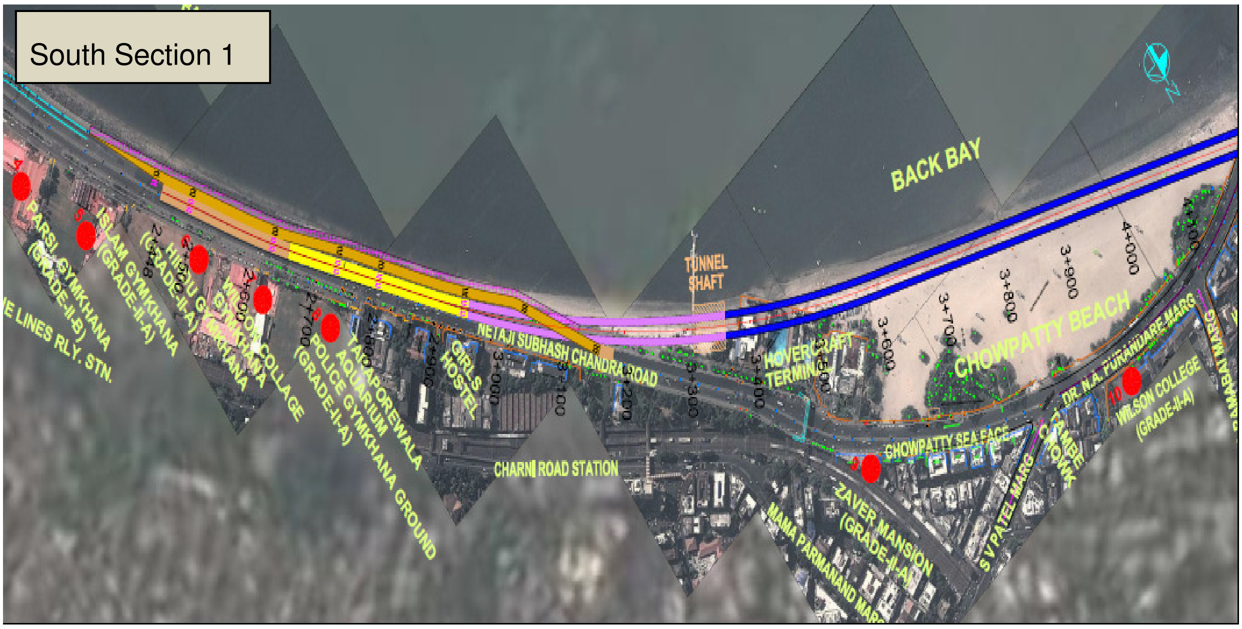
DB * Proposed North Drain No. CP B * Proposed Culvert No. North

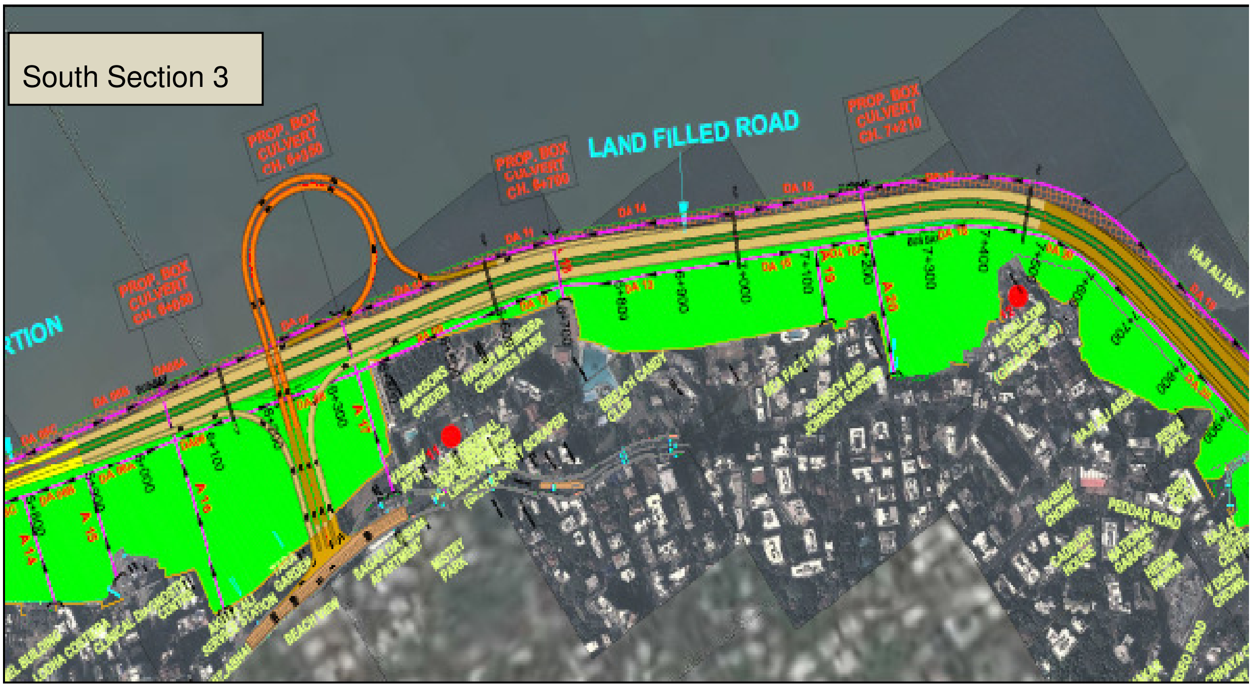
B * North Side Outfall No.

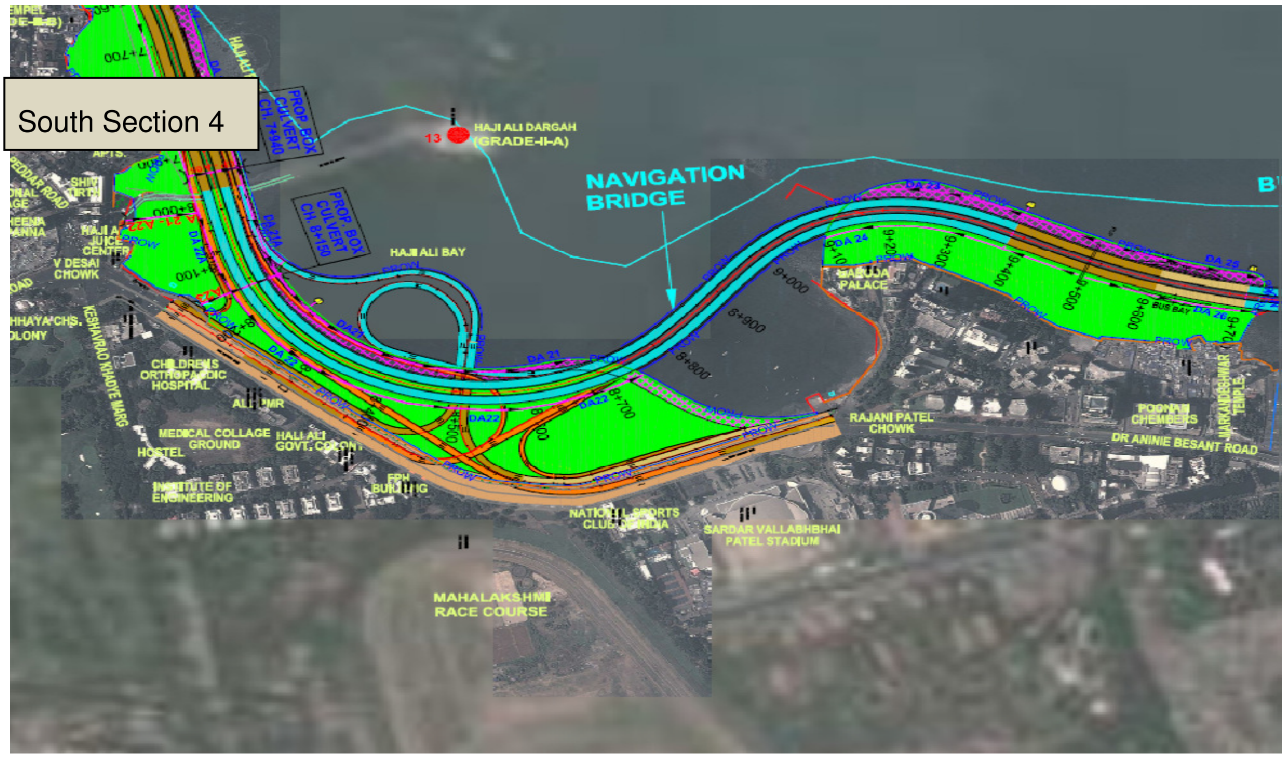
Appendix D

Layout of Drain along Proposed Alignment

South Section

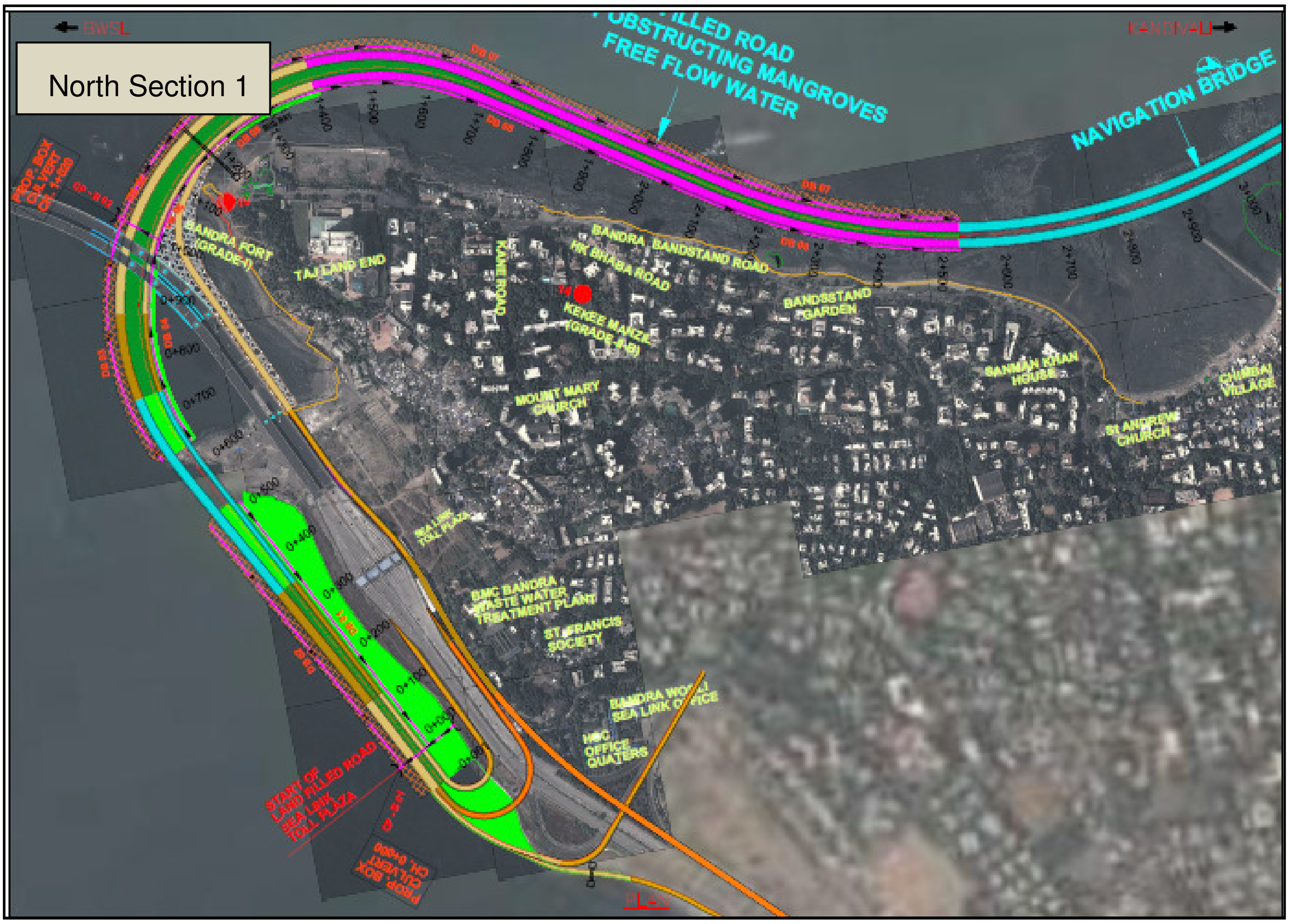


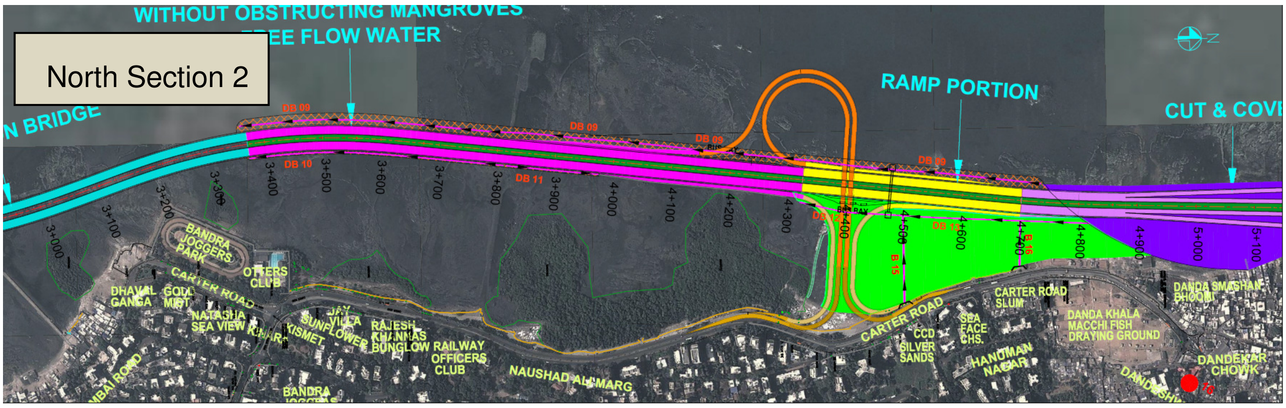

South Section 3
LAND FILLED ROAD

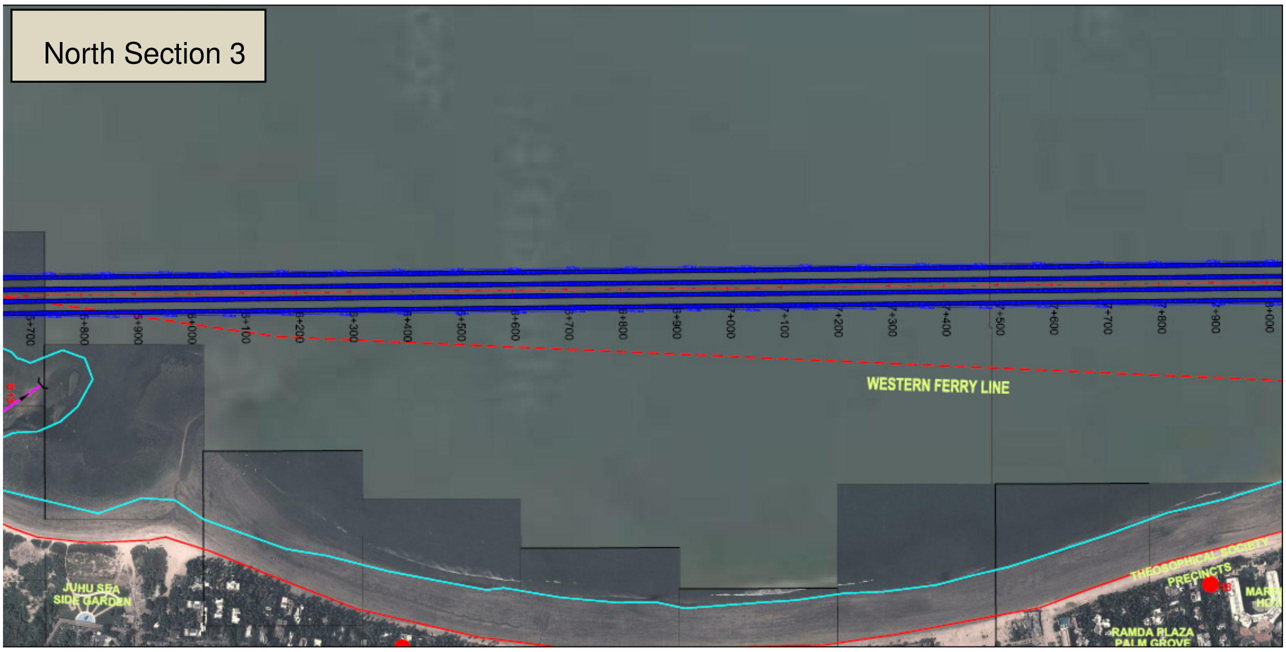

South Section 4
HAJI ALI DARGAH (GRADE-II-A)
NAVIGATION BRIDGE
HAJI ALI BAY
RAJANI PATEL CHOWK
SARDAR VALLABHBHAI PATEL STADIUM
MAHALAKSHMI RACE COURSE

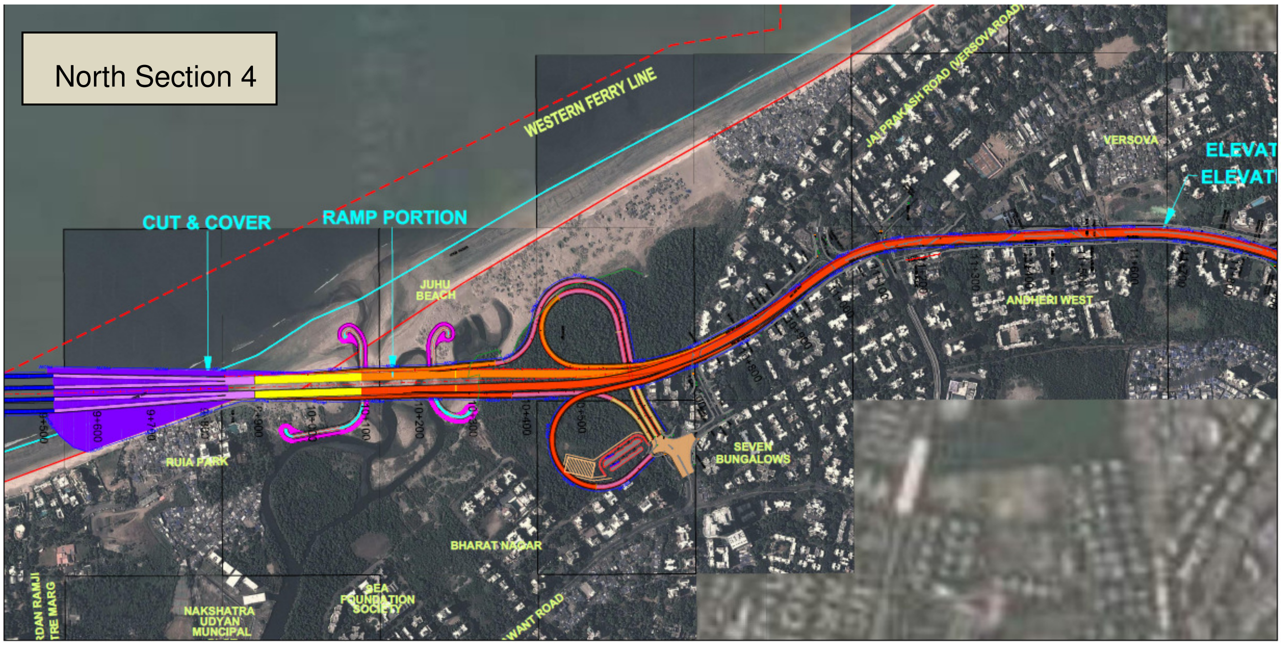

South Section 5
LAND FILLED ROAD
PROP. BOX CULVERT CH. 10+920
PROP. BOX CULVERT CH. 11+150
BRIDGE
BANDRA WORLI SEA LINK
DAIRY COLONY
WORLI DAIRY
HILL TRAINING CENTER
SHOOT BANGLA
VENUS APTS.

North Section



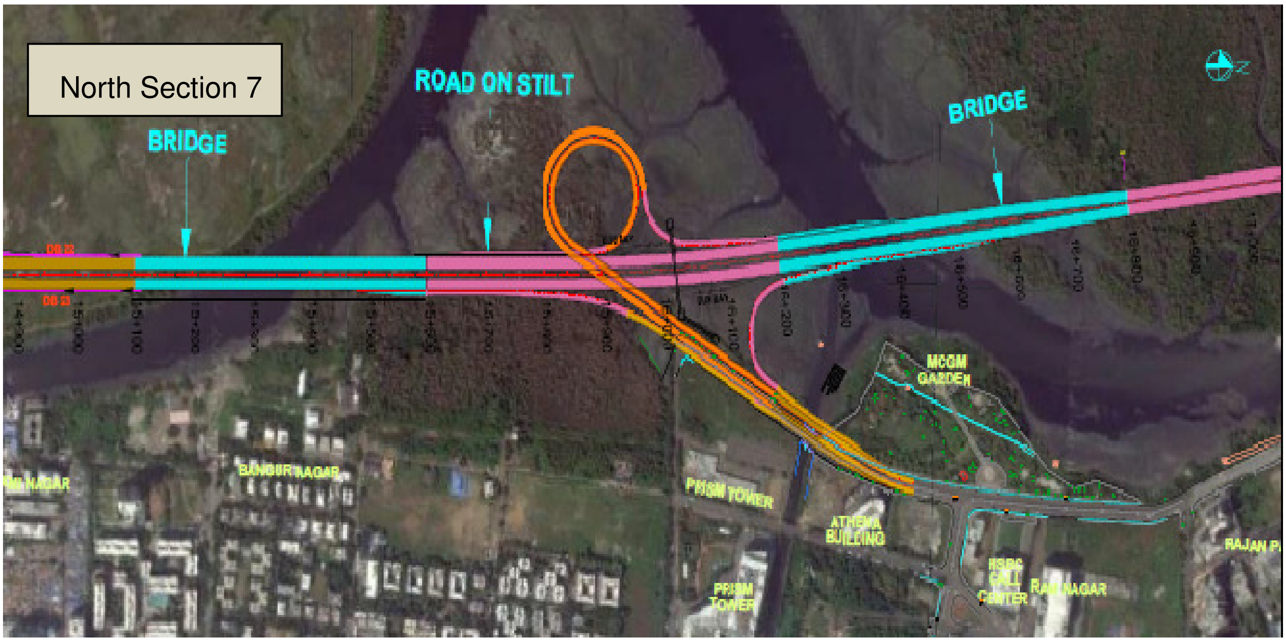


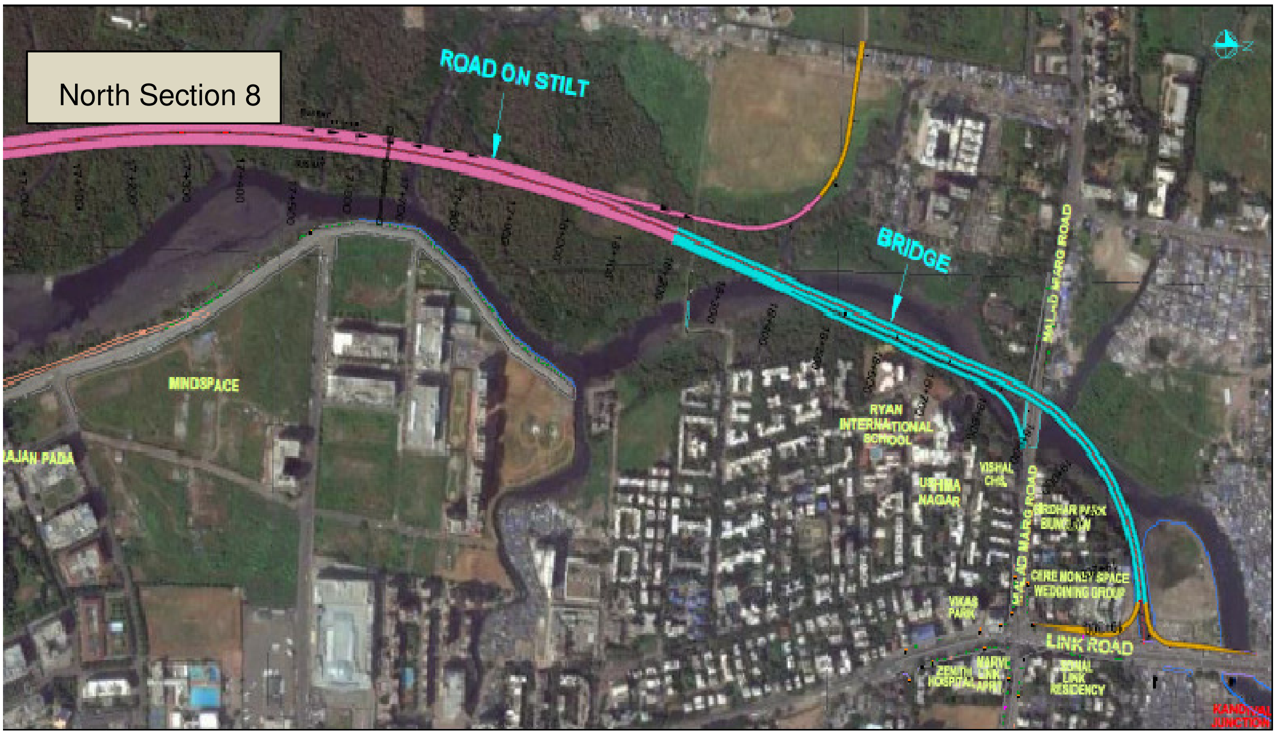

North Section 3
WESTERN FERRY LINE
JUHU SEA SIDE GARDEN
THEOSOPHICAL SOCIETY PRECINCTS
RAMDA PLAZA PALM GROVE


North Section 4
WESTERN FERRY LINE
CUT & COVER
RAMP PORTION
JUHU BEACH
JAI PRAKASH ROAD (VERSOVA ROAD)
VERSOVA
ANDHERI WEST
SEVEN BUNGALOWS
RUIA PARK
BHARAT NAGAR
SEA FOUNDATION SOCIETY
NAKSHATRA UDYAN MUNCIPAL


North Section 5
VERSOVA
ELEVATED ROAD 1st LEVEL
ELEVATED ROAD 2nd LEVEL
CENTRAL INSTITUTE OF FISHERIES EDUCATION
ELEVATED ROAD
BSES POWER SUB STATION
LOKHANDAWALA LAKE
ANDHERI WEST
S.V.P NAGAR (MAHADA COMPLEX)
BROOKHILL TOWER
OBEROI SKY HEIGHT


North Section 6
D 2nd LEVEL
BRIDGE
SURFACE ROAD
RE WALL ROAD


North Section 7
ROAD ON STILT
BRIDGE
BRIDGE
MCGM GARDEN
BANGUR NAGAR
PRISM TOWER
ATHENA BUILDING
PRISM TOWER
HSBC CALL CENTER
RAM NAGAR


North Section 8
ROAD ON STILT
BRIDGE
MINDSPACE
RAJAN PADA
RYAN INTERNATIONAL SCHOOL
USHMA NAGAR
VISHAL CHS.
MALAD MARG ROAD
LINK ROAD
VIKAS PARK