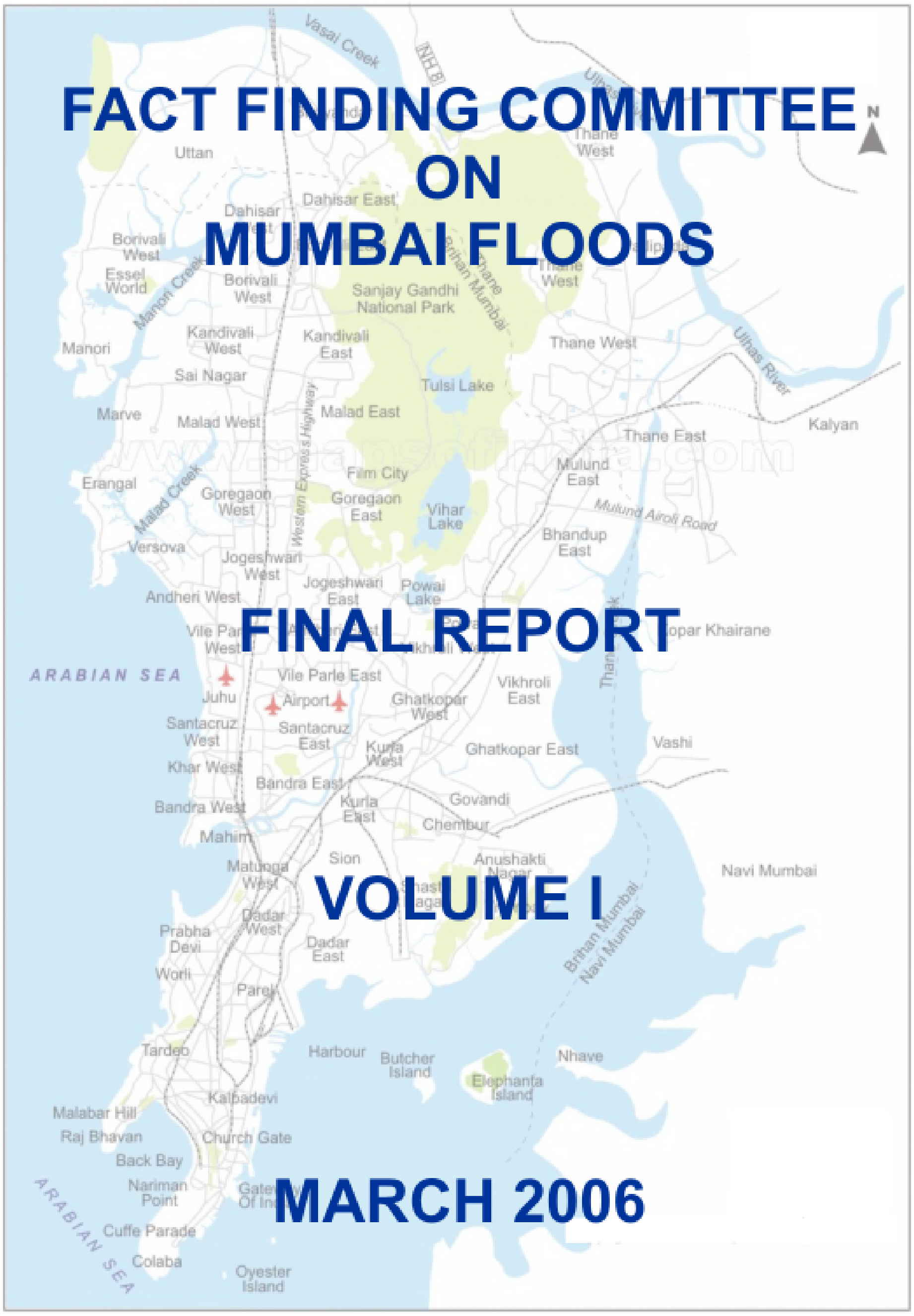
FACT FINDING COMMITTEE ON MUMBAI FLOODS



FINAL REPORT

VOLUME I

MARCH 2006

INDEX

VOLUME I

VOLUME II

Abbreviations

AAI	-	Airport Authority of India
ALM	-	Advance Locality Management
AMC	-	Additional Municipal Commissioner
B & P	-	Binnie & Partners
BARC	-	Bhabha Atomic Research Center
BEST	-	Brihanmumbai Electric Supply & Transport
BMP		Best Management Practices
BOD	-	Biochemical Oxygen Demand
BRIMSTOWAD	-	Brihanmumbai Storm Water Drainage
BUDP	-	Bombay Urban Development Project
BWSL	-	Bandra Worli Sea Link
CD	-	Chart Datum / Cross Drainage
Ch. E.	-	Chief Engineer
CIDCO	-	City & Industrial Development Corporation
CL	-	Center Line
COD	-	Chemical Oxygen Demand
CR	-	Central Railways
CRZ	-	Coastal Regulation Zone
CS	-	Cross Section
CST	-	Chatrapati Shivaji Terminus
CST Road	-	Coorla Salsette Tramway Road
CW&PRS	-	Central Water & Power Research Station
D.P.	-	Development Plan
DCR	-	Development Control Rule
Dia	-	Diameter
DMC	-	Deputy Municipal Commissioner
DMP	-	Disaster Management Plan
DO	-	Dissolved Oxygen
Dy.Ch.E.	-	Deputy Chief Engineer
E.S.	-	Eastern Suburb
EEH	-	Eastern Express Highway
EPS	-	Effluent Pumping Station

FFC	-	Fact Finding Committee
FSI	-	Floor Space Index
FSL	-	Full Supply Level
G.I.S.	-	Geographical Information System
G.T.S.	-	Great Trigonometrically Survey of India
GL	-	Ground Level
GOI	-	Government of India
GOM	-	Government of Maharashtra
Ha	-	Hectare
HFL	-	Highest Flood Level
HTL	-	High Tide Level
IAS	-	Indian Administrative Services
IIT	-	Indian Institute Technology
IITM	-	Indian Institute of Tropical Meteorology
IL	-	Invert Level
IMD	-	India Meteorology Department
IPS	-	Influent Pumping Station
IRS	-	Institute of Remote Sensing
Km	-	Kilometer
LGP	-	Love Grove Pumping
LPCD	-	Litres Per Capita Per Day
LS	-	Longitudinal Section
M.C.G.M.	-	Municipal Corporation of Greater Mumbai
MMC Act	-	Mumbai Municipal Corporation Act
M.S.L.	-	Mean Sea Level
MbPT	-	Mumbai Port Trust
Mg/L	-	Milligram per Litre
MHADA	-	Maharashtra Housing and Area Development Authority
MIS	-	Management Information System
MLD	-	Million Liters per Day
MMR	-	Mumbai Metropolitian Region
MMRDA	-	Mumbai Metropolitan Regional Development Authority

MOEF	-	Ministry of Environment & Forest
MPC	-	Metropolitan Planning Committee
MPCB	-	Maharashtra Pollution Central Board
MRTPA	-	Maharashtra Regional & Town Planning Act
MSDP	-	Mumbai Sewage Disposal Project
MSRDC	-	Maharashtra State Road Development Corporation
MSW	-	Municipal Solid Waste
MT	-	Metric Tonne
MTNL	-	Mahanagar Telephone Nigam Ltd.
MUIP	-	Mumbai Urban Infrastructure Project
MUTP	-	Mumbai Urban Transport Project
NEERI	-	National Environmental Engineering Research Institute
NGO	-	Non Governmental Organisation
NIT	-	National Institute of Technology
O & M	-	Operation & Maintenance
P & T	-	Post & Telegraph
P.W.D.	-	Public Works Department
RD	-	Reduced Distance
S.P.	-	Sewerage Project
S.W.D.	-	Storm Water Drains
SNDT	-	Shrimati Nathibai Damodar Thackersey
SRA	-	Slum Rehabilitation Authority
SSP	-	Slum Sanitation Programme
SW	-	Storm Water
SWM	-	Solid Waste Management
T.H.D.	-	Town Hall Datum
TDR	-	Transfer of Development Rights
TBM	-	Tunnel Boring Machine / Temporary Benchmark
TCE	-	Tata Consulting Engineers
TISS	-	Tata Institute of Social Sciences
ULCRA	-	Urban Land Ceiling Regulation Act
VJTI	-	Veermata Jijabai Technical Institute
W.S.	-	Western Suburb

W.S.P.	-	Water Supply Projects
WAPCOS	-	Water & Power Consultancy Services (India) Ltd.
WC	-	Water Closet
WEH	-	Western Express Highway
WWTF	-	Waste Water Treatment Facility

CHAPTER 1

PREAMBLE

Mumbai faced heavy rains on 26th and 27th July 2005. This resulted in the flooding of many parts of the Mumbai City and Suburbs. Roads and railway lines at many places were under water for more than 24 hours. The rail and road traffic came to a halt. The airport was also closed on account of water logging and climatic reasons. People at large were caught off guard. They were stranded for many hours. Thousands had to wade through water which was anything from knee deep to neck deep. Electric supply for many areas in the Suburbs was off for several days. Many lives were lost. The rains and the floods had also caused considerable damage to Public and Private Properties.

Govt. of Maharashtra appointed a Fact Finding Committee on these Mumbai Floods vide its decision under GR No. BMC/2324/05 C.No. 97/UD-21 dated 19th August 2005 comprising the following members.

1.	Dr.Madhavrao Chitale,	Chairman
2.	Shri Shirish Patel,	Member
3.	Dr. Shyam Asolekar,	Member
4.	Shri Nandkumar S. Salvi,	Member
5.	Shri Madhukar V.Patil,	Member
6.	Principal Secretary, Planning,	Member
7.	Principal Secretary, U.D.	Member
8.	Jt. Secretary and Director, U.D.	Invitee

The scope of work assigned to the committee was as below:

1. To analyse the short-term and long-term factors responsible for the situation that arose during July 26 to 29 in Mumbai City and suburbs.
2. To analyse the present status, deficiencies and limitations, of the Storm Water and Sewerage Disposal Systems, their development plans and their implementation.
3. To study the development of the various rivers and their basins in Mumbai City & the Suburbs and the administrative, technical and other factors responsible for ineffective routing of the natural flow in their watersheds.
4. To suggest guiding principles for preparation of short-term and long term development plans to overcome this situation.

A time period of 3 months was initially provided for the committee, which was further extended up to 31st March, 2006.

The first meeting of the Fact Finding Committee was held on 30th August, 2005, wherein It was decided to request Shri M.V. Deshmukh, Invitee of the Fact Finding Committee, Director & Fire Advisor to the Urban Development Deptt., Government of Maharashtra to function as a Secretary of the Committee. He was kind enough to extend his services to the Committee on voluntary basis in addition to his normal duties and responsibilities. The Committee was provided with an office and necessary office staff in Mantralaya. All the documents and the communications

meant for the FFC were received and kept in the Committee's administrative office in Mantralaya and the routine correspondence was handled there. But the technical support in collection, computation and analysis of the information along with preparation of new drawings & maps were provided by the office of the Dy. Municipal Commissioner (Environment & Waste Management) at Love Grove Pumping Station of Municipal Corporation of Greater Mumbai. Compilation of the final report was also arranged by this technical office.

In view of the large magnitude of the technical work involved, the need for support from some specialized technical persons was felt. Accordingly a request was made to the Urban Development Department, Government of Maharashtra. The services of many staff members from the Municipal Corporation of Greater Mumbai were made available for the Committee as and when required. As such, the total staff support that became available to the Committee was as per list attached. No professional, technical or administrative officer was engaged on full time basis for the work of the Committee. The voluntary work team provided all the needed support & deserves all the appreciation. All these officers and staff members willingly extended their services whole-heartedly. Without them, it would not have been possible for the Committee to pursue the work and to complete it as required. From amongst them, there was particularly a long-term involvement on a continuous basis from Shri Sanglikar, Shri Pahade, Shri Narkar, Smt. Marathe & Shri Kamble – right up to the phase of completion of the report. Their devotion to this work was exemplary.

In all, the Committee conducted 48 sittings. Written presentations were received by the Committee from a number of Government, Semi-Government organizations and political, social & professional groups as well as from individual experts. Their list is appended herewith. Initially discussions were held with the representatives of the political, social, academic organisations, residents' association's and individuals whoever presented written proposals for the consideration of the Committee. The Committee had an inter-action with the Indian Water Works Association and Marathi Vidnyan Parishad. They volunteered to conduct workshops in which analysis of the factual conditions during the deluge could take place and the possible remedial measures could be discussed. Indian Water Works Association organized a seminar-cum-workshop on storm water drains where many experts made their presentation, which were found to be very useful to the Committee. Marathi Vidnyan Parishad organized a field visit to the areas in the neighborhood of Chunabhatti and an interactive workshop with the representatives of the resident's association in the neighborhood. That helped us to understand the various expectations of the residents from the public civic services regarding storm water management.

The Committee members made site visits individually and in groups as necessary to the affected areas i.e. Kalina, Kurla, Juhu-Airport, Malad, Goregaon, Dahisar, Mulund, Bhandup, Hiranandani, Vihar & Powai Lake, Ghatkopar, Sakinaka, Grant Road, N.M.Joshi Road, Lower Parel, Parel, Chinchpokali, Lalbaug, Dadar, Wadala, Matunga (E) & (W), Bandra-Kurla Complex, Antop Hill, Reay Road, Dockyard Road, Cotton Green, Sewree, Chembur, Govandi, Mankhurd, Anik-Wadala etc. In addition, the Committee also made a special visit to Santacruz Airport in the company with the Airport Authority officers.

The Committee also visited the Central Water & Power Research Station (C.W.P.R.S.) at Khadakwasla, Pune & the Indian Institute of Tropical Meteorology, Pune (IITM). The physical model of the Mithi River prepared by the C.W.P.R.S., Khadakwasla, Pune was seen & discussions were held with the C.W.P.R.S. staff working on the Mithi problem. Discussions were held with the I.I.T.M. researchers on the hydro-meteorological extreme events in India. Later a brainstorming session was organized in the office of the Mumbai Metropolitan Region Development Authority (MMRDA) on issues related with urban planning for Mumbai. Amongst other, Shri D.M. Sukthankar, former Chief Secretary; Shri Pathak, former Chief Town Planner, MMRDA and Shri Apte former Chief Town Planner, MMRDA participated in the discussion.

Presentations made in person or in writing to the Committee, field-visits, workshops, interactions and perusal of the reports prepared by other Committees and consultants on Mumbai's flood related problems, appointed after the July 2005 deluge, have greatly helped the committee to understand the issues in their proper perspective. The Committee wishes to sincerely thank all those individuals, organizations and institutions for providing valuable inputs of information and suggestions to overcome such situations in future. .

Govt. of Maharashtra, Municipal Corporation of Greater Mumbai, CIDCO, SICOM, allowed use of their local offices and conference rooms for the meetings of the committee and the Committee thanks them for such a support. Govt. of Maharashtra and MCGM arranged transport and other services, for the working of the committee, and the Committee is thankful to them also.

Shri D.M. More, then Director General of Maharashtra Engineering Research Institute, Nasik and Shri H.Y. Kolawale, then Chief Engineer Hydrology, Govt. of Maharashtra took considerable interest and participated in all the deliberations of the committee on the topic of Hydrology including the discussions at C.W.P.R.S. and I.I.T.M. Shri Kolawale was further kind enough to help us with an initial draft on the topic of hydrology for Mumbai. Shri More was good enough to spare time and go through the final version of the chapter under the title "Hydrological setting". Their extensive help is gratefully acknowledged.

We had the opportunity of discussing the various aspects of the flood related issues both with Shri Johnny Joseph, Municipal Commissioner and Shri T. Chandrashekhar, currently acting Metropolitan Commissioner and Shri Vatsa, Relief Commissioner, Govt. of Maharashtra. There were free & frank discussions. We feel considerably benefited therefrom.

We were particularly happy to note the actions initiated immediately by the concerned organizations – after we presented our interim suggestions for immediate action to the Govt. of Maharashtra on 30.12.2005. We were also told that regular meetings are being held by the Chief Secretary, Maharashtra, as well as by the Municipal Commissioner for the follow-up actions on our interim suggestions.

Now we are presenting our final findings in this report – which has been compiled in two parts - Volume–I containing discussions on the various topics and Volume-II containing annexures of detailed information and the drawings. We hope

that they will be useful to the Government of Maharashtra, Municipal Corporation of Greater Mumbai, Mumbai Metropolitan Region Development Authority and the public agencies like the Airport Authority of India to chalk out their further activity plans in appropriate directions so that such eventualities – if at all required to be faced again – will not disrupt the civic life of Mumbai – the way it did on 26 & 27th July. We look forward to see a clean and safe Mumbai soon. Hopefully, that will be very helpful in securing a place of pride for Mumbai in the emerging new global .set up.

As required under the terms of reference, we have tried to analyse the situation and have suggested guidelines for immediate actions as well as for long term measures. We have refrained from working out specific details of any proposals. We hope that it will be done as required by the concerned public agencies keeping in view the guidelines suggested in this report.

Our findings as set out in the chapter on conclusions bring out only the more important considerations in brief. It is hoped that the details set out in the main chapters will be carefully referred while taking further actions.

Ours has not been a fault finding mission, but a serious exercise to understand as to which deficiencies need to be over come, so as to be able to face calamitous situations as on 26th & 27th July, 2005 in a better prepared way. We hope that our findings will help Mumbaikars to move in the right direction rapidly & with confidence.

APPENDIX 1A

LIST OF OFFICERS AND STAFF WHO ASSISTED THE COMMITTEE

Sr. No.	Name	Designation	Designation for F.F.C.
1.	Shri M.V. Deshmukh	Dir. & Fire Adviser to U.D.D., GOM (Invitee of F.F.C.)	Secretary
Staff from M.M.R.D.A.			
1.	Shri A.V. Deshingkar	Chief Engineer, M.M.R.D.A	
2.	Smt. U. Adsumilli	Planner, M.M.R.D.A.	
Staff from Municipal Corporation of Greater Mumbai			
1.	Shri P.R. Sanglikar	Former DMC, MCGM & OSD	Technical Co-ordinator
2.	Shri P.S. Pahade	Dy.Ch.Eng., M.C.G.M.	Technical Associate
3.	Shri D.K. Pathak	E.E., M.C.G.M.	Technical Associate
4.	Shri S.R. Narkar	A.E., M.C.G.M.	Technical Associate
5.	Smt. S. Marathe	A.E., M.C.G.M.	Technical Associate
6.	Shri B.P. Patil	A.E., M.C.G.M.	Technical Associate
7.	Shri M.S. Kamble	Asst. Protocol & Liaison Officer, M.C.G.M.	Administrative Associate
8.	Shri M.C. Satam	Jr.Stenographer, M.C.G.M.	P.A. to Secretary, Fact Finding Committee
Staff from Mantralaya, Government of Maharashtra			
1.	Shri A.D. Jadhav	P.A. to Principal Secretary (II), Urban Development Deptt.	Office Incharge, Mantralaya
2.	Shri N.M. Sanghle	Clerk, U.D.D.,G.O.M.	Clerk, F.F.C.
3.	Shri S.N. Kharade	Peon, U.D.D., G.O.M.	Peon, F.F.C.

APPENDIX 1B

LIST OF ORGANISATIONS, INSTITUTIONS, POLITICIANS, EXPERTS AND INDIVUDIALS, WHO GAVE PRESENTATION TO THE COMMITTEE

(Arranged in alphabetical order)

I. Agencies & Organizations

1. Army & Navy
2. Air India
3. Airport Authority of India
4. Aryachanakyya Rahivashi Sangh, Kandivali
5. Bangalore Agenda Task Force
6. Bombay Electric & Suburban Transport Undertaking
7. Fire Brigade, M.C.G.M.
8. Indian Meteorological Department
9. Insurance Companies
10. Mahanagar Telephone Nigam Limited
11. Maharashtra Council of Housing Industries
12. Maharashtra Housing & Area Development Authority
13. Maharashtra Pollution Control Board
14. Maharashtra State Road Development Corporation
15. Mahipada Sunder Nagar Rahivashi Sangh, Kalina
16. Mumbai Metropolitan Regional Development Authority/ Mumbai Urban Transport Project / Mithi Pradhikaran
17. Municipal Corporation of Greater Mumbai
18. Navi Mumbai NGOs Forum
19. Pawan Hans
20. Police of Mumbai
21. Railways (Central & Western)
22. Residents of Gazder Bund
23. Secretary, Relief & Rehabilitation, Government of Maharashtra
24. Slum Rehabilitation Authority
25. Transport Commissioner

II. Individuals & Experts

1. Shri Ahir Sachin, M.L.A.
2. Shri Apte V.N , Former Chief Town Planner, MMRDA
3. Prof. Arceiwala S., former President, India Environmental Society & Technical Expert, WHO
4. Smt. Bhide Asmita, Prof. Tata Institute of Social Science
5. Shri Dalvi Datta, Mayor of Mumbai, M.C.G.M
6. Shri Datar Ashok, Maharashtra Economical Council
7. Shri Deshpande Chandrahas, Ex. Secretary, Maharashtra Economical Council

8. Mr. & Mrs. Deshpande, Professor, Mumbai University.
9. Mrs. Devasthali Veena
10. Mrs. Fernandes Yashodhara, Architect
11. Shri Ghorule Keshav, Marathi Arth-shastra Parishad
12. Smt. Gore Mrinal, Former M.P.
13. Dr. Joshi and Smt. Roshani Udyavar, A report by Rachna Sansad's Institute of Environmental Architecture Prabhadevi, Mumbai (2005)
14. Dr. Kulkarni Vivek, Comments on mangrove restoration in Mumbai Note Submitted to the of the *Fact Finding Committee* on Mumbai Floods. Government of Maharashtra (GOM) (2005)
15. Shri Mokashi Arun, former Urban Transport Expert, World Bank
16. Shri Naik Ram, former Union Minister, Government of India
17. Mrs. Nanda Alka, Vartak College, Vasai
18. Shri Parab D.M.
19. Shri Patankar P.G., former Director Central Institute of Road Transport
20. Smt. Patkar Medha, Narmada Bachao Andholan
21. Shri Pethe Abhey, Head of Deptt. of Economics, Mumbai University
22. Shri. Phatak V.K, former Chief Planner, MMRDA
23. Shri Prabhu Sunil, Chairman, Standing Committee, M.C.G.M.
24. Shri Raghavan, P. V. R., Note Submitted to the of the FFC on October 13, 2005.
25. Shri Rakeshkumar, Director, NEERI, Mumbai
26. Shri Ranade Ajit, Chief Economist, Birla Group of Industries
27. Advocate Raut Girish, Social Worker
28. Prof. Samant Hrishikesh, Xavier's College
29. Shri Shah M.R., former Chief Engineer (SWM), M.C.G.M.
30. Shri Shirsat Bhalchandra, Chairman, Improvements Committee, M.C.G.M.
31. Shri Somaiyya Kirit, former M.P.
32. Shri Sukthankar D.M., former Chief Secretary, Government of Maharashtra

Note : A detailed note was also received from Mr. N.V. Merani, former Principal Secretary, Public Works Department, Government of Maharashtra and former Secretary, HURE Board, MMRDA which has been taken into consideration by the Committee.

CHAPTER 2

THE DELUGE & RESPONSE

2.1 On 26th July, 2005, in the afternoon after 14.00 p.m. the Mumbai Suburban Area and the entire M.M.R. Region was struck with a heavy storm. Indian Meteorological Department (IMD), Santacruz had recorded a 944 mm. of rain for the 24 hours ended at 8.30 hours on 27th July. The Municipal Corporation of Greater Mumbai [MCGM] control room and the key officers of the MCGM started receiving phone calls reporting the heavy rain and water logging in the suburban area.

2.2 Transportation System –

2.2.1 The train movement came to halt by 14.30 p.m. due to the water logging on the tracks, which created hue & cry situation and panic amongst the stranded passengers.

2.2.2 Due to stoppage of trains, vehicular traffic intensity on roads suddenly increased. But due to the water logging and submergence of certain pockets such as Dharavi, Bandra-Kurla Complex, Chunabhatti, Chembur, Ghatkopar, Milan Subway, Sion and many other areas, the traffic movement in certain areas got substantially slowed down, whereas, in certain areas, it came to grinding halts.

2.2.3 Due to the submergence of the Airport by the evening the Airport became dis-functional and the air traffic was suspended at the domestic and international aircrafts for more than 2 days. People had either to take shelter at public places or private as available. Many tried to reach homes by walking and paving the way through all sorts of obstructions. Some of them could reach their destination as late as 24 hours to 48 hours.

2.2.4 Schools and colleges allowed the students from the school & college to go home.

2.2.5 Around 1.5 lakh people were stranded at the CST and Churchgate local stations due to disruption of railway services. Commencing from 14.30 p.m. BEST ran extra buses - 52 from Churchgate to Mahim and 86 from C.S.T. to Sion to facilitate their dispersal on the 26th July, 2005. Additionally, 1,500 stranded people were provided shelter and food in the Municipal premises of 'A' ward area.

2.2.6 Many of them had even to pave their ways through dirty and contaminated water, which was the major cause for eruption of epidemic like lepto and other viral infections later.

2.3 Road

2.3.1 With sudden rush of vehicles after around 16.00 p.m., plying from VT/ CST area to north, it took about 4 hours for a BEST bus to reach from Churchgate to Mahim (17.00 p.m. to 21.00 p.m.). This was just the beginning of events unfolded later on and people at large understood it only the next day.

2.3.2 About 200 km of road length was submerged in flood water and the traffic was standstill on all such internal roads, major roads and corridors of traffic. The WE highway from Kalanagar to Goregaon and even some areas onwards, EE highway from Suman nagar to Kurla and Chembur, S.V. Road/ Linking Road from Khar onward to Goregaon/ Malad, B.A. Road at Lalbaug, Hindmata, King Circle, CST Road, LBS Marg, Milan Subway etc. were submerged in flood waters for 12 to 24 hours and more. Thousands of vehicles were left by the people on these submerged roads. The removal of these vehicles from road corridors after receeding of water on 27th July was a big task.

2.4 Rail Transport in M.M.R.

2.4.1 Due to simultaneous heavy rains in Mumbai and MMR on outskirts of Mumbai, Railway transport services got disrupted IN MUMBAI and MMR. The train services started collapsing from around 14.30 p.m. and came to standstill by around 16.30 p.m.

2.4.2 Local bus service and trains in Mumbai resumed on 28th July. However it took 1 to 4 weeks to make start normal bus and train services in MMR region and outskirts of Mumbai. Thus the vital transport link between Mumbai and surrounding area was dislocated for long period adding to the agony of the commuters.

2.4.3 More than 20000 small vehicles, about 2500 BEST buses and about 25% of trains, thousands of two wheelers/ three wheelers etc. were damaged in rains and were non operational for weeks.

2.4.4 People transiting took shelter of buses and raised surfaces such as flyovers. They spent night in buses stranded on roads or railway platforms or in train as they could not wade through water which reached higher levels.

2.4.5 Still Lakhs of people waded through waste deep waters for hours but could not reach the destination and were stranded.

2.4.6 Road services to Nashik, Pune and Ahmedabad as also the train corridors of Kasara and Karjat were disrupted due to rains for 3 to 10 days. Flooded roads prevented supply of essential goods such as milk and vegetables to the citizens.

2.4.7 Incidence of major landslide due to heavy rains on 26-07-05 at Sakinaka claimed several lives. The heavy rains made the rescue operations very difficult as little access was available even to reach up to site after heavy flooding.

2.5 Communication

2.5.1 The situation got further aggravated when The communication such as telephone, cellular phones got suspended on by one – after at around 17.00 p.m. Cellular phone network (G.S.M./C.D.M.A.) of all the service providers got suspended. Land-lines of M.T.N.L. were also only partially functional. The mass media channels such as “Doordarshan” & “Radio” were of no much help to the citizens, because they also did not know the exact situation. They could not

communicate with the masses about the over-all situation. Had the communication network been operational and the public address system effective, many people would have got some guidance and could not have ventured in putting their lives to unnecessary risk.

2.6 Power Supply

2.6.1 Due to submergence of the power stations and substations, the power supply in suburban area got suspended from the evening of 26th July and it was restored only after receding of water. Due to this some of the sewage pumping stations in western suburbs stopped working which resulted in submergence of pumping station itself. MCGM took tireless efforts to put these installations in operation at the earliest.

2.7 Water Logging

2.7.1 If we exclude the hilly areas of Forest and Lakes, about 22% of Mumbai's land was submerged in rain waters on 26th and 27th July. Around 20 lakh people were either stranded in transit or sheltering in transport means. Another about 25 lakh people were under waters for hours together. Of these half the people were from poor class staying in slums of Dharavi, Sion, Kurla, Goregaon etc. The ground floors of many buildings in areas like Govt. Colony Bandra, MHB colony in Khernagar area, Kalanagar, Bandra Reclamation, Vakola, Kalina, Juhu, Dhake Colony Andheri, Veera Desai Road areas, Jawahar Nagar, Goregaon, Chunabhatti, Shivshrusti, Nehru Nagar, Kurla, LBS/ Kalpana Kamran area etc were marooned. Such was a deluge that the list can never be exhaustive.

2.7.2 The property worth billions of rupees was lost/ damaged which still could not be estimated at large.

2.8 Food and Civil Supplies

2.8.1 Commencing from the evening of 26th July, the daily consumables could not reach to the people. In Mumbai, majority of the population is housed in flatted structures and most of the buildings are having indirect water supply arrangements (i.e. the storage and lifting pump to the terrace tank). Due to the failure of power, the water even if bought upto the ground storage tank could not be lifted and distributed. Due to submergence and water logging, contaminated water entered the main water storage tanks in many localities. Some of the water supply pumping stations could not be operated due to absence of power supply. In some sensitive areas like Air-India Colony, Kalina, Chembur, Chunabhatti, the water level cross by as much as 5 to 6 m. in many buildings the water had entered in the ground floor & first floor level houses and the people had to take shelter on the upper floors.

2.9 Prevailing Rainfall Alert System

2.9.1 The Disaster Management Plan of Mumbai – Clause 1.4 – 'Climate and Rainfall' in Vol. I, Page-7 does not define any "Rainfall Alert System." However, the practice in vogue in MCGM. Is given below.

2.9.2 The IMD provides the weather forecast and tidal information to the Disaster Control Room of Government of Maharashtra and Municipal Corporation of Greater Mumbai. IMD had accordingly conveyed their forecast is given below.

2.9.3 "Rather heavy to very heavy rainfall means a rainfall, in the next 24 hours." According to IMD's terminology, it meant 'from 65mm to 124.9mm of rainfall in 24 hours'. The actual rainfall was however of the order of 944 mm! This information is supposed to be taken as a forewarning for required safety measures. In reality the rainfall very much exceeded this limit & there has been no guidance as to how to react to such a situation.

2.9.4 Later it was revealed that Vihar Lake area also recorded 1,011mm of rainfall at the MCGM's rainfall station at Vihar. There has been no system of reporting the hourly measurements at Vihar to any higher authority or control room regularly at least during heavy down pour situation. The Powai Lake started overflowing at 16.00 hours on 26th July and the discharge was 5.95 mom (million cubic meters) in Mithi River. Reportedly, the MCGM used to have some other rain gauges since 1954 at critical locations in the catchments of lakes. This practice of rain monitoring was discontinued by 3 years ago.

2.9.5 From the rainfall hydrographs of 26th & 27th July, shown on drawing. It is clear that two flood waves were generated in the streams and river basins, of Mumbai one between 14.30 & 20.30 hrs coinciding with the high tide period & resulting into a deluge & the other between 20 to 22 hrs. In the normal course, the latter could have passed off easily in a harmless manner being in the ebb period. But that did not happen because the accumulated water from the first flood wave could not get flushed out effectively during the ebb period because of choked drainage system. The result was that the situation kept on aggravating & there was some relief in sight only when the second ebb period commenced at 18 hrs. on 28th July.

2.9.6 Rainfall recoded by IMD at Santacruz by manual measurement on 26th July, 2005

Date	Time	Rainfall in mm
26.07.05	8.30 to 11.30	0.9
26.07.05	11.30 to 14.30	18.4
26.07.05	14.30 to 15.30	100.2
26.07.05	15.30 to 16.30	190.3
26.07.05	16.30 to 17.30	90.3
26.07.05	17.30 to 18.30	100.4
26.07.05	18.30 to 19.30	95.0
26.07.05	19.30 to 20.30	72.2
26.07.05	20.30 to 21.30	60.2
26.07.05	21.30 to 22.30	22.5

26.07.05	22.30 to 23.30	18.4
26.07.05	23.30 to 00.30	40.0
27.07.05	00.30 to 01.30	42.5
27.07.05	01.30 to 02.30	33.7
27.07.05	02.30 to 05.30	11.0
27.07.05	05.30 to 08.30	48.2
	Total	**944.2**

2.9.7 It is sad that the IMD's self recording automated rain gauge itself got submerged after 14.00 p.m. because of water logging. As a result, rather valuable information about the 15 minute interval rain precipitation which gets recorded on there rain gauge was lost. After the submergence of their rain gauge, IMD could collect information from their normal manual rain gauge only which was obtained through special efforts. The submergence period made available subsequently when called for. There was no on-line communication of this information on 26th or 27th July.

2.10 Rescue & Relief Measures

2.10.1 As against all the odds, to cope up with these unprecedented situations, MCGM tried to organize safe evacuation of people through boats and buses. A detailed record of such operations has not been compiled so far. The No. of fleet in operation is not on record. The evacuated people were sheltered in public buildings including schools and transit shelters. Community kitchens were started and free food grains were provided by the Government of Maharashtra [GOM] and MCGM as well as voluntary NGOs and individuals.

2.10.2 With the help of Traffic Police and Fire Brigade, 26,000 stranded vehicles on roads were cleared on the following day i.e. by 14.30 p.m. on 27th July. Gradually power and water supply also got restored. Train services resumed to normal on 28th July. 24,000 animal carcasses were disposed and more than 2 lakhs tonnes of garbage was maneuvered with the help of about 1,000 dumpers & J.C.Bs deployed from all over the State. Support of NGOs and Transport Commissionerate deserves special mention.

2.10.3 Around 1.5 lakh people were stranded at the C.S.T. & Churchgate Railway Stations. B.E.S.T. plied 52 extra buses from Churchgate to Mahim and 86 buses from C.S.T. to Sion to facilitate movement of stranded people on 26th July, 2005. The supervisory staff deployed that day was specifically equipped with mobile-vans and wireless communication sets to ensure the safety of the stranded commuters.

2.10.4 The Fire Brigade and the "Rescue Teams" of MCGM undertook 282 major and minor rescue operations. Some of the major operations included rescuing school children as well as rescuing people from 140 marooned BEST buses. Thus, the Fire department rescued of around 3,700 stranded people on 26th and 27th July, 2005. Rescue boats of Navy were requisitioned deployed at Kurla, Kalina area. Stranded passengers in 6 buses at Bandra-Kurla Complex could get rescued with the help of Navy and Mumbai Police on 27th July, 2005 itself.

2.10.5 MCGM organized emergency relief arrangements on a war footing. Food packets and drinking water was arranged for the stranded people with the help of NGOs and Social Organizations on the 27th July,2005.

2.10.6 Over 25,000 people were provided relief at 15 locations across the city including Air India Colony, Kranti Nagar (Jari Mari Road), Filter pada at Bhandup and Panchsheel Nagar. Affected people were shifted to nearby Municipal schools, local buildings and halls on the 27th July, 2005.

2.10.7 MCGM conducted relief operations in several areas through its own rescue-and-relief teams. For example, 8,750 and 3,250 food packets were distributed in City and Western suburbs. At the Air India colony, MCGM distributed 5,000 food packets and 1,000 litres of milk to more than 3,500 families stuck in water. On 2nd August, 2005, relief operations lasted for more than 12 hrs. and were conducted by a joint team of MCGM and NGO using 1 rib boat, 1 rescue board and 3 rowing boats.

2.10.8 MCGM also coordinated relief work at other places with the help of social service organisations (such as Nirmala Niketan College of Social Work and Tata Institute of Social Science). Over 20 NGOs including Akanksha, Yuvak Pratishthan, Apnalaya and industry houses (e.g, Tata Group through Dorabjee Tata Trust) also volunteered their help. Coordination mechanism was set up through the DMC to co-ordinate the continuing relief operations by individuals, industry houses and NGOs on the 2nd August, 2005.

2.10.9 In addition to the challenge of relief and rescue operations, with the help of Governmental and non governmental agencies the MCGM Administration had to face major challenges in (i) Maneuvering the solid waste by creating temporary dumping grounds, (ii) Disposal of carcasses of more than 1,307 no. of buffalos and 15,000 no. of sheep & goats.

2.10.10 It so happened that, the Hon'ble Chief Minister of Maharashtra was already in discussion with the Govt. Officials when the heavy down pour started in Mumbai. The entire Government machinery along with the local offices of the MCGM was therefore asked to immediately get into action for the desired relief, rescue and thereafter in the mission for restoring the city to normally.

2.11 Post-Flood Sanitation measures undertaken by MCGM

2.11.1 Solid waste and debris

Due to incessant rains, waste got accumulated in various areas in the city. MCGM deployed 107 JCBs, 438 dumpers and 511 compactors and lifted a total of 2,53,612 Metric Tonnes of garbage from all wards from 29th July till 21st August, 2005. The waste lifted on a daily basis was almost double of what MCGM lifts on a normal day.

2.11.2 Carcasses

A total of 16,307 carcasses were disposed off including those of 15,000 sheep and goats (mainly from Deonar) and 1,307 buffaloes (mainly from Goregaon, Kandivli and Andheri), in a massive operation involving 27 cranes, 87 dumpers and 24 JCBs spanned primarily over three days between 27th and 30th July, 2005.

2.11.3 Preventive health measures

Because of the severe rains and the fact that people had walked extensively through flood waters, risk of epidemics of water-borne diseases such as gastroenteritis, hepatitis and also leptospirosis was high. MCGM implemented several preventive and therapeutic measures to minimize these risks. Extensive spraying of disinfectants and insecticides was undertaken to control pests and minimize flies and mosquitoes. In addition, water purification tablets and prophylactic medications were also distributed.

2.11.4 Disinfections of open spaces and waste collection areas

Over 24 metric tons of bleaching powder disinfectant and over 2 metric tons of carbophenol powder were sprayed to disinfect public spaces

2.11.5 Larval mosquito control measures

Vector detection activities were resumed in less than 48 hours after the deluge.

2.11.6 Adult mosquito control measures

Insecticide was sprayed and fogging operations completed in all identified 1,174 vulnerable locations immediately after the deluge.

2.11.7 Fly control measures

Fly menace was also effectively controlled by removing garbage from 29th July to the 20th August 2005 on a war footing.

Vigorous application of disease prevention methods played a significant role in minimizing the emergence of severe outbreaks of water borne and vector-borne diseases such as gastroenteritis, hepatitis.

2.12 Treatment measures

In view of the fact that lacs of people had to wade through dirty waters on the 26th and 27th July, 2005 there were apprehensions of major outbreak of leptospirosis which requires early diagnosis and treatment in all suspected cases for reducing the risk of mortality.

MCGM therefore decided to provide comprehensive healthcare services though 130 specially constituted medical teams and treated over 3 lakhs patients virtually at their door steps through health camps and outreach program.

Creation of adequate drug reserves and admitting capacity in public health institutions

MCGM has collaborated with the State Government and several other institutions to make additional doctors and admission capacity available to the people affected by the crisis. In addition, significant drug reserves have been created to manage the post-flood complications.

2.13 Additional physicians to manage increased patient load

2.13.1 GOM arranged for 31 doctors from Government Medical Colleges in Aurangabad, Pune and Dhule. In addition 40 doctors from 6 private colleges/hospitals were also assisting MCGM doctors at wards and peripheral hospitals.

2.13.2 Additional admission capacity to manage seriously affected patients: Over 4,500 beds were made available to admit patients of water / vector borne diseases - 2,200 beds at the Municipal hospitals, 2,000 beds at ESIC hospitals and 300 beds at government hospitals.

2.13.3 Creation of adequate drug and medication buffers:

MCGM, with help from the GOM had created a central stock of essential medicines like doxycycline, septran, paracetamol, chloroquine and chlorine tablets exclusively for relief operations. In addition to this, field officers had been authorized to directly purchase necessary medicines.

2.14 Water supply

The Hydraulic Engineer's department ensured normal operations during this period. However, due to flooding of suction tanks and failure of electric supply, consumers of Kalina, Kurla, Andheri, Borivali, Bhandup, Mulund, etc. areas could not get potable or even the normal supply of water. The measures taken by this department include the following:

1. Supply of water to the affected areas using more than 50 tankers delivering 57 lakh litres of water through 631 tanker trips
2. Repair of pumps damaged by the deluge: The pumping stations at Deonar and Chunabhatti were overhauled and put into service on 29th July, 2005 while the Shiv Tekdi pumping station was made operational on 28th July, 2005.
3. Repair of pipelines at Goregaon and Kandivili that had burst following collapsing of roads due to heavy rains.
4. Additional Chlorine dose at all reservoirs, as safety measure.

2.15 Dewatering

Immediately after the deluge, restoration programme was taken up and portable pumps were installed at Air India colony, Kalina, Kurla, Chunabhhatti, Kalanagar etc. which helped in early discharge of flood water.

2.16 Defense Services

The Defense services dispatched their resources at 19.00 hours, which geared into the operations by 20.00 hours. The details of the work done by the Defense is shown as under:

REQUISITON	ON TELE MESSAGE FROM MANTRALAYA	
DESPATCHED	261900 HRS	
EFFECTIVE	262000 HRS	
RESOURCES	1 X COLN EX 107 AD REGT	
	1 X MEDICAL TEAM	

	3 X ENGINEER TF (BEG & 201 ER)	
	7 X BAUTS	
	6 X OBMS	
	90 X LIFE JACKETS	
	9 JCBS	
	21 PUMPS	
	14 X RESCUE BOATS	
AID PROVIDED	DEAD BODIES RECOVERED	39
	EVACUATED	550 (INCL 250 SCHOOL CHILDREN)
	PATIENT TREATED	3,675
	FOOD PACKETS	20,000
	MINERAL WATER	2,000
	BREAD JAMS	2,000
	•RICE	750 KGS
	KERO OILS	650 LTRS

2.17 Fire Brigade:

The Fire Brigade received intimation through tele messages from public and instructions from Disaster Management Control Room of MCGM and acted with all resources pressed into operation. The work done by Fire Brigade in brief is shown as below:

REQUISITON	ON TELE MESSAGE starting from …. pm on 26th FROM PUBLIC & DISASTER MANAGEMENT CONTROL ROOM OF MCGM.	
RESOURCES	1 X CHIEF FIRE OFFICER	
	1 X JOINT CHIEF FIRE OFFICER	
	3 X DEPUTY CHIEF FIRE OFFICER	
	5 X DIVISIONAL FIRE OFFICER	
APPLIANCES & EQUIPMENT	56 X FIRE ENGINES	
	3 X RESCUE VANS WITH ALL RESCUE GEARS	
	27 X WATER BOUSERS	
	41 X PUMPS	
	3 X RESCUE BOATS	
AID PROVIDED	ATTENDED FIRE & RESCUE CALLS	282
	DEAD BODIES RECOVERED	82
	EVACUATED CITIZENS TO SAFE PLACES	8,292

2.18 Measures undertaken from health point of view

Water purification tablets & prophylactic medications were also distributed. Knowing the fact that no. of people had to wade through dirty waters on the 26^{th} & 27^{th} July, 2005, major outbreak of leptospirosis was apprehended. It was therefore decided to provide comprehensive health care services through Health Department of MCGM by arranging Health Camps in various areas of H-East ward.

2.19 IEC - ACTIVITIES

1) Posters, handbills were distributed in the areas.
2) Announcement on loudspeaker was done to increase public awareness regarding diseases.
3) Instructions were given regarding boiling of water, chlorination of water & other health- care measures.

To abate the risk of epidemic of water-borne diseases such as gastroenteritis, hepatitis and leptospirosis, MCGM implemented several preventive and therapeutic measures.

2.20 Preventive measures

Disinfection of open spaces and waste collection areas were undertaken using bleaching powder and carbophenol powder spraying.

Larval Mosquito Control – Anti-larval treatment was extensively undertaken.

Vector detection activities were resumed within 48 hours of the deluge.

2.21 Adult mosquito control measures

Fogging measures and insecticide spraying was extensively undertaken in the affected areas. Vigorous application of disease prevention methods played a significant role in minimizing the emergence of severe outbreaks of water borne and vector-borne diseases such as gastroenteritis, hepatitis, particularly, in view of buffalo carcass nuisance.

2.22 Treatment measures

In view of the fact that lacs of people had to wade through dirty waters on the 26^{th} and 27^{th} July, 2005 there were apprehensions of major outbreak of leptospirosis which requires early diagnosis and treatment in all suspected cases, for reducing the risk of mortality. MCGM therefore decided to provide comprehensive healthcare services though 20 specially constituted medical teams that had treated over 38,000 patients virtually at their doorsteps through health camps and outreach program. Essential medicines like paracetamol, doxycycline, septran and chloroquine had been distributed free of cost to all the patients throughout the city.

2.23 Lacunae

2.23.1 Rain monitoring and hazards warning -

The circumstantial evidence and the interactions committee had with the representatives of the IMD revealed that there was enough scope for IMD to be more proactive in providing the periodical data at an interval of at-least every one hour in an extreme situation on 26^{th} July.

The traditional reporting system based on 24 hours measurement cycle and release of bulletin by 12.30 hours on the next day was out of context under the Mumbai Disaster Estimation.

An initiative from IMD for forewarning about the impending disaster would have been of a great help. IMD has located the presence of a 15 km. cloud over Mumbai by 14.00 hrs. Implications of such an extreme meteorological phenomenon should have been immediately conveyed to the concerned authorities – overruling their earlier description of forecast as 'heavy or very heavy … ' The improvement in the condition of Colaba and Santacruz Rain gauging stations and the reporting practices during rainy periods will be very helpful in the future. However, there is a dire need to install more rain gauging stations in Mumbai Metropolitan Region immediately to cover.

(i) The city is not covered by adequate number of rain gauging stations at strategic locations. Automatic level gauging station from the catchments areas to the down stream are necessary along with a well laid out communication drill in the rainy periods.
(ii) The mass communication mechanism such as Television, Radio, Internet/email, web sites could have been of a great advantages to the society at large.
(iii) There is a lot of scope for improvement of the information in flow processes at the control room of he State Government, M.C.G.M. and other agencies with effective communication measures and certain Standard Operating Procedures (S.O.P.).

2.23.2 Incident command and control –

In the Disaster Management Plan of the Mumbai, the Municipal Commissioner, MCGM is empowered as a nodal controlling officer, but unfortunately, the experience has been that the different Central, State, Departments & Authorities connected with Mumbai affairs do and act as accountable to the M.C., MCGM. It is either through the long winding bureaucratic official mechanism or through the Personal Relation Net-work (P.R. Net-work) of the M.C., MCGM that action could be initiated on such occasions. This will have to undergo a change.

Co-ordination - The most important and critical job was co-ordination between the different agencies. It was experienced that though the M.C., MCGM is formally declared as a nodal controlling officer, his authority for directing action in case of a disasters in reality subjected to a lot of limitation, due to different high level authorities & agencies operating in the city independently, such as Police, Railways, Airport Authorities, Defense Authorities, Port Trust Authorities, Slum Rehabilitation Authorities, MHADA, MMRDA,. Their specific dealing with "Mumbai" do not appear to be clear as to from whom they should expect and receive orders for actions to be taken under the disaster management situation. These agencies in reality are not properly linked with the system of procedures and flow orders and directives from the Disaster Management Controlling Agency for Mumbai.

2.23.3 Communication -

(i) The public communication net-work such as M.T.N.L. Telephone and the cellular phones did not come out under the situation on 26th & 27th July as an assured dependable communication mechanism. The cellular network of all the service providers was down and M.T.N.L. telephones also were partially functioning. Mumbai can be in trouble for various reasons. To handle the large population under such situation a dependable communication network is a must. It is immediately necessary that their infrastructure and operating procedures are reviewed in details to be able to be available for service during the calamities.

(ii) Mass Media Communication – Particularly on 26th July, the public information role to be performed by the television or the radio channels left much to be desired primarily because of their weak association with the disaster management centre for Mumbai. In absence of timely accurate information there was aggravation of panic. Some channels were even disseminating contradictory information without ground verification at the time of relay. That exaggerated a panic situation and mislead to society in Mumbai – as well as the viewers of the network. As a good practice it was necessary to clearly mention in print the exact time and place of the situation photographed.

(iii) Mass Transit System –

(a) Mumbai's local trains on the Western, Central & Harbour tracks carry more than 40 lakhs passenger a day. The system came to a grinding halt. As per the present design of the railway system, when the water level rises (10 cms.) & above on the railway tracks, the local train services are suspended. There needs to be a much more dependable mechanism for smooth flow of storm water through culverts, nallas and other natural water courses to prevent the water logging on the railway tracks. A detailed technical review of the railway tracks to meet with the storm time requirements in Mumbai as outlined elsewhere in this report will be useful.

(b) Only if the mass transition system on the rail tracks remains operational, the people can move fast. The road infrastructure in Mumbai is far too inadequate to handle the large volume traffic – when railways stop functioning.

2.23.4 Power Distribution Network

It is a matter of serious concern that the main stations and sub-stations on the power distribution net-work got submerged which had a domino effect of affecting the communication network, operation of pumping stations of water supply, storm water and sewerage and many other systems which are power dependent in today's technological society. These will have to be immediately relocated beyond the flood risk zones and probable sub mergence areas as described elsewhere in this report.

2.23.5 No contingency planning of the Government offices as well as commercial, industrial and educational establishments appears to be available for an emergency situation. As it is a known fact that most of the offices, industries, commercial houses and educational institutes released in-housed occupants (with may be a good intention), but this had resulted in transferring the people from 'safe shelters' to the un-safe area, which is called as an 'adverse evacuation'. Specific procedures will have to be clearly spelt out for all such establishments for facing city wide or local emergency situation.

2.23.6 No road corridors or special tracks were kept open for the 'Relief and Rescue vehicles.' The limitations of Mumbai's transportation infrastructure is dealt in detail in Chapter on Transport system. In the future operational transport plan of Mumbai there is a need for earmarking specific tracks or lanes exclusively for the emergency service providers and for rescue & relief operations. Non-availability of such accesses compounded the crisis of 26th and 27th July, 2005.

2.23.7 The Mumbai Fire Brigade has a total of 2,021 personnel, out of which approximately only 550 personnel happen to be available on duty at any time. Even therein the Search & Rescue Team comprises of only 26 members i.e. 20 Fire Service Personnel, 4 Doctors and 2 Structural Engineers. This team is mainly trained for rescue from collapsed structures and confine search & rescue operations. Mumbai Fire Brigade does not have a team specialized in 'flood rescue' operations. It is reported that the Search & Rescue Team had rescued about 3,700 people but that does not appear to be factual. The fire brigade did excellent work in rescuing some drowning casualties and dead bodies from the coastal line and other water bodies. But the rescuing of 3,700 stranded people came out of the efforts of not only one search & rescue team, but all the fire service personnel available on duty, the number by itself is very meager for a city wide catastrophe. Strengthening the 'rescuer' operations through local help and association local agencies will have to be planned in a methodical manner to face any similar eventuality with a large scale wide impact. Current Management plan is silent on this aspect. Many working details will have to be added.

2.24 Suggestion for improvement of Disaster Management System

2.24.1 Mumbai Disaster Management Plan needs to be revamped in view of the lessons learned from the Disaster events during the last a decade and more the so with special reference to the 26th July, 2005 deluge due to the floods. The Committee has taken a review of the present Mumbai Disaster Management Plan and some of the findings are as below. The plan appears to be more of a generic document, rather than an operational one.

2.24.2 Operational details will have to be given more emphasis.

2.24.3 The vulnerability analysis of the city needs to be carried out in great detail with reference to different categories of possible disaster and there has to be a risk zoning of the city with clear guidelines for each zone in respect of do's and don'ts.

2.24.4 The disaster analysis should be based on a probabilistic approach. The data available with the Police Department, Fire Department, Railways, Coast Guard, Storm Water Management Department, Road Transport Dept. MET Department and such other essential service providers needs to be compiled and systematically analyzed in that direction. To collect such critical data in future, there needs to be an institutionalised arrangement as a part of the Disaster Management Cell for continuing that activity during the disaster free periods time. For the survival of the city, seismic data & hydrological data needs to be given great importance priority and the very basic approach to the appreciation and analysis of the nature of disasters will have to be modified: e.g. in <u>Volume-I, Page – 7 of Disaster Management Plan.</u>

2.24.5 In Para 2.9.3_of Disaster Management Plan, average rainfall has been mentioned which has hardly any relevance with a disaster situation. It is the intensity of the rainfall that will have to be given proper consideration. Fortunately this was also the aspect that was emphasized and dealt with the details in the Brimstowad report. That needs to be pursued and refined further.

2.24.6 Further in Volume-I, Page-11 The Disaster Management Plan refers to only 2 rivers in Mumbai. In fact, there are 5 rivers in Mumbai i.e. Dahisar, Poisar, Oshiwara, Mithi & Mahul. alike rivers, major nallas and watercourses also require in depth consideration, as was done in the Brimstowad report that type of analytical approach needs to be pursued further Management Plan.

2.24.7 The BRIMSTOWAD report which was ready in the year 1993, whereas the Disaster Management Plan document came to be published in the year 2000. But there has not been adequate coverage of the issues already dealt with in the Brimstowad report. There is no reference to the low levels of Mumbai's coastal areas which is one on the primary reasons for the sluggish channel flows under heavy storms. There is neither a mention about the evacuation plan for the city of Mumbai nor about the identified shelter places which are to be earmarked. The report does not have scientific back-up, proper risk assessment, & vulnerability analysis, e.g. geological setup of the city will have to be considered while considering earthquake phenomenon. The line of action for risks, & relief & rescue operations will vary according to the nature of disaster. Related with duties & responsibilities of the concerned officers also have a different vias. That should find a place in Standard Operating Procedures (S.O.P.'s.), for the different categories of disaster. A clear cut warning mechanism needs to be evolved along with a clear cut communication methodology for each category of disaster. For that to happen there is a need for proper instrumentation, rain gauges, stream gauges, wave responders and seismographs, geological maps,. This can provide ample clarity in respect of the phenomenon of the 'disaster' and help in devising the fore warning /early warning mechanism. It is further suggested that while reviewing the Disaster Management Plan, as a lesson from the 26th July deluge following points will have to be given special consideration.

2.25 Risk Zoning

2.25.1 A city that has been evolved out of seven islands and is developed and continuing to develop essentially on reclaimed lands. There is a process of settling of the reclaimed lands. Road levels, stream levels and gradients may thereby change. This point is important while doing vulnerability analysis & long term projection of submergence. This city also has a low level coastal line and average at some points just 1 m. above the mean see level – i.e. 1.5 m below the high tide level. (See Figure 2.1)

2.25.2 More than 60 lakhs populations is staying in the slum colonies or kuchha structures. These areas are highly vulnerable during the contingencies like floods, fire and commotion. They also constantly pose a threat to the hygiene of the city & its after effects. Based on type of risk, there needs to be risk zoning and on the

basis of the risk zoning, there needs to be an adequate preventive measures infrastructural provisions and post disaster access for relief and rescue work.

2.26 Communication Network

Mumbai's The Disaster Management Control Room is already linked with the other control rooms such as the Emergency Operation Centre of the GOM, Police, Fire Brigade, Railway, BEST, SWD,. There needs to be a proper communication protocol and the use of State of the Art communication Technology. On the analogy of Federal Emergency Management Agency (FEMA) of USA, the Emergency Operation Centers of the MCGM and the GOM need to be managed by the functional expertise in principal types disasters along with representatives from Transport, Communication, Public Works & Engineering, Fire fighting, including Urban Search and Rescue, Information & Planning, Mass Care, Resources Support, Health & Medical Services, Handling of Hazardous Material, Food, Energy & Water Supply, Police should have a base in the operational centre for proper and quick actions.

2.27 Command & Control Mechanism

To link such diverse persons and ground level operational units the Disaster Management Plan should be abundantly clear in terms of the powers and functions of the nodal officer i.e. M.C., MCGM. There should be a well plotted chain of command and span of command as a part of the disaster control mechanism. All the agencies involved to cope-up with the disaster situation needs to be well documented with the Standard Operating Procedures (SOP) clearly defining the role of each agency, their powers, functions to avoid laps.

2.28 Role of NGOs

NGOs are coming up in good numbers in & around the city of Mumbai. They do volunteer for necessary help. Each NGO has its own strength & capability and limitations. There need to be some clear criteria to evaluate these NGOs, may be by specifying pre-qualification conditions. Qualified and experienced NGOs should be listed for the city as a whole with their well defined role in different types of duties required. It appears that a dialogue with them on this matter is overdue.

2.29 Notification of Relief Shelter

The public buildings such as Schools, Colleges, Public Assembly Halls, etc., need to be properly notified with a board display on the conspicuous locations. There has to be proper awareness of such emergency shelters and there has to be backup mechanism to mobilize the basic facilities such as food, water, medicines, communication requirements and camp guides for these locations to avoid chaotic conditions and over-crowding of such shelters.

2.30 Logistic Support

It is a general experience that when resources are to be mobilized, the leader of the team has to exert and strive for logistic support e.g. search & rescue team is to be mobilized. Their potential & energy needs to be conserved to discharge their duties more effectively once they are placed at the location. But the experience of 26^{th} & 27^{th} July was that energies were often exhausted in organizing their movements and dispatching them to the strategic locations. Similarly, food & civic

supplies, transportation and other requirements are expected to be well organized by the professional logistic support teams.

2.31 Public Awareness & Community Involvement

It is said that "self help is the best help' and therefore involvement of the community in a conceding manner to family and individual level will help in minimizing the burden on the Governmental machineries and therefore involvement of the people and volunteering organization needs to be well planned in advance . For the communication purpose, there need to be sign boards, public address system, proper media management, defining the spokesman of each department. The Disaster Management Plan should have workflow from the macro level, government institutions to the micro level, public institutions, all the corporate, industrial houses, educational institutions, government & private offices should prepare their on-site & off-site contingency plan to cope with the disaster situation. The disaster in this perspective could be localized to their level and if properly managed, the disturbance to the surrounding vicinity and unnecessary panic can be avoided. Similarly, if there is a proper plan in major disaster situation like 26th July, the situation can be contended in a planned manner.

2.32 Early Warning Mechanism

2.32.1 Rainfall analysis of the Anjurun rainfall station of GSDA in Konkan shows that on the rainy days of 1st July, 24th July, 25th July, which had more than 100mm of precipitation in a day, the maximum 15 minute precipitation was of the order of 18.5mm, 18.5mm, 20mm against 179mm, 128mm and 278mm days total precipitation that is more than 10 times the day's average for a unit of 15 minutes if worked out on a uniform basis for the whole days. It is clear that for smaller area and Valleys in the Konkan belt, and particularly for the urban conglomerations as in MMR and in Mumbai daily rainfall has hardly any relevance in respect of the flood situation. This characteristic needs to be kept in mind while dealing with the crowded small catchments of Mumbai's urban localities. On the important rainy days, the intense precipitation does not occur uniformly over long periods but comes in as intense showers of 15m to 2 hour durations. Information and analysis of precipitation patterns carried out on that bases will help in the disaster preparedness.

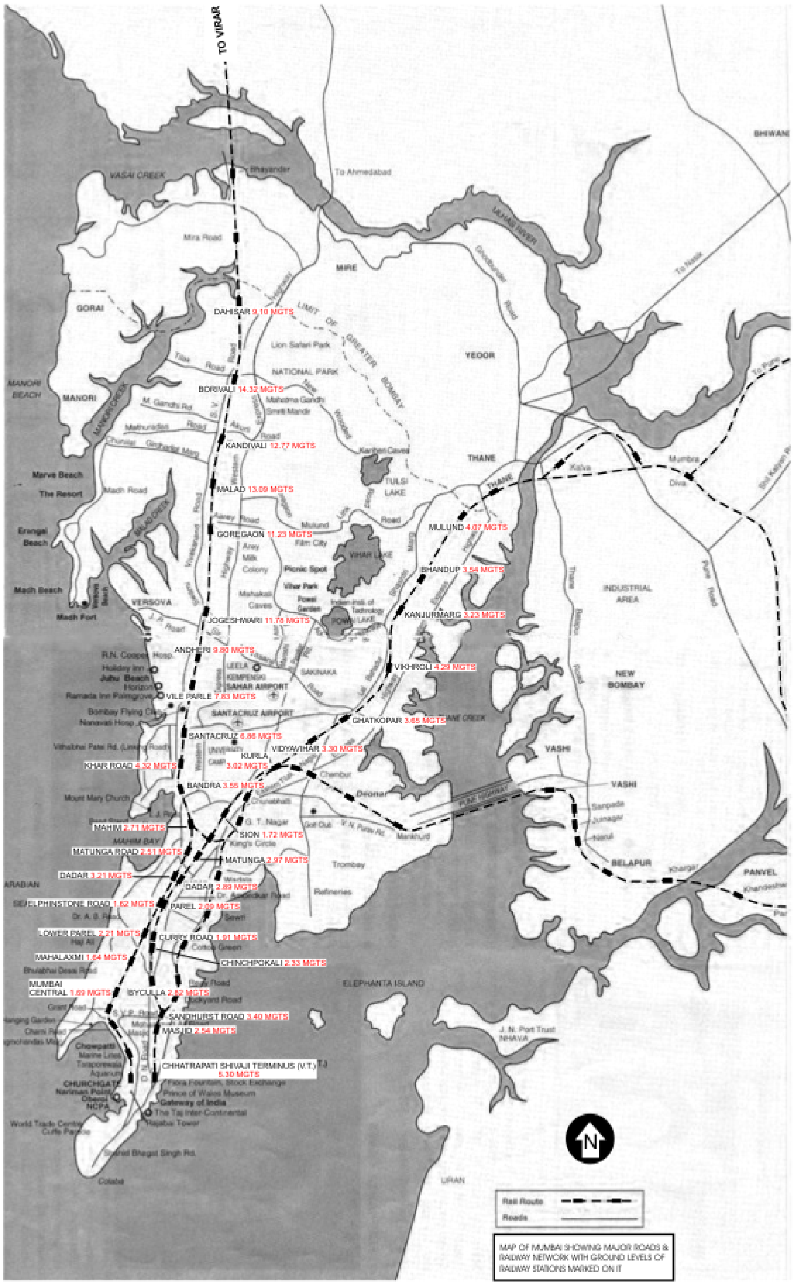
2.32.2 IMD's 48 hour's advance forecasting system is as yet based only for day's occurrence. It cannot be relied upon for the management of storm water in Mumbai or for that matter even in the Mumbai Metropolitan region at large. It will do well if MMRDA with the help of the water resources department of GOM develops a well co-coordinated rainfall analysis & forewarning system for the metropolitan region as a whole on the basis of more than 100 self recording rain gauges already working in Metropolitan Hydraulic region and adds more rain gauges at critical points in the region.

2.32.3 In the meanwhile, MCGM by itself should establish its rainfall recording & flood warning system with the help of 8 self-recording rain gauges spread over Mumbai. 15 minutes record is already available on the clock mechanism of the SRG. By manning the SRG continuously through the rainfall period & developing a system of communicating the observed rainfall intensity as soon as it exceeds 10mm in a 15 minute period to the disaster management centre an alert signal can be

issued to the localities in the concerned catchments. If this trend continues for over an hour i.e. 40mm in an hour (which is 10mm less than the 50mm/hr. precipitation for which Mumbai's storm water system will soon get upgraded following BRIMSTOWAD), a "risk warning" will have to be issued to the concerned catchments and their main river channels. If the hourly intensity exceeds 80mm in an hour, rescue operations will have to be in place because it is much more than what the river channels/stream channels can safely carry.

2.32.4 In the disaster management manual of Mumbai, detailed operational instructions on these lines will have to be incorporated. In due course, Mumbai will have a network of stream gauges as suggested at the interim stage by the Fact Finding Committee. Information from the stream gauges & rain gauges will have to be coupled together to decipher the risk zones & the level of risks involved. On the lines of MSEB generating stations/transmission grid stations, for power dispatches the central disasters control rooms in Mumbai will have to be manned by trained hydrologists & engineers who will be able to convert the information received into operational instructions for the ground staff in the wards. In the central management cell of Mumbai, specific provision for round the clock technical supports on these lines during the rainfall period 1st June to 1st Oct will have to be made.

FIGURE 2.1


TO VIRAR
DAHISAR 9.10 MGTS
BORIVALI 14.32 MGTS
KANDIVALI 12.77 MGTS
MALAD 13.09 MGTS
GOREGAON 11.23 MGTS
JOGESHWARI 11.78 MGTS
ANDHERI 9.80 MGTS
VILE PARLE 7.83 MGTS
SANTACRUZ 6.86 MGTS
KHAR ROAD 4.32 MGTS
BANDRA 3.55 MGTS
MAHIM 2.71 MGTS
MATUNGA ROAD 2.51 MGTS
DADAR 3.21 MGTS
ELPHINSTONE ROAD 1.62 MGTS
LOWER PAREL 2.21 MGTS
MAHALAXMI 1.64 MGTS
MUMBAI CENTRAL 1.69 MGTS
MULUND 4.07 MGTS
BHANDUP 3.54 MGTS
KANJURMARG 3.23 MGTS
VIKHROLI 4.29 MGTS
GHATKOPAR 3.65 MGTS
VIDYAVIHAR 3.30 MGTS
KURLA 3.02 MGTS
SION 1.72 MGTS
MATUNGA 2.97 MGTS
DADAR 2.89 MGTS
PAREL 2.09 MGTS
CURRY ROAD 1.91 MGTS
CHINCHPOKALI 2.33 MGTS
BYCULLA 2.82 MGTS
SANDHURST ROAD 3.40 MGTS
MASJID 2.54 MGTS
CHHATRAPATI SHIVAJI TERMINUS (V.T.) 5.30 MGTS
N
Rail Route
Roads
MAP OF MUMBAI SHOWING MAJOR ROADS & RAILWAY NETWORK WITH GROUND LEVELS OF RAILWAY STATIONS MARKED ON IT

CHAPTER 3

HYDROLOGICAL SETTING

3.1 Impacts of Human Activities

3.1.1 For a comprehensive understanding of the flood episode that convulsed Mumbai, and for devising preventive measures to avoid such situations and to minimize their impacts an in-depth analysis of the hydrological setting in which Mumbai operates is necessary. Basically hydrology is the study of nature's water cycle. Water moves in the environment through the process of cloud formation, precipitation, evaporation, condensation, retention, infiltration, run-off on the earth's surface and as ground water. Runoff is that part of the rainfall which flows over the ground into the stream channels and rivers. The science of hydrology helps to develop scientific procedures to estimate rates and amounts of runoff, river water levels and flood flows across the spillways of dams.

3.1.2 In urban areas, it also covers the study of the effects of urban conditions on rainfall–runoff relationships. Changes in the physical characteristics of urban areas change the runoff response of the area. The developmental works involving physical, topographical changes alter the natural hydrological process in the area. It is necessary to evaluate the effects of such changes on the hydrological performance of the urban area. Infrastructural planning of urban area should require careful attention to urban hydrological characteristics. But large volume of hydro meteorological, topographical and physical data is required to be collected for this purpose. When this is not done, the extreme rainfall event as was witnessed by Mumbai in July 2005 takes the city by shock and surprise.

3.1.3 The journey of water is continuous in time & space. It is necessary to study how the precipitated water travels in the catchment to understand the process of inundation and flooding. The soil type, the vegetative cover, topographical features of the land surface and the physical structure in the catchment play a key role in influencing the runoff process. Urban areas tend to reduce the natural vegetative cover as they develop. Population growth calls for more land development, re-development and densification of structures. The developmental structures in urban areas such as roads, pavements, buildings (residential and non-residential), paved parking lots and sidewalks, driveways increase the impervious surfaces in the catchments. They arrest ground infiltration, and take away the quantum of evapotranspiration from the grass cover and the tree cover that otherwise can take place. Having reduced the quantum of infiltration and evapotranspiration, the run-off component of the hydrological cycle is greatly increased. The impervious surface area within a watershed is a very important parameter which decides as to how much will be the quantum of change in runoff. When there are no detention basins to arrest this additional flow and the downpour is excessive the flooding and inundation of low lying urban areas can be catastrophic.

3.1.4 The normal annual rainfall values which a common man is generally acquainted with are useful for assessing the available supply of water. But for the urban drainage systems, it is the local intensity of precipitation rather than the total annual precipitation that is more relevant. The storm water arrangements are also

required to be handled on the basis of the return periods of different values of rainfall intensity i.e. the probability of occurrence of the rainfall of different intensities – in a 2 year period, 10 year period 25 year period 1000 year and so on.

3.2 Intensification of Surface flows

3.2.1 How much portion of precipitation is converted into runoff has been worked out by the Central Designs Organization and the state Hydrology organization of the Govt of Maharashtra as below for some typical cases.

SN	Area	% of runoff from Annual precipitation
1	Lower Vaitarna project	75.84
2	Upper Vaitarna Project	76.51
3	Konkan as a whole	70-80
4	Girna Basin	20-35
5	Godawari Basin	25-35

3.2.2 It can be seen that there is a very large difference between the runoff process, on the Deccan plateau and in Konkan. Considering the Konkan data, we expect about 75% of rainfall being converted into runoff even in the large natural valley. In the urban area, obviously the percentage of runoff will be much higher because of impervious ground cover and less of evaporation loss in the short length runs of the storm water flow. This percentage of runoff can be nearly 100% BRIMSTOWAD recommendation of considering 100% of precipitation as runoff is quite in keeping with the general hydrological characteristics of Konkan and the urban developments in Mumbai. The old practice of accounting for only 50 % of runoff was obviously not appropriate. Hence the old drainage works in Mumbai need considerable extent of retrofitting immediately. This is true about the old CD works in Mumbai also, such as the bridge below the Santacruz Airports run way, which was constructed for a much different condition of catchment than today. By and large the surface drainage system that exists today in Mumbai is quite inadequate for such large percentage of runoffs and actual higher intensities of precipitation being witnessed now.

3.2.3 Various committees and consultants were appointed by Mumbai's civic body from time to time to study the problem and to suggest improvements. Scope of their work was by and large complementary with no overlapping. In 1975 Natu committee had taken into account the changes that have taken place in the urban area and their impact on the patterns of surface flows and had suggested a drastic change in the design criteria for the storm water system. In place of 0.5 as a runoff coefficient the coefficient of runoff recommended was 1.00. It was also recommended that the storm intensity for the designs of storm water system should be 50 mm per hour rather than 25 mm per hour. When Brihan Mumbai storm water drainage project (BRIMSTOWAD) was prepared in 1993, these revised criteria were reiterated.

3.2.4 Even during a storm period, the intensity of rainfall varies with time. It is not constant over a number of hours or even for all the 60 minutes of an hour. The storms of different durations have different maxima for a one hour's rainfall. The design runoff for a catchment is to be obtained from the design storm of appropriate

duration to be prudently chosen with reference to the catchment characteristics – mainly the size and the ground slopes, the resultant time of concentration and the tidal influence. Mathematical models have been developed for this purpose and the computer software is also available. Extent of overland flow from a precipitation on a catchment depends upon the intensity of precipitation, nature of aerial distribution of the storm as well as the physical and topographical characteristics of the catchment. The time required for the overland flow of storm water from the remotest point of catchment to reach the point of collection and disposal depends on the distance of the farthest point in the catchment area to the terminal point of outflow as well as on the shape, characteristic and topography of the catchment. On steeper hilly slopes and for small size catchments in Mumbai this time is as low as 2 to 10 minutes. For larger catchments in flat terrains, the sluggish movement of surface water requires long time of concentration. All these factors are required to be properly reflected in the mathematical models for the storm runoffs. While the designers will use computer models, in common parlance it is desirable to be clear about the principal features of the criteria to be followed, such as the design intensity of precipitation, which is a much simpler reference figure to understand and follow. Hence we have tried to suggest such intensities for the storm water designs in Mumbai.

3.2.5 Different localities in Mumbai get flooded in a different way. In addition to hydro meteorological and topographical factors, other management practices of urban life including dumping of garbage determine the nature and extent of flooding. Broadly the central reclaimed areas in the island city near Hindmata Talkies, Lower Parel and Grant Road get flooded faster even with moderate intensity of rainfall during the high tide periods when the gates are closed. The flooding recedes when the gates are open. However this flooding is also now due to inadequate size of the drains to carry the increased storm flow.

3.3 Rainfall on 26th and 27th July

3.3.1 In the practice established by the India Meteorology Department (IMD), the previous 24 Hours cumulative rainfall is measured at 8.30 am everyday. It is actually the rainfall from 8.31am of yesterday to 8.30 am of today which is the measurement day. It is this figure that is reported through the weather bulletins of IMD released by 12.30 Hrs every day.

3.3.2 Much of the extreme rainfall that got recorded on the morning of 27th July was actually the rainfall that had occurred on 26th July. The extreme precipitation intensity had actually taken place on 26th July. The IMD in its All India Weather summary issued at 12.45 hrs on 26th July 2005 had forecast 'Very heavy rain' at isolated places in Konkan and Goa. The rainfall is called as 'heavy' if it is more than 65 mm and 'very heavy' if it is more than 130 mm in a day. The IMD in its forecast gives a very broad idea about the climate and the rainfall based on the data of earlier 24 hrs collected up to 08.30 hrs on every day and the forecast is then issued at 12.45 hrs of the same day.

3.3.3 After the heavy downpour on 26th, IMD described the causal factors for the extreme precipitation as. "Presence of a well marked low pressure area over Madhya Pradesh, marked offshore trough at the surface along the west coast and a well marked east-west oriented shear line in the lower troposphere must have contributed to a favorable setting for the enhanced meso-scale convection around Mumbai on that day."

3.3.4 Vihar Lake received maximum rainfall of 1011 mm rainfall as per the data of MCGM rain gauge records. The hourly sequential precipitation at Vihar from 12.00 Hrs on 26th July to 12.00 Hrs of 27th July, was as below.

	26th July											
T	13	14	15	16	17	18	19	20	21	22	24	00
R	30	30	30	136	51	83	77	109	120	123	20	44

	27th July									
T	01	02	03	04	05	06	07	08	09-12	Total
R	86	32	13	0	7	8	5	7	0	1011 mm

T= Time in hours

R= Hour's rainfall in mm

IMD measurements at Santacruz show a similar pattern but with slight less total rainfall as shown in the table in the previous chapter on Deluge and Response.

3.3.5 The heavy flooding on 26th July 2005 was due to very heavy downpour with the intensity of 380 mm for 3 hours between 14.30 PM to 17.30 PM i.e. more than 125 mm per hour which is 5 times more than the intensity of rain for which old drains were designed and 2.5 times more than the intensity of rains for which drains are currently being designed following BRIMSTOWAD that was adopted by MCGM for improvement of the storm water system. Even if the entire system had been upgraded as per BRIMSTOWAD, the same would not have been adequate for the rainfall intensity to the tune of 130 mm / hr. This was substantially more than the designed capacity of the storm water drainage system and hence flooding was inevitable.

3.3.6 Very high rainfall (more than 200 mm in a day) is quite common for Mumbai during the onset phase of the monsoon. An analysis of the probability of such extreme events and their expected return period based on historical data going back to 1886 for Colaba and 1957 for Santa Cruz reveals that in any year, the probability of 24 hr rainfall exceeding 200 mm is 50% for Santa Cruz and 33% for Colaba. Hydro meteorologists studying the Indian phenomenon have observed that after the monsoon has set in, the synoptic situation is conducive to the occurrence of very heavy rains over Mumbai when it has the following features collectively : 1) development of a low pressure area over the northwest bay of Bengal. 2) Intensification of the monsoon through and development of embedded convective vortices over central India. 3) Strengthening of the Arabian Sea current of the monsoon and 4) super positioning of a meso-scale offshore vortex over northeast Arabian Sea and its northward movement. All these conditions are said to have been met on 26th July 2005. The Mumbai downpour was the result of a combination of synoptic scale weather systems which have a span of 1000-2000 km. and the Meso-scale system localized over 20-30 km.

3.3.7 Monsoon was very active in south Konkan right from 25th July and also in north Konkan on 26th July. It is not clear why Mumbai and MMR could not be put on special alert for 26th and 27th by IMD – through special emergency messages and bulletins rather than continuing with only routine releases at 12.30 hrs of the day. Mumbai and other corporations in MMR do not have any mechanism for tracking and mapping the storms. IMD has that. But information available with them could not be put to use to alert the people about an exceptionally intense storm. A proper mechanism for spread of information that is available with IMD will have to be devised.

3.4 The regional characteristics

3.4.1 The heavy downpour conditions that were witnessed by Greater Mumbai in the last week of July 2005 were experienced at Ratnagiri, & Chiplun in Konkan and at many other parts of the Maharashtra State, also causing phenomenal damage in that week. They are of the category of extreme events. The observed rainfall data for Mumbai, MMRDA area and for Konkan area give an idea about the pattern of distribution of rainfall that was associated with this extreme event (Please see Figure 3.1 & Figure 3.2)

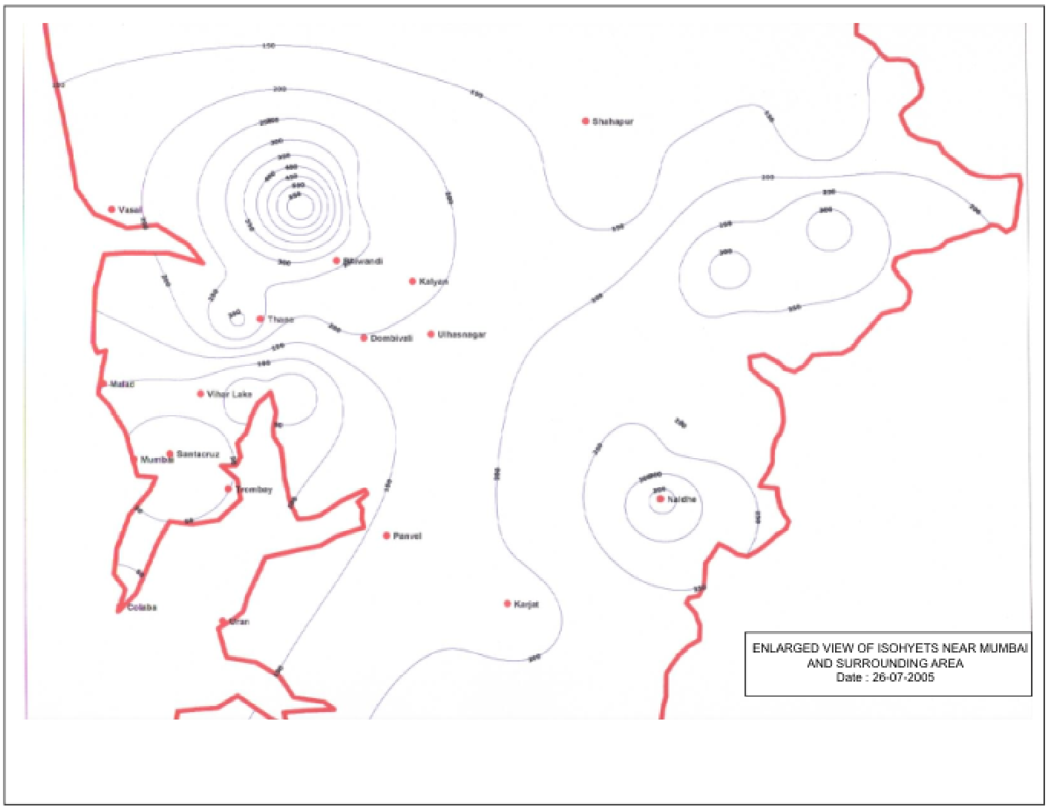
The precipitation figures as measured up to 8.30 Hrs on 27th July were as below.

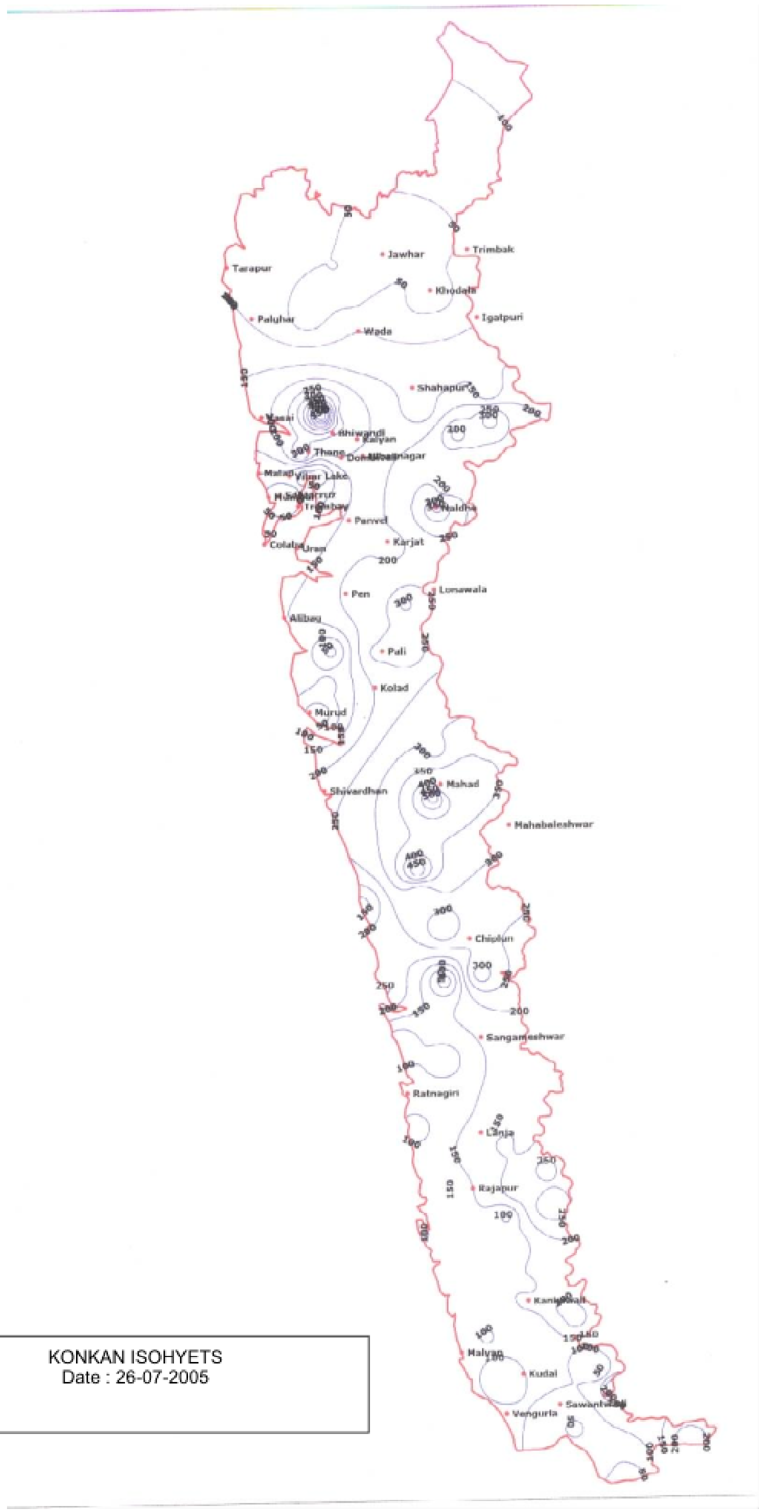
(Rainfall values are in mm)

Station	27 July	Agency
Colaba	73.4	IMD
Malabar Hill	74	
Dharavi	493	
Santacruz	944	IMD
Bhandup	815	
Vihar	1011	MCGM
Thane	720	
Tulsi lake	601	
Bhiwandi	748	
Kalyan	619	

Note: Except Colaba and Santacruz which are managed by the India Meteorological Department, other stations are managed by Govt, Semi Govt or private organisations.

3.4.2 In the context of Mumbai it has also to be remembered that the normal annual rainfall of the meteorological sub division of Konkan and Goa is 2980 mm, more than the normal annual rainfall of 2790 mm over the Assam and Meghalaya which includes Cherrapunji, and is only little less than the normal annual rainfall of 3060 cm over the Andaman and Nicobar Islands. On the time scale of a day, there are many past instances of Indian stations of IMD having recorded as much as half of their annual rainfall, and some times even more than their annual rainfall on one single day. Rainfall of 500 mm or more in a 24 hour period is not an uncommon phenomenon.


Shahapur
Vasai
Kalyan
Dombivali
Ulhasnagar
Malad
Vihar Lake
Santacruz
Panvel
Colaba
Karjat
ENLARGED VIEW OF ISOHYETS NEAR MUMBAI
AND SURROUNDING AREA
Date : 26-07-2005



KONKAN ISOHYETS
Date : 26-07-2005

3.4.3 The average rainfall in Mumbai is 2129.8 mm mostly spread over a period from June to September. The wettest month is July with a normal fall of 742.2 mm. Very heavy rainfall exceeding 250 mm at one stretch is not uncommon during the monsoon period.

3.4.4 Mumbai is at the mouth of Ulhas basin. The Ulhas basin's isohyets for 27 July show (See Figure 3.3) two additional points of concentrated heavy precipitation, one at Pundas 25 km NE from Vihar with 380 MM precipitation, and the other at Nalde, 55 km East from Vihar, with + 500 mm rainfall. Aerial spread at Pundas is small, just a radius of 2.5 km while that at Nalde it is 30 km. Nalde has a much more intense downpour on a large geographical area. It is situated close to the Sahyadri escarpment. But its precipitation pattern gives some indication about what can be expected for such an intense precipitation event in Mumbai. Monsoon intensity with + 100 mm per day rainfall lasted in its neighborhood for a long period commencing from 25th July and continuing up to 29th. In absence of any detailed information from IMD station at Santacruz which got submerged on 26th it is useful to look at the information at Nalde more closely.

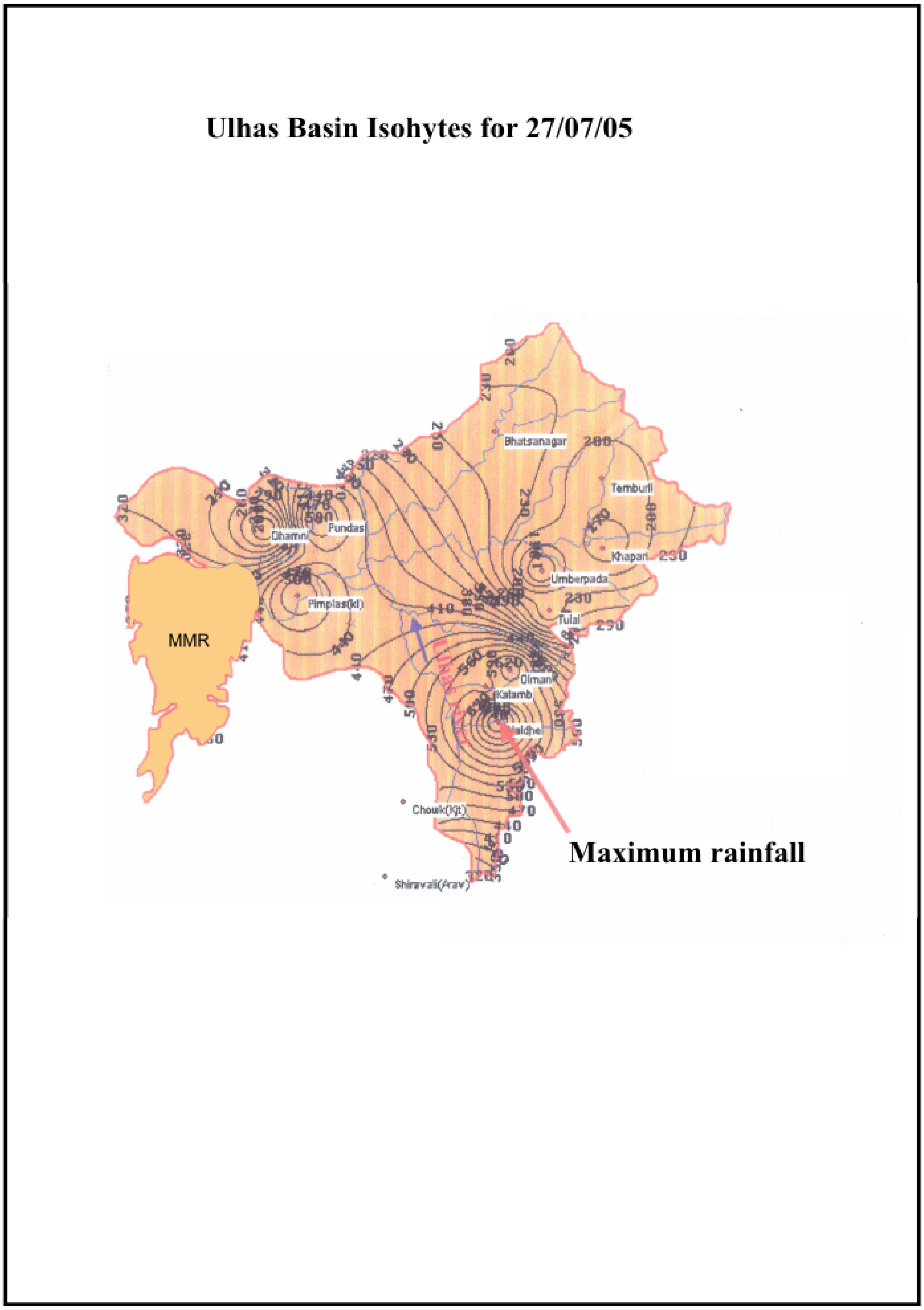
3.4.5 Because the 15 minute wise data of Santacruz station of IMD for the storm on 26-27 July was not available for analysis, the state's Hydrology project organization (Water Resources Department-GOM) was requested to derive the return periods of rainfall based on extreme event at Nalde in Ulhas basin which witnessed 800 mm rainfall on 26th July. The Nalde station is located just 40 km away from Santacruz. The data used is for the period from 1983 to 2005, which includes 800 mm rainfall recorded on 27th July. The return periods are worked out using HYMOS software available with the state's Hydrology project organization. The results are as below.

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

- **Probable rainfall intensities for 1 Hr duration and for a return period of 10 year, 25 year and 100 year are shown in colors.**

3.4.6 On 27th July, the precipitation gradient from + 1000 mm at Vihar (944 mm at Santacruz at a distance of 5 km) to only 67 mm at Colaba further 22 km south has been too steep – almost 30 mm/km. Storm water provisions may tend to get over designed by the measurement of such extreme point rainfall figures, if their aerial spread is not correctly taken into consideration. For every storm, we have to prepare a rainfall map of isolines to appreciate the aerial coverage of the different quantities of rainfall.


Ulhas Basin Isohytes for 27/07/05
MMR
Bhatsanagar
Temburli
Khapari
Dhamni
Pundas
Pimplas(kl)
Umberpada
Tulai
Olman
Kalamb
Chouk(Kjt)
Shiravali(Arav)
Maximum rainfall

3.5 Extreme Events

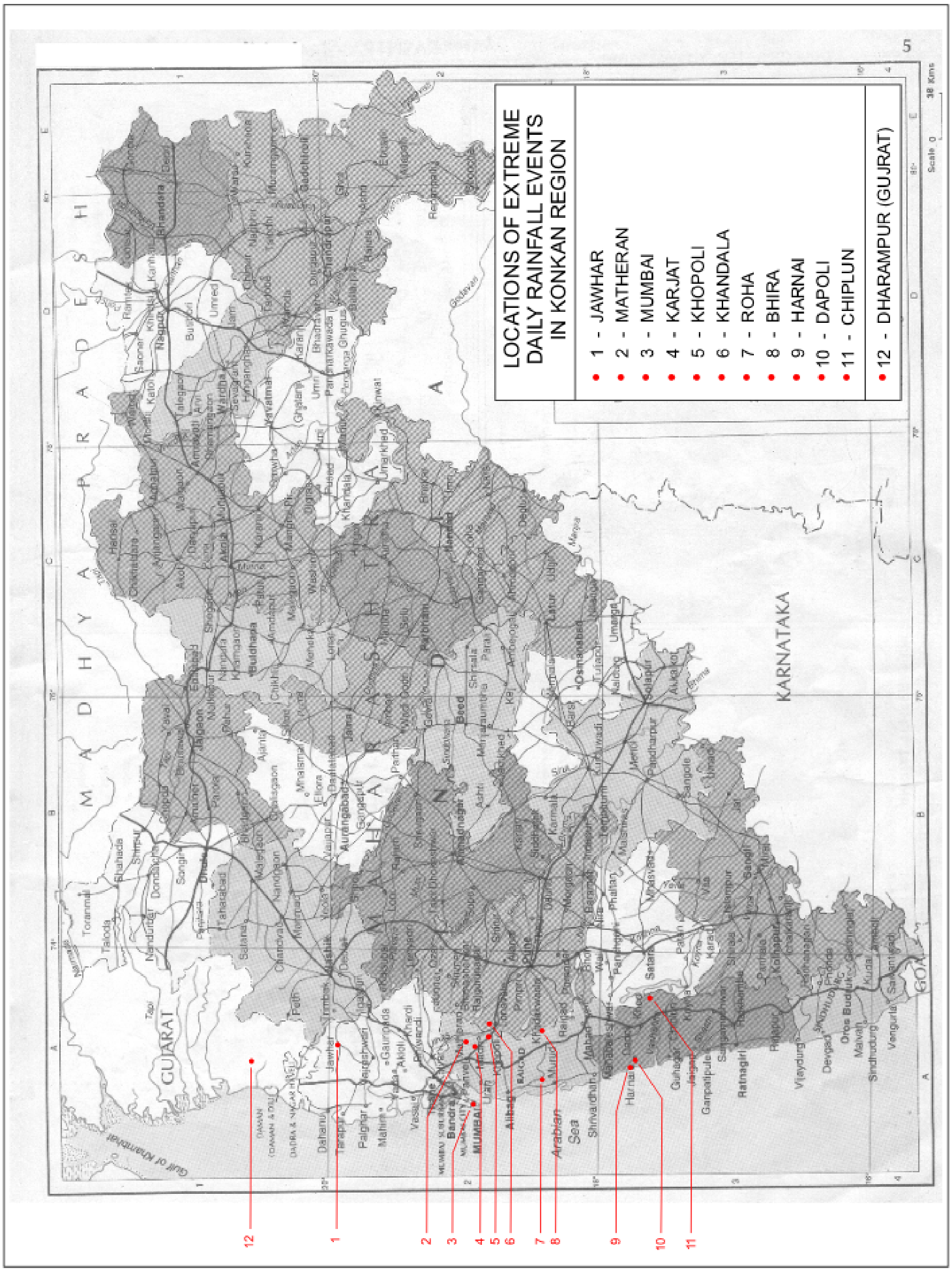
3.5.1 The previous extreme event was witnessed by Mumbai on 5th July 1974 with 570 mm precipitation recorded at Colaba. The extreme events recorded so far in Konkan are chronologically as below. (See Figure 3.4)

SN	Station	Rainfall mm	Date
1	Dapoli	540	3 Jun 1882
2	Chiplun	530	4 Jun 1882
3	Roha	630	18 Jun 1886
4	Jawhar	660	28 Jul 1891
5	Matheran	660	24 Jul 1921
6	Karjat	610	18 Jul 1958
7	Khandala	520	19 Jul 1958
8	Harnai	800	5 Aug. 1968
9	Mumbai (Colaba)	570	5 Jul 1974
10	Bhira / Jambulpada	713	24 Jul 1989
11	Mumbai	944 (& 1011 Vihar)	27 Jul 2005

Even during the last week of June in 2005 there had been as much as 1042 mm of rainfall at Ghatgar in the Bhatsa valley (Ulhas Basin) in three days of 27-28-29 June – which is 85% of the average annual rainfall of that place; with a day's maximum during the episode being 480 mm on 29th June. These instances point out the severity of the rainstorms that visit Konkan region somewhere or the other fairly frequently.

3.5.2 The extreme rainfall events do occur in nature occasionally. But they are randomly dispersed in space and time. Their determination in advance is not possible. The practice followed by scientists of the Indian Institute of Tropical Meteorology (Pune) for categorization as an extreme event is the precipitation value lying beyond the threshold of normal rainfall $\pm$ 5 times the standard deviation. There are many cases of catastrophic extreme hydro meteorological events reported across the globe. Such extreme cases have been taking place in India from time to time and also along the western coast of India. The Jambulpada incidence (Dist Raigad) with a day's precipitation of 713 mm had taken place just 65 km away from Mumbai in 1989. In India considering the Konkan region as a whole, what Mumbai witnessed is not something unimaginable. The situation got aggravated because of increased runoffs from covered catchments & reduced time of concentration, coupled with inadequate carrying capacity of the water ways because of encroachments and congestion. The impact was further worsened because of high tides occurring at the same time on 26th evening. Constriction of natural waterways, clogging of culverts, changes in natural stream flow directions, increased coefficients of rugosity because of crowding of structures and reduced hydraulic gradients by silting gave rise to high flood levels and longer periods of inundation. To get prepared for such events in the future and to design the city's systems adequately for the future probabilities, gathering of detailed hydrological information will need a much more serious and continued attention hereafter.

FIGURE 3.4



LOCATIONS OF EXTREME DAILY RAINFALL EVENTS IN KONKAN REGION
1 - JAWHAR
2 - MATHERAN
3 - MUMBAI
4 - KARJAT
5 - KHOPOLI
6 - KHANDALA
7 - ROHA
8 - BHIRA
9 - HARNAI
10 - DAPOLI
11 - CHIPLUN
12 - DHARAMPUR (GUJRAT)
GUJARAT
MADHYA PRADESH
MAHARASHTRA
KARNATAKA
Arabian Sea
Ref.: Navneet School Atlas, Maharashtra Edition

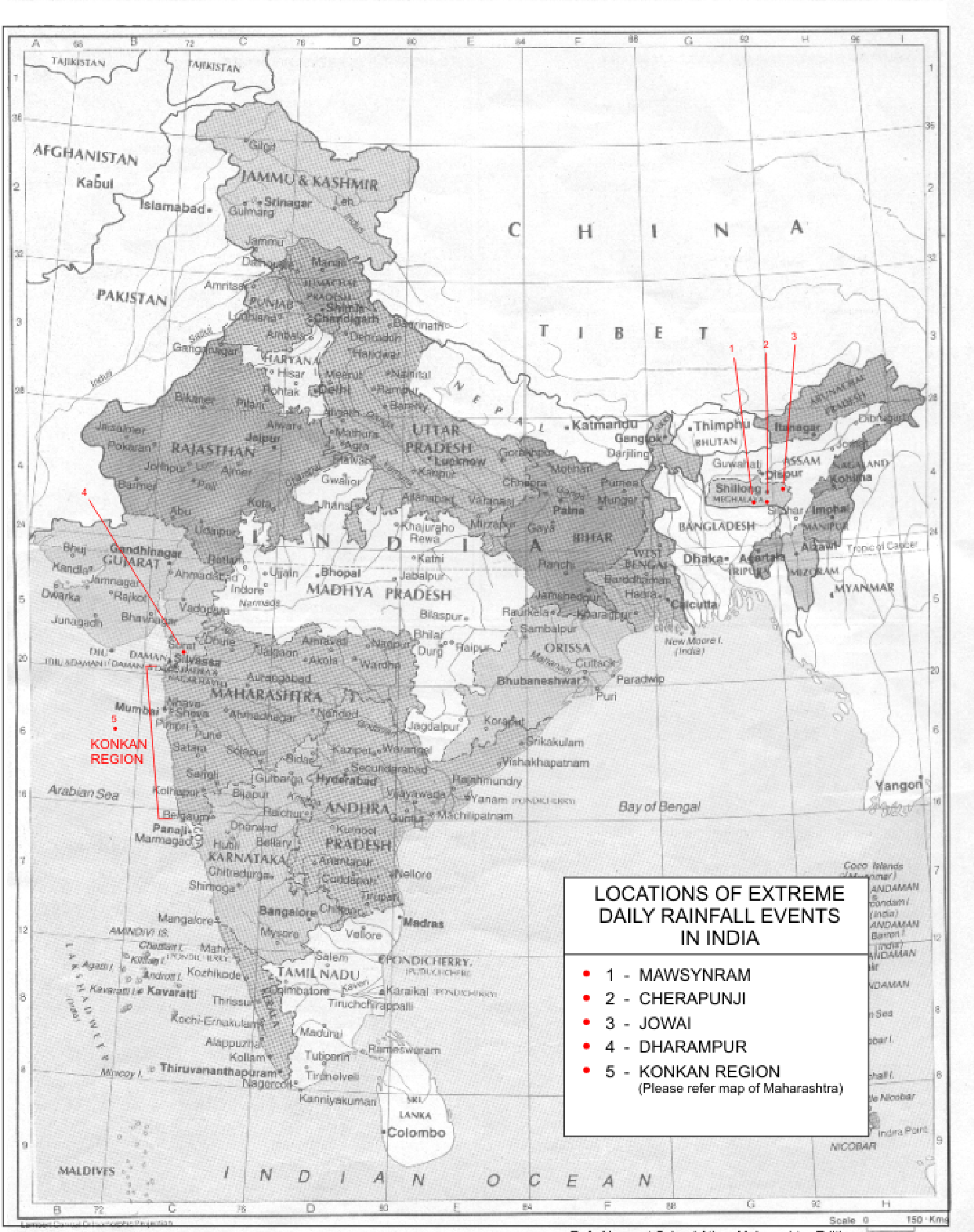
3.5.3 In the Jambulpada (Bhira) episode in 1989, (appearing at Sr. No.10 in the above list), the entire village was devastated due to the extreme event. The Jambulpada village is situated on the banks of the Amba river on Khopoli-Pali State highway. It is 10 km away from Pali towards Khopoli. Rainfall of 648.00 mm was recorded at the Rain gauge station Tuksai, Tal.-Sudhagad (Pali) Dist.-Raigad while that at Bhira it was recorded as 713mm. The Rain gauge station Tuksai is located 5 km away from Jambulpada and was established on 31/3/88 by the then Irrigation department. The incident occurred on the midnight of 23/7/89. The major quantum of the total rainfall occurred during 00.30 AM to 03.30 AM, which was 585.00 mm out of total of 648.00 mm. The average hourly intensity within those 3 hours worked out to 195 mm and that for the short time interval of 15 minutes, it comes out to be as high as 49 mm. As a result of heavy downpour, the water started accumulating around the Jambulpada at 4.00 AM. The floodwater was unable to flow out due to high tide in the river Kundalika, Jambulpada Bridge was almost 7 meters above the bridge. This level persisted for 24 hrs. Further downstream, Nagothane, Tal-Roha, also got affected. The bridge on Amba river of NH-17 near Nagothane submerged and the water level was 6 meters above the bridge. The Bus-stand of Nagothane was completely under water. The graphs of the rainfall recorded on the automatic rain gauges for at Pali & Tuksai stations are available and provide very useful information for 23/7/89.

3.5.4 For the country as a whole the Mumbai event on 27th July is the 10th extreme rainfall event– as can be seen from the chronological statement below. (See Figure 3.5)

Rank	Station	Date	Rainfall mm	State
1	Jowai	11.9.1877	1019	Meghalaya
2	Cherrapunji	12.7.1910	998	Meghalaya
3	Cherrapunji	21.6.1934	974	Meghalaya
4	Cherrapunji	12.9.1974	970	Meghalaya
5	Cherrapunji	13.9.1974	985	Meghalaya
6	Dharampur	2.7.1941	987	Gujarat
7	Mawsynram	10.7.1952	990	Meghalaya
8	Cherrapunji	14.7.1976	1036	Meghalaya
9	Aminidevi	6.5.2004	1168	N.A.
10	Mumbai	27.7.2005	944 (Santacruz) 1011 (Vihar)	Maharashtra

If we take into account the Vihar rainfall of 27th July which is 1011 mm then Mumbai gets the fourth highest rank in the above table. It is said that large scale synoptic system on 26th July 2005 as observed by IMD was very similar to any other previous very-heavy-rainfall days over Mumbai.

FIGURE 3.5



Ref.: Navneet School Atlas, Maharashtra Edition

3.5.5 The maximum possible rainfall termed as Probable Maximum Precipitation (PMP) as estimated by IITM has been 960 mm rainfall in one day for Bhira and Colaba and 800 mm for Santa Cruz. PMP is an estimation of theoretical upper limit of precipitation for a given duration that is meteorologically possible. This PMP is estimated by utilizing present day knowledge of the precipitation process. But this figure got exceeded on 27th July.

3.5.6 For 25, 50 and 100 year probabilities – 24 hour rainfall graphs have been developed by the Central Water Commission (CWC), Govt. of India on a regional scale for different parts of India. For the Konkan coastal areas their report is published under the title "Flood Estimation Report for West Coast Region: Konkan & Malbar Coast, Sub Zones – 5a & 5b in the year 1992. The values for Mumbai read from those graphs are (i) for 25 year probability =350 mm (ii) for 50 year probability =400 mm and (iii) for 100 year probability =440 mm in a day.

3.5.7 The outcome of the study on extreme events carried out by IITM Pune for the Indian region is available in a paper titled as "Rain depths associated with most severe rainstorms of the Indian Region", which is published by the American Meteorological Society in Nov.1985. The original table gives the extent of rainfall in mm for 1 to 3 day duration for most severe rainstorms of India (1880-1980) over areas from 250 Sq.Km upward to 50,000 Sq.Km. In the context of Mumbai, the 1 day duration maximum precipitation figures for an area of 250 Sq.Km is the nearest relevant figure. Therein the chronological position is as below.

Rainstorm	In mm
Sept.1880 Nagina (UP)	810
July 1927, Dakor Gujarat	520
July 1941 Dharampur (Gujarat)	950[1]

All these figures give an idea about the severity of the conditions for which a city like Mumbai, and more the so the Mumbai Metropolitan region as a whole entirely lying in the Konkan coastal belt will have to be ready in respect of 'disaster preparedness'.

3.6 Impact of Global Warming

3.6.1 Moreover, studies in global warming, have led to the conclusion that extreme rainfall events are likely to become more frequent in future. The Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change has concluded that the "amplitude and frequency of extreme precipitation events is very likely to increase over many areas". In other words, the 1-in-50 year probability event of today is likely to become a 1-in-25 year event of the future. Global climate researchers have pointed out 'increase in monsoon strength as earth's atmosphere is warming up'. They are suggesting that any future warming may give more rains to India, and more rains with increased intensity of precipitation. Higher intensities of

rainfall is therefore the likely hydrological future for India .Scientists are also warning about the rise in sea levels from increased snow melt process. Hence the planning of a coastal city like Mumbai – which has developed mostly on flat reclaimed lands, will have to be very carefully evaluated in terms of risks to the population from inadequate carrying capacities of the stream channels.

3.6.2 In respect of the issues associated with climate change, there exists a gap between the scientific knowledge, technical expertise, the disaster relief set ups, and understanding prevalent in the minds of the public representatives and the public at large which needs to be bridged in order to effectively address the issues and to generate a proper consensus on the required defense mechanism, preventive actions or ameliorative measures to be contemplated. It will be useful if systematic campaigns for this could be carried out by well established voluntary scientific associations of good reputation and public trust like the Marathi Vidnyan Parishad, at least as far as the Mumbai's sensitivities are concerned.

3.7 Rainfall risks at different return periods

3.7.1 To plan and design the storm water conveyance system in a city like Mumbai which is aiming at an international standard of civic management, the practice of considering 2 stoppages in a year, or even a 5 year return period of rainfall will not be appropriate for the major traffic routes. That will also not be adequate to protect the lives and property along the river channels. We need to design and change the storm water drains to some higher intensities of precipitation for important traffic routes. BRIMSTOWAD standard of 2 submergences in a year may be adequate for internal local roads. But important roads will have to be kept flowing even under lesser probability of precipitation intensity to avoid serious traffic congestions and to ensure quick evacuations from critical areas like schools and hospitals. Considering the hydrological characteristics in and around Mumbai, this metropolitan city may best be planned for three different levels of hydrological risks. While the large number of CD works on small streams and for minor internal roads in Greater Bombay may continue to be planned and constructed according to BRIMSTOWAD, the channel widths of the main rivers, and the CD works for the major roads and for the through corridors of traffic will have to be planned and handled for higher intensities of rainfall. In addition, f*or more severe conditions contingency plans will have to be kept ready and acted upon.*

3.7.2 From the analysis of the Nalde rain gauge station, it is seen that the maximum rainfall occurring in 1 hour for 10 year return period is 65.86 mm, that for 25 years period is 76.77 mm and for 100 year return period it is 92.89 mm. Though this data cannot be applied to Mumbai directly, but it gives an indication of the probable values which can be considered and the range of increase in intensities for larger return periods. At Nalde, The yearly probability of a maximum rainfall in an hour is 30 mm / Hr which is not far away from the 25 mm /hr that had been used for the drainage design of the Mumbai City in the past. But the one in 10 year probability figure however immediately jumps up almost by twice the amount and the 100 year probability figure is further up by three times. These are indicative of the scale of enhanced risks for larger return periods of rainfall probability. BRIMSTOWAD report mentions a value of 109 mm/hour intensity for 1 in 10 year return period. The maximum hourly rainfall values calculated by CWPRS on the basis of July 2005 event in Mumbai when compared with Nalde are as below.

Hour's rainfall in mm

Return period in years	CWPRS EV-1 distribution		Hydrology Project (HYMOS)
	Santacruz	Colaba	Nalde
1	Not calculated		29.911
2	54.1	53.4	Not calculated
10	78.8	81.4	65.861
25	91.3	95.5	76.770
50	100.6	105.9	84.862
100	109.8	116.3	92.894

[Ref: CWPRS Technical report October 2005 on mathematical model and desk studies for floods of Mithi river carried out at the request of MMRDA]

3.7.3 Because there are no actual one-hour measurements of the rainfall at Santacruz station on 26-27 July the values are required to be inferred from other related figures and other related information. It is very unfortunate that IMD rain gauge at Santacruz got submerged even by a little rainfall proceeding the heavy downpour period. Consequently the very valuable opportunity for obtaining useful data on the self recording automatic rain gauge was lost. M.C.G.M.'s Vihar station does not have a self recording automatic rain gauge. Hence we have to go by the manual measurements at Vihar and Santacruz and draw inferences from the automated rain gauge station at Nalde. .

3.7.4 The CWPRS study of 1978 was used to develop Bandra Kurla complex by reclamation of 220 Ha of area in the water spread area of Mithi river by canalizing it for 60 mm precipitation per 4 hours duration rainfall. The 4 Hr duration storms at Nalde show an annual probability of 15.336mm per hour intensity, which is just in line with the CWPRS – channelisation standard for Mithi river. In other words, the Mithi channel if designed according to CWPRS standard (1978) should not normally have a yearly problem of bank flooding. One of the major tasks for the Mumbai urban hydrology cell to be established immediately under MCGM will be to develop rainfall intensity-duration-frequency relationship based on 15 minute and hourly rainfall data for different durations of storms in and around Mumbai.

3.7.5 The CWPRS had not been asked to make recommendations of rainfall values for design of storm water drains and are silent on this aspect in their reports. Their focus has been on the Mithi river channel and not on the numerous small catchments in the Mithi Basin or on many other watersheds in Mumbai. Hence, till more data is generated and more in depth studies are carried out, it will be prudent to go by BRIMSTOWAD for the up-gradation of the numerous storm water channels and their CD works in Mumbai excerpt for the river channels, the major roads and the through traffic corridors. A review of the BRIMSTOWAD provisions for the small catchments may be considered if required – say after at least 5 years extensive data is compiled and well analyzed in Mumbai urban Hydrology cell.

3.7.6 The Central Public Health Engineering Organization's manual (CPHEO) contains guidelines for design of storm water drains. Frequency of permissible flooding for peripheral residential areas has been suggested as twice a year, for central high priced areas as once a year and for commercial high priced areas as once in 2 years. Under this is kept in view is the normal scale of tolerable 'flooding' – such as 250 mm on public roads and in the private premises. But the analysis of the monsoon precipitations has now clearly demonstrated a large variability in the intensity of precipitation from year to year. At exceptionally high intensities, it is not only 'inconvenience', there are risks to life and property particularly along the river channels in the urban areas. This aspect has remained to be covered by CPHEO manual as well as by BRIMSTOWAD. Hence beyond the normal conditions of operations there will have to be special provisions for risk aversion at higher intensities of rainfall and the more so in metropolitan areas like Mumbai. This is not only the question of design of storm water drains. The cross drainage works on the stream channels in the areas are also required to be properly designed. CPHEO has been silent on this. But the guidelines prepared by the Indian Roads Congress for urban roads throw some light on the requirements in this connection. The frequency of flows for which cross drainage works are recommended to be designed is 1 in 50 Y or 1 in 100 Y for railways and highways.

3.7.7 Crowded Metropolitan cities need very stringent standards keeping in view the adverse impacts of traffic stagnation and resultant hurdles in evacuating the people from the affected areas. Even the spillways of the medium sized dams are designed for 1 in 100 year probability of flood. It will be desirable if the few major corridors of the city which can evacuate the population in emergency situation are planned and designed for a flood probability of 1 in 100 years. Keeping this in view committee recommends adopting design criteria of 1 in 100 yrs return period for the crossings of the main arterial roads of Mumbai. The other major roads (feeders to the arterial roads) may be designed for the rainfall intensity of 1 in 25 yrs return period. BRIMSTOWAD recommendations should continue to be followed for all other internal roads and storm water channels.

3.7.8 The rainfall intensity analysis carried out in BRIMSTOWAD shows the following return periods for the different storm durations.

Average intensity in mm/hr

Return period	Duration hours				
	1	2	4	8	12
1 in 10 Yrs.	109.0	89.0	61.5	35.5	28.0
1 in 5 Yrs.	91.4	70.3	51.0	27.6	24.0
1 in 2 Yrs.	74.0	53.3	38.0	22.5	19.4
1 in 1 Yrs.	58.0	40.6	30.4	18.1	16.5
2 in 1 Yrs	48.0	33.0	23.2	14.6	12.0
10 in 1 Yrs	25.0	17.0	12.0	7.6	5.9

The 50 mm reference intensity, adopted by BRIMSTOWAD is good enough for a 4 Hr storm of 1 in 5 YR storm periods also. Hence there should be no hesitation in continuing with the BRIMSTOWAD provisions for all the storm water channel improvements, except for those required for the major roads, for the main traffic corridors; where a greater dependability of traffic movement needs to be ensured; and for river channels management where levels of risk are high.

3.7.9 The water ways suggested in BRIMSTOWAD may prove to be inadequate for some flood flow across the CD works of small catchments under heavy rainfall conditions. But that inadequacy will not have a large impact in terms of area under spread. Local stagnation of water will cause inconvenience, but not much of a risk as such to life and property. After 5 years of data collection, when more information on 15 minute intensities of precipitation is in hand the BRIMSTOWAD provisions for small catchments may be reviewed if necessary.

3.7.10 The analysis carried out by Hydrology project of the Maharashtra Government indicates the maximum rainfall occurring in one hour in a return period 10 yrs, 25 yrs, and 100 yrs as 65.86 mm, 76.77 mm and 92.89 mm respectively with reference to the studies for the Nalde station.

3.7.11 The extreme intense precipitation at Vihar – is a localized phenomenon and did not cover the entire Mumbai. Rather than going by such isolated extreme events, for the planning of the storm water channels in Mumbai, it will be more appropriate to go by the general regional trend in the western coastal area and adopt the probability criteria based on the regional experience. The Central Water Commission in collaboration with the India Meteorology Department has developed guidelines for the cross drainage works in the western coastal belt. Area. Based on those figures, and the theoretical estimates of the maximum probable precipitation (800 to 960 mm) at 414mm/day (much lower than the actually observed 1011 mm at Vihar), limited aerial spread of the extreme intensities of rainfall, and the differences in the results of the statistical analysis carried out by different research workers for different sets of data, we find that it will be adequate if Mumbai's storm water systems are basically designed in simpler terms for the following hourly intensities of precipitation

a) Small catchments – 50 mm/hr. – 2 in 1 year probability vide BRIMSTOWAD
b) 1 in 10 year probability – 70 mm / hr. – River channel areas to be kept free from any intrusion
c) 1 in 25 year probability – 80 mm / hr. River bank area with restrictions on pattern of land use and the type of constructions and for the CD works on major roads (Feeder Roads to Arterial Roads).

d) 1 in 100 year probability –100 mm / hr. - River bank area as a risk zone, CD works on main through arteries of traffic. Road length associated with the major roads and the arterial routes, if falling in the flood risk zone will have to be raised appropriately above the anticipated flood levels.

3.7.12 For rivers, the risk zones along the banks will have to be spelt out and demarcated on the ground, keeping in view the general guidelines in the flood zoning bill recommended by Govt. of India to the states.(See Figure 3.6) The local residents will have to be appraised of the risks involved and only the permissible type of development will have to be allowed in these zones. The smaller catchments and cross drainage works on internal roads in Mumbai should continue to be designed for 50 mm/hr intensity, as adopted in BRIMSTOWAD But all the balance work as was already contemplated in that report needs to be completed on priority immediately.

3.8 Hydrological measurements in Mumbai

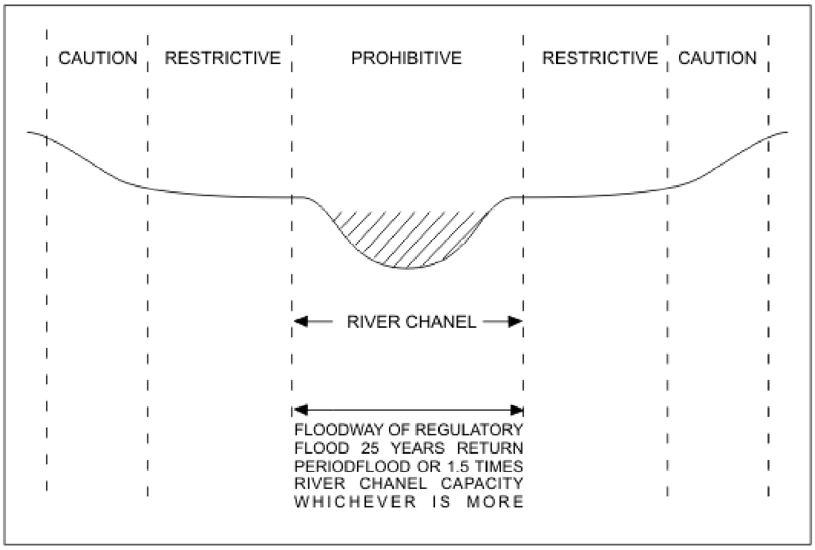
3.8.1 It is indeed very important to go to a greater depth of study in hydro meteorological and surface water flow processes in an urban area. The role of hydrology in the planning and designing of the developmental infrastructures of urban areas will become more and more important hereafter. Measurements of rainfall, river discharges, stream flow levels, tidal effects, detention time volumes and locations of inundated areas will need systematic recording and monitoring. Reliable hydrological information will have to be collected with sufficient density in both time and space. It will have also to be properly validated. Considering the growing importance of Greater Mumbai as an international Centre of activity, it is imperative that Mumbai should have an adequate spread of Hydro-meteorological observation stations immediately.

3.8.2 For planning of storm water works, two levels of rainfall statistics in required, one regarding the total annual flow and the other regarding intensity of precipitation over short periods. The former is required for estimating annual pumping costs and the latter for deciding about the size of drains and channel flow capacities. These hydrological stations will have also to be telemetrically linked with the alert, warning and relief action – phases of the disaster management plan for Mumbai.

3.8.3 Mumbai principally depends for its supply of water from the rivers on the main land. To monitor the rains in the 180km^2 catchments of the Bhatsa Dam (currently the major supplier of water), there are as many as 12 self recording automatic rain gauge stations operated by the Water Resources Dept of Govt of Maharashtra. Similarly in the 288 Sq.Km catchments of Modak Sagar, there are of 8 rain gauge stations. Compared to this, for Mumbai's geographic area of about 450 Sq.Km the dependence so far has been only on IMD's two stations and the Corporation's rain gauge station at Vihar. These are far too inadequate to monitor the rainfall conditions of the city. The rain gauge station density of at least one station for every 25 Sq.Km (i.e. population of about 5 lakh persons) will have to be achieved to measure the

FIGURE 3.6

REF.: DAM SAFETY MANUAL, GOVT. OF MAHARASHTRA



rainfall characteristics and the storm flow characteristics of the metropolis in meaningful terms.

3.8.4 Stream gauging : Developments of the suburban areas of Mumbai have been very rapid and at many places very close to the water courses. No measurement of floods has been carried out on any of these streams so far. Stream Gauging is vital for establishing hydrological connection between the rainfall and the surface flows on the ground. BRIMSTOWAD report has already adopted a watershed approach for storm water management. For watersheds and basins / sub basins of geographical spread of more than 1000 ha (i.e. 10 Sq.Km), it will be desirable to install immediately at least one stream gauge close above the tide level or above the confluence of the stream with the main river channel. Thus there will be about 50 stream gauges in Mumbai i.e. roughly one for a population of about 2 Lakhs. In absence of such gauges, quantitative information about the flood flows in the stream channels, accumulated water in and around the stream channels and extent and duration of submergence has not been yet available. For monitoring the safety of the people and for future refinements in storm water management, information from stream gauges will be very helpful.

3.9 Time unit for Analysis

3.9.1 From the hourly rainfall data available for the Nalde station.It is seen that the hour's maximum rainfall was 136mm between 15 pm to 16 pm on 26th July. By simple arithmetic it works out to an average of 34 mm per 15 minutes interval. But the maximum 15 minute rainfall that is required to be handled is not the fourth part of the hourly rainfall, but much more. The hourly data of Nalde broken into 15 minute interval is appended vide Appendix-3A & Appendix 3B. It is interesting to note that the measurement of rainfall from the automatic rain gauge at Nalde rain gauge station in Ulhas basin on 27th morning at 7.15 am gives a figure of 35 mm in 15 minutes and matches well with the hourly data of Vihar which gives an average of 34 mm rainfall in 15 minutes. But the 15 minute maximum value of rainfall for Bhira (Jambulpada) was 49 mm almost equal to the one hour value adopted by BRIMSTOWAD for drainage design. The 15 minute value of rainfall is relevant for Mumbai, because the time of concentration in many small catchments in Mumbai is small. Water can get accumulated in this much time at critical points to cause inundation and flooding

3.9.2 Hourly intensity between 20-21 hrs on 26th July was 50 mm, but 15 minute intensity during this period was 20 mm i.e. 140 % of the 15 minute average in that hour. This is also the position between, 2 hrs and 3 hrs on 27th July. On 27th, between 7-8 hrs the total precipitation was 65 mm but the 15 minute intensity was 35 mm i.e. more than 200% of the 15 minute average for that hour. Such local intense precipitations cause local congestions in the small urban water sheds. Mumbai urban hydrology cell will have to address such small duration intensities. Future rain gauging work – collection of information, monitoring and frequency analysis – will have to get focused on this time unit.

3.9.3 Duration of storm for design of river channels and cross drainage works will have to be according to the time of concentration of the surface rainfall for the concerned watershed. In Greater Mumbai, leaving aside the 4 major rivers namely – Mithi, Oshiwara, Poisar and Dahisar, other catchments are very small.

BRIMSTOWAD has analyzed them. Except the ten catchments viz. five major roads, Irla nalla system and major catchments in island city, nowhere is the time of concentration more than an hour. In fact in many smaller catchments, the time of concentration is just 15 minutes. Hence while studies on hourly intensities of rainfall – as carried out and used so far would take us somewhat close to the actual requirement, it will be useful to carry out more detailed '15 min' intensity analysis – hereafter when more data is generated from the hydro meteorological stations with self recording automatic rain gauges proposed to be installed in Greater Mumbai.

3.9.4 BRIMSTOWAD has worked out these periods for the catchments defined by them. But it did not cover the river basins area as a whole, which comprise a large number of small catchments. Hence those studies will be necessary hereafter – for the 4 main rives of Mumbai – namely – Mithi Oshiwara, Poisar and Dahisar. In the preliminary studies for Dahisar, Poisar and Oshiwara rivers carried out by Water and Power Consultancy Service (India) under the assignment from MMRDA after the July deluge, indications are that the time of concentration for these three rivers will be between 1 to 1.5 hours. Excluding the time required for water from the catchment upstream of Vihar lake, the time of concentration for Mithi river system from Vihar downwards is expected to be about 2.15 hours. In Mumbai 19 main catchments (as delineated by BRIMSTOWAD) and more than 30 % sub catchments have a time of concentration in the proximity of 15 minutes. Therefore rainfall intensities for duration of 15 min. become more important from local flooding point of view. Normally these intensities are 30 to 40 % higher than the intensities for the storm of one hour duration for the same return period.

3.9.5 Data on hourly intensities of precipitation has been somewhat easily available at present. That for 15 minute duration intervals needs to be specially read and compiled from the graphs of the self recording automatic rain gauges. There has been a dearth of such analyzed data. Hence it has not been possible to lay down immediately specific criteria for 15 minute intensities to be considered in the designs. More analysis and thinking on this aspect is necessary. At present, the important point to note is that hereafter in the urban Hydrology work of Mumbai, 15 min as the time unit for data collection and analysis will have to be followed. Graph papers of the self recording rain gauges will have to have clear graph lines for 15 minutes intervals. Currently, the graphs for the self recording automatic rain gauges are by and large for 10 minutes intervals. But that is too small a response time for alert or warning mechanisms in the arrangements to be handled for disaster management. It will be more practicable to follow '15 minute' – as the time period for information gathering and monitoring. Recording of the 15 minutes rainfall is not a problem. That time unit will have to be used also for alert and warning signals to be obtained for impending disaster situations to provide adequate lead time for safety arrangements and relief.

3.10 Sensing by Radars

3.10.1 Prediction of extreme events well in advance is very difficult. However their probable occurrence can be foreseen a few hours in advance say 3 to 4 hrs. This is possible with advanced instrumentation like Doppler radars. A Radar set consists of (i) a transmitter which produces radio energy; an antenna which radiates the energy; a receiver which amplifies, detects and transforms signals into video forms and clouds are identified accordingly. The pulses of radio waves produced typically are around 1000 per second. The Doppler weather radar has the capability of surveying

vast area and makes a large number of observations (almost millions of them) in a few minutes .The quantities that can be measured by the radar are the reflectivity of the precipitating clouds and / or spectrum of terminal velocities of precipitating hydrometeors. These two quantities are in turn used by meteorologists to calculate precipitation rates.

3.10.2 Doppler radar systems have been installed on the East coast of India and IMD has been publishing the information obtained from it on their web site. The data sets as published are however not yet at the level of understanding except for the meteorologists. Considering the severity of many storms impinging on the west coast also and the growing urbanization along the west coast, it will be desirable to have similar systems installed along the west coast also. There have been continuous developments in the radar systems. It will be very helpful if an advanced category radar system becomes available for Mumbai.

3.10.3 The cloud seeding experiments conducted by the Maharashtra State in 2003 and 2004 monsoons used the radars for detecting the rain bearing clouds, for predicting the storm behavior at least for half an hour period with the help of TITAN software employed therein. The cloud data sets (cloud pictures showing quantum of water in the form of reflectivity) captured during the experiment of cloud seeding has been made available to IITM Pune for research. They had no such data for Indian continent in the past. We will have to keep pace with the advancement in technology for a better understanding of the weather systems, and more the so for the risk prone cities like Mumbai. To fully understand the implications of changing climates and to build mitigation measures well in advance, there is an urgent need to spend adequately on climate related research in India. It will be desirable if agglomerations like the Mumbai Metropolitan region and the advanced educational institutions like IIT and VJTI located therein participate in these national efforts and translate the findings into planning and operational guidelines for the hydrometeriologically vulnerable areas.

3.10.4 There is a well organized system in this country for forecasting of river floods, which is run by the Central Water Commission with the active involvement of the Flood Meteorological Offices of the India Meteorological Department. However, the type of flooding that occurs in Mumbai is a very different matter. Here much of the flooding is not the result of water spilling over from a flooded river, but it is on account of an inundation caused by accumulation of heavy local rainfall under conditions of drainage congestion. In large basins, on the main India plateaus and in the Ganga Brahmaputra basins, river floods can be predicted because there is considerable time lag between the occurrence of heavy rainfall in the upper catchments and the consequent build-up of the flood flow in the river and its travel to a downstream area. Such a lead time is not available in case of drainage congestion caused by local rainfall as in Mumbai. Also the propagation of a flood wave in a river channel is easier to compute. Mathematical or physical modeling of city drainage is, from the hydraulics point of view, a far more complex problem. Hence the major dependence will have to be on the radar-measurements, and on the automated rain gauge stations to provide the alert and warning signals.

3.11 Topographical contours

3.11.1 It is sad that Mumbai does not have a contour map beyond what is prepared by the survey of India in 1976. Even the DP sheets of Mumbai currently in use do not include all the topographical details of the natural water courses and the information

about the area contours.. The survey of India's work was carried out in the period '62-'66, but the map was printed in 1976. Survey of India's topo sheet no. 47 A/16 covers most of Mumbai. The contour interval for mapping followed by Survey of India as per their standing practice is 20 meters – which has been adopted for this sheet also. There has been no survey thereafter. When this map is compared with the earlier maps of survey of India, one gets an idea about the topographical changes that have taken place in and around Mumbai.

3.11.2 History of development of Mumbai shows that urban Mumbai has been growing from South to North. The island city came into being by land fills between old seven islands commencing from 1816 and then expanding further through reclamation of coastal belts around the islands. The industrial / commercial development initially concentrated in South central part of Mumbai which subsequently shifted to suburbs and extended suburbs. Most of the population is now residing in North and the jobs are located in South. There is a heavy human traffic north to south in the morning and south to north in the evening. Rail transport covers almost 70 % share of this traffic. The low lying reclaimed areas in central Mumbai control the movement of this traffic as the railway routes and the major arterial roads had been laid through this belt. These areas are very sensitive to submergence under heavy rainfall conditions and many times give rise to stoppage of traffic.

3.11.3 The entire storm water outflow system of Mumbai has been so far based purely on gravity. There are closed drains in the old island city (Colaba to Mahim) and open drains or nallas in suburbs. They both discharge by gravity either in the creek arms or in to the open sea along the east and west coasts of Mumbai. The low lying portions of the island city have a history of getting regularly flooded up to 5-6 times a year, generally for a few hours every time, when high intensity rainfall is coupled with high tide in the sea. There is water logging in the central Mumbai belt under such conditions. At many locations, land levels are below the high tide level e.g. Sat Rasta, Lower Parel, Grant Road, etc. The mean sea level of Mumbai is very close to the Indian Mean Sea level at 0.01 m. The average high tide level is 2.5 m, the annual highest peak tide level being 2.75 m. The average low tide level is (-) 2.0 m (i.e. two meters below the mean sea level). It is the low tide periods (about 10 to 12 hrs in a day below the mean sea level) that have been providing relief during the storm by draining out the accumulated surface waters.

3.11.4 The original water courses which were discharging in creek arms in between the islands or over the reclaimed belt were later extended towards Eastern/Western coasts as more and more land near the coastline came to be occupied. They have very flat gradients and are prone to silting. The discharge levels of these water courses are at places much below mean Sea level. At such locations there is a regular tidal inflow in the drains. For the island city three major outfalls at Love Grove, Cleveland Bunder and Haji Ali are controlled with gates at their mouths near the sea to ensure that the city's reclaimed areas do not get flooded during the fair weather season by the tides. But when even moderate intensity 'rainfall takes place close to the high tide period, the water that accumulates behind the gates spreads into the low lying areas causing blockage of traffic.

3.11.5 The map no 47 A/16, much of the dense urban development of Mumbai is below the 20 meter contour line. But there are no contours available below 20 meters. The locations of survey of India's benchmarks are shown on the map along

with their levels. Some important spot levels are also marked on the map. The level of a large coastal belt in Mumbai is close to 3.00 M e.g. Juhu aerodrome; and Khar. These are the vulnerable areas for congestions and submergence by tide and flood interacting. Ground levels in many low lying areas in Island city & suburbs are just 2.25 to 3 meters above MSL, while the flood levels in the creeks also have the same heights. But the map under reference is of no use for storm water management planning of such areas as it does not contain the relevant levels.

3.11.6 Contour maps are vital for the management of the watersheds and for storm water handling. Therefore the contour mapping of the Greater Mumbai should be undertaken immediately to develop contour maps of all watersheds with a contour interval of 0.20 m (i.e. 200 mm) in the areas below the 20 M contour and with the contour interval of 0.5 m above the 20 m contour. The maps will have to be at least to the scale of 1 in 4000 (i.e. 1 cm on the map representing 40 m) which has been followed for the DP sheets of Mumbai. For the crowded areas, along the river channels maps to the scale of 1 in 1000 (1 cm on the map representing 10 m on the ground) will be desirable. It is necessary to mark out all such areas say below 5 m contour very carefully and handle their surface runoff very systematically. A fresh study of existing topography with very close contours to understand the surface depressions, and the likely possible diversions of surface runoff must also be taken in hand immediately

3.11.7 Before Survey of India established an all India systematic trigonometric survey and prepared contour maps of the country, the colonial regime in the early British period in Mumbai carried out the ground level measurements with respect to an arbitrary datum level – taken as '100 ft' (30.48m) on one of the steps for the famous historic Town Hall. All earlier works in Mumbai were carried out with reference to this arbitrary datum level. Somehow Mumbai Municipal Corporation continued with that arbitrary referencing system and did not switch over to national standard referencing pattern of survey of India, which is based on the mean sea level. It will be useful if survey of India's leveling system is followed hereafter in Mumbai also as a matter of normal practice. All measurements of levels of private premises should also be on that basis – so that their relationship with the tide levels and the river channel flows will be easily understood by the private property holders also.

3.11.8 It is noticed that there is no comprehensive GIS developed for Greater Mumbai so far. The sewerage system has the GIS base and is incorporated on "D.P. base maps". But that does not help in the management of storm water from the land surfaces. Different maps connected with Mumbai have been prepared with reference to different datum levels. That causes considerable confusion in the understanding of the relative ground conditions. Henceforth, steps should be taken to adopt levels in meters under the GTS system only (the Great Trigonometrically Survey of India) superseding the other arbitrary systems of Chart Datum (CD) or Town Hall Datum (THD) followed so far. Mean sea level (MSL) around Mumbai is just close to zero level of the GTS carried out by the officially recognized national organization namely the Survey of India. (MSL of Mumbai = 0.01 GTS).

Inter-relation between CD, GTS (MSL) & THD

Chart Datum (0 m CD) = -2.50 m GTS

City Town Hall Datum (30.48 m THD) = +6.02 m GTS

Therefore while converting values reported (in mts) with respect to CD in those with respect to GTS add 2.50 mts & while converting values reported with respect to THD (in mts) in those with respect to GTS deduct 24.46mts.

3.11.9 The waterways of the cross drainage works / bridges in the island city and in the suburbs are blocked by encroachments and by the crossing of the service lines. That has substantially reduced the carrying capacity of the storm water channels. Moreover incompatible development of lands with formation levels – much above the earlier ones have also created obstructions to natural surface flow leading to creation of new flooding spots as developments proceed. The older campuses and premises are facing threats of flooding through modifications in the pattern of surface movements of the precipitating water with increasing episodes of submergence and flooding. Over passage of time many changes have taken place in the topography of the city thereby disturbing the drainage patterns very much.

3.11.10 Flood experience of 2005 has brought out the immediate need for reconsideration of the design criteria with reference to risks to life and property, and the traffic handicaps under emergency situations. In 1993, BRIMSTOWAD had gone into the requirements of the drainage system and stressed the need for adopting the scientific approach with catchment as the basis in the management of storm water. Before the remedial works according to that report could be in place, there has been a deluge of July 2005, necessitating greater in-depth attention to catchment management and the river basin management in the context of the latest hydrological information base. Accurate information about the ground levels is necessary for that purpose and hence the immediate need for the survey of ground levels in Greater Mumbai.

3.11.11 Even the flood studies being carried out by CWPRS are handicapped on account of lack of information about the ground levels in the flood plains on both the banks of the Mithi river. The earlier this data becomes available, more scientific will be the further flood related actions. Earlier studies had shown that 10 year frequency HFL in Mahim creek is 3.20 M GTS, whereas 5 year HFL in Mahim creek is 2.90 M, GTS. When contour maps are available, flood risk zones and submergence areas for different frequencies of rainfall will have to be plotted on them and land developments regulated accordingly. The submergence maps of the restricted zones will have to be published for citizen's information.

3.12 Training of Rivers and Stream Channels

3.12.1 Because the river channels and the storm water channels have gradually developed over the reclaimed lands, they have no well designed geometry of the channel as such; either in terms of channel width or depth (vide Drawing no. 2). BRIMSTOWAD includes specific proposals for the training of the rivers and the stream channels for putting them into proper shapes. The river channels will have particularly to be accommodated within the reclaimed land portions in a scientific manner. Hydrological setting of Mumbai is not a natural setting. It has been man influenced in a variety of ways. Hence the next logical step is to channelise the streams and river courses in a systematic manner with proper hydrological considerations.

3.12.2 In the light of the hydrometereological, hydraulic, topographical and tidal conditions in and around Mumbai, a set of hydrological management measures will

have to be developed and adopted– as a ‘package’ – for that catchment to avoid risks to life and property. BRIMSTOWAD mainly aimed at the normal smooth flushing out of the yearly storm flows. Their catchment wise recommendations in that context are still valid by and large. But BRIMSTOWAD did not look at the impacts of the infrequent occurrences – of intense precipitation and flooding. Tough recommendations in that context were occasionally made by the expert committees in the past, such as for the Mithi barrage, the subject of risk coverage, risk zone planning and disaster preparedness started receiving attention only recently – after the disaster management plan for Mumbai was first published in 2000. It will be necessary to pursue the theme further assiduously and develop a specific set of provisions for each river basin on the basis of the experience of the July ‘05 deluge.

3.13 Mithi – Mahul inter connection

3.13.1 The common practice is to plan the management of water courses by a watershed approach. This approach works well when the ridge lines between catchments are well defined. In the crowded flat terrain of Mumbai, where 2/3 rd of the island city and considerable habitable part in suburbs is on reclaimed lands that are almost flat, identification of precise catchment area is difficult, particularly in absence of the contour maps having close intervals of levels. Even the roadside drains near the ridge or in a saddle portion may divert the flow to an opposite basin. The ground levels in reclaimed portions range between 2.74 to 3.74 m GTS, high tide level being 2.75 m. The moment there is overflow from the drains on the ground; these basins get interconnected and try to behave like a combined system. For storm water planning purposes such catchments cannot be looked at in total isolation e.g. catchment no. 125 (Britannia Outfall) and Catchment no. 129 Cleveland Outfall are in close proximity at Dadar (E). So are Catchment no. 129 Cleveland Outfall and Catchment no. 401 Senapati Bapat Marg – Mori Road Outfall in Dadar / Matunga (w). In Eastern Suburbs, the areas of Kurla, Chunabhatti, Chembur which were connected to one common creek earlier (Ref.drawing.no 26) act as one mass even today under heavy rainfall situations, connecting the catchment systems numbered as . 310, 500, 501, 502 and 400 in BRIMSTOWAD and joining Thane creek, Mahul creek and Mahim Creek together.

3.13.2 From the details of local inundations observed by MCGM staff and the residents in the neighborhood, the three rivers (except Mithi) had to face two separate flood waves on 26&27 i.e. first in the evening of 26^{th} which receded with the low tide and then again in the night of 26^{th}. The night flooding was far more severe than that in the evening. This is compatible with the rainfall hydrograph of Vihar. The night flooding receded within a couple of hours after the rain stopped, because of the low tide period following it after the midnight of 26^{th}.

3.13.3 But the story on the downstream part of Mithi was different. Near the airport it started flooding by 14.30 / 15.00 pm which went on increasing and did not completely recede even after 36 hrs. The immediate first victim in the neighborhood of the Airport Authority area after the initial outburst of downpour was the IMD rain gauge station near the airport which is said to have stopped functioning immediately after 14.30 hrs, having got submerged. The role of the cofferdam put across the Mithi river for the Bridge under the taxi bay in accentuating the early flooding phenomenon has left for us many lessons in this flood episode.

3.13.4 The adjoining catchments of Mahul – Nehru Nagar nalla system and Somaiyya – Reti Bunder nalla (outfall to Thane creek) witnessed a similar continuous

rise in flood levels. Only the starting time for flooding varied marginally. Lal Bahadur Shastri Marg (i.e. the old Mumbai Agra road) is by and large along the ridge line between Mithi basin and the eastern two systems. Ground levels of Lal Bahadur Shastri Marg are between 4.0 to 4.5 m GTS in the saddle region. Chunabhatti area drains to Mithi through various culverts under the railway tracks and Lal Bahadur Shastri Marg and is also connected to Mahul through Duncan Causeway system. The general ground levels in this area are such that once flood water in Mithi reaches a certain height (marginally above the high tide level) storm water of Mithi starts overflowing into Chunabhatti area. Kalpana Kamran system flowing across Lal Bahadur Shastri Marg also contributes to transferring of water from west of LBS to east of LBS. Surface flows on land in Mahul and Somaiyya catchments get interconnected at Tilak Nagar and the systems are further interconnected near Kurla Terminus in railway area between Vidyavihar and Tilak Nagar railway station within railway premises and at the railway culvert between Chembur and Tilak nagar railway station. Instances of flooding near these spots due to some problems of congestion in the adjoining catchment have occurred number of times in the past also. These were the marshy lands in the past and part of Mithi was discharging through Mahul and probably even through the Somaiyya nalla. (Ref Drawing no. No 27)

3.13.5 On 26th July once Mithi started heading up, the spill waters entered into this east-west system across the saddle. The result was that Chunabhatti and Nehru Nagar started getting flooded by 16.00 PM. Backwater of flooded Mithi near the Airport crossed Lal Bahadur Shastri Marg, flowed over CST road and railway track to Mahul storm water channel. Mahul system also failed to accommodate the flow and was probably even not in a position to discharge its own flow just downstream of EEH culvert. Water ultimately rushed to Somaiyya system which is reported to have got flooded almost at the same time. The water finally drained through Reti Bunder Outfall which kept on functioning and flowing continuously. The flood levels in Mithi have not been measured or recorded immediately after the flood episode. But from the general information available, it looks that even the catchments of Mithi on the south in the island city area received this backwater and got flooded on 26th & 27th July, 2005.

3.13.6 Catchment areas of these three linked systems are Mithi 7295 ha, Mahul – Nehru Nagar – 717 ha & Somaiyya – 366 ha. When voluminous overflows from the large catchments impinged on the smaller catchment of Somaiyya nalla, it had no flow capacity to accommodate it. The result was that the central railway tracks between Vidya Vihar, Kurla, Chunabhatti, Kurla car shed, Nehru Nagar, Sahakar Nagar in Kurla (E) Pestom Sagar and Tilak Nagar in Chembur i.e. area between EEH and MMRDA via Lal Bahadur Shastri Marg suffered inundation the most.

3.13.7 Mahul system failed to accommodate the flow just downstream of Highway because at the Vasant Dada Patil Polytechnic the channel width is considerably narrowed and reduced to just 8-9 mts, as against the 18 meters width in the upstream length. Flood flows towards the outfall were obstructed in Mithi because of comparatively higher ground levels in the MMR development region on the banks of Mithi and in Mahul because of Wadala Anik link road developments on the bank of Mahul respectively.

3.13.8 The Mithi flooding on 26th and 27th July 05 is generally attributable to a large number of factors, but the most dominating one clearly being the extreme

precipitation near Vihar (136 mm in one hour). Inadequate width of Mithi channel with encroachment on both the banks greatly aggravated the situation by constricting the flood flow and causing heading up towards the upstream. The two important bottlenecks have been, one near the airport and the MMRDA area and the other on the d/s of MMRDA region near the outfall itself. The first one caused flooding of Kurla and Chembur areas and the other at the island city catchments near Mahim.

3.13.9 In contrast with this, the Dahisar River having a bottleneck in the form of an old ancient pedestrian arch bridge in the downstream stretch (Ch. At 300) did not head up much because water could spread out in the underdeveloped low level marshy lands and could flow towards the creek as a surface sheet flow and not as a channel flow. This could not happen in the case of Mithi and Mahul because almost all such low lying downstream portions have been filled up.

3.13.10 It will not be possible to physically isolate fully these three catchment systems and prevent inter catchment transfer of water due to peculiar site conditions there providing easy interconnectivity. Inter catchment transfers will continue to be a recurring phenomenon under heavy storms. Hence a well planned strategy of managing the Mithi saddle will have to be evolved keeping in view the possibility of spills and the need for adjusting the combined behavior of these connected systems. While more stress is currently being laid on improvement for Mithi, Mahul should not to be forgotten. It would be prudent to ascertain more accurately the specific conditions of transfers of Mithi water to Mahul and then to decide upon the remedial measures for improving Mahul catchments also on priority. Downstream portions of Mahul catchments are not yet much developed. There is much greater maneuverability there. The line of action should be to first provide clear waterways immediately as recommended by BRIMSTOWAD by removing encroachments within and by the side of water course and then to explore the possibility of developing holding ponds or space for channelisation of storm water downstream of Eastern Express highway, and later thereafter to study the further potential of the system to act as a Mithi buffer or a bypass for the sever floods in Mithi.

3.14 Healthy Watersheds

3.14.1 This is something we need to pay attention to newly. Increasing only the physical capacities of storm water drains is neither the only alternative nor enough. We need to develop our watersheds as healthy watersheds. The aim should be that minimum surface runoff should be generated by absorbing the precipitation by way of infiltration, & evapotranspiration. The key to improvement in the health of urban watershed is to maintain a proper water balance by enhancing the land cover by vegetation and trees and by absorbing runoffs through infiltration and pondages. At the watershed level, we need to focus on how much rainfall volume has fallen rather than only the intensity of precipitation and the flow rates. What to do with the total rainfall volume generated by the storm should be the final concern. What cannot be absorbed or led away safely will generate flooding and submergence. This of course will need catchment by catchment detailed study over a longer period.

3.15 Holding Ponds

3.15.1 Flooding in Mumbai has been aggravated because the holding ponds in Mumbai which absorbed rainfall have disappeared after having been filled up by land

development activities. Road asphalting / concreting & pavement developments have prevented infiltration of storm water into the ground. Consequently the coefficient of runoff which was taken at 0.5 for the earlier designs for the city's drainage system is found to have changed. The volume of runoff – water to be carried by individual drains has substantially increased. There have been no systematic measurements of surface flows in the streams in Mumbai. But the indications are that much of the precipitated water is getting straightway converted into a surface flow.

3.15.2 Holding ponds have been part of water supply and storm water management system in India for centuries. But under pressures of urbanization and dense developments, their useful civic role has got ignored. Mumbai is not an exception. Most of the ponds in the city are lost to land development. Importance of the holding ponds in Mumbai's storm water management needs to be fully appreciated by the Mumbaiites in order to retain the existing holding spaces and to provide systematic new holding spaces at critical locations. They have to be treated as a part of the urban land space and as an integral part of the land use plans. For such ponds to have influence in flood mitigation, their cumulative capacity has to be at least more than 10 % of the catchments estimated runoff. In crowded Mumbai such spaces are now rare. However existing ponds and depressions have a useful role in controlling the severe floods. Their surface water holding capacity also gets supplemented by their potential for ground water recharge. Unharmful ponding within the private and public premises also is one way to capture and store temporarily the excess runoff. Extensive open spaces like public gardens, parks, race courses, golf clubs, play grounds and open lands of airports, not used for air traffic can provide the holding back and absorption capacities in the different catchments. Developing new holding ponds near outfalls may not be possible everywhere. But special efforts in that direction will be necessary for major water courses like the four rivers and the Mahul creek. Some space is still available near outfalls of these systems e.g. BKC, wetlands downstream of Oshiwara and Poisar, and open spaces downstream of Eastern Express Highway. These spaces should be reserved and developed at levels lower than the occupied urban locality but slightly higher than high tidal level to accommodate the extreme storm water flows. Even after doing everything that is possible for channelisation of water courses, and smoothening of water ways, adoption of best management practices locally and ponding of excess water of storm flows remain the useful supplementary measures for some of the low lying catchments.

3.16 High technology fixes: (A) Gates at the outfall

3.16.1 In a coastal city like Mumbai the discharging capacity of the storm water system is governed by relative clearance available for the storm water outfall over the tide level in the sea at that time. If the discharge levels are below high tide level, part of the storm water remains accumulated in the system till the high tide recedes. This time is called the tidal lock period. Greater the lock period, greater has to be the ponding / water accumulating facility that is required to be provided near the outfall. In Mumbai out of 186 outfalls, 45 discharge below the mean sea level. If the accumulated storm water for these outfalls is not withheld within the system, it spreads around and the low lying areas get submerged. The phenomenon is more predominant where the branch drains are shallow and the locality is relatively low

lying. Under such situations some relief can be obtained by providing tidal gates at the outfall end. Gates arrest the ingress of the tide and conserve the channel's storage capacity for absorbing the inflow of the flood. Where the channel capacity is very small compared to the flood inflow, regulation by gates does not have much of a beneficial impact during high tide periods. But still the flood absorption cushion provided behind gates helps to lower the flood levels on the banks of the channel. A proper gate operation schedule for each gated out fall structure needs to be laid down considering the channel capacity characteristics. It should not be difficult to train the operating staff for this purpose to ensure that in the monsoon period the gates remain properly attended and operated.

3.16.2 In the hydraulic system of Mumbai, gated outfalls will have an important role to play in future as densification of urbanization proceeds and expectations for a well protected urban life also increase. So far, there has not been any formal categorization of the gates at the outfalls on the basis of rainfall precipitation frequencies. For the catchments of more than 10 Sq.Km, or where some critical or vital installations are involved in the creek's tidal zone, it will be desirable to provide the gates to a flood flow of one in 100 year probability and for smaller catchments for 1 in 25 year's probability.

3.16 (B) Pumping

3.16.3 For a coastal city on reclaimed lands like Mumbai, pumping has also to be an integral part of the storm water system. Much of Holland (Netherlands) survives on that. That is the genesis of the windmills spread throughout Holland for pumping out water continuously. While planning and providing a physical wider opening at the costly cross drainage works of the roads / railways / airports does not give rise to issues of financial appropriateness, a similar exercise for the pumping arrangements gives rise to a controversy and debates, because of infrequent operation of the storm water pumping system. Balancing of cost and benefits for normal scenario (once in a year or twice in a year as adopted in BRIMSTOWAD) is easily possible. Unfortunately even the pumping installations recommended in BRIMSTOWAD were not in place before June '05. For infrequent occurrences, such as once in 25 years or once in 100 years, the analysis may be more complex. Pumping capacities for one in 10 year's probability of precipitation at least should not pose complex considerations. It means that in addition to the normal yearly operational pumping; about 25 % additional stand by capacity will have to be installed. At the submergence prone critical locations that affect the railway tracks and the through traffic transport corridors, such standby provisions will be an immediate worthwhile asset. It is difficult to arrange for pumping as a matter of relief and rescue later after the emergency arises.

3.17 International Examples

3.17.1 The city of Chicago owes its very existence to its location at the confluence of Chicago River and Lake Michigan. Lake Michigan provides abundant water supply, while Chicago river serves as a highway to move goods and services critical to the city's growth. To protect its water supply, the Chicago Sanitary and Ship Canal was constructed in 1900 to steer the human and industrial waste away from Lake Michigan. In 1972 Chicago pioneered the use of deep tunnels to capture, convey

and store the combined sewage and storm flow during the peak periods of the storm for treatment and disposal later. The deep tunnel system being developed by Chicago consists of a series of tunnels; some dug as deep as 110 meter and will extend over more than 200 km. They together serve as a large underground storage. They have been constructed utilizing a tunnel boring machine (TBM) called the mole, which cuts a hole about 10 meter in diameter through bed rock beneath Chicago. Similar type of equipment was used to construct the Chunnel beneath the English channel between England and France.

3.17.2 Storing of the peak flows underground and then pumping them out at a convenient period later is an essential part of the sewage and storm water management system of Chicago. As no space is available on the ground to store their combined flows, deep tunnels have been used. The huge sizes had to be adopted for tunnel because the speed of treatment and cleaning up of the dirty waters can not match with the run-off inflows. They are the holding spaces in the system which allows reduction in expenditure on installation of huge capacity treatment plants that would otherwise be required to match with the peak in flows.

3.17.3 But in addition, Chicago is promoting a new comprehensive approach towards improving the quality of its surface waters. This approach emphasizes adoption of simple storm water's Best Management Practices (BMP) at source in the catchment area itself to reduce negative impacts of storm water runoff. The city is making efforts to demonstrate the efficacy of various BMP approaches including turfing and infiltration measures and to promote public acceptance for its wider usage.

3.17.4 In Mumbai, quality of surface runoff has a much different characteristic than in Chicago. Garbage and floating material is a part of storm water flow in Mumbai which is not the condition in Chicago. Such materials damage the pumping installations and choke the outfalls. Moreover intensity of rainfall is very high in Mumbai compared to that in Chicago. Hence it will not be possible to adopt the Chicago's underground arrangements for Mumbai. But their work on BMP's to control the quality and quantity of surface runoff is worth emulation in Mumbai also with due modifications for the local urban conditions. Measures to promote awareness about better civic habits will have to be undertaken on priority as a campaign. That will substantially help in the better management of the storm water systems.

3.17.5 Floods in 1953 in the Thames river, on the banks of which London is situated, was a wake up call for the Londoners. They built a disaster management system assiduously- over the next 30 years. Their disaster prevention project included a barrier (a very large gated barrage structure across the river Thames) and the raising of Thames banks. The barrier has four 60 meter wide openings to protect London from the surge tides in the river. The barrier is so planned that in the worst scenario, a surge tide would exceed the height of the barrier only once in 1000 years. A similar defensive mechanism is necessary across the Mithi river also, now that it is going to accommodate a central business district and a vital communication centre like the Airport. Such a barrage across Mithi has been recommended long back, but has remained to come up. This barrage will have to consist of a barrier in the river channel, tidal control gates on it and a bridge on the top.

3.17.6 It has also to be remembered n this context, that there is very little similarity in the hydrological conditions of Europe or the United states and that of India. It will not be proper to rely fully on their pattern of planning for the flood related risks. When on

20th Aug in 2003, parts of Switzerland were hit by what was considered locally by them as a severe rain the precipitation was only 65 mm of rainfall in 24 hours. Loss of 6 lives was a matter of great concern. It was considered as an extreme event – worst in 50 years. This is also one of the probable reasons why in the British colonial period in Mumbai – a design intensity of 25 mm/hr was considered as adequate for Mumbai's drainage system. Indian rainfalls are much more intense than those in Europe and US. Hence even the spillway capacities on the Indian dams are required to be much larger than those in Europe.

3.17.7 Worth studying will be the case of Singapore – which has like Mumbai –a total land area of just 680 km^2. Annual rainfall averages 2400 mm. But it falls all the year round – most abundant being during November to January. They have recently undertaken the construction of the Marina barrage as a tidal barrage across the 350 m wide Marina channel, which is located in the Southern tip of Singapore. Storm water within the Marina catchment is drained by 5 main streams into the Marina channel. When the barrage is completed in 2007, it will keep sea water out of the 240 ha of the Marina basin. Marina catchment is about 100 Sq.Km –i.e. one and half times larger than that of Mithi in Mumbai.

3.17.8 Low lying pockets in the Singapore city like China town, Boat quay, Jalan Bizar and Geylang, are below or slightly above the high tide level. They are prone to flooding whenever heavy rains coincide with high tides. The barrage will keep out high tides. When heavy rains coincide with low tide, the crest gates will be operated to discharge the excess storm water to the sea. However when heavy rains coincide with high tide, gates will not be opened but the excess storm water will be pumped out into the sea- by six water pumps with a total capacity of 240 m^3/sec (seventh additional ump acting as a standby). Such packages will have to be put in place for Mumbai also.

3.18 Organizational requirements

3.18.1 For water to flow efficiently, all the cross drainage works for the streams in Mumbai whether constructed by Central or State Govt authorities, (Railways, Port Trusts, MMRDA and MCGM will have to be designed on the basis of common hydrological criteria. As present there is no systematic joint approach institutionalized firmly. No single body studies and examines the water way requirements of all such works, comprehensively and in an integrated manner stream by stream. Absence of an apex authority for hydrological issues has left the Mumbai as it is now. Mumbai Municipal Corporation as an authority responsible for the smooth civil life in Mumbai will have to take the lead and establish hydrologic guidelines for all the works in Mumbai. To begin with MCGM will have to establish a properly staffed Urban hydrology unit immediately and should commence scientific and systematic hydrologic measurements for Mumbai, for the precipitation as well as for the stream flows. It will also be desirable, if the MCGM's urban Hydrology unit is linked with a similar set up on a large scale to be established for the Mumbai Metropolitan Region by MMRDA, as the low lying areas in MMR need similar critical attention as in Mumbai simultaneously.

3.18.2 Normal rainfall measurement is not a very complex procedure. It will be worthwhile encouraging schools / science colleges / engineering colleges in Mumbai to have their own rainfall measurements on the top of their terraces and assist the local active groups like the ALM's in Mumbai with the local information. MCGM's

urban hydrology cell should be able to compile such information and publish the findings annually for the general information of the residents of Mumbai. Information on the local submergence spreads and congestions can also be included so that the efficacy of the measures undertaken following BRIMSTOWAD recommendations will get evaluated.

3.18.3 Somehow, the water related departments of Mumbai have remained away from the national hydrological scene and the international developments in the science of hydrology. India has a National Institute of Hydrology and also an internationally recognized prestigious School of Hydrology at Roorkee which runs courses for international participants. Govt. of Maharashtra has a 'hydrology project' as a part of the national hydrology project. Mumbai Corporation has not been able to draw benefits from these national level and state level activities. The subject of urban hydrology will have to be promoted and developed in Mumbai looking to the high stakes involved. It will be useful if staff of Mumbai's water related departments is encouraged to get trained at the School of Hydrology at Roorkee, or in similar such courses at Nashik by the hydrology organization of the State of Maharashtra. They should also be encouraged to obtain active memberships / life memberships of voluntary professional associations like the Indian Association of Hydrology and the International Association of Hydrological Sciences which is more than 75 years old. Their published literature on the topics like 'extremes of the extremes – extraordinary floods' or the 'hydrological extremes – understanding, predicting and mitigating' will considerably help the Mumbai staff to enhance their capabilities to handle the storm related difficult situations in Mumbai.

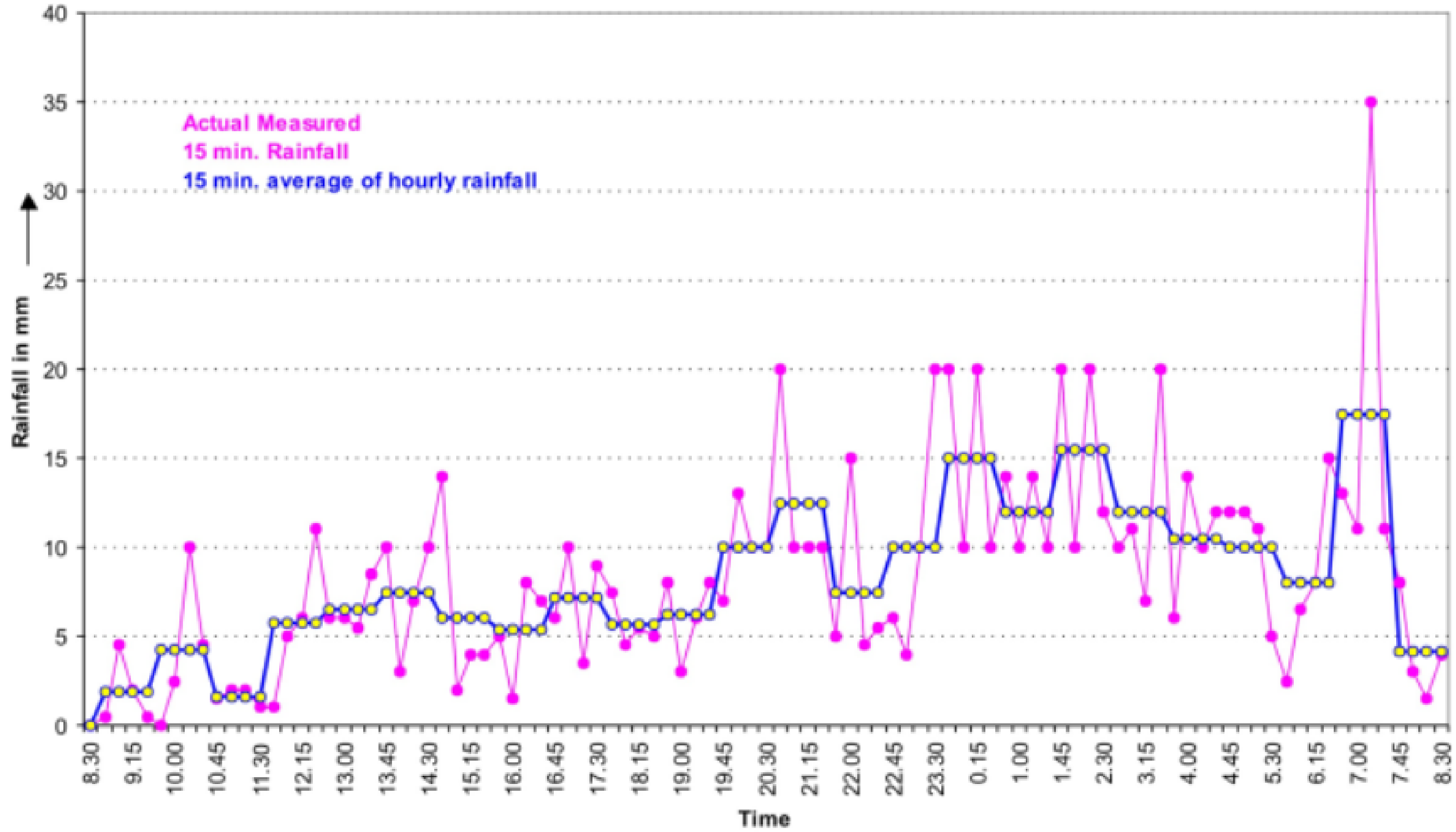
As an immediate step, MCGM will have to raise a proper hydrological organization to install and manage the extensive network of rain gauges and stream gauges proposed in the Para above. This organization will need to have a close link with IMD on one hand to receive the meteorological messages and with the Disaster management unit of MCGM on the other hand for timely alerts and warming. The desirable set up and functions and responsibilities for such an organization could be as suggested in Appendix 3C

The 15 minute rainfall data of Nalde R.G. Station

26.7	8:30	8:45	9:00	9:15	9:30	9:45	10:00	10:15	10:30	10:45
Rainfall mm	**0**	**0.5**	**4.5**	**2**	**0.5**	**0**	**2.5**	**10**	**4.5**	**1.5**
26.7	11:00	11:15	11:30	11:45	12:00	12:15	12:30	12:45	13:00	13:15
Rainfall mm	**2**	**2**	**1**	**1**	**5**	**6**	**11**	**6**	**6**	**5.5**
26.7	13:30	13:45	14:00	14:15	14:30	14:45	15:00	15:15	15:30	15:45
Rainfall mm	**8.5**	**10**	**3**	**7**	**10**	**14**	**2**	**4**	**4**	**5**
26.7	16:00	16:15	16:30	16:45	17:00	17:15	17:30	17:45	18:00	18:15
Rainfall mm	**1.5**	**8**	**7**	**6**	**10**	**3.5**	**9**	**7.5**	**4.5**	**5.5**
26.7	18:30	18:45	19:00	19:15	19:30	19:45	20:00	20:15	20:30	20:45
Rainfall mm	**5**	**8**	**3**	**6**	**8**	**7**	**13**	**10**	**10**	**20**
26.7	21:00	21:15	21:30	21:45	22:00	22:15	22:30	22:45	23:00	23:15
Rainfall mm	**10**	**10**	**10**	**5**	**15**	**4.5**	**5.5**	**6**	**4**	**10**
26.7*&27.7	23:30	23:45	0:00	0:15	0:30	0:45	1:00	1:15	1:30	1:45
Rainfall mm	**20**	**20**	**10**	**20**	**10**	**14**	**10**	**14**	**10**	**20**
27.7	2:00	2:15	2:30	2:45	3:00	3:15	3:30	3:45	4:00	4:15
Rainfall mm	**10**	**20**	**12**	**10**	**11**	**7**	**20**	**6**	**14**	**10**
27.7	4:30	4:45	5:00	5:15	5:30	5:45	6:00	6:15	6:30	6:45
Rainfall mm	**12**	**12**	**12**	**11**	**5**	**2.5**	**6.5**	**8**	**15**	**13**
27.7	7:00	7:15	7:30	7:45	8:00	8:15	8:30			
Rainfall mm	**11**	**35**	**11**	**8**	**3**	**1.5**	**4**			

APPENDIX - 3B

Rainfall on 26,27.7.05 at Nalde
(Rain Gaugung Station, Ulhas Valley), Maharashtra



Appendix –3C

Hydrology Cell for Storm Water Management

Deputy. Chief Engineer (Hydrology)

↓

Executive Engineer

↓

Assistant Engineer (City)		**Assistant Engineer (WS)**		**Assistant Engineer (ES)**	
↓	↓	↓	↓	↓	↓
Sub Engineer(S.E)	**S.E.**	**S.E.**	**S.E.**	**S.E.**	**S.E.**

Duty & Responsibility of Hydrology Cell

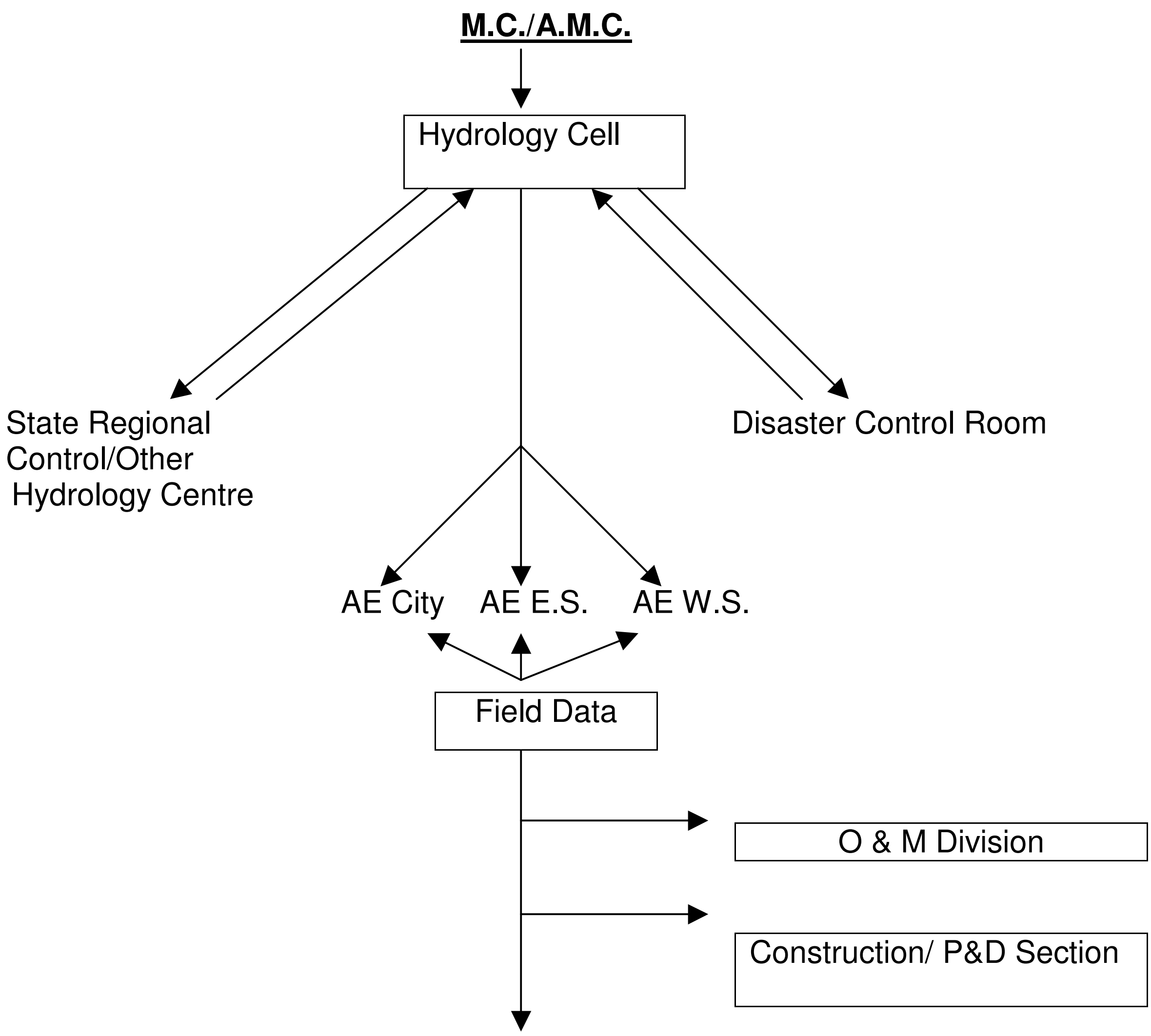
A: Round the year, including monsoon period

1) Acquisition, validation & analysis of hydrological data
2) Flow of analysed data to P&D Section, Construction division, O&M division & other departments
3) Incorporate/ implement data in all proposals/ remarks including private development.
4) Continuous monitoring and O&M of instrumentation/ gauges
5) Periodical calibration of instruments
6) Creation of MIS & data base
7) 5 yearly re-validation of all data
8) Organizing seminars, training courses, tours for hydrology division.
9) Regular interaction with State Hydrology Project Nasik & other National/ International organizations.
10) Preparing hydrographs, submergence maps, flood map/ levels, stream flows on annual basis & update the data base. Similarly exchange such annual data with IMD, Hydrology Project Nasik/ Thane and also with other departments in MCGM and Hydrology set for MMRDA
11) Co-ordination & acquiring/exchanging data on “Online” basis with IMD/ Hydrology Project Nasik/ Thane/ New Mumbai and any other hydrological Control center established for Mumbai/Mumbai Metropolitan Region.

B: During Monsoon

(1) Online acquisition, monitoring, and transmission of hydrological data i.e. Stream gauges, rain gauges etc.
(2) Data logging, analysis & communication to Disaster Control room, O&M section, administrative wing-Round the clock.
(3) One Sub-Engineer shall man the zonal control room round the clock. (i.e. one each in City, ES & WS)
(4) Acquisition of field data, preparation of submergence map, daily mapping of flood level/ water level as per stream gauging record on all rainy days

MONITORING AND INTERACTION SYSTEM:



CHAPTER 4

EARLIER STUDIES, REPORTS AND RECOMMENDATIONS

4.1 Genesis of the committees:

4.1.1 Flooding in Mumbai has been a recurring problem. Most of the business area of the city is located in south & the residential area in north. Every day lakhs of people travel north to south in the morning & south to north in the evening by rail & road. The major load (around 70 %) is shared by the Central & Western railway. Both the railways run through reclaimed creek arms in the central city, where the ground levels are lower than the surrounding area. The main trunk roads viz. Dr. Ambedkar road (Central Island Free Way) & Senapati Bapat Marg (Tulsi Pipe raod) are also running parallel to & very close to the railways. Major outfalls in island city discharge much below mean sea level. Even ground levels in some areas are much below the High tide level & hence the city has to be protected from tidal flooding in the fair season by tidal gates on major outfalls.

4.1.2 Under these circumstances, the entire traffic gets disrupted in monsoon when even a moderate intensity rainfall is coupled with high tide. Age old, partly dilapidated Storm Water Drainage (S.W.D.) system in the city was designed for rainfall intensity of 25 mm / hr. & a coefficient of run-off 0.50. Rainfall of 25 mm / hr occurs @ 10 times a year. With development, the holding ponds & infiltration ability is lost, therefore runoff has substantially increased. Consequently the city therefore has been getting flooded quite frequently. Various committees and Consultants have been appointed by MCGM and the Planning authorities to study these problems & to suggest improvements. Hydraulic studies also have been carried out by the Central Water and Power Research Station, Khadakwasla to asses the impact of reclamations proposed in the Mithi Basin. Efforts have been made to summarize the outcome of such studies important recommendations made & the compliances thereof in this chapter.

4.1.3 The committee has been able to appraise the following study reports:

1) Natu Committee report – 1975
2) Report on model studies on the effect of proposed reclamation in Mahim Creek (Bandra-Kurla Complex) – 1978 BY CWPRS.
3) Dharavi storm Water Drainage System – Detailed Project report by Shah Technical Consultants – (STC)1988
4) BRIMSTOWAD report – 1993
5) Remedial measures to abate flooding at Milan Subway & Slater road (Grant road) / Nana Chowk – 2005 by I.I.T. Powai.

Some recent Studies initiated by MMRDA and the Govt of Maharashtra, after the deluge in July 05 has also been partly or fully completed by now. Their reports have become available to the Fact Finding Committee. We have taken note of the outcome of those studies. In addition, the report of the Merani Committee on MUTP /MIEP works in Mumbai was also made available to us. We have taken note of the recommendations made by that committee also. The recent reports specifically taken note are -

i) CWPRS interim report on Mithi River development (Nov 2005)
ii) WAPCOS interim report on Dahisar, Poisar and Oshiwara (Nov 05)
iii) IIT's report on Mithi river Pollution (Nov. 05)
iv) MERI Interim report on Ulhasbasin (Nov.05)

4.2 Their Scope of Work:

Scope of the earlier studies listed in 1 to 5 under Para 4.1.3 are generally complementary & not overlapping. Their scope was broadly as below:

1. Natu Committee report: to study the problems of the S.W.D. system in the island city & the suburbs & to suggest improvements
2. CWPRS – BKC REPORT: To suggest guidelines for the reclamation works required for the Bandra Kurla complex.
3. STC – on Dharavi Storm Water Drainage System –. To study the components responsible for flooding at Dharavi, and to suggest remedial measures with detailed technical & financial proposals.
4. BRIMSTOWAD report: To study to S.W.D. system of Mumbai including detailed physical surveys & to suggest recommendations with preliminary engineering proposals for individual catchments.
5. I.I.T. (2005) - To select methodology to abate flooding at Milan Subway & Slater road, Nana Chowk.

Those aspects that have a more direct bearing on the deluge of 26-27th July 05 are and with the associated issues discussed elsewhere in this report of the Fact Finding Committee are underlined in the text here below for specific attention.

4.3 The Natu Committee report

Natu Committee was appointed by MCGM to study the reasons for 1974 floods and to suggest remedies.

4.3.1 Short Term Measures: This high level Committee in their report has given the recommendations for short term measures under Para 3.10 of Part – I in their Chapter 3, the brief summary of which is as below:-

(i) Desilting of arterial drains: - The committee recommended taking up desilting of Arterial drains from outfalls i.e. down stream most portion, towards up stream. The priority for desilting shall be given to major catchment areas viz. nos. 10 (erstwhile nos.) (Dharavi), 25 (Reay-Road), 29 (Cleave land Bunder), 30 (Love Grove) (These are old catchment numbers.) Brimstowad has renumbered the catchments in 1993 and only those revised numbers currently in and are related to accordingly elsewhere in this report of the Fact Finding Committee.
(ii) To employ labours exclusively for Storm Water Drain for various works such as desilting and cleaning gullies and gratings, replacing broken grating and minor repairs etc., desilting of lateral, sub-laterals and connections. The Committee recommended employment of contract agencies for desilting of intercepting drains and branch drains.

(iii) Clearance of Outfall channels and Outfall of Catchment nos.30, 29, 10 for proper desilting, re-sectioning and establishing proper hydraulic regime conditions including removal of encroachments on outfalls as well as on covered and uncovered drainage channels.
(iv) Maintenance of water entrances, gullies and branch connections to street and road drains. : The maintenance shall ensure proper positioning of grating, to keep the opening of gratings free of blockages and obstructions, during monsoon.
(v) Road-side open drains shall be desilted thoroughly as already recommended under (i) above. It was also recommended to keep the road-side open drains (In Suburbs) clean throughout the year. It was also suggested to give this work on contract basis after examining the economic and financial implications. The Committee recommended making provisions under bye-laws for compelling the property holder to construct masonry receptacle of adequate size for collection of garbage which will reduce the nuisance of garbage being thrown in the road-side gutters.
(vi) Desilting of Railway culverts shall be the responsibility of the Railways and B.M.C. shall make the payments to the Railways for the same.
(vii) Re-sectioning of Katcha drains: Katcha drains shall be properly re-sectioned right up to the outfall and obstructions of utilities shall be shifted.
(viii) Any bunds put across channels for cultivation / irrigation shall be removed.
(ix) To up-rate sewerage pumping stations (Love Grove, Dharavi, Versova and Ghatkopar on priority), to match with the water supply in the City.
(x) To investigate for long term measures in respect of the following:

- Inadequate Storm Water Culvert at Mahalaxmi, Curry Road, Masjid.
- Sewage Overflow at Sion Railway Station leading to flooding.
- Obstructions and garbage in Storm Water Drainage System near Byculla New Vegetable Market.
- <u>Pumping arrangement at Masjid Station.</u>

(xi) Re-structuring of the administrative set-up.

4.3.2 Long Term Measures: The high level Natu Committee in their report had given recommendations for long term measures in the various Chapters; the brief summary of which is as below:-

The Committee in its Chapter 5 of report discussed about the major drainage districts (having areas more than 1000 Acres (400 Ha each) are that prone to major flooding. These drainage districts are old district no. 10, 25, 29 and 30. There are few other areas viz. District no. 13, 14, 15, 16, 17, 18 and 39 discharging into Wadala Mahul Creek and Harbour Bay which are also prone to flooding. <u>The Committee suggested provision of Storm Water Pumping Station at outfalls at Drainage District Nos. 10, 29, 30 pertaining to the localities of Mahim, Cleveland Bunder, Lovegrove and a pilot project for smaller area of Drainage District No. 39 (Masjid).</u>

(i) Permanent measures for Drainage District No.10 (Dadar, Dharavi area on East of Western Railway discharging into Mahim Causeway.) were suggested as below.

- To re-design and construct intercepting channel from Dadar Railway Station to outfall in Mahim Creek.
- To provide bye-pass sluice and <u>Pumping Station at Mahim Causeway Outfall.</u>

- To investigate for the following works (i) to reduce the bed invert of Rocky sill under the Mahim Causeway from 78 T.H.D. to 74 T.H.D. (ii) To provide electrically operated sluice gates.
- To entrust further study for simulation and co-ordinated investigation of gated opening in Mahim Causeway to C.W.P.R.S. as development of Mahim Creek is already referred to them.

ii) Permanent measures for Drainage District No.29 (Parts of Dadar, Parel, and Worli discharging into Cleave land Bunder) were recommended as below

- ♣ To provide full water way as obtaining at sluice. The sluice structure should be restored to its original design with all 4 openings put in working conditions. The short outfall tail channel, down-stream of sluice structure shall be properly regraded, sectioned and built up to function efficiently hydraulically.

iii) Permanent measures for Drainage District No.30 (Parts of Fort, Pydhuni, Grant Road, Bombay Central, Sant Gadge Maharaj Chowk, Curry Road, Race-course Worli etc. discharging into Love Grove)

- To provide a bye-pass from Clare Road (Keshavrao Khadye Road) to Haji Ali for discharge of up to 2 inch per hours run-off. (i.e. 50 mm/hr)
- All Katcha open drains shall be built up into pucca ones and may be provided up to a run-off of 1½ inch. (@ 40 mm/hr)
- The Love Grove outfall drain upstream of sluice shall be built up and masonry cross structure at outfall near the Sea may be demolished and the entire drain completely desilted.
- To provide Storm Water Pumping Station to be served by bye-pass (Haji Ali) at its outfall with a sluice for gravity discharge.
- To provide Storm Water Pumping Station downstream of Annie Besant Road near existing structure to be demolished.
- To provide solid barrier at Haji Ali Bay (to serve the bay as a balancing reservoir) along an alignment as may be found technically and economically feasible and discharging sluices provided therein.

4.3.3 To eliminate bye-passes of Sewage into Storm Water Drain and adoption of "Rational Method" of Design of Storm Water Drains was also suggested as a long term strategy. In addition remedial Measures to abate localized flooding spots were suggested as here below.

Flooding Spot	Possible remedial measures
Masjid Railway Station	Enlargement and improvement of drain.
Sandhurst Road Railway Station	Enlargement of drain
Byculla Railway Station	Diversion of drains
Currey Road Railway Station	Enlargement of drain.
Matunga Central Railway Station North of it.	Provision of suitable drains.
Under King Circle Railway Bridge.	Provision of Pumping Station.
Sion Central Railway Station	Diversion of the sewage pumping main passing through the railway Culvert that is carrying storm water.
Chunabhatti Railway Station	Provision of a proper storm water drain in the area (possibly along with an installation of a pumping station for storm water)

4.3.4 For Suburbs, Municipal Corporation had decided to adopt a system of open Road-side drains which will then discharge into bigger open drains as per topography. The entire storm discharge is then carried to the natural water courses through which it ultimately discharges into the Creek or the Sea. A large part of Suburban areas has not yet been provided with underground Sewer network and the effluent water finds its way into the road-side open drain. Drains being open are used for dumping garbage leading to obstruction to the free-flow of Storm Water to the designed capacity. It is vitally necessary to re-grade and properly channalise, with adequate cross section, all natural streams and to build pucca drains throughout their length. The various streams include Boran Nalla, Kherwadi Nalla and Vakola Nalla, Vile Parle Sub-way Nalla joining Irla Nalla, Andheri Sub-way, and Malad Sub-way. In Eastern Suburbs, due to the topography, no major stream poses any serious flooding problem. The Committee recommended that underground Storm Water Drains shall be provided for the important roads where they are to carry a considerable discharge instead of deep road side drains.

4.3.5 The Committee in their report under Chapter 9 have discussed about Storm Water Inlets and Gullies and preventive measures against silting. The report recommended checking of the design of grating and gullies for their adequacy, as this is a cause for flooding in smaller catchments. New designs such as new side entrances were to be critically examined for adoption. The entry of sweepings into the water entrance shall be avoided.

4.3.6 Most of the short term measures recommended by the Natu committee appear to have been carried out. M.C.G.M. has earmarked departmental staff ward wise, to carry out the desilting works. There also now exists a contract system for the annual pre monsoon desilting activity. The Island City, Prestressed Cement Concrete gratings have been replaced by M. S. gratings to provide larger openings for water entry.

The major recommendations on long term measures in respect of which progress has been made are redesigning and reconstruction of S.W. nalla from Dadar Railway Station to Dadar-Dharavi Outfall, lowering of bed level at rocky sill at Mahim Causeway from 78 T.H.D. to 74 T.H.D., conversion of Katcha open drain into pucca built up drain, demolition of the structure at Love Grove Outfall, and providing of bye-pass from Clerk Road (Keshavrao Khadye Marg) to Haji Ali with sluice arrangement.

4.3.7 However, it is surprising that action has not been taken for the important following long term measures:

- To provide (electrically operated or otherwise) bye-pass sluice and Pumping Station at Mahim Causeway.
- To put all 4 openings in working condition at Cleave land Bunder Sluice Outfall & to provide pumping station at Cleave land Bunder.
- To provide Storm Water Pumping Station at Love Grove Bye-pass (Haji Ali) at its outfall with sluice for gravity discharge.
- To provide solid barrier at Haji Ali Bay to serve the bay as a balancing reservoir.
- To provide Storm Water Pumping Station downstream at Annie Besant Road near outfall.

Had all these works been in place, the situation during monsoon could have been eased to a great extent in Island city. In the MCGM's administration, there appears to be some reluctance for the provision of the pumping stations.

4.4 CWPRS – BKC REPORT (1978):

4.4.1 CWPRS was appointed by MMRDA to study the requirements of the storm water system for development of the Bandra Kurla Complex. Their recommendations and the present position thereon are as below.

- Provide a bed slope of 1:10000 from CST bridge to Mahim Causeway – This is said to have been done.
- Width of Mithi River from
  - Ch. 0-1280 to be 60 m, - It is reported to be between 50-90 m. at present.
  - Ch. 1280-5930 to be 200 m, at top & 175 m at bottom – It is reported to be 85m to 115 m at present.
- For Vakola nalla from Ch. 0-2433 width to be kept 60 m at top & 40 m at bottom – It is 20 m to 40 m at present.
- Side channels to be pitched – It is reported that this will be done after completion of the widening of channel.
- <u>Provision of sluice gate at Mahim Causeway</u> – After taking over the govt. land and appointment of the irrigation dept. (Now water resources dept) for execution of the look sluice gates are proposed to be installed. Committee under the Chairmanship of Shri Merani was appointed for the sluice gate structure and its report (September 1997) listed out the follow up actions needed and was singed by representative of all agencies (Railways, MCGM, Irrgn. Deptt., MMRDA, CWPRS etc). But even then no further action has materialized. The idea of the structure is to shut the gates before high tide occurrence so that the empty reservoir created by dredging upstream absorbs the flood water of rains which can then be discharged into sea by opening the gates during the low tide.
- 3 years maintenance dredging cycle – This is said to be carried out.
- Foundation levels of bridges to be lowered to cope with the designed bed slope of the river – Except for the Mahim Causeway where the recommendation is not fully implemented, other foundation levels have been lowered.
- <u>The cross drains which drain into Mithi river should be provided with non-return valve and pumping of waters to the creek during floods.</u>

- It has been reported that the channelisation of flows in BKC, the influx of tide has increased and the tide propagation has started upto C.S.T. Bridge. This has increased the flushing capacity as well as the improvement of water quality of the river where it meets the creek.

Had all these works been completed in time as recommended, the impact of the extreme rainfall event of 26-27th July would have been much less.

4.5 Dharavi Storm Water Drainage System – Report by STC (1988)

4.5.1 Shah Technical Consultants studied the whole of Dadar Dharavi catchment which ultimately discharges storm water from Dadar, Matunga, Mahim, Sion / King-

Circle into outfalls in Dharavi leading to Mahim Causeway. It was seen that flooding here was on account of the following reasons:

(i) Storm –run-off from upper catchment draining through the area and due to insufficient capacity of the drainage system to safely contain and to carry this run-off past the area, the storm flow spilling in the area
(ii) Storm run-off originating within the area itself due to insufficient capacity of its drainage system. The insufficiency arises due to topography and condition at the outfall of the system.
(iii) A sizeable area in Dharavi is comparatively low lying reclaimed land but without a proper storm drainage system.
(iv) The high Flood Waters in Mahim Creek basin reduce the discharging capacity of the drainage system. <u>When Mahim Creek swells, Dharavi Area within its enclosures becomes a closed drainage area in which storm water accumulates and causes flooding.</u>

4.5.2 The Primary broad Recommendations by the consultants were based on the following considerations

- Raising the level of the areas by conventional filling (up to an average level of R.L.4.1 m.) to the requisite extent which will permit gravity drainage.

OR

- To pump out the internal Storm Water from a pump in which the drainage system discharges (Max. demand 162.8 Ha, 50 mm/hr. intensity) Various combinations were discussed in the report. The major points in their Final recommendations were as below–
- To provide only trunk drains along existing drains (in four zones) as per catchment topography and design rain intensity.
- To divide the catchment into four drainage zones A, B, C, and D with special measures for each.

In Compliance with those recommendations, work of the outfalls has been completed. Most of the trunk (R.C.C.) drains are completed but still there are missing links & the Pumping Station is not installed. In the meanwhile the ground levels in Dharavi are since modified. The provisions for this work will have therefore to be once gain carefully reviewed.

4.6 BRIMSTOWAD Report:

4.6.1 In the year 1990 M.C.G.M. appointed M/s. WATSON HAWKSLEY International Ltd. of U.K. with their Indian counter part M/s. Associated Industrial Consultants (India) Pvt.Ltd. as consultants to carry out detailed studies for improvement of storm water drainage system. The scope of the consultancy was confined to:

- Survey of existing drains.
- To study deficiencies in the old storm water drains.
- Identity difficulties in cleaning and maintenance of old S.W.D.s. Review design criteria of existing S.W.D. system with respect to high population of the city and suggest revisions, if any.

- Prepare Master Plan for augmentation of S.W.D. system as per revised norms.

4.6.2 Consultants studied the rainfall data available from observatories at Colaba and Santacruz as well as the flooding events in the island city and the suburbs. It was observed that when high intensity rain fall and high tides occur simultaneously flooding was severe. Such events are six per year in the island city and four per year in the suburbs. Revenue loss on such days was calculated by studying the previous records and one of the worst events of 8, 9 and 10 June 1991. One flooding event in the City was then estimated to cause a loss of 37 crores to the Nation, while one flooding day in suburbs resulted in a loss of 12.5 crores (at 1991 prices). Thus the, Nation incurred a yearly loss of about 254 crores at (1991 prices) due to flooding in Mumbai.

4.6.3 Consultants used the software named “Wallrus” which has been developed by the Hydraulics Research Station of Wallingford, Oxon, U.K. The software simulates mathematical model of a catchment for a particular storm (rainfall) hydrograph and verifies results against the tide curve. It can accommodate flows through closed conduits as well as open channels & also has a facility to work out results with pumping station at an intermediate point or outfall. The model takes into account various factors like infiltration, time of entry, dry weather flow, level of silt in the drain, coefficient of roughness, losses due to constrictions, bends etc. to work out the actual flooding pattern. The results of simulation tabulate maximum flows and velocities for individual branches & along with maximum flood volume & floodable area in a particular branch. Trial runs were carried out for calibration of the model & the catchment coefficients were frozen only when the mathematical results were observed to be compatible with the actual site conditions. Every model was run for different tidal conditions w.r.t. storm in order to achieve results of all possible combinations & augmentations required for the worst case were worked out. The improvement options like augmenting the size of the drain, catchment diversion, holding ponds, pumping etc. were suggested considering the effectiveness Vis a Vis the minimum cost.

4.6.4 The Consultants submitted their final report in the year 1993. They had made the following recommendations to improve the S.W.D. system in Mumbai:-

- To regularly desilt and maintain the drains by using various types of modern machinery
- To remove the obstructions of water mains / cables in the S.W.D. system.
- To remove encroachment, structures in or above the nallas and the S.W.D.s.
- To provide S.W.D. network in the part of the City where it does not exist.
- Change the design criteria from 25 mm /hr. to 50 mm. / hr. rain intensity (i.e. twice a year storm in order to restrict the flooding events to 1/year)
- Augmentation of the S.W.D. system for new design criteria with tidal effects. That involved augmentation of S.W.D. conveyance system, provision of diversions to shorten the length of flow, provision of pumping stations to discharge storm flow from low lying areas and widening, deepening of a the open storm water channels.

4.6.5 A cost benefit study was also carried out to understand the consequence of not doing any improvement in the system (level zero), maintaining the system and preventing further deterioration (level one) and fully utilizing the system by removing obstructions, augmenting the system for (level two) for rainfall of twice a Year storm 48 (say 50) mm/ hr. (level three), and augmenting the system for rainfall intensity of once a Year storm i.e. 58mm. /hr. (level four). It was observed that level 1+2+3 i.e. maintaining & supporting the system & augmenting it to 48 (say 50) mm/hr. turn out to be economically viable. Hence, it was decided to accept the suggestion of augmenting the system to twice a Year storm. Based on the above approach, a Master Plan Report was prepared. Some of the Major works suggested therein were as below: -

4.6.6 Important proposals for the island city:

- Provide a new drain & outfall 5.5 m. x 3.00 m. high near Shivaji Park, diverting major flow between Kings Circle & Dadar station to Mahim beach through railways. This will relieve major flooding at Dadar T.T. & railway station & reduce the load on Dadar Dharavi nalla & S.W.D.s under Senapati Bapat Marg between Dadar & Elphinstone Rd stations.
- Provide a new drain 4 m. x 2 m. from Dr. B.A Rd. Parel T.T. to discharge into existing main drain in Fitwala Marg through railways. This will reduce load on Britania Outfall.
- <u>Provide a pumping station of capacity 40 cu. m. / sec. to pump flows from the outfall at Cleave land Bunder during adverse tide conditions.</u>
- ii) & iii) Together were to reduce flooding at Hindmata, Elphinstone road, Parel T.T. & Worli i.e. an Approx. flood prone area of 50 Ha
- Provide a new drain 8.5 m. x 3.0 m. from Sane Guruji Marg at Mumbai Central along W. Railway. – R.T.O. – Body Guard lane to discharge into Haji Ali Bay.
- <u>Provide a pumping station of capacity 36 cu. m. / sec. to pump flows out of body guard lane diversion.</u>
- & v) Together were to reduce flooding at Tulsi Wadi. Mumbai Central & Grant Road area i.e. an Approx. flood prone area of 65 Ha
- <u>Provide a pumping station of capacity 36 cu. m. / sec. to pump flows out of main nalla at Love grove.</u> This will relieve flooding at B.D.D. chawls, Lower Parel & Satrasta area. Approx. flood prone area i.e. 75 Ha.

Options for storage at Haji Ali bay & Mahalaxmi Race course were considered & priced as alternatives to pumping at Haji Ali & Love grove but were found to be significantly more expensive.

4.6.7 Important proposals for suburbs:

(i) Divert part catchment of Irla nalla through airport land to SNDT. nalla to reduce load on Irla nalla.

(ii) Divert flow east of Milan subway to Vakola River through highway channels.

(iii) Isolate catchment of Milan subway by providing S.W.D.s. on its north & south sides discharging towards above drains & provide a pumping station of capacity 100 lps at Milan subway.

(iv) Widen water way below Andheri subway.

(v) Provide additional S.W.D.s. culvert at Malad subway & avoid collision of flows of Kurar village nalla & Dhanji Wadi nalla upstream of railways.

(vi) Divert the flows from Nancy colony - Ashok nagar pond through new drains from Maruti nagar & WE highway.
(vii) Divert flows in Purushottam Kheraj road nalla to Nanepada nalla near Mulund sports complex.
(viii) Divert flow of Vallabhbhai lane main nalla near Shivaji technical institute.
(ix) Divert flows in Wadhavali nalla through RCF (after crossing refinery railway) to reduce load on Basant Park nalla.

4.6.8 It was specifically mentioned in the report that Mithi River & its tributary Vakola River were among the Major water courses carrying storm water from the Suburbs. These were however encroached upon at many places & the water ways had been drastically reduced. It was necessary to clear out the encroachment & reinstate the water courses of both these rivers by exhaustive dredging. Training of water courses had also to be taken up.

4.6.9 Total cost of improvements suggested by them was Rs. 616 Cr. based on 1992 prices. Since 1995-96 works worth Rs. 262.69 Cr. have been carried out as per BRIMSTOWAD recommendations. Works at Andheri & Dahisar subway have been almost completed, part works are done at Malad, & Milan subways, but Pumping Station is not yet installed at Milan subway. Rehabilitation of about 20% of the storm water drains has been done, but in a piece meal fashion. Desilting is a regular activity now. Many nallas are trained however major schemes for the island in city involving catchment diversions are not yet implemented. Most of the obstructions listed out in BRIMSTOWAD survey are not yet removed; instead many new obstructions have come up across the storm water channels.

It has been said that *BRIMSTOWAD* report could not be fully implemented because of financial constraints. However much better gains could have been achieved with whatever amount has been spent, if proper priorities were followed systematically.

4.7 Milan Subway & Slater road Nana Chowk – (I.I.T. Bombay) (March 2005).

M.C.G.M. approached I.I.T. Bombay for a technical opinion for remedial measures proposed to abate flooding at

1. Milan Subway, (Santacruz) &
2. Nana Chowk and Slater Road, (Grant Road).

Their Final recommendation for the Milan Subway was for Diversion of flows from Milan Subway through a new pipeline to Nehru Road drop shaft of sewerage system by gravity flow.

They also recommended installation of flap gates at Haji Ali and a Pumping Scheme to pump and divert excess Storm Water from Sleater Road @ 2.50 M3/s to the sewer (in 1st phase) and in the 2nd phase to the storm water mains

Installation of 2 state of art rain gauges in the catchment was also recommended. The diversion work at Milan subway has been partly done, but works for Slater road have not yet been taken up.

4.8 In addition, there were recommendations from the Paranjape Committee for expediting the Haji Ali bays development with a gated barrage and for the gated

barrage across the mouth of the Mithi river in 1988 and Shah Technical Consultants in the year 1997- 98 for the Postal Colony SWD diversion work.

After the deluge in July 05 studies have been carried out by various agencies at the instance of MMRDA. Highlights about their scope of work & their major recommendations are as below.

4.9 Interim Report Nov. 2005, by Maharashtra Engineering Research Institute – Nasik on Flood Zone Mapping and flood control measures for Ulhas River and its tributaries in Thane District

4.9.1 The present interim report covers the hydrology of the basin, flood values, & short term recommendation for flood mitigation. The total catchment area of Ulhas basin is 4900 Sq.Km. Two major storages Bhatsa & Barvi are situated in this Catchment. The rainfall varies from 2500 mm. to 3200 mm. from plain area to mountain. There are 83 rain gauge stations in the basin & in the nearby area. The basin recorded @ 1300 mm of rainfall in the spell of 25.7.2005 to 29.7.2005, maximum value being 765.8 mm. on 27.7.2005 at Nalde River gauge Station. The maximum hourly intensity however does not seem to have crossed 70 mm but the duration was long. The (24 hours) average rainfall for the basin has been worked out as 650 mm. and the maximum reported is 916 mm at Bendshil. It is such that studies on the Hydro meteorology of Ulhas basin are of general interest in the context of Mumbai's hydrological situation also. They will be of direct interest for MMRDA but it will be useful for MCGM to keep track of those studies also.

4.9.2 The unit Hydrographs & design storms for the return periods of 25 years and 100 years as well as for the storm on 26-27/7 have been developed & maximum discharges for various sectors have been worked out in the report. From available data, flood levels for 25 years return period are worked out which in turn decide the floodable area. The spread of urban area in the river basin especially along Ulhas & Waldhuni River has been surveyed to study various obstructions to the flow & its impact on 26-27/7.

4.9.3 The report is based on the requirements of Flood Zone Mapping as per the guidelines contained in the Govt. of Maharashtra circulars & their Dam Safety manual. It required defining of the prohibitive zone (required for passing 25 year's return period flood or a flood equivalent to 1.5 times the capacity of established river channel), the restrictive zone (required to pass the maximum design outflow flood of 100 years return period) and the Caution Zone: (extending there beyond for floods of greater magnitude than 1 in 100 years return period) Along with other recommendations regarding removal of encroachment and better garbage management, the report also suggests that the automatic operations of the Barvi dam's gates should be converted into manual operation for regulating the floods more systematically. Rivers in Brihan Mumbai are relatively small. But the experience of the flood zoning work being carried out in the Ulhas basin can provide useful guidelines for similar work to be carried out in Mumbai, once contour maps become available.

4.10 Study on Flood Mitigation Measures for Dahisar, Poisar & Oshiwara Rivers in North Mumbai – Interim Report – December 2005 by Water & Power Consultancy Services (India) Limited, Gurgaon.

4.10.1 Here the scope of work included topographic & hydrographic survey & Mapping of rivers, marking land use pattern in 200 m. strip on either sides of all the three rivers, analysis of rainfall data for 50 years & 100 years return period, evolving hydrographs for different return periods, development of mathematical models for flood hydrographs with different tidal conditions & recommendations about channelisation. Remote sensing technology was used by WAPCOS to assess the alignment or the rivers and the land use patterns. Actual readings were taken for tidal variation by setting up tidal gauges in Malad & Manori Creek. Even current flows in the Creek were measured. Detailed analysis of rainfall data available from I.M.D. Colaba & Santacruz Stations was done to arrive at design storms for 50 & 100 years return period. Mathematical models of the rivers were processed for these storms and the events of 26-27/7 to ascertain peak discharges in various stretches & channelisation is suggested for flood mitigation by analyzing the above results.

4.10.2 The report points out that the developmental activity has resulted in reduction of the river widths & depths have been reduced due to dumping of mud & siltation. Hydro-meteorological / Hydrological studies reveal that for 50 & 100 years return period 24 hours rainfall of 550 mm. & 667 mm. respectively be adopted for design hydrographs of the three rivers. Hourly rainfalls of 50 years, 100 years return period & hourly rainfall of 26/7 would be 119 mm, 134 mm. & 190.3 mm. respectively, which have been used by WAPCOS to determine the peak discharges of river. The channels sections for carrying peak discharges in the flood prone zone of the three rivers have been worked out are as under:-

Parameter	Rivers		
	Dahisar	Poisar	Oshiwara
Existing Width (m)	30	10	20
Proposed Width (m)	45	20	25
Depth	4.5	4.0	4.5
Discharge (Cumecs)	1185	500	569

From their Detailed tables & the Cross Sections presented, in the report, it is clear that Widening & Deepening is essential in all the three rivers. This will have to be pursued further in greater details once the contour maps are in hand.

4.11 1-D Mathematical Model & Desk Studies for Mitigating floods of Mithi River in Mumbai. – Interim Technical report January 2006 by Central Water and Power Research Station.

4.11.1 In this case, the scope of work included examination of the tidal hydraulics of Mithi river & Vakola nalla corresponding to return periods of 50 years, 100 years storms & 26/7 rainfall event for Bandra-Kurla Complex area and identifying the remedial measures for mitigating excess flood levels of discharges corresponding to 50 yrs. , 100 yrs. return period storms. Cross Sections of Mithi river up to the bank levels from Chainage 3 km. to outfall & available rainfall data from Santacruz & Colaba over a period of @ 50 yrs. & hourly records of July 2005 were used by

CWPRS as a base for developing the river model & the design hydrographs. The velocities observed in the year 2003 during monsoon & non-monsoon period were also taken into consideration. In order to reduce flooding, Channelisation requirements were studied, with specific attention to widening required at the Mahim Causeway.

4.11.2 As part of the data was still awaited, preliminary suggestions regarding channelisation & dredging have been furnished for a storm of 100 yrs. return period. They which include widening of waterway from Mahim Causeway to Morarji Nagar (i.e. area below Vihar Lake) and providing modified bed gradients to increase the conveyance capacity of the river. Recommended waterway width at Mahim Causeway is 100 m., while that up to C.S.T. Bridge is 200 m. Further, upstream the recommended bed widths are 100 m., 60 m. & 40 m. Up to Mathurdas Vasanji Road, Jogeshwari Vikhroli Link Road & Morarji Nagar with adequate side slopes & deepening. In absence of ground level data and contour maps, flood plain width (spillage zone width) has been assumed by CWPRS as 350 m., 300 m., 200 m., on either side of the bank, in BKC, Air India Colony to M.V. Road and M.V. Road to Vihar Lake, respectively.

4.12 Development Action Plan for Environmental Improvement of Mithi River and along its Banks – Final Interim Report, dated. February, 2006 by Centre for Environmental Science and Engineering, IIT – Bombay.

4.12.1 Their Scope of Work envisaged study of various aspects of the environment and development of an action plan for improvement of the Mithi River along its banks. The study area comprised the entire stretch of Mithi River including tributaries like Vakola Nalla and a bank area of 200 m. width on either side of Mithi River. An important Objective of the study was to determine the pollution load going into the River, and the assessment of the river water quality Mapping of Mithi River was done by IIT using Topographic sheets of 1923-24 & 1976-77 and the orbital satellite data, Mumbai Development Plan, Ground observations & Ground surveys carried out by M/s.Tandon & Associates. The river courses & streams were marked from the topo-sheets; the holding ponds then existing were also identified. The various hydrographical features prevailing at different times were marked on different plans along with land cover features for 100/200 m. width on either side of river courses. Impediments on river course were specifically studied & widths of river at various locations were measured & analyzed.

4.12.2 For determining pollution load, 43 polluting points' sources were identified along river course. 40 water sampling points were decided for assessment of water quality of Mithi River & 5 for Vakola nalla respectively. BOD and COD of samples from polluting sources were determined as per procedure given in the standard methods.

4.12.3 To eliminate or control pollution in the river so as to conserve the eco-system & to minimize the flood risk vulnerability, short term & long term measures have been suggested in this report. Short term measure consists of the creation of buffer zone of at least 20 m on either side free of any construction. Long term measures comprises of Rain Water Harvesting for all existing & proposed development to be made mandatory in the Catchment area of Mithi river & its tributaries & number of

holding ponds to be created by construction of Check bunds at suitable locations for retention of rain water.

4.12.4 Their recommendations also include: Restoring of the hydrological continuity between east & west i.e. Mithi River, Mahul Creek & Reti Bunder nalla by providing structures for adequate passage of water, Alternate new storages to be provided to make up loss of reservoir capacities of tunnel Adequate diameter or other alternative conveyance mechanism to be provided from Airport to Mahim bay. Removal of hutments on either side of Mithi River & Vakola nalla in phases of 15 m. & further 30 m. respectively has been suggested. To element or control pollution in the Mithi River so as to conserve the eco-system and to minimize the flood risk vulnerability, measures have been suggested in the report by I.I.T. Mumbai on Mithi River (November, 2005). Industries within first 15 m suggested to be removed & that within next 30 m. to be permitted with zero discharge or adequate treatment.

4.13 Utility of studies

4.13.1 The studies have generally been complementary to each other & not over-lapping. Natu Committee report covers entire Mumbai & BRIMSTOWAD also covers entire Mumbai except Dharavi & BKC. S.T.C. report is restricted to Dharavi. CWPRS studies mainly deal with flood modeling studies for Bandra Kurla Complex. But their work is now getting expanded to cover full length of the river as a whole. Report of C.E.S.E. - IIT mainly deals with environmental aspects of Mithi river. WAPCOS studies are essentially aimed at the channelisation requirements of the remaining three rivers. I.I.T. -2005 report is for flood abatement at two specific locations only.

4.13.2 Except report of Shah Technical Committee which was only for planning & designing the drains in Dharavi area, all reports have unanimously stressed the importance of proper desilting / dredging, maintaining water ways clean, clearing encroachments & removing impediments. Except IIT-2005 report, mixing of sewage with storm water has been strongly objected to. Natu Committee report had suggested a change in design rainfall from the earlier figure of 25 mm/hr to 50 mm/hr.

4.13.3 Option of pumping at various locations / holding pond at Haji Ali, recommended in Natu Committee report was further evaluated in BRIMSTOWAD and the recommendations were formulated thereafter. CWPRS 1978 report also included pumping and non return valves on streams meeting Mithi as one of the measures in the package proposed by them, but the same appears to have been differed by MMRDA. The latest CWPRS studies are currently focus on the requirements of channelisation of Mithi for flood mitigation. CESE-IIT report recommends a tunnel from Airport to Mahim bay which probably may have to work with pumping. C.E.S.E. – IIT report also recommends Rain Water Harvesting in Mithi river catchment as means to reduce run-off and improve ecology but no quantitative assessment has been provided.

4.13.4 The report of Ulhas basin is useful because it provide guidelines for the future studies in urban hydrology to be undertaken by M.C.G.M.

4.13.5 Natu Committee's work was the first attempt to address the problem of flooding in Mumbai in a comprehensive manner when Mumbai was growing and expanding fast. It initiated a new direction for handling the situation with modern technologies – like gates, barrages and pumping stations. Brimstowad was an excellent next step that introduced the 'catchment management' approach for the storm water issues in Mumbai. From all the reports, prepared on this topic so far, it is clear that the storm water related issues are gradually getting better defined on the technical side. Related designs standards are also getting upgraded. But on the administrative and social aspects, much remains to be achieved. The topic itself has not been adequately internalized within the corporation's general set up.

4.13.6 Natu committees report in 1975 and the Brimstowad report of 1993 are substantive exhaustive reports. But their processing in the Municipal Corporation appears to have been handled more or less just in a routine manner. There are no formal orders – accepting or rejecting the numerous detailed recommendations made therein. Even the copies of these reports do not appear to be having reached the ward offices and the departmental ground level offices who are expected to finally act on many of those recommendations. Brimstowad report particularly contains excellent detailed catchment wise drawings and catchment wise write ups on the actions to be taken. But this information is not readily available for the ground level functionaries. As a result, there was no scope for their taking initiative in the implementation of these matters for improving the local situation.

4.13.7 Looking to the expanse of the activities involved, it would have been desirable if there was a formal monitoring team to ensure and oversee the systematic follow ups on the recommendations of the Natu Committee and the Brimstowad. If a detailed programme of implementation could have been drawn up and implemented in consultation with the concerned citizens and the ground level functionaries, the situation would not have aggravated over the last 30 years after the Natu Committee's report and over 13 years after BRIMSTOWAD. 'Finance' does not appear to be a major constraint in all these years, because many other expensive works have been undertaken and completed by the corporation. Some how the flood related issues did not receive the required priority and the serious attention they deserve.

4.13.8 In the meanwhile, Mumbai's population grew substantially from 82 lakhs in 1981 to 120Lakhs in 2001. Population in slums has also shot up from around 40 lakh in 1981 to around 60 lakh in 2001 – quite a large part of it occupying the risky flood prone areas. The social aspects of the problem have got escalated in this intervening period. Encroachments on / in water courses, and reductions in waterways have remained unattended in the case of most of the rivers / nallas. There has been lack of flood consciousness.

4.13.9 To avoid such a situation hereafter, it will be helpful if the reports are formally processed for the acceptance or otherwise of the standing committee of the corporation. These reports appear to have been earlier dealt with only administratively in the offices. There have been no discussions on it in the people at large or even in the professional associations dealing with such issues that are active in Mumbai. The result was that the valuable guidance contained in these reports just got lost and failed to orient the concerned population and the citizens at

large in the desired direction. It is hoped that this would not be the fate of the report of this Fact Finding Committee also.

CHAPTER 5

STORM WATER, SEWERAGE AND SOLID WASTE DISPOSAL SYSTEMS

Storm Water Drains, Sewerage System and Solid Waste handling are the vital components of urban civic management. Given its geographical shape, topography, coastal & island nature, population density including floating population and rate of precipitation, proper performance of Mumbai's systems of Storm Water Drains, Sewerage and Solid Waste Handling is always very important. These systems are briefly outlined in this chapter.

5.1 Storm Water Drains

Mumbai City was originally comprised of seven individual Islands. This original cluster of seven islands, barring Mahim (Baradbet), was built around hill cores. Only Mahim was old sand bar, on the protected, inner side of the Mahim Bay, behind Worli head-lands. The present day Mumbai is not a single land mass and it is not even an island, with the effective filling in of the breach of Mahim Bay between Sion and Kurla and the construction of the Mahim Causeway. Present day Mumbai consists of a low-lying plain about 40 km. long north to south, and 5 to 7 km broad east to west, flanked by two parallel ridges of low hills running along two shores. The eastern ridge, more discontinuous, and leveled in many parts continues below high water level. The present Greater Mumbai limit consists of island city and suburbs. The city area has no natural drainage outlet. The central area forming a depression, flanked by hills, and being on reclaimed grounds barely two to three meters above sea level is liable to flooding during the monsoons. As in proper Mumbai (island city), in the suburbs too, natural drainage has been visibly affected by urban building activity. All along the shore fringes, extensive areas are flooded during high tides, during the heavy monsoon rains, many low lying areas are flooded and do not readily get drained.

Someone will hardly be able to visualize the original relief of the area, much less imagine the extent to which the topography and the configuration of the area on which Greater Mumbai stands has been shaped by human interference and action. A substantial area – possibly a half of the city area, and about a fifth to fourth of the suburban area – has been reclaimed from below sea level by infilling , and pushing the sea outwards through dyke walls like those of the Back bay reclamation. Many low hills have been quarried for road and plinth material, subsequently leveled and built up. Thus most of the low hills around Sion, Raoli, Sewree, and Dongri-Mazgaon in the City, and around Kurla-Ghatkopar, Andheri-Jogeshwari, and Marol have been reduced to ground level. Much of the initial surface drainage and streams, specially in the suburban Salsette have been so completely modified that there is practically no natural drainage in the area.

There are separate systems for disposal of sewage and storm water, in island city, the storm water system is mostly underground whereas the Storm Water streams in Suburbs are open. The storm water drainage system in the city is designed on the rainfall intensity of 25mm (1 “) per hour. It is observed that intensity of rainfall reaches up to 50mm to 100mm (2” to 4”) per hour but such occasions are

very rare and such high intensity lasts for a small duration. To deal with such occasional flooding during these heavy precipitations larger sized drains would have been necessary.

Though there are separate systems for disposal of sewage and storm water, there are interconnections through which Storm Water is discharged in sewerage network and vice-a-versa. Storm drains receive possibly 40% of sewage from the city either by direct discharge/ overflow from sewers or by drainage across the ground. A number of industries also discharge effluent directly into the drains.

The storm water is drained in the sea through various out-falls. The out-fall levels ranged from -2.0m GTS to 3.5m GTS (22.4 to 28 meters THD Town Hall datum). During monsoon when heavy rains synchronize with high tide of the sea, the outfall gets blocked causing inundation of areas with the result that road and rail traffic is disrupted and sometimes comes to a standstill. The impact of flooding is all the more important in the suburbs, where in addition to the flooding on the roads many low lying areas get submerged in water for a considerable time.

In island city SWD system consists of under ground arrangement of inlets (storm water entrances/road side open roads), laterals, collector drains (dhapa/ pipe/ open channels), trunk mains (arch/ box/ open nalla) and out falls; few out falls are gated and the remaining directly discharge in to sea. In suburbs the SWD system consists of open drains discharging into minor and major nalla or rivulets, which finally lead to creeks. Wherever the network is crossing railways or roads the cross drainage works (culverts) are provided.

The inventory of storm water drain in island city and suburbs is as below:-

5.1.1 Length of Nallas and Drains

TYPE	Island City	E.S.	W.S.	TOTAL
Major Nalla (Km) (Width > 1.5 M)	8.545	90.200	101.509	200.254
Minor Nalla (Km) (Width < 1.5 M)	20.762	66.400	42.104	129.266
Arch / Box Drains (Km)	59.20	40.00	51.93	151.13
Road side Open Drains (Km)	20.00	669.48	1297.50	1986.98
Closed pipe/ Dhapa Drains (Km)	443.180	36.200	86.031	565.411
No. of Water Entrances	27893	609	1706	30208

The List of Major nallas in island city, western suburbs & eastern suburbs is enclosed at Annexure 1

5.1.2 Railway Culverts (Nos)

	Island City	W.S.	E.S.	TOTAL
Central Railway	31	-	25	56
Western Railway	12	46	-	58

5.1.3 S.W.D. Outfalls (Nos)

Outfall→	Island City	W.S.	E.S.	TOTAL
Discharge in ↓				
Arabian Sea	107	29	-	136
Mahim Creek	4	14	8	26
Mahul Creek	4	-	6	10
Thane Creek	-	-	14	14
Total				**186**

Outfall levels vis-à-vis Mean Sea Level & High Flood Level

(A) Outfalls below Mean Sea level = 45
(B) Outfalls above M.S.L. but below High tide level = 135
(C) Outfalls above High tide level = 6

= 186

List of outfalls with all details like catchment number, area (in Ha), and outfall invert in m GTS is given in Annexure 2.

Construction of the existing drainage system in island city commenced in the 1860's and the major routes were laid by 1900. Practically all storm drains in the island city are covered, exceptions being nalla at Love grove, the Textile Mill nalla and some open nalla systems in the north / eastern areas. Most of the larger drains are of arch construction built either in brick or masonry with some recent construction in concrete arch or box culvert design. Older small and medium sized drains are of 'Dhapa' construction where open drains have been covered by stone or concrete slabs (dhapas) before filling on the top. Some of these Dhapa drains are recently been converted in pipe drain.

Major catchments in island city and suburbs have long drainage routes. The problem of long drainage routes is compounded by the fact that large areas are very close to high tide level while some are below high spring tide level. As the development was taking place continuously over past centuries, the outfalls are extended in island city with a very flat gradient and most of the major outfalls discharge much below Mean Sea level. This results in the flooding when rainfall coincides with high spring tides. In recent years the authorities issue public warnings during the monsoon when high spring tides coincide with rush hour travel.

Although 45 outfalls discharge below mean sea level, tidal control is only at 3 places. The major watershed areas i.e. Catchments 129 and 130 include low-lying

areas and flood-gates have been provided at their outfall mouths at Cleveland Bunder, Worli and Love Grove, Worli, since long ago. The flood-gates are also provided on bye-pass arrangement on Love Grove stream at Haji Ali. These gates prevent back entry of sea water into the drainage system during high tides.

The whole problem of flooding has arisen as the storm water drains are discharging rain water directly by gravity in the sea through outfalls. If balancing reservoirs are constructed with adequate sluice gates to receive storm water from low lying areas and the same is discharged in the sea during low tide the severity of the problem will be much reduced. At times Storm water will have to be discharged through pumping stations. However this will involve establishment of huge pumps to be used for brief periods and on rare occasions. Its necessity, location and capacity will be an area of study for MCGM

5.2 Deficiencies in the system and causes of flooding

The major deficiencies in the storm water system which causes flooding are elaborated below.

- Many gradients are flat and the drains are affected by tides. This and the fact that for most of the time flows are low; it results in low velocities in the drains resulting in siltation. The time period between high flows allows the silt to consolidate and it is not always removed by these high flows. Consequently much of the system is heavily silted.
- A large number of drains have been found to be of inadequate capacity for the flows produced by a 2 in 1 year storm and inadequate for the 25 mm/hr. design standard historically adopted in the city. It appears that the hydraulic head restriction imposed by the tide has not been taken into account while designing the drains.
- Many obstructions have been identified in the larger drains which were surveyed during the project period of BRIMSTOWAD. Most of the obstructions are caused by other utility services crossing the drains. Thought is required to be given to minimizing the head loss due to the restriction. Most of the services crossing the drains are well below the soffit and cause considerable restriction, often exacerbated by silt and debris trapped by the obstruction.
- Poor workmanship and lack of attention to proper repairs when the drains have been punctured to construct utility services has left many of these locations in a poor state of structural repair. Turbulence caused by the obstructions has frequently contributed to further structural deterioration.
- There are number of siphons in the system to cross major water pipes or other services. Generally these are poorly designed, provide a high head loss and are difficult to maintain free of silt.
- The locations where serious structural defects (grades 4 and 5, 1991 survey) are found are not extensive at 4.5% of the total lengths surveyed, but larger portions of the system, 10% contain grade 3 (1991 survey) defects which require attention to prevent further deterioration.
- Now about 15 years have passed since the drains are surveyed. No new survey has been done since then. The drains must have deteriorated further necessitating rehabilitation. (Structural survey /audit are also required to be carried out periodically.)

- Gullies are poorly placed at times and at wrong levels to collect the maximum amount of water from the road surface. Spacing is generally inadequate and the design of the gullies leads to siltation of the gullies themselves and the connections to the drains.
- Some catchments areas in the east of the city are affected by accretion of mudflats in the harbor area.
- Access for maintenance to some drains is restricted by development over the manholes.
- Dhapa drains have limited access and, as they often have flat inverts are more prone to siltation than pipe drains. They therefore are more difficult to maintain and keep free of silt.
- Absence of holding ponds/tanks to hold storm during high tide.
- Interconnection of storm water and sewerage networks & vice versa leading to siltation and loss of drainage capacity.
- Encroachment on system reducing access for maintenance/desilting and using system to dump garbage/ refuse which further reduces the capacity to drain out.

As explained earlier, the storm water system in city is developed with design criteria of rainfall intensity of @ 25mm/hr. and 0.5 run-offs during low tide hours. Since many of the outfalls discharge below mean sea level and without tidal control, the discharging capacity of outfall is reduced during higher tide levels. As such owing to situations beyond the design criteria it results in system inadequacy to discharge the storm water in the sea/creek and water logging takes place in the areas prone to flooding on upstream.

5.3 Situation of flooding in island city & suburbs

Drawing No. 5 & 10 shows Chronic flooding spots in island city & suburbs. Drawing No. 4 & 9 shows areas flooded in island city & suburbs on 26 July 2005. The list of locations flooded on 26 July 2005 along with details such as extent of flooding is enclosed as Annexure 3.

The volume - I of 'Mumbai Disaster Management Plan (2000)" also lists flooding locations giving names of flood prone slum areas and other flood prone low lying area and road (see Annexure 4).

It is understood that over the period the list of flooding spots is prune down. This is due to improvement works which are carried out over last decade or so.

In suburbs, historically flooding was not much of big concern. However in the recent past, flooding is taking place at more and more places in the suburb.

Flooding on traffic corridors is always a big concern, as it halts the transport means of commuters. The list of chronic flooding locations on major traffic corridors which halts trains or vehicles is enclosed as Annexure 5. These corridors are lifelines of the city and these corridors shall be made flood free. The map showing locations of chronic flooding spots on corridors are enclosed as Drawing No. 6 & 11). The approach for improvement of system along traffic corridors is addressed in the "Transport" chapter.

During rains generally the municipal ward staff mans chronic flooding spots to maintain the flow by clearing water entrance slots / choked screens. This generally helps in accelerating the discharge when water starts receding. At times the sewer manhole covers are opened for quick discharge of storm water.

Having the data of events of flooding the priority shall always be to plan and implement the schemes to reduce/ avoid flooding

5.4 Operation and Maintenance

As a part of maintenance of S.W.D. following works are undertaken every year by Ch. E. (SWD).

(1) Desilting of storm water entrances, laterals and manholes
(2) Desilting of dhapa / pipe/ arches / box drains
(3) Desilting of minor and major nallas
(4) Desilting of culverts
(5) Desilting of outfalls
(6) Desilting of roadside open drains
(7) Repairs of SWD System
(8) Conversion of dhapa drains (in island city) in pipe drains
(9) Removal of obstructions
(10) Replacement of dilapidated S.W.D. / augmentation / repairs etc.
(11) Other related works

Desilting work is carried out by MCGM in 3 stages i.e. pre-monsoon, during monsoon and post-monsoon. Desilting is carried out either departmentally or through contractual agency. Majority of desilting works is carried out through contractors and it is predominantly carried out in April and May. These are generally arterial drains, major nalla desilting works. Other desilting works like desilting of water entrances, manholes and minor nallas/ road side drains are carried out departmentally through departmental labours and through mechanical equipment owned by MCGM. The equipment such as suction machine, jetting machines, choke removal machines, road side drain desilting machines, excavators, amphibian dredger machines are used for this purpose.

Roadside open drains in suburbs form large chunk (about 2000km) of system. For desilting of these roadside drains departmental labourers are available with the Wards. There are machines with Corporation to desilt these drains. However the small stretches of such drains covered locally, do pose problem in effective cleaning. Desilting of railway culverts is the responsibility of railways that employ contractors for the same and the payment for this work is made by MCGM through one time lump sum payment to Railways before commencement of work. Local storm water drain system in MbPT area is maintained by MbPT and the desilting of same is done by them. The road culvert and storm water drains along Eastern & Western Express highway, Bandra- Kurla Complex are maintained and desilted by PWD/ MMRDA.

It has been observed that desilting contracts are framed on the fixed quantity basis .Thus the desilting carried out is partial as objective of providing waterway up to the desired level i.e. bottom of outfall/ drain is not achieved. Every year the fresh contracts are awarded for contractual portion of desilting and the tender document

clause 15 for desilting specifies for desilting in 3 stages as given below. This concept needs to be changed.

"Clause 15- The desilting operation will be carried out generally in three rounds during the span of contract period of 12 months as per the details given below :

(a) The first round of desilting will start within 10 days from issue of the work order and it will continue till onset of monsoon or as directed by the Engineer. The first round of the desilting work shall be completed to the extent of about 70% of the contract quantity or the percentage as directed, before the onset of monsoon i.e. 7th June 2005 and as directed by the Engineer-in-charge.

(b) The second round of desilting will be started immediately thereafter and work will be carried out whenever and wherever required to avoid flooding during the monsoon as directed by the Engineer. This work to continue up to the end of monsoon will be to the extent of 10% of the contract quantity or as directed by the Engineer-in-charge.

(c) The third round of desilting (Approx. 20% of contract quantity or as directed) will be started after the monsoon and will continue up to the end of the contract period."

Tide control gates at Cleveland Bunder, and Love Grove, are operated round-o'clock throughout the year. There exists sullage water flow in Cleveland Bundere and Love Grove streams. The tide control gates at Haji Ali are operated only during monsoon. Operation of gates at these locations helps in preventing back entry of sea water in to the Storm water system. As per observations taken by the Committee during low tide hours on 2.11.2005, these outfalls were found to have been silted to the extent of about a meter.

During monsoon of 2005, MCGM provided Pumping arrangements at following locations:-

(1).City: S.V.P. low level, Burhani College, Slater Road.
(2).Western Suburbs : Dahisar Subway, Malad Subway, Andheri Subway, Milan Subway, Boran Nalla , W.E. Highway, Andheri-Kurla Road.
(3) Eastern Suburbs: Bramhanwadi Nalla.

Few portable pumps were kept in sewage pumping stations to handle dewatering of rain water during monsoon.

Besides Pumping arrangement the Storm Water Flow was diverted to Sewage Pumping Station by providing links at following locations.

(1) Slater Road
From Slater Road to ovoid sewer at Diana Cinema (Discharging into Love Grove sewage pumping station.)

(2) Gilder Lane: From S.W.D. at Gilder Lane to ovoid sewer and also at Petit school to ovoid sewer. (Discharging into Love Grove Sewage pumping station.)

(3) Milan Subway

The old sewer line of 900 mm. dia. on west of Western Express Highway and new sewer line of 1800 mm. dia. on east of Western Express Highway was connected with 2 Nos of 600 mm. dia pipes. (Discharging into Bandra-IPS sewage pumping station.

After water logging on 26 July 2005, the portable dewatering pumps were put into operation for dewatering at Kalanagar, Suman Nagar, and Air India Colony etc.

5.5 Conversion of dhapa drains into pipe drains

In island city most of the storm water system is underground. Some portion of this underground system consists of dhapa drains. These dhapa drains are old rectangular open drains, covered by dressed stones or dhapas as city developed. They have very flat gradients and are of varying size generally from 450mm x 450mm up to 900mm x 900mm. These dhapa drains are hydraulically deficient on account of gradient, shape, and obstruction due to utilities like water pipes, cables etc passing through the same. BRIMSTOWAD consultants have recommended converting these dhapa drains into pipe drains. Many such drains have been converted into pipe drains on piecemeal basis which leaves scope to retain inherent defects like difference in invert levels, improper slopes etc. There is a need to plan and monitor these works for proper hydraulics of system as a whole including all the upstream and downstream network of such stretches.

5.6 Covering of storm water drains

Some storm water network in island city and most of the storm water networks in suburbs are open system. There is a large network of road side open drains in suburbs.

These roadside drains require attention throughout the year as many of these roadside drains carry sullage. Since these drains are open the swept material/refuse easily enters the drain and it obstructs flows. It is always an eyesore and a health hazard. The popular demand of locals is therefore to cover these drains. Sometimes even bigger storm water channels (called as major/medium/minor nalla) are recommended for covering on the demand of locals/ general public.

Along with road concretization / reconstruction works, roadside drains are now-a-days rebuilt and covered with side entry for storm water and chambers at intervals for desilting. Some nalla are also closed/ covered or are being covered. While reconstruction & covering no proper hydraulics is followed for efficient storm water run-off and maintenance become difficult. Such a covering is not a good practice for the storm water system.

Properly planned and designed underground storm water system is very essential and the same principle must be followed whenever it is planned to replace the road side open drains. At Times when such lines leads to lower inverts, the storm water should be pumped into the higher invert arm of network on down stream side of the storm water system and ensure that the system is not hydraulically deficient.

5.7 System of records:

Presently there is no formal system of records; however, records such as design, drawing and other related activities are maintained in Central Office. System of Records needs to be improved for quick referral and permanent recording and generating information system. G.I.S. integrated with M.I.S. therefore needs to be developed.

5.8 Sewerage system

5.8.1 Historical background of Mumbai

As already elaborated before, the original city of Mumbai consisted of seven islands namely Apollo Bunder, Malabar, Cumbala, Mazgaon, Worli, Mahim, and Parel-Dharavi-Sion. The idea of reclaiming submerged land is back from as early as middle of 16th Century. The first work of construction of Vellard between Worli and Mahalaxmi was done in the year 1772. Major areas reclaimed by the year 1860 were Wadi Bunder, Chinch Bunder, Curnac Bunder, Mint Road, Elphinstone Road, Tank Bunder, Clerk Road, Mahalaxmi, Seweree, and Frere Estate. There are several areas that were subsequently filled up and reclaimed. Subsequently a Causeway was constructed at Mahim to connect Mahim and Mount Merry. After independence major reclamations were carried out at Back Bay reclamation and Nariman Point.

5.8.2 History of sewerage system: Pre-independence era:

The history of sewerage of Mumbai commences with the old main drain constructed about the end of 18th Century, which at first was merely a nalla discharging at the Great Beach. As the urban area increased, sluices were constructed in 1842 at Love Grove.

In 1860, Vihar Lake was commissioned, during this period the idea of collection system for sewerage was mooted by Mr.Tracey. As such an interceptor sewer was laid which discharged into the harbor.

A commission appointed by the Government in 1866, recommended the discharge of all sewage into reservoir opposite old Light House at Colaba and then to pump it out in sea at ebb tide. By the close of 1867, the outlets with main sewer were laid.

Present sewage conveyance system is based on Report of Captain Tulloch. He recommended a separate system of storm water and sewerage. Accordingly, in 1880 all sewage was taken to Love Grove, where an outfall was constructed to discharge partially treated sewage into the sea.

From 1882 onwards new works like sewers in Queen's Road, Fort area and Girgaon were undertaken.

In 1890, Mr. Baldwin Latham presented a Comprehensive report on 'Sanitation of Bombay'. The report was approved in 1893 and five ejector stations to lift the sewerage through a height of 5 to 7 mts. were constructed to drain sewage from low lying areas to gravity sewer & sewerage network and system was extended from time to time as per demand and need.

In 1905, ejector stations at Mazgaon & Parel were constructed

In 1910, treatment plant was constructed at Dharavi.

In 1938, treatment plant was constructed at Dadar.

Even in the less crowded period of the last century, low lying areas could not be cleared off water without lifting them.

5.8.3 History of sewerage system: Post–independence era

After independence, city of Mumbai experienced a population explosion and rapid Industrialization.

In 1950, limits of Mumbai were first extended to include the suburbs and in 1957 it was further extended to include extended suburbs. These events necessitated complete re-orientation of sewerage system.

In 1960, primary treatment plants were constructed at Khar, Versova & Ghatkopar.

In the year 1962 a High Level Committee was appointed to study the Water Supply Resources and Sewerage. However, a very little progress was achieved mainly due to paucity of funds. In the year 1969, World Bank was approached to finance development of Water Supply & Sewerage System of the City. As a result an integrated project for Water Supply and Sewerage was formulated. This was planned and executed in three phases now known as Mumbai – I, II & III Projects. M.C.G.M. implemented Mumbai I, Mumbai II, and Mumbai III during 1975 to 1996. In these projects 123 Kms sewer lines were laid, 23 pumping stations constructed, 6 W.W.T.F. constructed. 1 pipe outfall & 1 aerated lagoon were constructed. Details of Mumbai I, II and III are described in subsequent paras. These projects were implemented with the help of World Bank.

Prior to start of Mumbai-I Project M/s. Binnie & Partners were appointed as Consultants, some time in the year 1970, to prepare feasible Development Plan for the sewerage system. The Consultants submitted their report in 1971 and suggested a complete sewerage system plan consisting of conveyance system, construction of Pumping Stations and Sewage Treatment in the form of secondary treatment at 3 locations. However, since higher priority was given to Water Supply Works it was decided to restrict the sewerage works to laying of some sewers and construction of few pumping stations.

M/s. Metcalf & Eddy Consultants were appointed in the year 1976 to review the proposed sewerage system with special reference to oceanographic surveys, proposed land use and feasibility of reuse of sewage. This was as per World Bank advice. The consultants carried out extensive studies and came out with a revised development plans by 1979, consisting of provision of marine outfalls at Colaba, Love Grove and Bandra and aerated lagoons at Versova, Malad , Bhandup and Ghatkopar for sewage disposal apart from conveyance system.

In 1979, M/s. Metcalf & Eddy in association with Environments Engineering Consultants prepared integrated Master Plan for Sewage Collection Disposal for the period up to 2005**.**

5.9 Sewerage master plan - 1979

- 1979 – Consultants Metcalf & Eddy submitted first Sewerage Master Plan which has following features.
- Feasibility studies.
- Design for the year 2005.
- Estimated population 94 lacs.
- Estimated waste water 2600 MLD including industrial flow of 240 MLD.
- Total 437.71 Sq.Km. Mumbai areas divided into seven zones.
- For 3 city zones preliminary treatment with marine outfall proposed due to non availability of land.
- For remaining 4 suburban zones preliminary and secondary treatments proposed due to adequate availability of mud flats land at cheap rates.

As stated above, these recommendations were accepted & implemented under Mumbai – I, II, III & M.S.D.P. - I with the assistance of World Bank.

5.10 MUMBAI – I

First integrated water supply & sewage project was implemented in the 1973-81 at a cost of Rs. 2162 Millions. B & P Partners were consultants for WSP and Metcalf & Eddy Inc. (USA) with EEC (India) for Sewerage Project. In this project, additional 455 MLD water from Bhatsa were brought in the City and six sewage pumping Stations were constructed.

5.11 B.U.D.P. –

During Mumbai – I, very small part of sewerage network was funded by the World Bank under B.U.D.P. Scheme.

5.12 MUMBAI – II

Second integrated water supply & sewage project was implemented in the year 1979-88 at a cost of Rs. 7400 millions. B & P Partners were Consultants for WSP and ES-AIC-PHE for SP for detailed Engineering & design. Additional 455 mld water from Bhatsa were brought in the City & seven IPS & WWTF , 14 satellite pumping stations, 7 Kms. length of collector tunnel & EPS , one marine outfall and 89 km of sewer were constructed.

5.13 MUMBAI - III

Third integrated water supply & sewage project was implemented in the year 1987-96 at a cost of Rs.6130 million. M/s. TCE were consultants for WSP & B&P for SP for detailed design & construction supervision.

Additional 455 MLD water was brought from Bhatsa in the City and 3 satellite pumping stations and 54 km of sewer was constructed.

5.14 M.M.R.D.A. Funding

Uncompleted and remaining works of Mumbai – II were funded by M.M.R.D.A. With the financial support of Rs.162 crores.

5.15 Sewerage Disposal Project

In August, 1990 M.C.G.M. reviewed the progress of Mumbai – II & Mumbai – III Sewerage Projects works and observed that supplemental financing would be

desirable to complete the ongoing works. Therefore, M.C.G.M. approached to the World Bank, who, indicated that following works could be considered for the further funding under as Mumbai Sewerage Disposal Projects.

a) Outfalls at Worli & Bandra.
b) Aerated Lagoons at Ghatkopar & Bhandup.
c) Remedial works for the existing pumping stations and conveyance system.
d) Operation and maintenance, topo-survey, condition assessment survey and consultancy for the same.
e) Bandra –Ghatkopar Tunnel.
f) Slum Sanitation Project
g) Master Plan for M.S.D.P.-II
h) Rehabilitation of sewer lines.

As a pre-requisite to the Pre-appraisal Mission & funding agency, it was necessary to undertake a detailed Environmental Impact Assessment Study. The Study was carried out by Environmental Engineering Research Institute (NEERI). The study indicated that M.C.G.M. has to come out and prepare for further projects to bring the pollution levels in and around Mumbai to the acceptable limits of Government of India/International Standards.

5.16 M.S.D.P. – I

The M.C.G.M. had approached to the World Bank for completing incomplete works of Bombay II & III and some additional works after EMS Study and finalization report. The World Bank had sanctioned loan, credit, aid amounting to U.S. $295 millions (Ln/Cr 3923/2763-IN) in July, 1995. The project was executed during the period of July 1995 to 31.12.2003. All major works of M.S.D.P.-I were satisfactorily completed except construction of certain community toilet blocks in slum area of Mumbai. The major works completed under M.S.D.P. and its benefits are as below:

5.16.1 Works completed under MSDP – I

- Worli Outfall.
- Bandra Collector Tunnel.
- Bandra Outfall.
- Bandra Pumping Station.
- Bhandup lagoon
- Ghatkopar High Level Tunnel
- Ghatkopar lagoons
- Missing links reestablished by micro-tunneling method & some Conveyance System.
- Rehabilitation of old sewer lines – 22.5 Kms.
- More than 300 toilet blocks constructed.
- Master Plan for 2nd stage studies prepared.
- Consultancy services for Condition Assessment.
- O & M study.
- Topo survey.

5.16.2 Benefits achieved

- Improvement in coastal water quality as visually seen & measured in high Sea.
- Improvement in aesthetics of Mumbai (in terms of odor, floating debris etc).
- Reduction of pollution load into water bodies around Mumbai.
- Increased fish yield by twice in the area as reported by fishermen (at Worli and Colaba).
- Improvements in Management of Sewerage Operation and Maintenance.
- Partial compliance with environmental standards.
- Slum Sanitation facilities extended to slum dwellers.
- Introduction of advance technology (i.e. T.B.M., segmental lining, Micro tunneling, lining coating, pipe bursting, pipe jacking.)

5.16.3 Additional works carried out under MSDP - I

As stated above during execution of the M.S.D.P. – I, Consultants were appointed to carry out the following studies.

- Condition assessment of Existing Sewers (Structural)
- Topo-survey
- Up-gradation of Operation and Maintenance of Sewerage System
- Segregation of Sewage Flow from Storm Water Drain

5.16.4 Projects implemented

- Based on recommendation of Consultants appointed for the above studies. Following recommendations were implemented.
- Construction of Manholes at cost of Rs. 9.124 m
- Repairs to Manholes at a cost of Rs. 6.050 m
- Replacement of Manholes Frames & Covers at a cost of Rs. 29.900 m
- Providing Vent Shaft & Improvement in Drop Connections at a cost of Rs. 17.090 m.
- Procurement of Sewer Cleaning Equipment at the cost of Rs. 71.340 m.
- Procurement of Laboratory Equipment at the cost of Rs. 2.682 m.
- Modification of Grit Chambers (a) Civil Work, (b) Air Diffuser at the cost of Rs.2.000 m.
- Procurement of Safety Equipment at the cost Rs. 10.570 Millions
- Procurement of Non Return Valve at the cost of Rs. 1.870 Millions
- Supply, Installation, Testing & Commissioning of Duck Bill Valves at the cost of Rs. 10.000 Millions.
- Rehabilitation of Sewer by Open Cut Method at the cost of Rs. 23.040 m
- Rehabilitation of Sewers by Lining/Coating Method (Phase– I) at the cost of Rs.294.97 m
- Rehabilitation of Sewers by Pipe Bursting Method at the cost of Rs. 39.180 m
- Rehabilitation of Sewers by Lining/coating Method (Phase – II) at the cost of Rs. 121.390 m
- Total 22.5 km. of line was rehabilitated under above contracts. Break up is as below. 1.5 km. by open cut method, 17 km. by lining coating method and 4 km. by pipe bursting.

- Thus majority of recommendations of consultants so appointed in this phase were implemented in this phase only, which was the major achievement.
- Work of segregation of sewage flow from S.W.D. network is under progress.
  - Providing & laying of pipe lines at various places for segregation of sewage from Storm Water Drain.
  - Pumping Station at Cleave Land Bunder for Segregation of Sewage from Storm Water Drain.
  - Construction of Diversion Chambers.

5.17 Current scenario:

The collection, conveyance and disposal system comprise of 7 sewerage zones. Each zone is operating independent of each other and each zone consists of a sewerage collection, conveyance system, pumping stations, rising mains and treatment facilities and disposal facilities.

5.18. Sewage collection and conveyance system

For proper implementation and management purpose, the area of Greater Mumbai limit is divided into seven sewerage zones.

* Colaba
* Worli
* Bandra
* Versova
* Malad
* Bhandup
* Ghatkopar

Zone 1 – Colaba_covers an area of 574 ha. Contains six pumping stations and about 32 km of sewers leading to preliminary treatment and the short pipe outfall to Colaba Harbor.

Zone 2 – Worli covers and area of 3891 ha. Contains sixteen pumping stations and about 339 km of sewers leading to preliminary treatment and the new, three-kilometer long sea outfall at Worli, discharging to the Arabian Sea.

Zone 3 – Bandra covers an area of about 7730 ha. have sixteen pumping stations and about 326 km of sewers. Flow from the IPS will pass to Bandra preliminary treatment works prior to discharge via the EPS and a 3.5 kilometer long sea outfall to the Arabian Sea.

Zone 4 – Versova_covers an area of about 2140 ha. There are only two stations, a final pumping station one small pumping station at Versova village. The 146 km. of sewers lead to preliminary and three stage aerated lagoon treatment discharging to Malad Creek.

Zone 5 – Malad_covers an area of over 11500 ha. There are six pumping stations and about 300 km. of sewers. A final pumping station delivers flows from the interceptor to preliminary treatment, which discharges to Malad Creek.

Zone 6 – Bhandup_covers an area of 4274 ha. There are three pumping stations and about 105 km of sewer leading to preliminary and single stage aerated lagoon treatment discharging to Thane Creek.

Zone 7 – Ghatkopar_serves an area of about 7730 ha. There are 3 pumping stations and 136 km of sewers leading to preliminary and single stage aerated lagoons treatments discharging Thane Creek.

Though sewerage lines are laid in above zones, due to rapid expansion, development, dense population and non- accessibility etc sullage in some of the parts particularly in extended suburbs and slums is connected to storm channels , which is required to be segregated.

Sewage collection system comprising of gravity underground sewer network and online satellite pumping stations are grouped in such way that the entire quantity of sewage collected from that zone is delivered to the terminal point located in that respective zone.

All such terminal points of seven zones are provided with appropriate Treatment Facilities and main disposal pumping stations of adequate capacity for final disposal.

Statistical data of Sewerage network.

1.	Area of the city	437 Sq.Km
2.	Population of the city	1,20,00,000
3.	Sewered area of the city	60%
4.	Unsewered area	40%
5.	% of population living in slum	60%
6.	% of population served with sewerage facility	40%

Sewerage System Statistical data

1.	Length of Sewer Lines	1400 Kms.
2.	No. of Sewage Pumping Station	51 Nos.
3.	No. of Waste Water Treatment Facilities	7 Nos.
4.	No. of Outfall	3 Nos.
5.	No. of Lagoons	3 Nos.
6.	No. of Street Connections	2,65,000
7.	No. of Manholes	53,000
8.	Size of Smallest Sewers	6” dia.
9.	Size of Maximum Sewers	6’ dia. Circular & 6’ X 9’ ovoid shape
10.	Total sewage handled	1700 mld

Treatment Facilities

Zone	Average Dry Weather Flow (Million Liters per Day)	Treatment Facility
Colaba	41.10	Aerated Grit Chamber and Marine Outfall.
Worli	756.90	- do -
Bandra	796.80	- do -
Versova	180.00	Aerated Grit Chamber and Lagoons
Malad	280.40	To be decided in Phase – II
Ghatkopar	386.10	Aerated Grit Chamber and Lagoons
Bhandup	230.00	Aerated Grit Chamber and Lagoons

5.19 Future scenario

The Consultant appointed under M.S.D.P. - I have carried out the feasibility studies and have prepared the master plan for sewerage system for the population growth by the year 2025. M.C.G.M. has accepted the report. The total cost of the project is Rs.55704 Millions and is proposed to be implemented in V stages. These works are critical and sensitive from environmental and health point of view. The works identified under phases I and II are most critical and are required to be attended on priority. M.C.G.M. has approached G.O.M. / G.O.I. / World Bank for financial assistance to implement Phase – I and II of the project. The phase- I and II is also proposed for the finance and under Urban Renewal Mission of Govt. of India.

The total cost of the project is Rs.55, 704 millions, out of that Sewerage works amounts to Rs.39, 451.5 millions and Slum Sanitation Project Works amounting to Rs.16, 252.3 million. These works are required to be carried out in V phases from 2005 to 2025. However, these works are not started so far.

Major components of M.S.D.P. - II are construction of Marine Outfall for Malad Zone, rehabilitation / upsizing of sewer lines, upgradation of pumping stations, provision of treatment plants, outfall, construction of new sewers and slums sanitation projects.

Brief details of the projects are as below:

5.19.1 Main components of MSDP Stage – II and its cost. (Cost in Rs. Millions)

Components	**Quantity**	Cost
Slum sanitation	3241ha	16252
New Trunk Sewers	58 km	600
Upsized Trunk Sewers	106 km	3824
Sewer Rehabilitation	363 km	11674
Illegal Connections		73
Area Sewers	3628 ha	4764
Pumping Stations	51 No	5476

Transfer Schemes	4 No	2465
Treatment Works	9 No	8153
Outfall	1 No	2423
Total		55704

5.19.2 Phasing of M.S.D.P. - II (Cost in Rs. Millions)

	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Total
	2002-05	2006-10	2011-15	2016-20	2021-25	
Slum sanitation	18.6	4058.5	4058.5	4058.5	4058.5	16252.5
Upsizing of sewers	564.0	1436.7	1144.1	668.9	9.8	3823.6
New sewers	98.8	97.0	150.2	101.3	152.9	600.2
Rehab of sewers						
Survey	252.9	286.4	0.0	0.0	0.0	539.3
Sewers	0.0	1798.2	3100.4	3100.4	3100.4	11099.3
Manholes	17.6	17.6	0.0	0.0	0.0	35.3
Area sewers	1664.1	760.7	591.2	1147.3	600.5	4763.9
Pumping stations	487.2	740.8	1493.5	661.3	1532.4	4915.3
Pumping Mains	160.5	114.5	243.4	16.7	25.4	560.5
Illegal connections	22.2	36.6	14.4	0.0	0.0	73.1
Outfall	121.2	2302.2	0.0	0.0	0.0	2423.3
Transfer	0.0	152.2	0.0	1307.7	1005.3	2465.2
WWTW	0.0	311.4	5741.7	144.3	1955.1	8152.5
TOTAL	3407.1	12112.7	16537.4	11206.5	12440.4	55704.0

5.19.3 M.S.D.P. Stage –II Priority Works

The works identified under Phase- I and II are priority works. The cost of this work is Rs.23, 760 millions, out of that Rs.18, 960.00 millions is for sewerage and Rs.4, 800 millions is for S.S.P. These works are to be carried out by the year 2010. Major sewerage works proposed are in Malad and Versova Zones.

Major components of priority works are as below:

Proposed Works	**Quantum**	**Cost Rupees. In Million**
New sewers	25 km.	195.8
Upsizing sewers	60 km.	2000.7
Sewer rehabilitation	75 km.	2372.7
Area sewers	1344 Ha.	2424.8
Pumping Station	17 Nos.	2122.3
Outfall	3.4 km.	2423.4
Treatment works		374.6
Others		519.5
Contingencies		6530.00
S.S.P.		4800.00
	Total	**23760.00**

On execution of the priority works, disposal facility will be provided in each zone. Extra capacity will be provided in collection, conveyance, pumping and treatment. Hygienic sanitation facilities will be provided to the slum dwellers. Due to this, there will be less foul flow, less health hazards and beaches will be cleaned. This will also result into extra breeding of fishes in the sea, good quality of the sea-shore and good health to citizens of Mumbai.

Slum population and sewerage facilities in slums

- More than half of City's Population live in SLUMS
- There are 6.9 Million Slum dwellers in Mumbai.
- SLUMS are un-planned and under served
- Located in HIGH RISK and BARELY HABITABLE areas of city
- Poorly equipped with Sanitation and Solid Waste collection facilities

Sanitation in slums

Current sanitation scenario is as below:

- Inadequate Public Toilets Infrastructure
- Public Toilets over-burdened, long queues
- Lack of Water, Electricity and Illumination
- General Discomfort among Slum Dwellers
- Forced to use open public places
- Not connected to sewers
- Near absence of sewerage system
- Sullage connected to storm channels
- Shorter life spans of Toilet Blocks
- MCGM bearing all O & M Costs.
- Health hazards and environmental degradation for the whole city

M.C.G.M.'s Action

- To Improve sanitation in Slums MCGM had taken up Slum Sanitation program as an integral part of MSDP-I/ MSDP- II
- Sanitation facility explicitly for poorer segment
- Based on the principles of community Driven demand
- Treats slum dwellers as initiators, collaborators & resources to build on
- Demand-driven and participatory approach
- Sustainable investments by community members
- Survey of sanitation facilities in slums of Mumbai.

5.20 Organization set-up

Municipal Commissioner is Executive head of the M.C.G.M. He is assisted by 4 Addl. Municipal Commissioners. A.M.C. (Projects) is In-charge of Sewerage. Sewerage activity is divided into 3 sub-activities i.e. (1) Construction projects for collection, conveyance and pumping stations and W.W.T.F. (2) Disposal works future planning and slum sanitations. (3) Operation and Maintenance of Sewerage network.

There are three Chief Engineers to look after each of the above activities. First 2 activities are under the control of D.M.C.(Eng.) and third activity is under D.M.C.(Env & WM).

Ch.E.(S.O.)'s dept. looks after the operation and maintenance of city's existing sewerage infrastructures i.e. collection and conveyance system, satellite pumping stations, treatment facilities (Lagoons and outfalls) and Disposal Pumping Station.

5.21 Objectives of sewerage departments are:

- Efficient operation and maintenance of sewerage network.
- Improving Health and Environmental conditions in Mumbai.
- Improving Sanitation Facilities in Mumbai.
- To meet the standards laid down by MPCB and MOFE.
- To redress the complaint received from the citizens.

For achieving above activities, department has framed preventive and break-down maintenance programme. Silent features of the maintenance programme are as described below:-

- To keep sewer lines in channel conditions
  - Periodical inspection
  - Planned programme of desilting and cleaning
- Systematic maintenance is carried out
  - Manually

  By use of Desilting Machinery like rodding machines, power buckets sewer cleaning machines, suction units, jetting machines, Suction cum Jetting units (combined units), water recycling units, crane and grab machines.

- Preventive maintenance programme for pumping plant machinery and W.W.T.F. equipments are observed to ensure the trouble free working of these units.
- Remedial Measures.
- Break-down maintenance.

By adhering to preventive remedial and break-down maintenance, department maintains the trouble free and operational system.

In the floods of 26 & 27th July pumping stations in island city area were functioning normally. It is worthwhile to note that at Colaba & Love Grove sewage disposal facilities maximum numbers of pumps were in operation which gave great relief to citizens.

In suburban areas some sewerage pumping stations were submerged due to stoppage of power supply. However department took Herculean efforts to restore these installations in minimum time.

5.22 Solid waste disposal

Conservancy/ Solid waste management is an obligatory duty of Municipal Corporation. It involves segregation & collection, storage, transfer, transportation, processing and disposal of solid waste in MCGM. There are two separate wings namely **Solid Waste Management** and **Transport** to handle Municipal Solid Waste.

Municipal Corporation under section 61 (A), 61 (C) and 61 (N)) of MMC Act, provides following services,

- Cleansing of public streets
- Collection of solid wastes including temporary storage
- Removal and transportation of solid wastes
- Processing of solid waste
- Disposal of solid wastes
- Disposal of carcasses of animals
- Construction, maintenance and cleansing of urinals and public sanitary Conveniences.

Now detailed guidelines are also provided in Municipal Solid Waste Management & Handling Rules 2000 to deal with MSW.

Public Road Sweeping is the prime activity of SWM. Eighteen Hundred kilometers of the public roads having width ranging between 3 mts to 50 m. are swept daily for sweeping tree leaves, dust and littering & the same is collected for disposal. The quantum of refuse swept and collected by street sweepers is around 35% of the total refuse collected. The sweeping is mostly carried out by departmentally.

The various sources of Municipal Solid Waste are

- House hold wastes
- Commercial wastes
- Industrial waste
- Hotels and restaurants wastes
- Market wastes
- Institutional wastes Le. Schools, Offices, Hospitals etc.
- Construction wastes such as earth, stones, sand etc.
- Street sweepings.
- Trade wastes
- Stable wastes
- Silt removed from drain/nalla cleanings.

About 7800 MT of Solid Waste is generated daily. Out of that 2300 MT is Construction and Demolition waste.

The MSW generated is broadly classified by weight as below:

- Wet Waste : 54%
- Dry Waste (Organic) : 17%
- Dry Waste (Recyclable) : 18%
- Construction & Demolition Waste : 13%

There are around 6000 community collection spots in Mumbai where the MSW is first collected; which are either Bins/ containers or open refuse dumps. House to House collection of MSW is implemented for 20% of MSW. These wastes are transported to disposal location or, refuse Transfer Stations, Processing site.

MCGM has a fleet of large number of vehicles, detailed below, for this purpose.

- Compactors : 454 Nos.
- Dumper Placer Vehicles : 123 Nos
- Dumpers : 125 Nos.
- JCB machines : 20 Nos.
- Bulk Refuse Carriers : 18 Nos.
- JCB plus Dumpers Services : 380 Nos.
- Tempos : 135 Nos.

There are three sanitary land fills sites for disposal of refuse generated in city

SR.NO.	LOCATION	AREA (IN HECTARES)
1.	Deonar	111.00
2.	Mulund	25.30
3.	Gorai	14.50
Total		**150.80**

One new landfill site is under development at Kanjur near Eastern Express Highway

MCGM has undertaken following initiatives to improve SWM Services.

- Segregation of Dry & Wet Waste at source.
- House to house collection of MSW (Elimination of Bins)
- Independent system for Collection of Construction & demolition Waste
- Decentralized Disposal of Bio medical waste
- Processing Of wet waste
- Scientific management of land fill sites
- Formation of ALMs & public participation.
- Formation of community based organizations like Dattak Vasti Yojana.

In spite of having initiated on the above areas, in the absence of public participation the results can not be satisfactory. System must therefore be devised whereby people are involved by way of incentives and penalties to take care of proper storage, segregation and disposal/ processing of their Solid Waste.

After the floods of 26/7 and 27/7 in 2005, the Municipal Corporation removed the refuse generated due to deluge in addition to regular refuse. MCGM removed on an average 10000 Tones of refuse per day against normal daily average of 5500 T (7800 t less 2300 C & D waste). MCGM also removed about 1300 carcasses of buffaloes and 15000 carcasses of sheep/ goats. This was done in adverse condition. The situation review of what happened after 26/7 highlights the need for "Zero Backlog" during rains. "Zero Backlog" is "Zero Garbage" at any point of time and this means no "Community Bins". The open spaces shall also be identified in wards for temporary storage of refuse during times of heavy rains. These open spaces shall be in areas which are not prone to flooding/ water logging.

The solid waste generated and dumped in storm water system is always an area of concern. The need of management of solid waste management from maintenance of SWD system is emphasized under storm water management section, however more concrete plans need to be thought of and devised for its effectiveness.

60% population of Mumbai resides in slums The refuse generation at these slums is always an area of concern. Schemes like Dattak Vasti Yojana are mainly formed to have clean slum colonies. But they lack in amenities of collection, storage & removal due to limited access and nature & frequency of generation of refuse in slums. Unless proper means are provided for collection storage and removal of solid waste, that too, frequently during the day, dumping in open streams/ nallas can not be avoided. In slums, Solid Waste Management will have to be attended to with much greater intensity. Organizational measures to achieve this in co-operation with the local groups of residents will have to be in place well before the next monsoon. It may need Corporation's internal organizational restructuring and strengthening to some extent. Even in general it is experience that solid waste generated and dumped in storm water system is always an area of concern. The need of solid waste management from maintenance of SWD system point of view is emphasized under storm water management section, however more concrete plans need to be thought of and devised for its effectiveness.

In the deluge MCGM understood the importance of unity of command and one authority for similar activities and grouped operation & maintenance activities of SWD, Sewerage Operation & Solid Waste under one umbrella of A.E. (ENVIRONMENT). This needs to developed further and strengthened. It is understood that the well spelt responsibility lies with the unified authority which will help the system. The deluge also pressed the need for SWM's organizational restructuring & strengthening, which shall be examined by MCGM at the earliest.

CHAPTER 6

STORM WATER MANAGEMENT

6.1 Objective

Storm Water Management's objective is essentially to safeguard health, safety and property of the citizens/ residents & to reduce inconvenience to them by having an integrated approach for developing & maintaining a system for storm water runoff which will provide better quality of life for the society. Flooding in Mumbai is a serious problem as city is developed on reclaimed land, which is not much higher than high tide levels.

6.2 Manual for management of storm water system

In island city SWD system consists of under ground arrangement of inlets (storm water entrances/ road side open roads), laterals, collector drains (dhapa/ pipe/ open channels), trunk mains (arch/ box/ open nalla) and out falls discharging in to sea or creek arms or mudflats. Few out-falls are gated. In suburbs the SWD system consists of mainly road side open drains discharging into minor and major nalla or rivulets, which finally lead to creeks. In suburb no gates exist now, though few existed in the past. The management of storm water system in Mumbai is managing the effective discharge of storm water through well-designed & maintained system to avoid or reduce the incidence of flooding.

Even when proper system exists, the flood may occur due to various factors in isolation or in combination like -

- Heavy rainfall
- High tide
- Loss of drainage capacity.

While factors like rainfall intensity and high tide effects are beyond the scope of operational management; factors like loss of drainage capacity can be monitored with the help of set of guidelines. Such set of guidelines, essentially, can be part of "Manual" for the system. There is no Storm Water Management Manual at present with MCGM. The same shall be prepared and mechanism shall be set for effective storm water management. The manual shall detailed out procedure of procurement of work/ equipment, records to be kept, data to be collected, control system, documentation of engineering systems, operating procedures, maintenance procedures, frequencies of operations, drills to be carried out, duties and responsibilities of staff, accountability, monitoring mechanism, procedure for handling emergencies etc. The manual shall provide guidelines for various steps required to be taken prior to monsoon, such as pre-monsoon river or storm channel survey to understand flow obstructions like cofferdams, pardis, dead line for their removal, officers responsible for removing and monitoring system, design criteria, formation and development level, procedures for rehabilitation/ construction, surveys & checks, verification of benchmarks/levels etc. MCGM deals with various outside agencies directly or indirectly while managing storm water drains system, e.g. Railways undertake desilting of railway culverts and also carry out work of improvements of railway culverts. PWD, MbPT, MMRDA carry out desilting works in their jurisdiction etc. Guidelines shall exist in manual, for dealing with outside

agencies. The manual shall also address to the needs of effective supervision, quality and accuracy, and as also the action plan for chronic locations prone to flooding during rains and water logging.

6.3 Contour Maps

There is no comprehensive GIS developed for Greater Mumbai by M.C.G.M. so far. The sewerage system has the GIS base and is incorporated on “D.P. Base Maps”. But that does not help in the management of storm water from the land surfaces.

6.3.1 Different maps connected with Mumbai have been prepared with reference to different datum levels. That causes considerable confusion in the understanding of the relative ground conditions. Henceforth, steps should be taken to adopt levels in meters under the GTS system only (i.e. the great trigonometrically survey of India) superseding the other arbitrary systems of chart datum (CD) or town hall datum (THD) followed so far. Mean sea level (MSL) around Mumbai is close to zero level of the GTS carried out by the officially recognized national organizations namely the Survey of India. (MSL of Mumbai = 0.01 m GTS). Ground levels in many low-lying areas are only 2 to 3 meters above MSL, while the flood levels in the creeks have the same heights.

Even the BRIMSTOWAD Project, which set up 198 benchmarks all over Mumbai, followed reporting pattern with respect to THD. This needs to be modified.

In Mumbai, Mumbai Port Trust maintains tidal reports. They report the levels with respect to Chart Datum which is again a different type of bench mark than Mean Sea level, used probably with a view to ease out movement of ships.
The relation between THD, MSL & CD is as under: -
Mean Sea Level = 24.46 M. THD
Chart Datum = 21.95 M.THD

Normally during monsoon season most of the newspapers report heights & timings of high tides & low tides for information of citizens. They are with respect to the Chart Datum (C.D.).

In order to avoid this confusion and misinterpretations it would be appropriate to report all levels with respect to GTS which is a simple mathematical exercise and then every one can talk in the same language that is being followed all over the world.

- City Town Hall Datum (THD) = 100 feet
  = 30.48 m
- Value in City Town Hall Datum (THD) m – 24.46 m =Value in M GTS
- Value in C.D. – 2.50 =Value in M GTS

6.3.2 Unfortunately the current DP sheets of Mumbai do not include all the topographical details of the natural watercourses and the information of the area contours. There is no systematic Contour map of the corporation area, after the Survey of India’s Map of 1976, which has the contour interval of as large as 20 meters. That is of little use in the storm water management of low lying areas. Contour maps are vital for the management of the watersheds and for storm water

handling. Therefore the work of contour mapping of the Greater Mumbai should be undertaken immediately to develop contour maps of all watersheds with a contour interval of 0.20 m (i.e. 20 Cm) in the areas below the 20 M contour and with the contour interval of 0.5 m above the 20 m contour. The maps will have to be at least to the scale of 1 in 4000 (i.e. 1 cm on the map representing 40 m) which has been followed for the DP sheets of Mumbai. For the crowded areas, along the river channels maps to the scale of 1 in 1000 (1cm on the map representing 10 m on the ground) will be desirable.

6.3.3 Earlier studies in 1988 had shown that 10-year frequency HFL in Mahim creek is 3.20 M GTS, whereas 5 year HFL in Mahim creek is 2.90 M, GTS. When contour maps are available, flood risk zones and submergence areas for different frequencies of rainfall will have to be plotted on them and land developments regulated accordingly. The submergence maps of the restricted zones will have to be published for citizens' information in due course. The concept of flood risk zones is explained in brief under "Flood plain zones"

6.3.4 Even the flood studies being carried out by CWPRS are handicapped on account of lack of information about the ground levels in the flood plains on both the banks of the Mithi River. The earlier these data become available, more scientific will be the further flood related actions.

6.4 Stream gauging and automated rain gauges

The developments of suburban areas have been very rapid and at many locations have taken place very close to the erstwhile natural river water courses. No measurement of flood waters have been carried out on any of these streams so far. Stream Gauging is vital for hydrological correction between the rainfall and the surface flows on the ground. BRIMSTOWAD report has already adopted a watershed approach for storm water management. For watersheds and basins / sub basins of geographical spread of more than 1000 ha (i.e. 10 sq km), it will be desirable to install immediately at least one stream gauge nearby above the tidal zone or little above the confluence with the main stream / water course. Thus there will be about 50 stream gauges in Mumbai i.e. roughly one for a population of about 2 lakhs. In absence of such gauges, quantitative information about the flood flows in the stream channels, accumulated water in and around the stream channels and extent and duration submergence has not been yet available. For monitoring the safely of the people and for future refinements in storm water management information from stream gauges will be very helpful.

Automated rain gauges are necessary at vital places in the important water sheds. These will be useful to generate advance warnings for the people. They will also be useful in the designs of the Storm Water Management system. At present, official rain measurement are only at Vihar (by MCGM) and at Santacruz and Colaba by IMD. For a large and crowded metropolis like Mumbai, these few are inadequate. At least 10 automated rain gauges will have to be installed, 2 in each of the Basins of Mithi / Dahisar / Poisar and Oshiwara and 2 in other areas. Govt of Maharashtra's State Hydrology Project Organization (HQ at Nasik) will be able to assist MCGM in the selection of sites, instruments and the data transmission and analysis of the system. There are already 360 automated rain gauges being operated in the state by this organization

Installation of stream gauges and automated rain gauges will provide the important information for effective urban storm water management plan. This data shall be permanently recorded, updated and reviewed from time to time. Data shall be available on-line for further studies.

Standards for setting gauges and procedures for their working will have to be developed in consultation with the Hydrology Project Organization of the Water Resources Department of Government of Maharashtra.

6.5 Maintenance of storm water network:

Maintenance of storm water system is an important component for its effective management. The periodical reviews have identified in the past the reasons and causes of flooding and focus shall be to address these deficiencies as a part of maintenance**.**

In the island city area, most of the storm water drains are underground, barring few open channels. But in the suburbs the system is mostly of open channels. The storm water disposal at present is by gravity. Because of the flat gradients of the water courses, sullage inflow, obstructions in the water ways (by the bridges/ by the utilities) and ineffective measures for restricting garbage dumping in the stream channels, there has been blocking of the storm water network and excessive silting in the river channels. For system to be fully operational in an efficient manner proper maintenance of the network is of prime importance. Attention will have to be given to the following measures on priority:

(a) Desilting of Storm Water Drains.
(b) Removal of obstructions caused by other utilities.
(c) Removal of constrictions.
(d) Rehabilitation of Dilapidated Storm Water Drains.
(e) Ban on Plastics.

6.5.1 Desilting

The current practice is that M.C.G.M. desilts storm water drains (pipes or channels) prior to monsoon on a ‘Fixed Quantity Basis ‘. This results into only partial desilting at many places. The capacity of the drain is not fully restored after the desilting operation, nor verified accordingly on a physical basis by invert levels of stream channels. The water cannot recede up to the bottom of the silted drain. That causes surcharging of the drain during floods. It is, therefore, necessary to desilt the storm water drains right up to the bottom & maintain it in the same condition throughout the year. Physical verification of the situation at the ‘bottom’ is necessary. Measurement of the quantity of silt removed and paid for on truckload basis cannot ensure full and proper clean up. The working procedures in the management and clean up of the storm water drains need to be immediately changed. L sections of the bed levels of the stream will have to be plotted on the basis of the ground verification surveys to verify that a required gradient has been established, before the onset of the monsoon. This will ensure that desired bottom levels of the carrier channels have been reached after the cleaning operations. Low-lying areas in Mumbai are very sensitive to the conditions of the stream channels during flooding.

Thickly populated slums even at the mouths of the outfalls surround many of the open storm water channels. For slum dwellers these open drainage channels are an easy space to dispose of their solid waste. That aggravates the congestion at the mouth of the outfall. It is necessary to stop the entry of the solid waste into the storm water channels rather than arranging for the removal of it.

Large poor population of city resides in slums. Usually these slums are near open drainage systems (nalla) for the obvious reasons of vicinity to the sullage disposal point, which is also a solid waste disposal point for them. It leads to creation of artificial obstruction to the storm water flow due to refuse dumped and that aggravates further when siltation takes place. This issue shall be addressed by creating a system for the sanitation and hygiene of the residents. The effective solid waste collection and transportation system with target to have zero garbage in slums shall be implemented to avoid disposal of refuse directly into nalla by the residents "n" times a day which makes the entire networks inefficient causing hardship to all the citizens. The sullage generated in these localities need to be diverted to a sewerage network preferably. Segregation of sewage from storm water drains can be effective only when adequate sewerage networks are available nearby to carry this sullage. In the absence of monitoring of these types of situations, we are sacrificing the storm water system and make it ineffective.

Desilting of railway culverts is done by railways and paid by MCGM as an arrangement between the two organizations for reasons such as safety within railway premises. There is a system of joint inspection and review, for this work. BRIMSTOWAD REPORT suggested MCGM to treat "railways" as contractors and monitor the works for satisfactorily desilting. The MbPT is responsible for desilting of SWD system in their area and PWD/ MMRDA are responsible for desilting of SWD system on Express Highway. There must be an inbuilt system or mechanism to monitor this desilting which shall include taking invert levels after desilting and maintaining the same throughout the monsoon period, responsibility of which shall be properly spelt out in the procedure itself.

Though silting is unavoidable, it can certainly be controlled and reduced. This can be possible with the monitoring and control on factors like disposal of garbage, encroachment, excavations and encroachment by other utilities, constructions, reclamation/ development works, inter connection with sewer lines, improper/ insufficient/ no-access, replacement of old/ outdated designs of appurtenances etc. Hawkers/ Road side vendors as also the vendors in markets generate lot of refuse throughout the day. Garbage bins at market places/ hawkers places overflow most of the time. The refuse is also spread over around the bin. Much of these wastes enter storm water system when it is not attended in time. The system must be put in place to collect and remove the refuse at such places. Emphasize on preventing the "Piling" of dumps will help greatly, this essentially means "No" to community bins.

Introducing "silt-traps" and "upstream screens" in open/ accessible portion may help reducing siltation in un-accessible/ closed portions "Silt-traps" also enables centralized and effective desilting.

Important aspect in desilting is removal & transportation of silt. The silt removed shall not be allowed to be stacked near SWD/ on roads. MCGM shall

develop a system whereby silt can be immediately transported in the vacant open spaces nearby for drying up and if necessary further transporting it to disposal places as per Municipal policy.

Access to storm water system for maintenance is very essential and must be available at all stretches of storm water system. If at any place if such access is not available steps such as shifting of structures, removal of encroachment, if any, etc. shall be taken immediately to have proper access for storm water system at all times and at all places.

6.5.2 Removal of obstructions caused by other utilities

Obstructions in storm water drains drastically reduce their carrying capacity. Floating material gets entangled with such obstructions and result into partial or complete blockade. The results are disastrous in closed drain system where the blockade can not be located easily. Due to blockage along a highway drain Pestom Sagar submerged for number of days during monsoon of 2005. The obstructions in railway culvert and nallas were responsible for severe flooding suffered by residents of Arya Chankya Nagar Kandivli. Reduction in waterway of nalla in MMRDA region resulted in flooding for many days in Kalina area. The obstructions could be utilities or in the form of pathways, pardis and cofferdams built during construction. All these need to be checked and removed by a fixed date prior to monsoon.

The previous physical survey carried out by the BRIMSTOWAD consultants and storm water department of MCGM, have identified the obstructions of utilities in the storm water network, both in underground system and open streams. It is observed that these obstructions are not removed in totality & new obstructions due to utilities are also seen in open channels in city and suburbs. As obstructions exist it was suggested in the interim report to carry out quick fresh survey for any such obstructions which are still existing or that may have come up subsequently and an immediate plan should be prepared for removal / diversion of these utility components. During the July episode, such obstructions were clearly visible at many bridges. Those will have to be attended to immediately. Needless to say that extreme care shall be taken that no new obstructions are 'created' in the waterways by any utility services. There is a need to set up a mechanism/system at ward and central agency level to monitor prevent & remove such obstruction of utility in future with responsibility spelt out in clear terms.

ALMs can be educated to keep watch on works of utility services in their area.

6.5.3 Removal of constrictions

At many places bottlenecks exist on account of constrictions in the storm water channels because of reduced cross sections or raising of invert levels. It is necessary to carry out immediate ground surveys to detail out the exact amount of constriction and to undertake channel restoration works including establishing of proper gradients and hydraulic efficiency

6.5.4 Rehabilitation of dilapidated storm water drains and other critical works

BRIMSTOWARD report proposed rehabilitation of dilapidated storm water drains after assessing the condition of storm water drains in island city. Though some recommendations of BRIMSTOWARD report are implemented exact statistics

of rehabilitation carried out is not made available. The fresh condition assessment shall be made for all arterial drain in city and suburbs and its rehabilitation shall be planned on priority. Rehabilitation shall also include correcting/ improving system, inverts, slopes & levels of entire network of storm water drains with catchment-by-catchment approach. There is a tendency to provide hume pipe culverts on nallas especially to facilitate faster construction. The limited height of pipes restricts free flow and water way becomes marginal with silting in hilly region as well as tidal zone. Low soffit cause heading up on the upstream side. This was reported to be cause of flooding in Kurar village in the past. It is understood that while widening of eastern express highway existing culverts are extended by putting pipes. This needs to be stopped and rectification is necessary wherever such construction exist.

BRIMSTOWAD report enlists the various critical works and options for up gradation of the storm water system. Many priority works of improvement and augmentation, which are either responsible for or can prevent /relieve large submergence on account of heavy rains are also identified. Many of these works are not taken in hand. It is necessary to give priority to all such critical works & the same shall be taken in hand immediately. Some of such critical works are listed in Annexure 6.

6.5.5 Ban on Plastics

Plastic is a nuisance and obstruction for storm water flows. Thin plastic bags have no recyclable value & are abandoned/ disposed by public directly or by packing refuse in it. Being cheap, hawkers/ vendors/ shopkeepers use them for packing of items. People demand for it from hawkers/ vendors and use it for its easiness of carrying/ storing. As such all forms of plastic are in use abundantly and there is no proper enforcement mechanism to prevent its misuse and its disposal. Government has taken a serious note of this plastic menace and even banned plastic ‘below certain thickness’ (along with plastic carry bags). It is necessary to have mechanism in place for regulating its use, recycling & disposal. And there must be a well spelt out responsibility.

Ban on plastic and its enforcement has improved the condition of storm water channels after 26/7/2005. Ban on the use of disposable shopping bags in particular will have to be continued.

6.6 Mixing of Storm Water and Sewage

Mumbai’s average yearly rainfall is of about 2000 mm. Since inception Mumbai has adopted separate sewerage and storm water systems for disposal of sewage and storm water. The sewerage system works on the principle of gravity-cum-pumping while storm water system purely works on gravity. In spite of having separate systems only 60% of sewage generated in city is discharged through sewerage network. Remaining 40% of sewage is discharged through storm water drain. This is mainly on account of slums and development in un-sewered area.

The sewage disposal to sea/ creek/ harbour is designed on following criteria:

a. With treated effluent having BOD equal to 20 mg / l and suspended solids equal to 30 mg / l

b. With preliminary treatment of screening, de-gritting and diffused aeration having effluent quality of BOD equal to 100 mg / l and suspended solids equal to 100 mg / l through marine outfall.
c. With achievement of dilution factor of 50 or more.

The storm water is disposed in sea/ creek/ mudflats/ rivers as below

a. Discharging directly on the shore.
b. Discharging by gravity, considering gradient in the conveyance system and matching the HTL, LTL, MSL.
c. Discharging without screening.
d. Discharging without pumping.

There exists interconnections between sewerage network and storm water drains. These interconnections upset the smooth functioning of the drainage systems. Storm water is admitted to the sewer system; or at times sewer system overflows in to the storm water drain. Storm water drains in Gandhi market area are observed to be over flowing even during the fair seasons and also during low tide periods. In many areas stagnation of monsoon water gets cleared if the sewerage manholes are opened but then the sewer system is loaded with the enormous storm flow. In fact in the 1960 development plans for Mumbai such an arrangement was recommended as a flood relief measure. However experience has shown that at times such interconnected admission of storm water merely shifts the flooding spot. We have to accept either flooding on railway tracks at Wadala if the pumping stations at Saltpan and Wadala stop operating or operate them which may lead to flooding at Kings Circle. The sewage diverted to storm water system and let out close to the coastline causes adverse environmental impact and coastal pollution.

It has also been observed that during heavy rain and generally during monsoon the storm water is discharged through sewerage network, which is not designed for storm flows.

Mixing of sewage in storm water is not desirable for following reasons.

a. No treatment to storm water provided before discharge in to water stream/ sea.
b. It does not provide for appropriate dilution in order to reduce the pollution load.
c. Foul gases of sewage cause nuisance to the public.

Similarly mixing of storm water in sewage is not desirable for following reasons.

a. Lot of floating matter jam the sewage inlet arrangement.
b. Siltation in sewage system causes loss of hydraulic properties of sewerage system.
c. Sudden load/ flush of floods cannot be sustained by pumps and allied equipment as the same are not designed for storm flows.

The efforts have reportedly been made in the past to segregate the sewage from storm water. However these remain to be resolved, as the required sewerage network is not laid. Change of this situation may take long but till then mechanism/ timeframe shall be set for such segregation of inevitable cross connections with proper records. To begin with list of cross connection be drawn. All cross connections, which can be diverted to respective networks, shall be identified and

attended. Even if sometimes Knowingly or unknowingly storm water is discharged through sewerage network and sewage pumping stations, such situation shall be analyzed & evaluated for effects by the criteria vis-à-vis technicality of various factors such as pump design, flow pattern, flow characteristics, effect of siltation on network, outfall, public hygiene, energy cost etc. with respect to sewage pumping station system.

6.7 Tidal Control

Out of total of 186 outfalls, as many as 45 S.W.D. outfalls (pipes or open channels) have their bottom levels below mean sea level. The back entry of seawater into the network is thereby inevitable. Except three outfalls in the city area, none of the S.W.D. outfalls are gated.

The reclamation, as a part of development over last 5 decades, necessitated extension of storm water outfalls with flat gradient and ultimately discharging below mean seal level. Much of the developed area of Mumbai is not higher than the high tide level. For these and other topographical reasons many storm water outfalls discharge below high tide level and high tide water enters the system at tide time. Such situation results in reduction in drainage carrying and storage capacity, low velocities & hence siltation, flooding/ water logging on upstream of the system as new flows cannot enter the system when the capacities are full. The adequate tidal control measures such as providing flap gates/tidal gates or reflex valves (and at times pumping along with tidal control) become desirable for such systems.

Function of the flap gates/ floodgates in regulating the tide ingress is to ensure the channel storage capacity for absorbing the inflow of flood rather than allowing it to be occupied by the tide flow and then the flood inflow resulting into backwater rise. Whether the channel capacity is insignificant compared to the flood inflow, regulation by gates may not be much of a beneficial impact during high tide periods, but still it will provide a flood cushion and flood levels in the channels can be lowered, in most of the other periods of rise of tide above MSL. It is understood that the flood gate operation schedule is based on the flow direction i.e. until the flow is from nalla to sea/ creek, i.e. generally low tide periods, the gates are kept open & when the tide water starts rising and entering back into the storm water channel i.e. generally high tide periods, the gates are kept closed & the time for opening and closing of gates for different installations shall generally be different & tide charts can be used for reference. If necessary, operating drills & guidelines can be obtained from the mechanical organization of the State's Water Resource Department.

For the outfall gates, the catchments of more than 100 hectares of area, it will be desirable to provide outfall gates for a flood flow of 1 in 100 year probability & for smaller catchments for a flood flow of 1 in 25 year probability unless some critical or vital installations are involved in the creek tidal zone.

Benefit Cost Analysis will not be wholly feasible in the traditional manner because all the benefits from avoiding of reducing congestion in the high tide period may be quantifiable. Some social weightage will have to be added beyond the economic cost benefit analysis before the specific decision is taken. It will be useful if specific guidelines in this context are developed by MCGM through a select team of

their experts including one from CWPRS & one from Dam Safety Organization of State Govt.

The corporation shall entrust the task of determining and applying criteria for adopting tidal controls on the basis of socio-economic cost benefit analysis to the group of expert professionals who have the experience in handling such works. BRIMSTOWAD report also proposed tidal control or means to prevent ingress of seawater for maintenance in dry season for all but the smallest outfalls significantly affected by the tides.

6.8 Pumping Arrangements

Looking at the topography and geographical location of the Mumbai, the pumping arrangement is essential for effective discharge of storm water. The need and concept of pumping arrangement is briefly discussed in the Chapter on Hydrological settings. Issue of providing storm water pumping stations in Mumbai has been pending over a long period. Its Development Control Plan of 1960, Natu Committee report, (in the year 1975), and also BRIMSTOWAD report (1993) have recommended provision of pumping stations for major catchments in Island City, to relieve some of the chronic flooding spots. However plea of non-utilization of these pumping stations during non-monsoon period / utilization of pumping stations only on 8-10 heavy rainfall days / year has been said to be a major obstacle in the implementation of Pumping Stations. Pumping of Storm Water is not a new concept. It is being practiced all over the world. Netherlands, which has general Ground Level below High Tide Level, has based its Storm Water disposal system on pumping. Bangkok, Kaulalampur are also practicing Storm Water pumping. Even New Mumbai has storm water pumping stations. Topography of Mumbai is such that pumping is inevitable option. With disaster of 26 - 27/7 the pumping proposals could get some extra weightage but again inappropriately planned pumping stations would not be able to give desired results. It is therefore, important to understand philosophy behind proposing / providing pumping stations in the Storm Water system of Mumbai.

In Mumbai, Storm Water system works on principle of gravity. The surface runoff from head of the system reaches outfall by virtue of gradient & it is then discharged into water body, which is either open Sea or Creek arms. Occurrence of high & low tide in the Sea directly affects discharging capacity of Storm Water system. The Island City has been reclaimed by filling in original Sea / Creek arms in between the old seven Islands. Major services like Rail routes / Major habitable areas & Mills have come up on this reclaimed land. Probably this land was cheaper than the original grounds. The reclamation levels are connected to lowermost stretches of original Islands. Therefore, submergence prone even in fair weather i.e. most of the reclaimed land is below high tide level & can get flooded by tidal water even during non-monsoon period. In island city storm water outfalls at Love Grove, Cleave Land and Haji Ali are protected by gates, which are opened only when the tidal level is lower than the Storm Water level in drains. Naturally, there is heading up/ accumulation of Storm Water in the system on the upstream side of outfall. The original outfalls which were discharging in between the islands and creek have been extended at a very flat gradient to east / west coasts, creating a critical situation where head / central portion of the Storm Water system is at ground level lower than level at the outfall end / in the downstream stretch. Due to closure of gates during

monsoon, this critical area is immediately submerged. The floodwater gets accumulated with the high tide when gates are closed and recedes with low tide when the gates are opened. Mumbaikars are used to this phenomenon over many decades. The traffic is disrupted, houses are waterlogged for many hours depending upon intensity & duration of rainfall but substantial reduction in accumulated water is noticed during low tide.

There are several options to solve this problem, off these three options are enumerated.

1. Raise Ground Level of reclaimed area above High Tide Level (i.e. H.T.L. + Free board). The area adjoining reclaimed land also needs to be raised simultaneously to avoid formation of new flooding spot.

This however appears to be impossible due to economical & social constrains as the city is fully developed.

2. Second option is to provide holding ponds in low-lying area on upstream sites, which will hold floodwater till appropriate (low tide) time. Water from these ponds could enter in Storm Water system either by gravity or by installing Pumping Station. However, there have to be one or multiple holding ponds for every flood prone catchments & it requires huge surface areas. These holding ponds can also be in the form of covered tanks & its top surface could be put for social, commercial or parking usage or otherwise. Alternately the entire SWD network up to outfall could be modified in such a way that all S.W. flows towards outfall & only one very big holding pond is provided near outfall. This option was verified in BRIMSTOWAD where Haji Ali bay & Race Course were examined/viewed, as proposed holding ponds. However, this option was not found economically viable. (Ref. Pgs. CD-130-10 to CD-130-16 of Preliminary Engineering and Catchments - Details for City Feb. 1993 of BRIMSTOWAD report.)

3. The third option recommended by BRIMSTOWAD is Pumping Stations at outfalls. This involves improvement of entire S.W. network up to outfalls (prior to gates) and providing a huge capacity Pumping Station at outfall, which would discharge incoming Storm Water flow in the Sea. It should be noted that the capacity of Pumping Station is to be decided by total runoff and the holding capacity available near outfall. Since this option do not include holding ponds near outfall the size of Pumping Station proposed in BRIMSTOWAD is quite huge i.e. ranging between 36-60 M^3/sec.

Pumping would keep on emptying storm water lines & therefore flooding on upstream side would be avoided. But it is pertinent to note that improvement of S.W. system from flood prone area up to outfall is pre-requirement of achieving results by Pumping. Otherwise huge capacity Pumping Station installed at outfall without the system improvement may not give desired results. The pumping stations would then remain substantially underutilized; the areas will continue to flood. The option of Pumping Station therefore needs to be adopted in consonance with the S.W.D. system.

Mumbai will require more such pumping stations in the city as well as suburbs in the years to come; because of aggravation in the storm water flows.

Smaller Pumps will have to be provided on storm water line to overcome invert problems and flat gradients. Open roadside drains shall only be converted into regular storm water system with proper gradients. In case if the inverts do not permit and when it leads to lower inverts, the storm water should be pumped (with the help of small pumps) into higher invert arm on downstream side of the storm water system and ensure that the system is not hydraulically deficient. Absence of self-cleansing velocity means more maintenance and which will be detrimental in long term.

Planning and providing of physical wider opening at the cross drainage works of the roads/railways/ airport runways at times will not pose many technical problems. However similar exercise for the pumping locations is normally beset with the controversial considerations like infrequent operations. Balancing the cost benefit for the normal occurrence scenario (i.e. once in a year or twice in a year as adopted in BRIMSTOWAD) is easily possible. But for infrequent occurrence such as 1 in 25 or 1 in 100 probabilities, the analysis may appear far-fetched and unrealistic. Hence it will be advisable to develop the pumping station for 1 in 10 probability of precipitation at the most. It means that in addition to the normal yearly operational pumping, about 25 % additional standby capacity will have to be installed. At the submergence location that affect the railway tracks & the through traffic transport corridor, such a standby provision will be worthwhile.

As suggested in the interim report to initiate the proposal of the pumping station at Haji Ali, L.G.P. & Cleave land, MCGM has now invited the bids for the storm water pumping Stations at these locations & at one more locations in suburbs (Irla Nalla).

In order to achieve desired benefits, proper criteria will be required to be set. MCGM shall appoint advisory committee of expert professionals who have handled such problems in the past, to evaluate and decide various criteria.

6.9 Flood Plain Zones

The importance of contour map & its role has been emphasized time & again and they play very important role in Storm Water Management. Contour Maps are the basic information this information enables to establish flood plain zones and delineate the areas subject to flooding. These areas (land) are classified vis-à-vis risk of flood plain. Based on relative risk, the use of plain around stream be prohibited or restricted for certain user with conditions. Owners or occupier be made aware of the relative risk, by notifying/exhibiting the information Thus the Storm Water Management also includes regulating the use of land in flood plain to restrict or reduce the damage caused by floods especially as urban drainage is not designed for worst condition. It must be remembered that such zoning may not be remedy to existing situation; however, it can definitely help in minimizing flood damage and flood losses.

Regulated land use in different flood plain zones is necessary for safeguarding general public from likely risks. The different types of buildings and utility services can be grouped under different priorities, (e.g. say priority 1, priority 2, priority 3) from the point of view of its importance and relative risk.

Installations such as electrical installation of utility /civil services, important utility services like hospitals, water supply, railways, defense installation, major arterial roads and railways, communication facility etc. can be placed under priority-1 and can be located above 1 in 100 years flood line. Installations such as Public Institution, Govt. Offices, residential areas, schools etc. can be under priority 2 and can be located above 1 in 25 years flood line. Parks/ Play Grounds and such open spaces can be placed under priority 3 and can be located above 1 in 10 years flood line. Urbanization leads to increase in storm run-off and open spaces, parks; play grounds facilitate for taking increased run off and can minimize drainage-to-drainage congestion.

It may therefore be noted that the relocation of all installations, under priority 1 type, above 1in100 flood line is essential. On top priority the installations like electrical substations for vital installations must be surveyed and relocated in above 1 in 100 years flood line to avoid recurrence of incidence of failure in electric supply to important installations as happened on 26/7/2005.

In the presentation made by I.M.D. officials to the Committee, it was informed that the automated rain gauge at Santacruz was under water when it was raining heavily and the rainfall could not be measured with automated rain gauge after 14.30 Hrs on 26.07.2005. This situation could have been averted if such installations were safely located. The Government of India's **Model Flood Zoning Bill** does provide a set of guidelines & procedure to be followed for 'Flood plain zoning'.

6.10 Reduction in Run - off

The storm water run off is said to have increased from 0.5 to almost 1.0, which has necessitated re-designing the storm water system for Mumbai. Plans for avoiding loss of drainage capacity by way of proper maintenance shall also explore the possibilities of reducing the run-off (which is equivalent to increasing drainage capacity). Besides maintaining existing open spaces as ponding area non-conventional methods like "rain water harvesting", introducing concept of "porous paver blocks" for pavements within open spaces/ parking areas/ internal roads of commercial complexes, residential colonies etc. and provision of detention/ retention tank/ ponds can be effective to reduce storm run off. This retained run-off can subsequently be let off in the storm water system during lean times. Such methods may initially turn out to be of little help, but with increased focus on planned implementation, it will help in reducing run-off over a period of time. In development works in city & suburbs implementation of these schemes can be a good start. Moreover introduction of such means through development control rules or similar provisions will be "No-Cost" measure to MCGM.

6.11 Restoration of Damages to SWD

Storm water drains are often damaged while the works on other utilities are carried out. Ex. Damage to storm water drains while construction of J.J. Flyover etc. Such damages must be restored to the original hydraulic requirement. There must be a mechanism in existence, which shall review such works of other utility services to ensure that no other systems are provided at the cost of the parent system, and other utilities are provided without any damage to the parent system.

6.12 Minimum sizes of SWD

All the SWD laterals shall be minimum 300 mm dia and all the SWD drains shall be minimum 450 mm size.

6.13 Completion of uncommissioned SWD system

It is likely that due to difficulties posed while construction of drains systems, some of drains remained to have been laid (missing links) on account of which some drainage network is yet to be commissioned (see Drawing no.7). At times such lengths have been put into use by providing pilot lines. Such uncommissioned drains shall be immediately commissioned which will be beneficial for the system of that area.

6.14 Access to SWD system

All the SWD system shall be accessible by the authorized staff of M.C.G.M. (at all times) including airport premises, railway premises, defense premises, BPT, MMRDA, BARC, and Docks etc.

6.15 Sewage Pumping Stations

Some sewage pumping stations are being abandoned. Corporation shall study the feasibility of such sewage pumping stations for storm water purpose. The criteria/direction shall be set for this and it shall be evaluated case by case before taking such decisions.

6.16 Design Criteria

The committee's suggestion about design criteria for storm water system has been elaborately discussed in Chapter on Hydrological settings.

Government of Maharashtra had appointed the Committee under the Chairmanship of Mr. N.V.Mirani in Sept 2005 to study water logging of roads widened by MMRDA under MUTP and MUIP in Mumbai. The Fact Finding Committee agrees in general with the findings of the Mirani Committee. The gist of the report is enclosed as Appendix 6A, 6B & 6C.

6.17 MIS

Efficient & Effective Management Information System including GIS for SWD as also the Maintenance Management System shall be in place for storm water management. Standardized reporting and recording is also necessary. The "Storm Water Management Manual" must have the guidelines for reporting and recording. This is a specialized activity and shall be attached to a specialized unit like 'Hydrology Unit'. The information such as extent of rainfall, rainfall intensity, location/duration/extent of flooding, short term analysis & short term remedies taken etc. is vital information for future development of the system and therefore, accurate and timely recording of all this information is important. There shall be appropriate feedback & monitoring mechanism to take appropriate decision in time.

6.18 Educating people/Public awareness

For years, ALM & NGO’s are playing some role of public participation towards betterment of city. They must be made part of the system for educating and making aware the people about the expectations from public. M.C.G.M. is a big organization & it runs hundred of schools & high schools. Teachers & students of this school

shall be made active participants in social education & awareness helps of private schools, colleges shall be enlisted. There are @ 50 Engineering Colleges in Mumbai University area. Help of all polytechnic & engineering colleges along with premier institutes like VJTI, IIT & NITIE be sought as active participant in solving problems of Mumbai.

Social institutes like Nirmala Niketan, TISS etc. can be also approached.

Institute of Engineers (Mumbai Chapter), Indian Water Works Association shall become part of public education. Journalist Association, Mumbai Patrakar Sangh, Indian Newspaper Association, Television Channels etc. shall be also roped in this exercise.

Assistance/help/association of workers, students, people mahila arthik vikas mandal/ women's organizations in general & association, press, mass media shall be sought.

6.19 Organizational restructuring and strengthening

6.19.1 Present status: Management of Storm Water is obligatory duty of MCGM as per Mumbai Municipal Corporation Act 1888. Hon. Mayor heads the deliberative wing, while Municipal Commissioner heads the executive wing. He is assisted by four Additional Municipal commissioners (AMC). Of which one AMC looks after the Storm Water Management in addition to other subjects. Director (E&SP) assists AMC in discharging his duties. Chief Engineer (SWD) is overall in charge of SWD wing. He is responsible for Planning, Designing, Construction, Operation and Maintenance of SWD system. Four Deputy Chief Engineers assist him. Executive Engineers, Assistant Engineers and Sub-ordinate staff in turn assist Deputy Chief Engineers. Out of the four Deputy C.E.s one Deputy C.E. looks after major constructions in City area. Another Deputy Chief Engineer looks after Operations and Maintenance in City, The two Deputy Chief Engineer's look or Constructions and Operations and Maintenance Western and Eastern Suburb in their respective jurisdictions.

6.19.2 Lacunae: The SWD wing of MCGM is a very neglected wing in the corporation, may be due to unglamorous work whose existence is felt only in default, citizens have taken flooding and stoppage of working 2-3 times in a year as fate accompli. Yearly ritual of partial de-silting of nalla resulting in to flooding has been taken by the Corporation in its own stride and citizens also forget the whole thing till next flooding. As the work is not vote catching and can not be show cased to public, it does not get much political attention. Similar treatment is meted out while preparing budget as SWD works are given last priority. Surprisingly budget for de-silting is given without hustle.

Though after every flood deluge in last 30 years committees were appointed and reports of the committees are available with corporation, no serious efforts have been made to implement those recommendations. Present committee is the third committee precisely on the same subject, though subject has been tackled by few other committees too. Luke warm enthusiasm on the part on the SWD wing, and absence of interest on the part of total system has made the SWD organization a

very dull and non-responsive. Posting of unwilling staff to the wing has further deteriorated the situation.

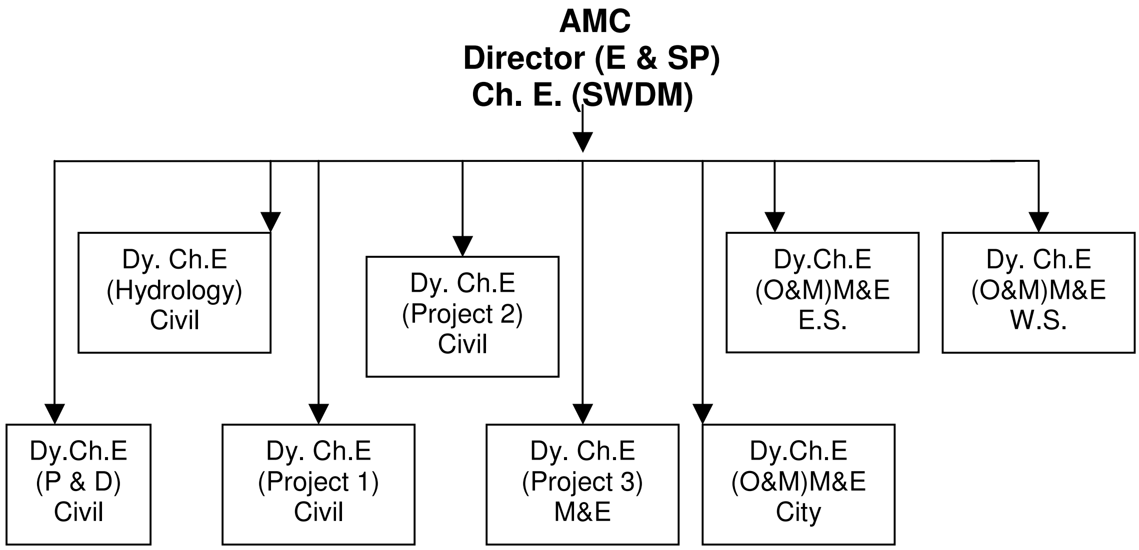
It is noted that, though BRIMSTOWAD report has pointed out deficiencies, damaged portions and dilapidated condition of sewers by attaching revealing photographs and giving exact locations, even the efforts to repair at least those spots has not been taken leave aside tackling other spots. Even a simple thing like measuring the existing channel widths and mapping them to enable comparison with BRIMSTOWAD recommendations has not been attempted. Not a single map exists with SWD prepared recently to show exact locations of underground utilities, blockages. For a city having a separate wing to take care of the storm water does not have a counter plan, though subjected to flooding and tidal variations. Even a plan showing a flow pattern of the drains and the nalla system could not be produced before the committee. In suburb at many locations developers have covered the minor and major nalla, but no record of such locations is available nor has any attempt been made for mapping them on the street maps. Openings provide for such coverings have not been checked whether they are adequate and kept clear as per requirement. At many places such coverings have not been constructed on straight alignment but they follow a crooked alignment, but no arrangement exists to facilitate their inspection. This has resulted in to blockades and obstructions to free flow, but no notices have been issued to them.

Most important things like fully de-silting the nalla system and establishing the required cross section of the watercourses is done in a very casual and perfunctory manner. Leave aside plotting cross sections and longitudinal sections, simple practice of taking levels after de-silting to ensure whether gradient exists or otherwise does not exist. It is reported that simple leveling instrument is not available in the corporation. Nowhere any silt traps or catch pits are provided before the entry into the cross drainage structure or coverings. While granting permission to the developers it is not insisted that they provide adequate arrangements for the storm water disposal and ensured that they do not encroach on the natural watercourses. All these things are reflections of the working of the wing. No manual exists with the wing as to how it should function and clear-cut responsibilities are not laid down.

Mumbai city is having most of its area, only marginally above the high tide level, and it receives heavy rainfall every year and most of it rain falls in the months of July and August only. It has got 3-4 small rivers having lengths ranging from 5 to 13 km only. As the catchments are small the time of flood concentration is small, at the same time upper reaches of the catchments are steeply sloping so the lower reaches are prone to flooding quickly. City like Mumbai, which is fondly call ‘Financial Capital ‘ of the country, should have its own arrangement for flood prediction, warning and regulated release of water from the dams in upper reaches as the financial losses are more in such cities, however it is lacking in this respect.

6.19.3 Restructuring: Considering all the above facts it is very essential to restructure the SWD organization and make it more responsive. It suggested that the organization should have capabilities to collect data, conceptualize, plan, design, construct, operate, maintain and monitor. It should aim at to become role model of Storm Water Drain Management (**SWDM**). It should be able to develop its own expertise in the subject.

It suggested that the organization should have following structure:



Storm Water Management Wing would have its own design and project preparation team headed by one Dy.Ch.E.(P&D). This team will be equipped with surveying and designing capabilities. This team will be associated in monitoring the work of the consultants and will liaise with other organizations and will be the think tank of the organization. This wing will make major project proposals and give clearances to the repair rehabilitation proposals of SWD forwarded by the other Dy.Ch.E. This team will formulate rules guidelines etc for Storm Water Management.

Storm Water Management Wing would have its own flood prediction and hydrology team headed by one Dy.Ch.E (Hydrology). This team will be equipped with automated self-recording rain gauges which will be installed by MCGM all over the city. It will also be equipped with river gauging stations which will be installed by MCGM on all the streams as per the recommendations of the committee. It will collect and compile the data of its own gauging stations and also supplement it with the data that might be available with State's Water Sources Department and IMD. It will also be scrutinizing the proposals of the developers from storm water management point of view. It will also have reliable communication system with disaster management cell, IMD, Dams in the city, gauging stations, other organizations and ward offices. Team will be responsible to issue warning of likely floods in consultation with the Ch.E. (SWDM).

There should be teams headed by Dy.Ch.E.(Project) for the execution of Storm Water Drainage Projects in Mumbai depending on the number and nature of the projects that will be taken. It should be equipped with surveying instruments and manned by suitable staff for the same.

There should be three teams headed by Dy.Ch.E.(O&M)s for operations and maintenance of the SWD system. It should be equipped with necessary labor force, equipments and know-how. In this modern era the cleaning and de-silting operations should preferably be done by mechanized means. This team will also be responsible for the operating the tidal gates and pumping installations within their jurisdictions. It will also handle minor works and rectification minor augmentations. This team will

handle inlet, laterals, collector drains and minor nalla too unlike the ward staff handling it previously; this will bring total unified control on the SW management. Executive Engineers and the Assistant Engineers should be made responsible on river basin basis instead of ward basis. The team should liaise with other organizations like Railways, MMRDA, PWD, Air port authorities, Port Trust etc. it will also be responsible to report any encroachments on the nalla system, non compliance of the conditions laid down by Ch.E. (SWDM) and taking action against the same.

At present the MCGM is heavily depending on consultants. Rather people comment that MCGM is a “consultant driven” organization. It is mainly due to lack of in house capacity. Lack of technical expertise, diffidence to take responsibility, frequent inter-wing transfers and no out side exposure might have been the reasons to this pathetic condition of the organization. Responsive organization should be in position to handle the complex situations. It should be able to extract quality out put from the contractors. It should be able to exert on the consultants, point out their short falls so that they deliver proper quality out put. This can only be possible if in house capacity is strong enough. This can be achieved through continuous training to the staff, giving sufficiently longer period to develop expertise in that wing, make them responsible by introducing award / punishment mechanism, laying down proper work procedure, giving out side exposure, introducing third party quality audit and pear review by an expert. Continuing training, global participation and updating knowledge must be in-built in the storm water management along with organization restructuring.

6.20 Financial implications:

a. The maintenance cost of works such as survey, gauging, desilting, removal of obstructions & constructions will be of the order of about Rs.100 to 150 crores.

b. The cost of capital intensive works like rehabilitation & up gradation of SWD, pumping stations and flood gates etc. for entire Greater Mumbai will be around Rs.2000 crores.

Appendix 6A

Findings of Merani Committee appointed by Govt. of Maharashtra to study water logging of roads widened by MMRDA under MUTP and MUIP in Mumbai

Govt. in Urban Development Department had appointed this committee vide letter no. MMRD 3305/CR-120/05/UD-7 dated 26th Sept. 2005.

Background:

Rainfall recorded at Santa Cruz rain gauge station on 26th July 2005 was unprecedented and its hourly intensity was also abnormal lasting for an uninterrupted duration of 7 hours. The hourly intensity of rainfall as recorded at the station was 100.2, 190.3, 90.3, 100.4, 95.0, 72.2, and 60.2mm, in those 7 hours between 2.30 p.m. to 9.30 p.m. Unfortunately the high tide peak of 4.48m occurred at 3.30 p.m. and the Sea refused to accept any storm water flow. That resulted into accumulation of back water and flooding.

Road and Railway Systems in Mumbai are laid, by and large, at a level susceptible to flooding two to three times even in normal years. On 26th July most of the length of these systems was flooded. All the four major corridors namely Eastern and Western Express Highways, S.V. Road and L.B.S. Road were under water for major length and they became operational only by the evening of 27th July 2005. Though rainfall intensity in island city was not so heavy, the chronic flooding spots namely Lalbaug, Parel, Tardeo, Dadar TT, King Circle, Hindmata etc experienced flooding. Railway electronic signaling system stops functioning once the water level touches the rails, and the trains are asked to slow down at crawling speed of 15km/hour. And once the water level reaches 10 cm above the rail top level all the train movements are stopped. This situation occurred on that day at 3.30 p.m. coinciding with the on rush of the commuters hurrying back to their homes. Due to this there was unprecedented accumulation of crowd at railway stations.

Due to flooding and fear of electrocution the main power supply was shut off. At the same time the generators and battery backup system also became non functional as they were also submerged. Failure of communication system created further chaos as no body could know as to what was going on. As TV system went dead even the important messages could not be relayed to the public. As an alternative to railway about 500 extra buses were pressed into service to clear the crowd. However, they too met with similar fate as they could not reach the destinations because of the blockage on main roads by the broken down and abandoned vehicles. Even the rescue operations were hampered as the rescue vehicles could not reach to the spots.

Reasons leading to water logging:

Extra ordinary heavy rainfall coinciding with hide tide spell created a dangerous situation on 2ath July 2005 in Mumbai. It is reported that the meteorological data available since 1843 does not show any such intensity ever occurring over Mumbai area. The general ground elevation of the major portion of the city is just marginally above the high tide level, and some portion is even below high tide level, hence it is susceptible to flooding under such conditions.

The past experience shows that the floods generally recede within 3 to 4 hours when the next low tide occurs. In the present case however, the flooding lasted for about 24 to 30 hours. Though extraordinary heavy rainfall intensity was undoubtedly the prime cause of flooding, the situation was further aggravated by retarding the rate of recession of flood waters on the major corridors due to certain other contributory reasons, such as, (i) incomplete cross drainage works, (ii) reduction of waterways due to blocking by garbage, (iii) non removal of excavated or heaped material, (iv) reduction of waterways of nallah system, (v) inadequate designing of SWD on project roads.

There are many low lying portions all over the city. The roads occasionally pass through some of these low lying portions and the height of embankment is also not much. At many locations the natural water courses have been blocked or narrowed. At certain locations the natural water courses are covered by the developers or the encroachers which has made them difficult to keep them clean. Silting of waterways has reduced their capacity and flood recession has got slowed down. Water courses are difficult to approach due to surrounding developments which has made impossible to completely clear them.

The SWD system is not properly designed on these project roads, relevant codes or guidelines are not followed and the work is not executed properly. Works were not brought to safe stage before monsoon. Proper fluming for guiding the flow smoothly has not been provided. Plastic and garbage got entangled on large scale in the reinforcement rods left exposed due to incomplete work resulting into blocking of waterway. There are many water supply and sewerage pipes crossing the drains that reduce the waterway which have not been compensated. There are cables crossing the drains which are not properly laid or supported and left dangling in the waterway, floating material got entangled into these lines and the flow was blocked.

Remedial measures suggested:

a) Complete review of the drainage design- proper drainage scheme should be worked out as per codes and guidelines and got reviewed by an expert.
b) Guide lines for design review are appended (appendix A)
c) In addition to these guide lines committee also suggested a few sound engineering practices to be kept in mind while designing and executing, those are also appended (appendix B)
d) De-silting, training and necessary improvements to the nallah and watercourses should be carried out before next monsoon
e) In case of any incomplete works, they should be brought to safe stage before monsoon.
f) Certain administrative measures need to be taken e.g. i) ensure that the consultants perform their job properly, ii) carry out third party quality audit, iii) introduce peer review, iv) mobilize sufficient number of well qualified staff, v) incorporate proper and practicable contract provisions like reasonable time limit, set mile stones, penalties for default etc.

<u>Appendix- 6B</u>

<u>Guidelines for design of SWD on Project Roads</u>

1) Proper drainage plan of the highway showing

a) Flow direction
b) Kerb channel
c) Side drains
d) Edge drains
e) Out falls
f) Invert levels at representative locations
g) Natural drainage pattern
h) Invert levels of water courses at U/S and D/S of crossings and 200m U/S and D/S

2) Longitudinal Sections showing

a) RTL at Median, at kerbs on Left and Right of the carriageways
b) L-section of proposed kerb channels
c) Invert levels of side drains and kerb inlets.
d) Outfall levels at natural water courses and their invert levels
e) Proposed cross sections of side and edge drains at ridge (starting point), intermediate location and outfall location with chainage and invert levels.

3) Index map showing Natural Water Course

a) Flowing across the highway
b) Flowing along the highway
c) Deficiencies if any
d) Suggested measures

4) Study the old topo-sheets and flow pattern

5) Check the adequacy of the waterways

6) Proper investigation of water courses at

a) Vile-Parle air port junction
b) Samta-nagar, Thakur complex
c) Mahindra nallah
d) Dahisar nallah
e) Mahananda dairy
f) Walbhat nallah
g) Covered nallahs

7) Remodeling at

a) Kalanagar junction
b) Kherwadi
c) Milan subway
d) Air port junction
e) Mahindra nallah
f) Thakur complex

g) Oshiwara nallah
h) Dahisar nallah
i) Mahananda dairy
j) Avenue park
k) Walbhat nallah

8) Properly design the road side drains taking into consideration 50mm rain storm/hour with 100% runoff as recommended in BRIMSTOWAD, and also the other catchments contributing to that system. Also advised to study CWC report of March 1992

9) Suggest augmentation of cross drainage works and additional drains if necessary

10) Review the drainage arrangement at Sub-way locations

11) Provide proper arrangements of run off from fly over

a) Inlet chambers at down take pipe outlets
b) Lead them to near by drains
c) Intercepting chambers / inlets at the end of the approach ramps
d) Proper drainage for slip roads.

Appendix 6C

Sound engineering practices to be kept in mind while re-designing the drains.

These may comprise as - providing kerb channel of at least 600 mm wide at the edge of the carriage way, providing inlet chamber with silt traps at suitable intervals, providing junction boxes at the junction of side drains and C.D structure, providing proper chamfer at corners of the invert and a center channel for dry weather flows, providing proper inlet chamber and disposal arrangement into side drains at the bottom of down take pipes catering for fly over deck runoff, provide catch pit silt pockets at entry of CD works, providing man holes at every change of alignment location etc.

Manholes should be so located that a person can easily climb down into the box. As far as possible the size of the drain should be such that it is easy to inspect and clean.

No C.D. works should be deleted or made redundant

While widening the existing C.D works proper consideration should be given to the hydraulic efficiency of the structure.

No abrupt reduction without flaring should be attempted.

Heavy pre-cast slab covers slabs should be avoided.

The structure proposed should be easily maintainable and accessible.

As far as possible bigger, single cell box section should be preferred rather than pipe or multiple cells.

Proper arrangements for utility services should be provided.

Proper camber should be provided.

Weep holes should be provided in box section and retaining walls.

IRC Standard guidelines on Urban Drainage should be followed.

CHAPTER 7

ENVIRONMENTAL MANAGEMENT OF MUMBAI'S RIVER BASINS

7.1 Introduction

It almost appears that our own understanding about the urban ecosystem of Mumbai will limit our abilities to make a turn-around after the floods of 26th to 29th July, 2005. It is high time that we undertake several serious studies and engage in a consultative process and chart the course of developmental planning. While the rain was indeed a natural phenomenon and certainly such cloudbursts occur very rarely, flooding of low-lying areas in Mumbai has not been any new thing in every monsoon. There are two-three broad scapegoats that are routinely blamed:

1. The drains were not cleaned and plastic bags and solid wastes choked the drainage system.
2. Storm water drains are not properly made.
3. Slums and recycling industry in coastal regions and flood plains of creeks and rivers are responsible for flood.

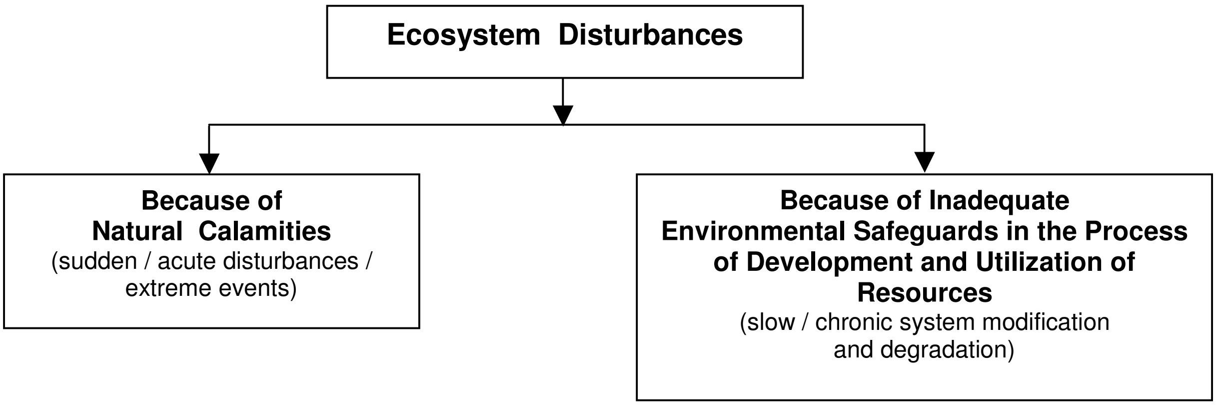
While all the above reasons do contribute to flooding in Mumbai in various locations and on various occasions every monsoon, they are not the only reasons for causing floods in Mumbai. Indiscriminate modification of our ecosystems and waterways and the resultant serious threats to communities have not yet attracted the serious attention it deserves. That has also disrupted the livelihoods of coastal communities, especially of fisher folks.

It is crucial that the developmental agencies understand the sensitivity of the structure and function of our urban ecosystem. It is well known that the green belts, gardens, hills, sandy beaches, sediments in creeks, estuaries, rivers, lakes, and oceans perform a crucial ecological function in a given eco-system. In addition, the natural processes that occur in such systems benefit humans by mitigating floods, maintaining water quality and quantity, recycling nutrients, and providing habitat for plants and animals.

7.2 Assessment of Mumbai's Urban Aquatic Systems

Ecosystems are made-up of several sub-systems and those sub-systems are further made-up of sub-sub-systems. A significant impact on any of the sub-systems or even on sub-sub-systems can eventually have the repercussions for the entire ecosystem. The impacts leading to disturbance of a typical urban ecosystem like Mumbai can broadly be divided into two categories (as shown below):

1. *Natural Calamities* (which mostly tends to pose sudden or acute disturbance to the system) and
2. Inappropriate and inadequate arrangements in the management systems.



Excessive rainy season flooding and the year long extreme deterioration of the quality of water flows in the stream channels have been the principle adverse ecosystem impacts of the last 150- years development processes in Mumbai. During the 150 year transition process of old seven islands to today's topographical features of Mumbai, MCGB area has progressively drifted away from the natural state. As a result, the natural processes of siltation, erosion, estuary movement, and interaction of mangroves with tides has been greatly affected. All the river ecosystems in Mumbai have drifted away and have been drifting away from their so-called 'natural state' because of 'land reclamation' activities and the development on those lands.

For example, the 1944-map of *Survey of India* does not mention 'Mithi', but shows Mahim River with tidal range up to Bail Bazar (Old Kurla). Even the mouth of the river then is unclear because of the mudflats all along between Bandra – Dharavi – Sion and Kurla. River channel in a recognizable form appears to have developed subsequently, when mudflats were occupied through raising of ground levels for reclamation. Channelization proposed by CWPRS happens to be only a sequel to how the 'Mithi' River came into existence between Kurla and Bandra. Area between Salsette Island and Mahim has also undergone considerable topographical modification. The objective hereafter will have to be to develop it and manage it in a risk free sustainable pattern.

Very few patches of Mumbai's ecosystem today are in fact survivors of the pristine 150 years-old ecosystem such as the west of the Manori Creek. Some patches, however, are present in today's modified ecological form because they adapted to human intervention and forces of development as at Mahul or places near the Manor Creek. Superimposed on the earlier natural ecosystem in and around Mumbai-Islands, are the man-made civil arrangements. Therefore, one needs to take a fresh look at Mumbai's urban ecosystem in the context of perpetual urbanization and search for answers to the following three questions:

(a) What are the present salient ecological zones of Mumbai?

(b) Is there anything like natural contours of Mumbai considering its reclamation history of past 150 years? Once it was a cluster of seven independent islands. Today we have a reclaimed and altered terrain.

(c) There is lot of discussion lately on the practical approaches to restoration of watercourses and water bodies in Mumbai. Is anybody addressing its practical dimensions? Is it possible (and more importantly – practical) to restore Mumbai to (*say*) pre-1950 status?

It has been recognized that Mumbai needs special consideration in its management because of being a coastal island-city with excessively large population density. While responding to these challenges of development, Mumbai Island has undergone a series of reclamations and transformations. Mere restoration of watercourses and water bodies in Mumbai will not provide the needed flood protection. We certainly need much higher capacity of carrying floodwater and wastewater in our rivers and creeks. But the inflow itself needs to be regulated through environmental up-scaling and up-gradation so that future floods can be handled with the help of appropriate engineering interventions in conjunction with improvement of the waste processing ability in the riparian zones, river beds and creeks.

Assessment of Mumbai's urban ecosystem in the context of 26th July flood will be the first step in this direction. The Mumbai's urban ecosystem comprise ten sub-systems including four rivers, Powai Lake, Sanjay Gandhi National Park (including Tulsi and Vihar Lakes), creeks, bays, Mithi River estuary, and the coastal zones. The following five tables show the comprehensive assessment of the current status of Mumbai's Urban Ecosystems. The tables give some factual information, major risk zones, urban activities leading to degradation of the environment and the impact of 26th July deluge on the ecosystem.

Encroachments in the riverbeds or on the banks of the rivers in the Mumbai have choked and pinched the watercourses and aggravated the risks of flooding. The field observations indicate that all the rivers in Mumbai are suffering from the following five assaults:

i. Open, dangling cable and pipe crossings on the sides of the bridges and culverts,

ii. Debris dumping (from construction activities as well as industrial wastes) on banks and into rivers,

iii. Sedimentation in river beds and dumping of urban solid wastes into rivers coupled with inadequate annual desilting efforts,

iv. Ingress encroachments from the banks (building, industries, and slums); and

v. Modification of river-courses and local diversion of streams.

There are four typical risk zones associated with each river-ecosystem in Mumbai, *namely*: (i) areas that are prone to wave action, (ii) naturally low-lying areas prone to submergence, (iii) riverbank areas prone to flooding, and (iv) chronic drainage congestion sites. Each one of these needs separate attention and distinct management strategy. It is hoped that in due course a detailed management plan for each category of risk zone will be evolved in consultation with the local residents. In the mean time, the broad assessment of the current status of the five major river systems of Mumbai is described as follows.

Each of these five river basins comprises of several small catchments, topographically very well detailed out and described in the BRIMSTOWAD report. These catchments belong to different four risk-zone categories mentioned above. Each catchment will have to be accordingly dealt with on a separate footing in greater details. Only the broad guidelines in that context are suggested here below. It will be desirable to update the catchment surveys initiated in BRIMSTOWAD project. This exercise should be taken up every ten years to record the changes that have taken place and also to assess and evaluate the gains from the measures undertaken to improve the situation. In absence of such catchment wise updating, it is not currently clear as to how Mumbai has been better off or otherwise after the measures undertaken in Mumbai in response to the actions taken based on BRIMSTOWAD report.

Urban activities responsible for environmental degradation include encroachment leading to narrowing of banks, reclamation of river beds for housing, un-authorized slum development, construction of industrial units, diversion of river flow due to dumping of construction debris and solid wastes as well as wastes generated by stables and cottage industries on the banks of the rivers.

7.2.1 Mithi River

No.	Particulars	Description
1.	Name of River	Mithi
2.	Point of Origin	Sanjay Gandhi National Park has upland streams and the river originates from the overflow of Vihar and Powai dams.
3.	Length in km (approximate)	17.9 km from Vihar Dam
4.	Areas (locations) through which the River flows	Sanjay Gandhi National Park, Royal Palm (Aarey colony), Filter Pada, L & T Junction, Jogeswari-Vikhroli Link Road, Saki Naka, Kranti Nagar, Bail Bazar, Air Port, Air India Colony, CST Road, Bandra-Kurla Complex, Bandra (East), Bandra-Mahim Railway Line, Mahim Creek, Bandra Reclamation-Arabian Sea.
5.	Major Nallas associated with the River within the catchment area	Nalla coming from the Chandiwali under Safed Pul joining Padma Talaw near Sahar Terminus. River from Jogeswari (E) joining Sahar Airport Authority, Joining Airport at Jarimari, Nalla Area coming from Kurla joing Mithi River at the extended part near Kalpana Theatre, Nalla carrying water from Kalina Region (millitery camp) and joing the river at the sounth side of the extended runway of Santakruz Airport, Few Nallas from the west side of the Kurla Hill, Two Nalla from Kalina hill area meeting to estuary

No.	Particulars	Description
		(drainages opening at Kapadi Nagar. Vakolla Nalla (originally it was a branch of Mithi River, which was partly reclaimed for construction of the Air Port.) joining the river in the Mahim Creek, Nallas running along side of Western Express Highway from Andheri-Parla and meets the river near Drive-In Theatre, Nallas from South Side Mahim Creek, Nallas from King Circle, Wadala, Sion, Dharavi, Hindu Colony (Dadar), Coming from south side of western railway (underground), Nalla coming from Elfinsten Station of Western Railway, Nalla coming from the Chuna Bhatti area, Nrayan Nagar, Asalfa Nagar, Hill No-3 (Ashok Nagar – Isnd slide location)
6.	Meeting point	Mahim Creek near Bandra
7.	Total Catchment area	7,295 ha* comprising of 21 catchments based on the BRIMSTOWAD report, Tables A6.3 (page ES-10) and A7.3 (page ES-16) see table bellow for further details.
8.	Potential Risk Zones	"Slums and Buildings" which are prone to flooding: Kapadia Colony, Taxi men's colony (Lohia Nagar), Anna Sagar Marg, L. B. S. Marg, LIG and MIG Colony (Kurla West), Nirmal Nagar, Golibar area, Sahitya Sabha, Kala Nagar, Behram Pada and surrounding areas, Government Colony (Bandra East), Khar East, Bail Bazar, Sahyog Nagar, Kranti Nagar, Hari Masjir Area, Indra Nagar (Kurla West), Shanti Nagar, Sunder Nagar (Kalina), *etc.*
		"Low-lying areas" prone to monsoon flooding: Dharavi Slum, Kismat Nagar, Rupa Compound, Kurla BEST Depot, Kalpana Cinema and adjoining areas, Shalimar Hotel, Sheetal Cinema, Dhobi Ghat, Halav Pool, Masarani Estate, Kartika School, Christian Village, Greator Khan Estate, Buddha Colony, LIG, MIG Colony, Hari masjid, Lokmanya Tilak Nagar, Indira Nagar, Lohia Nagar, Shivaji Kutir Mandal, Kapadia Nagar, D'souza Nagar, Kajupada, Jari-Mari, Motilal Nehru Nagar, Kalina, Shastri Nagar, e*tc.*
		"Chronic drainage choking sites": Kalpana Theatre area (Kurla), Western Express Highway, *etc.*

No.	Particulars	Description
		"Prone to cyclones/ strong wave action in monsoon": Destructive waves are found in Mahim Bay lately, water does not drain even in normal condition.
9.	Urban Practices and Activities Responsible for Environmental Degradation	Narrowing of the banks for housing: Locations are (a) Faujia Hosptial, Kurla (b) South Side of the Saki Naka Bridge (c) Wadia Estate (d) In front of Kalpana Theatre (Kurla), Runway Extension of the Santakruz Airport (e)
		Reclamation of River bed for industrial units: at several locations On back side of Fauzia Nursing home, River coarse was bifurcated and again reunited farming a small island reunited near Nasibullah compound area (H ward). This is shown in DP sheets. This was reclaimed by the Air Port Authority and was used for extension of run-way in late 80s.
		Diversion of River flow due to dumping of construction debris/ solid waste/ industrial waste: at several locations The Air Port Authority went ahead and reclaimed the wetland in the same area on the bank of the Mithi River in 2004-2005.
		Industrial Waste, Air Port Oil at several locations. Habbibullah compound and Air India Colony

10.	Major impact of July 26 incidence	
		Entire area under submergence faced a great loss and psychological shock. The damage was worst in suburbs. Poor probably were among the worst affected families because many lived in flood plains, near coast and low lying areas. The eastern ridge of the Mithi basin – is very critical from the point of flooding, because of the 2 km long low level saddle near Jarimari shown in **Drawing Nos. 26 and 27** The surplussing of Mithi waters across this saddle on 26th July led to unprecedented extreme flooding in the eastern nallas flowing into Mahul basin. Management of the Mithi basin will play an important and critical role in the 'risk free' status or otherwise of the upstream areas at the source of the Mahul basin. Stream flow / flood flow arrangements along the ridge between the Mithi and Mahul basin will have to be detailed out hereafter very carefully.

* **Catchment areas of Mithi River and Mahim Creek System**
[Adapted from the BRIMSTOWAD report, Tables A6.3 (page ES-10) and A7.3 (page ES-16)]

Catchment No.	Name of the Streams / Nalla System	System Area (ha)
400	Mithi River and Mahim Creek System	7,295
401	Senapati Bapat Marg outfall near Fishermen Colony, Mahim (input into Mahim Creek)	96
402	Adjoining Marol	NA
403	Adjoining Saki Vihar	NA
404	Marol	832
405	Safed Pool	730
406	Airport (North)	NA
407	Airport (South)	NA
408	Thana Cabin	160
409	Kalpana Kamran	24
410	Three outfalls in Dharavi area namely, Dadar-Dharavi Nalla, Naik Nagar Nalla, and Outfall near Mahim Flyover (input into Mahim Creek)	487

411	Air India	80
412	Kolivery Village	112
413	Sunder Nagar	192
414	L.B.S.	NA
415	Vakola River	907
416	Housing Board	NA
417	W.E.H. (East)	40
418	Kherwadi	320
419	Boran	128
420	Bandra Flyover	NA
421	Vihar, Powai Lake	NA

NA means "not available"

It would be useful to note that spillway discharges from the Tulsi, Vihar, and Powai Lakes meet the Mithi River at its points of origin. There is an additional high-level spill way for the Tulsi Lake, which spills directly into the Dahisar River. Details of the locations are as follows:

1. Tulsi Lake: The FSL (full supply level) of the lake is 114.74 m GTS. Presently, the dam has two ungated spillways. One spillway at crest level is situated at 115.42 m GTS. This spillway discharges into Dahisar River. The other spillway at 114.74 m GTS discharges into Vihar Lake.

2. Vihar Lake: The FSL of the lake is 56.21 m GTS and foot of the dam is 27.36 m GTS. This dam is also having ungated (*i.e.*, unregulated) spillway. The Vihar Lake spillway discharges into Mithi River.

3. Powai Lake: The FSL of the lake is 94.97 m GTS. This spillway discharge also meets Mithi River.

Before implementation, necessary studies shall be conducted to ensure that no utility / structure would get submerged due to the proposed gates. If any such possibility emerges out of the studies, appropriate majors shall be taken.

It is learnt that the IIT Bombay is engaged in estimating land use / land cover within specified corridors adjoining both the banks of Mithi River using recent satellite data. In addition, there are certain systemic issues that need to be addressed to ascertain meaningful development on the banks of a given river. Among all the rivers of the Island of Mumbai, Mithi River happens to be one of more investigated rivers. Mithi River is the natural drainage to sea in the heart of the city – but it's specific flood flow requirement remained to be adequately covered by the BRIMSTOWAD study. The CWPRS study was then supposed to address the last 3-4 km stretch of the Mithi River (including the portion meeting Mahim Bay) only. While the individual catchments in the Mithi basin were looked at in the BRIMSTOWAD, the behavior of the river system as a whole – particularly near the Airport area and it's upstream -

remained to be dealt with. Following are some of the important issues related to management Mithi River and its basin:

(a) The IIT Bombay [2005] report has vividly depicted diversion, bends, and channelization made to the Mithi River course by superimposing information from 1976 topo-maps onto IRS satellite images of years 2000 and 2004 (Figures 2.7a through 2.7e in their report). The main river has been forced to turn in 90^0 for four times in rapid succession, and made to pass through a culvert, and bunded with walls and embankments on both sides. (Source: "Development of Action Plan for Environmental Improvement of Mithi River and Along Its Banks". *First Interim Report* by the Centre for Environmental Science and Engineering, Indian Institute of Technology – Bombay, Mumbai. November 2005)

(b) As reported by IIT Bombay [2005], the entire river stretch is contaminated by heavy metals. However, the concentration of the various metals varies from point to point. The variation in concentration is due to different quality and quantity of inputs from the neighboring / adjacent industrial establishments. In sum, the Mithi River is highly affected by the adjoining small industrial units, whose untreated (or in some cases partially treated) effluents go to the Mithi River. Therefore, a systematic effort should continue to quantify and regulate pollution from the small-scale industries on the bank of the river. Relocating some of them to appropriate places will be a desirable option in view of their present location where they are subjected to rather high flood risk in the Mithi basin.

(c) Santacruz Airport is located half way in the length of Mithi River from Powai Lake to Mahim bay. It is 6 meter above the mean sea level (the high tide level in the Mithi creek is less than 2.7 m). Survey of India's map of 1976 clearly shows that the tidal reach of the Mahim creek was close up to the south-east end of the airport area. Hydraulics of the Mahim River at this tip is critical from the point of flood routing. Additional challenges have been posed in the vicinity of the airport due to reclamation (done using construction debris) and buildings / constructions erected right on its course and banks between LBS Marg and Mithi River as well as flood plain within their boundary walls.

(d) Comparison of the river course published in the Survey of India's topographic sheet of 1976 with the QuickBird satellite image of 8 April 2005 at 9.30 am IST (0.6 m of ground resolution) reveals that the semi-circular structure of the Chhatrapati Shivaji Maharaj International Airport at Sahar appears to have been placed within the area of natural bend of the Mithi River. It can also be seen that the river has been bent several times by the extension of runway (already in place) and taxi bay (currently being constructed).

The river course near Kalpana Cinema (Kurla) seems to have been substantially altered during 1976 and 2005 to extend the runway. Also, the river islands were cut and leveled and two water bodies (on runway) seem to be filled and reclaimed by the Airport Authority. Clearly, over the years, the river course seems to have been narrowed and guided / trained significantly.

It is also evident from the imagery that the entire area south of airport boundary wall (in front of the AI colony and IAL colony) happened to be situated on the periphery of a low-lying reclaimed pond area. It can be seen

from the 1925 survey record that it was a portion of water-logged wetland system of Mithi estuary (then named as Mahim River estuary). Reclamation of ponds seems to have aggravated flooding in this area because the natural draining of the landmass must have been towards the ponds.

(e) **Drawing No. 31** depicts changes in Mithi River estuary between 1976 and 2005 (Source and credit: IIT Bombay). The river course published in the Survey of India's topographic sheet of 1976 has been superimposed in this image onto the QuickBird satellite data of 8 April 2005 at 9.30 am IST (0.6 m of ground resolution). The blue line shows the extent of submergence during high tide and therefore the spread of mangroves and vegetation as per the survey records of 1976. It would be interesting to notice that the entire estuary of Mithi River has under gone extensive landfilling, reclamation, encroachment, river course modification and all these alterations have impacted the estuary movement and hydraulics of the entire creek (khadi) and bay. It is also clear that mangroves and vegetation have been diminished in the creek eco-system since 1976.

(f) The encroachments and blockages of Mithi River course between Kurla-Kalina Road bridge and CST Road bridge, especially due to dumping of solid waste / debris as revealed by the QuickBird satellite image of 8 April 2005 (before flood situation). The situation appears to have relatively improved after the MCGM undertook the clean-up drive of the river channel and may be the floods pushed the blockages by sheer force of flood – as seen in the Cartosat satellite image of 8 October 2005.
In addition, the blockages of Mithi River course between Kurla-Kalina Road bridge and CST Road bridge due to dumping of solid waste / debris as revealed by the IRS P6 satellite image of 8 March 2004 and the IRS – 1D satellite image of 17 April 2000, respectively. Clearly, disposal of construction debris, municipal solid wastes, and industrial wastes has been a chronic problem for Mithi River as reveled by the above images taken in last five years.

(g) **Drawing No. 32** shows the temporary diversion of Mithi River course for construction of box culvert under proposed taxi-bay extension (north of runway) as revealed by the QuickBird satellite image of 8 April 2005 (details can also be seen in the Cartosat satellite image of 8 October 2005). The satellite pictures shown in the above image covers 590 m x 754 m ground area of the Airport (Source and credit: IIT Bombay). Several individuals and agencies have expressed their concern about the diversion of Mithi River as shown in above image. It has been opined that such diversions of Mithi River proved to be hazardous in the event of flash floods and probably aggravated the impact of floods in the immediate surroundings.
The green cover patches (seen in red colour) north of runway on both the banks of Mithi River course and elsewhere as revealed by the IRS P6 satellite image of 8 March 2004 and the IRS – 1D satellite image of 17 April 2000, respectively. The satellite pictures shown in the above two images cover 590 m x 754 m ground area of the Airport. Reservations have been expressed for years about developments in these areas, which have apparently altered hydraulics of river and flood plains and consequently impacted vegetation and

ecosystem adversely. Adverse comments have been recorded against such development projects in Mumbai because the pace at which the terrain has been modified and conspicuous absence of integrated planning and application of defendable engineering practices have made the development activity appear unsustainable.

(h) One desires not to displace encroachments on the banks of the river (zopadis, kachcha houses, multistory residential and commercial structures, *etc*) because one does not want to cause disruption to community's habitat and livelihood. Although one wishes to evolve the non-displacing ways of restoration and revival of Mithi River; frankly, it does not seem to be practical. Some of the major developments closer to the vicinity of the Mithi River bed and flood plain that have had an adverse impact on the flood flow regime of the Mithi river are:

i. Sahar Airport construction debris of underground tunnel near Jari-mari,

ii. Santa Cruz runway and taxi bay extensions,

iii. Walls around Air India and Indian Airlines colonies,

iv. Bandra-Kurla Complex reclamation, and

v. Buildings / constructions, housing societies, and slums on the bank of Mithi River.

Some doubts have also been expressed about the impact of the reclamation works associated with the Worli-Bandra sea link reclamation. Their relationship with the river regime, impact on the risk-proneness or otherwise, extent of obstruction to river flow has to be properly analyzed and understood. Studies on physical 3D model or the mathematical models are going to be very helpful in this context. Reports of these studies at CWPRS station will therefore be very helpful in deciding upon the future management of Mithi Basin – specially its flood plains. Only the interim report of CWPRS studies is available at present. While the activities need to be lined up immediately in the light of the interim findings, it is hoped that the final report of CWPRS studies will be placed before the *Mithi River Authority* and widely discussed among the Mithi Basin stakeholders before long term actions are finalized. Implications of the CWPRS findings will have to be properly understood by all concerned before any actions commence in haste.

Unfortunately, the extensive painstaking work carried out for BRIMSTOWAD report was not adequately publicized and discussed within the municipal wards and ALM-groups. It was not even formally accepted or modified by the decision making authorities before commencing actions. The result was haphazard half hearted approach to its implementation. This should not now repeat in the case of the studies being carried out by CWPRS for Mithi or by WAPCOS for other rivers on the Mumbai Island.

(i) In the light of the above listed five major impacting activities along the Mithi River's channel, it will be instructive to study the following features of the ecosystem of Mithi River: Impact of any reclamations in Mahim Bay,

particularly on the estuary motion in Mahim Creek, and zone of influence of Mithi River in its own watershed will have to be properly analyzed. If the above studies indicate that flooding risks are likely to be aggravated. Proper remedial measures will have to be undertaken well in time.

(j) As stated earlier, the spillway discharges from the Tulsi, Vihar, and Powai Lakes meet the Mithi River at its points of origin. The FSL (full supply level) of the Tulsi Lake is 114.74 m GTS. Presently, the dam has two ungated spillways. One spillway at crest level is situated at 115.42 m GTS. This spillway discharges into Dahisar River. The other spillway at 114.74 m GTS discharges into Vihar Lake. The FSL of the Vihar Lake is 56.21 m GTS and foot of the dam is 27.36 m GTS. This dam is also having ungated (*i.e.*, unregulated) spillway. The Vihar Lake spillway discharges into Mithi River. The FSL of the Powai Lake is 94.97 m GTS. This spillway discharge also meets Mithi River.

It is crucial to study the hydraulics and environmental context of these lakes to investigate possibility of providing a "river flushing system" for Mithi River by providing 0.6 m gates at the Vihar and Powai Spillway Dams. Our preliminary calculations suggest that about 2,700 ML of volume may be made available for river flushing. This water could be made available for improving riverine status of the Mithi River after the rainy season (October to May). A flowing river channel is an added environmental asset for the city. A technical review of the management of these lakes will be desirable. A flood warning system – emanating from Vihar and Powai Lakes will also have to be in place along with such upgradation of the role of the reservoirs.

7.2.2 Dahisar River

No.	Particulars	Description
1.	Name of River	Dahisar
2.	Point of Origin	Tulsi Lake (within the Sanjay Gandhi National Park), Borivli (East)
3.	Length in km (approximate)	12 km from the Origin to the Mouth
4.	Areas (locations) through which the River flows	National Park, Sri Krishna Nagar, Daulatnagar, Leprosy Colony, Kandar Pada, Sanjay Nagar, Dahisar Gaonthan
5.	Major nallas associated with the River within the catchment area	Rawal Pada Nalla, Chandawarkar Lane Nalla, Ghartan Pada Nalla, Bhayander-Mira Nalla
6.	Meeting point	Bhayander Creek (*i.e.* Manori Creek)
7.	Total Catchment area	3,488 ha (catchment number 203 as described in the BRIMSTOWAD report Table A7.1, page ES-14)

No.	Particulars	Description
8.	Potential Risk Zones (map)	“Slums” which are prone to flooding: Locations are (a) Bablipada near Sub-way, Dahisar (East); Abhinav Nagar, Charkop; (b) Ghartanpada near Vaishali Nagar, Dahisar (East); (c) Rawal Pada (Maruti Nagar Road, Konkanipada), Dahisar (East); (d) Devipada, Near Western Express Highway, Borivli (East), (e) Jivlapada, Near Western Express Highway, Borivli (East), Nutan Nagar, Harijan Wada, L.T. Road, Borivli (West); (f) Babhai Gaonthan, L.T. Road, Borivli (West).
		“Low-lying areas”: which are prone to monsoon flooding: Locations are (a) Areas near Gorai Creek, i.e., Gorai II – Sector No. 2,3,5,6; (b) Mhatre Nalla at Mhatre Wadi, S.V.Road, Borivli (West); (c) Main Kasturba and 7th Kasturba Cross Road, Borivli (East).
		“Chronic drainage choking sites”: Locations are (a) Jivlapada, Borivli (East), and (b) Ganesh Nagar, Near Western Express Highway, Borivli (East),
		“Prone to cyclones/srong wave action in monsoon”: Locations are (a) banks of Dahisar River at Sri Krishna Nagar, Dhobi Ghat, Ambawadi, Daulat Nagar, Dahisar (East), (b) Rawal Pada, Dahisar (East); (c) Eksar Village – Talepakhadi, Borivli (West) and (d) Kandar Pada, Dahisar (West).
9.	Urban Practices and Activities Responsible for Environmental Degradation	Narrowing of the banks for housing: Location is Leprosy Colony, located between Dahisar and Borivli, and Tabelas
		Diversion of River flow due to dumping of construction debris/solid waste/industrial waste: Region from Western Railway Tracks on Dahisar West up to Dahisar Bridge.
		Dumping of solid waste generated at Stables: Stables bear Daulat Nagar and areas near S.V.Road (Leprosy Colony).

10.	Major impact of July 26 incidence	
	(i) Economic Losses	During the Deluge, about 10,000 houses and shops in Rawal Pada, Ghartan Pada and Sri Krishna Nagar were badly affected (submerged) causing heavy losses. The level of water in this region was about 2.5 m. Various locations such as Daulat Nagar, Leprosy Colony, Mhatre Wadi and Kandar Pada were completely submerged (the high tide also played major role in the incidence and water rose up to 3 m in these areas The need for tide regulatory gates at the mouth of the river should be investigated thoroughly.
	(ii)Social Impact	Thousands of families living below poverty line became shelterless overnight, losing entire livelihoods.

Land use / land cover area for Dahisar River Catchment estimated from IRS data of February-April, 2005 [Adapted from Table 4.4 on page 4-7 reported by WAPCOS, 2005]

Sr. No.	Class	Area in ha	% of total area
1	Slum (Dense Built-up Land)	376	9
2	Built-up (Spare)	650	15
3	Dense Vegetation / Forest Cover	842	20
4	Spare Vegetation	1,344	32
5	Barren Land	208	5
6	Land with Grass / Rough Pasture	309	7
7	Mangrove Forest	294	7
8	Marshy Vegetation	9	0
9	Exposed Rock	157	4
10	Water Body	37	1
	Total	**4,226**	**100**

As seen from the above table, dense vegetation / forest cover and spare vegetation (Sr. No 3 and 4) are special assets of the Dahisar River catchment. They will have to be allowed to play their desired proper role in the environmental behavior of the basin. Ponding facilities in the area of category 4 will be a welcome feature in the long-term sustainability of the basin and the quality of life in the ponds neighborhood area. Detailed studies in that context will have to be undertaken.

Encroachments in the riverbed as well as on the banks of this river has choked and pinched the watercourse and aggravated the risks of flooding. The field observations indicate that this river is also suffering from debris dumping (from construction activities as well as industrial wastes) on the banks, and dumping of municipal solid wastes into river coupled with inadequate annual desilting efforts. Ingress encroachments from the banks (building, industries, and slums) as well as modification of river-course and local diversion of streams have compounded the risk of flooding. Some of the glaring encroachments are: Bridge along Dahisar River between Western Express Highway and S. V. Road, Marble Shop near Western Express Highway, Leprosy Colony, slum pockets between Bhagwati Hospital and Rustamji Park, and Ranchhoddas Marg. This is not a comprehensive list. The assessment of flow obstructions and encroachments will have to be taken up on the priority basis so that those could be cleared immediately.

7.2.3 Poisar River

No.	Particulars	Description
1.	Name of River	Poisar
2.	Point of Origin	Sanjay Gandhi National Park near Appa Pada and Kranti Nagar, Kandivli (East) which is also the boundary of R South and P North Wards of MCGM
3.	Length in km (approximate)	7 km
4.	Areas (locations) through which the River flows	Appa Pada, Kranti Nagar, Kurar Village, Hanuman Nagar, Thakur Complex, Mahindra & Mahindra establishments (near Western Express Highway), Poisar
5.	Major Nallas associated with the River within the catchment area	Samta Nagar Nalla (324 m), Thakur Complex Nalla (170 m), Asha Nagar Nalla (456 m), Joglekar Nalla (2790 m), Magitia Nalla (817 m), Kamla Nehru Road Nalla (2429 m), Vickers Spery Nalla (258 m) (some of the local names of the nallas are also listed below: Kurar Nalla, Pushpa Park Nalla, Irani Wadi Nalla, Joglekar Nalla and about four Nallas in Hanuman Nagar)
6.	Meeting point	Malad Creek.
7.	Total Catchment area	2,095 ha (catchment number 211 as described in the BRIMSTOWAD report Table A7.1, page ES-14)

No.	Particulars	Description
8.	Potential Risk Zones (map)	"Slums" which are prone to flooding: Locations are (a) Abhilakh Nagar (b)Sunder Nagar near Raheja Nalla, Malad; (c) Sai Nagar,Kandivli (West); (d) Lalji Pada, Kandivli (West); (e) Irani Wadi near ahagirdar Estate, Kandivli (West); (f) Mahavir Nagar, near Dahanukarwadi, Kandivli (West);(g) Dahanukarwadi, Kandivli (West).
		"Low-lying areas" prone to monsoon flooding: Locations are (a) Poisar Village and Lalji Pada, Kandivli (West); (b) Parts of Dahanukar Wadi, Kandivli (West); (c) Babrekar Wadi, Kandivli (West); (d) parts of Sai Nagar, Kandivli (West); (e)Charkop Sector I and II and Gorai, Kandivli (West); (f)Ram Nagar, Kandivli (East).
		"Chronic drainage choking sites": Locations are (a) Charkop - Sectors 1 to 8; (b) Zopadpatti (slums) of Ganesh Nagar; (c) Ekta Nagar; (d)Poisar Village; (e) Ekveera Devi; (f) Gamdevi Road
		"Prone to cyclones/ strong wave action in monsoon": Locations are (a) Lalji Pada, (b)Ekta Nagar, (c) Abhilakh Nagar, Kandivli (West); (d)Valnai, Malad (West).
9.	Urban Practices and Activities Responsible for Environmental Degradation	Narrowing of the banks for housing: Locations are (a)Appa Pada and Hanuman Nagar, (b) Poisar Village, (c)1ari Mari Mandir, S.V. Road, (d) Dahanukarwadi, (e)Lalji Pada, (f) Abhilakh Nagar, (g) Irani Wadi, (h) EktaNagar, Kandivli (West); (i) Valnai, Malad (West).
		Reclamation of River bed for industrial units: Small unitsare located near (a) Lalji Pada, Kandivli (West) and (b)Valnai, Malad (West).
		Unorganized growth of livelihood activities along the banks as well as slum encroachment, stables and unplanned housing development. Reclamation of secondary channels of the River at Hanuman Nagar (Kandivli - East), Lalji Pada and Irani Wadi (Kandivli - West), and Valnai (Mal ad - West) has led to complete disappearance (original could be seen in the 1964 town planning maps).
		Reclamation of secondary channels of the River at Hanuman Nagar (Kandivli - East), Lalji Pada and IraniWadi (Kandivli - West), and Valnai (Mal ad - West) hasled to complete disappearance (original could be seen inthe 1964 town planning maps

No.	Particulars	Description
10.	Major impact of July 26 incidence	
	(i) Ecological Changes	Mangroves stand in the downstream region of the River near Ekta Nagar (Kandivli - West) and Valnai (Malad - West). The role of these mangroves with respect to the flushing capability of the river channel will have to be properly analyzed and their size and extent regulated accordingly.
	(i) Economic Losses	The areas such as Hanuman Nagar, Kranti Nagar, AppaPada, part of the Kurar Village, Poisar Village,Dahanukarwadi, Irani Wadi, Abhilakh Nagar, EktaNagar, Lalji Pada, and Valnai were severely affected.More than 35,000 houses were submerged for more thantwo days. More than 5000 families (more than 20,000people) became shelterless overnight. Apart from the above, one of the big industries namelyMahindra and Mahindra suffered heavy losses since theCompany premises including its Shop floor weresubmerged under flood water. The production was halted for few weeks.
	(iii) Social Impact	The people residing in the slums of this region belong to the category of carpenters, mesons, coolies, porters and meet their basic livelihood demands on daily earnings. More than 40,000 such 'workers' remained jobless for more than a month.

Land use / land cover area for Poisar River Catchment estimated from IRS data of February-April, 2005 [Adapted from Table 4.5 on page 4-7 reported by WAPCOS, 2005]

Sr. No.	Class	Area in ha	% of total area
1	Slum (Dense Built-up Land)	419	18
2	Built-up (Spare)	823	35
3	Dense Vegetation / Forest Cover	74	3
4	Spare Vegetation	633	27
5	Barren Land	206	8
6	Land with Grass / Rough Pasture	137	6
7	Mangrove Forest	0	0
8	Marshy Vegetation	0	0

Sr. No.	Class	Area in ha	% of total area
9	Exposed Rock	56	2
10	Water Body	22	1
	Total =	2370	100

As seen from the above table, future use of the area of spare vegetation (category 4) will have to be carefully planned with respect to the ecological long-term sustainability of the Poisar Basin's eco system. (any special comment in BRIMSTOWAD ?)

Encroachments in the riverbed as well as on the banks of this river has choked and pinched the watercourse and aggravated the risks of flooding. The field observations indicate that this river is also suffering from debris dumping (from construction activities as well as industrial wastes) on the banks, and dumping of municipal solid wastes into river coupled with inadequate annual desilting efforts. Ingress encroachments from the banks (building, industries, and slums) as well as modification of river-course and local diversion of streams have compounded the risk of flooding. Some of the glaring encroachments are: Slum colonies for Wadarpada cemetery up to Hanuman Nagar Road, encroachments from Gaondevi to east of railway track, encroachments in Poisar Village between east of railway track and S. V. Road (slums and tablelas), encroachment near Narwade School (Tulsakar Wadi), Lalji Pada, Valnai, and Abhilakh Nagar. This is not a comprehensive list. The assessment of flow obstructions and encroachments will have to be taken up on the priority basis so that those could be cleared immediately.

7.2.4 Oshiwara River

No.	Particulars	Description
1.	Name of River	Oshiwara
2.	Point of Origin	Aarey Milk Colony, Goregaon (East)
3.	Length in km (approximate)	7 km
4.	Areas (locations) through which the River flows	Aarey Colony, Pahadi Area, Western Express Highway,Walbhat Road, Jawahar Nagar Slums, Ram Mandir Road , Oshiwara, Bohri Compound, Areas between Motilal Nagar and Hindu Cemetery, area behind BEST Depot, region along the "K" West and "P" South Ward boundaries, Link Road, Malad Creek.
5.	Major Nallas associated with the River within the catchment area	Majas Nalla (originates in Jogeshwari (East), also meets the Oshiwara River at Goregaon - East), Excel Nalla, Gogatewadi Nalla, Prem Nagar Nalla,

No.	Particulars	Description
		Shastri Nagar Nalla, Bimbisar Nagar Nalla.
6.	Meeting point	Malad Creek.
7.	Total Catchment area	2,938 ha (catchment number 217 as described in the BRIMSTOWAD report Table A7.1, page ES-14)
8.	Potential Risk Zones (maps)	"Slums" which are prone to flooding: Locations are (a) Slums near Walbhat Road(Goregaon - East); (b) Slums near Jawahar Nagar(Goregaon - West); (c) Slums of Bhagat Singh Nagar(Goregaon- West, on Link Road).
		"Low-lying areas" prone to monsoon flooding: Locations are (a) Siddhartha Nagar;(b) Motilal Nagar; (c) Bhagat Singh Nagar Slums; (d)BEST Colony; (e) Ram Mandir Road industrial area. All these locations are in Goregaon (West).
		"Chronic drainage choking sites": Locations are Ram Mandir Road and Siddhartha Nagar in Goregaon (West).
		"Prone to cyclones/ strong wave action in monsoon": Locations are (a) Shaheed Bhagat Singh Nagar, on Link Road opposite BEST Bus Depot;(b) Indira Nagar Goregaon (West) and (c) Lakshmi Nagar, Goregaon (West).
9.	Urban Practices and Activities Responsible for Environmental Degradation	Narrowing of the banks for housing: Locations are (a) Jawahar Nagar, Goregaon (West); (b) Bhagat Singh Nagar, Goregaon (West); (c) BEST Colony, Link Road, Goregaon (West).
		Encroachment of River bed for industrial units: Locations are (a) Industrial establishments (small scale) located along the I.B. Patel Road and Walbhat Road (Goregaon-East); (b) Ram Mandir Industrial Estate, Goregaon(West).
		Obstructions of River flow due to dumping of construction debris/ solid waste/ industrial waste: Locations are (a) S.V. Road Bridge at Oshiwara; (b) Ram Mandir Road, Goregaon (West).
		Dumping of solid waste generated at Stables: Locations are (a) Walbhat Road, Goregaon (East); (b) Ram Mandir Road, Goregaon (West).
10.	Major impact of July 26 incidence	
	(i) Ecological Changes	Loss of extensive mangrove stands in the down stream region of the River behind Bhagat Singh Nagar, Goregaon (West).

No.	Particulars	Description
	(i) Economic Losses	The catchment areas of the River is conspicuous with establishment of various housing colonies of middle income groups, particularly Jawahar Nagar, Siddhartha Nagar, BEST Colony, Motilal Nagar and Bhagat Singh Nagar. The water of high intensity floods that occurred on July 26 entered all these areas and submerged the residents. Moreover, the small-scale entrepreneurs in the Walbhat Road region (Goregaon - East) and Ram Mandir Road (Goregaon - West) suffered heavy losses.
	(iii) Social Impact	The Stable-based economy of the local area (Walbhat Road and Ram Mandir Road areas) collapsed due to the deluge. Most of the buffalos (almost 1400) drowned in the floods due to which the people suffered heavy capital losses. The indirect impact of this calamity also affected most of the residents in the Goregaon region due to paucity of milk and milk based products.

Land use / land cover area for Oshiwara River Catchment estimated from IRS data of February-April, 2005 [Adapted from Table 4.6 on page 4-8 reported by WAPCOS, 2005]

Sr. No.	Class	Area in ha	% of total area
1	Slum (Dense Built-up Land)	793	23
2	Built-up (Spare)	1054	30
3	Dense Vegetation / Forest Cover	96	3
4	Spare Vegetation	549	16
5	Barren Land	136	4
6	Land with Grass / Rough Pasture	699	20
7	Mangrove Forest	96	3
8	Marshy Vegetation	0	0
9	Exposed Rock	0	0
10	Water Body	51	1
	Total =	**3474**	**100**

As seen from the above table, spare vegetation and land with grass / rough pasture (category 4 and 6) together almost account for half of the basin. Their future role in the basin's integrity will have to be carefully thought about; because they also provide the potential areas and open spaces for rehabilitation of the families and work unit from the flood risk zones on the river systems.

Encroachments in the riverbed as well as on the banks of this river has choked and pinched the watercourse and aggravated the risks of flooding. The field observations indicate that this river is also suffering from debris dumping (from construction activities as well as industrial wastes) on the banks, and dumping of municipal solid wastes into river coupled with inadequate annual desilting efforts. Ingress encroachments from the banks (building, industries, and slums) as well as modification of river-course and local diversion of streams have compounded the risk of flooding. In the case of this river, too, a detailed assessment of flow obstructions and encroachments will have to be taken up on the priority basis so that those could be cleared immediately.

7.2.5 Coastal Zones and Mangrove-Ecosystem

Beyond the well defined four basin areas described above, there are some hydraulically sensitive zones on the coasts of Mumbai. The following account of those coastal zones and mangrove ecosystem have been included here for shake of the completeness of the discussion on aquatic subsystem in and around Mumbai.

No.	**Particulars**	**Description**
1.	Length in km (approximate)	52 kms (approximately for Mumbai Island alone) 200 kms (approximately for MMR)
2.	Names of Bays	Mahim Bay, Haji Ali, Worli (bay like)
3.	Names of Major Creeks	Thane, Mahim, Versova, Manori, Gorai
4.	Names of Rivers	Mithi, Dahisar, Poisar, and Oshiwara
5.	Names of Major Nallas	Several nallas in suburbs joining above rivers and creeks
6.	Salt Pan	Along the eastern express highway, Anik – Wadala Road
7	Total Catchment Area	12,986 ha (*i.e.* 4,534 ha$^{\#}$ + 5,042 ha$^{\$}$ + 3,410 ha$^{@}$) see tables bellow for further details. [Source: Table A7.1 (page ES-14), Table A7.2 (page ES-15), and Table A7.4 (page ES-17) of the BRIMSTOWAD report]
8.	Names of Beaches	Girgaon, Dadar, Mahim, Juhu, Versova, Malad, Gorai, Mudh Island, *etc.*
9.	Rock-outcrops and Mudflats	Colaba, Worli, Bandra, Khar, and mudflats (*i. e.* wetland)

10.	Potential Risk Zones	Slum in Arya Samaj area, west of Gazdhar bund
		Mahim Fort,
		Abdul Court to Mahim Fort (all buildings, Mayor Bungalow, MG Swimming Pool)
		Dharavi Slum, Fisherman Colony in Mahim
		Sun and Sand Society to Versova Koliwada
11.	Urban Practices and Activities Responsible for Environmental Degradation	Disposal of wastewater, Disposal of municipal solid waste
		Reclamation for bridges, roads, buildings, *etc.*
		Mangrove deforestation, Wetland degradation
12.	Major impact of July 26 incidence	
		Appropriate studies have not yet been undertaken and enough data are not yet available except those aspects covered by the BRIMSTOWAD report for the relevant catchment.

 # Catchments of Coastal Zones in Western Suburbs of Mumbai
[Adapted from the BRIMSTOWAD report ,Table A7.1 (page ES-14)]

Catchment No.	Name of the Streams / Nalla System	Total Area (ha)	Disposal Place
201	Dhasakwadi	568	Manori Creek
202	Dahisar	52	
204	Chanda Varkar	179	
205	Mhatre	215	
206	Rajendra Nagar	242	
207	Industrial Housing	42	
208	Housing Board	62	
209	Charkop	62	
210	Charkop P.S.	88	
212	Malavani	104	Malad Creek
213	Pushpa Park	503	
214	Ram Nagar	20	
215	Piramal Nagar	457	
216	Shashtri Nagar	210	
218	Mogara	600	

Catchment No.	Name of the Streams / Nalla System	Total Area (ha)	Disposal Place
219	Irla	668	
220	Juhu SNDT	174	Original sea beach Khardanda Now extended
221	P & T	66	
222	North Avenue	23	
223	Main Avenue	19	
224	South Avenue	36	
225	Sherli Rajan	29	Sea
226	Mount Mary	15	
227	Reclamation	21	
228	Chapel Street	25	
229	Bandarwadi	54	
	Total – Western Suburbs	**4,534**	

$ Catchments of Coastal Zones in Eastern Suburbs of Mumbai
[Adapted from the BRIMSTOWAD report ,Table A7.2 (page ES-15)]

Catchment No.	Name of the Streams / Nalla System	Total Area (ha)	Disposal Place
303	Nanepada-Nahur-J&J	334	Thane Creek
305	Usha Nagar-Datar Col.	848	
309	Pant Nagar	664	
301	Boundary-Acc	574	
302	Kesar Baug	81	
304	Bombay Oxygen	269	
306	Crompton-Kanjur	558	
307	Kannamwar Nagar	74	
308	Godrej	178	
310	Somaiyya	366	
311	Subhash Nagar	356	
312	Deonar	330	
313	Mankhurd-C.A.	391	

Catchment No.	Name of the Streams / Nalla System	Total Area (ha)	Disposal Place
314	Mankhurd-P.M.G.	19	
Total – Eastern Suburbs		**5,042**	

@ **Catchments of Mahul Creek**
[Adapted from the BRIMSTOWAD report ,Tables A7.4 (page ES-17) and Table A6.3 (page ES 10]

Catchment No.	Name of the Streams / Nalla System	Total Area (ha)
500	Mahul Creek	1915
501	Nehru Nagar	717
502	not available	62
503	not available	10
504	Wadhavali	205
505	Refinery-South	189
506	not available	209
507	not available	24
509	Vashi Naka	214
510	Oswal	170

Reclamation due to construction of housing, industries, and commercial complexes along the coasts, in wetlands, creeks, and mudflats has aggravated the risk of flooding. The field observations indicate that several coastal zones are also suffering from debris dumping (from construction activities as well as industrial wastes) and dumping of municipal solid wastes as well as encroachments by slums. Some of the glaring landfilling activities have been by MHADA at Gorai, Charkop, and Versova. The impact of the reclamation conducted in Wadala area by MMRDA for Bhakti Park residential buildings and IMAX Theatre, which is in Catchment No. 500 (Mahul Creek System) needs to be evaluated. On the western side objections have been raised for Oshivara area landfilling at Lokhandwala (BRIMSTOWAD Catchment No. 218) and also in the vicinity of Oshivara River (BRIMSTOWAD Catchment No. 217). This is not a comprehensive list. The assessment of encroachments will have to be taken up on the priority basis so that those could be cleared immediately. As far as possible the landfills sites in western zones be developed as recreational areas slightly above high tide level so that they can provide space for holding flood water during measure events and help population on the upstream side.

There is one more interesting feature of hydrological interconnection of Mithi and Mahul systems. The adjoining catchments of Mahul – Nehru Nagar nalla system and Somaiyya – Reti bunder nalla (outfall to Thane creek) witnessed a similar continuous rise in flood levels during 26th and 27th July storms. Only the starting time for flooding varied marginally. Lal Bahadur Shastri Marg (*i.e.* the old Mumbai-Agra Road) is by and large along the ridge line between Mithi basin and the eastern two systems. Ground levels of Lal Bahadur Shastri Marg are between 4.0 to 4.5 m GTS in the saddle region. The general ground levels in this area are such that once floodwater in Mithi reaches a certain height (marginally above the high tide level) storm water of Mithi starts overflowing into Chunabhatti area. Kalpana Kamran system flowing across Lal Bahadur Shastri Marg also contributes to transferring of water from west of LBS to east of LBS.

Surface flows on land in Mahul and Somaiyya catchments get interconnected at Tilak Nagar and the systems are further interconnected near Kurla Terminus in railway area between Vidyavihar and Tilak Nagar railway station within railway premises and at the railway culvert between Chembur and Tilak nagar railway station. Instances of flooding near these spots due to some problems of congestion in the adjoining catchment have occurred a number of times in the past also. These were the marshy lands in the past and part of Mithi was discharging through Mahul and probably even through the Somaiyya nalla.

As a result, management of the coastal zones becomes complicated because it is not possible to physically isolate fully the three catchment systems of Mithi, Mahul and Somaiyya Reti bunder nalla and prevent inter-catchment transfer of flood water due to low level ridge lines providing easy interconnectivity. Inter catchment transfers will continue to be a recurring phenomenon under heavy storms. Hence a well-planned strategy of managing the Mithi saddle will have to be evolved keeping in view the possibility of spills and the need for adjusting the combined behavior of these connected systems.

While more stress is currently being laid on improvement for Mithi River, Mahul should not be forgotten. It would be prudent to ascertain more accurately the specific conditions of transfer of Mithi water to Mahul system and Somaiyya catchment and then to decide upon the remedial measures for improving them also on priority. The saddle zone and the Mahul Creek is a relieving feature naturally available to accommodate spillover of the Mithi River across the eastern boundary of the Mithi catchment. There is an immediate need to study this area and develop it for the purpose of relieving flood in sub-catchment numbers 501, 502, 503, 509, and 510 of the Mahul Creek System. There is strong case for renamimg the Mahul system as the "Mahul River" and manage it like a river hereafter.

7.2.6 Ponds

Ponds in Mithi Watershed estimated from IRS data of 8th March, 2004
[Reference: Table 2.2 on page 13 reported by IIT Bombay, 2005]

Sr. No.	Location of the Pond	Area (ha)
1	Tulsi	135.00
2	East of Marol-Aarey road at pipeline crossing	0.19

Sr. No.	Location of the Pond	Area (ha)
3	West of Marol-Aarey road at pipeline crossing	0.72
4	Marol	0.74
5	Vihar	726.00
6	NITIE (Between Powai and Vihar Lake)	3.81
7	Powai	223.00
8	West of Mohili	0.80
9	Mohili (bellow hill) (preset day dharka)	0.50
10	Sahar	1.18
11	East of Narayan Nagar Hill	0.86
12	West of Narayan Nagar Hill	0.70
13	Padam Talao	1.19
14	Old Kurla (Sheetal Cinema)	1.31
15	Kola Kalyan (Kalina)	10.05
	Total (ha) =	**1,106**

It can be seen from the above table that except for Tulsi, Vihar, and Powai, the pondage is very small compared to the flood flows in the basins. However, the significance of ponds is much higher in the context of flood protection in their micro-catchments and the possibility for recreation, fishing, storm retention, and even for siltation are numerous. Thus, there is a need to identify ponds in other river basin so that they can be used for improvement of community life as well as they can be saved from the pressure of urbanization.

7.3 Risk Zones to be Identified for Immediate Action

It is desirable to incorporate environmental and ecological concerns in developmental planning of Mumbai region. One important lesson we need to learn from the 26th July floods that something urgently needs to be done to ensure immediate hydraulic safety of the riverine area. The MMRDA has entrusted the study of the five major river streams to the different agencies after the 26th July floods. Amongst all the rivers of Mumbai, Mithi River happens to relatively more investigated rivers. It is the natural drainage to sea in the heart of the city – but its specific flood flow requirements remained to be adequately covered by the BRIMSTOWAD study. In fact, the earlier CWPRS study of 1978 was also supposed to address only the downstream-most 5-6 km stretch of the Mithi River Creek up to Mahim Bay. While the individual catchments in the Mithi basin were looked at adequately in the BRIMSTOWAD study, the behavior of the river system as a whole – particularly near the Airport area and its upstream - remained to be dealt with. In

this context, the following action pointers have been recommended for immediate action.

7.3.1 Long-pending works in Mithi River

There are some long-pending works in Mithi River that need to be immediately taken up. It is useful to recall that the reclamation of land for the Bandra Kurla Complex (BKC) has been subject to widening and deepening of the Mithi River being in place (among other things) as per the recommendations in the earlier CWPRS study of 1978. There was a report furnished by the Merani Committee (in 1997), which had reiterated the need for taking up such balance work. We are aware that some more studies by the IIT Bombay and CWPRS on Mithi River are in progress (initiated by the MMRDA after 26th July disaster). Based on the outcome of those studies, a time bound programme needs to be drawn up for completing the balance work to ensure immediate hydraulic safety of the river, especially the downstream-most 5-6 km stretch of the Mithi River Creek up to Mahim Bay.

The interim report on the study for Flood Mitigation Measures for the three rivers, *namely* Dahisar, Poisar and Oshiwara Rivers in North Mumbai (December 2005) by the Water and Power Consultancy Services (WAPCOS) clearly brings out that the developmental activity has resulted in reduction of the river widths. Depths have also been reduced due to dumping of debris and siltation. From their detailed tables and the Cross Sections presented in the report, it is clear that widening and deepening is essential in all these three rivers [WAPCOS, 2005]. A time bound programme needs to be drawn up for the works in other rivers also to ensure immediate hydraulic safety of the riverine areas.

7.3. 2 Demarcation of the "Flood Risk Zones"

On a more mathematical basis, the high risk areas which are bound to get affected by floods of 1 in 10 years probability and the medium risk areas with 1 in 25 years probability will have to be worked out and indicated on the DP sheets. An indicative representation of such map has been illustrated in **Drawing No. 17**. The hydraulic analysis leading to the identification of these areas has been described in the chapter on "hydraulics of the catchments and the river basins in Mumbai". It has been recommended therein that the rehabilitation of the population and work activities falling under the high-risk zones (covered by the floods from 1 in 10 year probability), shown as purple zone, should be undertaken on priority immediately. For the medium risk areas (to be affected by 1 in 25 years probability of flood), shown as red zone, environmental safeguards - such as a review of the buildings structural arrangements and conversion of land use to more safe purposes has been suggested. It is hoped that the residents and users of this zone will protect their potential risks through appropriate risk-cover insurance policies. Beyond this also, for the areas likely to be affected by the floods of lesser frequencies –up to rainfall of 1 in 100 years probability, shown as blue zone - insurance cover will protect the residents and users of this zone.

7.3.3 Channelization of Mithi and other rivers

For the Mithi River as part of the data was still awaited; only interim suggestions regarding canalization and dredging have been furnished by CWPRS in their interim

report in January 2006. They include widening of the waterway from Mahim Causeway right upto Morarji Nagar *i.e.* area below Vihar Lake and providing modified bed gradients to increase the conveyance capacity of the river which will then be able to accommodate mostly flood flow of one-in-100-year probability. Similar channelization proposal has been made by WAPCOS in the interim report on Dahisar, Poisar and Oshiwara rivers for one-in-100-year probability floods.

There are three yardsticks available for working out the land widths along the Mithi channel that will have to be assigned to the flood flow function.

a. FFC's risk zoning criteria of 1 in 10 year, 1 in 25 year and 1 in 100 year flood probabilities.

b. CWPRS recommendations (interim report of January 2006) for channelisation widths of Mithi River which is said to mostly accommodate the 1 in 100 year probability flood. The CWPRS proposal envisages substantive re-grading of the river channel in addition [CWPRS, 2006].

c. IIT-Bombay's endorsement of the decision of Government of Maharashtra ("Development of Action Plan for Environmental Improvement of Mithi River and Along Its Banks". *Final First Interim Report* by the Centre for Environmental Science and Engineering, Indian Institute of Technology – Bombay, Mumbai. 23rd February, 2006; page 156-157) of removing all structures up to 45 m width on either side along the river in two phases (in Phase-1, 15 m width shall be cleared and in Phase-2 remaining 30 m or less shall be cleared). Elsewhere in the report (pages 143-147, sub-section 7.5 on "Proposal") IIT-Bombay has proposed for provision of at least 20 m of buffer-zone on either side of the river, free from construction. The widths proposed are beyond channel widths recommended by CWPRS.

In our opinion, it will be desirable to immediately provide the minimum buffer-strips of 15 m on both sides of the existing Mithi channel for creating access to the channel for maintenance and management. In the meanwhile, more detailed calculations should be made with reference to the flood widths required to provide the 'prohibited zone' for accommodating the 1 in 10 year probability flood (at 70 mm/hr precipitation intensity) with existing channel gradients. Added to this will be 12 m carriageway on either side - which may be able to accommodate the additional requirement of the land width for 1 in 25 year probability flood (at 80 mm/hr precipitation intensity) along much of the river length (it will be clear only after detailed survey and calculations). Decision on re-grading of the Mithi river channel may be taken thereafter, if the above provisions are found to be inadequate.

We are of the opinion that the channel width criteria for accommodating the 1 in 100 year probability flood may be applied only to the tidal creek portion (estuarine length) which is also subjected to reclamation activities, and widening the channel to accommodate the 1 in 100 year flood should not apply upstream of the tidal portion. It must be borne in mind that such a planning of riverbanks under possibilities of risks requires general acceptability in the people also. Hence, this approach will have to be discussed with the residents on the banks of the rivers and the detailed requirements explained to them, namely: (a) 1 in 10 year flow probability risk zone to

be a prohibited zone for non-tidal portion and (b) 1 in 100 year containment approach to the tidal estuarine portions at the mouths of the rivers.

We have already recommended (elsewhere in the earlier chapters) that all the gated outfalls for catchments larger than 1,000 ha be designed for 1 in 100 year probability; to ensure that excessive choking by land encroachments does not take place near the mouths of the streams and along the shore lines. There are also stream channels in the upstream portions, which have been proposed to be regulated according to the BRIMSTOWAD standard of two submergence possibilities in a year. In addition, the possibility of containment of 1 in 25 years and 1 in 100 years floods from extensive water spreads by providing embankments beyond the prohibited zone will have also to be considered where the river is passing through flat terrain.

It must be borne in mind that considerable extent of river training will be required on both the banks of all the five rivers – because the river channels have no well-defined geometry – either in terms of channel widths or depths of their beds as can be seen from the **Drawing Nos. 18 to 25** (for the widths and longitudinal sections of the rivers). Over the reclaimed areas in particular, the rivers are spilled in the "formative" stages and will need proper containment to avoid their bank spills. The suggestions of this Committee for flood zoning of the river basin and the channelization widths proposed for the rivers in Mumbai have been summarized in the following **Table** .

Suggested Zoning and Channelization Widths of Rivers in Mumbai

River Name	**Stretch Descr-iption**	**Existing Width**	**BRIMSTO-WAD 1993 Report Width for 50 mm/hr rainfall**	**CWPRS 1978 Report Width for 60 mm/hr for 4-hr rainfall**	**CWPRS 2006 Report Width for 1 in 100 yr flood**	**WAP-COS 2005 Width for 1 in 100 yr flood**	**Criteria Recom-mended by the FFC (This Report)**
Mithi	Upstream	16-40 m	25 m*	X	50 m	X	**A** & **B**
	Middle	20-30 m	35-40 m*	X	100 m	X	**A** & **B**
	Tidal Range	30-60 m	X	1) 200 m 2) 60 m 3) X	1) 225 m 2) 100 m 3) 60 m	X	**A** & **C**
Dahisar	Upstream	8-39 m	35 m*	X	X	X	**A** & **B**
	Middle	16-44 m	40 m*	X	X	54.4 m	**A** & **B**
	Tidal Range	15-46 m	45 m*	X	X	61 m	**A** & **C**
Poisar	Upstream	8-20 m	11 m*	X	X	22.5 m	**A** & **B**

River Name	Stretch Descr-iption	Existing Width	BRIMSTO-WAD 1993 Report Width for 50 mm/hr rainfall	CWPRS 1978 Report Width for 60 mm/hr for 4-hr rainfall	CWPRS 2006 Report Width for 1 in 100 yr flood	WAP-COS 2005 Width for 1 in 100 yr flood	Criteria Recom-mended by the FFC (This Report)
	Middle	7-23 m	20 m	X	X	28.5 m	**A** & **B**
	Tidal Range	11-38 m	29 m	X	X	33 m	**A** & **C**
Oshi-wara	Upstream	12-19 m	30 m (Walbhat Branch)	X	X	21 m	**A** & **B**
	Middle	19-35 m	42 m	X	X	37 m	**A** & **B**
	Tidal Range	32-52 m	46 m	X	X	47.2 m	**A** & **C**
Mahul	Upstream	8-10 m	15 m	X	X	X	**A** & **B**
	Middle	15-18 m	25 m	X	X	X	**A** & **B**
	Tidal Range	8-20 m	35 m	X	X	X	**A** & **C**

Notes:

All widths are at ground level as per respective studies.

* Minimum recommended widths after widening. In addition, there will be 6 m carriageway on either side.

X Not worked out case.

A Stage 1: Immediate Action:
Existing constricted width of water channel plus 15 m buffer strip on either side to be cleared immediately and maintained open and free from any intrusion.

B Stage 2: Further Detailed Planning and Action for Rivers:

i. For Prohibited Zone: Required channel width to be worked out finally for 1 in 10 year probability flood (70 mm/hr rainfall) plus 12 m carriageway / service road on either side. This is likely to need 10% to 30 % more width than in the BRIMSTOWAD report, depending on the re-graded bed slopes.
ii. For Restrictive Zone: For 1 in 25 year probability flood (80 mm/hr rainfall) to be demarcated for regulated constructions
iii. For Risk Zone: For 1 in 100 years probability flood (100 mm/hr rainfall) width to be demarcated.

C Stage 2: Further Detailed Planning and Action for Tidal Zone:

Channelisation for 1 in 100 years flood probability plus 12 m carriageway / service road on either side prohibited for any intrusion. This is likely to need 30% to 50 % more width than in the BRIMSTOWAD report, depending on the re-graded bed slopes.

7.3. 4 Survey of the residents and property owners in different flood risk zones

In addition to the above recommendations for immediate action, efforts have been made to be made to list the residents and occupants in the flood risk zones in each river system. The following **Table** highlights the areas of concern expressed by the community, social activists as well as by the municipal officials. It should be recognized that the list presented in the following table is not a comprehensive list. It is meant to serve merely the indicative purpose. It might be advisable to start flood risk assessment of these areas in details and articulate an action plan for minimization of risk to the community and property on the banks of the rivers. It is strongly recommended that these communities be made aware that they are living in the flood plains of the rivers and their risks could be unbearable in times to come unless they plan to get rehabilitated in time. The rehabilitation plans need to be chalked out in consultation with them in transparent manner by addressing their concerns appropriately. The plans will have to be implemented on priority basis. A detailed discussion and recommendations on several other issues associated with urban governance and resettlement has appeared in Chapter 9 as well as Appendix 9 E of this report.

Name of River	The Risk Areas	Brief Description
1. River: BRIMSTOWAD catchment number 400 and many other sub-catchments [See BRIMSTOWAD report, Tables A6.3 (page ES-10) and A7.3 (page ES-16) or see the table in the section on Mithi River appeared earlier in this Chapter.]	Airport area, LBS Road, Chunabhatti, Nehrunagar, Suman Nagar, Bharat Nagar, Kurla-Andheri Road, Kalina, Air India Colony, Indian Airlines Colony, Bail Bajar, Fauzia Hospital, Sheetal Cinema, Kalpana Talkies, Samarth Nagar, Sahkar Nagar, Tilak Nagar, Kurla Car Shed, Brahiman Wadi, Pestam Sagar in Chembur, Government Colony, Sahitya Sahawas, Kalanagar in Bandra, Aadi Sankaracharya Marg, Saki Vihar-Road in Powai	Several cases are subjudice in regards to bottlenecking, encroachments, pollution and waste dumping into Mithi River. As a result, several agencies have initiated studies on these aspects and various actions have been initiated as per the court directives. Besides, the hydraulics of Mithi River Catchments is complicated due to inter-basin transfers, encroachments, obstruction due to variety of land use, *etc.*

Name of River	The Risk Areas	Brief Description
2. Dahisar River: BRIMSTOWAD catchment number 203	Sri Krishna Nagar, Abhinav Nagar and Dhobhi Ghat Slums, Borivli(East)	These areas are located near the boundary of Sanjay Gandhi National Park and face severe risk of floodwaters, even due to heavy rains.
	Rawal Pada, Ghartan Pada, Dahisar - East (to the East of Western Express Highway)	These areas are not in the immediate vicinity of the River banks; however, fall in the catchment areas of the River. In these areas, huge slums have encroached various Nallas (namely Rawal Pada Nalla and Ghartan Pada Nalla) that are subsidiaries of the River.
	Daulat Nagar andLeprosy Colony (Borivli - East);Mhatre Wadi - Dahisar (West)	The Leprosy colony is located near the Railway Tracks and S.V. Road belowflyover bridge, which along with MhatreWade and its surroundings fall in low-lying areas.
	Kandar Pada	Along both the banks of the DahisarRiver from Leprosy Colony up toKandar Pada, slums have come up,obstructing the flow of the River.
3. Poisar River: BRIMSTOWAD catchment number 211	Appa Pada, Hanuman Nagar, Poisar Village (Kandivli - East), Dahanukarwadi, Irani Wadi, LaljiPada, AbhilakhNagar (Kandivli-West) and Valnai (Malad - West),	These areas are located along the River,and possess highest population density.
	Kurar Village,Malad (East)	These areas are in the catchment regionof the River, though not directlyadjoining the River banks.

Name of River	The Risk Areas	Brief Description
	Poisar (East) slums(Kandivli - East).	This slum area is in the low-lying tracks along the River and possesses considerable risk during heavy showers of Monsoon.
	Thakur Complex (Kandivli - East).	The River in this region has been converted into a Nalla, when the construction of Thakur Complex was undertaken. This area gets invariably flooded even in normal monsoons.
4. Oshiwara River: BRIMSTOWAD catchment number 217	Shaheed Bhagat Singh Nagar, Motilal Nagar (bothlocated in oregaon - West).	These are residential areas that fall in the low-lying catchment.
	Walbhat Road egion (Goregaon-East) and Ram Mandir Road Region (Goregaon -West)	These are industrial areas and also stable areas
	Siddhartha Nagar, BEST Colony, both located in Goregaon (West).	These residential areas have externalwater drainage systems through narrow Nallas that pose a greater threat offlooding the region in heavy rains.
	Jawahar Nagar Slums, Goregaon (West).	The Slums located right on the Riverbanks pose a risk of getting affected by the floodwaters. The untreated discharge of sewerage also threatens the areas with health hazards.

All the actions discussed above will indisputably have environmental and ecological impacts including the impact on mangrove ecosystem. Similarly, residents and occupants in the flood risk zones will have to be removed for their own safety and safety of others in the vicinity. These impacts should be categorically analyzed scientifically on priority basis so that compensatory remedial measures could be

provided simultaneously. More importantly, the principles of "compensatory pre-forestation" (in case of mangroves, vegetation and ecosystem components) and "prehabilitation" (in case of residents and occupants in the flood risk zones) should be adopted.

7.4 Framework for Addressing Environmental Challenges in Mumbai's Urban Management

If the Mumbai's peoples are to enjoy a high quality of life, we must move quickly toward a sustainable future. Mumbai's aquatic systems will have to be managed keeping the principles of sustainable development in view and encouraging wide participation through, partnerships and networked institutions. Key to sustainable development is the empowerment of the residents through action-oriented partnerships at all levels. Some important elements of the framework for addressing environmental challenges in Mumbai's urban management are listed below:

7.4.1 Sustainable development should be our ultimate objective. *Sustainable development* is a process of achieving human development (widening or enlarging the range of peoples' choices) in an inclusive, connected, equitable, prudent, and secure manner [UNDP, 1994]. Advanced Locality Management (ALM) groups could be an effective mechanism in that direction. Their role in urban governance has been discussed in relevant chapter on that topic.

7.4.2 Adoption of "polluter pays principle" should be integrated into planning and decision making process because it promotes internalization of the environmental costs. The polluter should, in principle, bear the costs of remediation and control of pollution, so that the polluter will eliminate or minimize emissions and imposition of controls would always prove to be the least-cost option. The sense of shared responsibility for river cleanups will also have to be strengthened through the public activities of ALM groups. Without adequate treatment to effluents (collectively or individually) no effluent should be disposed into stream channels.

7.4.3 Adoption of "precautionary principle" should be central to preventive approaches. This principle dictates that in the situations of incomplete data or understanding, one shall take a path that is more precautionary than any other less precautionary plausible alternative. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing applications of measures to prevent environmental degradation. Hence, immediate evacuation of 1:10 year rainfall probability flood zone on both banks of the rivers and regulation of 1:25 year rainfall probability flood zone on both banks of the rivers is necessary on priority basis. More an island like Mumbai, the possibility of increased frequency of intense precipitation and sea-level rise on account of global warming has to be kept in view in the long range planning of the city. Developmental plans and the land use Maps of the city should accordingly clearly show the flood risk zone and the probable impact areas of sea level rise. In the past, this has not been done in DP maps of Mumbai and hence ought to be immediately reviewed in this context.

7.4.4 "Ecosystem services" are not adequately quantified in commercial markets and are often given too little weight in policy decisions objective. As a result, economic implications of environmental damage and costs of degradation of natural resources and common property continue to be the "externalities" in our

economic analysis. But the quality of the city life very much depends on the ecosystem status – weather of the landmass, water bodies or the air and the vegetation and biotic life around. Stream flows, ponds, river flows, shorelines, parks, forests have a great role to play in this respect. Hence their specific location *vis a vis* necessary protective measures for them must be fully defined in the land use plans and DC rules, because they are public goods and it is the collective responsibility.

7.4.5 The "system's approach" and "watershed" based development planning can ensure sustainable development of urban habitat and security against deluges as occurred on 26 July 2005. We all know that the quality of life in our urban settlements has been declining due to progressive deterioration of lakes, rivers, and coastal zones. In addition, it is well known that these small streams and wetlands have historically protected the communities from flooding (to an extent) by the virtue of their carrying capacities. BRIMSTOWAD report had provided a well-defined catchment-based approach to the management of storm waters in Mumbai – which was absent in the past.

While other measures for civil life could possibly be handled at least partly on the basis of administrative jurisdictions such as wards, storm water management has necessarily to be handled on the basis of a natural environmental unit as a catchment / watershed. Hence, the approach lead out in the BRIMSTOWAD report need to be pursued and strengthened.

People living in the catchments should be able to clearly identify themselves as belonging to that catchment and understand the natural upstream downstream relationship also. They get impacted and they also impact others. Hence, together they have developed and organized themselves in a watershed / catchment area community and decide as to how they would like to live in the context of flood risks and quality of the stream flows that they have to see and experience in their everyday life.

Because of absence of this realization, ALM groups have not been able to identify themselves with well-defined catchments / watersheds outlined in BRIMSTOWAD report. Hence, a mass campaign for clarifying and strengthening this relationship needs to be undertaken in Mumbai immediately. The neglect of the watershed – solid waste disposal, congestion of stream channels, and chocking of cross drainage works by debris, plastic bags and washed of garbage led to excessive submergence resulting in to risk to life and property. Partly, this was the out come of the catchment's own misdeeds.

There will have to be THREE core components of the aquatic ecosystem rejuvenation program for Mumbai. Firstly, there has to be a clear realization and awareness about the inputs meeting the aquatic ecosystems including garbage, effluents, and solid wastes. That is expected to change the behavioral response of the catchment community.

Second step thereafter is to look at the condition and status of the aquatic ecosystem's infrastructure. The polluted and degraded aquatic ecosystem typically has huge accumulation of contaminated sludges and sediments due to the prolonged abuse of the ecosystem through disposal of untreated and partially treated municipal and industrial wastewaters as well as disposal of municipal garbage and

solid wastes. This has happened in Mithi, Dahisar and most of the river channels and stream estuaries around Mumbai Mudflats near Cheeta camp and Mankhurd is such a case in point.

It is necessary that the aquatic ecosystem rejuvenation program addresses this issue of "accumulated contaminated sediments" in the ecosystem and systematically dredges them out so that a newer healthy ecosystem can be instituted. Suffering of dysfunctional water body is aggravated by poorly designed or dilapidated gates, protective dykes and walls, and broken / spoiled edges of the aquatic ecosystem. There is a great urgency of incorporating the activities of designing and commissioning of all the above-mentioned components of ecosystem infrastructure in the context of the aquatic ecosystem rejuvenation program along with a systematic river front development programs at least for the major rivers and estuaries

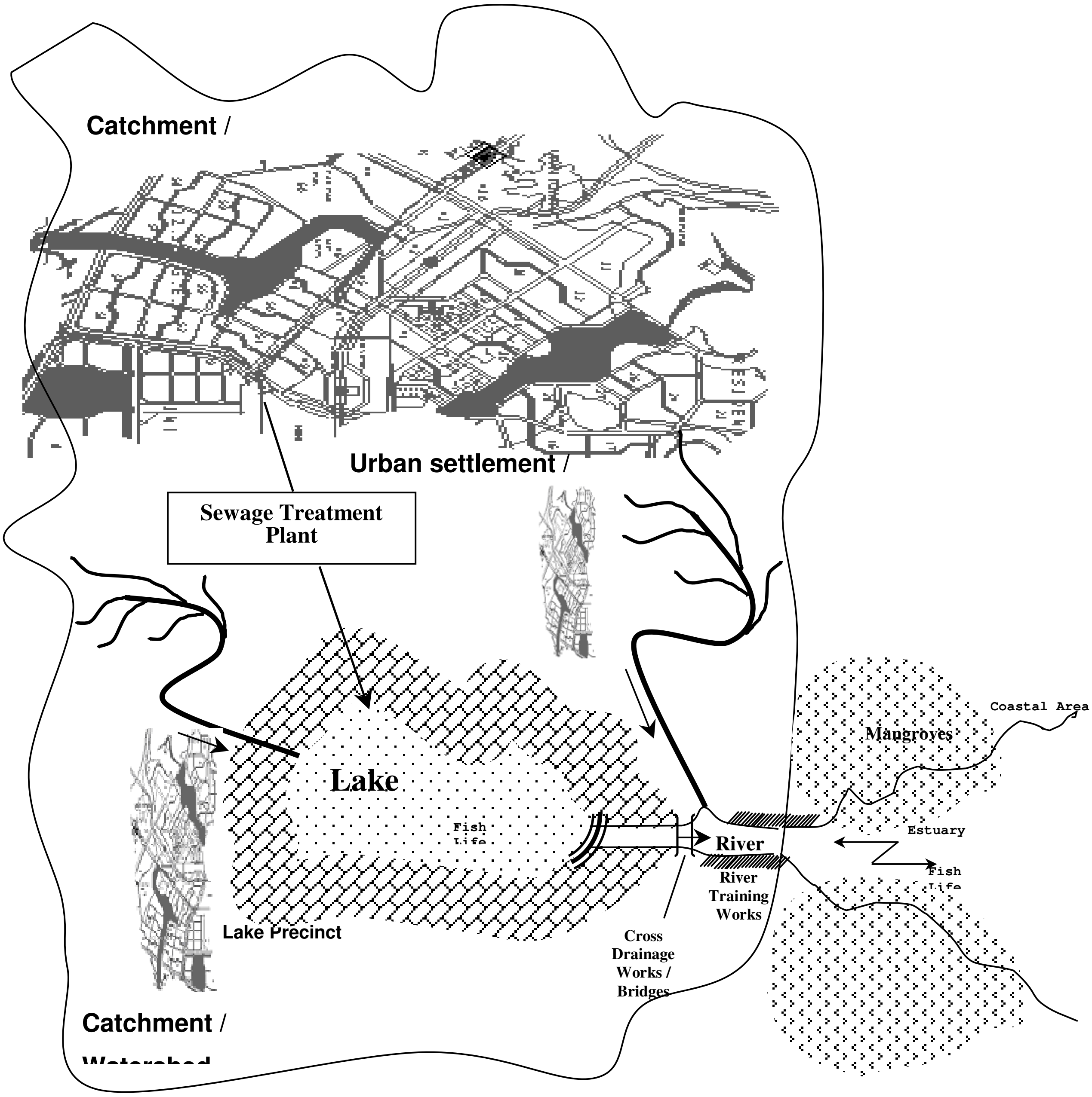
Third, the attention is to be paid to all the deficiencies in the existing water management practices of the ecosystem. Presumably, those wrong practices have lead to drying/flooding of the aquatic ecosystem and malfunction of the ecosystem infrastructure. Mixing of sewage and storm water flows have aggravated the silting processes at the outfalls and in the estuaries. Our committee has therefore insisted on separation of sewage and storm water drainage and their appropriate safe disposal.

It is therefore critical that the *Aquatic Ecosystem Authority* (*e.g.* Mithi River Authority) and *user community* (catchment community / ALM groups) together decide about correct practices to be adopted for the gainful use of the water body and the steam channels. Implications of all inputs and outputs of the ecosystem in the context of its rejuvenation program will have to be understood by all the stakeholders.

A schematic layout of a typical urban aquatic ecosystem in Mumbai to be subjected to rejuvenation and management program has been presented in the figure given bellow. It can be noticed from the figure that, by and large, any aquatic ecosystem can be sub-divided into four subsystems *namely*: (1) upstream watershed, (2) mid-course settlement areas, (3) the water body including river channels, and (4) the areas at the mouth of the rivers and estuaries. Clearly, if one wants to protect and improve a given aquatic ecosystem, interventions will have to be made in all the subsystems of the ecosystem with a proper systematic approach. Each subsystem has a distinctive role to play. Relevant environmental factors will have to be woven together in the respective subsystems in the most beneficial manner.

Extensive tree covers are most welcome in the upstream zone in particular for reducing the flood emanating potential of the basin. Grassland and ponds are most welcome in the mid course areas for arresting the gush of water. Flood zoning regulations for the land use patterns are a must along the river channels. Mangroves are most welcome along the open sea face coastlines, but could be a hindrance to the free flow of floodwaters – particularly where the stream channel is already choked. The objective is to restrict and hold back the flows in the first two ecosystems and to make it flow smooth without "increased rugosity – in the next two downstream ecosystems. Land use pattern will have to be regulated accordingly. Ground water has been a relatively "weaker" – smaller element of the aquatic ecosystem of Mumbai because of the geological rock formation and the narrow

coastal strips. But, its quality - for whatever quantity happens to be available – needs to be protected vigilantly. Disposal of the industrial effluents, raw and partially treated sewage and sullage and solid wastes and debris in the two upstream ecosystem zones has been damaging the ground water and reducing its utility to the society. Regulations will have to be strictly implemented to avert this continuing damage.



Environmental Relationships in an Urban Aquatic-Ecosystem

7.5 Recommendations

In the context of 26th July flood, the social and political reactions have been rather sharp and emotional, trying to do anything and everything to avoid the kind of flooding experienced due to the unprecedented heavy rains. A measured, well thought-out plan and interventions, however, should in fact address the issues of frequently encountered floods in Mumbai region, land use planning, encroachments, population density, sustainability of present-day exploitation of water and natural resources. In this direction, the following course of action for systemic changes and improvement in management practices will have to be followed for improved environmental integrity and upgradation so as to achieve sustainable development of Mumbai.

Recommendation 1: First, restore the existing degraded rivers and river-banks to initiate recovery of the urban ecosystem.

Mithi River is not shown on several ward maps and development plan (DP) sheets. It is even named as Mithi Nalla if at all it appears on the plan sheets. Hence, the first step should be to reinstate each river, nalla, and lake or pond in its rightful place into the respective DP sheets at once. Although, up scaling of the river-courses should be the ultimate objective of the environmental improvement program, the first step should be the restoration of river channels and riverbanks. Restoration will have to be achieved by implementing the following action plan:

1. Investigate the pollution loads and encroachment problems on the banks of rivers and in coastal zones. This needs to be undertaken before suggestions for solutions are spelled out. For example, quality and quantity of sewage, the number of nallas emptying into the river/lake/coast, existing sewage network in the area, existing industries and their pollution, the causes of flooding and the areas that are risk-prone, the number and type of encroachments (buildings and slums), *etc.* have to be ascertained. As regard the obstacles to stream flows the IIT Bombay Report [2005] as well as BRIMSTOWAD report have identified most of these elements. Removal of those obstructions should be completed immediately without further delay to restore stream flow capacities.
2. To identify the specific environmental boundaries and risk-zones of the rivers, lakes, coastal zones; especially the areas that are important for Mumbai's ecosystem.
3. To provide for buffer zones of appropriate width with unpaved pathways and green public recreation spaces on both banks of the rivers and lakes (precinct development).
4. To provide access ramps into rivers from major roads and at critical location to ensure proper disilting.
5. To provide vegetation on hill slopes, check dams and contour bunds for rivers at appropriate locations allowing for the formation of ponds to slow down the pace of water flow during the monsoon.
6. To provide bio-gas plants by the owners of stables from which methane gas as well as manure can be generated and sold (or utilized). This could in fact bring financial incentive for the stable owners. It is high time that the stable-

owners take responsibility of waste management and MCGB implements (and even make some appropriate new) by-laws and ensure compliance.

7. The implementation of the proposed plan for restoration may be undertaken by encouraging adoption of portions/stretches of the rivers and coast by NGOs and citizen's groups on the lines of functioning of Advance Locality Management (ALM) groups.

Recommendation 2: Provide river flushing system to initiate rejuvenation of river channels

It will be useful to study the hydraulics and environmental context of the Tulsi, Vihar and Powai lakes for the possibility of providing a "river flushing system" for Mithi River. Without sacrificing the potable water contents of Vihar Lake, if the spillway is regulated / gated, along with Powai Lake, based on our preliminary calculations, we can get an additional storage of about 2,733 ML if 0.6 m gates are provided at the two dams *i.e.*, Vihar and Powai Spillway Dams. In that case, the Vihar Lake will be able to store extra 1,800 ML volume of water and the Powai Lake will be able to store extra 900 ML volume of water. Thus, this arrangement will be able to accumulate extra volume of say 2,700 ML. Assuming that one flushes thrice in a week, there would be approximately 100 days of flushing in a year. Due to the proposed gated spillways for Vihar and Powai Lakes, we get 27 MLD flow for flushing. This water could be made available for improving riverine status of the Mithi River after the rainy season (October to May).

A technical review of the management of these lakes will be desirable in this direction. A rigorous flood warning system – emanating from Vihar and Powai Lakes will have to be in place along with the upgradation of the role of the reservoirs in the management of the Mithi River. A flowing river channel is an environmental asset for the city. Flushing of the river channel will help in minimizing anaerobic spots in the river. In fact, a detailed review of Mumbai's aquatic subsystems aimed at development of management plans for all rivers, lakes and ponds in Mumbai will be desirable.

Recommendation 3: Rejuvenate degraded urban ecosystems including lakes / ponds, rivers, creeks, and costal zones

Re-naturalization of river and lake watersheds is considered a better strategy worldwide. There are three major benefits of re-naturalization:

1) Native plants are typically hardy since they are adapted to the soil conditions and weather of the location. Thus, by and large, their demand of water, fertilizers, pesticides and maintenance is modest.
2) Native plants provide food and shelter to native wildlife. Given the amount of land that is being developed, it's essential to replant urban parks and even backyards, with as many native species as possible if we want to maintain viable populations of native wildlife.
3) Trees, green canopies, and vegetation are well known for their ability of dampening noise, barriers for atmospheric suspended particulate matter as well as improvement of micro-climate under canopy (by providing cooler environment and minimization of soil moisture evaporation).

4) Renaturalized areas provide an opportunity to learn about the natural heritage of our area. They provide enhanced opportunities for education and recreation for children and adults alike. In addition, naturalized landscapes provide a place of solace from our often too ordered worlds.

There are many ways in which re-naturalization can be accomplished. Remedies that are practiced on large scale are:

(a) Re-naturalization of riparian zones and

(b) Rehabilitation of riverbeds and lake through phytoremediation and ecological engineering.

It must be recognized that riparian areas are fragile ecosystems. Although these vegetations generally have relatively low timber value, their important social and environmental functions have been increasingly recognized in management decisions. Some of the rational activities could be:

(i) Focus attention on riparian areas (ecotones) since they are the "hot spots" of geobiohidrological interactions. Preservation of ecotones of lakes and streams ensures habitat integrity and sustainability,

(ii) Re-integrate the fragmented riparian corridors to enhance these natural detention areas; and

(iii) Recover the riparian corridors, preferably using the indigenous flora, which promotes rational re-naturalization.

Recommendation 4: Restore the Mangrove-Ecosystem and rejuvenate the coastal zones

Restoration and rehabilitation of existing or former mangrove forest areas is extremely important today. In fact, given the importance of mangrove forest eco-systems, and current threat to these coastal forests, this is an imperative. But actual planning of mangroves is really needed as mangroves annually produce hundreds or thousands of seeds or seedlings per tree, which under the proper hydrologic conditions can re-colonize former mangrove areas, returned to normal hydrology, very rapidly. Today, most people have realized the importance of mangroves and people are talking about conservation and restoration of mangroves. Here are some salient points towards the conservation/restoration of mangroves around Mumbai:

1. Mangroves have been grossly misunderstood as forests growing from point of low tide to the point of High tide. In reality, mangroves grow just above the mean sea level till the mean High water line (MHHW)
2. Hydrology is very important in determining the health of mangroves.
3. Mangroves cannot sustain prolong flooding. Experimentally, it has been found out that Mangroves are flooded for not more than 30% time in a day. It is easy to kill mangroves by increased flooding.
4. Mangroves do not build land. They do not extend the shorelines inside the sea. They are however important as protectors of the fragile coastal land.
5. Salt is not a physiological need of mangroves. Mangroves thrive well if freshwater sources are closer to the mangrove belts.

6. Restoration means bringing the ecosystem to a known previous condition. This is a very difficult exercise as very few restoration sites are previously studied for composition. Therefore rejuvenation or replanting is a better word for describing the mangrove revival efforts.
7. Most of the mangrove rehabilitation (restoration) projects do not require plantation. Once the hydrology is restored the mangrove species available in that area will automatically start growing. Plantation is required only on the propagule limitation sites (i.e., sites where mangrove seeds are not available naturally). There are propagule limited sites around Mumbai.
8. Direct dibbling of propagules is an economic than planting nursery raised seedlings.
9. Site selection for mangrove rehabilitation is the first key task.
10. Growth of saline grasses like Porteresia coarctata, Aeluropus lagopides or even some of the mesohaline grasses like Typha are conducive for mangrove growth. These grasses first grow on the site and then allow mangroves to grow as secondary vegetation.
11. These grasslands are also important catchment areas for flood control. Along with mangroves, these areas store the heavy rainfall runoffs before the sea assimilates the excess water.
12. A typical restoration project to be considered as minimum 5-7 year project.
13. Trenching may be required at certain sites to restore hydrology. If at all trenching has to be done, it should not be done in a linear fashion. One needs to determine best possible slope and a meandering channel tapering landwards to be dug. The channel may have further sub arms. Even these sub arms need to be dug in meandering fashion rather than a straight cut. The width and depth of the channels needs to be determined by a hydrologist, only then, one can have self-maintaining channels that will not get silted up in next twenty years.
14. After the channels are dug, either the grasses or mangroves will start rejuvenating on their own. If the site is propagule limited site, then only introduce the propagules or saplings of the desired (but appropriate) species. Do not plant in channels. But plant outside the channels. Also, plant exactly at the levels where adjoining mangroves are present.
15. It is not necessary to cover all the saline blanks. Saline blanks are natural in a mangrove area and they have an ecological role to play too. Restore only those saline blanks that are induced by altered hydrology or heavy cutting.
16. Abandoned prawn farms are one of the most suitable areas for mangrove rehabilitation.
17. No mangrove restoration project is complete without community participation. While getting the community involved, make sure that the community within the restoration area keeps interventions to minimum. Providing alternative sources of income, fuel, fodder, *etc* would reduce pressure on the mangrove community.
18. Restoration efforts on the east or west coast would have similar patterns. However, every mangrove restoration project is a prototype and depends on the physical conditions on site.

19. For Mumbai, there is a dangerous trend going on of training and paving of channels of creek or sub-creek. Due to this activity, along with debris dumping, the hydrology of the Mumbai coast has completely altered. Scientifically rejuvenating the mangroves in these areas would be logical to safeguard Mumbai from further flooding.

There are many different techniques and methods utilized in restoring mangrove areas, returned to normal hydrology, very rapidly. Because some of these have resulted in identifiable successes or failures, we wish to present herein a summary description of a preferred method for planning and implementing mangrove rehabilitation.

Step 1 Understand the autecology (individual species ecology) of the mangrove species at the site; in particular the patterns of reproduction, propagate distribution, and successful seedling establishment.

Step 2 Understand the normal hydrologic patterns that control the distribution and successful establishment and growth of targeted mangrove species.

Step 3 Assess modifications of the original mangrove environment that currently prevent natural secondary succession (recovery after damage).

Step 4 Design the restoration program to restore appropriate hydrology and, if possible, utilize natural volunteer mangrove propagule recruitment for plant establishment.

Step 5 Only utilize actual planting of propagules, collected seedlings, or cultivated seedlings after determining (through step 1-4) that natural recruitment will not provide the quantity of successfully established seedlings, rate of stabilization, or rate of growth of saplings established as objectives for the restoration project [Lewis and Marshall, 1997].

Recommendation 5: Rejuvenation and environmental upgradation of hills, slopes, and lakes / ponds in Mumbai Region.

The nexus between trees, vegetation, green cover, soil erosion, dampening of monsoon flood waters, siltation in lakes / ponds has been emphasized earlier. It must be understood that all uplands (areas above 8 m GTS) play crucial role in control of runoff in all the river / nalla systems and lakes / ponds in Mumbai. It is strongly recommended that rejuvenation and environmental upgradation of hills, slopes, and lakes / ponds in Mumbai Region must be undertaken to achieve minimization of top-soil erosion, enhancement of groundwater recharging, improvement of flows in rivers, and several allied benefits of improvement of the ecosystem. The municipal authorities should encourage ALM groups in maintenance and vigilance as well as consider public-private partnership (PPP) for bringing in capital and professional management.

Recommendation 6: Improve MSW management

Improper disposal of municipal solid waste (MSW) has contributed to choking of sewers and storm water drains and thereby aggravating flooding. In addition, it has

also degraded Mumbai's coastal ecosystems. Present status of collection, compaction, transportation, and disposal of MSW in Mumbai is far from satisfactory. Immediate action is required to at least make it compliant with the requirements of the *MSW Management and Handling Rules (2000)* as well as *Environmental Protection Act (1986)*. Some specific additional interventions might help:

(I) Incentives may be provided to rag pickers to collect recyclable plastics and formalize their activities.

(II) Severe disincentives in the form of fines should be imposed on those throwing wastes into the river.

(III) A media campaign should be undertaken to educated people not to dispose nirmalya in plastic bags in rivers, creeks, and lakes.

(IV) An estimate of the pollution caused by immersion of idols should be prepared and steps taken to prevent the same.

Recommendation 7: Upgrade the sewage treatment plants and sewerages

The events of 26th July 2005 have clearly demonstrated the glaring shortcomings and inadequacies in Mumbai City's and suburb's storm water drains and sewerages. The task of upgradation of storm water drains and sewerages must be undertaken as the top most priority. These networks provide flood protection on one hand and ensure environmental protection on another hand. A detailed discussion and guidance on upgradation of storm water drains and sewerages has appeared elsewhere in this report.

Escalating volumes of Mumbai's sewage and sullage has contributed to overloading of sewers and storm water drains in the City and Suburbs and thereby aggravating flooding. In addition, it has also degraded Mumbai's ecosystem. The MCGM has implemented several developmental project for addressing the issue of storm water and sewage including BSWDP, MSDP-I, and MSDP-II (ongoing). In South Mumbai there exists the system of pre-primary treatment of Mumbai's sewage and pumping it into creeks and ocean through marine outfalls (and this system meets all the consent condition legally applicable to Mumbai). However, there is shortfall of sewage collection and conveyance in the suburbs for example there is shortfall of treatment and disposal facilities in Versova zone and no disposal facility is available in Malad (these shortcomings will be tackled in MSDP-II). Clearly, by the end of MSDP-II, the legal obligation of collection, treatment, and disposal may be fulfilled to a great extent. It must be remembered that the prevailing system is far from the desirable because it caters for only half of the population in Mumbai (about 50% people live in slums who do not have proper sanitation and drinking water supply).

Further, it should be kept in mind that disposal of such untreated sewage on the coast of Mumbai shall one day prove to be disasters because even the ocean has a finite carrying capacity. Pumping of the phenomenal quantities of untreated sewage daily into our coastal ecosystem shall certainly degrade the system in future. Besides, such an act violates the principle of "sustainability". Immediate action is required to at least make it compliant with the requirements of the *Water (Prevention and Control of Pollution) Act (1974)* as well as *Environmental Protection Act (1986)* by treating the 100% flow of sewage and sullage from all the residents of Mumbai. As stated earlier (in the second point of the *Framework* section), it is important to

remember that the *directive principle* for the executives and regulators, as enshrined in India's Constitution, emphasizes protection and “improvement" of the natural environment.

Recommendation 8: Recommendation for Airport Authority’s actions

(i) Some time back the runway of the Airport was extended across the Mahim River (the new name: Mithi River) channel by providing a bridge on the river channel. It has a clear water way opening of about 27 m for the flow of Mahim River. The Airport Authority now has plans to provide a taxi bay in parallel to the runway on its north. Hence it has to provide an additional crossing on the Mahim River – which is currently under construction as shown in the sketch below. This crossing is being provided with a clear water way opening of about 40 m for a flood level of 4.6 m and a flood flow of 403 cumecs.

(ii) This water way below the taxi bay will be effective and useful only when the existing 27 m waterway below the run way is also widened at least to 40 m in line with the water way being provided below the taxi bay. The original proposal of the consultants for the airport was for a total width of 60 m. It will be worthwhile reviewing the hydraulic calculations of this bridge in critical depths while detailing the design of the Mithi River crossings below the Airport and initiate appropriate actions for widening of Taxi Bay bridge as well as the runway bridge.

(iii) Because of the very critical location of the position of the airport in the Mithi basin, from the point of flood hydraulics it will be useful if a high level technical committee of the representatives of the Airport Authority, the MMRDA, and the MCGM is appointed to settle and supervise the fine-tuning of the arrangements for the widening work of the runway bridge for the Mithi River.

(iv) Waterway to be provided for the Mithi River below the runway and the taxi bay will have to be liberal to avoid any obstruction to the flow and consequent heading up of water in the upstream areas. The airport is near the saddle point between the west-ward flowing of Mahim River and the east-ward draining areas lying on the east of the airport. Spills of the Mithi River on the eastern side adversely affect the habitations on that side as happened on 26th and 27th of July resulting into submergence of the Lal Bahadur Shashtri Road. Such spills will have to be meticulously avoided.

(v) Close monitoring of the availability of adequate clear waterway below the airport for the flood flows in the Mithi River will be extremely necessary for the safety of these areas. The exact condition of the water way that was actually available below the runway in July 2005 is not yet clear, because there was no monitoring mechanism in position for reporting the condition of the Mithi River channel so far. Mithi River Authority will have to lay down a rigid monitoring procedure for this purpose well before the monsoon of 2006. Removal of silt and debris from the taxi bay and the runway is not going to be an easy task. Proper accesses to the underneath of the run way will have to be provided for the purpose. Design of the taxi way bridge and the run way bridge will have to make suitable provisions for the same.

(vi) Even otherwise, residents on the east of Mithi River, in the vicinity of the airport and the Bandra Kurla Complex are very apprehensive about the raising of the ground levels in the vicinity of the Mithi River channel. Some land raising work is in progress in the Airport authority’s area, on the east of Mithi River. It will be prudent not to vitiate the ground conditions further, till the works on the channelisation of the Mithi River have progressed sufficiently well. All such works that raise the ground

levels along the Mithi River near the airport and in the river reach on the down stream of the airport should be immediately stopped.

(vii) The high level technical committee, suggested above, will have to periodically, say monthly, review the situation regarding the work on the channelisation of the Mithi River in the context of the CWPRS recommendations and give permissions for any land filling activities in these stretches as may be necessary only after ascertaining that the alteration would not compromise the flood protection measures in the vicinity of the airport.

(viii) From the outcome of the new studies recently undertaken by CWPRS on full length of the Mithi River, on behalf of the Mithi River Authority, lowering of the bed levels of the Mithi Rivers at the Airport by 2.1 meters has been suggested to contain one in 100 year flood within the river channel. The hydraulic and structure designs of the airport runway and taxiway bridge will have to be reviewed in due course in the context of the final nature of channelization that will be decided by the Mithi River Authority. It will, therefore, be useful to keep an expert from the CWPRS associated with the current work on the Taxiway bridge and the widening work that will have to be undertaken for the runway bridge within airports premises.

Recommendation 9: Protect and improve the Sanjay Gandhi National Park, Borivali

The Sanjay Gandhi National Park is one of the most important ecosystems in Mumbai. This Park spans over 100 square kilometers (more than 10,000 ha area) in North-Mumbai and boasts of extremely valuable forest cover, biodiversity, and habitat of some of the endangered species. It is popularly referred to as “the green lung of Mumbai”. Unfortunately, it is plagued with encroachments and deforestation (see the two frames of remotely sensed composites showing difference of forest cover of 1986 *versus* 2002). Immediate action is required for protection and improvement of the National Park and initiate steps for complying with the requirements of our forest laws.

Recommendation 10: Construct detention basins and infiltration zones for flood control and provide spaces for people to escape to in case of disasters and calamities

Historically, while the chain of islands were being connected through reclamation and the present day contiguous island of Mumbai City was being developed; the spaces for many mill lands were created by reclaiming the wetlands and inter-tidal zones. From the ecosystem’s viewpoint, such wetlands and inter-tidal zones are the natural flood control devices. It is recognized that there is a need for huge areas of vacant lands for slum rehabilitation projects as well as construction of transit-camps. Efforts should be made to strike a balance between the needs for transit-camps / slum rehabilitation projects and provision of measures for flood protection and disaster mitigation. Convert portions of mill lands, salt-pans, and all possible vacant patches of land in Mumbai into “lungs and kidneys” of this urban ecosystem. Develop constructed wetlands, ponds, green belts, and spaces for people to escape to in case of disasters and calamities.

Recommendation 11: Remove encroachments and strictly adhere to the Development Plan

The developmental plan (DP) of Mumbai (prepared in 1982) provides for spaces for gardens, public parks, play grounds, recreation areas, and vegetation. Such spaces improve the quality of life of community and also serve several critical functions in the urban ecosystem. Free space per capita has been dramatically diminishing in the city of Mumbai in the recent past. In addition, the situation is deteriorating from bad to worse because of violations of the DP provisions. First, there is an immediate need to review the ground reality *vis-à-vis* the DP maps. Second, there is need to update the DP of Mumbai immediately. Coastal areas, salt pan lands, mill lands, and all vacant lands due to relocation of industries need to be reserved for public use in the new DP – especially for gardens, wetlands, detention basins, public parks, play grounds, recreation areas, and vegetation.

It is important that all the encroachments of buildings and slums from the flood planes and risk zones of rivers and coasts are removed on a priority basis. The prevailing legal framework of environmental laws in India must be effectively used to address the encroachments in flood planes and CRZ.

Recommendation 12: Remove encroachments and facilitate flow in Mahul Creek System. Name the Mahul system as the "Mahul River" and manage it like a river.

The Mahul Creek is a relieving feature (saddle zone) naturally available to accommodate spillover of the Mithi River across the eastern boundary of catchment. There is an immediate need to study this area and develop it for the purpose of relieving flood in sub-catchment numbers 500, 501, 502, 503, 509, and 510 of the Mahul Creek System. It is advisable to name the Mahul system as the "Mahul River" and manage it like a river hereafter. The development and administration of the Mahul River should be included in the jurisdiction of "authority for rivers".

Recommendation 13: Demarcate potential flood-zones on DP sheets. Develop a policy for management of development in those areas and amend DC rules suitably

The high risk areas which are bound to get affected by floods of 1 in 10 years probability and the medium risk areas with 1 in 25 years probability will have to be worked out and indicated on the DP sheets. It is strongly recommended that the rehabilitation of the population and activities falling under the high-risk zone (covered by the floods from 1 in 10 year probability) should be undertaken on priority basis. For the medium risk areas (to be affected by 1 in 25 years probability of flood), shown as red zone, safeguards will have to be suggested under the amended DC rules - such as alternative buildings and structural arrangements and conversion of land use to more safe purposes in flood-risk zones. It is hoped that the residents and users of this zone will protect their potential risks through appropriate risk-cover insurance policies. Beyond this, for the areas likely to be affected by the floods of lesser frequencies – up to rainfall of 1 in 100 years probability, shown as blue zone - insurance cover will have to be mandatory. Some such rules will have to be

developed and DC rules will have to be amended suitably based on a sound policy for management of development in those areas.

Recommendation 14: Strengthen monitoring, assessment and auditing of environmental and ecological status-related activities in Mumbai Region

Mere restoration of watercourses and water bodies by channelization, embankment, and desilting in Mumbai will not provide the needed flood protection in future; especially in the context of excessively large population density. We certainly need much higher capacity of carrying floodwater and treated wastewater in our rivers and creeks. In fact, inflow itself needs to be regulated through environmental up-scaling and up-gradation so that future floods can be handled with the help of appropriate engineering interventions in conjunction with improvement of the waste processing ability in the riparian zones, river beds and creeks. This will be possible only when we collect, collate, and publish the monitored data on environmental and ecological status of Mumbai Region. It is understood that the MCGM has been publishing "Environment Status Report" (ESR) every year. It is important to make this activity more comprehensive and through. It should be recognized that the information-base generated during such exercise would also serve the management for decision support. It is critical that a special cell be created, funded and empowered in the MCGM to upscale to monitoring, assessing and auditing environmental and ecological status routinely in Mumbai Region. Such a cell shall function with the help of an "Expert Committee" comprising of DMC (Environment), Member Secretary of the MPCB, independent experts (for example from IIT-Bombay, Institute of Science, NEERI, *etc*).

Recommendation 15: Empower the "Disaster Management Authority" to monitor, assess and audit environmental and ecological status after any disaster

It has been recommended elsewhere in this report that a "Disaster Management Authority" be set-up. Empower the "Disaster Management Authority" to monitor, assess and audit environmental and ecological status after any disaster and make it mandatory to publish that information immediately. It is crucial that such monitoring, assessing and auditing activities shall be conducted through an independent expert agency.

Recommendation 16: Set up the Mumbai Watershed Council.

Introducing basin orientation in the land use management and land development activities is essential for efficient storm water management. Water shed should be considered as a basic unit of storm water and river management planning. As articulated in the framework section, sustainable development of any region is possible only when the so-called "watershed approach" is used while planning and implementing development projects. All the aspects of development and their corresponding environmental footprints may not be considered and addressed in an integrated manner if different agencies are responsible for different projects and components thereof. For instance, railway-related transportation projects are typically handled by *Railways*, the *Airport Authority* looks after expansion of airport and runways, and road development is planned and implemented by the *MSRTC*.

Monitoring of pollution is the responsibility of the *MPCB* and monitoring of encroachments and removal of sludge and solid waste from storm water drains, nallas and rivulets is the responsibility of *MCGM*. Clearly, delegating all the responsibility of planning and implementation of development projects should be entrusted to one agency. Elsewhere in the report, we have recommended revival of MMRDA's "Water Management Board". In any case, some appropriate authority should be made to bring the entire planning and implementation-related function under one roof.

Further, we are proposing to constitute the *Mumbai Watershed Council* to assists and advise the appropriate authority in planning and assessment. Such a council should have representatives from stakeholders (*for example* ALMs on the riverbanks, trade associations, housing societies), technical experts (*for example* MERI, CWPRS, IIT Bombay, other academic institutions), municipal corporation officials, concerned developmental and regulatory agencies. This would avoid duplication of efforts, provide scientific approach to long-term planning and advise the nodal agency regarding the restoration and developmental projects. It may prove to be effective to motivate and involve the respective ALM groups and citizen groups in monitoring and reporting encroachments.

Recommendation 17: Set up the Mumbai Transportation Council

One of the aggravating factors during the flood of 26th July was lack of proper infrastructure of roads and suburban railways. All the major roads and railway lines were inundated and hence the entire transportation system collapsed in Mumbai. A detailed discussion has appeared on this issue and several recommendations have been given elsewhere in this report. Significance of taking a systemic approach and approaching the transportation challenge from even the so-called "airshed management" perspective will help in minimizing vehicular pollution in Mumbai. Setting up of the *Mumbai Transportation Council* would hopefully integrate all the transportation system and routs in a manner to achieve the optimum solution as well as minimize vehicular air pollution and noise. It should be noted that elsewhere in this report we have recommended the revival of the MMRDA's "Transportation Management Board" to which the proposed the *Mumbai Transportation Council* will advise.

Recommendation 18: Set up the "environmental cess" for providing targeted O & M budget to sustain environmental services

Provision of adequate O & M budget for providing a given environmental service appears to be crucial for offering and maintaining a given service. It is envisaged that the Government sets up the "environmental cess" for providing targeted O & M budgets to sustain various environmental services including solid and biomedical waste management, wastewater treatment, drinking water treatment, control of noise and odor.

Recommendation 19: The MPCB should facilitate implementation of India's environmental policy in a proactive manner and ensure compliance of environmental regulations by the Municipal Corporation

The scrutiny and investigation, which followed the floods in Mumbai, revealed that environmental governance of Mumbai has been far from satisfactory. While the developmental and planning agencies renamed rivers and streams as nallas and in some cases even removed them from the DP maps; environmental regulatory authorities did not take exception to derogatory treatment given to environmental and ecological systems and sub-systems by citizens, civic administrators, and elected representatives. Standards of disposal of effluents into rivers were prescribed suitable for nallas rather than reinstating the river status to the streams. For example, India's Water (Prevention and Control of Pollution) Act of 1974 and Environment Protection Act of 1986 aim at maintaining wholesomeness of rivers. The MPCB should facilitate implementation of India's environmental policy in a proactive manner and ensure compliance of environmental regulations by the Municipal Corporation.

Recommendation 20: Recommendations for conducting following studies

(A) Comprehensive study of Mithi River ecosystem should be instituted immediately in the context of flood proofing measures. It has been argued lately that the faulty development planning was the root cause of floods. It will be instructive to critically review all the developmental projects in Mumbai – especially those that were taken up despite numerous reports in opposition to them. For example: the Worli-Bandra Sea-link project related reclamation had begun in August 1999. On 11th, 12th & 13th of July, 2000 there was heavy flooding. The near costal regions from Bandra to Borivali and areas like *Sahitya Sahawas* on the bank of Mithi River got flooded for the first time in year 2000. This project was apparently criticized unfavorably by the Government's own studies. Despite the serious objections to and warnings against any new reclamation in the Mumbai Sea, the reclamation was not halted. We strongly recommend that the environmental impact of Worli Bandra sea link project (predicted versus observed in reality so far) be undertaken with a multi stakeholder independent team of investigators. Also, a through investigation of the hydrology of bay area be conducted with the help 3-D model studies of reclamation site for long-term prediction.

(B) Institute a comprehensive study of environmental impacts of MUIP / MUTP's reclamation and building projects in Mumbai and in fact in all the developmental projects undertaken by MMRDA and MCGM. It is desirable to incorporate environmental and ecological concerns in developmental planning of Mumbai region. This study should aim at development of best practices and guidelines for ensuring environmental and ecological safeguards in a variety of developmental projects typically undertaken by MMRDA and MCGM and evolve mechanisms for instituting such practices in real life projects and implement them in day-to-day practice. Retraining of personnel in development planning agencies, municipal authorities and employees as well as contractors executing the projects must be retrained to bring environmental and ecological focus in their activities.

(C) Study to evolve "ecosystem health indicators" that integrate ecological and socioeconomic criteria so that the developmental programs can be monitored. Because "ecosystem health indicators" integrate ecological and socioeconomic criteria of management, they provide holistic, yet quantitative measures that can be monitored over time, and can communicate complex information effectively,

they serve as an ideal tool to for both researchers and groups to evaluate tangible outcomes of the collaborative effort.

(D) Study to estimate the "carrying-capacity" of Mumbai's urban ecosystem *vis-à-vis* the issue of transportation, housing, sanitation, and drinking water. This study should aim at focusing those correlates of carrying capacity indicators so that the "carrying capacity" becomes the basis of development planning. Carrying-capacity of a region, comprising of the so-called supportive and assimilative capacities, is defined as the ability to produce desired outputs from a constrained resource base to achieve a higher and more equitable quality of life while maintaining desired environmental quality and ecological health. The planning process should explicitly include interaction between the community, experts and decision-makers to arrive at trade-offs between the desired production-consumption levels through the exploitation of supportive capacity within its regenerative potential, and environmental quality within the assimilative capacity of the regional ecosystem. These trade-offs result in structural shifts necessary for reconciling competing demands in the overall process of socio-economic development through appropriate technological, managerial and organizational interventions. It is recommended that following steps should be initiated to leverage "sustainability" every-where:

- Assess and rank all development proposals using tools of *Environmental Impact and Risk Assessment*, *Environmental Audit, Natural Resource Accounting, Full Cost Accounting, and Life Cycle Assessment*.
- Initiate *carrying-capacity-based micro-planning* of urban habitats,
- Institution of *preventive environmental management* policy,
- *Harmonization* of environmental policy with policies for industrial development as well as urban and rural development, and
- *Plan and implement structural changes* in economic sectors.

(E) Except Tulsi, Vihar, and Powai, the pondage is very small compared to the flood flows in the basins. But the ponds do indicate the favorable low-level depressions which could be developed for the temporary flood absorption for immediate local relief- if necessary and for adding to the water bodies in the developed crowded localities to improve the scenic beauty, provided measures for protecting the water quality of the ponds could also be put in place simultaneously. As a city, Mumbai is short of water bodies. Hence, special efforts for protecting them and improving them will be desirable for city's environment. Their role in the local hydrology has been partly covered in the BRIMSTOWAD report. Further consideration for upgrading of some of these ponds for city's beautification will be desirable.

There is scope for examining the role of lakes and ponds in Mumbai in the context of beautification and flood protection, provision for detention or silt accumulation in conjunction with the management of the rivers and environmental upgradation of the aquatic ecosystems.

CHAPTER- 8

TRANSPORT SYSTEM

8.1.1 General :

Brihan Mumbai is an Island City. The shape of the island is a somewhat elongated triangle having a maximum width of about 16 Km. in the northern suburbs reducing to an average width of about 4.5 km. in South city portion and narrowing to zero at the South tip. The city covers about 438 sq. km and houses about 1.19 crores of people. Average population density is about 27,209 persons per sq.km. The majority of the population lives in the suburbs. However the day-time population in the Southern portion of the city is 45,00,000 with a density of about 3,94,400 person / sq. km, while the night-time population is hardly 2,00,000 persons, a density of only 17,528 persons / sq.km.

Most of the business centers, offices of the Government and other Institutions are located in the southern part of the city. Though many attempts have been made in the past to decentralize and establish other CBDs (Central Business Districts) in the northern part and on the mainland, while these have partially succeeded in taking the pressure off the southern-most CBD, there has been simultaneously tremendous growth and the demand for travel has greatly increased. Traditionally the southern area continues to be a business magnet and the pattern of heavy north-south travel is continuing though many of the establishments have now been set up in the north and on the mainland.

Due to strong attraction towards south during daytime and limitations on the spread at the south a traffic pattern has been established comprising of heavier traffic flows towards south during the daytime and north ward during night-time. It is estimated that about 43,00,000 people make to and fro journeys every day.

Traditionally only two modes of public transport namely local Railway and BEST (Bombay Electric Supply and Transport) are handling the commuters. Up to the 1960s the city also had a Tramway which was abandoned later for some reasons. Local transport by air has not been established so far. Transport by water is very negligible and limited to southern tip to mainland trips only. In addition to the city population in the suburbs, a large population in the hinterlands of Mumbai Metropolitan Region (MMR) is traveling towards south in the morning and going back in the evening using the local railway system.

This pattern is a matter of concern to the administration and is straining the system to the extreme. This situation is getting further aggravated due to the increasing use of private vehicles. The transport system totally collapsed on the frightful day of 26th July 2005 and was one of the major causes of the sufferings of the people of Mumbai on 26th and 27th July 2005.

8.2 Railways :

8.2.1 General :

Mumbai City is served by three routes namely Western Railway, Central Railway and Harbour Line. Excepting for some length of the Harbour line, for most of their length all these lines are at general ground level. Most of the lengths of these lines were laid more than 100 years back and are passing through reclaimed lands. When these lines were laid about a century back there was not much development along the lines and the area around the lines was totally open with creeks, wet lands and mangroves. As the area was open with a large flood absorbing capacity, it was not felt necessary to raise higher embankments. Also a number of closely placed small culverts were sufficient to cater for the discharge coming from the higher grounds or hills on one side and vast low lying mud flats or creeks on the other side. So the general rail top levels everywhere in the city and suburbs are very marginally above the spring tide level.

8.2.2 Experience on 26th July 2005 :

On 26th July 2005 at about 15.00-15.30 water started rising in the railway yards. As the signaling system got water-logged the trains started to move at a crawling speed of less than 8 Km. per hour. After 16.00 the train movement was completely stopped. The process of accumulation of commuters had already started from 15.30 coinciding with the rush of office employees who were allowed to go home early as per usual practice on such occasions. This resulted in a large crowd of more than 2 lacs commuters piled up in the Churchgate and CST stations.

At the same time due to failure of telephones and the cell phone communication system, anxiety about the safety and whereabouts of family members started mounting and people became desperate. More than 500 extra buses were pressed into service by BEST at 16.30 hours to handle the situation. However they also quickly met with a similar fate of immobility, which will be discussed later on.

8.2.3 Lacunae in the system:

The rail lines in the city (as they are) are laid at a low level and are very vulnerable to flooding. Flooding of rails and stoppage of local trains twice or thrice in a year is a usual phenomenon in the city; however as the stoppage is for a period of only a few hours on each occasion nobody minds it much. The usual drill of allowing the employees to go home early, to come late or granting holiday etc. is followed to deal with such situations. But on 26th July 2005 the situation was quite abnormal as everything had come to a halt.

It is the Railways' usual practice that once the water touches the electronic signaling system the trains are asked to move at a very slow speed of less than 8 km. per hour, that too very cautiously with frequent halting and stopping. Such movement is continued till the water level reaches 10 cm above rail top level. Once the water level rises more than 10 cm above the rail top level train movement is completely stopped.

Though the C.D. works under the rail lines were quite adequate in the olden days they are now proving to be insufficient even for slight spell of heavy showers. There are in all 44 Cross Drainage Works which need to be modified on Central and Western Railway routes. It is reported that 7 C.D. works have been remodeled so far and 37 C.D. works are yet to be tackled.

Blockages and silting of the drains have reduced their water way. As the situation would have it, the clearance between the sleepers and the high flood level (and also high tide level) is also very small and therefore there is hardly any safety margin left to play with.

Plastic, garbage and other litter finds its way into these waterways. Due to gush of air created by the fast moving trains large litter and dust is blown into the air and while settling it finds its way to the culverts through side channels resulting in silting.

Increasing the waterway is beset with the difficulty of getting traffic blocks and clearance from the railway safety department. MCGM and railway authorities themselves are helpless about the situation.

Hundred percent clearing of the existing water ways is also often doubted.

8.2.4 Approachability to the stations:

Excepting a few stations like Churchgate, CST, Dadar, Mumbai Central etc. the railway station areas are not very easily accessible. Access roads leading to many stations are very narrow and crowded by hawkers and encroachers. To name a few the worst affected stations are Kurla, Ghatkopar, Wadala, Byculla etc. Access roads of many of these stations also get flooded during critical hours.

8.2.5 Suggestions:

Raising the existing rail lines and simultaneously keeping the train traffic moving is not practicable. It will also involve remodeling other structures which will also be required to be raised to get necessary headway; this may further lead to traffic problems. So one is left with only one alternative and that is to improve the existing system.

<u>Signaling:</u> Possibility of improving the signaling system which will be independent of the rail and water levels so that the movement of the trains could be better regulated for still some more depth of flooding above rails.

<u>Cross Drainage Structures:</u> Remodeling of the existing culverts by providing bigger boxes with bigger spans and shallow girders can be under taken. New trench-less technique has made if possible to carry out the work without much inconvenience to the running traffic. Fortunately there are almost no utilities passing under or along the tracks and whatever utilities are crossing the tracks are well documented. So it should not pose any serious problem. Railway authorities should take up this programme on priority. They should take up these works as their own works and not as deposit works as the experience of deposit works is not very encouraging in case of Railways.

Clearing and Desilting: Clearing and desilting work should be taken up by railways on priority as their own work since their own operations get affected. Present arrangement of MCGM making payment for clearance of work system does not seen to be working properly.

Plastic and other Garbage: Sweeping and keeping their own premises is the responsibility of property owners. The same rule applies to Port Trust lands, Airport lands etc. However the lands belonging to Railways do not seem to have been kept as clear as those of other properties of similar undertakings. Railways should be asked to take the necessary steps in this regard as this litter and plastic is finding its way into the nalla system.

Sewerage connections: Some sewerage is directly let out in to the nalla system and it flows into railway property. Similarly in absence of a proper storm water drainage system for the adjoining property the storm water from these properties flows along the track. MCGM should take up necessary schemes to divert the sewerage lines and also provide separate Storm Water disposal system for the adjoining properties.

Approach roads to stations: It is the duty of MCGM to provide proper access to the Railway station. The roads should be widened; encroachments and hawkers blocking the roads should be removed.

Pumping: Considering the rail levels in the city and the frequent occurrence of flooding, Railway authorities should seriously think about pumping arrangements for chronic spots to ease the problem.

8.3 ROADS:

8.3.1 General:

Mumbai has three entry and exit points by road namely Dahisar, Mulund and Mankhurd. Main routes serving them are Western Express Highway, Eastern Express Highway and Sion-Panvel road. In the suburbs, Swami Vivekanand Road and Lal Bahadur Shastri Roads are complementary and parallel to these roads. In the island city main roads feeding these highways are Veer Savarkar, Lady Jamshetjee Road and Senapati Bapat Road on the western side, and Dr. Ambedkar Road and Rafi Ahmed Kidwai Road on the eastern side.

8.3.2 Experience on 26th July 2005:

On 26th July, 2005 fortunately the rainfall intensities recorded at Colaba gauging station were not so heavy in comparison to Santa Cruz gauging station, so there was not much problem in the island city portion except the usual chronic flooding spots mainly at Lalbaug, Parel, King Circle, Matunga, Hindmata etc. which usually get flooded during heavy showers every year. However in the suburbs the situation on most of the roads was serious. Almost all roads in the suburbs were flooded. Both the Express highways were also flooded for a substantial length. These highways had never experienced flooding in the past since their construction in the 1960s.

As the water starts rising on the road the traffic on the road start slowing down. Traffic can continue crawling through water up to a water depth of 25 to 40 cm. Once the water level rises above this level the exhaust pipes of cars get choked and even the engines of low clearance vehicles get affected. Due to that the engine stalls. Restarting of these vehicles becomes difficult. Such vehicles are then abandoned by the drivers and occupants. These vehicles remain on the road and block the passage of other vehicles. Even the bigger vehicles having more clearance also get bogged down and the whole traffic comes to a standstill. Due to bumper-to-bumper queuing of the vehicles retrieving the vehicles back also becomes impossible. This all results into a total traffic jam. Precisely the same thing happened on that frightful day. All the roads were jammed and due to failure of communication network nobody knew what really was going on. As the local trains were totally stopped, BEST authorities promptly pressed into service 500 extra buses to various stations hoping that the commuters could be sent to some nearby area around their destinations. At that point of time nobody knew the actual situation of the road on which these buses were to go. As it happened, all these buses could go some half way and they met with abnormal traffic jams. Though their engine height would have permitted them to move through that much sheet of water on the roads, as their passage was blocked these buses were unable to move further. Returning back also became impossible and the passengers were required to be seated in the bus for 6 - 7 hours. A few of them waded through knee-deep or chest-deep water and after walking for 5 - 6 hours some of them reached their homes.

8.3.3 Lacunae:

As already mentioned about the rail level, the same is applicable for road levels in the city.

Though storm water drainage system exists in the city the capacity was designed based on old norms which are now proving to be inadequate.

Cross-drainage works are also of similar design and the problem has got further aggravated because developers have covered the natural water courses. At many locations they have completely filled up the natural water courses and the cross-drainage structures are now rendered non functional. Since the passage is not available to the water it starts piling up on the road.

8.3.4 Traffic Control:

In the absence of a proper communication system in working order, nobody knew what the condition on the roads was and therefore the traffic could not be guided properly. Once the broken-down and abandoned vehicles occupied the road, traffic control became impossible till these vehicles could be towed away which was still more difficult as the access was blocked. A Central Electronic Traffic Control Room with visual aids could have reduced the chaotic conditions to some extent, and advance warnings to the commuters to stay back in their offices would have substantially reduced their suffering.

8.3.5 Flooding locations

In the city the flooding spots are well identified from the experience of last 50 years. The major flood prone spots are at Lalbaug, Parel, King Circle, Matunga, Sion, Kurla, Hindmata, Milan Subway etc. The reasons of flooding of these parts are

(i) they are low-lying, (ii) storm water drains provided at these spots are not sufficient, (iii) the down-stream system has been damaged or is in choked condition, (iv) spots are surrounded by development having higher elevation and (v) in the absence of holding ponds they themselves are serving as holding ponds.

8.3.6 Suggestions:

Raising: Possibility of raising these spots is limited to some 25 to 30 cm only and that too wherever sufficient headway below flyover and under-passes is available. In many cities in the world headway below such structures are limited to 4.5 m in urban areas as against 5.5 provided in our country. As we are discouraging heavy vehicle movements in the city the possibility of reducing the headway will be worth examining. It was experienced on 26th July that during flooding vehicles and pedestrians were hugging to the median or central divider. One can take a cue from this and lanes near the central divider can be slightly raised by suitably increasing the camber of the road without much affecting the kerb level. Thereby water accumulation on the extreme right lanes of traffic can be reduced. This will enable movement of vehicles on extreme right lanes a little more freely. Such practice is followed in other countries too. Similar such arrangement also exists near the King Circle under-pass in Mumbai.

Augmenting SWD System: Augmentation of the existing SWD system wherever it has been suggested by the Natu Committee and the BRIMSTOWAD report is very essential. Necessary works of improvements, restorations, augmentation as well as establishment of proper channel widths, at least for the system catering for these spots, should be undertaken on a priority basis without further waste of time.

Pumping: Due to typical topography of the city, the tidal variations and absence of holding ponds flooding of certain spots is inevitable in the city unless measures like pumping and provision of tidal gates are resorted to. It is not understood as to why the pumping schemes have not been executed by MCGM in spite of strong recommendations made in the BRIMSTOWAD and Natu Committee reports. Argument against the scheme put forth by some sections in the organization, that why spend money on this scheme when it will be used only for a few days in a year, has proved to be unwise. Taking into account the public inconvenience and direct as well as indirect losses to the economy the pumping schemes deserve serious considerations. It is understood that MCGM has decided to take up the work of review of BRIMSTOWAD report in the light of the developments that have taken place since 1993 and the recent occurrence of 26th July 2005 flooding. This is no doubt a very good step but it may take some time to give fresh recommendations. Till then it will be worthwhile to go ahead with the earlier recommendations as the fresh recommendations will only be supplementary to the earlier ones and can be implemented later on without wasting the work carried out until then.

Traffic Control : The chaotic traffic jam that occurred on 26th July and continued till 27th July evening due to the broken-down vehicles blocking the road and other stranded vehicles waiting in queue behind them for clearance of the roads made it impossible for the rescue and relief vehicles to reach the desired locations, resulting in tremendous suffering to the public. All this could have been minimized if

a Central Traffic control room for the city, equipped with Area Traffic Control System, had been in existence.

8.4 Air Transport System:

8.4.1 General:

Transport by air does not exist in the city though some attempts had been made in the past in this regard. A few landing facilities do existing on the roof tops of a few buildings and a few grounds in south Mumbai. But they are used only occasionally, two landing strips are located in the Western suburbs namely Juhu airport and Santacruz - Sahar airport. Juhu airport is exclusively use for private helicopters and ONGC. It has a small air strip which can serve only very small planes. Santacruz-Sahar airport is used for domestic and international flights. It has two runways / landing strips.

8.4.2 Situation on 26th July 2005:

On that day all the suburbs experienced intense rainfall. Santacruz gauging station recorded 944 mm while Vihar gauging station recorded 1011 mm rainfall in 24 hours. Due to heavy downpour in the catchments, Mithi river water rose to an alarming level. The flood water could not be contained by the bridge under the runway and the banks, so it broke the compound wall of the airport and entered the airport area flooding the runways. The airport become non-functional and all the operations of take-offs and landings were cancelled. Outgoing passengers were already stranded in the airport and the passengers who had landed before the flooding were also stranded. As the stranded passengers could neither proceed to their desired destination nor go back to their homes, the situation become chaotic in the airport. Food supply was also limited as the contingency was never thought of.

8.4.3 Lacunae:

Airport is situated on one of the old holding pounds (Padam talav) which subsequently has been filled up and nallas have been diverted. Airport is skirted by Mithi River, Vakola nalla and their tributaries on 3 sides. While increasing the length of the landing strips Mithi River has been bridged under one strip and diverted around the other strip. Further, the work of Taxibay is in progress for which widening work of the existing bridge under the first strip is in progress. River was temporarily diverted for the construction work.

8.4.4 Suggestion:

Water way of the Mithi River Bridge under the strip needs to be reviewed and if found necessary, increasing the water way by providing additional spans may be undertaken. Around the second strip where Mithi River has been diverted and geometry of the original course has been disturbed, this will also need a re-look and may require compensating the disturbance by widening the river channel and remodeling the bridge near Airport colony at down stream.

<u>Juhu air strip:</u> This Air Strip gets flooded frequently even in normal years. Raising of this strip may be undertaken so that during calamities like this rescue operations can go on using Juhu landing strip.

Over head wires: Cable operators have hung their cables from building to building. Helicopter operations in such a situation become dangerous. Necessary measures need to be taken to regulate the cable operators in this regard.

Air Rescue Operations: It would be advisable to get some study conducted about air rescue operation requirements in the city. One possibility to examine is that the building regulations should require that any building over 16 stories high must have its terrace slab designed to allow for the load of a helipad, and this helipad must be kept clear at all times for emergency use.

8.5 Water Transport

8.5.1 General:

Though Mumbai City is surrounded on all sides by the sea and water bodies and has got two all-weather international ports, the inland water transport system has not been fully harnessed so far. Probably it might be due to the fact that fast alternatives like local trains and buses are available, and in the monsoon four months the sea is quite rough on the Western Cost.

8.5.2 Rescue Operations:

On 26th July, 2005 there was not much of a problem in the port itself as rainfall intensity in the southern part of the city was much less compared to the Northern part. On that day, as per the request of Maharashtra Govt., Navy and Army were undertaking rescue and relief operations in Raigadh and Ratnagiri Districts. By the time the subsequent request for help in Mumbai Suburban area was made to them, at 16.30 hours, many of their resources had left for Raigadh and Ratnagiri District. Generally the Navy requires an operational lead time of about three hours to go into action. However whatever resources they had and they could gather from near about area was promised to be diverted but when they were ready to launch the operations, the boats and other equipments could not be taken to the rescue spots as all the roads were blocked by stranded vehicles.

As no landing facilities were available on the West Coast, and conveyance by sea was also not possible in rough seas, air dropping was resorted to. However that operation was also hampered by the overhead cables and low visibility in the evening hours.

8.5.3 Lacunae:

There is no inland water transport system though thinking is going on for quite some time. The main problem faced by these projects is about their reliability in four months of monsoon, as in the monsoon four months the sea is quite rough on the west coast and the west coast is strewn with rock outcrops so navigation is risky. Travel time is more in case of water transport and suitable terminal facilities are not available. Due to international cargo traffic in the ports on the eastern coast, doubts are raised about the hazard of collusion with vessels and possible hindrance to the towing operation due to carriers etc. Though terminals do exist on eastern coast in Mumbai bay their potential is not fully exploited.

8.5.4 Suggestions:

Serious thought needs to be given to the inland transport facilities to be established around Mumbai. If well-equipped terminals with good connectivity are established all around the city the system may catch-up. Initially it may cost little more for establishing primary infrastructure facilities and the tariff may need some subsidy. In addition to giving some relief to the regular transport systems, these infrastructure facilities will be useful in rescue and relief operations in emergencies. The facilities will also be useful in eventualities like evacuation etc. These facilities should be made a part of the National Disaster Management System.

Inflatable Boats: A stock of sufficient inflatable boats should always be kept readily available in the ward offices to make them available to the rescue teams.

8.6 Bus System

8.6.1 General:

City bus system in Mumbai is handled by Bombay Electric Supply and Transport Undertaking. The system was set up a long time ago and is well established. It handles about 41.2 lacs of people daily.

8.6.2 Experience:

On 26th July 2005, when the information about gathering of huge crowd of commuters at CST and Churchgate station was received by the BEST, the authorities immediately diverted 500 buses to various stations to carry the stranded commuters to their destinations. However the buses could travel half-way only and they were met with a traffic jam created by the broken-down cars and deserted vehicles. They could not move further even though the higher elevation of their engines would have allowed them to ply though deeper waters. Passengers could not reach their destinations and had to remain seated in the buses overnight. It is noted with gratitude that the passengers and the drivers were given food and tea by the local residents. It is also noteworthy that no driver of the BEST bus left the bus.

8.6.2 Suggestion:

Coordination and Communication System: Though BEST administration reacted very well in the time of crisis, the buses could not reach their destinations and were stranded midway. If a good communication system had existed between the traffic control branch and BEST authorities, so many buses would not have been deployed as these buses themselves contributed to the traffic jams.

Information System: Information system, display system, public address system would have help in optimum utilization of the BEST's resources.

8.7 Traffic control

8.7.1 General:

Traffic control branch of Brihan Mumbai Police is entrusted with the job of regulating traffic in the city. Signals are installed at important junctions and they are programmed to operate on some fixed cycles depending on the surveyed traffic pattern. A few consecutive signals are synchronized for uninterrupted flow of an average number of vehicles. Power supply for their operation is through regular BEST or Reliance supply.

8.7.2 Experience on 26th July 2005:

As the information of heavy rains was spread and office goers were allow to go home early a rush of vehicles started coming on the roads. When the traffic reached certain low lying parts it was interrupted or slowed down. When water level further rose smaller and low clearance vehicles started stalling and broke down. These vehicles blocked the road and traffic started piling up behind them. These vehicles were deserted by their occupants. In absence of clear passage, even towing away of these vehicles was difficult. This created total chaos and a traffic jam which continued for the next 24 hours.

8.7.3 Lacunae :

Traffic control Branch do not have a good communication system to inform road users about the traffic conditions ahead, alternative routes to be followed to avoid the traffic jams etc. No overhead displays to relay the information are provided. Traffic control Branch is not having central control or a closed circuit T.V. system established. In case of crises of similar nature the Traffic Branch is not equipped sufficiently.

8.7.4 Suggestion:

Visual display system: Visual display system should be installed on overhead gantries whereby drivers can be informed about the traffic conditions, speed, alternative route to be followed etc.

Public Address System: A good public address system with visual aids should also be established at Railway stations, Bus Stations and at prominent locations like road intersections, theatres etc. to inform the general public about the situation.

Power to Signaling System: The signaling system should also have its own independent power backup to handle emergencies.

Dedicated Lane: The introduction of a Bus Rapid Transit (BRT) system on lanes reserved exclusively for the BRT will provide a system which can be used in emergencies for rescue vehicles, ambulances and other services.

Area Traffic Control System: The traffic branch should be modernized and should have Area Traffic Control System established. This system comprises of integrated video cameras, T.V. monitors, Computers and communication system consisting of visual display system on overhead screens.

In this system video cameras are established at various important junctions and they relay information to the commuters in the central control room. TV monitors enable viewing the traffic situation at various locations and as the situation warrants, necessary instructions, warring, alerts etc. can be relayed through audio as well as display system on the screens mounted on overhead gantries. The timing of traffic signals can also be centrally controlled. Being a unified control system traffic regulation becomes very easy and effective. Total overall traffic system can be viewed at one place so traffic can be diverted to suitable routes which may have spare capacity, or the action can even be holding back the traffic flow temporarily to avoid further jamming. Errant vehicles can also be brought to book as a permanent record also can be kept. Such a system needs to be installed for Mumbai City.

8.8 Design Considerations for Cross Drainage Works:

There has been frequent reference and emphasis on the day's total precipitation in the flood related data. IMD's normal weather forecasts and reporting are also lined up on a 24-hours basis. Though for large basins and regional situations such data have some significance, however, for urban conglomerations of relatively limited geographical expanse and consequently shorter time of concentration of flows, the 'flooding' situation on basis of 24-hour rainfall considerations fails to have specific relevance. In most urban streams the time of concentration is as small as 15 minutes and the signs of excessive flooding start appearing immediately thereafter. Hence analysis of the rainfall data for smaller intervals of time is what is important for urban situations.

In fact, BRIMSTOWAD has been able to shift the focus from '24 hours' events to 'one hour' precipitation analysis. It was on that basis that a 50 mm rainfall per hour was specified as the norm for planning the cross drainage works and the storm management arrangements in Mumbai. It is desirable to basically continue that norm and the required waterway at C. D. works stipulated by the BRIMSTOWAD report.

Over the next five years, when more data on 15 minute precipitation intensities become available from the self-recording rain gauges that MCGM will be installing in Mumbai, thereafter—coupled with similar analysis that may be available from earlier IMD rainfall record graphs of their automated self recording rain gauges in Mumbai—a clear picture will emerge about the rainfall intensities that the smaller catchments have to face annually, or at 1 in 10 years probability. A review of the waterway required for the C. D. works on critical transport corridors and BRIMSTOWAD's provisions should be carried out thereafter. In crowded urban areas as in Mumbai, Road layouts have to be an integral part of the surface flow management system. Under the storm situations, road widths have to function efficiently to drain away the accumulated water on the individual plot premises and carry them smoothly to the storm water drains without hampering the traffic. Performance of this function requires very meticulous planning with reference to the ground contours and more the so in the flat terrains.

8.9 Corridor Approach:

As the 'financial capital' of the country Mumbai will have to remain as risk-free as feasible particularly from natural calamities. For dealing with excessive precipitations, which are predicted to be more frequent in future due to the effects of global warming and climatic changes, it would be desirable to follow more stringent criteria for waterway requirements of the Cross Drainage Works. At the same time one will have to take into account the geographical constraints of the city and the developments that have already taken place which prohibit any drastic and extensive modifications in the present system. Therefore a suitable solution addressing all the issues is essential. Main objective should be that the city life does not get paralyzed under excessive rainfall or while carrying out the require modifications.

Keeping this in view it will be necessary to categorize the existing routes into three categories namely, a) Arterial routes—corridors serving as escape routes—Eastern Express Highway, L. B. S. Road, Central railway, Western Express Highway, Western Railway, S. V. Road, Sion-Panvel Highway, Harbor Railway and link roads, b) Main roads—roads on which BEST buses run and c) Minor roads—remaining feeder roads in the city.

For designing the C. D. works on these routes different criteria should be applied depending on the importance.

a) on Arterial routes cross drainage structures should be designed for 1 in 100 years precipitation intensity. This should also be applicable for C. D. works below the air strips. A special technical review of all the C. D. works on these routes will be worthwhile in this context. The object should be to reach the risk-free status within the next 5 years by upgrading the structures and raising of the routes to the extent possible. Channel capacity establishment and augmentation will have to be taken up simultaneously.

b) on main roads catering for buses the C. D. works should be designed for 1in 25 years rainfall intensity. It should be aimed to be attended in the coming 10 years.

c) on minor roads the C. D. works should be designed as per the BRIMSTOWAD recommendations.

For example there are 14 bridges on Oshiwara river in its length of 6.5 km, 24 on Poisar river in its length of 9 km and 20 on Dahisar river in its length of 13 km. Out of these, 3 bridges on each river exist on the Arterial routes. They should be upgraded to cater to 1 in 100 year rainfall intensity, while on other bridges there may be some heading up of water for some time when that intensity occurs.

8.10 Integrated transport System:

Though quite a number of transport studies have been made in the past the city does not have any well defined comprehensive transport plan as on today. It has also been pointed out in some studies that poor transportation facilities is one of the

major factor responsible for the decline of economic growth rate of the city and the city is loosing its place in national economy. It is high time now for such a plan for the city hither to called financial capital of the nation.

Traffic and transportation in Mumbai is managed by different agencies in fragmented manner. At present railways, bus system, traffic control and ferry operators etc function in isolation. Railways have their separate domain being a limb of Central Govt. and are handling the local train service very unwillingly, as it is a loss making preposition which nobody is ready to take over. Bus system is handled by BEST organization a limb of Mumbai Corporation. The ferry service is handled by private operators on few routes between city and main land. All these agencies do not have any effective coordination between them.

Though the ultimate aim is to provide comfortable and efficient transport system for the metropolis, there is no integrated approach in providing these services in the form of comprehensive planning and establishing a unified authority. In the absence of such integrated approach necessary investment in the transport sector is not forthcoming. Most of the capital intensive projects suggested in the previous studies have not materialized because of complexities involved in dealing with multiple agencies for implementation. So it is essential to establish some unified transport authority which will coordinate and control all the modes of the transport in the city.

Several studies in the past have indicated that the Public Transport caters for 82 to 85% of the commuters (Train-51%, BEST-26% and chartered Buses 5%), while Rickshaws account for 5%, Taxies 1%, Bicycles & Two wheelers 8% and Private Cars 4% only.

It is also to be noted that the other modes are used mostly for shorter trips only and serving as feeder or giving east-west transport links. However if the road Space Occupancy is taken into account the picture is far more dark in respect of personal vehicles.

<u>Road Space Occupancy</u>

Category	Number of Vehicles	Road Space Occupancy	Passenger Trips
Personal Vehicles	9,64,502	84%	17%
BEST Buses	3,391	4%	51%
Taxies & Rickshaws	1,58,683	12%	32%

Present carrying capacity of existing Local Railway Transport has been frustratingly exceeded. Augmentation with additional lanes is not possible as no additional land is available for expansion. Slight augmentation is possible by way of increasing the frequency by providing links between terminals and integrating two railways for local traffic which has not been possible because of the resistance on part of both railways to integration with each other.

We would like to draw attention here to one proposal that is being studiously ignored by the Railways. This is for an underground loop connecting Churchgate and VT stations. Today the headway between trains at both these stations cannot be

reduced much below 3 minutes, because that is the time it takes for a train to pull into a terminus platform, unload and reload, and then pull out its full length of 9 cars (proposed to be increased to 12 cars) on to another track to let another train in. Once the underground link between the two stations is established it will be possible for trains to follow each other on the same track. This can reduce the headway between trains to about a minute, thus providing a dramatic increase in the capacity of the entire suburban railway system. Our understanding is that this proposal is not being pursued because Western Railway does not want to run its coaches on Central Railway and vice versa. It is high time that the functioning of these two separate entities is thoroughly co-ordinated. One way of doing it would be to have a separate Mumbai Railway Zone for the Railways, as distinct from either Western or Central Railway. Another, as suggested elsewhere in this Report, would be to have a Mumbai Transport Authority provided this can effectively co-ordinate the two Railways.

Past experience has also indicated that building freeways and flyovers in an area that is already congested does not reduce the congestion to much extent. The capacity of the existing road system is already exhausted. Widening of Arterial Routes is being done to full right of way, so no further augmentation is possible except through traffic management.

So alternative means of transport like Metro, Mass Rapid Transit System, Water Transport and constructing the East Island Freeway need to be vigorously pursued. A high level body taking care of these issues need to be constituted comprising of experts in traffic planning, management, economists, other agencies dealing with transport, representatives of stake-holders etc. along with the revival of the Transport Board of the MMRDA – which existed in the initial years of its functioning. It should also be made more broad-based than before to ensure participatory approach to the further development of the transport routes in partnership with the other municipal corporations like Kalyan-Dombivali and Thane etc.

8.11 Handling Extreme Events:

The future eventuality of similar extreme events taking place due to sabotage, act of enemy, earthquake, tsunami type waves etc. cannot be ruled out. So also a contingency of the necessity of total evacuation of the population cannot be ruled out. The city should be equipped suitably to handle such eventualities in future. As far as transport is concerned it is desirable to identify a few projects which will be helpful to the authorities in emergencies.

In the last five decades various transportation studies have been carried out in Mumbai and the Mumbai Metropolitan Region. A note on Transport Infrastructure in Mumbai Region is appended. A few suggestions flowing out of these studies and observations made by the committee deserving immediate consideration are as follows:

1) Anik-Panjrapol road work is being taken under MUIP. However at present, it is planned to terminate at Barkat Ali Durga Road instead of joining it straight to Nana Fadanvis Flyover. Such an arrangement will create bottle-necking at B.A.

Durga Road where it takes a very acute “U Tern” to go to Nana Fadanvis flyover. It is suggested to provide a tunnel below Antop hill here and join the road straight to flyover.

2) Barrister Nath Pai road is very narrow and has less capacity compared to Rafi Ahmed Kidwai Road from Sewree Station. To utilize its full potential B. N. Pai Road should be raised and taken up at elevated level like J.J. flyover so that incoming and outgoing traffic can be segregated and dispersal will be speedy.

3) Anik Panjrapol Road should be further extended upto Ghatkopar-Mankhurd Link Road through Deonar. So one more independent route will be available for the purpose of quick dispersal in emergencies.

4) Proposal of Sewree - Nhava Sheva Road (Main Land Link) should be implemented on priority along with a rail link. This will open out vast area on main land and serve as a quick dispersal route. Such routes are very essential for this city which is dwelling in risky conditions.

5) Water transport project should be seriously considered to augment the transport system. The same will also be very useful for rescue and relief operations.

6) Eastern and Western Express Highways and Vashi- Panvel Road should be provided with concrete surfacing like all other roads being developed. Bituminous roads are vulnerable to water and get damaged which reduces their capacity to a great extent. In case of disasters and evacuation such handicaps can give a major set-back to the operations.

7) Under ground Metro or suitable transport system should be pursued vigorously. At least intermediate cross-connections should be developed on priority.

8) Scheme of East and West Island Freeway should be undertaken. These routes will serve as escape routes and also will be helpful in relief and rescue operations.

9) Suitable cross-connecting roads should be improved in city as well as in suburbs. This will improve the internal mobility and efficiency of the arterial routes.

10) Waterways of all the C.D. works on Railway, Strategic Roads and Mithi river crossing below the runway at Santacruz should be designed and reconstructed for 100-year return period.

11) While increasing the waterways or reconstructing the existing C.D. works box-type construction should be preferred. The minimum size of box should be 1m x 1m for easy accessibility during maintenance.

12) Pumping arrangements at chronic flooding spots should be installed and it should be ensured that they are in working condition by carrying out regular drills.

13) Juhu Air Strip should be raised to suitable level so that it remains operational in emergencies.

14) Helipads should be established at various locations in the city and suburbs. These will be very useful in emergencies. One possibility to examine is whether building regulations can be altered to make it mandatory for buildings above a certain height to have helipads on the terrace for emergency use.

15) Integrated traffic management system should be established for Mumbai Metropolitan Region.

16) A recently commissioned transport study (TranSfoRM) by MMRDA should be asked to address the issue of emergency evacuation route.

APPENDIX - 8A

Transport Infrastructure in Mumbai Region

1 Review of past studies

In the last four to five decades, various transportation studies have been carried out in Mumbai with different objectives and for different models. Table below provides a summery of various studies done for Mumbai Region and its transportation infrastructure requirements recommended by them.

Study Name (Consultants)	**Agency**	**Year**	**Focus Area**	**Major Recommendations**
Bombay Traffic and Transportation Study (Wilbur Smith and associates)	Ministry of Transport (Govt. of India), Govt. of Maharashtra, Bombay Municipal Corporation.	1963	Freeway and Expressway System Major Route Improvement	West Island Freeway East Island Freeway Eastern and Western Expressway Cross island Freeway Mahim Creek Connector Central Island Expressway Tardeo Expressway Sewari Expressway
Development Plan for Greater Mumbai	Barve Committee Bombay Municipal Corporation	1964	Confined to major civic problems of Greater Mumbai	Develop Area on neighbourhood basis Encourage housing activities in sub urban areas
Regional Plan for Bombay, Panvel and Poona Regions	Gadgil Committee	1965	Need for integrated Development of the region to help slowing down the upsurge of population	Creation of CIDCO for development of counter magnet to Mumbai Creation of BMRDA for coordinated development
Mass Transport Study	Town Planning and valuation department	1969	Mass Transport	6th and 7th Rail corridors
Feasibility Study for Railway Corridor (IIM Bangalore)	CIDCO	1979	Bandra-Mankhurd-Panvel Line	
Planning of Road System for Bombay Metropolitan	PWD	1983	Formulation of Major Road network system for BMR	Western Freeway from Kalanagar to Nariman Point Eastern Freeway

Region (Central Road Research Institute, New Delhi)				from Andheri Ghatkopar Link with Eastern Expressway and upto Mukharjee Chowk Thane Creek Bridge II Sewari Nhava Sheva Link Expressway on elevated alignments Improvements of major arterials on 20 links Up gradation of district roads to Two Lanes
Report of High Level Committee for prioritization of Road works in Greater Bombay	Paranjape Committee	1988	Traffic Demand Management and Short term road Improvement Plans	TDM measures Station Area Improvement Plans New Link Roads New Terminals and Fleet Renewal Validation of CRRI Projections and to adopt need based approach in implementing the Proposals of CRRI
Techno-economic Feasibility Study for Passenger Water Transport Service (Kirloskar)	CIDCO	1992	Passenger Water Transport Service between South Bombay and New Bombay	Recommended suitable crafts Establish navigation channel Waterfront facilities
Comprehensive Transport Plan for Bombay Metropolitan Region (W. S. Atkins International, Kirloskar and ORG)	BMRDA	1994	Multimodal study covering road, rail and water transport	Various railway improvements to strengthen and optimize its use Strengthen bus system Provision of ferry system between Colaba and Belapur/ Vashi
Mumbai Metro Study	Mumbai Metro Planning Group	1997	7^{th} Corridor	

Feasibility Study of Mumbai Trans-harbour Link (CES)	Govt. of Maharashtra MMRDA	1984 and 1998	Mumbai Trans-harbour Link	Detailed study of the trans-harbour link Suggested Northern alignment
Traffic and Transportation Study for Bandra-Worli Sea Link Project (CES)	MSRDC	2000	Study of Bandra-Worli Sea link Project	
Development of Passenger Water Transport on West Coast for Mumbai (Dalal, Mott Mc Donald and IIT Mumbai)	MSRDC	2003	Development of Passenger Water Transport on West Coast	
Preparation of Master Plan for Road net work Improvement and Traffic Dispersal in Greater Mumbai –MUIP (CES)	MMRDA	2003	Road improvement and traffic dispersal	Prepare plan of traffic dispersal system Provide priority to bus system Eliminate railway level crossings Provision of pedestrian facilities

2 Comparison

From the above table, it can be seen that the comprehensive studies done till date have been confined to mainly road related projects. Other studies were mainly project specific.

Further, most of the above studies done after 1983 have been relying on home interview data collected by CRRI during 1978-79 updated through supplementary surveys from time to time. All these studies pertain to specific requirements. Further, these studies were limited in their scope to Greater Mumbai area and treated rest of the Mumbai Metropolitan Region as external are.

3 Ongoing Comprehensive Transport Study (CTS)

As part of technical assistance programme under MUTP, MMRDA (in collaboration with World Bank) is carrying out a Comprehensive Transportation Study (CTS) for MMR which is known as TranSfoRM (Transportation Study for the Region of Mumbai). Consultants from Canada, LEA International Ltd are conducting the study. This study departs from previous attempts in following ways:

- It treats the whole Mumbai Metropolitan Region as one single contiguous area.
- All comprehensive surveys, including home interview survey, are being done afresh.
- All modes of transportation are being considered, with special emphasis on public transport.

3.1 Objectives of the study

This aims to formulate long-term transport strategy for Mumbai Metropolitan Region (MMR) and to recommend a practical and effective investment programme for coming ten years that is consistent in approach for another ten years i.e. for a total period of 20 years.

Following are the major objectives of the study:

- Identify travel pattern of residents of MMR,
- Select, develop and make operational one Urban Transport Planning model,
- Assess the relevance of the 1994 strategy, identify the consequences of pursuing alternative transport strategies and recommend/update a long-term comprehensive transport strategy for MMR up to 2031,
- Identify a phased programme of investments and policy proposals up to 2016, and
- Help strengthen transport-planning skills of MMRDA and other concerned agencies in MMR.

3.2 Scope of the Study

To achieve above objectives, following activities come under scope of work of the study:

- Data collection,
- Simulation/Modeling,
- Formulation of a transport strategy,
- Identification of transport investments and management proposals,
- Training and knowledge transfer to MMRDA and other agencies, and
- Assist MMRDA in public consultation process.

As per the economic census 1998, 60% (approximately 15.8 lakhs) of the formal sector jobs are concentrated in the island city. Details of number of establishments and the kind of employment with its special distribution are shown in the following figures.

Assuming a trip rate of 1 during the peak period, 15.8 lakhs person trips will be made during peak hours. Apart from this, informal sector has its share in further loading on the network. Thus, further improvement in the economic activities in the Island City would lead to further increase in number of person trips, for which transport supply is a constraint for the time being.

MCGM	EMPLOYMENT 1998
Island City	15 89 356
Western Suburbs	6 53 999
Eastern Suburbs	3 82 507
Total JOBS	26 25 862

APPENDIX 8B

COSTING OF SUGGESTED WORKS PERTAINING TO TRANSPORT

NOTE: In the absence of detailed survey and required data it has not been possible for the committee to arrive at exact costs of the components involved. Individual organizations are also unable to asses the exact implications so the cost estimates could be base on rough judgment only.

Cost of balance works – suggested by BRIMSTOWAD

- SWD 1800 Crores

Railways:

- Improving Signaling : 30 Crores
- Remodeling the C.D. works 30 Crores
- Local pumping arrangements 20 Crores
- Diverting sewer lines 10 Crores

Roads:

- Remodeling C. D. works 40 Crores
- Raising certain roads 50 Crores
- Local pumping arrangements 30 Crores
- Approaches to railway stations 50 Crores

Air transport:

- Juhu air port 20 crores
- Landing facilities for rescue & relief oprs. 10 Crores
- Mithi-bridge as per new recommendations 50 Crores

Water Transport:

- Landing facilities on west and East Coast 50 Crores
- Acquisition of inflatable boats 30 Crores

Bus Transport:

- Communication system 10 Crores

Additional Escape Routes:

• Tunnel below Antop hill	7 Crores
• Barrister Nath Pai Road Elevation	200 Crores
• Anik Panjarpol Extension to E.E. Highway	80 Crores
• Sewari Nhava – Along with rail component	6200 Crores
• Western Freeway	3550 Crores
• Water Transport Package	6000 Crores

CHAPTER 9

URBAN PLANNING & GOVERNANCE

9.1 Mumbai is losing its place as one of the leading performers in the Indian economy. It has one of the largest percentages in the world of commuters who use public transport (85%). Yet the transit system is massively overcrowded, and commuting times are longer on average than in most other world cities. Apart from Africa, Mumbai has a higher proportion of its population living in slums than any other city in the world (now about half). Land is in extremely short supply and as a consequence real estate prices are among the highest in the world. There are archaic laws governing real estate development still in place, and not enough effort is being made to increase the land supply. The procedures for serious urban planning have fallen into disuse. Governance of the city and particularly planning decisions have been over-centralised and effectively taken out of the hands of the local authority.

9.2 A city works because of its infrastructure: water supply, sewage handling, solid waste collection and disposal, drainage and flood control, reliable and continuous electric supply, a telecommunications network, and above all mass transit and road systems. The better the infrastructure, the better the working of the city. The better its working, the higher will be its economic productivity, and the higher will be the level of satisfaction of citizens with the quality of their lives. Disruption of the working of Mumbai is particularly damaging, because it has a Net Domestic Product per working day of over Rs 250 crores[2], expecting to grow at about 8% per annum. Our goal therefore should be to build a better, less risk-prone and more equitable city to live in.

9.3 The Centre for Research on the Epidemiology of Disasters (CRED) defines a disaster as "…a situation or event which overwhelms local capacity, necessitating a request to national or international level for external assistance." Disasters in an urban area can be caused by one or more of the following:

(i) Earthquake
(ii) Flood
(iii) Cyclone
(iv) Storm surge (an extreme form being tsunami)
(v) Fire
(vi) Atomic reactor accident
(vii) Chemical Industry accident
(viii) Epidemic
(ix) Terrorism
(x) Breach of a dam.

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[2] Maharashtra Economic Development Council, *Fact Book*, Bombay First, 2006.

9.4 The Human Development Report of Maharashtra (2002) has clearly brought out that the natural increase in the population of Greater Bombay during the decade 1991-2001 has been of the order of 12 lakh persons, leaving aside the migration of 7.32 lakh persons into Mumbai[3]. In other words, there will be increasing congestion on Mumbai Island even from the natural growth of population. It is hoped that the development and management policies of an overpopulated city like Mumbai will keep in view the consequent risk of further deterioration in the conditions of Mumbai and will prevent further encroachment and crowding in the stream-flow areas.

9.5 The slum population in Greater Mumbai in 2001 was 58.2 lakhs vis-à-vis the non-slum population of 60.9 lakhs[4]. Because of continuing migration, as well as continuing natural growth, with no viable policy for low-income housing, it is estimated that by 2025 the slum population will be greater than 64 lakhs, in excess of the estimated non-slum population of 62 lakhs. Clearing of the stream flow areas thus has to be achieved in the context of increasing crowding.

9.6 Studies by TranSForM (Transportation Study For the Region of Mumbai) have highlighted the aggravation of land scarcity in Mumbai on account of the Coastal Zone Regulation. They have pointed out that almost 25% of the land area of the city falls under the categories of CRZ-II and CRZ-III. The supply of land on Mumbai Island and Suburbs is already severely constrained. The basic intention of the CRZ laws was to protect the normal coastline areas of India: it was surely not the intent to constrict housing activity in an already over-populated city like Mumbai. Environmental clean-up and upgradation of Mumbai as a whole will be greatly hampered by such restrictions. It is hoped that the concerned authorities will take a proper view of the special requirements of Mumbai while applying the CRZ philosophy, and will remove the hurdles in the thinning process that is required to be carried out in Mumbai while clearing the slums occupying risky areas in the flood zones of rivers.

9.7 Doubts about the capability of the local administration to manage a complex city like Mumbai may come in the way of securing a brighter future. The administrative setup of Mumbai needs to be arranged in a coherent manner to manage normal civic life effectively, as well as to handle emergency situations in a well co-ordinated manner.

9.8 Because of the presence of a large number of operational establishments of the Government of India like the Airports Authority, Army, Navy, Port Authority and the headquarters and workshops of large Railway networks, the Municipal Commissioner of MCGM has a very difficult role to perform. The GoI establishments tend to be not directly accountable to the city's principal administrator or the local elected body. His position and the position of the elected MCGM has been eroded by direct instructions emanating from the Urban Development Department of the State Government, and somewhat further overshadowed by the presence of MMRDA in Mumbai, not only as a planning and co-ordinating body, but also as an executive 'independent' authority. This

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3 Human Development Report of Maharashtra, 2002, Table 3.4

4 Ibid, Table 3.12

was made abundantly clear in respect of the development of the Bandra-Kurla complex, the airport's Mithi river bridges, and channelization of the Mithi river. In all these cases the role of the MCGM got progressively marginalized, leading to un-co-ordinated management of the Mithi river.

9.9 The Mithi River Authority is hereafter expected to undertake the required overarching responsibility for managing the Mithi basin in a comprehensive and co-ordinated manner. The Slum Rehabilitation Authority and the Mumbai Housing and Area Development Authority though dealing with the housing problem in Mumbai have their own independent exclusive authority, overriding the rules, regulations and general development and management strategies of Mumbai's civic life. This is not a desirable trend. Within the Corporation's area, all authorities, whether State level or Central level, should have to abide by the town management principles, as reflected in the Municipal bye-laws, development plans, rules and regulations.

9.10 Disasters will happen. We cannot know when. We cannot know in advance what form they will take. But we can set in place systems for swift and effective response, so that post-disaster recovery is quick and well organised. From the experience of recent disasters it is also clear that in any disaster management plan the citizens must be actively and heavily involved. More than being victims of the disaster, we have to look to them as being the first line of defence in responding to the disaster. To that extent they are not subjects of government, but partners in governance. An excellent beginning has been made in this direction through the Advanced Locality Management groups (ALMs) already active in various parts of the city. The working of the ALMs and how it should be strengthened is discussed at length in Appendix A.

9.11 Any Disaster Management Plan expresses the nature of the underlying, existing Governance System. To a large extent therefore, if the governance system has weaknesses, they will show up in the disaster management process, in a more exacerbated manner due to the pressure of the disaster situation. Hence, establishing a solid Disaster Management Plan requires that the underlying urban management and governance process also be addressed. Currently, there is a plethora of authorities and agencies responsible for different aspects of urban life in the Mumbai Metropolitan Region. In some cases their responsibilities are overlapping, or uncertain. There is no clear accountability, and often no clear command structure for resolution of conflicts between authorities. There are far too many authorities, and too many of these see themselves as answerable to no one else in the city, and as a law unto themselves. We need to clarify roles, accountability, and mechanisms for negotiation as well as for dispute resolution. In doing this, we should take into account the Constitutional requirement that urban local bodies form the third tier of government, and function as the agents for social and economic change. So we need to constitute effective Ward Committees (or even smaller units of governance, like the Grama Sabhas in rural areas) with meaningful public participation; as well as a Metropolitan Planning Committee (MPC) for inter-agency co-ordination. Incidentally, it has been shown that in the Tsunami disaster response in Tamil Nadu, villages that had effective Grama

Panchayats/Grama Sabhas were less affected, and more nimble in their response.

9.12 Financing is equally muddled. Each authority is an island. It finds its own funds, and proposes and manages its own development projects. There is no prioritization of projects, based either on a comparison of their cost-benefit ratios, or any other kind of comparison. The MMR would benefit from a comprehensive review of projects, and their funding, and a clear delineation of priorities. Without clear prioritization, our apprehension is that drainage and flood control will be relegated to the background, while other more glamorous projects like the Worli-Nariman Point Sea Link are given more whole-hearted support. We should note that two of the most important functions assigned by the MMRDA Act 1974 are to review any physical, financial and economic plans and to review any project or scheme of development in the MMR.[5] Article 243 EZ of the Constitution requires the establishment of a Metropolitan Planning Committee (MPC). The National Commission to Review the Working of the Constitution (NCRCW), in making the case for the MPC, specifically cites the example of Mumbai's multiple agencies. One possibility could be for the MMRDA to be converted into the MPC, with appropriate changes in its constitution and mandate.

9.13 On the legislative front, a number of initiatives are seriously overdue:

9.13.1 The Rent Act. The continuation of the Rent Act has had two damaging effects in regard to the drainage of the city.

The first is the proliferation of slums. Before the end of World War II rental housing accounted for more than half the pucca housing in Bombay. This included housing for the poor, which was in pucca built chawls. By freezing rents, the Rent Act effectively killed all construction of new rental housing. In the last 50 years there has been no new private sector housing built for rental. Even when a family goes away for a few years, it dares not give out its flat on rental. So flats remain vacant rather than get rented out. When ownership housing is unaffordable, citizens have no choice but to move into slums. Slums provide the only accommodation that can be had on rental. And when they constitute more than half the city's housing, it comes as no surprise that they are built in a way that blocks drainage channels.

The second is in regard to the buildings where rents are frozen ("cessed" buildings). Landlords are supposed to maintain these buildings at their own cost. With rents frozen, they naturally see no reason to do this. Tenants refuse to contribute to repairs, because the law says this is the landlord's responsibility. MHADA has thrown up its hands on account of the scale of the problem; and experience shows that even when it does carry out repairs, there is no guarantee that the repaired building will not collapse. While the deluge of 26 July may not have de-stabilized such buildings, it is certain that a disaster of another

[5] MMRDA Act 1974 Section 12, sub-section (1), parts (a) and (b).

kind, such as an earthquake, would devastate large numbers of such buildings. It is urgent therefore that mechanisms be devised by which responsibility for maintenance and safety is firmly placed with those who will most benefit from it—the occupants.

So we would like to see three changes in the Rent Act, without disturbing the difficult issue of revising frozen rents:

(i) One is that all new tenancies, after a specified date, are free of rent control. This is essential to enable private financing of construction of new pucca housing for rental as an alternative for families who would otherwise be condemned to living in slums.

(ii) The second is a change in the provisions of the Rent Act so that where someone has taken housing finance and mortgaged his flat, a subsequent leasing of the flat does not protect the tenant from eviction if the owner defaults on his repayments. The purpose of this provision is to ensure that housing finance becomes available for properties intended for rental. Incoming tenants would be informed, if they care to inquire, that a particular property is mortgaged, and would then take their tenancies knowing the risk of eviction.

(iii) And the third change is a provision that it is the occupiers of a building, whether they are tenants or owners, who are responsible for the upkeep and maintenance of the property, in proportion to the areas they occupy. Unless upkeep of old buildings is taken care of by the occupants (and housing finance where necessary made available for this) we foresee recurrence of the kinds of collapses that occurred following the disaster of 26 July.

9.13.2 Urban Land Ceiling (Regulation) Act (ULCRA): While its objectives were well-intentioned, to make land available for low-income housing, this Act has grossly failed in that respect. Some land was indeed acquired at low cost and turned over to low- or middle-income housing. A notable example is Nagari Niwara Parishad with just over 6,000 houses on 25 hectares of land, where the project is nearing completion. Another example is the Mathadi Kamgar Co-operative Housing Society, which has 18 hectares of land, but seems to have done nothing with it since it got the land about 12 years ago. Apart from these two schemes, we are not aware of any other lands acquired under ULCRA and turned over to housing. So by and large the main impact of ULCRA has been to keep land locked up and unavailable for development. Without the requisite will to use it, in practice the Act has if anything reduced land availability, aggravated land prices, and made housing for low-income groups even more intractable. If we want to reduce slums in the city, and move those who live there into sturdier housing that is less prone to damage in disasters, then the repeal of ULCRA seems essential. The expectation is that with its repeal more land will come on the market, land prices will fall to more reasonable levels, and private developers may take up low- and middle-

income housing projects, more particularly for rental if the Rent Act is also simultaneously modified to exclude all new tenancies from its purview.

If for any reason ULCRA is nevertheless continued, its provisions should be strictly applied, particularly in regard to construction of housing on vacant lands arising because of demolition of mills in central Mumbai.

9.13.3 Urban taxation: Completing the decentralisation process and empowering the city to manage itself also means that it has adequate fiscal capacity to fulfill its obligations. The primary source of revenue for cities is property tax. Unfortunately, compliance on property taxes is low across the country, and Mumbai is no exception – levels of compliance are often as low as 25% to 35%. Linked to the issue of compliance is also the tax basis – rental versus capital. Best practices worldwide are to use capital value systems. In addition to property taxes, other municipal sources of revenue can also be augmented substantially. These require detailed financial reform within the municipality, both in terms of tracking information on tax compliance, and also in accounting for the funds being managed.

9.13.4 Town Planning: The whole process of urban planning as currently conducted is flawed and obsolete. Our suggestions in this regards are set out separately below. The changes suggested would call for a slew of legislative and administrative initiatives, all necessary, in our view, for future developments to take place in a way that minimizes disaster damage. Before we turn to these issues, we should note that the single most important constraint in regard to Mumbai's development is the availability of land. We begin therefore by discussing how this can be addressed.

9.14 Land Availability

The issue of storm water drainage is intimately linked with the restructuring of Mumbai. Incessant pressure on lands in Mumbai has been the principal reason for encroachments on the stream flow areas, congestion and pollution. Relieving this unbearable pressure of population on Mumbai's lands will have to be the mainstay of the long-term strategy for storm water drainage. Otherwise whatever physical arrangements are made will in due course stand nullified—because the storm water channels remain unused by water flow in the non-monsoon periods. That attracts settlers. The remedy partially lies in putting these stream channel strips to appropriate public and private uses during the non-monsoon period—like playgrounds or golf courses. Use as permanent parking spaces is not recommended as these will have to be vacated during the monsoon, and in that case, where will those cars go? Mumbai's development maps will have to show the flood zones clearly and specify the appropriate uses of those areas in consultation with the local people. Residents of Mumbai will finally have to decide about their own future.

To make new land available for development, we need to examine several possibilities, and weigh each one carefully before deciding whether to accept or reject it:

9.14.1 Reclamation: “Bombay owes everything to successive reclamations”—Report of the Committee appointed by the Government of India to inquire into the Back Bay Scheme in 1926. The history of reclamation in Bombay can be seen in Appendix B.

Currently, we have become acutely conscious of our need to protect and preserve the environment, and rightly so. But in consequence of this new awareness, reclamation has become a dirty word, something to be avoided at all costs as somehow damaging to the environment. That is a position we should reconsider. Reclamation from the sea, per se, does not damage the environment. It needs to be undertaken, if required or considered desirable, with the proper attendant hydraulic model studies, to ensure that reclamation somewhere does not have undesirable consequences elsewhere, particularly with regard to erosion, or siltation of channels whose depth it is important to preserve. The location of the reclamation also matters from the point of view of urban development: whether land is being added at places that are easy and economical to service with urban services, particularly transport. When searching for landfill sites for solid waste disposal, for example, we should certainly consider reclamation as a viable and valid option. And we should learn from other cities, like Hong Kong, which have recently reclaimed land for a new airport and new city development sites while taking the utmost care to protect the environment and promote ecological balance.

In the context of the Mithi River, we should note that while the river existed earlier in its northern reaches as the overflow of Powai lake, it petered out into many channels and a swamp towards its junction with the creek at Mahim, and can hardly be said to have been a river at that point. It was channelised by the reclamations at Bandra-Kurla, on the basis of careful studies on a hydraulic model at the Central Water and Power Research Station (CWPRS) at Khadakvasla. Restoring it to its “original course” is therefore not meaningful. What needs to be ensured is that this important drainage feature is kept to the required width, free of encroachments, cleaned of siltation, and not subject to sudden right-angle changes of direction such as have recently been forced upon it by the work at the airport.

9.14.2 Increasing FSI: This is an enormously powerful tool, and like all powerful tools, must be used with disciplined precautions and the utmost care. The underlying principles and the basic purpose must never be lost sight of. The objective is to control densities, both of resident population and of commercial activity, at levels that the local infrastructure can support. In an already built-up area, further increasing the densities might be acceptable, provided this can be achieved without damaging the quality of life. Among the infrastructure needs, besides water supply, sanitation and solid waste disposal (all of which might be expandable with some effort) the most intractable is transport. Once road and surface rail widths have been established, increasing capacities later is very difficult. Managing transport then becomes a matter of managing transport demands, The only ways in which this can be done are to:

(i) limit the densities of population, resident or employed, in a locality. One way to ensure this is to limit the extent of built-up floor space, that is, to limit the FSI. Another is to limit the number of dwelling units per hectare, as well as the car population per hectare. This alternative needs to be carefully examined, particularly from the point of view of enforcement;

(ii) persuade users to move from private to public transport (because per unit of road width public transport provides several times the capacity of private transport);

(iii) attract new development to locations which the transport system can more easily service.

If transport capacities in a locality can be increased (for example, by adding an underground railway) then of course increasing densities (by increasing FSI) becomes a viable proposition, provided this is done in such a way that social infrastructure (schools, hospitals, open spaces) are also commensurately increased.

We should also note that other than the pursuit of equity, there is no logic in having a uniform FSI across vast tracts of the city. Equity, that is, fairness to all landlords, can be achieved in other ways, in particular by requiring those who are permitted additional construction on their plots, above the average, to buy the rights for this from those landlords who are required to restrict their construction to below the average. From the point of view of transport demand it would make far more sense to have high intensities of public transport demand around the railway stations, tapering down to lower densities as one gets further away. It would also make sense if the population resident in the vicinity of railway stations has low car ownership, so in these locations instead of specifying a minimum amount of car parking per building it would make sense to specify an upper limit, the maximum number of car parking spaces, either open or covered, that would be permitted; and on-street parking in such localities around the railway stations could also be totally prohibited, including overnight parking[6]. Variable FSI that takes into account transport considerations, and is integrated with parking controls, is thus a perfectly viable tool for the micro-planning of localities. But care must be taken at the macro level that in terms of overall densities of population and intensities of commercial activity the locality remains viable for transport and other physical and social infrastructure, particularly schools and open spaces. In other words, that while the FSI on a particular plot may be high because it is well serviced by transport and other infrastructure, the Global FSI of the whole locality (as an instrument for controlling densities of residence and business activity) is kept within strictly controlled limits.

9.14.3 <u>Recycling Land Uses</u>: As the city develops, it is possible that some uses of its land become obsolete and such uses are unimportant for the proper

[6] Donald Shoup, *The High Cost of Free Parking*, Chicago: Planners Press, 2005, and other publications.

working of the city, while at the same time there is a mounting demand for land for other uses. In such a situation it makes sense to convert the land from one use to another. There are four examples one can cite which are pertinent to the current situation in Mumbai:

(i) The land occupied by the textile mills in Central Mumbai. The Supreme Court has decided that this land may be developed by the various mills. However, such development will still need to fit within the framework of building control regulations, and we would urge the Government of Maharashtra to urgently consider amending the D.C.Regulations such that development on any vacant land in Mumbai provides for housing in a manner that is consistent with the Regional Plan for the MMR 1996-2011. Briefly, the requirement is as follows:[7]:

   (1) 30% of the FSI shall be consumed for apartments of less than 25 m^2.

   (2) 20% of the FSI shall be consumed for apartments of 25-50 m^2.

   (3) 30% of the FSI shall be consumed for apartments of 50-80 m^2.

   (4) In addition to these provisions which exist in the Regional Plan, we would recommend that the balance may be consumed as desired, except that in computing the FSI for commercial activities a weightage of 1.5 shall be applied—that is, 1 sq.m. of built-up commercial space would count as 1.5 sq.m. of FSI consumed.

(ii) Land used as salt pans is well located in regard to access to the transport systems of the city. The pressing demand in the city is for such land to be used for low- and middle-income housing. There is a clear case here for a change of land use. Once again, the matter of fair compensation to the original land owners has to be resolved.

(iii) The land owned by the Mumbai Port Trust (MPT). With the setting up of the Jawaharlal Nehru Port Trust on the mainland across the harbour, the need for a similar major facility on the Island city has diminished. Instead of complementing each other's activities, we find the two ports are rivals, trying to duplicate each other's facilities and outdo each other on parallel lines. Container traffic is well handled by JNPT. MPT should confine itself to cargo intended for consumption within Mumbai Island and Suburbs only. The rest of its land should be freed for other urban uses. The arterial transport connections of this MPT land are excellent, and it would make sense to convert this too to commercial and residential use,

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[7] Mumbai Metropolitan Region Development Authority, *Regional Plan for Mumbai Metropolitan Region 1996-2011, Table 8.17,* MMRDA.

particularly for mixed-income housing with an emphasis, as in Charkop, of ground-level plots for the very poor. The proportions for housing of different sizes may be as suggested in MMRDA's Regional Plan 1996-2011.

(iv) The CRZ law achieves very little beyond removing perfectly viable land for housing from the possibility of development. The gains from protecting coastal land within the city are far outweighed by the suffering of additional commuting travel times to which millions are thereby subjected, for ever. This is not to say that we should not preserve Mumbai's beaches, or mangroves, or other ecologically sensitive areas. But it need not be done as mindlessly as the CRZ law prescribes.

9.14.4 <u>Bridging the Harbour</u>: Altering the transport network of the city so that more urban land is brought under its scope is an obvious way of increasing land availability. The network has already been sufficiently stretched in the north-south direction to the limit of acceptable travel times. But there is scope to add east-west links across the harbour to large new areas of relatively undeveloped tracts on the mainland. What is vital is that such east-west links be mass transit links over a railway line. Road-only connections will serve little useful purpose. As the example of the Thane Creek bridges shows, duplicate links, one by road and a separate one by rail, are an unnecessary double expense: a combined rail-cum-road bridge would have been significantly cheaper. For the same reason, the proposed Sewri-Nhava-Sheva link should necessarily be a combined rail-cum-road link.

9.15 Development in Mumbai over the last century, and its impact on storm flows

This is set out in Appendix C. In summary, we can say that it is observed that whether the development is planned or unplanned, authorized or unauthorized, it is driven only by forces of property development and not by civic amenities or the infrastructural services or other environmental factors. Instead, property development has severely affected the natural ability of the city to manage rain water in an environment friendly way.

9.16 The history of post-Independence urban planning in Mumbai

This is set out in Appendix D.

9.17 The current urban planning process

In Mumbai and indeed Maharashtra the current urban planning process is archaic. It cannot cope with contemporary demands, pressures and needs. It consists essentially of local authorities preparing Development Plans at 20-year intervals. These are sent for approval to the State Government. They are basically land-use plans. They are accompanied by a set of Development Control Regulations (DCR) which are essentially building design controls. A

cursory, not-serious process of inviting public suggestions and objections is gone through, but this is at the end of the planning process, after all details have been finalized. The principal instrument for regulation of building design is Floor Space Index (FSI), which determines the amount of floor space that can be built on each plot. Other considerations such as density in terms of dwelling units per hectare (du/ha), open space, light and ventilation, access to fire tenders, or heritage controls are all considered secondary, and are either ignored altogether or frequently permitted to be compromised by modifying or overriding the DCR, examples being the Slum Rehabilitation Authority (SRA) and reconstruction of cessed buildings under DCR 33(7). Indeed, in the case of the latter two schemes, FSI is also significantly and in some cases drastically enhanced. In terms of land use also, major changes are permitted, particularly from public amenity spaces to private or commercial use. All these departures from the approved Development Plans take place in the guise of "modifications that do not change the nature of Development Plan". We should note incidentally that while many such modifications have been made, suggestions contained in the BRIMSTOWAD report have not been made part of the Development Plan (DP). Indeed, the DP does not even show the Mithi River in its northern reaches, nor does it clearly define all nallah boundaries.

9.18 Current urban planning practice world-wide

This has moved away from the preparation of detailed land-use plans to a process that consists of the following steps[8]:

9.18.1 Adoption of a set of "goals", or guidelines that will drive the planning process, and against which each policy, regulation, development proposal or project will be measured. These would be articulated and refined through a process that mandates genuine public participation. These would be reviewed over a long time span, say once every 10 years. Typical goals might be such as the following:

(i) Provide Municipal services to all income groups in the city.

(ii) Public transport has priority over private transport: each receives funding in proportion to the number of its users.

(iii) Discourage the use of cars; manage traffic with a combination of improved technology, better policing, and pricing policies.

(iv) Encourage preservation of the character of the city.

[8] See Together Foundation Best Practices Database, *Growth Strategies Act and Associated Initiatives, Burnaby, Canada.*

(v) Expand green spaces and make them accessible to all, within walking distance of where they live.

(vi) Preserve mangroves and beaches and ecologically sensitive zones.

(vii) Provide public access to the shore line.

(viii) Remove all obstacles to the provision of rental housing.

(ix) Facilitate home ownership loans for all income groups.

9.18.2 Preparation of a long-range strategy plan for the entire metropolitan region with a 25 or 30 year horizon. This would take into account anticipated economic and population growth for the region and set out the broad parameters that would govern development. In particular it would plan for the infrastructure systems that cut across local area jurisdictions and serve the entire region. This work should be carried out by a body with region-wide responsibilities. Here also genuine public participation through various interim and the final proposal stages of the Regional Plans must be ensured. The plans would be reviewed every 5 years, while maintaining a vision of the 25 or 30 year horizon beyond. The areas of concern would cover:

(i) Water supply
(ii) Storm water drainage and disposal
(iii) Sewage treatment and disposal
(iv) Broad delineations of land use, including identification of risk-prone areas
(v) Strategies for risk mitigation
(vi) Adequate provision of Low Income Housing stock
(vii) Solid waste secondary collection and disposal, including identification of landfill sites
(viii) Public transport, with particular attention to inter-modal change facilities
(ix) Highways and arterial roads
(x) Power generation, transmission and distribution up to the level of final transformers that convert from high voltage to 440V 3-phase
(xi) Environmental protection, safeguards and measures suggested for cleanup and environmental improvement
(xii) Guidelines for the preparation of local area plans, which may vary from one sub-region to another. These guidelines would include broad controls of land use and intensity of permitted development
(xiii) Maintaining and making available for public access a database of all existing features as well as all new development activity in the region, from the stage of granting the first permissions until completion and incorporation in the database as part of the hardware that now exists in the region. Part of the database would also map the existing physical condition of different elements, whether buildings or bridges or pipelines or drains.
(xiv) All the above have to be dealt with in the context of likely economic growth, employment generation and population growth.

9.18.3 Preparation of local area plans. By “local area” is meant something smaller than a Municipal Ward in Greater Mumbai, about the size of an electoral Ward; an area with a population of the order of 40,000, such that there is a real possibility of genuine local public participation in the planning process. The area is small enough that we can expect all residents to be familiar with the details of the area, while at the same time sufficiently extensive that it is meaningful for planning. While defining the areas it may be useful to keep in mind where it falls within a catchment, so that its drainage characteristics are known and taken into account in planning. These local area plans would be the responsibility of the various local authorities. They would also be reviewed every 5 years and would cover the following:

i. Water distribution network
ii. Storm drainage network, including rain-water harvesting
iii. Sewage collection network
iv. Solid waste primary collection, including sorting of garbage.
v. Location of bus stops, taxi parking ranks, public parking
vi. Power distribution
vii. Road and footpath widening
viii. Location and demarcation of public open spaces
ix. Location and sizing of various public amenities, including public toilets, schools, colleges, hospitals, police stations, fire brigade stations
x. Definition of land uses at the detailed, local level, in consonance with the overall regional guidelines
xi. Development of building control regulations, which may vary from one locality to another within the local area, but which are again in consonance with the guidelines spelt out in the regional plan.
xii. For both the planning and the implementation of the above, we may formally involve citizens’ Area Sabhas. These would be much like our Advanced Locality Management groups, except that each Area Sabha has a footprint coinciding with that of a group of a small number of election booths (each such booth normally accounts for between 800 and 1,500 persons), such that the group contains about 1,000 families (5,000 persons) and can have different professions represented. These participatory mechanisms should be embedded into law.
xiii. For purposes of co-ordination between these local level planning units, the Municipal Corporation may be required to provide professional services to each planning unit, as well as to manage conflict resolution between neighbouring units, and to impose on any particular unit requirements for facilities that serve the wider city.

9.19 Other relevant experience

This includes in particular the following:

9.19.1 The work done by the Bangalore Agenda Task Force (BATF) where a leading private-sector individual is placed in overall charge of a major urban initiative. What is particularly noteworthy is that the excellent work done under one Chief Minister can be completely unraveled by his successor. Obviously what is needed is a legislative mandating of such an initiative.

9.19.2 Another valuable experience of BATF has been the salutary improvement in performance of virtually all civic authorities and bodies by holding regular six-monthly "summit" meetings on a platform that is open to the public to attend. Each agency is asked to present its plans for the next six months, and at the next meeting is asked to state how much it has achieved, and what it plans to do next. This makes for at least some measure of public accountability.

9.19.3 Similarly, there is something to learn from Bangalore in the way they have used IT to improve accounting methods, and the collection of property taxes.

9.19.4 The experience of West Bengal and Madhya Pradesh where local urban government is effectively headed by elected leaders, with officials clearly subordinated to the political authority. This is in conformity with the 74th Constitutional Amendment, and is a long overdue obligation of the State Government to implement.

9.20 What should we do in Mumbai?

One further requirement of the 74th Amendment is that the work of metropolitan planning be entrusted to a Metropolitan Planning Committee (MPC). In Maharashtra the legislation for establishing an MPC has been enacted but MPCs have not yet begun functioning.

9.20.1 The Mumbai Metropolitan Regional Development Authority (MMRDA) was formed in 1975 and has been looking after various aspects of regional development since. It seems to be the right agency to carry out the regional planning work defined in 9.18.2 above.

9.20.2 The MMRDA is governed by an Authority consisting of various officials, including political leaders. It would make sense to replace the current body governing MMRDA with the MPC. The MPC would need to have representation from the Municipalities of each of its sub-regions. It is also important that the three important Boards MMRDA had when it was first established be re-activated: one was for Water Resources, one for Transport & Communication, and the third for Housing, Urban Renewal and Ecology.

9.20.3 The Executive Committee of MMRDA is a small professional group that monitors the day-to-day working of the MMRDA, where the Chief Executive (called the Metropolitan Commissioner) is an IAS officer from the State cadre. The Executive Committee is currently chaired by the Chief

Secretary. It could be chaired instead by a leading private sector individual.

9.20.4 The Mayor-in-Council was tried in Mumbai, but half-heartedly, during the period 1998-99. We should take this up again for serious implementation. Elected individuals would be in overall charge of the local authorities, with officials clearly subordinated to them. As a research report by the World Bank Institute says, with decentralization, as with many complicated policy issues, the “devil is in the details”[9].

9.20.5 While the overall infrastructure planning for the region will be the responsibility of the MPC, the suggestion is that detailed area planning with a 5-year horizon should be carried out at the local level of Wards, or parts of Wards (population size about 1,50,000) under overall guidelines regarding densities and permitted land uses which are defined by the regional authority. ‘Urban planning’ will thus have to be an ongoing process that takes into account continuing changes and responds with mid-course corrections as necessary. The MCGM will need to establish a proper town planning department which has the requisite skills and can be entrusted with these responsibilities. Currently there is an excessive reliance on consultants and committees—these may render useful services but they cannot replace what needs to be an integral part of the Corporation’s own administrative system. Civic management in Mumbai has become quite complex. Plans need to be tuned to the changing requirements in respect of traffic, security, public amenities and the lessons learned from calamities such as on 26th July. It would be well for the MCGM to establish a standing setup of professionals experienced in town planning to analyse the changing scenarios and advise the civic body periodically on the emerging requirements.

9.21 Time Frames for Planning

The suggestion is that the Regional Planning Authority finish its basic infrastructure plans over a maximum initial period of 1 year—some elements may finish faster than others—and submit these to the local authorities for their comments. The regional planning work should incorporate public participation as an essential constituent of the planning process. The local authorities will also follow a process of public participation—through the Ward Committees for example, or with local ALMs—in evaluating the regional plans and coming up with comments. They are required to complete this work within a period of 6 months. The Regional Authority then has another 6 months to finalise its plans. Meanwhile the local authorities can start work on their detailed area plans. These are also required to involve the public, and are to be completed within 6 months of the Regional Authority finalizing the regional infrastructure plans. They are to be submitted to the Regional Authority for acceptance, which must take place within 4 months. In case of a dispute between the Regional and a Local Authority, the State Government decides within a period of 4 months, failing which the Local Authority’s view prevails.

[9] Jennie Litvack and Jessica Seddon, *Decentralisation,* World Bank Institute, no date, probably 1998.

Whatever final time-frame numbers are decided, what is important is the process is time-bound and there is a mechanism for enforcing closure.

9.22 Financing

9.22.1 An essential constituent of the contents of each plan, whether regional or local, is a financing and investment-recovery plan. Without this, no plan proposal should even begin to be considered. We cannot emphasise this sufficiently. All plans for urban development in the past have remained just that: plans only, but with no clear direction as to how they are to be implemented. In future we should expect every plan to be accompanied by a detailed, companion financing plan, which covers how capital is to be raised, where the funds for servicing loans will come from, and how borrowed capital is to be repaid. Acceptance of the development plan should necessarily require simultaneous acceptance of the financing plan. It is only if this is done that the plan proposals will be meaningful and implementable. Pure technical plans, even if accompanied by cost implications, in the absence of clear tax and financing arrangements will undoubtedly meet the same fate as earlier reports and recommendations: of decorating a shelf.

9.22.2 We need to clearly establish the principle that "beneficiaries must pay". And the further principle that no one is provided with housing free of cost, neither slum dwellers nor frozen-rent tenants. Payment from the beneficiaries for whatever improvement in living conditions they enjoy is a sound cardinal principle to adopt.

9.22.3 In this report we can provide only broad indications of financing avenues to be explored. We begin by noting that a large amount of capital expenditure will need to be undertaken. Some of these capital works have been necessitated by an accumulation of incremental demand for services, but there has been no corresponding capital charge or betterment levy to pay for the upgradation of infrastructure. Over a period of time, these incremental deficits lead to major gaps both on the physical and financial sides. It is imperative that any incremental demand on infrastructure, whether by construction of new commercial or residential premises, or by expansion of existing activities, should be offset by a levy which should be held in a Reserve Fund meant for undertaking infrastructure upgradation works requiring large capital outlays.

9.22.4 Given the absence of a system for such levies in the past, it is appropriate that the capital works are carried on with infusion of capital from outside. But clearly this capital will have to be serviced (in the form of payment of interest and repayment of principal) by the citizens of the city. To the extent that the cost of some of these services are borne by the city but the benefits accrue to particular enterprises (the levies on such services not being collected by the city authorities for provision of such services) there needs to be an enabling provision for local authorities to be able to tax for these services. For instance,

economic activities relating to the ports in Mumbai draw heavily on civic services but do not contribute proportionately to the city coffers. Similarly, the MMRDA in its Bandra-Kurla complex would be the major financial beneficiary from the effective functioning of the Mithi River Authority and should therefore logically bear that cost.

9.22.5 All operational and maintenance expenditure, apart from the cost of servicing capital involved in the upgradation of infrastructure to overcome vulnerabilities to disasters will need to be recovered by way of appropriate levies. A separate study will need to be conducted to indicate the appropriate mix of taxes between property tax, user charges and local taxes on goods. An appropriate tax system is a very healthy signal to the kind of economic activity that a city can afford. If based on sound economic principles it can allow for rational adjustments to those drawing the services, their ability to pay for these services and the quality of services provided to them. It is high time that this debate is conducted on rational and economic lines on the basis of a thorough study.

9.23 Implementation and monitoring of development

This would be with the regional authority for the basic infrastructure that cuts across local area boundaries, and with the local area authorities for everything that is local in nature. It would include responsibility for managing the design process, as well as for awarding and managing construction contracts. Where good design and construction management capabilities exist, as for example in the water supply or sewerage departments of the MCGM, the regional authority may choose to ask that particular department or agency to manage a particular project (including projects that may lie outside the territorial area of the MCGM). On completion of construction of the regional basic infrastructure facilities, maintenance would either be handed over to the respective local authorities, or would remain with the regional authority, whichever is most appropriate in each case.

9.24 Transparency

Apart from responses to specific queries which the Right to Information Act provides, we should mandate in some way the construction and regular updating of a publicly-accessible website that provides information on a variety of public services and decisions (such as building permissions, or individual building taxation levels) that are of public interest. This type of broadening engagement with the public will serve the city well when it wishes to involve the citizenry in post-disaster recovery. And ideally, such information should include geographical information, and thus should be part of a publicly accessible Geographical Information System (GIS).

9.25 Metropolitan Transport Authority

We need someone to take an overall, integrated view of public and private transport, with appropriate allocation of funds between the two. This is a

mammoth task in itself, and could well be separated from the other work of MMRDA, with the proviso that broad land-use planning decisions are taken in consultation with the transport authority. The transport authority would also need to interface with local authorities for planning of areas around railway stations and other places where inter-modal transfers take place. The variety of agencies that today looks after different aspects of transport would be brought under a single umbrella for better co-ordination. It would not be an implementation agency. Its mandate would be to integrate between transport agencies as well as with the development authority in terms of land use and zoning, organize financing, and monitoring. We have no doubt that such improved co-ordination would enhance the city's ability to respond to a disaster. The MTA would ensure the 7 critical parameters in public transport: comprehensive connectivity; convenience; affordability; frequency; reliability; safety & environment standards, and urban aesthetics.

9.26 FSI & TDR

We believe that recent policies in regard to TDR and FSI are seriously flawed and have led to a deteriorating situation in regard to Mumbai's capacity to cope with disasters. As a result, floor space (and consequently population) is being added, often without restraint, in localities where the infrastructure cannot support the additional burden. A serious re-consideration of current policies is called for. If our suggestions set out above regarding urban planning and governance are implemented, this aspect of FSI and TDR policies will consequently get reviewed as part of that process.

9.27 Resettlement

This is a complex issue, and we deal with it at length in Appendix E. However, we would like to draw attention here to the priorities with which resettlement should be undertaken. This is as follows:

(i) Those obstructing drainage channels and waterways.

(ii) Those obstructing city infrastructure which is required to be immediately commissioned—for example, obstruction to rail or road widening, or laying a new water supply line, or obstruction of a plot needed for a sewage treatment plant.

(iii) Those in hazardous locations, such as landslide-prone areas, where life and limb are at risk.

(iv) Those who are in flood-prone areas, with priorities within such areas as follows:

(1) Those within the 10-year flood mark. They should be shifted within the coming year.

(2) Those above the 10-year flood mark, but within the 25-year flood mark. They should be subject to new DC Regulations which may be drawn up after careful study of the problem,

taking into account contours and the likely extent of flooding. Occupants must clarly understand the risk they run and should be advised to take out insurance against this risk.They should be required to comply with the new DC Regulations within the next 3 years.

(3) Those above the 25-year flood mark, but within the 100-year flood mark. As above, but they should be required to comply within the next 10 years.

9.28 Recommendations

The following recommendations emerge from the foregoing discussion. They are arranged in approximate order of urgency for implementation. This does not mean they need to be undertaken sequentially. As each measure may take time to implement, work on them in parallel is called for.

9.28.1 Modify the base for property tax to land prices in a locality, not rateable value. *This is to ensure a buoyant source of revenue for improvement of city infrastructure.*

9.28.2 Ensure that the property tax is passed through to frozen-rent tenants. *This is to ensure equity among citizens in regard to the basic charge for urban infrastructure.*

9.28.3 Amend the Rent Act to free all future tenancies, whether in old buildings or new, from the purview of standard rent. Also make existing frozen-rent tenants responsible for the upkeep of their buildings. And ensure quick re-possession by financing agencies of premises in default, in particular premises that have been rented out after the mortgage was taken. *The objective is to free the rental housing market, and encourage ownership of housing for rental.*

9.28.4 Repeal ULCAR. The Act does not at all serve the purpose for which it was enacted. *Repeal may bring more land on the market, and will speed up approvals for construction.*

9.28.5 If ULCAR is retained, it should be applied to the mill lands in central Mumbai, so that lands rendered vacant as a consequence of demolition are required to provide housing of specific sizes and in specific proportions as suggested in the Regional Plan for Mumbai Metropolitan Region 1996-2011. *Mixed-income housing across a range of income groups is important for the city both socially and to minimize transport demands.*

9.28.6 Bring the salt pan lands into the housing market. Compensate the present salt pan owners generously, on the basis of their present returns from the land. The profits, if any, arising from the change of user should largely flow to Government, and much of the land should be reserved for low- and middle-income groups who pay for their construction but for whom the land cost is nil. *This will bring to market more land for low- and middle-income housing, at a location where transport is more readily provided.*

9.28.7 Negotiate with the Mumbai Port Trust for a change of user for part of their land, with the intent that much of it is turned over to use for mixed-income housing. The area is well located for transport. *As above.*

9.28.8 Modify the CRZ regulation so that lands above the CRZ-I line are open to planned development, including the provision of proper and adequate public open spaces, as well as common public access to the shoreline. *As above, and the public spaces and access to the sea front will improve the quality of life for millions.*

9.28.9 Legislate a modification of the planning process by which metropolitan planning becomes a two-stage exercise: preparation of a strategy plan with a 25-year horizon by an authority with regional responsibilities, followed by detailed 5-year area plans prepared by local authorities in consonance with guidelines specified in the strategy plan. The second, low-level stage will require co-ordination at the level of each Municipal Corporation. In Mumbai it will require the setting up of an urban planning unit within the MCGM which has the requisite expertise and is charged with these responsibilities. *The current planning process is obsolete and has in effect been discarded. There is an urgent need for change, so that meaningful urban planning can be resumed.*

9.28.10 Convert the MMRDA into the planning and executive arm of Mumbai's Metropolitan Planning Committee, with responsibility for strategy planning as well as execution of the physical infrastructure for the region: area drainage, water supply, sewage treatment and disposal, selection of landfill sites in the region for disposal of solid waste, co-ordination of all transport infrastructure, and preparation of guidelines for local area authorities for their detailed area planning, including specifying overall built-up areas (and consequently densities). Meaningful public participation must be mandated. And the 25-year horizon strategy plans prepared by the MPC must be accompanied by a financing, investment, and recovery-of-investment plan. *The MPC is mandated by the 74th Amendment.*

9.28.11 Subordinate all executive powers at the municipal level to politically elected representatives, and devolve local area planning to local authorities. The preparation of local area plans, to be reviewed every 5 years, should be with the involvement of the public, and must also be accompanied by a financing, investment, and recovery-of-investment plan. *The devolution of powers to local authorities is also required by the 74th Amendment.*

9.28.12 Set up ALMs throughout Mumbai and the Metropolitan Region. *Involve citizens in the management of disaster situations.*

9.28.13 When undertaking resettlement, follow the principles and the guidelines set out in Appendix E of this Chapter. *Presettlement should be a precondition to demolition of homes.*

Appendix 9A

9A - Advanced Locality Management

9A.1 Formation of the ALM Scheme:

MCGM formulated the Advanced Locality Management Scheme to encourage co-ordination of efforts to resolve citizens' difficulties relating to the Municipal Administration's duties and responsibilities. It was initiated as a voluntary social programme at Ghatkopar in Mumbai on an experimental basis in June 1996. Accordingly, exploring the possibilities in this direction and identifying the benefits from this scheme, probable difficulties, the required co-operative responses and the role of citizens, the specific duties of citizens group and the nature of involvement of the Administration were defined. One officer on Special Duty (S.W.M.) was appointed by the then A.M.C. to pursue this matter. The main objective of this scheme was to generate a spirit of self-governance and co-ordination between the citizens and the Municipal Corporation to clean up the locality and improve the environment. The intention was also to raise awareness in citizens about their duties as citizens of their city. It was expected to enhance the feeling of national integrity and inculcate a feeling in the citizens' minds that this city is their own city and to keep it clean and beautiful is also their own responsibility more than that of the Municipal Administration alone.

9A.2 Scope of Advanced Locality Management:

9A.2.1 Under this scheme, a citizens' social organization comprising of those who are interested in social work is set up. It is encouraged to get established is a formal way, and decide about the types of members to be selected in their Executive Committee. Two members of this Committee are entrusted with the responsibility of working as representatives of that locality for co-ordination with the Municipal Administration to sort out various problems. Difficulties of their area are noted in a formal register and the follow-up noted every month on the first Saturday at Ward level; on the fourth Saturday at higher level a follow up review is taken. For the Committee's work, financial assistance is made available to the citizens as per norms. Citizens become aware about their responsibilities and the need to co-operate, as they realize that this is their own scheme. The Committee is responsible for handling various problems related to civic services.

9A.2.2 The second part is the Administrative role. If citizens voluntarily come forward from Wards by way of the ALM scheme, then representatives of Administration will visit the concerned Ward to resolve the problems of the ALM Committee and give them proper guidance and remedial advice.

9A.2.3 The first phase of this programme is to keep & maintain cleanliness of the area. The second phase is the beautification of the locality and the third phase is garbage disposal planning, and classification for vermiculture of wet garbage as the social beneficiary scheme is introduced.

9A.3 Diffusing of Advanced Locality Management Scheme:

This scheme adopted by MCGM has been widely accepted by citizens of the main cities in India, representatives of social organizations, and various levels of government administration. Information regarding these schemes has been given to adjoining areas like Navi Mumbai, Thane, Kalyan, Satara, Sangli, Amalner, Kulgaon-Badlapur and Aurangabad. Local Institutions of Self-Government have organized workshops on this project at Bhayandar, Mahabaleshwar and Belgaum. Foreign delegations have also visited and appreciated this scheme. Leading newspapers, magazines, local newspapers and supplementary editions have also highlighted the ALM scheme. Civic general, Lokprabha, various environmental magazines, housing and other magazines have also appreciated this scheme.

9A.4 Municipal Administration for ALM Schemes

9A.4.1 By acceptance of a new procedure by the Corporation at the Councilor's Ward Level, one Jr. Engineer and one Supervisor will be responsible for the ALM. Problems of encroachments, water licences etc. will be co-ordinated with the concerned department, with follow up by the Liaison Officer.

9A.4.2 Concerned liaison officers will visit in the area within 10 days to take cognizance of complaints for taking necessary action, besides the remarks in the register. If an appropriate response is not provided, or action is not taken by the concerned ALM committee, action will be taken as per Municipal rules.

9A.4.3 Assistant Commissioner once in a month and Assistant Engineer along with A.H.S. once in fifteen days to visit the concerned area to observe the work and to make notes in the register.

9A.4.4 Excavation carried out by Mahanagar Gas, B.S.E.S. (Reliance Energy), B.E.S.T., Mahanagar Telephone Nigam, Water Dep't. shall be immediately reinstated by the administration, for which the Liaison Officer of the concerned area will initiate this matter. Information regarding work carried out on the road will be obtained from the concerned officer of the Committee.

9A.4.5 Wet garbage generated at marriage ceremonies and at other public places shall be directly removed by the Municipal Corporation. The concerned ALM Committee has to inform the Administration, and in this matter additional charges should be collected from the concerned agencies.

9A.4.6 Administration shall not take objection to display information notice of the ALM scheme at public places. This will help to reach the message of ALM to the maximum number of citizens. Due to increase in the scope of ALM scheme, Municipal Corporation has implemented this at the following places:

(i) For efficiency in the work of ALMs, meetings will be held at the level of Ward by the Coordination Committee on the 4th Saturday in every month at 10.00 a.m. in the concerned Ward office.

(ii) For co-ordination and monitoring the work of ALM, Monitoring Committee has been established at the level of Head Office. Meeting of Monitoring Committee is being now held on 4th Saturday of every month.

9A.5 Solid Waste Management and ALM

9A.5.1 Solid Waste Management Facts

- The area of Municipal Corporation of Greater Mumbai is approximately 437.71 sq. km. and population is 1.3 crores. As one of the biggest metro cities in the world, disposal of solid waste is a critical problem.

- Every day 6,260 metric tones of garbage is generated in Mumbai including 3,960 metric tone of bio-medical waste.

- Accumulation of garbage is fodder for flies, mosquitoes and insects. Hence diseases may spread like Malaria, Cholera and Plague. Lifting solid waste and its disposal, removal of carcasses and cleaning the roads is the responsibility of the Municipal Corporation.

- Municipal Corporation of Greater Mumbai collects and disposes of the huge amount of garbage lying on debris mixed with earth on roads. After the roads are cleaned by the Municipal Corporation, very soon thereafter the same roads are filled again with new garbage and debris mixed with earth. This is due to a lack of civic sense and discipline in the citizens.

9A.5.2 <u>Creation of atmosphere before introducing ALM scheme</u>

- Local citizens should take responsibility for disposal of generated garbage in their area; otherwise it is not possible to maintain environmental cleanliness.

- Without co-operation of local citizens, Solid Waste Management is not possible. Therefore, since 1993 the Municipal Corporation engages in a dialogue with societies to pursue this matter effectively.

- To prepare the citizens' minds to segregate the garbage in their own house. Segregated wet and dry garbage in housing societies should be collected by the concerned ALM.

- ALM can use the bio-degradable and wet garbage for compost or vermiculture.

- Some co-operative societies have accepted the scheme; they collect Rs.1/- per house for segregation of garbage for composting. Approximately 700 societies are working in the jurisdiction of the Municipal Corporation following the above guidelines.

- It has been learned that rag pickers should be included for collecting and disposing of dry garbage. It helps to streamline the same work.

- Initially local citizens showed their efficiency to prepare their self-rules and regulations for ALM. The accounts of expenditure for ALM were kept by the co-operative societies for the maintenance of the ALM scheme.

- After some time, citizens realized that there is a change in the surrounding premises. House gullies, roads, nallas were cleaner due to minimizing the generation of debris and garbage. All citizens are gradually trying to segregate the garbage into wet and dry. Co-operative societies are now establishing more ALM schemes. Municipal Corporation has taken cognizance of civic problems like excavation, garbage on roads, leakage of drainage and water lines, throwing of water, overflowing drainage etc. Municipal Corporation felt that generation of garbage is minimized and wet & dry garbage is also segregated neatly. It helps in saving manpower and garbage collection vehicle expenditure. After implementing ALMs, it is easy for the Municipal Corporation to co-ordinate with citizens using the ALMs.

- Deficiency in supply of water, major repairs of roads, reconstruction of flooding drainage are pointed out by the ALM to the Municipal Corporation's Administration. Such types of civic problems were discussed with the representatives of the ALM by the Assistant Commissioner of the concerned Ward and Heads of the Departments on the 2nd Saturday of every month. The positive changes gradually lead towards improved civic services in the area.

9A.5.3 <u>The effect observed after establishment of ALM</u>

- Within three years, in the whole of Greater Mumbai approximately 700 Locality Management Committees have been formed throughout 24 Wards. Pursuing the amplified area of Greater Mumbai, altogether 1,200 to 1,500 more ALMs are required.

- Many groups of citizens are taking the lead to manage the critical problem of waste.

- It is incumbent to have a discussion between different Heads of Department of various sections of the Municipal Corporation of Greater Mumbai each month at the level of Advance Locality Management groups. The meetings were held for pending problems such as encroachments, poor water supply, garbage accumulation, hawkers etc, thus giving a direction for work to follow.

- Rag pickers, sweepers, small scale middlemen can reprocess solid & dry waste, and also regenerate new products. They get inspired for segregation of dry waste and bio-degradable waste through composting and vermiculture. Bio-degradable waste is transferred into manure and the upshot is that the appearance of homes, lanes, pavements and roads is improved by the ALM.

- At many places Advance Locality Management was initiated by established Hotel Proprietors and Shopkeepers. In some hotels, all dry and wet waste was disposed of at their level. In some schools, information is given about separation of dry and wet waste, and also practicals are shown of vermiculture with its importance.

- At many places, voluntary organizations are inspired to dispose of the bio-degradable waste lying at vegetable markets by forming a vermiculture manure project.

- Advance Locality Management is a vital part of the Municipal Administration's system as they are handling such projects as beautification of roads, cultivation of trees etc. It is observed that these groups help the Municipal Administration in dealing with

hawker's problems and restricting encroachments in the respective areas, and makes these manageable. Wherever such groups are part of the working process, the personal habits to throw waste on roads are decreasing gradually at residential levels and the activity of segregating waste is increasing. Advance Locality Management is also playing the role of one type of pressure group which is coming across with work that makes an impact.

- Suggestions and recommendations are appreciated, and citizens can approach the Municipal Administration through members of the Advance Locality Management group. Since the Municipal Corporation of Greater Mumbai gives preference to such matters, simultaneously it helps to change the view citizens have of the Corporation.

- Because of modus operandi of Advance Locality Management, new volunteer organizations and social organizations have been established. Very few Committees amongst Advance Locality Management have been set up in slum areas. Urban life needs more such distinct committees. It is incumbent to set up 700 more Advance Locality Management committees, preferably in slum areas.

9A.6 Efficiency of Advanced Locality Management Scheme

9A.6.1 Most of the Advanced Locality Management groups have been working for more than 3 years. The comprehensiveness of their work has crossed the limit of only dealing with waste. In some divisions, they have established organizations and embarked on projects such as cultivation of trees.

9A.6.2 Because of financial help from volunteer organizations, social organizations, and donors, publicity of such projects is possible. Municipal Corporation rewards the best workers and volunteer organizations.

9A.6.3 For Advance Locality Management, no extra financial help or workers are designated.

9A.7 Revolution has taken place in society due to the Advanced Locality Management Scheme

9A.7.1 Advanced Locality Management, which was pioneered in a suburban area like Ghatkopar in Mumbai at one locality called Joshi Lane, has been spreading in such a way that now in 24 wards of Municipal

Corporation, more than 700 committees have been established, and all those are well-settled committees that continue to work effectively.

9A.7.2 Using Advanced Locality Management, every day 500 metric tones wet waste is being converted into vermiculture manure. Its social and financial value is apparent.

9A.8 <u>Advance Locality Management can work with more efficiency under disaster conditions</u>

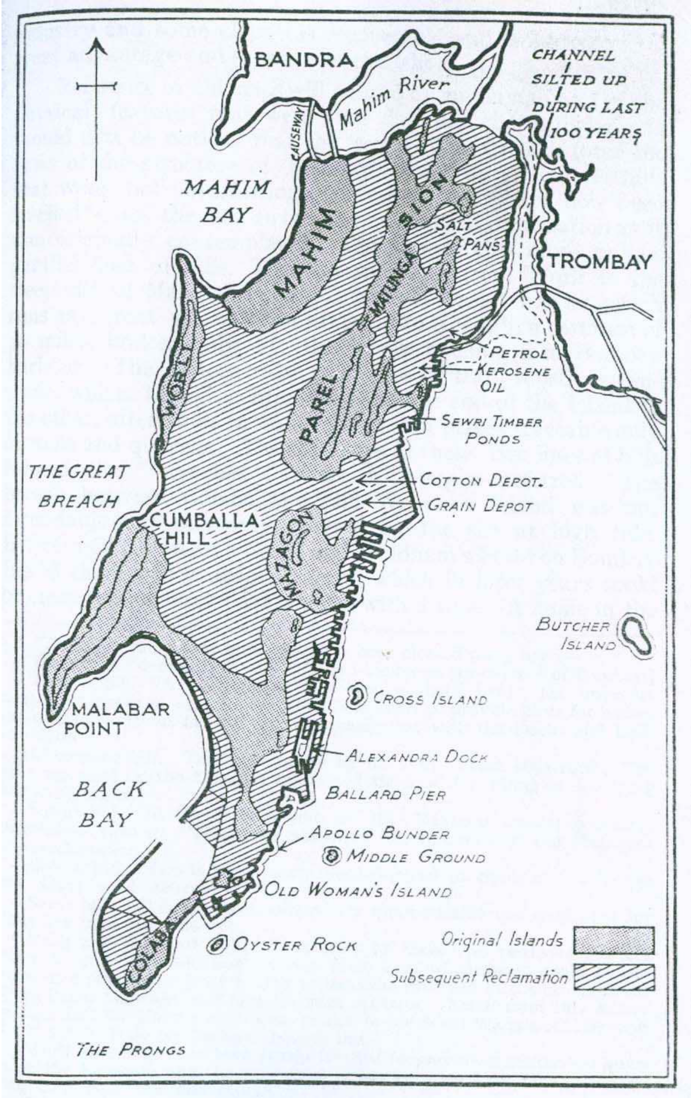
9A.8.1 Advance Locality Management Schemes can be implemented on a large scale in Greater Mumbai. Today more than 700 Advance Locality Management Committees are working in the whole of Greater Mumbai. Considering the total population of Mumbai, such committees should grow to double. It is expected that 10,000 population should represent one Advanced Locality Management committee. By these criteria, for the whole of Greater Mumbai altogether approximately 1,500 Advanced Locality Management committees are required. In Mumbai on 26th July, 2005, a heavy downpour occurred with 944mm of rainfall. More than half of Mumbai was submerged in contaminated water due to failure of the drainage system. More important is that in such a situation, the available drainage and monsoon water discharge systems were not cleaned and tidy. If Advanced Locality Management schemes had been in place, then certainly this would have minimized the impact of the rain flood that happened in Mumbai. The drainage system of Mumbai was choked due to waste littered by citizens. In drains there were items like plastic bags, wood pieces, scraps of metal, papers, vegetable shoots and debris. In Mumbai at some locations, the water was stagnant for 2 or 3 days, because of blocks in the drainage system. After heavy rains in the whole of Mumbai and its suburban areas, everywhere dirt accumulation was taking place. Citizens threw out wet garbage, food stuff, and other material on the roads. Cattle carcasses were lying on the site of cattle sheds. Because of stagnation of drainage water for two days, the rehabilitation process faced great difficulties. It was very difficult to provide medical aid to the affected people. All these aspects increased the intensity of the distress due to the flood situation in Mumbai.

9A.8.2 To cope with such situations in future, and minimize the impact of disasters, it is necessary to set up such Advanced Locality Management committees on a large scale in Mumbai. It is important to change the views at all levels of society. To set up such committees, different social organizations, Rotary Club, Lions Club, Major Government & Semi Government localities, housing societies, chawls, slums, and sports clubs of youth should come forward with enthusiasm.

Appendix 9B

9B - History of Reclamation

9B.1 "Bombay owes everything to successive reclamations"—Report of the Committee appointed by the Government of India to inquire into the Back Bay Scheme in 1926. Samuel Sheppard opens his Chapter on Reclamations in his book on Bombay[10] with this quotation. It is also worth reminding ourselves of the map of Bombay towards the last quarter of the 17th century:



[10] Samuel T Sheppard, *Bombay*, Times of India Press, 1932

9B.2 The hatched area in the map is all low-lying, inundated by the high tide. Dr John Fryer, writing of the year 1673[11], says the Breach [between Worli and Cumballa Hill] "drowns 40,000 acres of good land" [16,187 ha]. There are other breaches too, and from 1668 onwards much discussion about the feasibility of closing the breaches. In May 1970 it is reported that "two of the breaches are near stopt"—the ones between Mahim and Dharavi, and between Dharavi and Sion. But the big breach, between Worli and Cumballa Hill, proves more intractable. Under the direction of Capt. Elias Bates a start is finally made on it in 1721, and it is finished in 1728, with Capt. Bates disgraced for having grossly overshot his estimates of both time and cost. Adding the ultimate insult to injury, the closure of the Breach later comes to be known as Hornby Vellard, after William Hornby, who was Governor of Bombay from 1771 to 1784, but had nothing to do with the closing of the breach.

9B.3 What emerges quite clearly in the correspondence with the East India Company is that the reclamation projects are driven by the expectation of a handsome reward in terms of subsequent land prices for the reclaimed land. The costs of reclamation and the value of land may have changed over time, but the fundamental principle is still valid.

9B.4 Sheppard writes that practically the whole of the Port Trust docks and estates are on reclaimed land. In 1908 the Trust embarked on the great Mazgaon-Sewri Reclamation scheme, which was completed in 1912 and added 583 acres to the area of Bombay [236 ha]. Subsequent filling and reclamation work at Wadala, Tank Bunder and Colaba provided a further 310 acres [125 ha].

9B.5 Another very large scheme was the Backbay Reclamation, planned as 1,145 acres of reclamation on the western foreshore [463 ha]. This was finally restricted to Blocks 1 and 2 at the northern end, and Blocks 7 and 8 at the southern, Colaba end, an area of 552 acres [223 ha]. This was at the time of Sheppard's writing, in 1932. Block 3 was subsequently reclaimed, and produced our present Marine Drive. The completion of the remaining reclamation, connecting up to Block 7, was taken up by the Government of Maharashtra in the 1960s, starting at the northern end at Nariman Point, and in the middle opposite Cuffe Parade, but was stopped by a High Court order. This was in response to a Writ Petition filed in the early 1970s: the argument in the Petition being that adding new office space at the southern tip, the most inaccessible part of the Island city, was unwise from the point of view of urban planning, and would only add to the commuting miseries of the bulk of the city's population.

[11] Dr John Fryer, *A New Account of East India and Persia; Being Nine Years' Travels, 1672-1681,* Hakluyt Society 1909-1915

Appendix 9C

9C - Development in Mumbai over the last century, and its impact on storm flows

9C.1. The history of the development in Mumbai over the last century begins with Mumbai already functioning by then as the commercial capital of India. Starting as a paradise for textile mills and medium industries employing manual and semi-skilled labour, coupled with its function as a centre for commerce and trade, it has now moved on to becoming a centre for highly skilled services. The huge opportunities for employment attract people from all over India to this city.

9C.2. General History: Industrial and commercial development has been concentrated in the south and central part of Mumbai. Urbanization became rapid after the Second World War and subsequent Independence because the Secretariat, Share Market and other major business centres also developed in the Island city. Industries however, developed on the outskirts of the Island city i.e. initially in Chembur, Ghatkopar, and Andheri (conventionally called the Suburbs) and then in Vikhroli, Bhandup, Mulund, Goregaon, Kandivali etc. (conventionally called the Extended Suburbs). The suburbs and extended suburbs where amalgamated into Mumbai Municipal Corporation area in the years 1955 and 1957 respectively, thus forming the Municipal Corporation of Greater Mumbai. The historical background of development of Mumbai indicates that Mumbai has been growing from South to North, invariably heavy congestion in the southern part pushing population northwards. There was continuous pressure on civic services due to the creation of new employment and the consequent heavy influx of population in search of this employment. The Municipal Corporation therefore published a Development Plan and as part of it framed the 1960 Development Control Rules (popularly known as D.C.Rules) to regulate development in a planned fashion. The focus of the D.C.Rules was to discourage industries in the old city and promote commercial and residential development northwards in the suburbs and extended suburbs. It was observed that the city had plenty of potential for employment generation but the land prices could not provide affordable housing to the economically lower classes of society. This influx found itself accommodation in low-priority areas, generally in the central part of the island city and in the suburbs and extended suburbs. Efforts were made by the Government of Maharashtra through the Bombay Housing Board to construct houses for rental for this class of society, but the volume of construction achieved was a small fraction of the demand. In particular, the condition of lower income class people staying in slums who provided supporting services (mostly demand-based temporary jobs e.g. Mechanic, Plumber, Carpenter, domestic servant etc.) was not good. Their slums were always situated in neglected areas either up hills or along banks of nallas and near marshy

lands in creek areas. All this has brought in large scale new developments ignoring the original geography & natural terrain of the city.

9C.3. Categories of Development: New developments in Mumbai can be broadly divided into the following five categories for the purpose of this report :

(i) Reclamation of creek arms & marshy lands or otherwise.

(ii) Development of previously unoccupied green areas for habitation disturbing natural water courses.

(iii) Change of user.

(iv) Development of new roads modifying the natural drainage pattern.

(v) Encroachment on some part of the s.w.d. system by the developments listed above.

Each type of development has a specific impact on the environment of the city in general and the ability to drain off rain water in particular which is discussed in the following paras.

9C.4. Reclamation: This is one of the oldest activities of development in Mumbai and has been discussed at length above. What is worth noting in particular is that these reclaimed areas remained low-lying as compared to the original islands. Moreover, the original water courses which were discharging into creek arms in between the islands were extended towards the eastern and western coasts. Obviously they had very flat gradients leading to silting in drains. Their discharge levels are much below mean sea level. Therefore, there is a regular tidal flow back into most of the major catchment drains and outfalls in the island city. At many locations the development level is below high tide level, e.g. at Sat Rasta, Lower Parel, Grant Road etc. Three major outfalls are controlled with gate structures to ensure that the island city's reclaimed areas do not flood during the fair season. Moreover, movement arteries in the island city (i.e. Central and Western railway lines) situated in the centre of the island city are in this reclamation area. Naturally, they stop functioning when even a moderate intensity of rainfall is coupled with a high tide.

9C.5 Side Effects of Reclamation:

9C.5. 1 Diminishing Ponds: The City had a number of ponds which disappeared with development. Only names like Dhobi-Talao, C.P.Tank, Gowalia Tank remain in use and remind us that there were ponds or tanks here. The ponds were filled up to accommodate the incoming population and to create a land mass for city development. Diminishing ponds indicate a loss of the hydraulic holding capacity of the system.

9C.5. 2 Increase in run-off: The original design criteria for design of Storm Water Drains in Mumbai assumed an intensity of rainfall of 25 mm per hour and a coefficient of run-off of 0.5. This implies that 50% of the rainfall infiltrates into the ground through various open spaces, or is held temporarily in low-lying areas and ponds. Now there is a trend to provide paving over entire plots instead of plinth protection works, for aesthetic reasons. Such paving has curtailed infiltration. The entire amount of rain water falling on a developed area goes into the S.W. drainage system in almost zero time. There is no infiltration and the coefficient of run-off is increased enormously.

9C.5. 3 Creation of new flooding spots: Reclamation has also been at different levels in different areas as it was done in a piecemeal fashion. The earlier development was on the original land away from the sea-shore, creek arms or nalla river banks. The pressure of over-population has pushed the new development more and more into those areas which are generally low-lying and act as water spread areas for the rain water. In these areas the development had to be done by reclamation or filling, which limited the water spread area only to the actual water courses, thus increasing the height of flood in flood-prone areas. There were many vacant lands, natural depressions which acted as local holding ponds for the locality, reducing the severity of floods, increasing percolation, and re-charging the ground water table, thus strengthening the ground water reserves of Mumbai. With development taking place in these areas, the floodable areas are lost and earlier developed localities which were naturally draining into these depressions have now become new flooding spots which are more difficult to attend to as the water will now have to be drained against the natural gradient. An ideal example would be the Postal Colony area in Chembur which became flood-prone due to development in the adjoining area starting right from reclamations by MHADA in 1947 – 48, Eastern Express Highway (EEH) in the year 1963 & subsequent developments on the east side of EEH. The rain water from this area had natural drainage into the adjoining creek via open or marshy land on the west side. With reclamation by MHADA on the west side, it started flowing southwards; with development of EEH it was forced to take a detour via a small culvert under EEH towards Sahakar Nagar through Shramajivi Nalla & finally discharged into Mahul creek. The open land on the east of EEH which extended almost up to the Refinery Railway Tracks served as a holding pond for the locality & contained the problem. However with development of this land and encroachment on the bank of the artificially decided path of Shramajivi Nalla, the area of the Postal Colony became a chronic flooding spot. MCGM had to rectify this problem by providing a new diversion entirely along east side of EEH up to Mahul Creek which cost Rs 13.48 crores. The latest developments along the Western

Express Highway leading to raising or merging of service roads and covering, reducing, or deleting highway channels also disturbed the natural surface flow of rain water from east to west and reduced the holding ponds in the entire western suburbs. Filling levels in the low lying areas have also been haphazard, invariably above the formation levels of the old development. One of the prominent examples would be Link Road & developments on either side in the extended Western Suburbs. This development is at a level higher than the earlier development on the east of Link Road so new flooding spots have started developing. In fact this is the real reason why flooding spots in Suburbs have increased over a period of last 12 years, i.e. post the BRIMSTOWAD Report.

9C.5. 4 Loss of Mangroves & Silting: Development near creek arms and on marshy land has to be done at the cost of mangroves. Actually mangroves in Mumbai have been a creek eco-system; they provide basins for silting, constrain velocities, and prevent tidal water erosion. With the loss of mangroves, obviously, there is erosion of banks, heavy silting in the water courses and sea water ingress on land. Previously, the river banks are supposed to be have been deltas at a mouth which was made with silt. The deltas of the Mumbai rivers are no longer in existence. There are only straight courses discharging into the sea. Naturally the whole silting is in the zone near the outfall and if not properly removed, it is bound to create flooding on the upstream side in nallas and rivers. In addition to conventional silt being carried during the monsoon, a heavy load of Solid Waste is deposited in the nallas throughout the year. This waste consists of a mixture of bio-degradable and non-bio-degradable material like rubber and plastic. Flood material in the form of plastic bags and bottles is not only an eyesore, but also an environmental problem since many a time thin polythene bags are consumed by animals and fishes along with the food particles attached to the plastic. This creates a serious threat to the environment and to ecological balance. Every year, MCGM removes silt measuring about 3,90,000 cu. mt. by spending approximately Rs 18 crores, and still at any time of the year one can find substantial deposits of silt over the natural bed levels.

9C.5. 5 The quality of landfill material is also a debatable question. Barring reclamations done by Government agencies, no mechanism to control quality of landfill material is in existence in Mumbai. Therefore most of the time the landfill material is debris surplus from construction sites, or mixed material also including things like garbage, thin plastic bags etc. In fact, restricted dumping grounds and the policy of discouraging transport of construction surplus to dumping grounds has led to unauthorized dumping on roads in the localities with less night traffic, on major development sites and of

course on water courses. Use of substandard material can modify properties of ground water & can even cause health hazards. One must remember that the entire Dharavi area and most of Deonar have come up on sanitary landfill and are discharging into major water courses like Mithi River and Thane Creek respectively.

9C.6. Development of previously unoccupied green area for habitation disturbing natural water courses. To facilitate easy development the original water courses are either filled up (if small sized) or are diverted suitably generally along the periphery. The natural drainage pattern also drastically changes. This change in alignment does create problems like erosion, silting & flooding on the upstream side if not carefully designed.

9C.7. Change of User: Housing creates a simultaneous demand for basic amenities like roads, drainage, water supply plus other amenities like schools, shopping areas and recreation areas. For planning these facilities naturally more and more area has to be put under use. Since the last 15 years, the stretches east of the Western Express Highway, on either side of Link Road in the western suburbs and that on the east side of Central Railway or Eastern Express Highway have been put to use. The original land in this area was vacant. and was acting as lungs for the mainland, purifying the air, aiding drainage etc. The same is lost resulting in pollution of the shoreline because now there is no water spread area. The process of natural purification of water standing in these areas is no more in existence. The entire rain water, sullage, and sewage flow is now restricted to a defined limited water course, say a nalla, which is designed to discharge towards its outfall as early as possible. Hence the entire pollution load is transferred to outfalls i.e. the coast line, where it deposits or keeps on moving to and fro with the tides. The building pattern has also changed with development. With growing land prices there is a tendency to create townships with thickly populated towers utilising T.D.R. The infrastructure services laid many years ago fall short and cannot accommodate this extra load. That is why this metropolis has from November 2002 reduced the size of water connections to 90 lpcd for new developments, instead of the earlier prevailing 135 lpcd and as against the target of 240 lpcd recommended by the Chitale Committee in 1994. There is a tendency to discharge septic tank waste and sometimes even sewage into the storm water drains. In addition to utilizing the capacity of s.w.d. for sewage this also causes silting throughout the year as the properties of flowing matter are different from the design parameters.

9C.8. Development of new roads modifying natural drainage pattern: Continuous over-laying of road construction on concrete roads in previously developed areas has in many places raised the formation level of roads above development or even plinth level of existing properties. The floodable area available in the form of road width is lost. Instead, now open spaces around the buildings have become flood-prone areas since during heavy

showers water from the road-side storm water drains now enters these open spaces, instead of traveling from plot to the s.w.d. system. Newly developed roads especially highways by MSRDC / MMRDA in the last 5-7 years have been developed at a level inconsistent with the natural terrain (much higher than the original level). This has affected surface flow of rain water to a very great extent aggravating flooding conditions generated by poorly maintained or inadequately sized longitudinal and cross drains.

9C.9. Encroachment on some part of s.w.d. system by the above development: Hutment colonies have been developed on the banks of nallas mainly for two reasons. Since it is a non- priority area it is less likely that huts will be demolished. Secondly, as there are no sanitary facilities, nallas act as flowing toilets taking away filth, garbage, plastic and excreta and thus stinking is avoided. As the income of slum dwellers grows, they tend to extend from all the sides, preferably on the nalla side, thus covering part of the nalla and restricting or reducing its waterway. Moreover, there is a huge amount of garbage and debris generated in the slums which is thrown into the nalla, without any discrimination, reducing the cross-section of the nalla. The shopkeepers in the city tend to cover water entrances to road-side open drains to avoid dirty smells. The road-side open drains are also covered with the intention to use them as footpaths but eventually they are encroached by hawkers. In both cases the rain water does not find adequate space to enter into the storm water drains and causes flooding.

Appendix 9D

9D - The history of post-Independence urban planning in Mumbai

9D.1 The history of post-Independence urban planning in Mumbai begins with a statutory development plan of Greater Bombay published in 1964 and sanctioned in 1967. The plan strengthened the north-south pattern of growth by proposing Backbay Reclamation at an FSI of 4.5. It also introduced FSI as a tool of controlling volume of construction for the first time. Following this, the limitations of planning a city in isolation of its surrounding region were being debated, particularly in the context of a proposal by three young professionals to develop a twin city across the harbour.[12] Given industrial growth already taking place in Thane-Belapur, a planned new port on the mainland at Nhava-Sheva, and the new road bridge across Thane Creek their plan recommended developing a metro centre (called New Bombay and later Navi Mumbai) on the mainland as a way of restructuring the city's growth on an east-west axis. In 1966 following the recommendations of the Dr D R Gadgil Committee, the Maharashtra Regional and Town Planning (MRTP) Act was enacted. In 1970 the City & Industrial Development Corporation of Maharashtra (CIDCO) was set up to take up the planning and development of New Bombay, and other growth centres in Maharashtra.

9D.2 Under the provisions of the MRTP Act the first Regional Plan of the Mumbai Metropolitan Region was published n 1970 and sanctioned in 1973. This diagnosed the north-south orientation of development with employment concentrated on the southern tip of the island as the basic structural problem of the city. In addition the Plan recommended internal restructuring of Mumbai by developing the Bandra-Kurla Complex and stopping further reclamation at Backbay. Recognising the need of continued coordination of metropolitan development, the Mumbai Metropolitan Region Development Authority (MMRDA) was established in 1975 under the MMRDA Act 1974. When first established, MMRDA had three important Boards: one in charge of Water Resources, one in charge of Transport & Communication, and the third in charge of Housing, Urban Renewal and Ecology. These Boards were inexplicably and in our view unadvisedly dissolved in 1983. Had they remained in place the situation in Mumbai would not have deteriorated as rapidly as it did. Dissolving the Boards was a regressive step that centralised authority instead of encouraging wider participation in decision-making processes.

9D.3 The Authority undertook development of the Bandra-Kurla Complex from 1978 onwards as recommended by the Regional Plan, and notified that

[12] Marg, June 1965

development for office and wholesale purposes; and that development exceeding FSI of 1.33 in the Island City cannot be undertaken without the permission of MMRDA.

9D.4 Preparation of the second Municipal Corporation's Development Plan of Greater Mumbai (1981-2001) under the MRTP Act 1966 began in 1977 but the Plan was sanctioned after 16 years in 1993, more than halfway into the period for which the plan was intended. The Plan prescribed a uniform FSI of 1.33 for the Island City and 1.0 for the Suburbs. It also prohibited office development in the Island City. The Plan for the first time introduced the concept of TDR (Transfer of Development Rights) as an alternative to monetary compensation for acquiring land for parks, gardens and playgrounds, as well as incentive or bonus FSI for slum redevelopment. These concepts were then recklessly extended to promote slum redevelopment free of cost in 1995, and free reconstructed housing for existing tenants of cessed buildings in 1999. The MRTP Act inter-alia requires that the Development Plan provide for transport infrastructure, water supply, drainage, sewerage, sewage disposal, flood control etc. The Development Plan instead ignored the planning of such infrastructure services. Sectoral plans individually dealing with infrastructure were prepared by consultants or ad-hoc committees but were not integrated with the Development Plan.

9D.5 The second draft Regional Plan (1996-2011) was published in 1996 and was sanctioned in 1999. The Plan covered regional economy and employment, population growth, industrial location, office location, urban land, shelter, transport, water resource development, environment and land use. The Plan proposed development of Bandra-Kurla Complex as a new financial district and relaxed the prohibition on office use in the Island City

9D.6 It may be worth noting that in the case of both the first and the second set of Plans, the Municipality's Development Plan preceded the Regional Plan.

Appendix 9E

9E - Resettlement

9E.1 More than half of Mumbai's population lives in jhopdies—that is, unauthorised and illegal settlements. We can categorise these as follows according to location:

(a) Hazardous locations, prone to flooding or landslides, where continuing in this location represents a threat to life or limb. Being under transmission lines is also a potential hazard, though perhaps a lesser threat.

(b) Areas which are needed for infrastructure development, such as extension of the airport runway or other facilities, widening of roads or drainage channels and so on.

(c) Areas which are neither hazardous to be in nor needed for public infrastructure.

9E.2 In respect of resettlement associated with items (a) and (b) above, we may adopt the following principles:

(a) Land for resettlement may be provided free, but the construction and infrastructure are not free. Those who are being resettled should be expected to pay for the cost of the construction, and infrastructure, with the facility of long-term housing mortgage finance being made available to them.

(b) No one gets free housing. The policy of free housing of the GoM has to be reviewed as being unsustainable, and contrary to the public interest for resettlement to be systematically undertaken.

(c) Compensation is paid for the value of the structures being demolished.

(d) Resettlement precedes demolition. No demolition takes place unless the families concerned have first been resettled and have moved out.

(e) Resettlement activities will have to be undertaken hereafter according to the following priorities:

(v) Those obstructing drainage channels and waterways.

(vi) Those obstructing city infrastructure which is required to be immediately commissioned—for example, obstruction to rail or road widening, or laying a new water supply line, or obstruction of a plot needed for a sewage treatment plant.

(vii) Those in hazardous locations, such as landslide-prone areas, where life and limb are at risk.

(viii) Those who are in flood-prone areas, with priorities within such areas as follows:

(1) Those within the 10-year flood mark. They should be shifted within the coming year.

(2) Those above the 10-year flood mark, but within the 25-year flood mark. They should be subject to new DC Regulations which may be drawn up after careful study of the problem, taking into account contours and the likely extent of flooding. Occupants must clarly understand the risk they run and should be advised to take out insurance against this risk.They should be required to comply with the new DC Regulations within the next 3 years.

(3) Those above the 25-year flood mark, but within the 100-year flood mark. As above, but they should be required to comply within the next 10 years.

(ix) Within each of the above areas, the highest priority should be given to shifting schools, medical facilities, BEST depots and other public services; the next priority to shifting residences; and the lowest priority to shifting industries.

(x) Those who are obstructing badly needed social infrastructure, such as open grounds, schools or recreation spaces, where clearing the obstruction is necessary but not of immediate urgency. Such resettlement and clearance should also be taken up only if there is some assurance that the plot once cleared will be protected thereafter for its intended use. An example of a situation where clearance is eventually called for, but not of immediate urgency, is the pavement dwellers on Tulsi Pipe Road (Senapati Bapat Marg) adjoining the Railway tracks. This is a footpath that is hardly used, or likely to be used, and one cannot be confident that once it is cleared it will not again be re-occupied. In this situation, resettlement is best postponed.

9E.3 Resettlement is undertaken in the following stages:

(a) A detailed mapping of the area, showing the boundaries of different huts, as well as the extent of upper stories in each. The extent of floor area of each tenement is important, as this will form the basis for the area provided in the resettlement. The materials of construction should also be recorded in this survey. Infrastructure should also be mapped. The entire exercise should be put on a GIS database.

(b) Estimation of the cost of each construction. This is to provide the basis for compensation if any to be paid later.

(c) A census of residents in the area, together with various demographic characteristics, and related to which tenement they reside in, with

particulars of whether they are owners or tenants, and if tenants who is the landlord. Details of access to various kinds of social infrastructure (schools, medical facilities, playgrounds) should also be recorded. This is the time at which all residents should be issued with uniquely identifiable swipe cards (see para 3 below).

(d) Vacating of the structures as residents are moved into their new accommodation.

(e) Demolition of the structures that are to be removed, and this should follow as quickly as possible thereafter.

(f) Where any project calls for the cutting of trees, there should be a program of "preforestation". This requires that three times as many trees are successfully planted, and live for 3 years, as the number of trees expected to be cut. Particular attention needs to be paid to the implementation of "prehabilitation" and "preforestation" because until now Government's track record has been dismal on these fronts.

9E.4 For resettlement to work properly, and not be misused, an essential first step is to issue all residents of the region with uniquely numbered swipe cards that carry a chip that also records a photo or a thumbprint or both. This individually unique swipe card can then be an entry point to a variety of databases: medical history; ration card particulars; records maintained by financing institutions; GIS information showing exact location and material of construction of residence, as well as place of work (useful for transportation studies); and so on. All this personal information is stored not on the card (which could be lost, but which we do not want misused) but on separate databases which are used to validate various kinds of transactions by the individual.

9E.5 Historical data for Mumbai and in the Metropolitan region shows that by and large there has been a major flood episode or heavy precipitation event at least once in 10 years. Hence it will be necessary to plan for the safety of Mumbai's residents of a once in 10 years probability of flood events along the major rivers—while the numerous small streams and the cross-drainage works across them continue to be planned and built according to BRIMSTOWAD for a twice-a-year probability of rainfall occurrence. The geographical area falling within the flood line of a once in 10 years rainfall probability will have to be treated as a prohibited zone for all construction purposes. Much of this flow is expected to be contained in trimmed up and developed river channels.

9E.6 Risk zones will remain, and the important consideration in dealing with them is to improve access, and to keep the accesses clear. We have identified 3 types of risk zones: those susceptible to a once in 10 years flooding; those within the 10-25 years flooding; and those within a 25 years to once in 100 years flooding. The activities and construction permissible within each of these zones should be clearly spelt out in the DC Regulations and strictly enforced, as follows:

(a) In the once in 10 years flood zone there should be no construction permitted at all. These are strips along river banks which should paved as necessary to permit access for vehicles to clean the river channel; and beyond the paving should be open spaces for public recreation. The strictest enforcement is required to make sure that these strips are not encroached upon.

(b) In the risk zone susceptible to less than once in 10 years but likely once in 25 years, the construction permitted should be residential only, and must be on stilts, so that while the ground may be flooded, all residences are safe. Commercial activity on the ground floor should not be permitted. Vehicle depots may be allowed, from which vehicles can be removed at short notice.

(c) In the risk zone susceptible to less than once in 25 years but likely once in 100 years, the construction permitted should residential on stilts, and commercial on the ground floor. The occupants of commercial premises must clearly understand the risk they run of flooding, and should be advised to take out insurance accordingly against this risk. No schools, hospitals, cinemas, government offices or any activity where the public gather in large numbers should be permitted in this risk zone. Electrical installations such as sub-stations should also be placed above this zone.

9E.7 These risk zones are shown on the accompanying maps for the four major rivers in Mumbai, namely Mithi, Oshiwara, Poisar and Dahisar. When detailed contour maps of Mumbai become available these zones should be properly demarcated.

9E.8 What is the minimum size of tenement that we should provide? Should we accept the current policy that the minimum size of tenement to be provided should be 225 sq ft (20.9 sq m) with its own private internal toilet and bath? It seems inconsistent with rising present day standards to suggest that the old system of chawls (single-room tenements with common baths and toilets) worked very well for decades, and continues to work well today in many areas of the city. Approaching the problem from the opposite perspective of price affordability as well as the shortage of land, we should perhaps think instead in terms of a design with one-room tenements of 120 sq ft (11 sq m) with common toilets and baths, designed in such a way that in the long run two adjoining tenements could be combined into one, with a private toilet and bath added in the second room, thus converting these present-day 11 sq m tenements eventually into 22 sq m ones. This conversion can be done without difficulty provided the original building is planned with this kind of future modification in mind. The rationale for choosing 11 sq m in the first place is that many hutments currently are of this size, and families are well accustomed to living within such a space. So while we may provide for eventually enlarged accommodation of 20.9 sq m or slightly more, for the immediate future, and considering the numbers to be dealt with, a practical, affordable and immediately implementable norm should be the more realistic 11 sq m.

9E.9 What do we do when someone already has something larger than the minimum in the existing settlement? We should allow the same area in the resettlement: it is unfair that the area should be curtailed arbitrarily. We do need however to guard against malpractices and misuse: hence the importance of the initial ground survey, with a proper audit and validation of the survey, as well as the issuing of uniquely numbered swipe cards with a photograph and thumbprint recorded on the card.

9E.10 No resettlement should be undertaken except as part of a plan that provides not only for housing but also for schools and open spaces and a small amount of space for a local market for daily items. The density of such housing has been somewhat arbitrarily defined as 500 dwelling units per hectare (du/ha). The following table reveals how extreme this is in comparison with other densely populated cities[13]:

Locality	Area (ha)	Density (du/ha)
New York Community District 8, one of the most crowded residential districts in Central Manhattan	513	265
Punggol New Town, Singapore	844	114
Yishun Town, Singapore	810	111

We should also look at densities in some typical areas of Mumbai[14]:

C Ward	178	206
D Ward	663	119
Charkop-Kandivli Sites-&-Services	51.4	170

Our current density norm of 500 du/ha clearly calls for a review in the context of accessibility, safety, civil services and social welfare.

9E.11 Resettlement can take place either in-situ, that is, on the plot where jhopdies already exist, or on a different plot preferably not too far away. If it is on the same plot, we deal with the situation differently for settlements on

[13] Data for New York city from the website www.nyc.gov, for Singapore on enquiry from their Housing Development Board.
[14] Ward data for Mumbai from www.mcgm.in. Charkop data from VKPhatak who dealt with the project.

Government lands, and settlements on private lands. We should note that except in the rarest of cases, it is possible to achieve resettlement on the same plot with densities well below 170 dwelling units per hectare. If resettlement is off-site, it must necessarily be on Government lands, or land acquired for the purpose by Government. We deal with each situation separately:

(a) *Resettlement on the same plot on Government lands*: We should first of all consider carefully whether resettlement is required at all. It may well turn out that resettlement is not urgent, in which case all that is needed is that the settlement be provided with Municipal infrastructure, including solid-waste disposal. We should also take steps to carry out a mapping of the settlement, a census, and an issuing of swipe cards. Following this, the residents may be permitted to come together and form one or more co-operative societies, to whom ownership of the land should then be transferred. The residents are then free to continue as they are, or to re-plan their development and re-construct using housing finance for which arrangements will have separately been made.

(b) *Resettlement on the same plot on private lands*: We need the intervention of Government on a locality by locality basis, where existing residents and land-owners are assumed to have entitlements to building rights which are as follows:

   (i) For the land-owners, an area equivalent to FSI 1.0 on the area of their plots (1.33 in the Island City).

   (ii) For squatters, to each person the area he currently occupies in the unauthorised settlement.

   (iii) The locality is then re-planned on a locality basis, where squatters will have some plots in the locality, and land-owners will have other plots in the locality on which each can exploit his building rights.

(c) *Resettlement off-site on Government lands*: The key to this is the availability of sufficient land within reasonable access to the city's mass transport systems. There is no alternative to adding more urbanizable land within reasonable commuting distance. This means taking up the following:

   (i) Salt pan lands, because the manufacture of salt is an inappropriate use for lands that are so strategically located for residential accommodation. Developing such lands would imply acquiring them at costs that compensate the present owners adequately in terms of revenue lost from salt manufacture. It would also imply putting in new infrastructure, both by way of mass transport (perhaps by Bus Rapid Transit systems connecting to railway stations) and by way of water supply and sewerage. The cost of the infrastructure could be recovered

from the new occupants. The total land area available from salt pans is about 507 hectares (including land currently zoned as NDZ-82 and CRZ II-79). At a gross density of 170 dwelling units per hectare (du/ha), the number of families that could be resettled here is about 54,000.

(ii) Open lands presently blocked from development by the CRZ regulation. This is an absurd regulation in the context of Mumbai's geography, and we need to work at persuading the Central Government of the suffering it is causing to the citizens of the city for no perceptible gain.

(iii) Lands that are presently put to an inappropriate use, such as the Port Trust lands. With the Jawaharlal Nehru Port Trust functioning across the same harbour, Mumbai does not need its original extensive port facilities on this side, and much of its land could be turned over for residential use. The Bombay Port Trust currently is about 744 hectares. About half of this may be required for continuing port operations. The balance 372 hectares could house 63,000 families.

9E.12 In recent years, resettlement has proceeded on the basis that squatters must be provided pucca accommodation entirely free of cost, and that this subsidy is met by the profits made from selling higher-income housing. The policy is clearly unsustainable, because the size of higher-income market needed to provide free construction to all the lower-income population simply does not exist. Nor is this kind of subsidy necessary. The vast majority of the lower-income population can pay for their own housing, provided long-term housing finance is made available to them. We need to turn our attention to enabling such low-income housing finance, and searching for lands on which it can be built.

9E.13 The MUTP model for resettlement is well worked out and should be followed, but with an emphasis on preferring the town planning model (similar to Charkop in North-west Mumbai) rather than the SRD model which constructs housing but neglects all associated infrastructure. Further, what is notable about the Charkop model is that this is a successful mixed-income development. Apart from serving the original intention of cross-subsidising the low-income groups by charging higher for the middle- and upper-income groups, there is considerable social value to be obtained from a mixed-income development. Instead of concentrating the poor in ghettos of poverty, mixed-income housing builds sustainable communities, with many of the poor finding opportunities for a livelihood within the same community. Plans for post-Katrina reconstruction also support the view that reconstruction should be in the form of mixed-income communities.[15]

9E.14 Dharavi: We have been given to understand that the redevelopment of Dharavi is proposed with a Global FSI of 4. A Global FSI of 4 implies a Plot-

[15] *Rebuilding Homes and Lives: Progressive Options for Housing Policy Post-Katrina,* by Joel Horwich et al, New Vision (an institute for policy and progress).

wise FSI of about 6. This is to be compared with the currently permissible FSI in the Island City of 1.33, that is, the proposed FSI will be about 4.5 times more than the current norm. Our objections to this are the following:

(a) The area is low-lying, adjoins the Mahim creek and is therefore particularly prone to flooding.

(b) The transport links serving the area are already heavily saturated with no capacity to carry additional demand. This is therefore not the right location to add more development.

(c) The intensity of development proposed is much too high. In no city in the world are densities of occupation as high as those being proposed here.

We would urge therefore that the nature of resettlement in Dharavi be carefully reconsidered.

CHAPTER 10

CONCLUSIONS

1) On 26th July, 2005, in the afternoon after 14.00 the Mumbai Suburban Area and the entire M.M.R. Region was struck with a heavy storm. Train movements started slowing down from 14.30 and at 16.00 came to a halt due to water logging on the tracks, which created a hue and cry situation and panic amongst the stranded passengers Due to stoppage of trains, vehicular traffic intensity on roads suddenly increased. But due to the water logging and submergence of certain pockets such as Dharavi, Bandra-Kurla Complex, Chunabhatti, Chembur, Ghatkopar, Milan Subway, Sion and in many other areas, the traffic movement got substantially slowed down, whereas in other areas it came to a grinding halt. Around 1.5 lakh people were stranded at the CST and Churchgate stations due to disruption of railway services.

2) The situation got further aggravated when communication systems such as telephone and cellular phones got suspended one by one – after 15.00. Due to the submergence of the power stations and its sub-stations, the power supply in the suburban area started getting disrupted from 15.00 onwards. Commencing from the evening of 26th July, the daily consumables could not reach the people. In some sensitive areas like Air-India Colony, Kalina, Chembur, Chunabhatti, the water level rose by as much as 5 to 6 m. In many buildings the water entered the ground floor & first floor level houses and the people had to take shelter on the upper floors.

3) There has yet been no formal survey of the sufferings & losses of the people and the public agencies. But the indications are that the losses have been huge. More than 20,000 cars, 2,500 BEST buses and a very large number of two wheelers / three wheelers were damaged. 24,000 animal carcasses had to be disposed of. Though exact assessment of the loss to the private property is not forth coming but guess can be made, as 2 lakh tons of garbage mostly comprising of personal household belongings, furniture, food stuff and electronic gadgets was required to be thrown off. Gravity of the situation can also be deciphered from the amount of bleaching powder and disinfectants spread and number of persons required to be treated. It is reported that 24 metric tons of bleaching powder and 2 metric tons of phenol had to be sprayed for disinfection and 3 lakh patients had to be treated. 450 persons lost lives during flooding and 248 thereafter. Railways, electricity supply stations & telecommunication equipment also suffered extensive damages. More than 1 lakh houses suffered from submergence at different scales. There is no count of the personal inconvenience and sufferings.

10.1 Causes for the deluge

10.1.1 Immediate causes

(i) Excess Rain

1) The principal cause of the deluge on 26-27 July 2005 was the unprecedented heavy rainfall (1,000+ mm) surpassing all known daily rainfall records on the Mumbai

peninsula, and also the extreme intensity of precipitation (136 mm/hr).

2) Much of the extreme rainfall that was reported on the morning of 27th July was actually the rainfall that had occurred on 26th July. The extreme precipitation intensity had actually taken place on 26th July. IMD described the causal factors for the extreme precipitation as: "*Presence of a well marked low pressure area over Madhya Pradesh, marked offshore trough at the surface along the west coast and a well marked east-west oriented shear line in the lower troposphere must have contributed to a favorable setting for the enhanced meso-scale convection around Mumbai on that day.*"

3) The Vihar lake received the maximum rainfall of 1011 mm as per the data of MCGM's rain gauge records.

4) The heavy flooding on 26th July 2005 was due to very heavy down pour with the intensity of 380 mm over a short period of 3 hours between 14.30 to 17.30 *i.e.* more than 125 mm/hr, which is five times more than the intensity of rain for which old storm water drains were designed and 2.5 times more than the intensity of rains for which drains are currently being designed following the *Brihan Mumbai Storm Water Drainage* (BRIMSTOWAD) study that was adopted by MCGM for improvement of the storm water system in Mumbai. Even if the entire system had been upgraded as per the BRIMSTOWAD recommendations, the same would not have been adequate for the rainfall intensity to the tune of 130 mm/hr. This was substantially more than the designed capacity of the storm water drainage system and hence flooding was inevitable.

5) The Mumbai downpour was the result of a combination of synoptic-scale weather systems which have a span of 1,000-2,000 km. and the meso-scale weather system localized over 20-30 km.

(ii) Blockages

1) The situation got aggravated in terms of depth of submergence, spread of submergence and prolongation of the submergence periods because stream channels were not in good shape. The silt was not removed up to the specified invert levels, waterways of bridge and culverts continued to be blocked by service lines placed along the openings, and clogging of the mouths of culverts by garbage and plastic bags.

2) Even the cofferdam at the mouth of the Bridge under Airports taxi bay was left in place, triggering the eastward overflow of the Mithi River across Eastern Expressway submerging the Central railways tracks. Near the airport it started flooding by 14.30 / 15.00, which went on increasing and did not completely recede even after 36 hrs. The immediate first victim in the neighborhood of the Airport Authority area after the initial outburst of downpour was the IMD rain gauge station near the airport, which is said to have stopped functioning immediately after 14.30 having got submerged. The role of the cofferdam put across the Mithi River for the Bridge under the taxi bay in accentuating the early flooding phenomenon has left for us many lessons in this flood episode.

3) The Mithi flooding on 26th and 27th July '05 is generally attributable to a large number of factors, the most dominating one clearly being the extreme precipitation near Vihar (136 mm in one hour). Inadequate width of Mithi channel due to encroachment on both the banks greatly aggravated the situation by constricting the flood flow and causing heading up towards the upstream. The two important

bottlenecks have been one near the airport and the MMRDA area, and the other on the d/s of MMRDA region near the outfall itself in Mahim bay. The first one caused flooding of Kurla and Chembur areas and the other at the island city catchments near Mahim.

(iii) Non-operational disaster management plan

1) The disaster management plan for Mumbai prepared & published in 2000 had remained to be translated into operational instructions for dissemination of information and for rescue & relief. The unexpected extent of flooding came totally as a surprise and shock and there was no preparedness or co-ordinated mechanism in operation at the catchment levels. In spite of the difficult ground position being known from the BRIMSTOWAD report since 1993, there was no dialogue with the local residents & the ground level operational staff on that report also .

2) The Disaster Management Plan of Mumbai – Clause 1.4 – 'Climate and Rainfall' in Vol.I, Page-7 does not define any 'Rainfall Alert System.' However, the practice in vogue in MCGM. was as under : The IMD provides the weather forecast and tidal information to the Disaster Control Room of Government of Maharashtra and Municipal Corporation of Greater Mumbai. IMD had accordingly conveyed their forecast as under : "Rather heavy to very heavy rainfall means a rainfall, in the next 24 hours." According to IMD's terminology, it meant 'from 65mm to 124.9mm of rainfall in 24 hours'. The actual rainfall was however of the order of 944mm!

(iv) IMD's silence

1) IMD's failure to communicate about the impending danger after sighting at about 13.30 the 15 km deep cloud formation gathering in the sky and approaching towards Mumbai was particularly very unfortunate. The result was that the lead time available for forewarning & rescue between cloud formation and actual submergence of public infrastructure, properties and life could not be put to use.

2) It is not clear why Mumbai and MMR could not be put on special alert for 26th and 27th by IMD – through special emergency messages and bulletins rather than continuing with only routine releases at 12.30 hrs of the day. Mumbai and other corporations in MMR do not have any mechanism for tracking and mapping the storms. IMD has that. But information available with them could not be put to use to alert the people about an exceptionally intense storm.

3) From the circumstantial information gathered through the interactions that the committee had with the representatives of the IMD it was clear that there was enough scope for IMD to be more proactive in providing the periodical data at an interval of at-least every one hour in an extreme situation on 26th July – commencing at least from 15.00. An initiative from IMD for forewarning about the impending disaster would have been of a great help. IMD had located the presence of a 15 km cloud over Mumbai by 14.00 hrs Implications of such an extreme meteorological phenomenon should have been immediately conveyed to the concerned authorities – overruling their earlier description of forecast as 'heavy or very heavy'.

(v) High tides

1) The impact was further worsened because of high tides occurring at the same time on 26th July evening. Constriction of natural waterways, clogging of culverts, changes in natural stream flow directions, increased coefficients of rugosity because of crowding of structures and reduced hydraulic gradients by silting gave rise to high

flood levels and longer periods of inundation.

2) Though rainfall intensity in island city was not so heavy, the chronic flooding spots namely Lalbaug, Parel, Tardeo, Dadar TT, King Circle, Hindmata etc experienced flooding. Railway electronic signaling system stops functioning once the water level touches the rails, and the suburban trains are asked to slow down at crawling speed of 8 km/hour. And once the water level reaches 10 cm above the rail top level all the train movements are stopped. This situation occurred on that day at 15..30 pm coinciding with the on rush of the commuters hurrying back to their homes. Due to this there was unprecedented accumulation of crowd at railway stations.

(vi) Two flood waves

1) From the details of local inundations observed by MCGM staff and the residents in the neighborhood, the three rivers (except Mithi) had to face two separate flood waves on 26th & 27th *i.e.* first in the evening of 26th which receded with the low tide and then again in the night of 26th. The night flooding was far more severe than that in the evening. This is compatible with the rainfall hydrograph of Vihar. The night flooding receded within a couple of hours after the rain stopped, because of the low tide period following it after the midnight of 26th July.

2) From the rainfall hydrographs of 26th & 27th July it is clear that two flood waves were generated in the streams and river basins of Mumbai, one between 1430 hrs to 1630hrs coinciding with the high tide period & resulting into a deluge & the other between 20 hrs to 22 hrs.

(vii) Mithi Mahul interconnection

1) The adjoining catchments of Mahul – Nehru Nagar nalla system and Somaiyya – Reti bunder nalla (outfall to Thane creek) witnessed a similar continuous rise in flood levels. Only the starting time for flooding varied marginally. Lal Bahadur Shastri Marg (i.e. the old Mumbai Agra road) is by and large along the ridge line between Mithi basin and the eastern two systems. Ground levels of Lal Bahadur Shastri Marg are between 4.0 to 4.5 m GTS in the saddle region. The general ground levels in this area are such that once flood water in Mithi reaches a certain height (marginally above the high tide level) storm water of Mithi starts overflowing into Chunnabhati area. Kalpana Kamran system flowing across Lal Bahadur Shastri Marg also contributes to transferring of water from west of LBS to east of LBS. Surface flows on land in Mahul and Somaiyya catchments get interconnected at Tilak Nagar and the systems are further interconnected near Kurla Terminus in railway area between Vidyavihar and Tilak Nagar railway station within railway premises and at the railway culvert between Chembur and Tilak nagar railway station. Instances of flooding near these spots due to some problems of congestion in the adjoining catchment have occurred a number of times in the past also. These were the marshy lands in the past and part of Mithi was discharging through Mahul and probably even through the Somaiyya nalla.

2) On 26th July, once Mithi started heading up, the spill waters entered into this east-west system across the saddle. The result was that Chunabhatti and Nehru Nagar started getting flooded by 4.00 pm. Backwater of flooded Mithi near the Airport crossed Lal Bahadur Shastri Marg, flowed over CST road and railway track to Mahul storm water channel. Mahul system also failed to accommodate the flow and was probably even not in a position to discharge its own flow just downstream of EEH

culvert. Water ultimately rushed to Somaiyya system, which is reported to have got flooded almost at the same time. The water finally drained through Reti Bunder Outfall.

3) Mahul system failed to accommodate the flow just downstream of Highway because at the Vasant Dada Patil Polytechnic the channel width is considerably narrowed and reduced to just 8-9 m, as against the 18 meters width in the upstream length. Flood flows towards the outfall were obstructed in Mithi because of comparatively higher ground levels in the MMR development region on the banks of Mithi and in Mahul because of Wadala Anik link road developments on the bank of Mahul respectively.

(viii) Road Constructions

1) Continuous over-laying of road construction on concrete roads in previously developed areas has in many places raised the formation level of roads above development or even plinth levels of existing properties. The floodable area available in the form of road width is lost. Instead, now open spaces around the buildings have become flood-prone areas since during heavy showers water from the road-side storm water drains now enters these open spaces, instead of traveling from plot to S.W.D. Expansion of the carriageways by MSRDC / MMRDA have covered the open space and ditches on either side which were part of the drainage system. This has affected surface flow of rain water to a very great extent aggravating flooding conditions generated by poorly maintained or inadequately sized longitudinal and cross drains.

2) Though extraordinary heavy rainfall intensity was undoubtedly the prime cause of flooding, the situation was further aggravated by retarding the rate of recession of flood waters on the major corridors, which were being improved under the activities of MUTP and MUIP. The contributory reasons were (i) incomplete cross drainage works, (ii) reduction of waterways due to blocking by garbage, (iii) non removal of excavated or heaped material, and (iv) reduction of waterways of nallah system.

(ix) Electricity failure

Due to flooding and fear of electrocution the main power supply was shut off in the suburbs and some parts of the Island city. At the same time the generators and battery backup system also became non-functional as they were also submerged. Failure of communication system created further chaos as nobody could know as to what was going on.

(x) Road jams

1) As an alternative to railway about 500 extra buses were pressed into service to clear the crowd. However, they too met with similar fate as they could not reach the destinations because of the blockages on main roads by the broken down and abandoned vehicles. Even the rescue operations were hampered, as the rescue vehicles could not reach to the spots.

2) 26,000 stranded vehicles on roads were cleared on the following day i.e. by 14.30 on 27th July.

10.1.2 Accumulated factors

(i) Low land levels

1) At many locations, existing ground levels are below the high tide level e.g. Sat Rasta, Lower Parel, Grant Road, *etc.* The average high tide level is 2.5 m, the annual highest peak tide level being 2.75 m. The average low tide level is (-) 2.0 m (i.e. two meters below the sea level). It is the low tide periods (a total of about 10 to 12 hours in a day below the mean sea level) that have been providing relief during the storms by draining out the accumulated surface waters.

2) In Mumbai out of 186 outfalls, 45 discharge below the mean sea level. If the accumulated storm water for these outfalls is not held within the system, it spreads around and the low lying areas get submerged. The phenomenon is more predominant where the branch drains are shallow and the locality is relatively low lying.

3) The entire area south of airport boundary wall (in front of the AI colony and IA colony) happened to be situated on the periphery of a low-lying reclaimed pond area. It can be seen from the 1925 survey record that it was a portion of water-logged wetland system of Mithi estuary (then named as Mahim River estuary).

4) Entire estuary of Mithi River has under gone extensive landfilling, reclamation, encroachment, river course modification and all these alterations have impacted the estuary movement and hydraulics of the entire creek (khadi) and bay.

(ii) Uncoordinated Mumbai

The GOI establishments tend to be not directly accountable to the city's principal administrator or the local elected body. His position and the position of the elected MCGM has been eroded by direct instructions emanating from the Urban Development Department of the State Government, and somewhat further overshadowed by the presence of MMRDA in Mumbai, not only as a planning and co-coordinating body, but also as an executive 'independent' authority. This was made abundantly clear in respect of the development of the Bandra-Kurla complex, the airport's Mithi river bridges, and channelization of the Mithi river. In all these cases the role of the MCGM got progressively marginalized, leading to un-co-ordinated management of the Mithi River.

(iii) Harmful legal regimes

1) <u>The Rent Act</u>. The continuation of the Rent Act has had two damaging effects in regard to the drainage of the city. The first is the proliferation of slums. By freezing rents, the Rent Act effectively killed all construction of new rental housing. In the last 50 years there has been no new private sector housing built for rental. When ownership housing is unaffordable, citizens have no choice but to move into slums. Slums provide the only accommodation that can be had on rental. And when they constitute more than half the city's housing, it comes as no surprise that they are built in a way that blocks drainage channels.

2) <u>ULCR Act</u> has if anything reduced land availability, aggravated land prices, and made housing for low-income groups even more intractable.

(iv) Land scarcity

1) The issue of storm water drainage is intimately linked with the restructuring of Mumbai. Incessant pressure on lands in Mumbai has been the principal reason for

encroachments on the stream flow areas, congestion and pollution.

2) Reclamation has also been at different levels in different areas as it was done in a piecemeal fashion. The earlier development was on the original land away from the seashore, creek arms or nalla riverbanks. The pressure of over-population has pushed the new development more and more into those areas, which are generally low-lying and act as water spread areas for the rainwater. In these areas the development had to be done by reclamation or filling, which limited the water spread area only to the actual watercourses, thus increasing the height of flood in flood-prone areas.

(v) Neglected critical items of work

1) While the BRIMSTOWAD report dealt with the normal occasions of rainfall in Mumbai, the situations of infrequent rainfall intensities and consequent disruption of civil life remained uncovered by the report. Many suggestions offered by the earlier committees appointed after instances of unusual heavy flooding in 1974 and 1991 remained to be implemented including channelization of the Mithi River which was a concurrent condition for any reclamation of land for development along the Mithi River in the Central Business District of Bandra-Kurla Complex contained in the recommendations of CWPRS.

2) In the meanwhile encroachments on river channels the Mithi , Oshiwara, Poisar & Dahisar continued unabated because of very large increase in the population (25 lakh) in the MCGM area in the last two decades without any systematic provision for their housing.

3) Most of the short term measures recommended by the Natu Committee in 1975 appear to have been carried out. But action has not been taken for the important long term measures such as providing (electrically operated or otherwise) bye-pass sluice gates and Pumping Station at Mahim Causeway, providing Storm Water Pumping Stations at Love Grove, Haji Ali bypass, and Cleveland Bunder; and providing a solid barrier at Haji Ali Bay to serve as a balancing reservoir.

4) The BRIMSTOWAD Study in 1993 had identified 672 obstructions in the SWD network due to other utilities and many of them still exist and more might have been newly added across the storm water channels.

(vi) Congestion in South Mumbai

Decentralization of the administrative commercial & employment generating activities in Mumbai will have to be achieved as envisaged in the Development Plans and MMRDA objectives. However, north-south traffic has been on the rise in the absence of any ameliorative measures in the last few decades. The deluge of 26th July got heightened partly because of excessive unidirectional traffic giving rise to unmanageable traffic jams on the main urban corridors cutting off at least a million people from their homes.

(vii) Absence of contour Maps

1) There was no realization amongst the citizens as well as in the municipal administration that population & commercial activities are crowding on flat reclaimed lands of Mumbai having areas with inadequate natural drainage potential the more so near the tidal reaches of the creeks. Measures for administratively regulating this crowding in the risky areas and for protecting these developments through modern technological packages like pumping on such lands; ponding, channelisation or

gated structures at the mouths of the outfalls did not receive adequate priority in keeping with the increasing pressure from land occupation.

2) Development plans of Mumbai were prepared without reference to the land levels in Mumbai and the catchment physiography. In the absence of detailed contour maps the patterns of surface runoff resulting from heavy precipitation could not be easily deciphered. Carrying capacities for road gutters or stream channels had to be provided arbitrarily. Interlinkages between the ground formations or individual properties, roads and drainage channels have been unclear. For a crowded urban settlement like Mumbai all these have to be planned and managed in a comprehensive holistic manner.

(viii) Lack of civic planning

1) The focus of development in Mumbai got essentially centered around individual properties and the single-minded search for individual shelter, with total disregard to accesses transport needs, public hygiene, toilet facilities and sullage disposal. There has been a complete collapse of urban planning & management, with no identifiable single unit responsible or accountable for this. Storm water and sewerage services have suffered the most, because even otherwise those are not prestigious works. The accumulated result is a chaotic situation in this respect in many crowded localities.

2) CWPRS was appointed by MMRDA to study the requirements of the storm water system for development of the Bandra-Kurla Complex. The package of measures included provision of a sluice gate at Mahim Causeway. A Committee under the Chairmanship of Shri Merani was appointed for the sluice gate structure and its report (September 1997) listed out the follow-up actions needed and it was signed by representatives of all agencies (Rlys, MCGM, Irrgn. Deptt., MMRDA, CWPRS etc). But even so no further action has materialized thereafter. The idea of the structure is to shut the gates before a high tide occurrence so that the empty reservoir created by dredging on the upstream stores the floodwater of rains, which can then be discharged into the sea by opening the gates during the low tide. Had these works been completed in time as recommended, the impact of the extreme rainfall event of 26-27th July would have been much less.

10.2 Storm water drainage and sewerage system of Mumbai

10.2.1 Current Status

1) The present storm water system is designed for 25 mm/hr precipitation and 50% runoff from the catchment. Due to developments in Greater Mumbai, the run-off is now almost 100%. The design criterion of 25 mm/hr is also inadequate considering the rainfall history of Mumbai. Moreover, in the island city, the storm water and sewerage systems are more than 100 years old and have been in a dilapidated condition at many places. Capacities are reduced and the systems need a planned rehabilitation. In addition the maintenance of the system is poor and no standard guidelines are available with the departments of MCGM . There is no manual for the work procedures of the Storm Water Department.

2) The BRIMSTOWAD report had listed the rehabilitation and other works for up-gradation/ improvement/ augmentation etc. of the storm water system in 1993. Works of improvement and augmentation, which can prevent large submergence after heavy rains have been identified. But many of these works have remained to be taken in hand. It is necessary to carry out all the balance works immediately. Simultaneously a fresh assessment survey of the SWD network will be desirable to assess the present condition as further deterioration of old systems may have taken place after 1993 as new obstacles & obstructions in the storm water flow have clearly been added.

3) The BRIMSTOWAD study also provided a well-defined catchment-based approach to the management of storm waters in Mumbai – which was absent in the past. Storm water management has necessarily to be handled on the basis of a natural environmental unit as a catchment / watershed. Hence the approach laid out in the BRIMSTOWAD report needs to be pursued and strengthened.

4) The major gain from the BRIMSTOWAD report was the establishment of a full-fledged storm water department under the MCGM. But for the existence of such a separate department, even the partial success in the implementation of the BRIMSTOWAD would not have been possible.

5) The Natu Committee's report in 1975 and the BRIMSTOWAD report of 1993 are substantive and exhaustive reports. But their processing in the Municipal Corporation appears to have been handled more or less just in a routine manner. There are no formal orders – accepting or rejecting the numerous detailed recommendations made therein and no continuous follow-up reviews. Even the copies of these reports do not appear to have reached the concerned offices, all the ward offices, and the departmental ground level offices who are expected to finally act on many of those recommendations. BRIMSTOWAD report particularly contains excellent detailed catchment-wise drawings and catchment-wise write ups on the actions to be taken. But this information is not readily available for the ground level functionaries. The report seems not to have been disseminated, and there was thus no scope for the local groups and ground-level functionaries of the administration to take the initiative in implementation of these matters for improving the local situation.

6) Because of the very specific area-wise detailed recommendations contained in the Natu Committee's report and BRIMSTOWAD, it will be useful if MCGM appoints an internal review and monitoring group to see how best the balance actions would be systematically pursued hereafter.

10.2.2 Separation of sewage from storm water

1) Sewage flow is connected to SWD system at many places. The slums also invariably discharge 'sullage' into the S.W.D. System. Slum Colonies generate garbage which finds its entry into SWD and causes siltation and obstructions. The system of garbage collection and disposal needs improvement.

2) Mixing of sewage and storm water flows has aggravated the silting processes at the outfalls and in the estuaries. Our committee has therefore insisted on separation of sewage and storm water drainage and their appropriate safe disposal. All the reports so far (except the IIT-2005 report) have unanimously stressed the importance of separation of sewerage from storm water; the mixing of sewage with storm water has been strongly objected to.

3) In the island city there exists a system of preliminary treatment of Mumbai's sewage and pumping it into the ocean through marine outfalls. For the present this system meets all the consent conditions legally applicable to Mumbai. However, there is shortfall in the sewage collection and conveyance arrangement for the suburbs.

10.2.3 Treatment facilities

1) There is a shortfall in treatment and disposal facilities in Versova Zone and no disposal facilities are available in Malad. These shortfalls of treatment facilities in Versova and Malad nave been expected to be tackled in phase II of Mumbai Sewage Disposal Project only. On completion of M.S.D.P.-II, (costing approximately Rs. 5,570 crore at year 2000 prices) there will be adequate collection, conveyance, pumping, treatment and disposal capacities in Mumbai to meet current standards.

2) From the point of view of "sustainability", disposal of such untreated sewage on the coast of Mumbai shall one day prove to be disastrous because even the ocean has a finite carrying capacity. Letting out of the phenomenal quantities of untreated sewage daily into our coastal ecosystem will certainly degrade the system in future. Immediate action is required to plan and execute sewage treatment works all over Mumbai Region. Maintenance of "wholesomeness" of rivers and aquatic systems and adoption of an integrated systems approach in environmental management are the core principles embedded in the *Water (Prevention and Control of Pollution) Act* (1974) as well as *Environmental Protection Act* (1986). These laws can be truly implemented by treating all the flow of sewage and sullage from all the residents of Mumbai.

10.2.4 Limitations of the BRIMSTOWAD study

1) Terms of reference for the studies on storm water management initiated by MCGB in 1989 did not specifically highlight the need for looking at the heavy rainfall events and the ameliorative measures necessary. The BRIMSTOWAD exercise got restricted towards physical civil engineering works required for the conveyance of Mumbai's storm drainage. Elements of risk to life & properties under excessive flooding did not get adequately highlighted. The topic of urban Hydrology also did not get introduced in Mumbai's concerned departments in its comprehensive form. It was not even picked up by any of the technical institutes in Mumbai as a subject that needs to be pursued for greater research & analysis in the local context. As a result related technical and administrative provisions in the corporation's rules of work remained only peripheral while the crowding in Mumbai was simultaneously getting out of control.

2) Natu Committee's work in 1975 was the first attempt to address the problem of flooding in Mumbai in a comprehensive manner when Mumbai had started growing and expanding fast. That report initiated a new direction for handling the situation with modern technologies – like gates, barrages and pumping stations. BRIMSTOWAD was an excellent next step that introduced the 'catchment management' approach for the storm water issues in Mumbai. From all the reports prepared on this topic so far, it is clear that the storm water related issues have been getting gradually better defined on the technical side. The related design standards are also getting upgraded. But on the administrative and social aspects, much

remains to be achieved. The topic itself has not been adequately internalized within the corporation's general set up. For example, encroachments along drains / nallas reduce the access for desilting and maintenance and need to be removed or relocated early. But that has not happened. These activities will have to be looked at as an integral part of the storm water system's improvement plan. Completion of only the physical works for storm water conveyance do not provide the desired relief.

3) The extensive painstaking work carried out for BRIMSTOWAD report was not adequately publicized and discussed within the municipal wards and with the ALM-groups. The result was the haphazard half hearted approach to its administrative implementation.

10.2.5 Absence of Contour maps

1) In the crowded flat terrain of Mumbai, where two-thirds of the island city and considerable habitable part in suburbs is on reclaimed lands that are almost flat, identification of precise catchment areas is difficult, particularly in absence of contour maps having close intervals of levels. Even the roadside drains near the ridge or in a saddle portion can divert the flow to an opposite basin. The moment there is overflow from the drains on the ground, these basins get interconnected and try to behave like a combined system. For the purpose of storm water planning purposes such catchments cannot be looked at in total isolation. What is required is a further improvement on the catchment wise work initiated in BRIMSTOWAD to deal with high rainfall conditions, which were not covered under BRIMSTOWAD.

2) To plan and design the storm water conveyance system in a city like Mumbai which is aiming at an international standard of civic management, the practice of considering 2 disruptions in a year, or even a five year return period of rainfall will not be appropriate for the major traffic routes. That will also not be adequate to protect the lives and property along the river channels. BRIMSTOWAD standard of 2 acceptable submergences in a year may be adequate for internal local roads. But the metropolitan city as a whole may best be planned for three different levels of hydrological risks. While the large number of CD works on small streams and for minor internal roads in Greater Bombay may continue to be planned and constructed according to BRIMSTOWAD, the channel widths of the main rivers, and the CD works for the major roads and for the through corridors of traffic, in our opinion, will have to be planned and handled for higher intensities of rainfall.

10.2.6 Upgraded design criteria

1) Crowded Metropolitan cities' flat terrains need very stringent standards for storm water management keeping in view the adverse impacts of storm water stagnation on the traffic movements and the resultant hurdles in evacuating people from the affected areas.. It will therefore be desirable if the few major corridors of the city, which can evacuate the population in emergency situations, are planned and designed for a flood probability of 1 in 100 years. . The other major roads, feeders to the arterial roads, may be designed for the rainfall intensity of 1 in 25 yrs return period. BRIMSTOWAD recommendations should continue to be followed for all other internal roads and storm water channels.

2) The water ways suggested in BRIMSTOWAD may prove to be inadequate for high intensity flood flows through the CD works for small catchments under heavy rainfall conditions. But that inadequacy will not have a large impact in terms of area of water spread. Local stagnation of water will cause inconvenience, but not much of a risk as such to life and property. After five years of data collection, when more information on 15 minute intensities of precipitation is in hand the BRIMSTOWAD provisions for small catchments may be reviewed if necessary.

3) Keeping in view the theoretical estimates of the maximum probable precipitation of 800 to 960 mm/day (much lower than the actually observed 1,011 mm at Vihar), limited aerial spread of the extreme intensities of rainfall, and the differences in the results of the statistical analysis carried out by different researchers for different sets of data, we find that it will be adequate if Mumbai's storm water systems are basically designed in simpler terms for the following hourly intensities of precipitation:

a) For Small catchments = 2 in 1 year probability *vide* BRIMSTOWAD (50 mm/hr)

b) 1 in 10 year probability = 70 mm/hr. - For river channel areas to be kept free from any intrusion (prohibited area)

c) 1 in 25 year probability = 80 mm/hr. - For river bank areas with restrictions on pattern of land use and the type of constructions and for the CD works on major roads in Mumbai (restricted zone)

d) 1 in 100 year probability = 100 mm/hr.- For river bank (occasional flood spread) area as a risk zone and for all CD works on main through arteries of traffic.

4) Except the five major rivers, nowhere is the time of concentration more than an hour. In fact in many smaller catchments, the time of concentration is just 15 minutes. Hence while studies on hourly intensities of rainfall – as carried out and used so far would take us somewhat close to the actual requirement, it will be useful to carry out more detailed '15minute' intensity analysis – hereafter when more data is generated from the hydro meteorological stations with self recording automatic rain gauges to be installed in Greater Mumbai.

5) The key to improvement in the health of the urban watershed is to maintain a proper water balance by enhancing the land cover by vegetation and trees and by absorbing runoffs through infiltration and pondages. At the watershed level, we need to focus on how much rainfall volume has fallen rather than only the intensity of precipitation and the flow rates. What to do with the total rainfall volume generated by the storm should be the final concern.

6) Importance of the holding ponds in Mumbai's storm water management needs to be fully appreciated by the Mumbaites in order to retain the existing holding spaces and to provide systematic new holding spaces at critical locations. They have to be treated as a part of the urban land space and as an integral part of the land use plans. For such ponds to have influence in flood mitigation, their cumulative capacity has to be atleast more than 10 % of the catchments estimated runoff. Unharmuful ponding within the private and public premises also is one way to capture and store temporarily the excess runoff. Extensive open spaces like public gardens, parks, race courses, golf clubs, play grounds and open lands of airports, not used for air traffic can provide the holding back and absorption capacities in the different catchments. Developing new holding ponds near outfalls may not be possible everywhere. But

special efforts in that direction will be necessary for major watercourses like the four rivers and the Mahul creek.

10.2.7 Gated outfall structures

1) In the light of the hydrometereological, hydraulic, topographical and tidal conditions in and around Mumbai, a set of hydrological management measures will have to be developed and adopted– as specific 'packages' – for each catchment to avoid risks to life and property.

2) In the hydraulic system of Mumbai, gated outfalls will have an important role to play in future as densification of urbanization proceeds and expectations for a well protected urban life also increase.

3) As per MCGM inventory, 45 (out of 186) S.W.D. outfalls (pipes or open channels) have their bottom levels below mean sea level. Except three outfalls in the city area, none of the S.W.D. outfalls are gated. The corporation should immediately entrust the task of determining and fixing the criteria for tidal controls on the basis of socio-economic cost benefit analysis to a group of experts in coastal hydraulics.

4) For the catchments of more than 10 sqkm, or where some critical or vital installations are involved in the creek's tidal zone, it will be desirable to provide the gates to a flood flow of one in 100 year probability and for smaller catchments for 1 in 25 years probability. A proper gate operation schedule for each gated outfall structure needs to be laid down considering the channel capacity characteristics. It should not be difficult to train the operating staff for this purpose to ensure that in the monsoon period the gates remain properly attended and operated.

10.2.8 Pumping

1) Mumbai will require pumping stations in the city as well as in the suburbs. The requirement of pumping stations should be examined immediately and such stations installed wherever warranted.

2) Even smaller Pumps will have to be provided on some smaller storm water channels to overcome invert problems and flat gradients. Storm water channels will have to provided with proper gradients. Where inverts levels on the downstream are higher and when upstream arrangements lead to lower invert levels, the storm water will have to be pumped (with the help of small pumps) into the higher invert level arm on the downstream side of the storm water system to ensure that the system is not hydraulically deficient. The "Global Warming" effect and the consequent rise in tide level merits advance planning for pumping for a coastal city like Mumbai.

3) Pumping will be inevitable at many places and must be adopted on the basis of rational criteria which should be prepared and implemented in due course. The Storm Water Department's present organization is inadequate and needs reorganization, upgrading and restructuring for adopting such new hydrological management approaches.

10.2.9 Garbage handling

1) There must be an effective system for collection, storage and removal of solid waste from all the areas near the storm water system which will ensure that solid waste does not enter the storm water system. Unified responsibility for maintenance

of the storm water system, sewerage and solid waste management is essential. The procedural objective will have to achieve "Zero Backlog" that is Zero Garbage at any point of time and this means no "Community Bin". This scheme will have to be implemented particularly in the slum areas to avoid clogging of nallas, to stop the entry of solid waste into the storm water channels rather than arranging for its removal. Organizational measures will have to be implemented in co-operation with local groups of residents. Open spaces shall also be identified in wards for temporary storage of refuse during times of heavy rains. These open spaces shall be in areas which are not prone to flooding or water logging.

2) Improper disposal of municipal solid waste (MSW) has contributed to choking of sewers and storm water drains and thereby aggravating flooding. In addition, it has also degraded Mumbai's coastal ecosystems. Present status of collection, compaction, transportation, and disposal of MSW in Mumbai is far from satisfactory. Immediate action is required to at least make it compliant with the requirements of the *MSW Management and Handling Rules* (2000) as well as *Environmental Protection Act* (1986). Some specific additional interventions might help:

a) Incentives may be provided to rag pickers to collect recyclable plastics and formalize their activities.

b) Severe disincentives in the form of fines should be imposed on those throwing wastes into the river.

c) A media campaign should be undertaken to educate people not to dispose idols and nirmalya in plastic bags in rivers, creeks, and lakes.

10.2.10 Desilting

1) Introducing "silt-traps" and "upstream screens" in open/accessible portions such as at locations like the upstream of highway culverts/ bridges, upstream of Airport Runway/ new taxi bay bridge etc. will also help reducing siltation in the related un-accessible/closed portions. "Silt-traps" will enable collection of silt and its convenient removal. Ban on Plastics has already been implemented by the MCGM. It will be desirable continue such a ban.

2) The desilting of the storm water drains has to be right down to the specified bottom invert level. Physical verification of the situation at the 'bottom' before the onset of monsoon is necessary to ensure the planned drainage capacity and hydraulic effectiveness. The silt removed should not be allowed to be stacked near SWD or on roads. A system will have to be developed whereby silt can be immediately transported. There has also to be a standing mechanism to monitor the status of desilting activity carried out independently by various agencies like MCGM, Railways, MbPT, PWD, MMRDA within their territories, based on the required invert levels. Responsibility in respect of desilting activity to be carried out by individual agencies will have to be properly spelt out in the procedure itself.

10.2.11 Improved catchment management

1) The storm water runoff for the city has increased from 50% to almost 100% of the precipitating rainfall due to impervious land cover, which has necessitated re-designing the storm water system for Mumbai. Measures such as providing porous

paver blocks, rain water harvesting, detention / retention tanks for holding floods for short times and letting them out in lean periods in the system could be beneficial in reducing run-off. Such measures can be implemented through suitable provisions under the DC Rules.

2) There is also a need to set up a mechanism at the catchment level, ward level, and central level to prevent obstructions in the storm water channel by the public or private utilities in future. ALMs can be educated to keep a watch on the local situation in their area.

3) Storm Water Management cannot be isolated from Solid Waste Management. ALM & NGO's will be able to play a useful role in the better management of the catchment. They must therefore be made part of the system for educating the people and also for monitoring the achievements.

4) What BRIMSTOWAD aimed at did not get monitored systematically ward-wise or locality-wise or catchment-wise.. Internal work procedures in the storm water department will have to be realigned following the BRIMSTOWAD along with greater involvement of ALMs, voluntary scientific associations like *Marathi Vidnayan Parishad* and professional bodies like *IWWA* that are already active in Mumbai .

5) It will be desirable to update the catchment surveys initiated in BRIMSTOWAD study. This exercise will have to be taken up every ten years to record the changes that have taken place and also to assess and evaluate the gains from the measures undertaken to improve the situation. In the absence of such catchment-wise updating, it is not currently clear as to how Mumbai has been better off or otherwise after the measures undertaken in Mumbai in response to the actions so far taken based on BRIMSTOWAD.

10.2.12 Society's involvement

People living in the catchments should be able to socially identify themselves as belonging to that catchment and clearly understand the natural upstream-downstream relationship. They get impacted and they also impact others. Hence, together they will have to develop and organize themselves in a watershed / catchment area community and decide as to how they would like to live in the context of flood risks and quality of the stream flows that they have to see and experience in their everyday life. Because of the absence of this realization, ALM groups have not been able to identify themselves with well-defined catchments / watersheds outlined in BRIMSTOWAD. Hence a mass campaign for educating the residents and strengthening this relationship needs to be undertaken in Mumbai immediately.

10.2.13 Improved Procedures

There is need to prepare a "Manual" for design, construction, operation & maintenance management of the storm water system which will put guidelines and procedures in place for carrying out all the above mentioned activities effectively.

10.3 Rivers and river-basins

10.3.1 Status of development

1) During the 150-year transition process of the old seven islands to today's topographical features of Mumbai, MCGM area has progressively drifted far away from its original natural state. Superimposed on the earlier natural ecosystem in and around Mumbai-Islands, are the man-made civic arrangements required by dense urbanization. But the result is that the encroachment in the riverbeds or on the banks of the rivers in the Mumbai have choked and pinched the watercourses and aggravated the risks of flooding.

2) The interim report on the study for Flood Mitigation Measures for the three rivers, *namely* Dahisar, Poisar and Oshiwara Rivers in North Mumbai (December 2005) by the Water and Power Consultancy Services (WAPCOS) clearly brings out that the developmental activity has resulted in reduction of the river widths. Depths have also been reduced due to dumping of debris and siltation. From their detailed tables and the Cross Sections presented in the report, it is clear that widening and deepening is essential in all these three rivers.

10.3.2 The Mithi River

1) The 1944-map of *Survey of India* does not mention 'Mithi', but shows Mahim River with tidal range up to Bail Bazar (Old Kurla). Even the mouth of the river then is unclear because of the mudflats all along between Bandra – Dharavi – Sion and Kurla. River channel in a recognizable form appears to have developed subsequently, when mudflats were occupied through raising of ground levels for reclamation. Channelization proposed by CWPRS happens to be only a sequel to how the 'Mithi' River came into existence between Kurla and Bandra.

2) Amongst all the rivers of Mumbai, Mithi River happens to relatively more investigated rivers. It is the natural drainage to sea in the heart of the city – but its specific flood flow requirements remained to be adequately covered by the BRIMSTOWAD study. In fact, the earlier CWPRS study of 1978 was also supposed to address only the downstream-most 5-6 km stretch of the Mithi River Creek up to Mahim Bay. While the individual catchments in the Mithi basin were looked at adequately in the BRIMSTOWAD study, the behavior of the river system as a whole – particularly near the Airport area and its upstream - remained to be dealt with.

3) There are some long-pending works in Mithi River. It is useful to recall that the reclamation of land for the Bandra Kurla Complex (BKC) has been subject to widening and deepening of the Mithi River being in place (among other things) as per the recommendations in the earlier CWPRS study of 1978. There was a report furnished by the Merani Committee (in 1997), which had reiterated the need for taking up such balance work. We are aware that some more studies are in progress (initiated by the MMRDA after 26th July disaster). Based on the outcome of those studies, a time bound programme needs to be drawn up for completing the balance work to ensure immediate hydraulic safety of the downstream-most 5-6 km stretch of the Mithi River Creek up to Mahim Bay.

4) Spillway discharges from the Tulsi, Vihar, and Powai Lakes meet the Mithi River near its point of origin. It may be noted that the main river has been forced to turn at 90^0 for four times in rapid succession, and has been made to pass through a box

culvert below the runway of the airport, and bunded with walls and embankments on both sides at many places without any scientific consideration.

5) From the untreated effluents discharged by the local industrial units in the Mithi basin the entire river stretch has been contaminated by heavy metals. The concentration of the various metals varies from point to point.

10.3.3 Mithi Mahul Interconnection

1) Santacruz Airport is located half way in the length of the Mithi River from the Powai Lake to the Mahim bay. The airport area is 6 metres above the mean sea level (the high tide level in the Mithi creek is less than 2.75 m). Survey of India's map of 1976 clearly shows that the tidal reach of the Mahim creek was close up to the south-east end of the airport area. Hydraulics of the Mahim River at this tip is critical from the point of flood routing. The eastern ridge of the Mithi basin – is very critical from the point of view of flooding, because of the 2 km long low level saddle near Jarimari.

2) Management of the Mithi basin will play an important and critical role in the 'risk free' status or otherwise of the upstream areas at the source of the Mahul basin.

3) It will not be possible to physically isolate fully the three catchment systems of Mithi, Mahul and Somaiyya-Reti bunder nalla and prevent inter-catchment transfer of flood water due to low level ridge lines providing easy interconnectivity. Inter catchment transfers will continue to be a recurring phenomenon under heavy storms. Hence a well-planned strategy of managing the Mithi saddle will have to be evolved keeping in view the possibility of spills and the need for adjusting the combined behavior of these connected systems.

4) While more stress is currently being laid on improvement for Mithi, Mahul should not be forgotten. It would be prudent to ascertain more accurately the specific conditions of transfer of Mithi water to Mahul system and Somaiyya catchment and then to decide upon the remedial measures for improving them also on priority. The saddle zone and the Mahul Creek is a relieving feature naturally available to accommodate spillover of the Mithi River across the eastern boundary of the Mithi catchment. There is an immediate need to study this area and develop it for the purpose of relieving flood in sub-catchment numbers 501, 502, 503, 509, and 510 of the Mahul Creek System.

10.3.4 Mithi River flushing facility

It will be useful to study the hydraulics and environmental context of the Tulsi, Vihar and Powai lakes for the possibility of providing a "river flushing system" for Mithi River by providing gates on the spillways of the Vihar and Powai Dams. Our preliminary calculations for 0.6 m gates suggest that about 2,700 ML of volume may be made available for river flushing. This water could be made available for improving riverine status of the Mithi River after the rainy season (October to May). A flowing river channel is an added environmental asset for the city. A technical review of the management of these lakes will be desirable in this direction. A rigorous flood warning system – emanating from Vihar and Powai Lakes will have to be in place along with the upgradation of the role of the reservoirs in the management of the Mithi River.

10.3.5 River Channelization

1) For the Mithi River as part of the data was still awaited; only interim suggestions regarding channelisation and dredging have been furnished by CWPRS in their interim report in January 2006. They include widening of the waterway from Mahim Causeway right upto Morarji Nagar i.e. area below Vihar Lake and providing modified bed gradients to increase the conveyance capacity of the river which will then be able to accommodate mostly flood flow of one-in-100-year probability. Similar channelization proposal has been made by WAPCOS in the interim report on Dahisar, Poisar and Oshiwara rivers for one-in-100-year probability floods.

2) There are three yardsticks available for working out the land widths along the Mithi channel that will have to be assigned to the flood flow function.

I) FFC's risk zoning criteria of 1 in 10 year, 1 in 25 year and 1 in 100 year flood probabilities.

II) CWPRS recommendations (interim report of January 2006) for channelisation widths of Mithi River which is said to mostly accommodate the 1 in 100 year probability flood. The CWPRS proposal envisages substantive re-grading of the river channel in addition.

III) IIT-Bombay's endorsement of the decision of Government of Maharashtra (page 156-157, final first interim report of February 2006) of removing all structures up to 45 m width on either side along the river in two phases. (In Phase-1, 15 m width shall be cleared and in Phase-2 remaining 30 m or less shall be cleared. The widths proposed are beyond channel widths recommended by CWPRS).

3) In our opinion, it will be desirable to immediately provide the minimum buffer-strips of 15 m on both sides of the existing Mithi channel for creating access to the channel for maintenance and management. In the meanwhile, more detailed calculations should be made with reference to the flood widths required to provide the 'prohibited zone' for accommodating the 1 in 10 year probability flood (at 70 mm/hr precipitation intensity) with existing channel gradients. Added to this will be 12 m carriageway on either side - which may be able to accommodate the additional requirement of the land width for 1 in 25 year probability flood (at 80 mm/hr precipitation intensity) along much of the river length. Decision on re-grading of the Mithi river channel may be taken thereafter, if the above provisions are found to be inadequate.

4) We are of the opinion that the channel width criteria for accommodating the 1 in 100 year probability flood may be applied only to the tidal creek portion (estuarine length) which is also subjected to reclamation activities, and widening the channel to accommodate the 1 in 100 year flood should not apply upstream of the tidal portion.

5) But, such a planning of riverbanks under possibilities of risks requires general acceptability in the people also. Hence, this approach will have to be discussed with the residents on the banks of the rivers and the detailed requirements explained to them, *namely*: (a) 1 in 10 year flow probability risk zone to be a prohibited zone for non-tidal portion and (b) 1 in 100 year containment approach to the tidal estuarine portions at the mouths of the rivers.

6) Even otherwise, in general, we have already recommended that all the gated outfalls for catchments larger than 1,000 ha be designed for 1 in 100 year probability;

to ensure that excessive choking by land encroachments does not take place near the mouths of the streams and along the shore lines. There are also stream channels in the upstream portions, which have been proposed to be regulated according to the BRIMSTOWAD standard of two submergence possibilities in a year. In addition, the possibility of containment of 1 in 25 years and 1 in 100 years floods from extensive water spreads by providing embankments beyond the prohibited zone will have also to be considered where the river is passing through flat terrain.

7) It must be borne in mind that considerable extent of river training will be required on both the banks of all the five rivers – because the river channels have no well-defined geometry – either in terms of channel widths or depths of their beds as can be seen from the **Drawing Nos. 18 to 25** (for the widths and longitudinal sections of the rivers). Over the reclaimed areas in particular, the rivers are spilled in the "formative" stages and will need proper containment to avoid their bank spills. The suggestions of this Committee for flood zoning of the river basin and the channelization widths proposed for the rivers in Mumbai have been summarized in **Table 10.1.**

10.3.6 Eco-System Management

1) The Mumbai's urban ecosystem comprise ten sub-systems including four rivers, the Powai Lake, the Sanjay Gandhi National Park (including Tulsi and Vihar Lakes), the creeks, the bays, the Mithi River estuary, and the coastal zones. Specific requirements of each will have to be addressed carefully. There are four typical impact zones associated with the ecosystem-units in Mumbai, *namely*: (i) areas that are prone to wave action, (ii) naturally low-lying areas prone to submergence, (iii) riverbank areas prone to flooding, and (iv) chronic drainage congestion sites. Each one of these needs separate attention and a distinct management strategy. A detailed management plan for each category of impact zone should be evolved in consultation with the local residents group. The individual catchments have different geographical proportions of each of the four impact zones. Each catchment will have to be accordingly dealt with on a separate footing in greater details.

2) For management purposes, the river basins will have to be sub-divided into four parts, *namely*: (1) upstream watershed, (2) mid-course settlement areas, (3) the water body including river channels, and (4) the areas at the mouth of the rivers and estuaries. Each portion has a distinctive role to play and hence has to be handled accordingly. Extensive tree covers are most welcome in the upstream zone for reducing the flood emanating in the basin. Grassland and ponds will be most welcome in the mid course areas for arresting the gush of water. Flood zoning regulations for the land use patterns will be a must along the river channels. Mangroves though most welcome along the open sea face coastlines, could be a hindrance to the free flow of floodwaters – particularly where the stream channel is already choked. The objective will have to be to restrict and hold back the flows in the first two parts and to make it flow smoothly without "increased rugosity" – in the next two downstream portions. Land use patterns will have to be regulated accordingly.

3) The uplands areas, approximately above 10 m GTS, play a crucial role in the control of runoff in all the river and nalla systems in Mumbai. Rejuvenation and environmental upgradation of hills, slopes, lakes / ponds in the upland region will have to be undertaken to achieve minimization of top-soil erosion, enhancement of groundwater recharging, and the improvement of flows in the river channels.

Table 10.1 Suggested Zoning and Channelization Widths of Rivers in Mumbai

River Name	Stretch Descr-iption	Existing Width	BRIMSTO-WAD 1993 Report Width for 50 mm/hr rainfall	CWPRS 1978 Report Width for 60 mm/hr for 4-hr rainfall	CWPRS 2006 Report Width for 1 in 100 yr flood	WAP-COS 2005 Width for 1 in 100 yr flood	Criteria Recom-mended by the FFC (This Report)
Mithi	Upstream	16-40 m	25 m*	X	50 m	X	**A & B**
	Middle	20-30 m	35-40 m*	X	100 m	X	**A & B**
	Tidal Range	30-60 m	X	1) 200 m 2) 60 m 3) X	1) 225 m 2) 100 m 3) 60 m	X	**A & C**
Dahisar	Upstream	8-39 m	35 m*	X	X	X	**A & B**
	Middle	16-44 m	40 m*	X	X	54.4 m	**A & B**
	Tidal Range	15-46 m	45 m*	X	X	61 m	**A & C**
Poisar	Upstream	8-20 m	11 m*	X	X	22.5 m	**A & B**
	Middle	7-23 m	20 m	X	X	28.5 m	**A & B**
	Tidal Range	11-38 m	29 m	X	X	33 m	**A & C**
Oshi-wara	Upstream	12-19 m	30 m (Walbhat Branch)	X	X	21 m	**A & B**
	Middle	19-35 m	42 m	X	X	37 m	**A & B**
	Tidal Range	32-52 m	46 m	X	X	47.2 m	**A & C**
Mahul	Upstream	8-10 m	15 m	X	X	X	**A & B**
	Middle	15-18 m	25 m	X	X	X	**A & B**
	Tidal Range	8-20 m	35 m	X	X	X	**A & C**

Notes:

All widths are at ground level as per respective studies.

***** Minimum recommended widths after widening. In addition, there will be 6 m carriageway on either side.

X Not worked out case.

A Stage 1: Immediate Action:
Existing constricted width of water channel plus 15 m buffer strip on either side to be cleared immediately and maintained open and free from any intrusion.

B Stage 2: Further Detailed Planning and Action:

i. For Prohibited Zone: Required channel width to be worked out finally for 1 in 10 year probability flood (70 mm/hr rainfall) plus 12 m carriageway / service road on either side. This is likely to need 10% to 30 % more width than in the BRIMSTOWAD report, depending on the re-graded bed slopes.
ii. For Restrictive Zone: For 1 in 25 year probability flood (80 mm/hr rainfall) to be demarcated for regulated constructions
iii. For Risk Zone: For 1 in 100 years probability flood (100 mm/hr rainfall) width to be demarcated.

C Stage 2: Further Detailed Planning and Action for Tidal Zone:
Channelisation for 1 in 100 years flood probability plus 12 m carriageway / service road on either side prohibited for any intrusion. This is likely to need 30% to 50 % more width than in the BRIMSTOWAD report, depending on the re-graded bed slopes.

10.3.7 Coastal Catchments

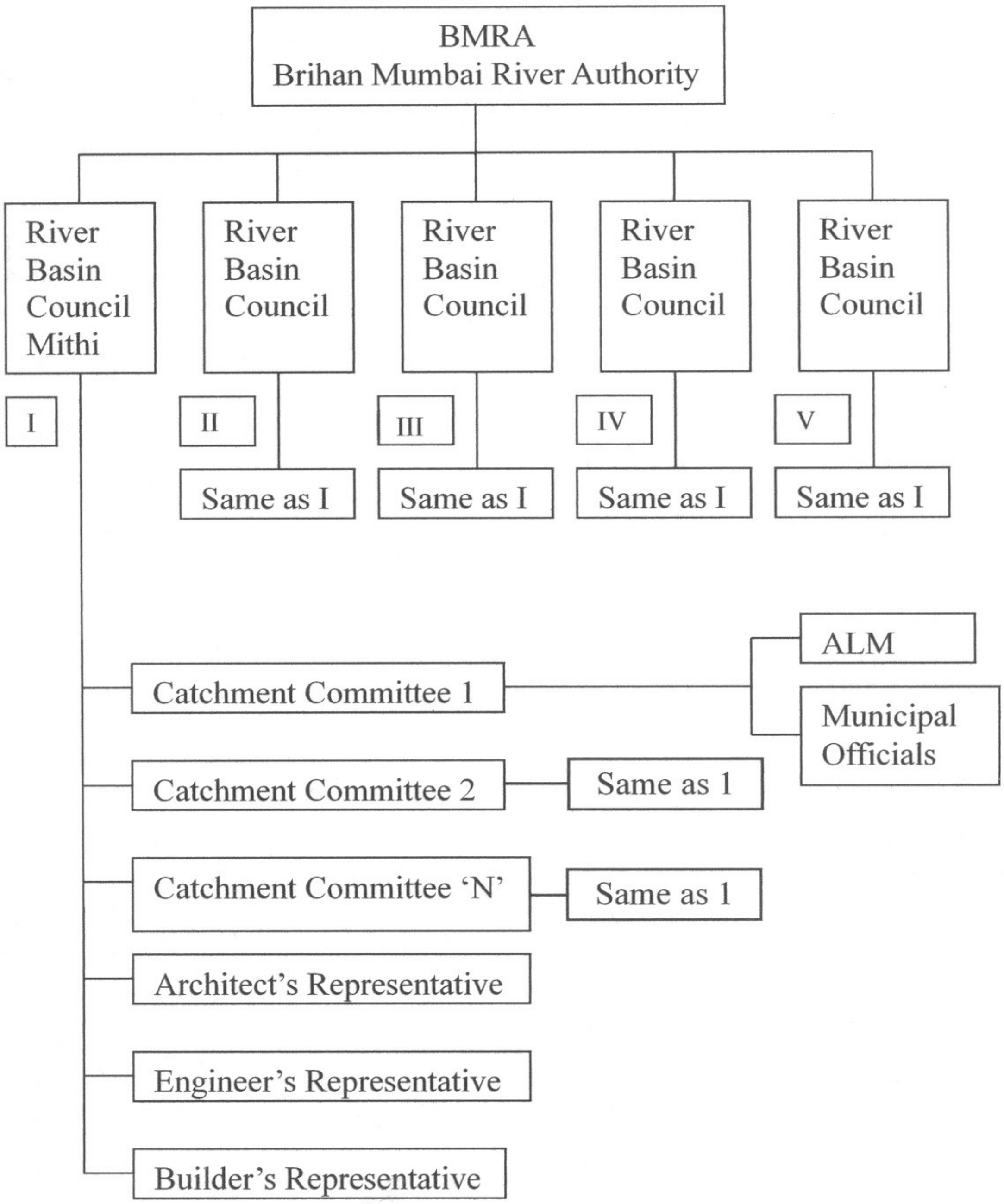
Beyond the well-defined four basins discussed above, there are some hydraulically sensitive zones on the coasts of Mumbai. Appropriate studies have not yet been undertaken and enough data are not yet available except those aspects covered by the BRIMSTOWAD report for the relevant catchments. Field observations indicate that several coastal zones are suffering from debris dumping, from construction activities as well as industrial wastes and dumping of municipal solid wastes as well as encroachments by slums. Careful planning of these catchments will have to undertaken early. Mangroves will have a substantial role to play in their case. Mangroves exist in the downstream region of the River basin near Ekta Nagar (Kandivli - West) and Valnai (Malad - West). The role of these mangroves with respect to the flushing capability of the river channel as well as for local erosion protection will have to be properly evaluated and their size and extent regulated accordingly.

10.3.8 Administrative aspects

1) Unfortunately rivers and river basins were not a significant part of Mumbai's land use planning in the past. There was no identification of risk zones as such from the flooding point of view. It is high time that such zoning is now carried out immediately with introduction of a prohibited zone (for 1 in 10 year probability of flood), a restricted zone (for 1 in 25 year probability of flood), where structures on stilts may only be allowed with certain other restrictions, and a risk zone for (1 in 100 year) probability of submergence which may be allowed to be developed carefully, under insurance cover. It is hoped that with the establishment of a Mithi River Authority and with the entrusting of other three rivers (Oshiwara, Poisar and Dahisar) as well as Mahul River also to it, it will be possible hereafter to initiate steps in this direction. The experience of the flood zoning work proposed to be carried out by MMRDA in the Ulhas basin can provide useful guidelines for similar work to be carried out in Mumbai.

2) But a regulatory administrative authority on the current pattern of the *Mithi River Authority* (to be reformatted as the *Brihan Mumbai Rivers Authority*) alone will not be able to achieve the results. There will have to be a river basin consultative council for each of these five rivers comprising organized stakeholders, ALM groups and representatives of professional associations such as the architects association, builder's association and Indian Water Works Association that are active in Mumbai. Planning of remedial works as well as future developmental activities in the basins will have to discuss in these councils to ensure a safe and sustainable balanced development. Monitoring of the Rain gauges and stream gauges will have to be carried out under the active supervision of these councils during the rainy season so as to be able to ensure the required advance alerts, warnings or relief and rescue missions as required. **Figure 10.1** depicts the structure of the *Brihan Mumbai Rivers Authority* (BMRA) envisaged for participation of various stakeholders in planning and management of river basins in Mumbai.

Figure 10.1


BMRA
Brihan Mumbai River Authority
River Basin Council Mithi
River Basin Council
River Basin Council
River Basin Council
River Basin Council
I
II
III
IV
V
Same as I
Same as I
Same as I
Same as I
ALM
Catchment Committee 1
Municipal Officials
Catchment Committee 2
Same as 1
Catchment Committee 'N'
Same as 1
Architect's Representative
Engineer's Representative
Builder's Representative

10.3.9 Social Aspects

1) Once contour maps are available for rivers, the flood risk zones will have to be spelt out on maps and demarcated on the ground, keeping in view the general guidelines in the flood zoning bill recommended by Govt. of India to the states. The local residents will have to be appraised of the probabilities of the risks involved and only the permissible type of development will have to be allowed in these zones. The maps of the flood risk zones will have also to be published for citizen's information as a part of the development planning rules.

2) Although the efforts will be to evolve the non-displacing ways of restoration and revival of rivers in Mumbai region; it does not seem to be fully possible. It is hoped that the final reports of studies on them will be placed before the *Brihanmumbai Rivers Authority* and widely discussed among the river-basins' stakeholders, before long term actions are finalized. Implications of the outcome of the studies will have to be properly understood by all concerned.

3) The communities residing in the high flood risk zones will have to be made aware that they are living in the flood plains of the rivers and their risks could be unbearable in times to come and it is in their interest to get rehabilitated in time. For the high-risk areas, which are bound to get affected by floods of 1 in 10 years probability, rehabilitation of the population and work activities falling therein will have to be undertaken immediately.

10.4 Guidelines for other improvements

10.4.1 Guidelines for immediate action

(i) Hydrological monitoring

1) The role of hydrology in the planning and designing of the developmental infrastructures of urban areas will become more and more important hereafter. Measurements of rainfall, river discharges, stream flow levels, tidal effects, detention time volumes and locations of inundated areas will need systematic recording and monitoring. Reliable hydrological information will have to be collected with sufficient density in both time and space.

2) The rain gauge station density of at least one station for every 25 sq km (*i.e.* Population of about 5 lakh persons) will have to be achieved to measure the rainfall characteristics and the storm flow characteristics of the metropolis in meaningful terms. These will have to be provided with automatic self-recording rain gauges. There is also a dire need to install more rain gauging stations in Mumbai Metropolitan Region immediately to cover the neighborhood territories adequately with information about storms visiting Mumbai. It will be worthwhile encouraging schools / science colleges / engineering colleges in Mumbai to have their own rainfall measurements on the top of their terraces and assist the local active groups like the ALMs in Mumbai with the local information.

3) Stream Gauging is also vital for establishing hydrological connection between the rainfall and the surface flows on the ground. For watersheds and basins / sub-basins of geographical spread of more than 1000 ha (*i.e.* 10 sq km), it will be desirable to

install immediately at least one stream gauge just above the tide level or above the confluence of the stream with the main river channel. Thus there will be about 50 stream gauges in Mumbai i.e. roughly one for a population of about 2 lakh. Standards for setting up of stream gauges and procedures for their working will have to be developed in consultation with the Hydrology Project Organization of the Water Resources Department of Government of Maharashtra.

4) Absence of an apex authority for hydrological issues and the related activities has left Mumbai as it is now. Mumbai Municipal Corporation as an authority responsible for the smooth civic life in Mumbai will have to take the lead and establish hydrologic guidelines for all the works in Mumbai. To begin with MCGM will have to establish a properly staffed Urban hydrology unit immediately and should commence scientific and systematic hydrologic measurements for Mumbai, for the precipitation as well as for the stream flows. MCGM's urban hydrology cell should be able to compile all the related information and publish the findings annually for the general information of the residents of Mumbai. It will also be desirable, if this unit is linked with a similar set up on a large scale to be established for the Mumbai Metropolitan Region by MMRDA, as the low lying areas in MMR need similar critical attention as in Mumbai simultaneously. Both these organization will need to have a close link with IMD on one hand to receive the meteorological messages and with the Disaster management unit of MCGM on the other hand for timely alerts and warming.

5) One of the major tasks for the Mumbai urban hydrology cell to be established immediately under MCGM will be to develop rainfall intensity-duration frequency relationship based on 15 minute and hourly rainfall data for the different durations of storms in and around Mumbai. The lead-time available for dissemination of alert signals warning signals and or relief and rescue signal is very short. A well laid out communication drill in rainy periods with transmission of information online from rain-gauging and stream-gauging stations to the central control room will have to be operationalized early.

6) The subject of urban hydrology will have to be promoted and developed in Mumbai looking to the high stakes involved. It will be useful if staff of Mumbai's water related departments is encouraged to get trained at the School of Hydrology at Rorkee, or in similar such courses at Nasik by the hydrology organization of the State of Maharashtra. They should also be encouraged to obtain active memberships / life memberships of voluntary professional associations like the Indian Association of Hydrology and the International Association of Hydrological Sciences which is more than 75 years old.

(ii) Sensing by radars

Prediction of extreme events well in advance is very difficult. However their probable occurrence can be foreseen a few hours in advance say 3 to 4 hrs. This is possible with advanced instrumentation like Doppler radars. It will be very helpful if an advanced category radar system becomes available for Mumbai.

(iii) Topographical contours

1) It is sad that Mumbai does not have contour maps - beyond what is prepared by the Survey of India in 1976 (map no. 47 A/16) – with 20 m contour intervals. As can be seen from the map, much of the dense urban development of Mumbai is below the 20-metre contour line. Because there are no contours available on this map

below 20-metre, the map of 1976 is of no use in the storm water management of low-lying areas.

2) Contour maps are vital for the management of the watersheds and for the planning of storm water conveyance. Ground levels of a large coastal belt in Mumbai are close to 3.00 m e.g. Juhu aerodrome, and Khar. These are the vulnerable areas for congestions and submergence by the tide and the flood interacting. It will be necessary to mark out all such areas say below 5 m contour very carefully and handle their surface runoff very systematically. A detailed contour map with 0.2 m contours (*i.e* contours with 200 mm interval) will be necessary to plan the conveyance of surface flow systematically.

3) Unfortunately the DP sheets of Mumbai currently in use do not include all the topographical details of the natural watercourses and information about the ground contours. Hence the contour mapping of the Greater Mumbai should be undertaken immediately with a view to develop contour maps of all the catchments defined by the BRIMSTOWAD report with a contour interval of 0.2 m in the areas below the 20 M contour and with the contour interval of 0.5 m above the 20 m contour. The maps will have to be at least to the scale of 1 in 4000 (*i.e.* 1 cm on the map representing 40 m) which has been followed for the DP sheets of Mumbai. For the crowded areas, along the river channels maps to the scale of 1 in 1000 (1 cm on the map representing 10 m on the ground) will be desirable.

4) Even the flood studies being carried out by CWPRS are handicapped on account of lack of information about the ground levels in the flood plains on both the banks of the Mithi River. The earlier this data becomes available, more scientific will be the further flood related actions.

5) Somehow Mumbai Municipal Corporation has continued with the arbitrary referencing system and did not switch over to the national standard referencing pattern of survey of India, which is based on the mean sea level. It will be useful if survey of India's levels referencing system is followed hereafter in Mumbai also as a matter of normal practice. All measurements of ground levels should be on that basis – so that their relationship with the tide levels and the river channel flows will be easily understood by the private properly holders also.

6) Steps should be taken to adopt levels in meters under the GTS system only (the great trigonometrically survey of India) superceding the other arbitrary systems of chart datum (CD) or town hall datum (THD) followed so far in Mumbai . Mean sea level (MSL) around Mumbai is just close to the zero level of the GTS carried out by the officially recognized national organization namely the Survey of India. (MSL of Mumbai = 0.01 GTS).

(iv) Santacruz Airport

1) The Airport Authority now has plans to provide a taxi bay in parallel to the runway on its north. Hence it has to provide an additional crossing on the Mithi River – which is currently under construction. Its waterway below the taxi bay will be effective and useful only when the existing 27 m waterway below the run way is also widened to at least 40 m in line with the water way being provided below the taxi bay. The original proposal of the consultants for the airport was for a total width of 60 m. It will be worthwhile reviewing the hydraulic calculations of this bridge in critical depths while detailing out the design of the Mithi River's crossing below the

Airport and initiate appropriate actions for widening of taxi Bay bridge as well as the runway bridge.

2) The hydraulic and structural designs of the airport runway and taxiway bridge will have to be reviewed in due course in the context of the final nature of channelization that will be decided by the Mithi River Authority. It will, therefore, be useful to keep an expert from the CWPRS associated with the current work on the Taxiway bridge and the widening work that will have to be undertaken for the runway bridge within the airports premises.

3) Waterway to be provided for the Mithi River below the runway and the taxi bay will have to be liberal to avoid any obstruction to the flow and consequent heading up of water in the upstream areas. The airport is near the saddle point between the west-ward flowing of Mithi River and the east-ward draining areas lying on the east of the airport. Spills of the Mithi River on the eastern side adversely affect the habitations on that side as happened on 26th and 27th of July resulting into submergence of the Lal Bahadur Shashtri Road. Such spills will have to be meticulously avoided at least for a flood probability of 1 in 100 years.

4) Because of the very critical location of the position of the airport in the Mithi basin, from the point of flood hydraulics it will be useful if a high level technical committee of the representatives of the Airport Authority, MMRDA, MCGM and CWPRS is appointed to settle and supervise the fine-tuning of the arrangements for the widening work required for the runway bridge on the Mithi River. This high level technical committee will have to periodically, say at least monthly, review the situation regarding the work on the channelisation of the Mithi River in the context of the CWPRS recommendations and give permissions for any land filling activities in these stretches as may be necessary only after ascertaining that the alteration would not compromise with the flood protection measures in the vicinity of the airport..

(v) Evacuation routes and facilities

1) MMRDA has recently commissioned one Comprehensive Transport Study for MMR, which is known as TranSfoRM (Transportation Study for Region of Mumbai). It is suggested that the scope of the study should also include undertaking appropriate public dialogue in respect of upgradation of transport system to meet the emergency requirements in the light of July 2005 flooding and the suggestions made by FFC in this report. The TranSfoRM should also address the need for dependable evacuation routes for the people in Mumbai city in case of emergencies.

2) All the C. D. Works on Eastern, and Western Expressways, L.B.S. Marg, S. V. Road, linking road, J.V.L. road, and the Santacruz – Chembur road, should be checked for the condition of 100 mm/hr rainfall and a runoff co-efficient of 1.0 (i.e. 100 % runoff) so as ensure availability of these corridors even under intense precipitation in Mumbai.

3) Properly designed road side drains taking into consideration a 50 mm/hr storm with runoff co-efficient of 1.0 as recommended by BRIMSTOWAD, will have to be provided, taking into account all the other catchments contributing to that system. Contour maps of the catchments will be very useful for that purpose.

4) Guidelines for the design review of the work undertaken by MUTP/MUIP are appended to Merani Committee's report (November 2005). In addition to those guidelines, that committee has also suggested a few sound engineering practices to

be kept in mind while designing and executing the MUTP/MUIP works. Those will have to be followed while continuing with the MUTP/MUIP works further.

5) In addition, following facilities will have to be kept ready:

   a) sufficient stock of inflatable boats in every ward office,

   b) good and reliable communication instruments with all drivers of the public transport system for a contact with their head office control room,

   c) a full fledged Area Traffic Control System of the police linked with the Disaster Control Room,

   d) a proper visual display system on roads at and the railway stations with advance warning system for the travelers,

   e) public address system at important locations; and

   f) equipping the signaling and advance warning systems with independent power back up.

(vi) Upgraded Railway culverts

1) Mumbai's suburban trains on the Western, Central and Harbour tracks carry more than 40 lakh passenger a day. The system came to a grinding halt on 26th and 27th July. Unless the mass transit system on the rail tracks remains operational, the people cannot move fast in large numbers, as the road infrastructure in Mumbai is far too inadequate to handle the large volume of traffic when railways stop functioning.

2) The work of remodeling and augmenting the existing cross drainage structures under the railways get delayed inordinately as the experience of getting clearance from railway safety wing is said to be very frustrating. Both MCGM and railway construction wing have expressed their helplessness in the matter. Some efficient mechanism, through the involvement of the railway board and the home ministry, will be desirable.

(vii) Resettlement

1) We have identified 3 types of risk zones: those susceptible to a once in 10 years flooding; those within the 10-25 years flooding; and those within a 25 years to once in 100 years flooding. In the once in 10 years flood zone there should be no construction permitted at all. In the risk zone susceptible to less than once in 10 years but likely once in 25 years and in the risk zone susceptible to less than once in 25 years but likely once in 100 years, construction permitted should be subject to new DC regulations, which may be drawn-up after careful study of the problem taking into account the contours and the likely extent of flooding. The occupants must clearly understand the risk they run of flooding, and should be advised to take out insurance accordingly.

2) Resettlement activities will have to be undertaken hereafter according to the following priorities:

   a) those obstructing drainage channels and waterways.

   b) those within the 10-year flood mark: They should be shifted within the coming year.

c) those above the 10-year flood mark, but within the 25-year flood mark: They should be required to comply with the new DC regulations within the next 3 years.

d) those above the 25-year flood mark, but within the 100-year flood mark: They should be required to comply with the new DC regulations within the next 10 years.

3) The Government of India have in their "model flood zoning bill" suggested some criteria for the identification of risk-zones. It has been circulated to all the states for consideration and enactment. The approach recommended therein has been kept in view by the Government of Maharashtra while finalizing the manual on dam safety in the context of dam reservoirs and river channels. In a given cross-section of river and terrain on its banks, the zone covered by the river water channel and floodway of 25 years return period or 1.5 times of the river channel capacity, whichever is more, has been designated as the "prohibitive" zone. We have taken a lenient stand on this matter in view of the dense population residing on the banks of rivers in Mumbai. We have suggested the "prohibited zone" suitable for carrying floodwaters corresponding to 1 in 10 year probability flood.

4) Historical data for Mumbai and in the Metropolitan region shows that by and large there has been a major flood episode or heavy precipitation event at least once in 10 years. Hence it will be necessary to plan for the safety of Mumbai's residents for once in 10 year probability of flood events along the major rivers, (Mithi, Dahisar, Poisar and Oshiwara) - while the numerous small streams channels and the cross-drainage works across them continue to be planned and built according to BRIMSTOWAD for a twice-a-year probability of rainfall occurrence. The geographical area falling within the flood line of a once in 10 years rainfall probability will have to be treated as a prohibited zone for all construction purposes.

5) The "principle of prehabilitation" and "principle of compensatory preforestation" must be employed in the activities related to decongestion of banks of rivers and coasts while undertaking resettlement and disturbing ecosystem.

(viii) Electric supply

It is a matter of serious concern that the main stations and sub-stations on the power distribution net-work got submerged which had a domino effect of affecting the communication network, operation of pumping stations of water supply, storm water and sewage and many other systems which are power dependent in today's technological society. They will have to be located immediately above the 1 in 100 year flood level. This should also be practiced for equipment for telecommunication network.

(ix) Disaster management plan

1) Mumbai's Disaster Management Plan needs to be revamped in view of the lessons learned from the Disaster events during the last a decade and more the so with special reference to the 26th July, 2005 deluge due to the floods. The vulnerability analysis of the city needs to be carried out in great details with reference to different categories of potential disasters and there has to be a risk zoning of the city with clear guidelines for each zone in respect of do's and don'ts.

2) Mumbai's Disaster Management Control Room is already linked with the other control rooms such as the *Emergency Operation Centre* of the GOM, Police, Fire

Brigade, Railways, BEST, SWD, *etc.* There needs to be a proper communication protocol and the use of State of the Art communication Technology. There should be a well defined chain of command and span of controls as a part of the disaster control mechanism. All the agencies involved to cope with the disaster situation need to be well documented with the Standard Operating Procedures (SOP) clearly defining the role of each agency, their powers, and functions to avoid overlaps and confusion.

3) By manning the self-recording rain gauges of the hydrological network in Mumbai continuously through the rainfall period and developing a system of communicating automatically as well as manually the observed rainfall intensity as soon as it exceeds 10mm in a 15 minute period to the Disaster Management Centre, an alert signal can be issued to the localities in the concerned catchments. If this trend continues for over an hour *i.e.* 40 mm/hr (which is 10 mm less than the 50 mm/hr precipitation for which Mumbai's storm water system will soon get upgraded following BRIMSTOWAD), a "risk warning" will have to be issued to the concerned catchments and their main river channels. As soon as the hourly intensity exceeds 80 mm/hr, rescue operations will have to be initiated because then the flood flow will be much more than what the river channels/stream channels can safely carry. In the disaster management manual of Mumbai, detailed operational instructions on these lines will have to be incorporated.

(x) Electronic Media

Particularly on 26th July, the public information role to be performed by the television or the radio channels left much to be desired primarily because of their weak association with the disaster management centre for Mumbai. In the absence of timely and accurate information, there were confused reporting. This aggravated panic and misled society in Mumbai as well as the outside viewers of the network. As a good practice it is necessary to clearly mention in print the exact time and place of the situation photographed.

(xi) Interactive lead role of the MCGM

1) The most important and sensitive critical job in Mumbai is the co-ordination between different agencies. It was experienced that though the Municipal Commissioner of the MCGM is formally declared as a nodal controlling officer, his authority for directing action in case of a disaster; in reality is subjected to many limitations, due to different high level authorities and agencies operating in the city independently (including the Police, Railways, Airport Authorities, Defense Authorities, Port Trust Authorities, Slum Rehabilitation Authorities, MHADA, and MMRDA). Their specific role while dealing with "Mumbai" do not appear to be clear as to from whom they should expect and receive orders for actions to be taken under the disaster management situation. These agencies in reality are not properly linked with the system of procedures and flow of orders and directives from the Disaster Management Controlling Agency for Mumbai. The situation needs to be rectified immediately.

2) Hydrological safety guidelines will have to be laid down clearly by MCGM. All the agencies stationed within the MCGM area will have to strictly observe them, whatever may be their agencies' internal rules on their behalf. Within the Corporation's area, all authorities, whether State level or Central level, should have

to abide by the town management principles, as reflected in the Municipal bye-laws, development plans, rules and regulations.

(xii) Urban planning

1) Urban planning as a process in Mumbai has been more or less abandoned. It needs urgently to be restored, and converted into a two-stage process with public participation in both stages.

2) The first stage would be strategic level planning, for the Metropolitan Region, which would cover such aspects as articulating objectives, drainage of the region, water supply, transportation, sewage treatment and disposal, identification of landfill sites, broad indicators of land use, strategies for risk mitigation and so on.

3) The second stage would be detailed area-level planning at the level of electoral Municipal Wards. For this, a well-organized urban planning department manned by trained professionals for a metropolis like Mumbai is a must. It should be in place immediately and should be well nurtured in the years to come to play an effective role in the future development and management of Mumbai. Such a department would provide the technical support needed by each Ward in preparing its plans.

4) The preparation of plans at the Ward level must be done with the maximum possible citizens' participation. In this way, citizens can be made effective partners in also managing post-disaster recovery.

5) Mumbai should adopt of a set of "goals", or guidelines that will drive the planning process, and against which each policy, regulation, development proposal or project will be measured. These should be articulated and refined through a process that mandates genuine public participation. These would be reviewed over a long time span, say once every 10 years.

6) Currently there is an excessive reliance on consultants and committees. These may render useful services but they cannot replace what needs to be an integral part of the Corporation's own administrative system. Civic management in Mumbai has become quite complex. It would be useful for the MCGM to establish a standing setup of professionals experienced in town planning to continuously analyze the changing scenarios and advise the civic body on the emerging requirements.

7) The key to sustainable development is the empowerment of residents through action-oriented partnerships at all levels. Sustainable development should be our ultimate objective. Advanced Locality Management (ALM) groups could be an effective mechanism in that direction. Hence ALMs should be set up throughout Mumbai and in the Metropolitan Region to involve citizens in the management of civic life as well as to handle *disaster situations*.

(xiii) Monitoring of the follow-ups

Immediate activities that ought to be taken-up in hand have already been brought to the notice of the Government through an interim report by this committee on 30th December, 2005. It is seen that those points are being attended to and the progress is getting monitored through a committee under the Chairmanship of the Chief Secretary. A similar mechanism will have to be continued at least for the next five years to see that the numerous actions suggested in this report get implemented with required priority.

10.4.2 Long-term strategies

(i) Improved transport system

1) Though quite a number of transport studies have been made in the past, the city does not have any well defined comprehensive transport plan as on today. At present railways, bus systems, traffic department, ferry operators function in isolation. They do not have much of the coordination, as such even the building permissions which are issued by MCGM do not take into account the impact on the transport infrastructure by such developments, though providing the infrastructure is also its own responsibility. So it is essential to establish an integrated transport system mechanism to keep the city moving even under most trying circumstances.

2) Decline in the use of public transport and increasing use of private cars is choking the road system to a frustrating level. So a major boost is required to be given to the public transport and serious efforts are required to discourage the use of private vehicles. To achieve this, measures such as enforcing minimum occupancy in personal vehicles in certain zones during specified hours, restricting the purchase of new private vehicles in the city, increasing parking charges in certain zones, no parking zones on roads, providing dedicated lanes for buses, introduction of BRT (Bus Rapid Transit) systems on through routes, improving the quality of service in public transport will have to be under taken. Introduction of a Bus Rapid Transit (BRT) system on through routes with lanes dedicated to such a system will greatly serve in emergencies for relief and rescue services.

3) Studies have also indicated that building freeways in an area that is already crowded does little to reduce congestion. Past experiences have indicated that building fly-overs, in an already crowded area, does not reduce the congestion to much extent. So, alternative means of transport like Metro, Mass Rapid Transit System, Water Transport and traffic ways need to be vigorously pursued. A high level body for taking care of these issues needs to be constituted comprising of experts in traffic planning, management, economists, representatives of other agencies dealing with transport, and representatives of passengers association etc.

4) Additional links with main land are very essential for the growth of the city and to reorient the city towards the main land. Sewaree Nhava Main Land Link needs to be implemented on priority. This should essentially be a rail link. If in addition a road link is desired this may be taken up simultaneously to make this a combined rail-cum-road link, which will be significantly cheaper than having two separate links, one for rail and one for road.

5) City roads may be categorized in three groups a) the arterial routes, b) the major roads and c) the minor roads. Cross drainage works on arterial routes should be designed for a rainfall intensity of once in 100 years. C. D. works on major roads should be designed for rainfall intensity of once in 25 years. And those for minor roads for a rain fall intensity as in BRIMSTOWAD. Road lengths associated with the major roads and the arterial routes, if falling in the flood risk zones, will have to be raised appropriately above the anticipated flood levels.

(ii) Pumping facilities

For a coastal city on reclaimed lands like Mumbai, pumping has also to be an integral part of the storm water system. While planning and providing physical wider openings at the costly cross drainage works of the roads / railways / airports do not give rise to issues of financial appropriateness, a similar exercise for the pumping

arrangements gives rise to a controversy and debates, because of infrequent operation of the storm water pumping system. Pumping capacities for one in 10 years probability of precipitation at least should not pose complex considerations. It means that in addition to the normal installation capacity, about 25% addition as a stand-by will have to be provided. At the submergence-prone critical locations, that affect railway tracks and through-traffic corridors, such standby provisions is a worthwhile asset. It is difficult to arrange for pumping as a matter of relief and rescue later after the emergency arises.

(iii) International examples

1) There is very little similarity in the hydrological conditions of Europe or of he United states and that of India. It will not be proper to rely fully on their pattern of planning for the flood related risks.

2) Worth studying will be the case of Singapore – Marina river catchment is about 100 sq km – *i.e.* one and half time larger than that of Mithi in Mumbai., They have recently undertaken the construction of the Marina barrage as a tidal barrage across the 350 m wide Marina channel, which is located in the Southern tip of Singapore. When the barrage is completed in 2007, it will keep sea water out of the 240 Ha of the Marina basin. The barrage will keep out high tides. When heavy rains coincide with high tide, gates will not be opened but the excess storm water will be pumped out into the sea- by six water pumps with a total capacity of 240 m^3/s (seventh additional pump acting as a standby). Such packages will have to be put in place for Mumbai also.

(iv) Global warming

1) Any future warming may give more rains to India, and more rains with increased intensity of precipitation. Higher intensities of rainfall are therefore the likely hydrological future for India. Scientists are also warning about the rise in sea levels from increased snowmelt process. Hence, the planning of a coastal city like Mumbai, which has developed mostly on flat reclaimed lands, will have to be very carefully evaluated in terms of risks to the population from inadequate carrying capacities of the stream channels.

2) It is necessary to effectively address the issue and to generate a proper consensus on the required defense mechanism, preventive actions or ameliorative measures to be taken. It will be useful if systematic campaigns for this could be carried out in local languages by well-established voluntary scientific associations of good reputation and public trust, like the *Marathi Vidnyan Parishad*, at least as far as the Mumbai's sensitivities are concerned.

3) To fully understand the implications of changing climates and to build mitigation measures well in advance, there is an urgent need to spend adequately on climate related research in India. It will be desirable if agglomerations like the Mumbai Metropolitan region and the advanced educational institutions like IIT, VJTI, Xaviers College located there in participate in these national efforts and translate the findings into planning and operational guidelines for the hydrometereological vulnerable areas.

(v) Ecosystem programmes

1) Ecosystem in and around Mumbai is under stress and is continuously deteriorating. It is necessary that a systematic aquatic ecosystem rejuvenation program to deal with the issue of "accumulated contaminated sediments" in the ecosystem is undertaken and the accumulated pollutants are systematically dredged out so that a newer healthy ecosystem gets progressively instituted. There is a great urgency of incorporating the activities of designing and commissioning the different components of the ecosystem infrastructure with a systematic river front development programs for the major rivers and the estuaries.

2) The scrutiny and investigation, which followed the floods in Mumbai, revealed that environmental governance of Mumbai has been far from satisfactory. While the developmental and planning agencies renamed rivers and streams as nallahs and in some cases even removed them from the DP maps; environmental regulatory authorities did not take exception to derogatory treatment given to environmental and ecological systems and sub-systems by citizens, civic administrators, and elected representatives. Standards of disposal of effluents into rivers were prescribed suitable for nallahs rather than reinstating the river status to the streams. For example, India's Water (Prevention and Control of Pollution) Act of 1974 and Environment Protection Act of 1986 aim at maintaining wholesomeness of rivers. The MPCB should facilitate implementation of India's environmental policy in a proactive manner and ensure compliance of environmental regulations by the municipal corporation.

(vi) Land for middle-income and low-income housing

1) The pressing demand in the city is for land that can be used for low- and middle-income housing. If ULCRA is continued in Mumbai, its provisions should be strictly applied, particularly in regard to construction of housing on vacant lands arising because of demolition of mills in central Mumbai. We would also urge the Government of Maharashtra to urgently consider amending the D.C. Regulations such that development on any vacant land in Mumbai provides for housing in a manner that is consistent with the Regional Plan for the MMR 1996-2011. Another way to provide land for low-and middle-income housing, at a location where transport is readily provided, will be to bring the saltpan lands into the housing market.

2) The basic intention of the CRZ laws was to protect the normal coastline areas of India. It was surely not the intent to constrict housing activity in an already over-populated city like Mumbai. Environmental clean up and up-gradation of Mumbai as a whole will be greatly hampered by such out-of-context restrictions. It is hoped that the concerned authorities will take a proper view of the special requirements of Mumbai while applying the CRZ philosophy, and will remove the hurdles in the thinning process that is required to be carried out in Mumbai while clearing the slums that are occupying risky areas in the flood zones of the rivers.

3) If we want to reduce slums in the city, and move those who live there into sturdier housing that is less prone to damage in disasters, then the repeal of ULCRA seems essential. The expectation is that with its repeal more land will come on the market, land prices will fall to more reasonable levels, and private developers may take up low- and middle-income housing projects, more particularly for rental if the Rent Act is also simultaneously modified to exclude all new tenancies from its purview.

(vii) Urban planning and management

1) MCGM does not have a planning department for developing the city's civic services. They also do not have the practice of issuing a policy paper on the subject or holding a public debate. There is an immediate need to constitute an urban planning cell in the MCGM.

2) Ultimately, it is the residents of Mumbai who will have to decide as to what pattern of civil life they want to lead and what type of urban life they want their children to face . Hence dialogues on the various related issues will have to take place in the different localities, in different professional groups, commercial and industrial establishments and the MCGM's administrative wings to address the future challenges in a proper manner.

3) Key to sustainable development is the empowerment of the residents through action-oriented partnerships at all levels. Sustainable development should be our ultimate objective. Advanced Locality Management (ALM) groups could be an effective mechanism in that direction. Hence, ALMs should be set up throughout Mumbai and in the Metropolitan Region. To involve citizens in the management of the civic life as well as to handle the disaster situations

4) In any disaster management plan the citizens must be actively and heavily involved. More than being victims of the disaster, we have to look to them as being the first line of defense in responding to the disaster. To that extent they are not subjects of government, but partners in governance. An excellent beginning has been made in this direction through the Advanced Locality Management groups (ALMs) already active in various parts of the city. The working of the ALMs should be strengthened

5) Relieving the unbearable pressure of population on Mumbai's lands will have to be the mainstay of the long-term strategy for storm water drainage. Storm water channels remain unused by water flow in the non-monsoon periods. That attracts settlers. The remedy partially lies in putting the stream channel strips to appropriate public and private uses during the non-monsoon period like playgrounds, gardens, bus stands, *etc.*. Mumbai's development maps will have to show the flood zones clearly and specify the appropriate uses of those areas in consultation with the local people.

6) Urban local bodies form the third tier of government, and function as the agents for social and economic change. So we need to constitute effective Ward Committees (or even smaller units of governance, like the Grama Sabhas in rural areas) with meaningful public participation; as well as a Metropolitan Planning Committee (MPC) for inter-agency co-ordination

(viii) Restructuring of MMRDA

1) The MMRDA is governed by an Authority consisting of various officials, including political leaders. It would make sense to replace the current body governing MMRDA with a Metropolitan Planning Council. The MPC would need to have representation from the Municipalities of each of its sub-regions. It is also important that the three important Boards MMRDA had when it was first established be re-activated: one was

for Water Resources, one for Transport & Communication, and the third for Housing, Urban Renewal and Ecology.

2) We need someone to take an overall, integrated view of public and private transport, with appropriate allocation of funds between the two. This is a mammoth task in itself, and it could well be separated from the other work of MMRDA, with the proviso that broad land-use planning decisions are taken in consultation with the transport authority. The variety of agencies that today looks after different aspects of transport would be brought under a single umbrella for better co-ordination. It would not be an implementation agency. Its mandate would be to integrate between transports as well as with the development authority in terms of land use and zoning, organize financing, and monitoring.

3) MMRDA will then be a planning and executive arm of Mumbai's Metropolitan Regions Planning Committee, with responsibility for strategy planning as well as execution of the physical infrastructure for the region such as regional drainage, water supply, sewage treatment and disposal, selection of landfill sites in the region for disposal of solid waste, co-ordination of all transport infrastructure, and preparation of guidelines for local area authorities for their detailed area planning, including specifying overall built-up areas (and consequently densities). Meaningful public participation must be mandated

(ix) Emergency preparedness

1) For the survival of the city, seismic data and hydrological data needs to be given great importance and priority. The very basic approach to the appreciation and analysis of the nature of disasters will have to be modified. The line of action for risks, and relief and rescue operations will vary according to be nature of disaster. Related duties and responsibilities of the concerned officers will have also to be a different and should find a place in the current Standard Operating Procedures (S.O.Ps.), for the different categories of disaster. A clear cut warning mechanism needs to be evolved along with a clear-cut communication methodology for each category of disaster. For that to happen, there is a need for proper instrumentation, rain gauges, stream gauges, wave responders and seismographs, geological maps,. This can provide ample clarity in respect of the phenomenon of the 'disaster' and help in devising the early warning mechanism.

2) More than 60 lakh population is staying in the slum colonies or kachcha structures. These areas are highly vulnerable during the contingencies like floods, fire and commotion. They also constantly pose a threat to the hygiene of the city and its after effects. Based on type of risk, there needs to be risk zoning and on the basis of the risk zoning, there needs to be an adequate preventive measures, infrastructure provision and post disaster access for relief and rescue work.

3) There is neither a mention about the evacuation plan for the city of Mumbai nor about the identified shelter places which will have to be earmarked in advance. The public buildings such as Schools, Colleges, Public Assembly Halls, *etc.*, need to be properly notified with a board display on the conspicuous locations. There has to be proper awareness of such emergency shelters and there has to be backup mechanism to mobilize the basic facilities such as food, water, medicines, communication requirements and camp-guides for these locations to avoid chaotic

conditions and over-crowding of such shelters. Involvement of the people and volunteering organizations need to be well-planned in advance.

4) For communication purposes, there need to be sign boards, public address system, proper media management (radio, TV-channels), liberal use of internet, mobile-phones and land-line telephone network, and defining clearly the spokesperson of each department. The Disaster Management Plan should have workflow from the macro level, government institutions to the micro level, public institutions, all the corporate, industrial houses, educational institutions, government and private offices should prepare their on-site and off-site contingency plan to cope with the disaster situation. There is lot of scope for improvement of the information in flow processes to the control room of he State Government, and of M.C.G.M. and other agencies. Effective communication measures with certain Standard Operating Procedures (S.O.P.) will have to be in place immediately.

5) The Juhu Air-strip, which currently gets flooded, becomes unusable in emergencies. Emergency landing facilities available at both the air ports Juhu and Santacruz will be a part of disaster preparedness for Mumbai. In addition there will have to be providing landing facilities for helicopters on public grounds and building terraces in the city will have also to be planned as a part of city's infrastructure. Storm water arrangements near the Juhu Airport are crucial in this respect.

(x) Financial support

1) Empowering the city to manage itself also means that it has adequate fiscal capacity to fulfill its obligations. For collection of municipal revenue, the best practice worldwide is to use the capital value systems. It is time that this is adopted in Mumbai also. In addition to property taxes, other municipal sources of revenue will have also be augmented substantially. They will require a financial reform within the municipality,

2) Some of the capital works in storm water drainage and similar other civic amenities have been necessitated by an accumulation of incremental demand for services, but there has been no corresponding capital charge or betterment levy to pay for the up-gradation of the infrastructure. Over a period of time, these incremental deficits lead to major gaps both on the physical and financial sides. It is imperative that any incremental demand on infrastructure, whether by construction of new commercial or residential premises, or by expansion of existing activities, should be offset by a levy, which should be held in a Reserve Fund meant for undertaking infrastructure up gradation works requiring large capital outlays. A separate study will need to be conducted to indicate the appropriate mix of taxes between property tax,

user charges and local taxes on goods. In addition for allocation of funds for SWD projects should be made on priority basis.

3) Provision of adequate O&M budget for providing a given environmental service appears to be crucial for offering and maintaining a given service. It is envisaged that the MCGM sets up the “environmental cess” for providing targeted

O&M budgets to sustain various environmental services including solid and biomedical waste management, wastewater treatment, drinking water treatment, control of noise and odor.

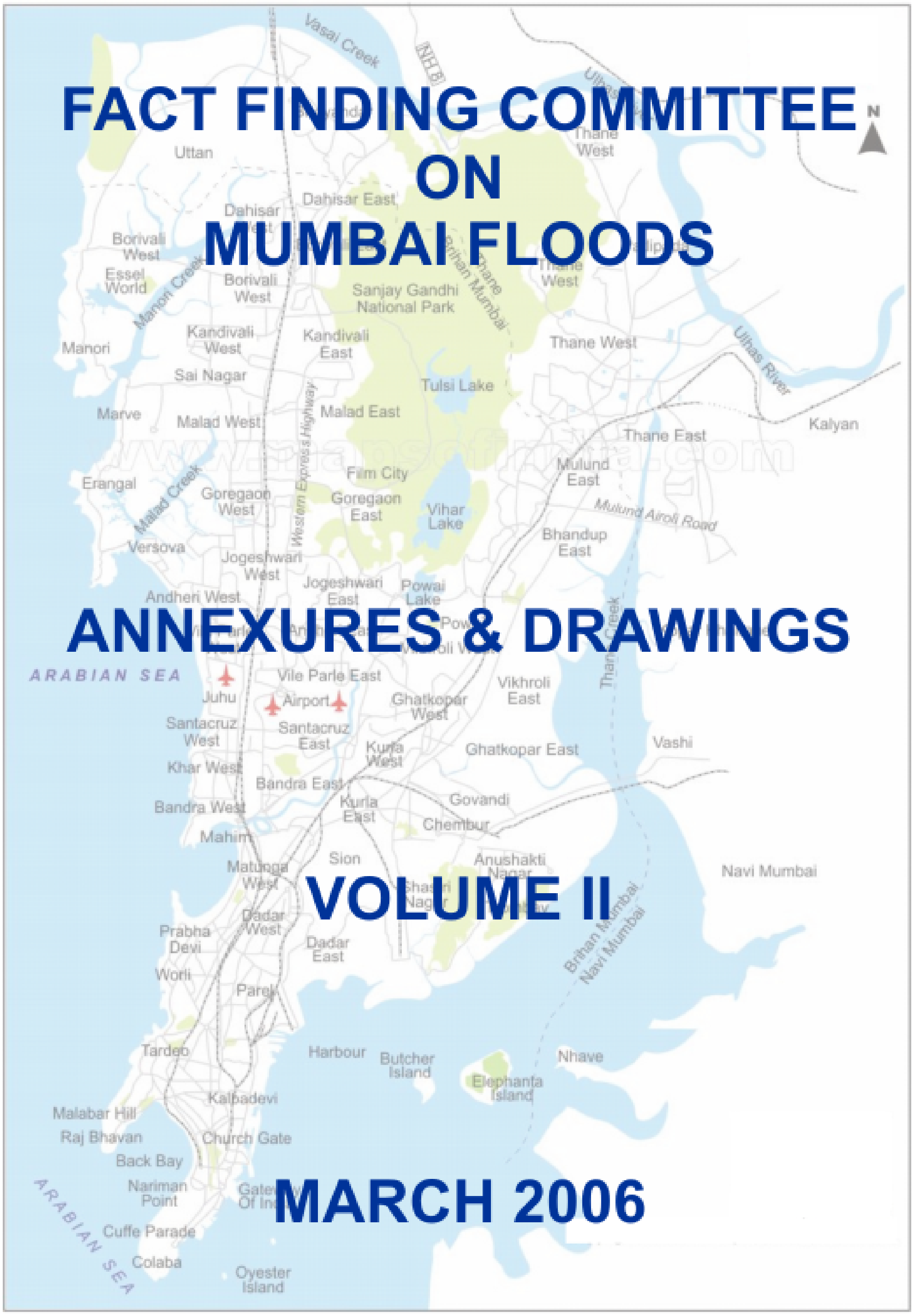
4) Urban local bodies form the third tier of government, and function as the agents for social and economic change. So we need to constitute effective Ward Committees (or even smaller units of governance, like the Grama Sabhas in rural areas) with meaningful public participation; as well as a Metropolitan Planning Committee (MPC) for inter-agency co-ordination.

(Madhav Chitale)
Chairman

(Shirish Patel) Member	(Shyam R. Asolekar) Member
(Nandkumar S. Salvi) Member	(Madhukar V.Patil) Member
(Nanasaheb Patil) Member	(Jatindersing Sahani) Member

(Milindkumar.V.Deshmukh)
Secretary

FACT FINDING COMMITTEE
ON
MUMBAI FLOODS



ANNEXURES & DRAWINGS

VOLUME II

MARCH 2006

ANNEXURES

INDEX- ANNEXURES

	FACT FINDING COMMITTEE ON MUMBAI FLOODS
	LIST OF STORM WATER NALLAS (OPEN CHANNELS) (PLEASE ALSO REFER DRAWING NO.4,7&9)
	ANNEXURE : 1 PAGE 1

LIST OF MAJOR NALLAS IN ISLAND CITY, EASTERN & WESTERN SUBURBS

The List of Major Nallas in Island City

- J.K.Chemical Nalla
- Nehru Science Centre
- Race Course Nalla
- Joglekar Nalla Dharavi
- Dadar Dharavi Nalla
- Anna Indira Nagar Nalla, Dharavi
- Textile Nalla.

List of Major Nallas in W.S.

- Chamdawadi Nalla System
- Highway Channel and Vakola River System.
- Boran Nalla System
- S.N.D.T.Nalla
- Majas Wadi Nalla System
- Mogra Nalla System
- Irla Nalla System
- Marol Nala System
- Indian Oil Nala System
- Oshiwara River System
- Piramal Nala System
- Pushpa Park Nalla System
- Malwani Nalla System
- Poisar River System
- Chandavakar Nalla System
- Dahisar Nalla River System
- Kajupada Nalla System

List of Major Nallas in E.S.

- Safed Pool Nalla
- Nehru Nagar Nalla
- Build Craft Nalla
- Refinery Parallel Nalla
- Sahakar Nagar Nalla
- Brahmanwadi Nalla
- Gauri Shankar Wadi Nalla
- Vallabh Baug Lane Nalla and Culvert
- Laxmi Baug Nalla
- Pant Nagar Nalla
- Upper Pada, Lower Pada, Indira Nagar Damodar Park.
- Barve Nagar Nalla, Azad Nagar Nalla, N.S.D. Nalla
- Somaiya Nalla
- Vashi Nalla

	FACT FINDING COMMITTEE ON MUMBAI FLOODS
	DETAILS OF SWD OUTFALLS
	ANNEXURE : 2 PAGE 1

SR. NO.	CATCH MENT NO.	CATCH-MENT AREA HA	LOCATION	INVERT LEVEL W.R.T. THD (m.)	SIZE (mm)		CLASS	INVERT LEVEL W.R.T. GTS
					WIDTH	HEIGHT		
1)	102	5	Macchimar Colony	26.70	450ϕ		PIPE	2.24
2)	103	13	Mahim Fort Road	26.12	1450	1200	ARCH	1.66
3)	104	17	Mahim Kapad Bazar	25.99	1450	1400	ARCH	1.53
4)	105	16	National Hospital	25.00	1200	1400	ARCH	0.54
5)	106	31	Pandurang Naik Road	25.50	1750	1100	ARCH	104
6)	107	50	Ranade Road	25.32	2520	1670	ARCH	0.86
7)	108	44	Kashinath Dhuru Rd.	25.13	1400	1200	ARCH	0.67
8)	109	70	P.Balu Marg	23.88	2438	1219	ARCH	- 0.58
9)	117	118	Kharoo Creek (Nullah End)	25.20	13500	2000	CUL	0.74
10)	118	138	Wadala Incinerator	24.30	1800	1250	ARCH	- 0.16
11)	119	44	Times of India	25.32	900	1200	ARCH	0.86
12)	120	15	Colgate Palmolive	23.80	1050	750	ARCH	- 0.66
13)	122	65	Hindustan Lever	24.87	2700	1500	RECT	0.11
-	124	519	Britania (merged in 125)	-				
14)	125		Britania	23.00	4250	2750	ARCH	- 1.46
15)	126	15	Dockyard Road	25.18	600	900	ARCH	0.72
16)	127	1	Malet Basin	27.50	230ϕ		PIPE	3.04
17)	128	75	Frere Basin	26.25	1200	1150	ARCH	1.79
18)	129	464	Cleveland Bunder	21.47	4500	3200	GATES	- 2.99
19)	130	1308	Love Grove	23.07	5250	5680	GATES	- 1.39
20)	130		Haji Ali Byepass	22.79	1400	1900	RECT	- 1.67
21)			N.S.C.I.	27.14	450ϕ		PIPE	2.68
22)	131	22	R.G.Thadani	26.50	900ϕ		PIPE	2.04
23)	132	155	Haji Ali Juice Centre	22.79	2700	1800	ARCH	- 1.67
24)			Haji Ali Juice Centre	26.30	900ϕ		PIPE	1.84
25)	133	18	Bhulabhai Desai Road	25.48	900ϕ		PIPE	1.02
26)	134	}	Vaibhav Apartments	26.48	900ϕ		PIPE	2.02
27)		}	Kinari Congress	24.43	1200ϕ		PIPE	- 0.03
28)		}	Kinari Congress	UTS	600ϕ		PIPE	
29)		}	Dhurabsha Road	28.10	300ϕ		PIPE	3.64
30)		} 59	Setalwadi Lane	25.44	450ϕ		PIPE	0.98
31)		}	Priyadarshini Park	24.43	1200ϕ		PIPE	- 0.03
32)		}	Priyadarshini Park	UTS	300ϕ		PIPE	
33)		}	Petit Hall	23.42	1000	1000	RECT	- 1.04
34)		}	Runtha Lane	24.80	600ϕ		PIPE	0.34
35)		}	Nana Chudasama	UTS	1200ϕ		PIPE	
36)		}	Bhagwanlal Indrajit	28.40	600ϕ		PIPE	3.94
37)		}	Banganga Outfall	29.08	750ϕ		PIPE	4.62
38)	135	18	Walkeshwar Road	25.50	600	600	RECT	1.04
39)	136	14	Sardar V.Patel Road	23.83	600ϕ		PIPE	- 0.63

				ANNEXURE : 2 PAGE 2				
SR. NO.	CATMENT NO.	CATCH-MENT AREA HA	LOCATION	INVERT LEVEL W.R.T. THD (m.)	SIZE (mm)		CLASS	INVERT LEVEL W.R.T. GTS
					WIDTH	HEIGHT		
40)	137	45	Mafatlal Swimming Pool	23.86	1200φ		PIPE	- 0.60
41)	138		Near Mafatlal	25.91	900φ		PIPE	1.45
42)	138		City Police ground	25.75	1200	800	EGG	1.29
43)	140	180	ONGC Outfall	22.90	1150	1950	ARCH	- 1.56
44)	141	41	Shantiniketan	24.45	2500	1000	ARCH	-0.01
45)	142	17	F.Road	24.65	900φ		PIPE	0.19
46)	143	37	Wankhede Stadium	23.17	1450		ARCH	- 1.29
47)	144	57	Veer Nariman Road	23.23	2050	2050	ARCH	- 1.23
48)	145	102	Mint Reserve	24.27	2520	2400	ARCH	- 0.19
49)	146	7	Shoorji Vallabhdas	25.30	600	750	ARCH	0.84
50)	147	6	Jamnagar St.	25.00	300φ		PIPE	0.54
51)	148	116	Madam Cama Road	22.00	2300	2200	ARCH	- 2.46
52)	148		N.C.P.A.(Vinay K.Shah Marg)	26.30	900φ		PIPE	1.84
53)	148		Atlanta Building	27.33	450φ		PIPE	2.87
54)	148		Badhwar Park (148 M)	25.00	900φ		PIPE	0.54
55)	149 a)	37	Gateway of India	26.00	700	450	RECT	1.54
56)	149 b)		Orminster Street	24.95	600φ		PIPE	0.49
57)	149 c)		Arthur Bunder Road	24.95	600φ		PIPE	0.49
58)	150 a)	22	Lala Nigam Street	25.43	825	900	ARCH	0.97
59)	150 b)		Rajwadkar Street	UTS				
60)	151 a)	12	Dumaine Street	23.06	900φ		PIPE	- 1.4
61)	151 b)		Dumaine Street	UTS				
62)	152 a)	78	Rambhau Salgaonkar	26.87	900φ		PIPE	2.41
63)	b)		G.D. Somani	24.30	2100	1100	ARCH	- 0.16
64)	c)		Sadhu Vaswani	23.20	1800φ		PIPE	- 1.26
65)	d)		Zulelal Temple	24.55	400φ		PIPE	0.09
66)	153	35	Homi Bhabha Marg	23.98	2100	2100	ARCH	- 0.48
67)			Geeta Nagar	20.98	2250	2250	RECT	- 3.48
68)	401	96	Senapati Bapat Marg	23.50	1700	1800	RECT	- 0.96
69)	410 a)	487	Dadar Dharavi	24.19	13000	4250	CUL	- 0.27
70)	b)		Naik Nagar	23.35	19650	2750	NULLAH	- 1.11
71)	c)		Yellow Bungalow	24.85	600φ		PIPE	0.39
72)	501	717	Nehru Nagar	24.46	15400	3980	CUL	0.00
73)	502	62	Peripheral Nullah	25.21	2500	1900	CUL	0.75
74)	503	10	Pratiksha Nagar	25.98	3000	2000	CUL	1.52
75)	504	205	Wadawali	24.65	15000	3717	CUL	0.19
76)	505	189	RCF South	24.92	12500	1400	CUL	0.46
77)	506	209	J.K.Chemicals	23.38	11000	4250	NULLAH	- 1.08
78)	507	24	Cemindia	25.68	5000	630	NULLAH	1.22
79)	509	214	Vashi Naka	24.92	12500	1400	CUL	0.46
				ANNEXURE : 2 PAGE 3				

SR. NO.	CATMENT NO.	CATCH-MENT AREA HA	LOCATION	INVERT LEVEL W.R.T. THD (m.)	SIZE (mm)		CLASS	INVERT LEVEL W.R.T. GTS
					WIDTH	HEIGHT		
80)	203	3488	Dahisar River	23.23	56000	2570	RIVER	- 1.23
81)	206	242	Rajendra Nagar	25.71			NULLAH	1.25
82)	211	2095	Poisar	24.26	29000	2610	RIVER	0.20
83)	213	503	Pushpa Park	26.18	5500 4100	2200 2200	CUL	1.72
84)	215	457	Piramal	24.08	6500	2420	CUL	0.38
85)	216	210	Shastri Nagar	23.90	6000	3000	NULLAH	0.44
86)	217	2938	Oshiwara	22.07	62000	3760	RIVER	- 2.39
87)	218	600	Mogra	21.50	96000	4890	NULLAH	- 2.96
88)	219	668	Irla	23.73	1200	2300	GATES	- 0.73
89)	220	174	SNDT(Juhu)	24.29	26000	2200	NULLAH	- 0.17
90)	221	66	P &T	24.15	10000	610	NULLAH	- 0.31
91)	222	23	North Avenue	28.98	1200	2000	GATES	4.52
92)	223	19	Main Avenue	26.65	3200	2000	GATES	2.19
93)	225	29	Sherli Rajan	26.35	3700	2440	CUL	2.19
94)	228	21	Chappel Street	23.90	2500ϕ		PIPE	- 0.56
95)	301	574	Bombay and ACC Nullah	24.00	4600	4200	CUL	- 0.46
96)	302	81	Kesarbaug	26.10	1200		CUL	1.64
97)	303	334	Nanepada	24.86	11000	4870	CUL	0.40
98)	304	269	Bombay Oxygen	24.50	8000	4600	CUL	0.04
99)	305	848	Usha Nagar	22.60	6000	4560	CUL	- 1.86
100)	306	558	Crompton Kanjur	23.26	6000	3800	CUL	- 1.20
101)	307	74	Kannamwar Nagar	24.45	1200		CUL	- 0.01
102)	308	178	Godrej Nullah	27.46	3700	1650	CUL	3.00
103)	309	664	Pant Nagar Nullah	24.08	6700	4500	CUL	- 0.38
104)	310	366	Somaiya Nullah	23.94	6000	4400	CUL	- 0.52
105)	311	356	Subhash Nagar	23.96	5100	4700	CUL	- 0.50
106)	312	330	Deonar Nullah	23.96	5100	4700	CUL	- 0.50
107)	313	391	Children's Aid Mankhurd	24.08	4700	4180	CUL	- 0.38
108)	314	19	Mankhurd MGP	24.00	4000	4500	CUL	- 0.46
		1			4700	4500		
109)	400	7295	Mahim Causeway (Mithi River Catchment)		38000		BRIDGE	

Note : A) Catchment Nos are those as adopted in BRIMSTOWAD.

B) Details of major outfalls to sea/creek are given (109 out of 186)

C) i) No. of Catchments more than 1000 Ha = 6 Nos.

ii) No. of Catchments between 100 Ha and 1000 Ha = 30 Nos.

iii) No. of Catchments less than 100 Ha = 41 Nos.

D) i) Outfall Invert Level below Mean Sea Level = 45 Nos

ii) Outfall Invert Level above Mean Sea Level = 135 Nos

iii) Outfall Invert Level above High Tide Level = 6 Nos

E) No of Catchments having outfall below Mean Sea Level are 45 Nos and Catchment area 24028 Ha.

FACT FINDING COMMITTEE ON MUMBAI FLOODS	
AREAS FLOODED ON 26.7.2005/27.7.2005 **(PLEASE ALSO REFER DRAWING NO. 5 & 10)**	
ANNEXURE : 3	**PAGE 1**

Sr. No.	Location	Ward	Peak flood level in ft.
	ISLAND CITY		
1	Sardar Vallabhbhai Patel Road, Nal Bazar	'C'	2'
2	Sleater Road, Gilder Lane, Mumbai Central, Kher wadi, Nana Chowk	'D'	2'
3	Hind Mata, Kala Chowky.	'F/S'	3'
4	Lakhamsi Napoo Road	'F/N'	3'
5	Gandhi Market	-"-	2 ½
6	Wadala, near station	-"-	3'
7	Pandurang Budhkar Marg	'G/S'	3'
8	Sakhubai Mohite Marg, Curry Road.	-"-	3'
9	Matunga W.R., S.B.Marg.	'G/N'	2 ½'
10	Laxmibaug Road, Sion C.R.	-"-	2'
11	T.H.Kataria Marg, W.R.	-"-	2 ½'
12	Dadar, W.R.	-"-	1'

Approx. Area under Submergence in Island City = 500 Ha
= 7.3 % of City Area

	WESTERN SUBURBS		
1	Milan Subway	H/E	10'
2	Prabhat Colony Road No.2, near Municipal School.	-"-	3'
3	Guru Narayan Marg, near Reliance Energy Office.	-"-	2' 6"
4	Khar Subway	-"-	8' 9"
5	J.P.Road near Khar Railway Station.	-"-	2'
6	Ananad Nagar near Ganesh Mandir & Vakola Police Station	-"-	3'
7	Hanuman Tekadi Gate 1 to 4 Service Road	-"-	4' 5"
8	Dawry Nagar, Service Road, Chembur Link Road.	-"-	4' 6"
9	Golibar Road	-"-	2' 5"
10	Khernagar, Bapuji Stall, Kalanagar, Gandhi Nagar.	-"-	5'
11	Govt. Colony, Kala Mandir, Shastri Nagar, Ahinsa Nagar.	-"-	4'
12	C.S.T.Road	-"-	2'
13	Air India Colony	-"-	6' 6"
14	Sunder Nagar	-"-	3'

ANNEXURE : 3	PAGE 2

Sr. No.	Location	Ward	Peak flood level in ft.
1	1st Road behind Sulabh Sauchalaya, Old Khar.	H/W	2 ½' to 4'
2	Linking Road near Mukut House, Khar.	-"-	Upto 2' to 3'
3	3rd Road, Khar & Jai Bharat Society	-"-	5' x 8'
4	2nd Hasnabad Road near Harijan Colony, Khar.	-"-	2' 3"
5	Near traffic police Chowky, Khar, Swami Vivekanand Road(S.V.Road)	-"-	2' to 3'
6	Gitanjali Arcade, Hill Road, Bandra.	-"-	2' to 3'
7	Turner Road and S.V. Road junction, Bandra.	-"-	1' to 2'
8	Milan Subway	-"-	10' to 12'
9	Khar Subway	-"-	8' to 10'
10	Khira Nagar, S. V. Road, Santacruz.	-"-	5' to 6'
11	Daulat Nagar, Santacruz.	-"-	4' to 5'
12	Immigration office, Santacruz.	-"-	5' to 6'
13	Dattatraya Road, Santacruz.	-"-	2' to 3'
14	Santacruz Police Station, near Juhu Road & Linking Road Junction.	-"-	3' to 4'
15.	Perry Road, Junction. with St.Paul Road and St.Andrews Road, Bandra.	-"-	4' to 5'
16	Gazdhar Bandh, Santacruz (W)	-"-	5' to 6'
1	Milan Subway, Vileparle.	K/E	10'
2	Shradhanand Road, Vileparle (E)	-"-	4'
3	Kurla Garage, Junction. N.P.Thakkar Road. & Chokhamela Road., Vileparle.	-"-	4'
4	Bhogale Chowk, Nehru Road., Vileparle.	-"-	2'
5	Mahatma Gandhi Road Junction. Subhash Road. Vileparle	-"-	3'
6	Sahar Road Junction with Jiva Mahale Road.	-"-	2'
7	Andheri Police Stn., S.N.Road., Andheri	-"-	3'
8	Andheri Subway	-"-	6'
9	Caves Road. Opp. Jogeshwari Rly. Station.	-"-	4'
10	R.K.Singh Road., near Ambawadi, Andheri	-"-	5'
11	Jn. of P.P.Road. & Mishra Road.	-"-	4'
12	Andheri Kurla Road, near Sun Sheel Hotel.	-"-	4"
13	J.N.Nagar, near Bagadka Nalla.	-"-	7"

ANNEXURE : 3	PAGE 3

Sr. No.	Location	Ward	Peak flood level in ft.
1	Milan Subway, Vileparle.	K/W	10’
2	S.V.Road junction with V.M. Road	-“-	3’
3	S.V.Road junction with Jayprakash Road	-“-	3’
4	Andheri Subway, Andheri Market	-“-	3’
5	S.V.Road Indian Oil Nalla culvert	-“-	2’
6	V.M. Road junction with Gulmohar Road.	-“-	2’
7	V.M. Road junction with Gurunanak Road.	-“-	2’
8	Shamrao Parulekar Marg at Bus Stop	-“-	4’
9	Vidyanidhi Complex	-“-	4’
10	D.N.Nagar, Link Road, near the Club.	-“-	3’
11	J.P.Road, near Sony Mony Shop	-“-	3’
12	Swami Smarth Circle, Lokhandwala Complex.	-“-	2’
13	Kajupada junction, Link Road	-“-	3’
14	Shantivan MHADA	-“-	3’
15	Veera Desai Road Junction with Sarotpada Road and Dattaji Salvi Road.	-“-	5’
16	Juhu Old Airport	-“-	2’
1	S.V.Road, near Oshiwara, Goregaon (W)	P/S	3’
2	Motilal Nagar, Goregaon (W)	-“-	7’ 8”
3	Shastri Nagar, Goregaon (W)	-“-	7’ 8”
4	Bhagatsingh Nagar, Goregaon (W)	-“-	3’ 4”
5	Bangur Nagar, Goregaon (W)	-“-	4’
6	Ram Mandir Road, Goregaon (W)	-“-	4’
7	Walbhat Road, Goregaon (E)	-“-	4’
8	Vishweshwar Road, Goregaon (E)	-“-	4’ 5”
9	Ambedkar Chowk & Pravashi Estate, GMLR, Goregaon (E)	-“-	3’ 4”
1	S.V.Road, near Malad Shopping Centre, Malad (W)	P/N	5’
2	Malad Subway	-“-	3’
3	S.V.Road, N.L. High School, Malad (W)	-“-	3’
4	Adarsh Dughdalay Complex, Marve Rd., Malad (W)	-“-	2’
5	Link Road, Malad (W)	-“-	1’-1’ 6”
6	Malvani, Malad (W)	-“-	3’ 4”

ANNEXURE : 3	PAGE 4

Sr. No.	Location	Ward	Peak flood level in ft.
1	Damupada, Gautam Nagar, Kandivali.	R/South	3'
2	Janupada Thakur Complex.	-"-	4'
3	Thakur Complex, Kandivali (W)	-"-	2' 6"
4	Shopper's Stop, S.V.Road., Kandivali (W).	-"-	3' 6"
5	Fire Brigade, S.V.Road., Kandivali (W)	-"-	4' 6"
6	Dahanukarwadi, M.G.Road., Kandivali (W)	-"-	8'
7	Valnai	-"-	10'
8	Sony Mony, S.V.Road., Borivali (W)	R/Central	3'
9	Saibaba Nagar, Borivali (W)	-"-	2' 6"
10	Daulat Nagar, Borivali (E)	-"-	6'
11	Rajendra Nagar, Borivali (E)	-"-	3' 6"
12	S.B.I. Colony, Borivali (E)	-"-	5'
13	Y.R.Tawde, Dahisar (E)	-"-	4'
14	V.H.Desai, Dahisar Subway	-"-	4' 6"
15	Kajupada Dahisar (E)	-"-	3' 6"
16	Dhasakwadi, Gharatanpada, Dahisar (E)	-"-	4'
17	Agarwal Industries, S.V.Road., Dahisar (E)	-"-	3' 6"

Total Area under Submergence in Western Suburbs = 4200 Ha
= 19.6 % of Western Suburbs Area

ANNEXURE : 3	PAGE 5

Sr. No.	Location	Ward	Peak flood level in ft.
	EASTERN SUBURBS		
1	Kurla (E) & Kurla (W) except the hilly portion like Chandivali farm Road, Khadi No.3, Kasai Wada. Maharashtra Kata to Surve Chowk Lal Bahadur Shastri Road (L.B.S Road)	L	2.10
2	Surve Chowk to Kamani Junction .	-“-	1.50
3	Kamani Junction to NSS Road.	-“-	1.20
4	Nehru Nagar, Mother dairy	-“-	1.50
5	Sakinaka road to Jrimari.	-“-	1.50
6	Everard Nagar, Chuna Bhatti	-“-	1.50
7	Kurla Station (W),Near Rickshaw Stand	-“-	0.90
8	L.B.S. Road,C.S.T.Junction. to Sheetal Cinema, Kurla(W)	-“-	2.70
9	From Premier Road upto Milind Nagar Nalla, Kurla(W)	-“-	2.50
1	Deonar Colony & its vicinity	M/E	2.00
2	Phule Nagar in Mankhurd	-“-	0.90
3	Gaikwad Nagar area	-“-	1.20
4	Shanti Nagar, Baingan Wadi	-“-	0.60
1	Subhash Nagar area	M/W	1.50
2	Postal Colony Nalla (E.E.Highway Nalla)	-“-	2.00
3	Vicinity of Charai Nalla, Kokan Nagar & Sindhi Society	-“-	1.50
4	Vashi Naka Culvert including Islampura area and its vicinity	-“-	0.90
5	Collector Colony, Maravali Village and its Vicinity	-“-	1.50
6	Pestam Sagar Chedda Nagar	-“-	2.00
7	Sindhi Society Chembur(W) behind lav-kush Bungalow	-“-	1.20
8	Between 21st Road &Subhash Nagar Road, Jeevan Bahar Society, Chembur (W)	-“-	1.50
9	Shanta jog Marg Tilak Nagar, Chembur(W)	-“-	1.20
10	Savan Bazar,N.G.Acharya Marg, Chembur(W)	-“-	1.20
1	Kurla Terminus Road	N	1.80
2	Garodia Nagar	-“-	2.00
3	Ramabai Naga	-“-	0.90
4	Pantnagar	-“-	0.90
5	LBS Road G.A. Link Road to Vikroli stn.	-“-	0.60

Sr. No.	Location	Ward	Peak flood level in ft.
6	Kirol Road near Fatima High School, Ghathopar(W)	N	1.20
7	New Pant Nagar from Vallabh Baug Extension Lane upto Railway Police Quarters, Ghatkopar(E)	-"-	1.80
8	Navai Dockyard at L.B.S.Marg, Junction Chirag Nagar Road, Ghatkopar (W)	-"-	1.00
1	Sahyadri Nagar	S	1.20
2	Patil Wadi/Bhandup Station.	-"-	1.20
3	Tagore Nagar Group No. 1 & Group No. 3	-"-	1.00
4	Bhandup(E) from Datar Colony to Railway Crossing	-"-	0.60
5	Bhandup Village Road.near Progressive Steel Co.,Bhandup (W)	-"-	1.20
1	Veena Nagar/Govardhan Nagar, L.B.S.Marg	T	1.00
2	Mulund Colony Near Tansa Main	-"-	0.60
		-"-	
3	Dumping Road near city of joy	-"-	0.60
4	Nanepada,Mulund(E)	-"-	1.20
5	Neelam Nagar,Mulund(E)/Vrindavan Dham	-"-	1.20
6	Mehul circle	-"-	0.75
7	LBS Marg Junction G.M.Link Road	-"-	0.60
8	ESI Hospital LBS Marg	-"-	0.60
9	Bhakti Marg	-"-	0.60

Total Area under Submergence = 3000 Ha
= 13.7 % of Eastern Suburbs Area

FACT FINDING COMMITTEE ON MUMBAI FLOODS
SLUMS AND LOW LYING AREAS PRONE TO FLOODING IN GREATER MUMBAI (AS PUBLISHED IN DISASTER PLAN OF 2000)
ANNEXURE : 4 PAGE 1

Ward	Flood prone slum areas	Other flood prone low lying areas and roads
A	Machhimar Nagar	Junction of Anandilal Poddar road & Queens road (Maharshi Karve road).
	Shivshakti Nagar	Dinshaw Mullah Jn. Maharshi Karve Road
	Ambedkar Nagar	Metro Cinema Junction
	Ganesh Murty Nagar Part I & II	M.G.Road near Gymkhana
	Geeta Nagar	LokmanyaTilak Marg near Police Commissioner's office.
	Azad Nagar	Junction of market road and D.N. Road, A.Daundkar Marg.
	Sudam Nagar	Mint Road near Kabutarkhana.
	Sunder Nagar	Ramjibhai Kamani Road Junction Shoorji Vallabhdas Marg.
	Dhobhighat	Junction of Veer Nariman Road and Vitthaldas Thakersy Road.
		Aram, Capital Cinema near Zunka Bhakar Kendra.
		S.B.S.Road from Regal Cinema to Kushro baug.
		S.B.S.Road Jn. N.A.Sawant Marg.
		Radio club.
		Wood house Road (Jn. of Fazal Road & Khatau Road).
		General Jagannath Bhosle Marg.
		Nathalal Parikh marg and M.K.Road, Cooperage Road Junction, Tata garriage, Benet Villa

ANNEXURE : 4 PAGE 2		
Ward	**Flood prone slum areas**	**Other flood prone low lying areas and roads**
B	Nil	Masjid Railway Station.
		P. D'mello Road, Kaklji Chowk Junction.
		Mohd. Ali Road, Mandvi Post Office.
		Jinabhai Mulji Rathod Marg.
		Sandhurst Road Low Level.
C	Nil	Trimbak Parshuram Street, Jn. Durgadevi Road.
		Durgadevi Road, Junction Ist & IInd Pathan Street.
		Brigadier Usman Marg, Nalbazar Market
		Sardar Vallabhbhai Patel.Road, Gol Deol.
		Yagnik Chowk.
		Kalbadevi Road ben Dadisheth Agiyasi Lane & Dr. Veigas Street.
D	Janta Nagar, M.P. Mill Compound, Tardeo	Petit Hall, Napean Sea Road.
	M.P. Mill Compound, Tardeo	Kashinath Compound, Nepean sea Road.
	Jaiphalwadi, Zopadpatti, Forget Street.	Omkar Park, Bhulabhai Desai Road.
	Simla House Zopadpatti.	Breach Candy, B.D. Road
	Vitthal wadi, Namdeo wadi, Sherichi wadi.	Band Stand Chowpatty.
		Nana Chowk
		Tardeo Circule
		Earth quake, Tardeo Road.

ANNEXURE : 4		PAGE 3
Ward	**Flood prone slum areas**	**Other flood prone low lying areas and roads**
		Grant Road Station, Noshir Bharucha Marg.
		Apsara Cinema, Alibhai Premji Junction, Lamington Road.
		R.R. Road Junction Khetwadi Back Road.
		Kalewadi / Kandewadi, J.S.S.Marg.
		Alankar Cinema, S.V.P. Road Jn. of Pathe Bapurao Marg and Adjoining area of Khetwadi.
E	Mahatma Phule Nagar	Sankli Street Junction Sankli Street No.3
	Khalipha Chawl	Anandrao Nair Marg, Opp. Maratha Mandir.
	Sankli Street	Sheth Motisha Lane, Byculla Station.
	Nwiyal wadi	Nexbit Road, Low Level, Burhani College.
	Bhundarwada	Maulana Azad Road Junction Maulana Shaukat Ali Road.
	Transit Camp, Tank Pakhadi	Sitafalwadi, Mazgaon, Dr.Mascarhans Road Junction Sant Sawata Marg.
	Mominpura	
	Huns Road, Transit Camp.	
	D.P. Wdi	
	Anandrao Vakil Chawl	
	Undhiya Street Water	
F/N	Plot No.9,10 and Vicinity Wadala	Road No.26-A, Gandhi Market
	Santoshimata Nagar, Ramnagar and Vicinity Wadala.	Road No.26, Road No.6, Mukhyadhyapak Bhavan.

ANNEXURE : 4		PAGE 4
Ward	**Flood prone slum areas**	**Other flood prone low lying areas and roads**
	Nityanand Nagar, Wadala	Vachharaj Lane
	Sadashi Wadi, Wadala	Rafi Ahmed Kidwai Marg, Gate No.4
	Ajmar Nagar, Wadala	
	Sundar Kamla Nagar, Sion	
	Shivaji Nagar, B.D.Road,	
	Sion Fort	
	Azad Nagar, Wadala	
	Punjabi Slum Colony	
	Raoli Mat. Home	
	Indira Nagar	
	Chindiwala Colony	
F/S	Nil	Dadasaheb Phalake Road (Gautam Nagar)
		Dr.Babasaheb Ambedkar Road, Hindmata
		Dr.B.A.Road, St.Xavier Street
		Dr.B.A.Road, Junction D.L. Road, Sardar Hotel
		Zakeria Bunder Cross Road No.1,2,3.
		R.A.Kidwai Road Junction Road No.26
		Sewree Cross Road, Gate No.7
		J.B.Road, F/South Office
		Mahadeo Palav Road, Near Railway Bridge
		Godrej / Gas Company Lane

Ward	Flood prone slum areas	Other flood prone low lying areas and roads
G/N	Transit Camp No.2 & 3, near Sion Station (near Dhobighatt)	Mahim Causeway
	Muslim Nagar, Jn. of 90' & 60' Road	Ambedkar Road, Matunga Labour Camp.
	Gopinath Colony, Off. Sant Rohidas Marg	Meghwadi, T.H. Kataria Marg
		Chronic Spots : Dadar Station (West)
		Matunga Station (West)
		Mahim Station Railway Side
G/S	Nariman Bhat Nagar	B.D.D.Chawls, N.M.Joshi Marg.
	Janata Colony, Worli	Currey Road, Low Level
	Golphadevi, Worli Koliwada	Fitwala Road
	Madraswadi (Mahatma Phule Nagar)	Balusheth Madurkar Marg
	Markandeyshwar Nagar	G/South Ward Office, N.M.Joshi Marg
		Pandurang Budkhar Marg, Near Globe Mill Pumping Station.
H/E	Dawri Nagar, Vakola, Santacruz (E)	Vakola / Kalina Section :
	Chaitanya Nagar, Vakola, Santacruz (E)	Anand Nagar, Vakola
	Golibar, Ambewad Slum, Khar (E)	Agripada, Vakola
	Ghas Bazar Slum, Naupada, Bandra (E)	Datta Mandir Road, Vakola

ANNEXURE : 4		PAGE 6
Ward	**Flood prone slum areas**	**Other flood prone low lying areas and roads**
	Chamada wadi open Plot 116, Bandra (E)	Kalina-Kurla Road, Kalina
	Indira Nagar Slum, Govt. Colony, Opp. Kala Mandir, Bandra (E)	Air India Road, Kalina
	Valmiki Nagar Slum, Bharat Nagar, Bandra (E)	Sunder Nagar, Kalina
		C.S.T. Road, Kalina
		Hanuman Tekdi Section :
		J.P. Road
		Prabhat Colony, Road No.2, Near B.S.E.S. Ltd. Office.
		Khar Subway
		Kherwadi Section :
		Gate No.18, Naupada, Bandra (E).
		Junction of Service Road and Anand Kanekar Marg, Bandra (E).
		Bapuji Stall Road, Bandra (E).
		Apex Nalla, Kherwadi Road, Bandra (E)
		Chamada wadi Open Plot No.116, Bandra (E)
		Shastri Nagar Market, Bandra (E)
		Near Govt. Colony, Bldg. No.7, Bandra (E)
		Near Govt. Colony, Bldg. No.10, Bandra (E)
		Near Walmiki Nagar, River Over Bridge, Bharat Nagar, Bandra (E)

		ANNEXURE : 4 PAGE 7
Ward	**Flood prone slum areas**	**Other flood prone low lying areas and roads**
		Navpada Dhakka, Bandra (E)
H/W	J.J. Colony	Bazar Road
	3rd Road Khar	Khar Railway Station Road
	South Avenue	Khar Subway
	Main Avenue	Ramkrishna Marg
	North Avenue	Milan Subway
	17th Road Khar	
	Nutan Nagar, Bandra (West)	
	Mira Baug, Santacruz (West)	
K/E		
K/W	Khadda Hutment	M.A.Road, Near Andheri Station
	Nehru Nagar Hutment	Dhobighat, Near Irla
	Keoni Gaothan	Kripa Nagar
	Amboli Village	Vaikunthlal Mehta Road, Near Conservancy Chowky
	Vaishali Nagar	Bajaj Road, Bapu Vashi Road
	Azad Nagar	Juhu Road, Centaur Hotel
	Indira Nagar	Juhu Road, Palmgrove, Gandhi Status
	Kripa Nagar Dhobighat	Gulmohar Road, Junction Wirwlwss Road
	Irla Gaothan	Santacruz Garage, Swami Vivekanand Road
	Gilbert Hill	Link Road, Junction Andheri Versova Link Road

ANNEXURE : 4		PAGE 8
Ward	**Flood prone slum areas**	**Other flood prone low lying areas and roads**
L	Almeda Baug Slum, behind Sheetal Cinema, Kurla (West)	S.G.Barve Marg, Junction of Lal.Bahadur.Shastri.Marg, Kurla (W).
	Takshasheela Nagar, Kurla (E)	Sonapur Lane, Kurla (W)
	Slum along Patel wadi nalla, Kurla (W).	Sunder baug Lane, Kurla (W).
	Bhartiya Nagar, Achanak Nagar, along Railway track, Kurla (W).	Kajupada Pipe line Junction with Kale Marg, Kurla (W).
	Following slums at Parigh khadi along the banks of the Mithi river : Lokmanya Nagar	Vidyavihar Road, Kirol Road, Near Premier Co., Kurla (W).
	Uday Nagar	Pipe line Road, Kurla (W)
	Milind Nagar	Akash Lane, Kurla (W)
	Muran Nagar	Kurla Station, Kurla (W)
	Tanaji Nagar	Shivshrusthi, 60' D.P. Road, Kurla (E)
	Kranti Nagar	Chunabhatti along railway line, Kurla (E).
	Jarimari	Swadeshi Mill, Kurla (E).
	Kismat Nagar	
M/E	Matang Rushi Nagar	Deonar Municipal Colony
	Walmiki Nagar	Bharat Nagar, Transit Camp. Near Mankhurd Railway Station (West)
	Ekta Nagar	
M/W	Postal Colony	Amar Mahal Junction Eastern Express Highway
	P.L. Lokhande Marg	V.N.Purav Marg
	Vatsalatai Naik Nagar	R.C. Marg

ANNEXURE : 4		PAGE 9
Ward	**Flood prone slum areas**	**Other flood prone low lying areas and roads**
	Sindhi Colony	10th Road
	Collector's Colony	15th Road
	Munjal Nagar	N.G.Acharya Marg
		Shell Colony Road
N	Narayan Nagar, L.B.S. Marg, Ghatkopar (West)	Lal Bahadur Shastri Road Junction Chiragnagar, Ghatkopar (W).
	Kirol Village, Vidyavihar (W).	Gangawadi signal (Gangawadi nalla) L.B.S.Marg, Ghatkopar (W).
	Laxmi Nagar, Ghatkopar Andheri Link Road, Ghatkopar (W)	Damodar Park, L.B.S.Marg, Ghatkopar (W).
		Pooja Hotel, M.G. Road, Ghatkopar (E),
		90 feet Junction & Hingwala Lane (During high tide only)
		Seven Pipe Culvert, Pant Nagar, Ghatkopar (E).
		Market Road, Pant Nagar , Ghatkopar (E) (During high tide only)
		Rajawadi "D' Colony (Heavy rains), Vidyavihar (E).
		Premier Road, Vidyavihar (W).
		R.N.Gandhi School, 7th Road, Rajawadi, Vidyavihar (E).
		Garodia Nagar, Ghatkopar (E).
		Chittaranjan Nagar, Ghatkopar (E).
		7th Rajawadi Road, Ghatkopar (E)

ANNEXURE : 4 PAGE 10		
Ward	**Flood prone slum areas**	**Other flood prone low lying areas and roads**
P/N	Valani Malad (West)	**In Malad (West) :**
	Malawani - Malad West	Underai Road Junction of S.V. Road
	Kachpada - Malad West	S.V. Road (Near Shankar temple)
	Kurar Village - Malad East	S.V. Road (Near Natraj Market)
	Pushpa Park - Malad East	Mamlatdarwadi Main Road Junction of S.V.Road
	Bandongari - Malad East	S.V. Road (Near N.L. High school)
		Marve Road (Near Nutan School)
		Marve Road (Near Rahul Apartment)
		Sunder Gulli Jn. of Link Road
		Link Road (Guddiya Pada)
		Adarsh Road Jn. of Ramchandra Lane
		Ayojan Nagar
		Nahar Nagar (Near Culvert)
		Sainath Road (Near Sub-way)
		Somwar Bazar (Near Maruti Temple)
		N.L. Road (Near Ganga Niwas)
		Valnal Hutment Colony
		In Malad (East) :
		Dhanajiwadi
		Khot kuwa wadi (Near P.S.C.)
		Rani Sati Road (Khatiya wadi chowk)
		Subhash Lane Junction of Daftari Road

ANNEXURE : 4 PAGE 11		
Ward	**Flood prone slum areas**	**Other flood prone low lying areas and roads**
		Junction of Dattamandir Road to Khanwala Lane.
		Subway Malad Western Railway
		Kurar Village (Jain Mandir)
		Jitendra Road (Near Tabela)
		Rani Sati Road (Dahyabhai Patel Road Junction)
		Ramesh Nalla (Hanuman Nagar Nalla)
		Junction of Kedarmal Road
		Vaishetpada Road No.2
		Govind Nagar, Chincholi Phatak near Dhobighat.
P/S	Prem Nagar (Siddharth Rameshwar Nagar), Goregaon (W)	Garden Hotel, Link Road, Goregaon (W)
	Bhagat Singh Nagar 1 & 2, Goregaon (W)	Haral Kutir, Near Chincholi Bunder Road, Goregaon (W).
	Ettabhatti, Goregaon (E)	Pawn Baug Nalla and S.V. Road, Goregaon (W)
	Santosh Nagar, Goregaon (E)	Sunder Nagar, S.V. Road, Goregaon (W)
		In Boundary of Aarey Road & Station Road, Goregaon (W)
		B.E.S.T. Depot, Goregaon (W)
		Motilal Nagar, Goregaon (W)
		Near B.E.S.T. Colony, Goregaon (W)
		Sharma Industrial Estate, Goregaon (W)

ANNEXURE : 4 PAGE 12		
Ward	**Flood prone slum areas**	**Other flood prone low lying areas and roads**
		Nirlon Industrial Estate & Walbhat Road, Goregaon (E)
		Walbhat River & Highway, Goregaon (E)
		I.B. Patel Road, Goregaon (E)
		Near Railway Station, Goregaon (E)
		Kotkar Nalla, Gogate wadi, Goregaon (E)
		Chincholi Goregaon-Mulund Link Road, Goregaon (E)
		Ram Mandir Road, Goregaon (W)
		Unnat Nagar Municipal School, Goregaon (W)
		Gaondevi Slum Link Road, Goregaon (W)
		Udyog Nagar, Service Road
		Chronic Flooding spots :
		Sunder Nagar Nalla Junction of Pawan Baug Nalla, Goregaon (W)
		M.G. Road, Goregaon (W)
		Jawahar Nagar Road No. 2 & 3, Goregaon (W).
		S.V. Road & Jawahar Nagar Road No.2, Goregaon (W)
		Jawahar Nagar Road No.1, Goregaon (W)
		Shrirangs Marg & Siddharth Nagar Road No.2, Goregaon (W)
		M.G. Road Junction of Link Road, Goregaon (W)

ANNEXURE : 4		PAGE 13
Ward	**Flood prone slum areas**	**Other flood prone low lying areas and roads**
		Ram Mandir Road, Goregaon (E)
		I.B. Patel Road Junction of J.P. Nagar Road, Goregaon (E)
		Squarter Colony, Near Railway Crossing, Goregaon (E)
		Chincholi Railway Crossing, Goregaon (E)
		Nandadeep Nalla, Goregaon (E)
		Service Road Nalla, Goregaon (E)
R/N	Babali Pada, Near Subway, Dahisar (E)	Behind Laxminarayan Temple Road and Behind Gagangiri Bldg., Eksar, Borivali (W)
	Near Matru Mandir School, Shivaji Road, Dahisar (E)	Roshan Nagar, Roshan Nagar Road, Off Chandawarkar Road, Borivali (W).
	Gahartan Pada, Near Vaishali Nagar, Dahisar (E)	Gorai-II, Section No.2,3,5,6, R.D.P. - I Road, Borivali (West)
	Rawal Pada, Dahisar (E)	Mhatre Nala at Ravaji Premji Aprt. Mhatre wadi, S.V. Road, Borivali (W)
	Jai Santoshi Maa Nagar, Rawal Pada Road, Dahisar (E)	Main Kasturba and 7th Carter Road, Borivali (E)
	Maroti Nagar Back side, Shiv Vallabha Road, Dahisar (E)	
	Shiv Vallabha Road, Near Western Express Highway, Dahisar (E)	
	Kokani Pada, Maroti Nagar Road, Dahisar (E)	
	Kaju pada, Maroti Nagar Road, Dahisar (E)	

ANNEXURE : 4 PAGE 14		
Ward	**Flood prone slum areas**	**Other flood prone low lying areas and roads**
	Kaju pada, Kaju pada Road, Dahisar (E)	
	Devi Pada, Near Western Express Highway, Borivali (E)	
	Lalji Pada, Behind Magathane Depot, W.E.Highway, Borivali (E)	
	Sukarwadi, M.G. Road, Borivali (E)	
	Nutan Nagar, Harijan Wada, L.T.Road, Borivali (W)	
	Babhai Gaonthan, L.T. Road, Borivali (W)	
	Ambedkar Nagar, Link Road & Kasturpark Road Jn., Borivali (W)	
R/S	Ram Nagar, Kandivli (West)	Poisar Nalla (Poisar Village to Lalijipada)
	Sunder Nagar, Kandivli (West)	Dahanukar wadi, Kandivali (West)
	Sai Nagar, Kandivali (West)	Babrekar Nagar, Kandivali (West)
	Laljipada, Kandivali (West)	Gangesh Nagar, Kandivali (West)
	Santosh Nagar, Iraniwadi, Kandivali (West)	Sai Nagar, Kandivali (West)
	Ekta Nagar, Mahavir Nagar, Kandivali (West)	Charkop Sector 1 & 2, Kandivali (West)
	Babrekar Nagar, Kandivali (W)	Bunderpakhadi, Kandivali (West)
		Ram Nagar, Kandivali (East)
S	Ekveera Nagar, Kanjur (E)	Fitwel Industries, L.B.S. Marg, Vikhroli (W)

Ward	Flood prone slum areas	Other flood prone low lying areas and roads
	Jai Santoshi Mata Nagar, near last Bust Stop of Bust No. 353, Vikhoroli (E)	Junction of Vikhoroli-Jogeshware Link Road and L.B.S. Marg, Gandhi Nagar Junction.
	Haryali Village. Vikhroli (E)	Opp. Kanjur Railway Station (W), Laxmi Udyog Bhavan.
		Opp. Bombay Oil Mill, L.B.S. Marg, Bhandup (W)
		Maharashtra Nagar, Quarry Road, Bhandup (W)
		Along Kokan Nagar, near Culvert, Bhandup (West)
		Gamdevi Road and Khot Road Junction, Bhandup (W).
		Bhattipada, National High School, Bhandup (W)
		Kastury Vidyalaya, Village Road, Bhandup (W)
		Usha Nagar, Village Road, Bhandup (W)
		Subway, Filterpada, Powai Near Powai Garden.
		Jolly Board Co. near Mansukh Dyeing Co., Kanjur (E).
T	Ashok Nagar, Sarojini Naidu Road, Mulund (West)	Subway Across Central Railway Tracks at Mulund
	Lande wadi, Opp. Dindayal Upadhayaya Marg, Mulund (W)	Sarojini Naidu Road, near Shanti Industrial Estate, Mulund (West)
	Gavanpada Gaothan, Near Mukund Society, Mulund (East)	Landewadi, Mulund (West)
	Nanepada Gaothan, Opp. Nandepada Road, Mulund (E)	Railway Station, Mulund (East & West Side)

ANNEXURE : 4		PAGE 16
Ward	**Flood prone slum areas**	**Other flood prone low lying areas and roads**
		Panch Rasta Jn., Mulund (West)
		Devidayal Road, Mulund (West)
		P.K. Road, Mulund (West)
		Indira Steel Yard, Mulund (West)

	FACT FINDING COMMITTEE ON MUMBAI FLOODS
	CHRONIC FLOODING SPOTS ON CORRIDORS IN ISLAND CITY, EASTERN & WESTERN SUBURBS
	ANNEXURE 5 **PAGE 1**

SR. NO	ZONE	NAME OF THE CORRIDOR	LOCATION
1.	**2.**	**3.**	**4.**
		Railway	
1.	Island City	Central Railway	Masjid Bunder
2.			Byculla
3.			Sion
4.			Chunabhatti
5.		Western Railway	Grant Road
6.			Mumbai Central
7.			Lower Parel
		Roads	
8.	Island City	Eastern Corridor from Museum to Sion (J.J.Flyover, Babasaheb Ambedkar Road route)	Dadar T.T.
9.			Hindmata
10.			B.A.Road ,Jn. Dattaram Lad Marg.
11.			B.A.Road, Byculla to Lalbaug
12.			B.A. Road, .J.J. Hospital
13.		P.D'mello Road / Barrister Nath Pai / Rafi Ahmed Kidwai Marg (Ballard Estate to Wadala route).	Between Wadala and Sewree.
		Roads	
14.	Western Suburbs	Western Express Highway	Anand Nagar, Santacruz
15.			Mahananda Dairy, Goregoan.
16.		Swami Vivekanand Road	Jn Khar Subway Road.
17.			Khira Nagar
18.			Jn. Milan Subway Road.
19.			Jn. Andheri Subway Road.
20.			Jn. Vaikunthlal Mehta Road
21.			Behram Baug, Jogeshwari.
22.			Piramal Nagar, Malad
23.			Near Malad Shopping Centre
24.			Near N.L.High School
25.			Near Fire Station, Kandivali
26.			Near Sony Mony, Borivali(W).

	ANNEXURE 5	**PAGE 2**

1.	2.	3.	4.
27.		Linking Road	Anna Bhau Udyan, Andheri.
28.			Kaju Pada Jn. , Jogeshwari
29.			Chincholi Bunder
30.			Guria Pada, Malad.
31.			Dahnukar Wadi, Kandivali.
		Railway	
32.	Eastern Suburbs	Central Railway	Kurla Stn.
33.			Vidya Vihar, near Fatima School
34.			Bhandup Station
		Roads	
35.	Eastern Suburbs	Lal Bahadur Shastri Marg	Between Kalpana cinema and Sheetal cinema, Kurla
36.			Near Naval Dock Yard, Ghatkopar
37.			Near Nirmal Life style, Mulund.

THE WORKS OF AUGMENTING/ IMPROVEMENT/ REMODELLING/ REHABILITTAION OF SWD IN CITY AND SUBURBS ARE IDENTIFIED IN BRIMSTOWAD REPORT. IN THE CHAPTER "TRANSPORT" THE GUIDELINES ARE GIVEN FOR THE APPROACH TO BE ADOPTED FOR CROSS DRAINAGE WORKS FOR MAJOR CORRIDORS. MCGM SHALL REVIEW ALL THOSE WORKS INCLUDING THOSE ON DOWN STREAM SIDE OF SWD FROM THE CORRIDDORS.

SWD works to be carried out by MCGM at priority

1) Widening of Nehru Nagar Nalla / Mahul Creek arm downstream of Eastern Express Highway by demolishing ground floor structure encroaching water way in the premise of Vasantdada Patil Polytechnique.
2) Widening of entire stretch of Nehru Nagar nalla / Mahul Creek arm from Eastern Express Highway to Mumbai Port Trust culvert. Wherever trapezoidal sections with pitching are recommended, the widening of untrained waterway should be to done to have clear bottom width equal to top width recommended with pitching. Deeping / desilting of this stretch to be done as per levels recommended in BRIMSTOWAD.
3) Thorough desilting of Highway culvert connecting Duncan Causeway nalla to Peripheral Nalla, if necessary using a appropriate machinery
4) Widening of culvert of Sommaiya peripheral nalla under Anik-Wadala Road to prescribed section to be completed prior to monsoon 2007.
5) Regarding of Duncan Causeway nalla to drain flow from area of Ambekar Nagar and Pramukh Swami Eye Hospital, Chunabhatti to Nehru Nagar nalla prior to monsoon 2007.
6) Augmenting culvert of Nehru Nagar nalla / Mahul Creek arm under Bombay-II Main on priority preferably prior to monsoon 2006 in any case prior to monsoon 2007.
7) Study of stretch of Mahul Creek downstream of B.P.T. culvert to check rectifications if any required.
8) Restoring storm water channel in MMRDA region & Study of storm water drainage network in Kalina Area upto discharge points in Mithi River to check rectifications wherever required
9) Modification of pipe culvert of Usha Nagar nalla under Mulund Goregaon Link Road.

10) The Catchment of Irla nullah south of V.M. Road including Milan Subway and the LIC colony, should be diverted to SNDT nullah by constructing a new nullah across the airport land.

    Construct a new nullah joining Irla nullah and SNDT nullah of 10m width and 2.1 m depth and a length of 760 m through airport land as proposed in BRIMSTOWAD.
11) Rehabilation of dilapidated drain in City as identified in BRIMSTOWAD report.
12) Diversion of storm water from catchment 125 Hindamata, Parel area, to catchment 129 via J. Shankar Marg.
13) Diversion of Storm water from Sane Guruji Marg via Body Guard lane.

	FACT FINDING COMMITTEE ON MUMBAI FLOODS
	UPSTREAM STORAGES IN MITHI BASIN - VIHAR & POWAI LAKES
	ANNEXURE : 7 **PAGE 1**

Vihar Lake

FSL	=	80.68 M THD (264.75’)
Catchment Area	=	18.96 sq.km. (7.32 sq.miles)
Water Spread at FSL	=	7.26 sq.km. (2.81 sq.miles)
Contents at FSL	=	41768000 CuM
	=	18.16 ML/CuM
Contents of 0.6 m (2’)	=	1816000 CuM
At FSL contents	=	5753000 CuM/ Sq.Km.
Length of spillway	=	107.9 M (354’)
Add. Storage with 2’ gate	=	1.816 Million CuM.(Million Cubic Metre) ….(A)

Powai Lake

FSL	=	59.44 m. THD (195’)
Catchment Area	=	6.61 sq.km.
Water spread at FSL	=	2.23 sq.km.
Contents at FSL	=	5448000 CuM
	=	4.58 ML/CuM
Contents of 0.6 M (2’)	=	917000 CuM
At FSL contents	=	2443000 CuM/Sq.Km.
Length of spillway	=	176.78 M (580’)
Addl. Storage with 2’ gate	=	0.917 Million CuM ….(B)

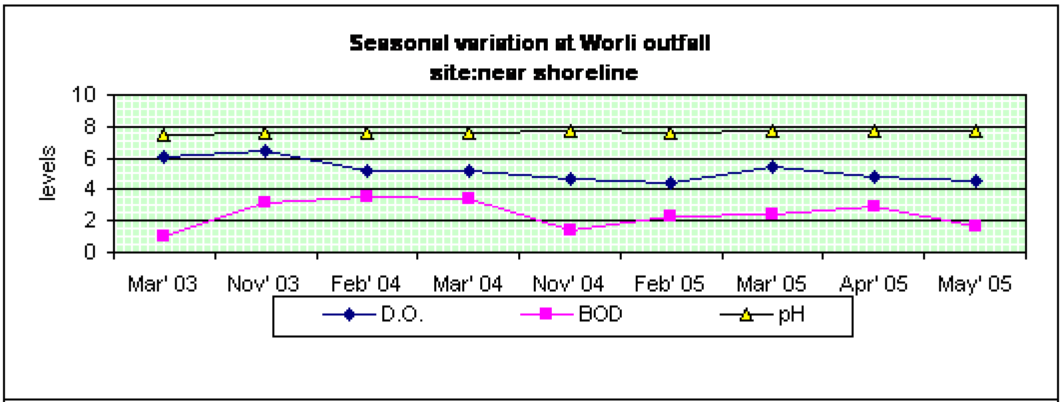
Total Contents = A + B = 1.816000 + 0.917000 = 2.733 M Cu M

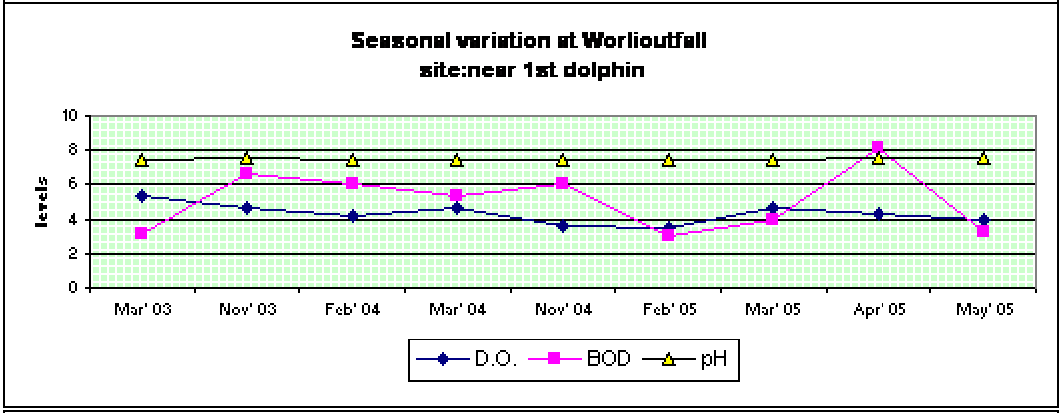
Note : i) The run off with 1 : 10 return is of the order of 4.7 M Cu. M in one hour.
ii) The run off with 1 : 25 return is of the order of 5.74 M Cu. M in one hour.
iii) The run off with 1 : 100 return is of the order of 6.72 M Cu M in one hour.

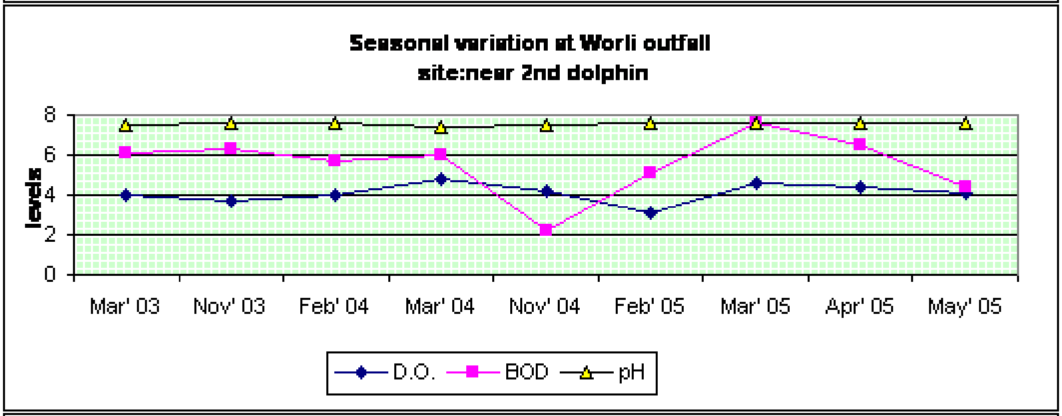
	FACT FINDING COMMITTEE ON MUMBAI FLOODS			
	WATER QUALITY AT THE COAST : WORLI			
	ANNEXURE : 8 PAGE : W1			
Site	Mon/Yr.	D.O.	BOD	pH
1km away shore line	Mar' 03	6.1	1.0	7.5
1km away shore line	Nov' 03	6.5	3.2	7.6
1km away shore line	Feb' 04	5.2	3.5	7.6
1km away shore line	Mar' 04	5.2	3.4	7.6
1km away shore line	Nov' 04	4.7	1.4	7.7
1km away shore line	Feb' 05	4.4	2.3	7.6
1km away shore line	Mar' 05	5.4	2.4	7.7
1km away shore line	Apr' 05	4.8	2.9	7.7
1km away shore line	May' 05	4.5	1.7	7.7
1st dolphin pt.	Mar' 03	5.4	3.1	7.5
1st dolphin pt.	Nov' 03	4.6	6.6	7.6
1st dolphin pt.	Feb' 04	4.2	6.0	7.5
1st dolphin pt.	Mar' 04	4.7	5.4	7.4
1st dolphin pt.	Nov' 04	3.6	6.1	7.4
1st dolphin pt.	Feb' 05	3.5	3.0	7.5
1st dolphin pt.	Mar' 05	4.6	4.0	7.5
1st dolphin pt.	Apr' 05	4.3	8.1	7.6
1st dolphin pt.	May' 05	4	3.2	7.6
2nd dolphin pt.	Mar' 03	4.0	6.1	7.5
2nd dolphin pt.	Nov' 03	3.7	6.3	7.6
2nd dolphin pt.	Feb' 04	4.0	5.7	7.6
2nd dolphin pt.	Mar' 04	4.8	6.0	7.4
2nd dolphin pt.	Nov' 04	4.2	2.2	7.5
2nd dolphin pt.	Feb' 05	3.1	5.1	7.6
2nd dolphin pt.	Mar' 05	4.6	7.6	7.6
2nd dolphin pt.	Apr' 05	4.4	6.5	7.6
2nd dolphin pt.	May' 05	4.1	4.4	7.6
Midway	Mar' 03	5.8	3.3	7.5
Midway	Nov' 03	4.6	5.9	7.5
Midway	Feb' 04	4.1	4.2	7.5
Midway	Mar' 04	4.9	5.8	7.5
Midway	Nov' 04	3.9	1.5	7.6
Midway	Feb' 05	3.9	2.6	7.5
Midway	Mar' 05	4.8	6.0	7.6
Midway	Apr' 05	4.4	7.0	7.6
Midway	May' 05	4.2	2.9	7.6
Avg.		4.5	4.34	7.6
Max		6.5	8.1	7.7
Min		3.1	1.0	7.4

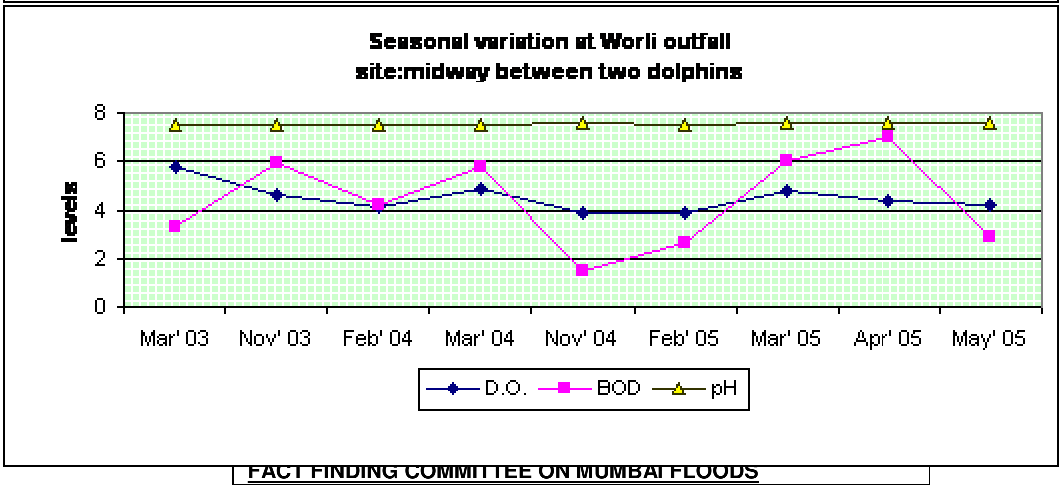
CPCB Norms

D.O.	= 3.0 mg/l min
B.O.D	= 5.0 mg/l min
pH	= 6.5 to 8.5


Seasonal variation at Worli outfall
site:near shoreline
levels
10
8
6
4
2
0
Mar' 03
Nov' 03
Feb' 04
Mar' 04
Nov' 04
Feb' 05
Mar' 05
Apr' 05
May' 05
D.O.
BOD
pH


Seasonal variation at Worlioutfall
site:near 1st dolphin
levels
10
8
6
4
2
0
Mar' 03
Nov' 03
Feb' 04
Mar' 04
Nov' 04
Feb' 05
Mar' 05
Apr' 05
May' 05
D.O.
BOD
pH


Seasonal variation at Worli outfall
site:near 2nd dolphin
levels
8
6
4
2
0
Mar' 03
Nov' 03
Feb' 04
Mar' 04
Nov' 04
Feb' 05
Mar' 05
Apr' 05
May' 05
D.O.
BOD
pH


Seasonal variation at Worli outfall
site:midway between two dolphins
levels
8
6
4
2
0
Mar' 03
Nov' 03
Feb' 04
Mar' 04
Nov' 04
Feb' 05
Mar' 05
Apr' 05
May' 05
D.O.
BOD
pH

WATER QUALITY AT THE COAST : COLABA	
ANNEXURE : 8	PAGE : C1

Site	Mon/Yr.	D.O.	BOD	pH
1km away shore line	Dec' 04	5.7	0.75	7.9
1km away shore line	Jan' 05	5.55	1.11	7.9
1km away shore line	Feb'05	5	1.4	7.8
1km away shore line	Mar' 05	5.37	0.77	7.7
1km away shore line	Apr' 05	4.56	1.2	7.7
1km away shore line	May' 05	4.78	1.61	7.8
1st dolphin pt.	Dec' 04	5.22	1.8	7.8
1st dolphin pt.	Jan' 05	5.1	3.36	7.6
1st dolphin pt.	Feb'05	4.28	6	7.7
1st dolphin pt.	Mar' 05	4.91	2.8	7.6
1st dolphin pt.	Apr' 05	4.04	2.7	7.7
1st dolphin pt.	May' 05	4.28	2.61	7.6
2nd dolphin pt.	Dec' 04	5.3	2.6	7.8
2nd dolphin pt.	Jan' 05	5	2.48	7.7
2nd dolphin pt.	Feb'05	4.12	6.1	7.8
2nd dolphin pt.	Mar' 05	4.96	2.58	7.6
2nd dolphin pt.	Apr' 05	4.12	3	7.7
2nd dolphin pt.	May' 05	4.3	2.16	7.6
Midway	Dec' 04	5.19	4.5	7.8
Midway	Jan' 05	5.04	2.48	7.7
Midway	Feb'05	4.15	6.4	7.8
Midway	Mar' 05	4.97	1.3	7.6
Midway	Apr' 05	4.1	3.2	7.7
Midway	May' 05	4.53	1.92	7.5
Avg.		4.8	2.70125	7.7
Max		5.7	6.4	7.9
Min		4.04	0.8	7.5

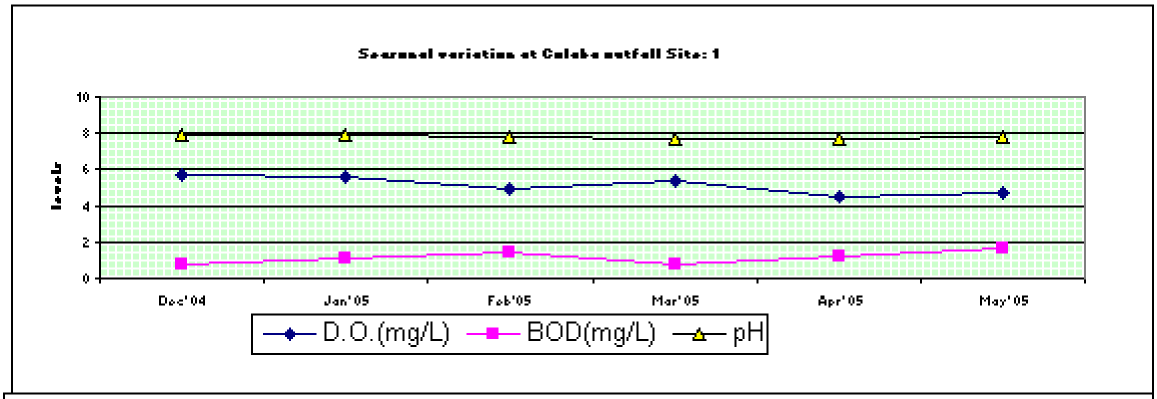
CPCB Norms

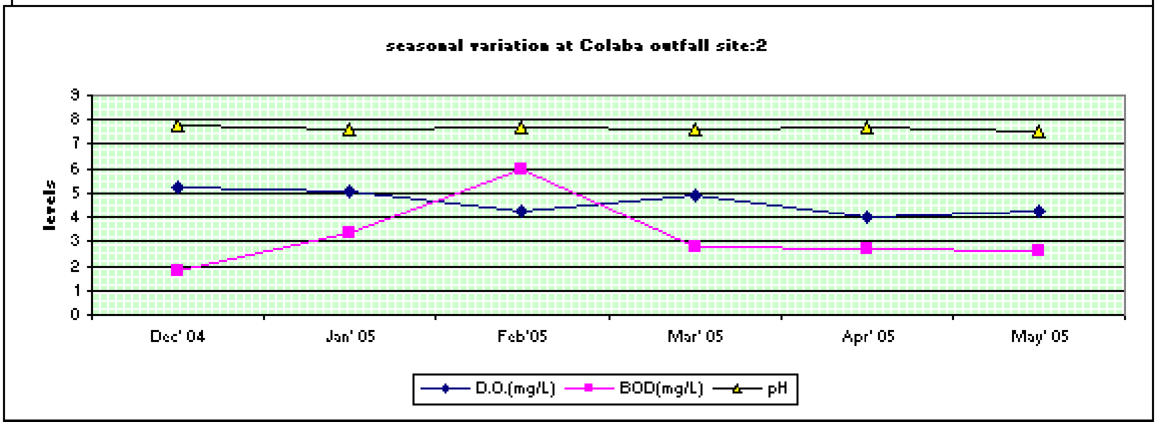
D.O.	= 3.0 mg/l min
B.O.D	= 5.0 mg/l min
pH	= 6.5 to 8.5

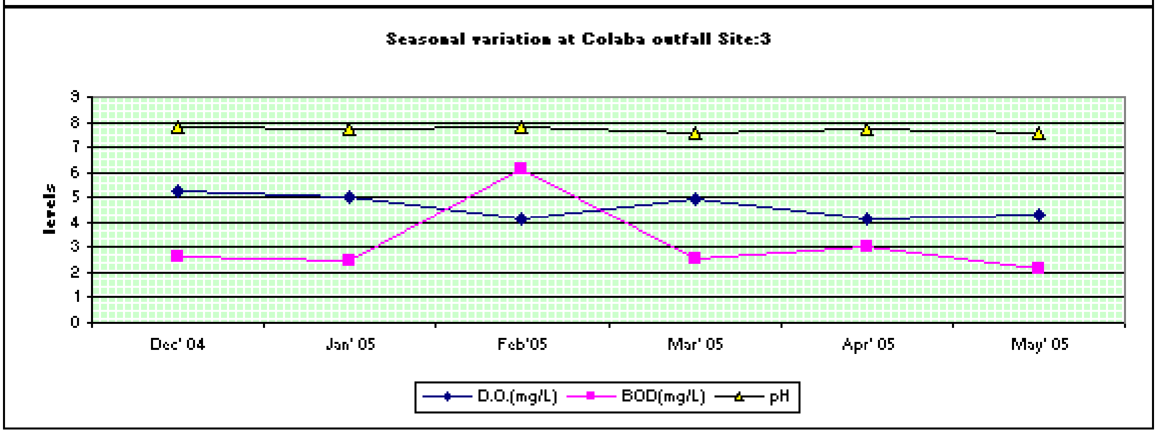
FACT FINDING COMMITTEE ON MUMBAI FLOODS

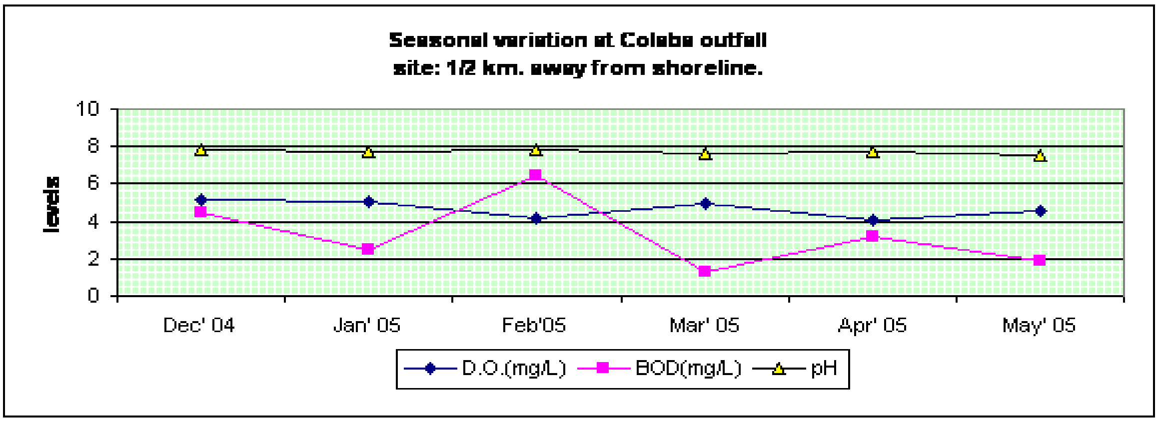
GRAPHICAL REPRESENTATION OF WATER QUALITY AT THE COAST : COLABA

ANNEXURE : 8 **PAGE : C2**









	FACT FINDING COMMITTEE ON MUMBAI FLOODS **WATER QUALITY AT THE COAST : BANDRA** **ANNEXURE : 8 PAGE : B1**

Site	Mon/Yr.	D.O.(mg/L)	BOD(mg/L)	pH
1km away shore line	Nov' 03	4.8	6.6	7.6
1km away shore line	Feb' 04	5	3.4	7.6
1km away shore line	Mar' 04	4.9	3.7	7.5
1km away shore line	Nov' 04	4.26	3.88	7.6
1km away shore line	Feb' 05	4.62	2.77	7.7
1km away shore line	Mar' 05	5.42	2.1	7.6
1km away shore line	Apr' 05	4.93	2.29	7.7
1km away shore line	May' 05	4.72	0.72	7.7
1st dolphin pt.	Nov' 03	2.9	12.8	7.5
1st dolphin pt.	Feb' 04	3.4	6.0	7.5
1st dolphin pt.	Mar' 04	4.1	4.6	7.4
1st dolphin pt.	Nov' 04	3.63	5.92	7.4
1st dolphin pt.	Feb' 05	4.23	9.1	7.6
1st dolphin pt.	Mar' 05	4.38	19.0	7.4
1st dolphin pt.	Apr' 05	4.23	8.26	7.6
1st dolphin pt.	May' 05	4.12	7.09	7.5
2nd dolphin pt.	Nov' 03	2.9	7.2	7.4
2nd dolphin pt.	Feb' 04	3.3	5.6	7.4
2nd dolphin pt.	Mar' 04	4.3	5.4	7.4
2nd dolphin pt.	Nov' 04	3.43	2.96	7.5
2nd dolphin pt.	Feb' 05	3.91	7.27	7.6
2nd dolphin pt.	Mar' 05	4.41	19.2	7.4
2nd dolphin pt.	Apr' 05	4.5	8.6	7.5
2nd dolphin pt.	May' 05	4.2	2.84	7.5
Midway	Nov' 03	3.6	14	7.5
Midway	Feb' 04	3.8	4.7	7.4
Midway	Mar' 04	4.3	6.6	7.4
Midway	Nov' 04	3.45	3.06	7.5
Midway	Feb' 05	4.02	9.4	7.5
Midway	Mar' 05	7.49	7.4	7.4
Midway	Apr' 05	4.35	7.5	7.6
Midway	May' 05	4.06	2.95	7.5
Avg.		4.2	6.65	7.5
Max		7.49	19.2	7.7
Min		2.9	0.7	7.4

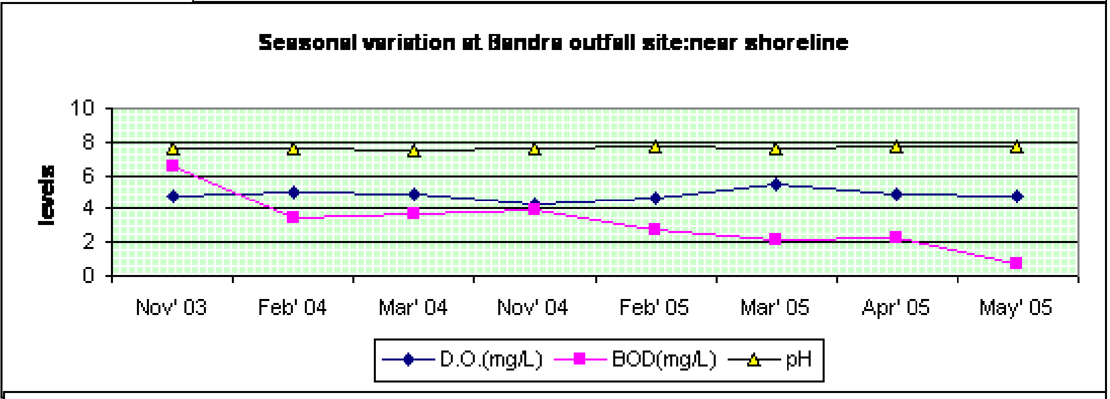
CPCB Norms

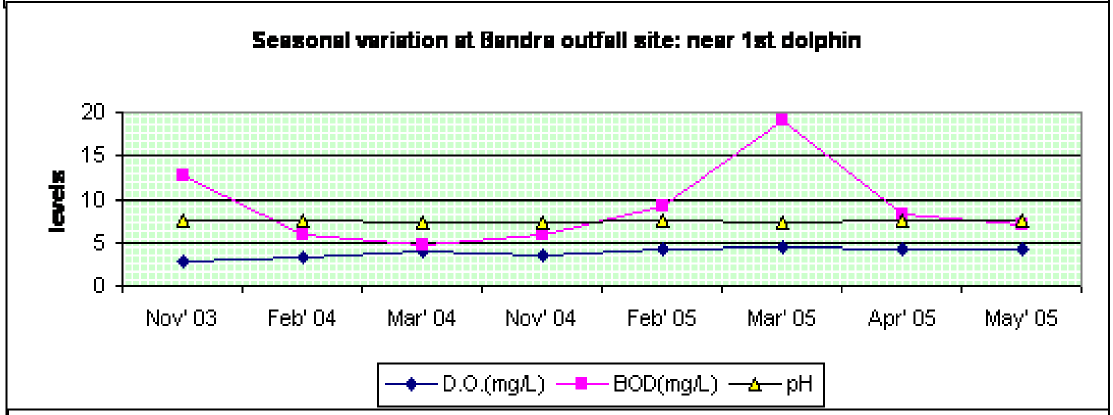
D.O.	= 3.0 mg/l min
B.O.D	= 5.0 mg/l min
pH	= 6.5 to 8.5

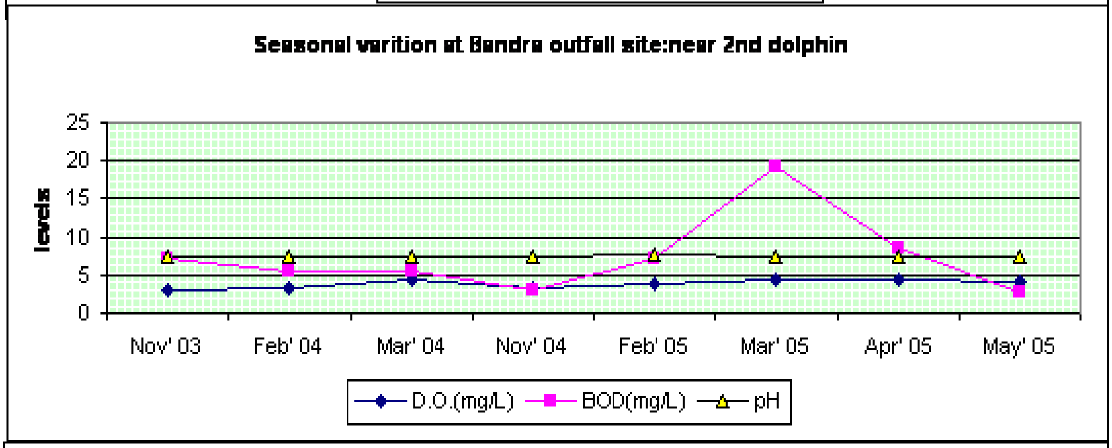
FACT FINDING COMMITTEE ON MUMBAI FLOODS

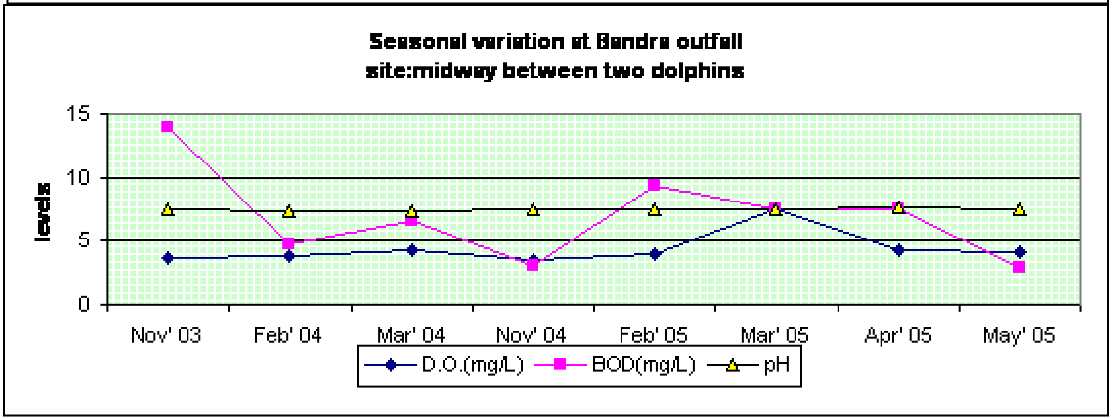
GRAPHICAL REPRESENTATION OF WATER QUALITY AT THE COAST : BANDRA

ANNEXURE : 8 PAGE : B2



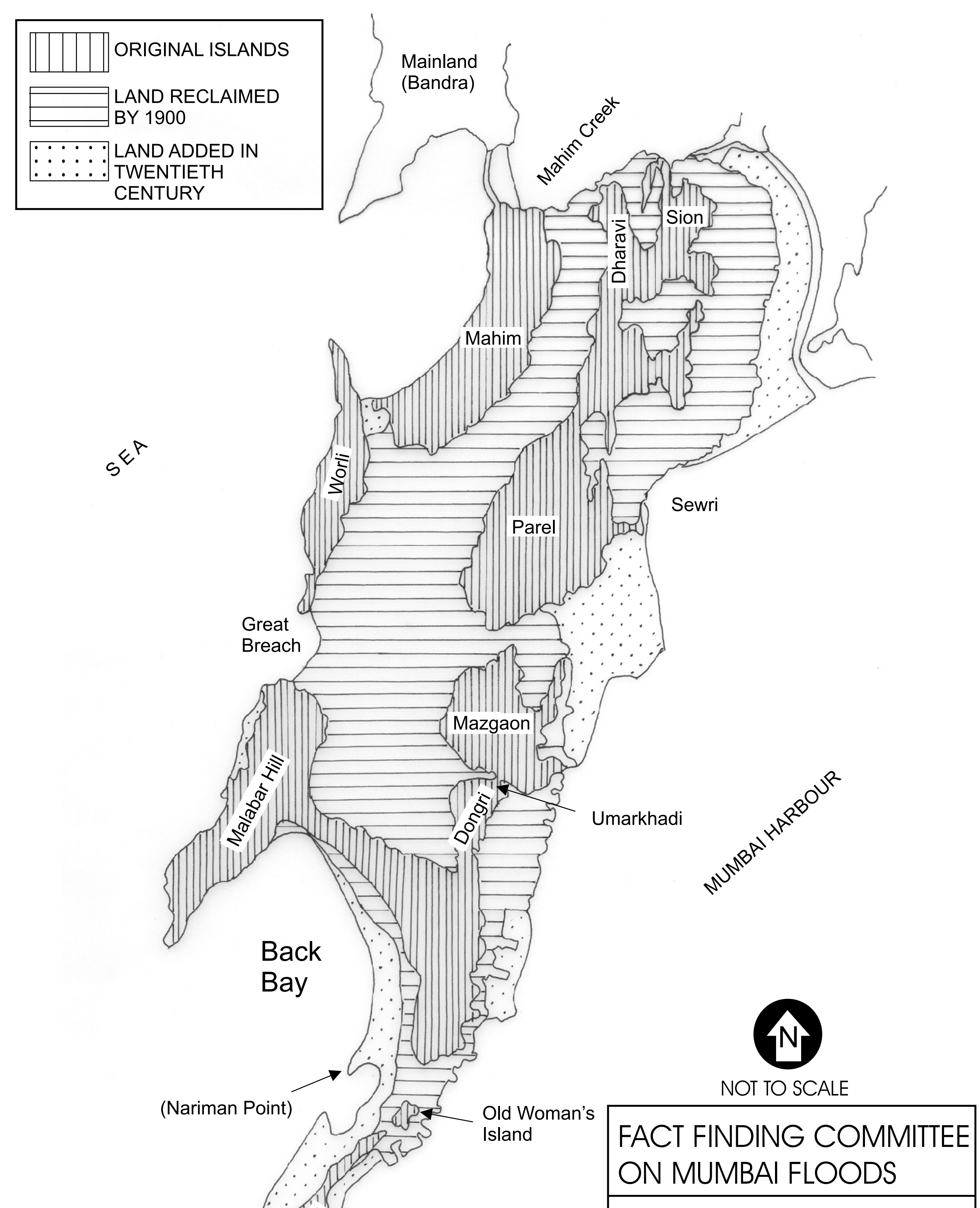






DRAWINGS

INDEX- DRAWINGS

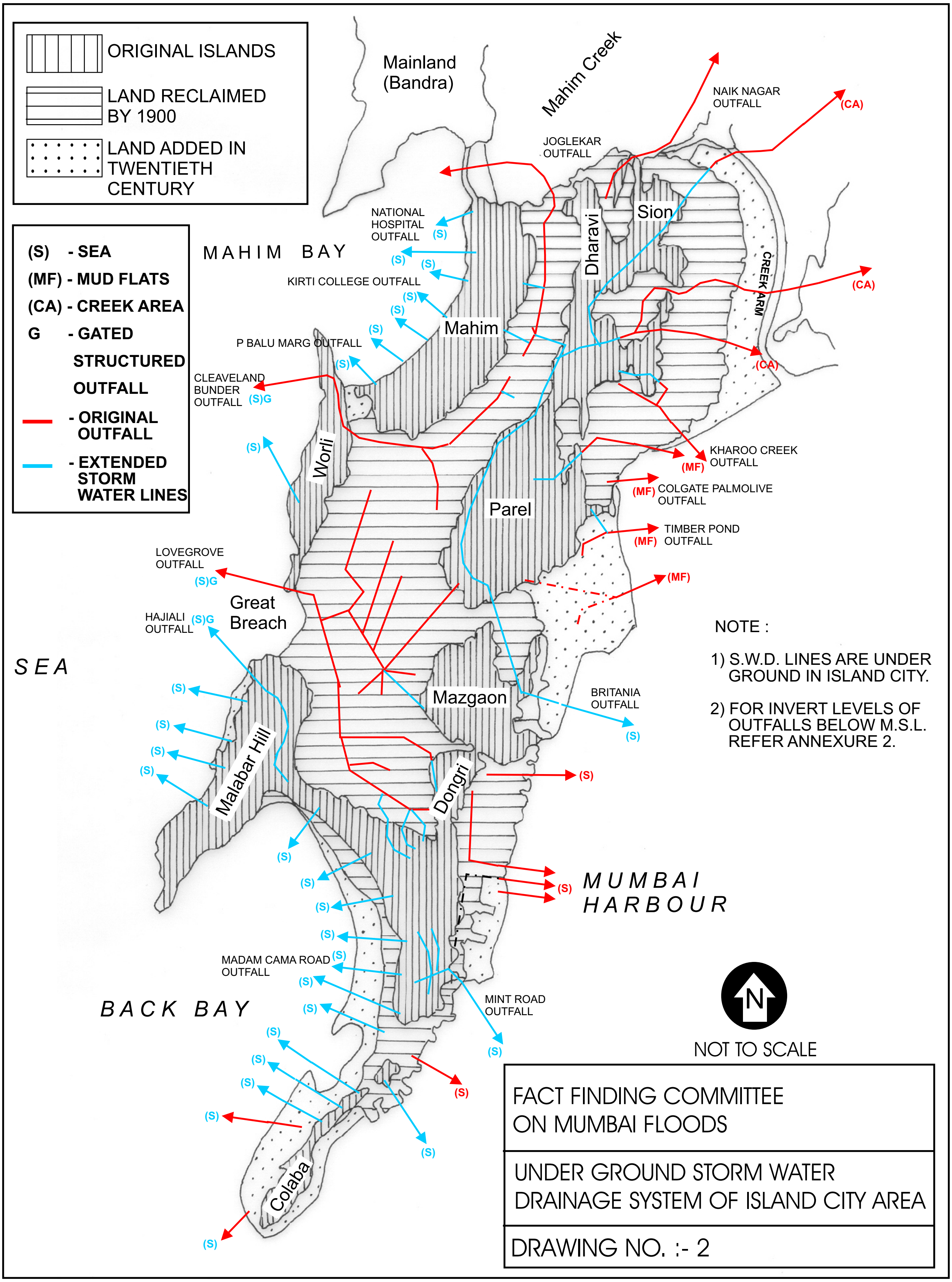


FACT FINDING COMMITTEE ON MUMBAI FLOODS

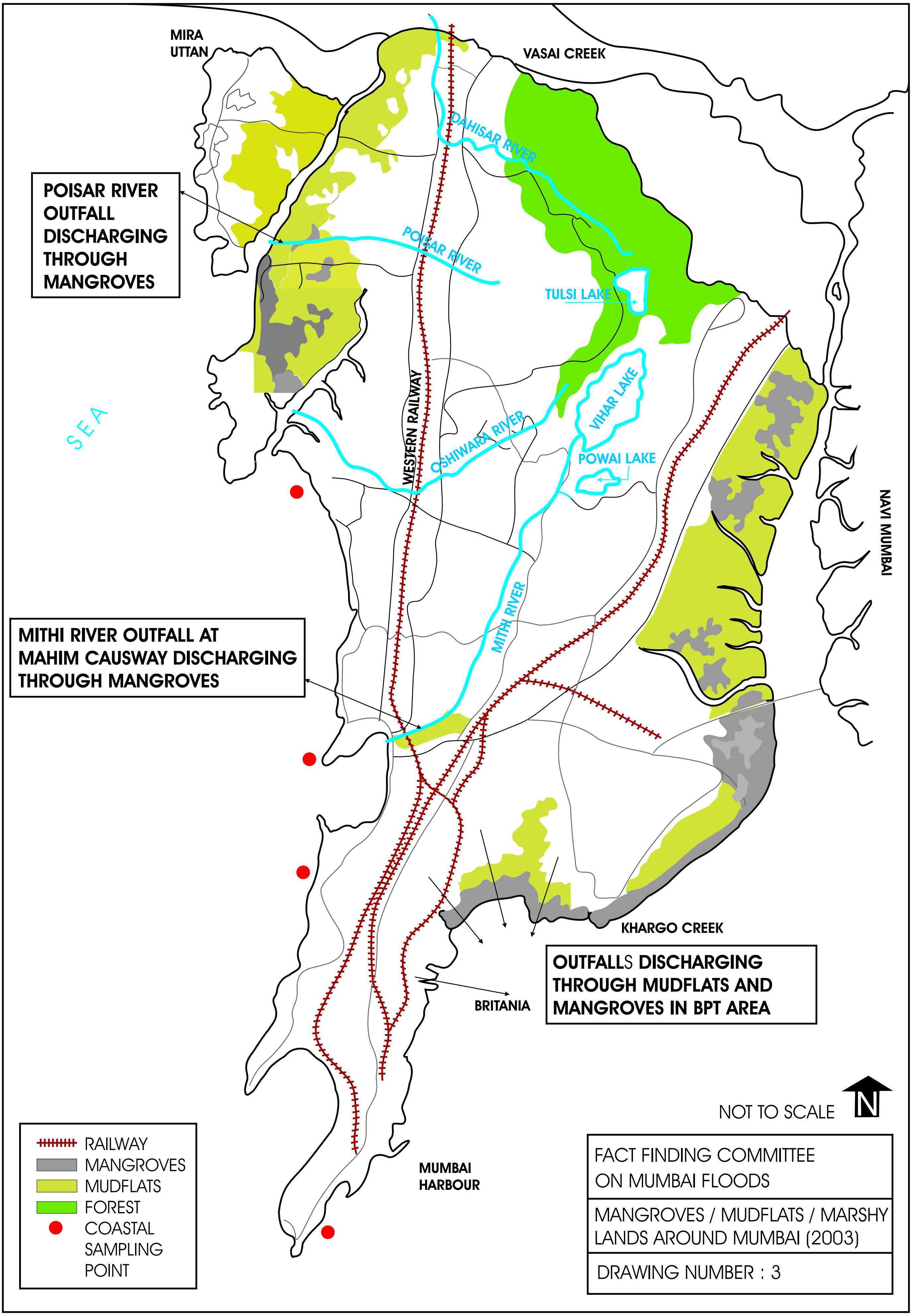
MAP SHOWING ORIGINAL SEVEN ISLANDS AND SUBSEQUENT PHYSICAL GROWTH OF MUMBAI

DRAWING NO :- 1

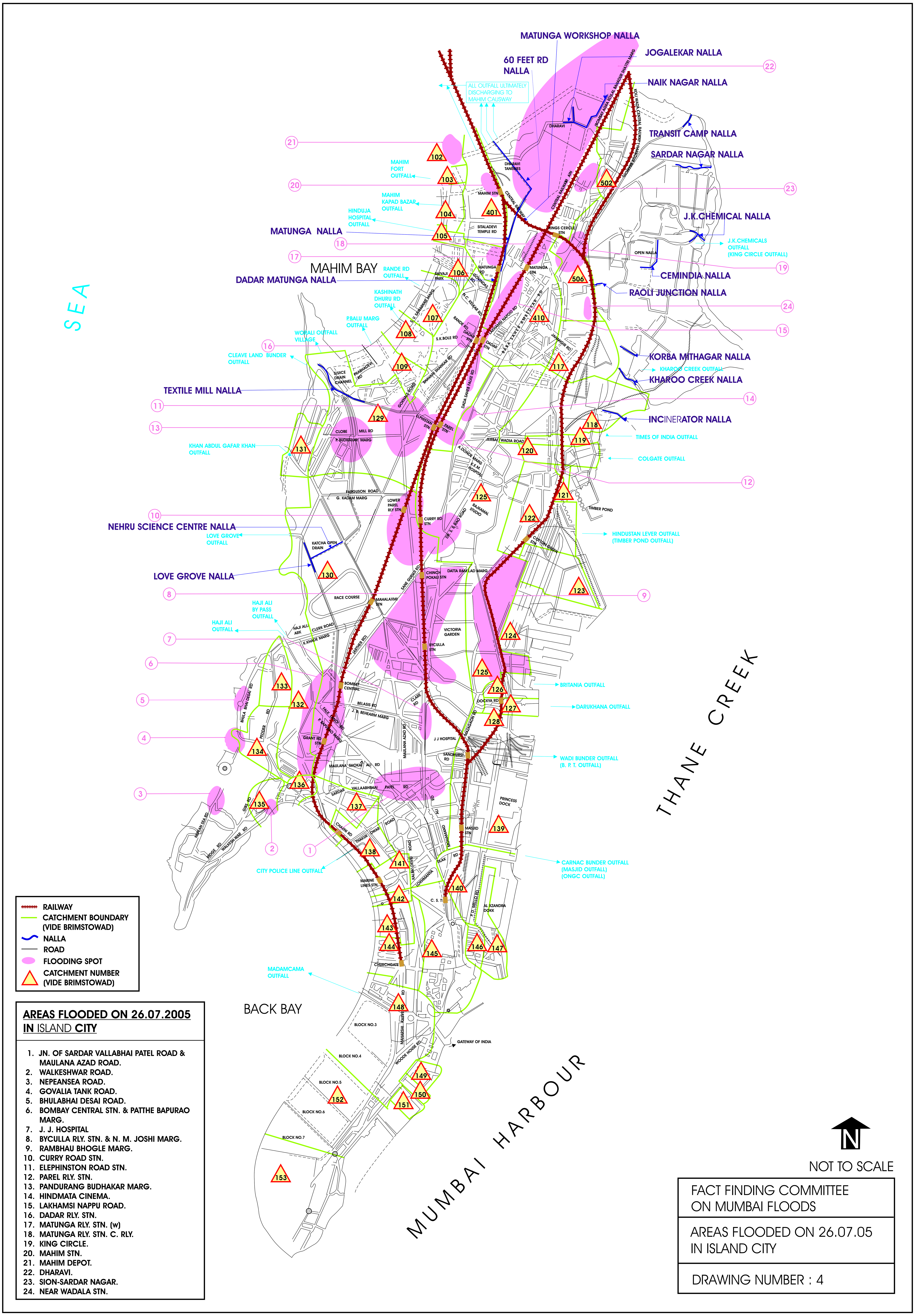
Reference - Gazetteer of India, Maharashtra State, History of Bombay, Modern Period 1987



Reference - Gazetteer of India, Maharashtra State, History of Bombay, Modern Period 1987



NOTE : This drawing being small may not show all the patches of vegetation, mangroves, forest & mudflats
This is only an indicative drawing.



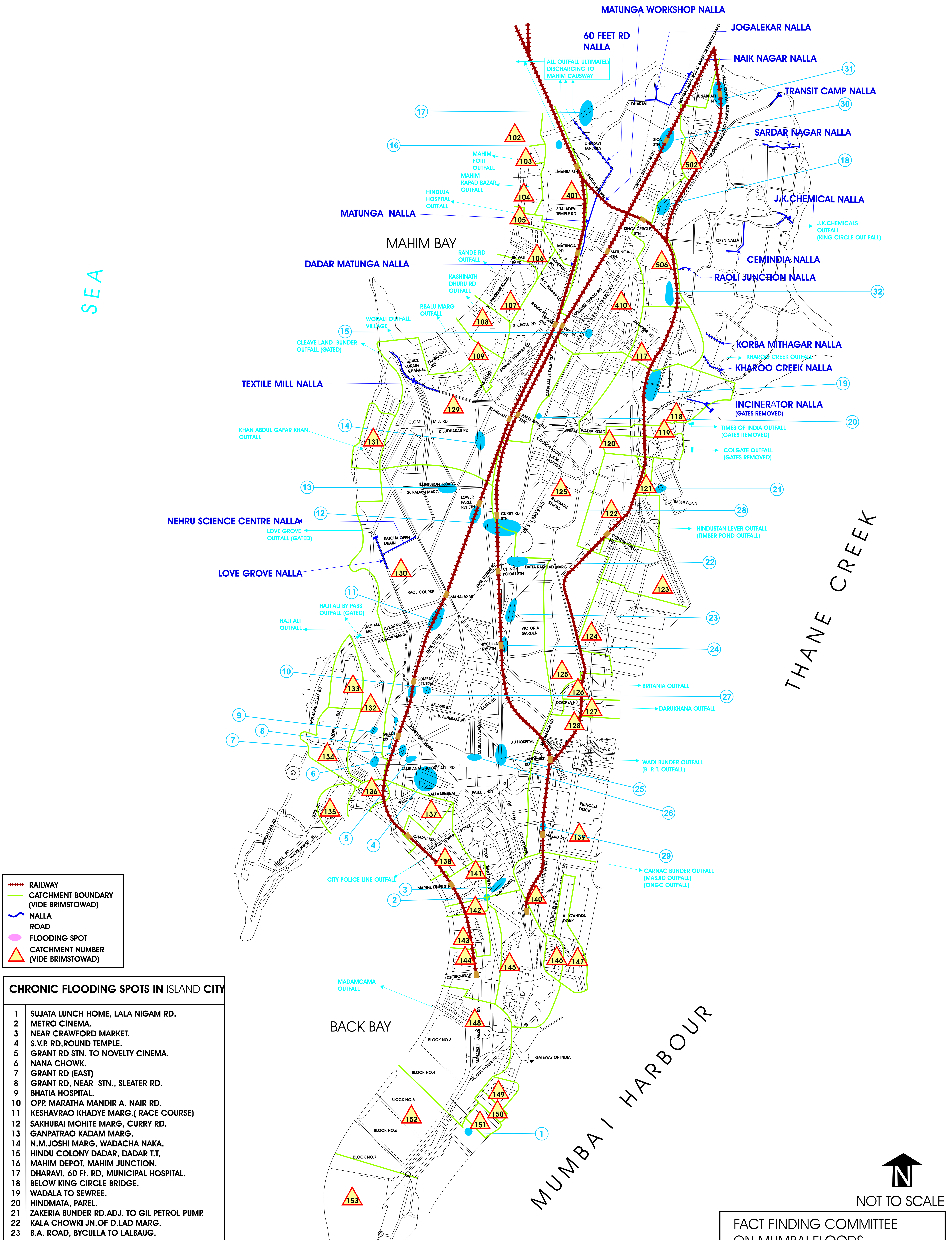
AREAS FLOODED ON 26.07.2005 IN ISLAND CITY

1. JN. OF SARDAR VALLABHAI PATEL ROAD & MAULANA AZAD ROAD.
2. WALKESHWAR ROAD.
3. NEPEANSEA ROAD.
4. GOVALIA TANK ROAD.
5. BHULABHAI DESAI ROAD.
6. BOMBAY CENTRAL STN. & PATTHE BAPURAO MARG.
7. J. J. HOSPITAL
8. BYCULLA RLY. STN. & N. M. JOSHI MARG.
9. RAMBHAU BHOGLE MARG.
10. CURRY ROAD STN.
11. ELEPHINSTON ROAD STN.
12. PAREL RLY. STN.
13. PANDURANG BUDHAKAR MARG.
14. HINDMATA CINEMA.
15. LAKHAMSI NAPPU ROAD.
16. DADAR RLY. STN.
17. MATUNGA RLY. STN. (w)
18. MATUNGA RLY. STN. C. RLY.
19. KING CIRCLE.
20. MAHIM STN.
21. MAHIM DEPOT.
22. DHARAVI.
23. SION-SARDAR NAGAR.
24. NEAR WADALA STN.

FACT FINDING COMMITTEE ON MUMBAI FLOODS

AREAS FLOODED ON 26.07.05 IN ISLAND CITY

DRAWING NUMBER : 4



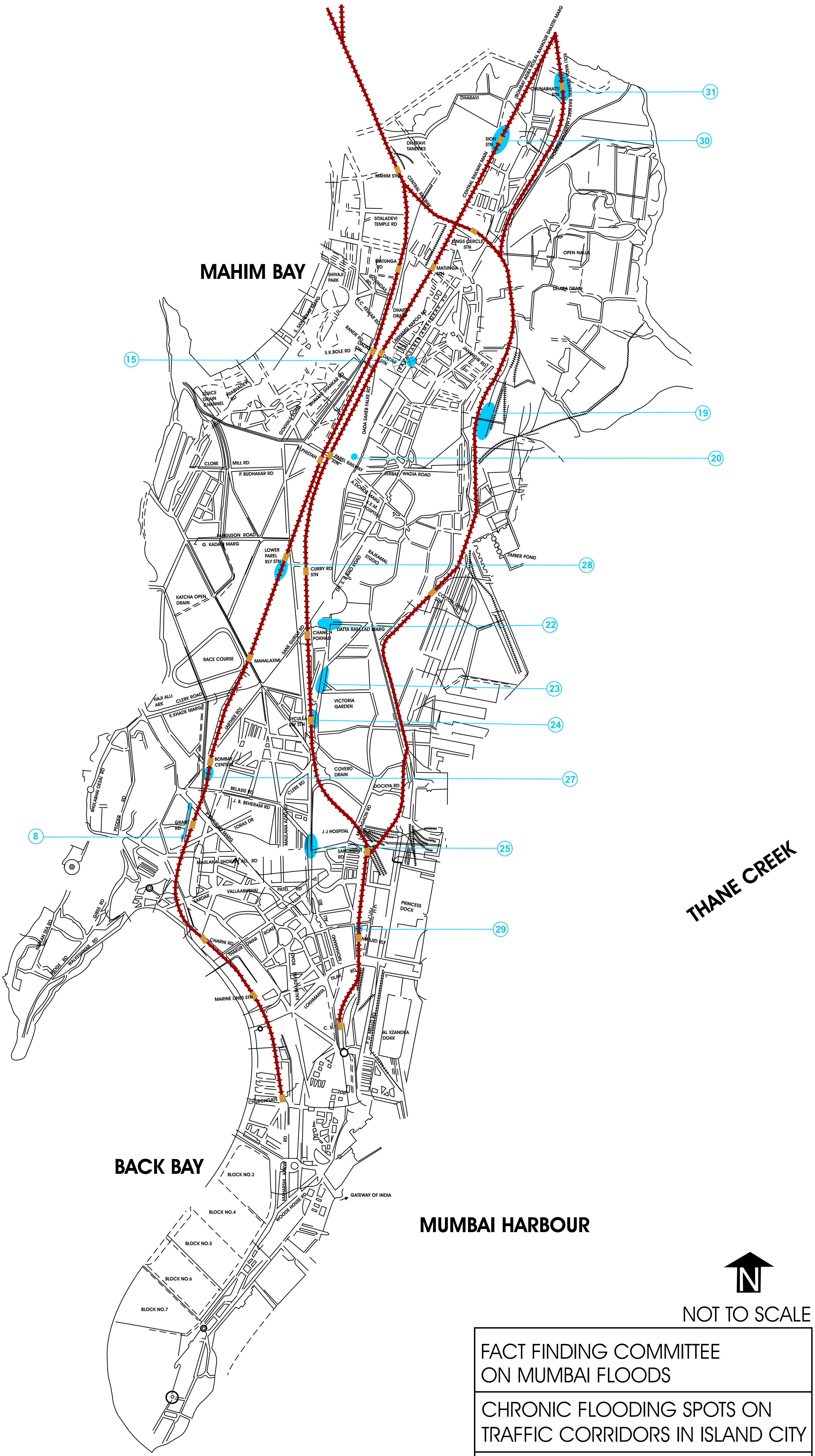
CHRONIC FLOODING SPOTS IN ISLAND CITY

1	SUJATA LUNCH HOME, LALA NIGAM RD.
2	METRO CINEMA.
3	NEAR CRAWFORD MARKET.
4	S.V.P. RD,ROUND TEMPLE.
5	GRANT RD STN. TO NOVELTY CINEMA.
6	NANA CHOWK.
7	GRANT RD (EAST)
8	GRANT RD, NEAR STN., SLEATER RD.
9	BHATIA HOSPITAL.
10	OPP. MARATHA MANDIR A. NAIR RD.
11	KESHAVRAO KHADYE MARG.(RACE COURSE)
12	SAKHUBAI MOHITE MARG, CURRY RD.
13	GANPATRAO KADAM MARG.
14	N.M.JOSHI MARG, WADACHA NAKA.
15	HINDU COLONY DADAR, DADAR T.T,
16	MAHIM DEPOT, MAHIM JUNCTION.
17	DHARAVI, 60 Ft. RD, MUNICIPAL HOSPITAL.
18	BELOW KING CIRCLE BRIDGE.
19	WADALA TO SEWREE.
20	HINDMATA, PAREL.
21	ZAKERIA BUNDER RD.ADJ. TO GIL PETROL PUMP.
22	KALA CHOWKI JN.OF D.LAD MARG.
23	B.A. ROAD, BYCULLA TO LALBAUG.
24	BYCULLA RLY. STN.
25	J.J.HOSPITAL .
26	TWO TANK J.J.HOSPITAL, CAFFE PARADISE HOTEL.
27	MUMBAI CENTRAL RLY. STN.
28	LOWER PAREL RLY. STN.
29	MASJID RLY. STN.
30	SION RLY. STN.
31	CHUNNA BHATTI RLY. STN.
32	NEAR WADALA STN.

FACT FINDING COMMITTEE ON MUMBAI FLOODS

CHRONIC FLOODING SPOTS IN ISLAND CITY

DRAWING NUMBER : 5



RAILWAY
FLOODING SPOT

CHRONIC FLOODING SPOTS

8	GRANT RD, NEAR STN., SLEATER RD.
15	HINDU COLONY DADAR, DADAR T.T.
19	WADALA TO SEWREE.
20	HINDMATA, PAREL.
22	KALA CHOWKI JN.OF D.LAD MARG.
23	B.A. ROAD, BYCULLA TO LALBAUG.
24	BYCULLA RLY. STN.
25	J.J.HOSPITAL .
27	MUMBAI CENTRAL RLY. STN.
28	LOWER PAREL RLY. STN.
29	MASJID RLY. STN.
30	SION RLY. STN.
31	CHUNNA BHATTI RLY. STN.

FACT FINDING COMMITTEE ON MUMBAI FLOODS

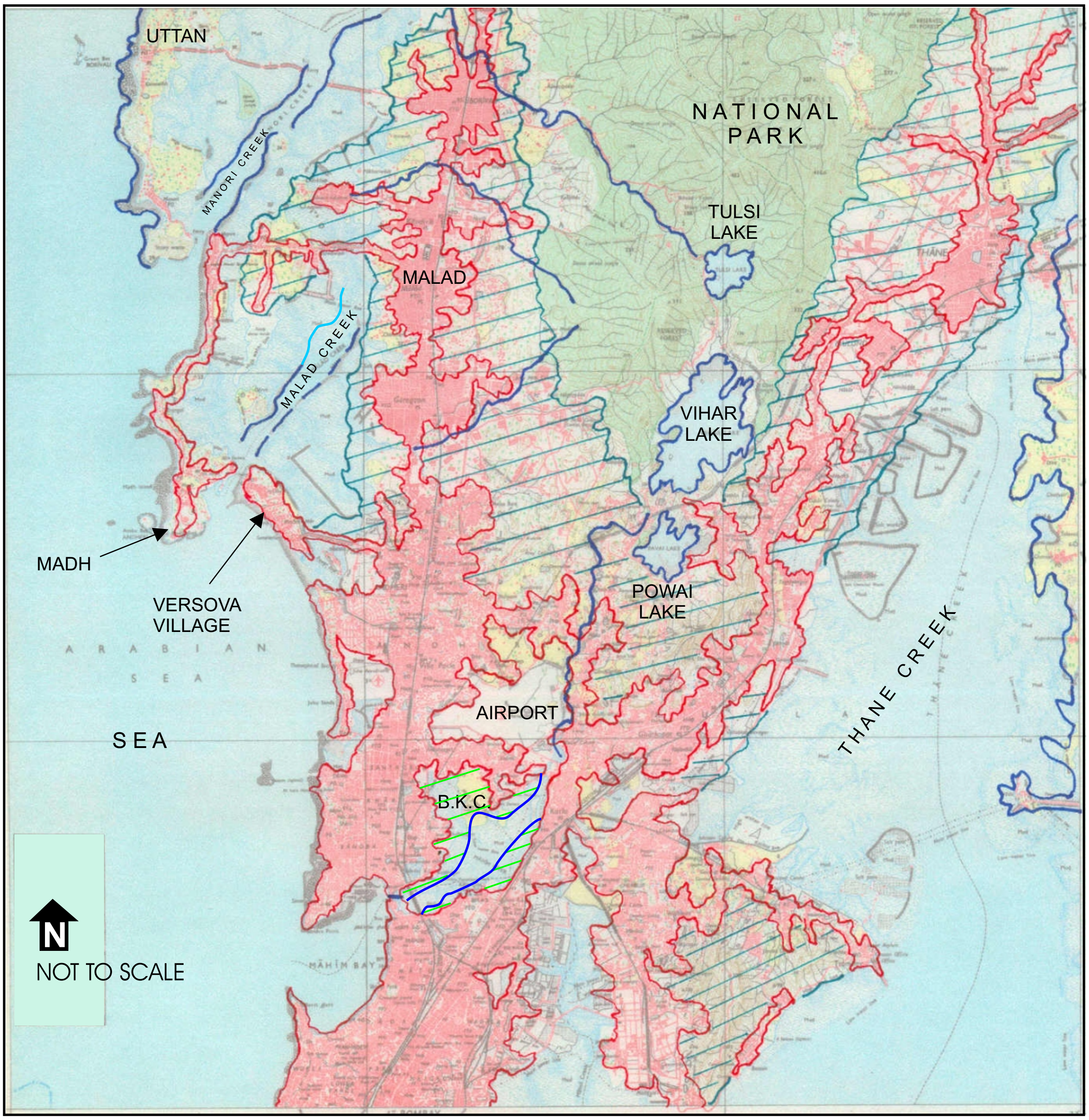
CHRONIC FLOODING SPOTS ON TRAFFIC CORRIDORS IN ISLAND CITY

DRAWING NUMBER : 6

FACT FINDING COMMITTEE
ON MUMBAI FLOODS

UNDER GROUND & OPEN STORM WATER
DRAIN NETWORK & OUTFALLS IN DHARAVI

DRAWING NUMBER : 7



HABITATIONS PRIOR TO 1962

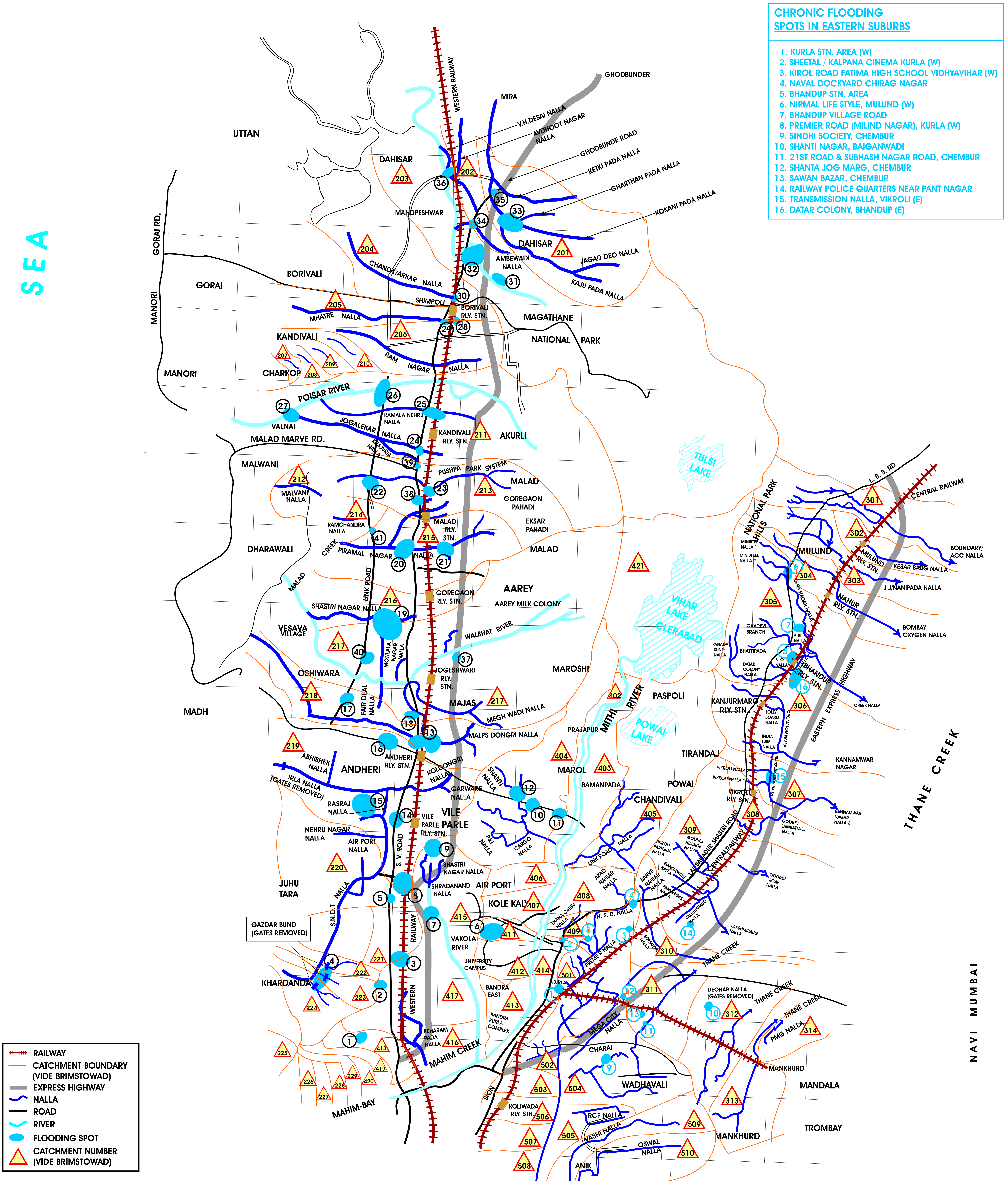
HABITATIONS AFTER 1962

FACT FINDING COMMITTEE ON MUMBAI FLOODS

DEVELOPMENT OF SUBURBAN AREAS

DRAWING NO.:- 8

LIST OF AREAS FLOODED ON 26.07.05 IN EASTERN SUBURBS
1. KURLA STN (W), L. B .S. ROAD UP TO CHIRAG NAGAR
2. NEHRU NAGAR KURLA TO TILAK NAGAR CHEMBUR / PESTAM SAGAR
3. DEONAR COLONY
4. PHULE NAGAR, MANKHURD
5. GAIKWAD NAGAR & SUBHASH NAGAR
6. GARODIA NAGAR & PANT NAGAR
7. POSTAL COLONY, SINDHI SOCIETY
8. VASHI NAKA
9. COLLECTOR COLONY & MARAVLI VILLAGE
10. RAMABAI NAGAR
11. KAMALANE, GHATKOPAR (W)
12. JN OF L.B.S. MARG & GOREGAON MULUND LINK ROAD
13. SAKI NAKA
14. LBS MARG, GHATKOPAR TO VIKHROLI
15. TAGORE NAGAR
16. SAHYADRI NAGAR
17. DATAR COLONY, BHANDUP (E)
18. PATILWADI, BHANDUP (W)
19. USHA NAGAR, BHANDUP (W)
20. NANI PADA, MULUND (E)
21. MULUND (W), MEHUL CIRCLE
22. NEELAM NAGAR, MULUND (E)
23. DUMPING ROAD, MULUND (W)
24. BHAKTI MARG, MULUND (W)
25. VEENA NAGAR, MULUND (W)
26. MULUND COLONY
LIST OF AREAS FLOODED ON 26.07.05 IN WESTERN SUBURBS
1. PARRY ROAD, BANDRA (W)
2. 3RD ROAD & KHAR SUBWAY, KHAR (W)
3. SOUTH, MAIN AND NORTH AVENUE, SANTACRUZ (W)
4. AIR INDIA COLONY, SANTACRUZ (E)
5. ANAND NAGAR, SANTACRUZ (E)
6. MILAN SUBWAY & S. V. ROAD, V. M. ROAD, J. V. P. D., VILE PARLE (W), NEHRU ROAD, VILE PARLE (E)
7. AIRPORT ROAD & MAROL NAKA / ANDHERI (E)
8. J. B. NAGAR / ANDHERI (E)
9. ANDHERI SUBWAY AND SONY MONY / VEERA DESAI ROAD / ANDHERI (W)
10. KAJUPADA JUNCTION & BEHRAMBANG JOGESHWARI (W)
11. SHASTRI NAGAR / MOTILAL NAGAR / GOREGAON (W)
12. S. V. ROAD / PIRAMAL NAGAR / GOREGAON (W)
13. GURIA PADA / LINK ROAD / MALAD (W)
14. MALAD SUBWAY
15. N. L.HIGHSCHOOL, BALBHARATI SCHOOL, FIRE BRIGADE, S. V. ROAD / KANDIVALI (W) & CHANAKYA NAGAR / KANDIVALI (E)
16. DAHANUKAR WADI / KANDIVALI (W)
17. VALNAI / KANDIVALI (W)
18. RAILWAY COLONY, KASTURBA PARK / BORIVALI (E) SONY NAGAR, S. V. ROAD / BORIVALI (W)
19. RAILWAY COLONY M.G. ROAD / BORIVALI (E)
20. SHRI KRISHNA NAGAR / BORIVALI (E). DAULAT NAGAR, SBI COLONY / BORIVALI (E)
21. GHARTANPADA & RAVAL PADA / DAHISAR (E)
22. AMBEWADI, S. V. ROAD / DAHISAR (E)
23. AGARWAL INDI. ESTATE / DAHISAR (E)
24. DAHISAR SUBWAY
RAILWAY
CATCHMENT BOUNDARY (VIDE BRIMSTOWAD)
EXPRESS HIGHWAY
NALLA
ROAD
RIVER
FLOODING SPOT
CATCHMENT NUMBER (VIDE BRIMSTOWAD)
MIRA BHAYANDAR
UTTAN
DAHISAR
EKSAR
BORIVALI
GORAI
MANORI
KANDIVALI
POISAR
AKURLI
MALAD
DINDOSHI
GOREGAON
AAREY
AAREY MILK COLONY
DHARAWALI
VESAVA
OSHIWARA
MAJAS
MAROSHI
MADH
ANDHERI
CHAKALA
MAROL
VILE PARLE
SAHAR
JUHU TARA
SANTACRUZ
KHARDANDA
BANDRA
BANDRA WEST
MAHIM-BAY
SEA
NATIONAL PARK
TULSI
TULSI LAKE
VIHAR LAKE
POWAI LAKE
PASPOLI
POWAI
CHANDIVALI
MOHLI
KOLE KALYAN
BANDRA EAST
CHEMBUR
ANIK
GAVANPADA
THANE
MULUND
NAHUR
THANE CREEK
NAVI MUMBAI
MUMBAI HARBOUR
WESTERN RAILWAY
CENTRAL RAILWAY
HARBOUR RLY
WESTERN EXPRESS HIGHWAY
EASTERN EXPRESS HIGHWAY
MITHI RIVER
NOT TO SCALE
FACT FINDING COMMITTEE ON MUMBAI FLOODS
AREAS FLOODED ON 26.07.05 IN EASTERN & WESTERN SUBURBS.
DRAWING NUMBER : 9



CHRONIC FLOODING SPOTS IN EASTERN SUBURBS

1. KURLA STN. AREA (W)
2. SHEETAL / KALPANA CINEMA KURLA (W)
3. KIROL ROAD FATIMA HIGH SCHOOL VIDHYAVIHAR (W)
4. NAVAL DOCKYARD CHIRAG NAGAR
5. BHANDUP STN. AREA
6. NIRMAL LIFE STYLE, MULUND (W)
7. BHANDUP VILLAGE ROAD
8. PREMIER ROAD (MILIND NAGAR), KURLA (W)
9. SINDHI SOCIETY, CHEMBUR
10. SHANTI NAGAR, BAIGANWADI
11. 21ST ROAD & SUBHASH NAGAR ROAD, CHEMBUR
12. SHANTA JOG MARG, CHEMBUR
13. SAWAN BAZAR, CHEMBUR
14. RAILWAY POLICE QUARTERS NEAR PANT NAGAR
15. TRANSMISSION NALLA, VIKROLI (E)
16. DATAR COLONY, BHANDUP (E)

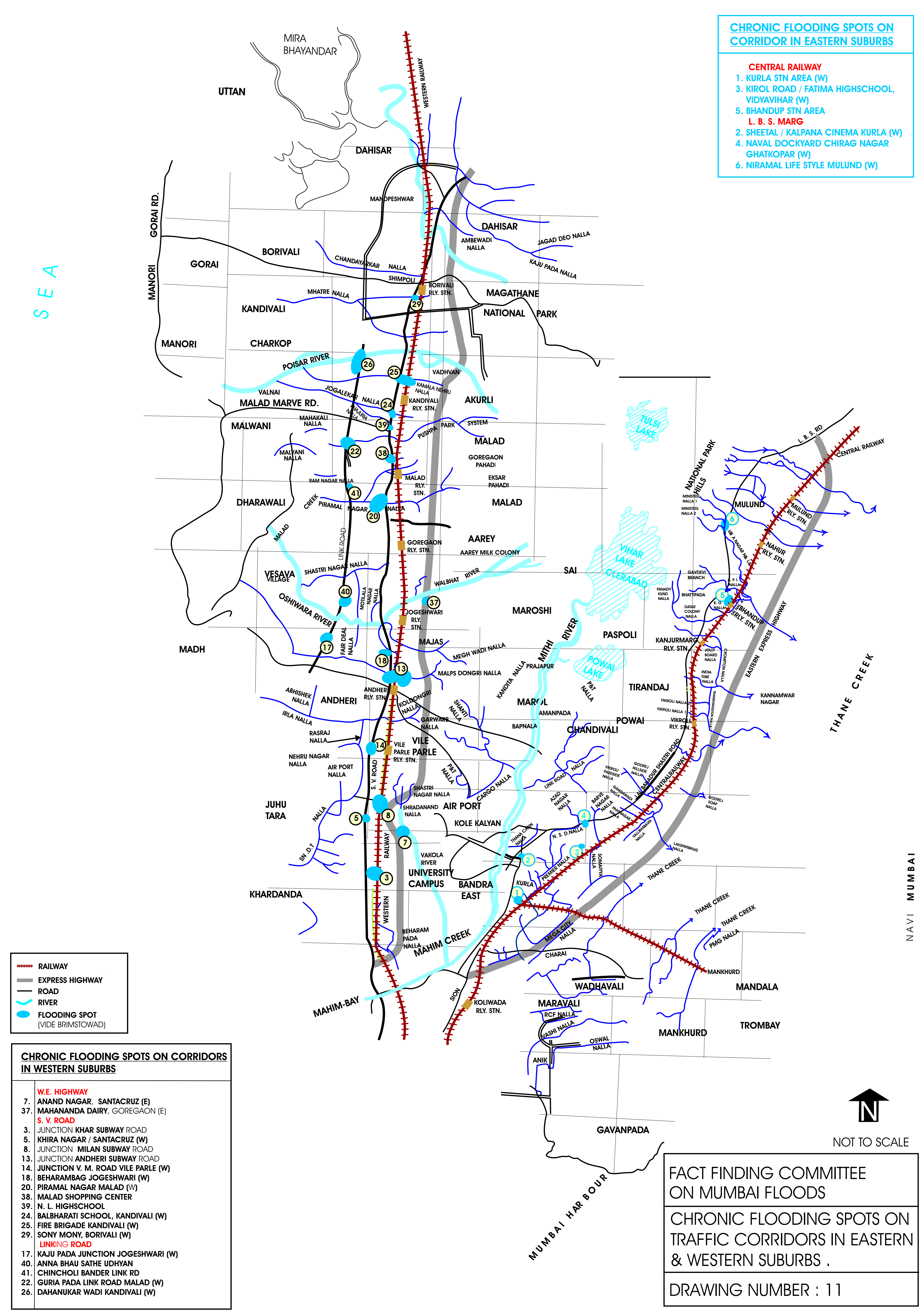
CHRONIC FLOODING SPOTS IN WESTERN SUBURBS

1. PARRY ROAD, BANDRA (W)
2. 3RD ROAD, KHAR (W)
3. KHAR SUBWAY UPTO JN. S. V. ROAD
4. SOUTH, MAIN & NORTH AVENUE SANTACRUZ (W)
5. KHIRA NAGAR, S. V. ROAD, SANTACRUZ (W)
6. AIR INDIA COLONY, SANTACRUZ (E)
7. ANAND NAGAR, SANTACRUZ (E)
8. MILAN SUBWAY UPTO JN. S. V. ROAD
9. NEHRU ROAD, VILEPARLE (E)
10. AIRPORT ROAD, ANDHERI (E)
11. MAROL NAKA, ANDHERI (E)
12. J. B. NAGAR, ANDHERI (E)
13. ANDHERI SUBWAY UPTO JN. S. V. ROAD
14. V. M. ROAD JUNCTION S. V. ROAD, VILE PARLE (W)
15. J. V. P. D., VILE PARLE (W)
16. SONY MONY VEERA DESAI ROAD, ANDHERI (W)
17. KAJU PADA JUNCTION JOGESHWARI (W)
18. BEHARAMBAUG, JOGESHWARI (W)
19. SHASTRI NAGAR / MOTILAL NAGAR, GOAREGAON (W)
20. S. V. ROAD PIRAMAL NAGAR MALAD (w)
21. AMBEDKAR CHOWK, MALAD (E)
22. GURIA PADA LINK ROAD, MALAD (W)
23. MALAD SUBWAY
24. BALBHARATI SCHOOL, S. V. ROAD, KANDIVALI (W)
25. FIRE BRIGADE, S. V. ROAD, KANDIVALI (W)
26. DAHANUKAR WADI, KANDIVALI (W)
27. VALNAI KANDIVALI (W)
28. RAILWAY COLONY KASTURBA ROAD BORIVALI (E)
29. SONY MONY S. V. ROAD BORIVALI (W)
30. RAILWAY COLONY M. G. ROAD BORIVALI (E)
31. SHRI KRISHNA NAGAR BORIVALI (E)
32. DAULAT NAGAR, SBI COLONY, BORIVALI (E)
33. GARTANPADA & RAVAL PADA, DAHISAR (E)
34. AMBEWADI, S. V. ROAD DAHISAR (E)
35. AGARWAL INDI. ESTATE DAHISAR (E)
36. DAHISAR SUBWAY
37. MAHANANDA DAIRY, GOREGAON (E)
38. MALAD SHOPPING CENTER, MALAD (W)
39. N. L. HIGHSCHOOL, MALAD (W)
40. ANNA BHAU SATHE UDHYAN
41. CHINCHOLI BANDER LINK ROAD

FACT FINDING COMMITTEE ON MUMBAI FLOODS

CHRONIC FLOODING SPOTS IN EASTERN & WESTERN SUBURBS.

DRAWING NUMBER : 10



CHRONIC FLOODING SPOTS ON CORRIDOR IN EASTERN SUBURBS

CENTRAL RAILWAY
1. KURLA STN AREA (W)
3. KIROL ROAD / FATIMA HIGHSCHOOL, VIDYAVIHAR (W)
5. BHANDUP STN AREA

L. B. S. MARG
2. SHEETAL / KALPANA CINEMA KURLA (W)
4. NAVAL DOCKYARD CHIRAG NAGAR GHATKOPAR (W)
6. NIRAMAL LIFE STYLE MULUND (W)

CHRONIC FLOODING SPOTS ON CORRIDORS IN WESTERN SUBURBS

W.E. HIGHWAY
7. ANAND NAGAR, SANTACRUZ (E)
37. MAHANANDA DAIRY, GOREGAON (E)

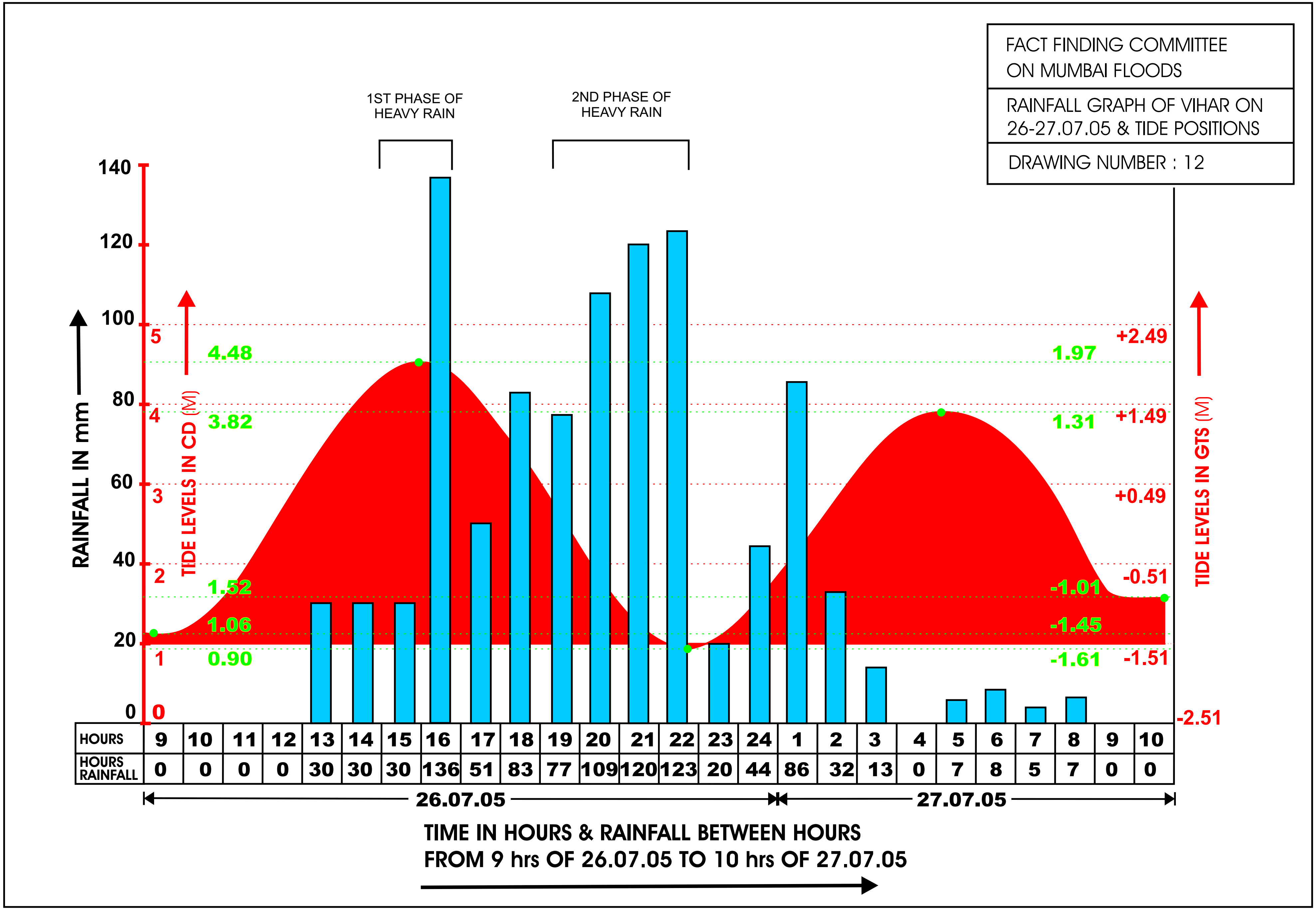
S. V. ROAD
3. JUNCTION KHAR SUBWAY ROAD
5. KHIRA NAGAR / SANTACRUZ (W)
8. JUNCTION MILAN SUBWAY ROAD
13. JUNCTION ANDHERI SUBWAY ROAD
14. JUNCTION V. M. ROAD VILE PARLE (W)
18. BEHARAMBAG JOGESHWARI (W)
20. PIRAMAL NAGAR MALAD (W)
38. MALAD SHOPPING CENTER
39. N. L. HIGHSCHOOL
24. BALBHARATI SCHOOL, KANDIVALI (W)
25. FIRE BRIGADE KANDIVALI (W)
29. SONY MONY, BORIVALI (W)

LINKING ROAD
17. KAJU PADA JUNCTION JOGESHWARI (W)
40. ANNA BHAU SATHE UDHYAN
41. CHINCHOLI BANDER LINK RD
22. GURIA PADA LINK ROAD MALAD (W)
26. DAHANUKAR WADI KANDIVALI (W)

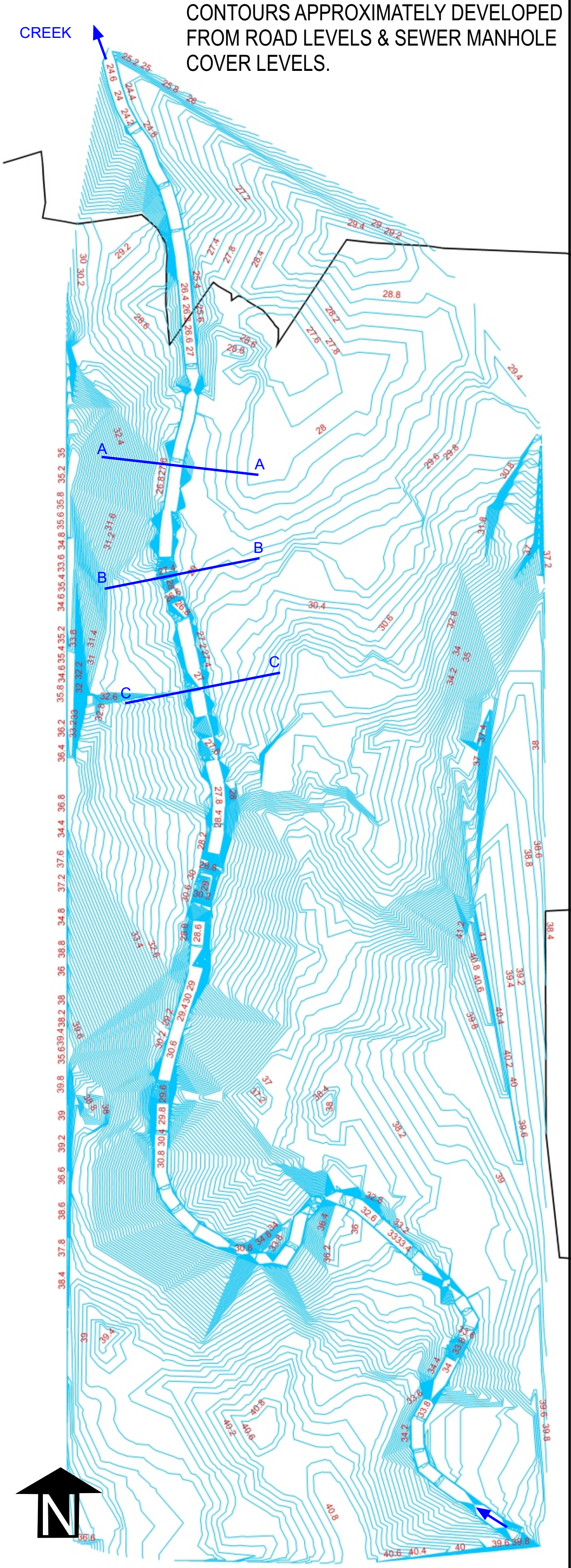
FACT FINDING COMMITTEE ON MUMBAI FLOODS

CHRONIC FLOODING SPOTS ON TRAFFIC CORRIDORS IN EASTERN & WESTERN SUBURBS .

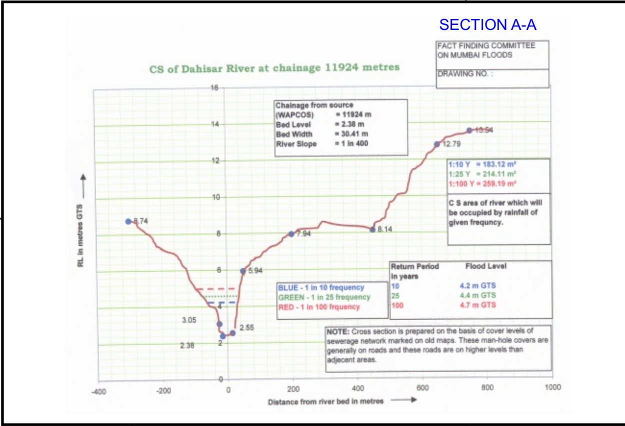
DRAWING NUMBER : 11

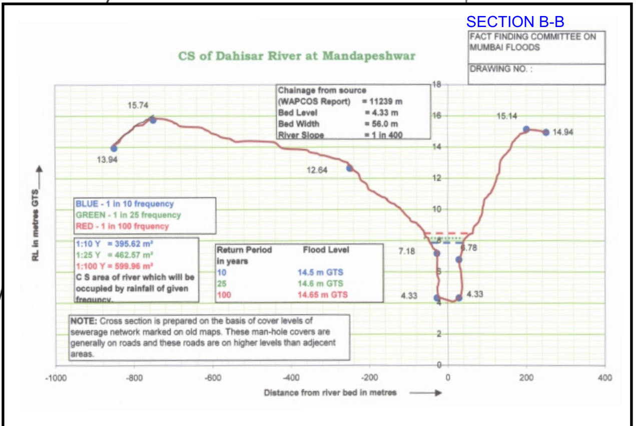

FACT FINDING COMMITTEE
ON MUMBAI FLOODS
RAINFALL GRAPH OF VIHAR ON
26-27.07.05 & TIDE POSITIONS
DRAWING NUMBER : 12
1ST PHASE OF
HEAVY RAIN
2ND PHASE OF
HEAVY RAIN
RAINFALL IN mm
140
120
100
80
60
40
20
0
TIDE LEVELS IN CD (M)
5
4
3
2
1
0
4.48
3.82
1.52
1.06
0.90
1.97
1.31
-1.01
-1.45
-1.61
+2.49
+1.49
+0.49
-0.51
-1.51
-2.51
TIDE LEVELS IN GTS (M)
HOURS
9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 1 2 3 4 5 6 7 8 9 10
HOURS RAINFALL
0 0 0 0 30 30 30 136 51 83 77 109 120 123 20 44 86 32 13 0 7 8 5 7 0 0
26.07.05
27.07.05
TIME IN HOURS & RAINFALL BETWEEN HOURS
FROM 9 hrs OF 26.07.05 TO 10 hrs OF 27.07.05

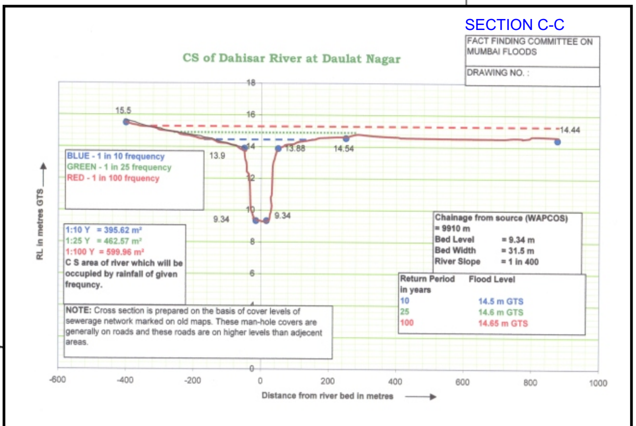
NOTE :
CONTOURS APPROXIMATELY DEVELOPED
FROM ROAD LEVELS & SEWER MANHOLE
COVER LEVELS.



NOT TO SCALE







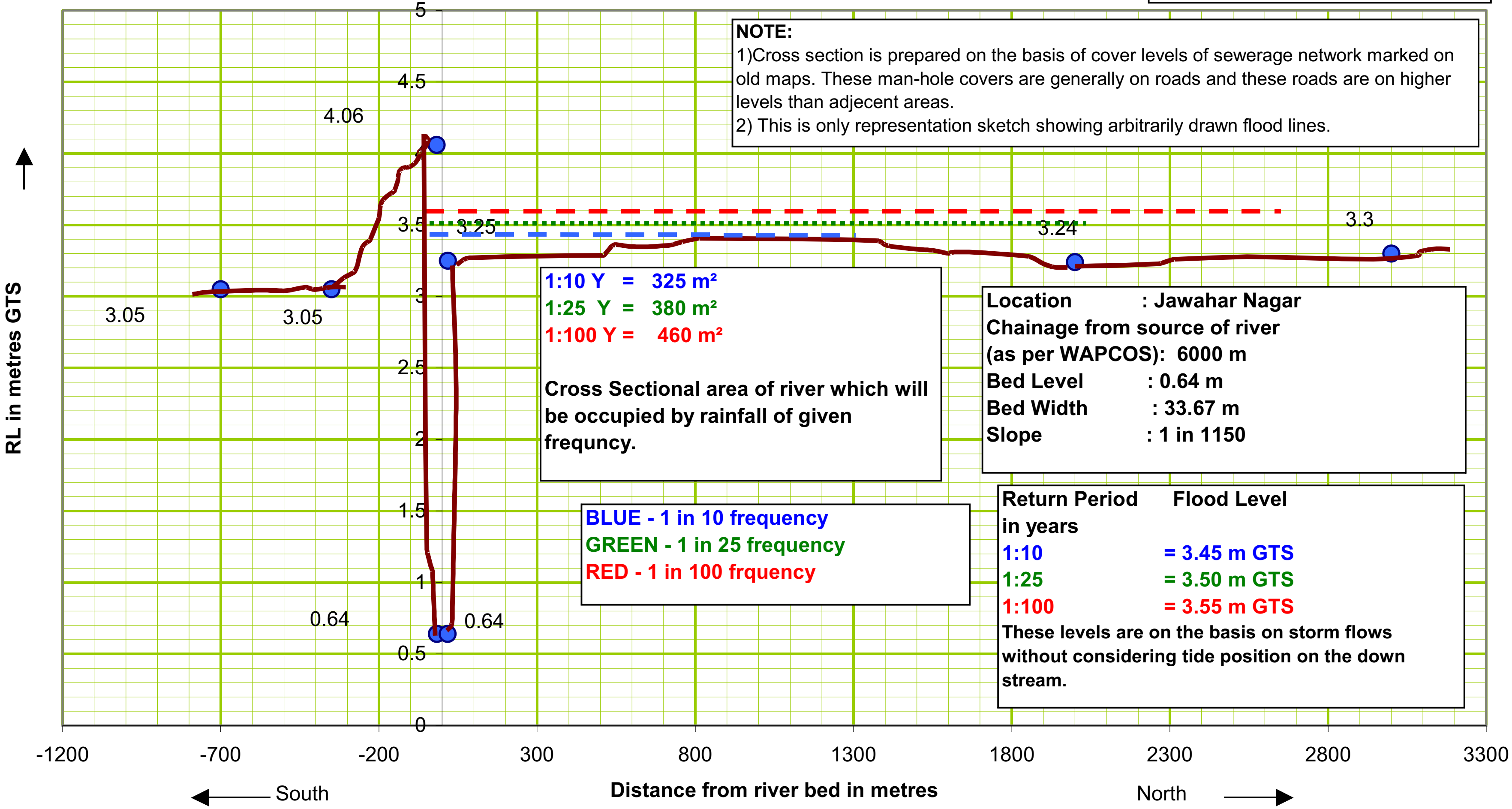
FACT FINDING COMMITTEE ON MUMBAI FLOODS

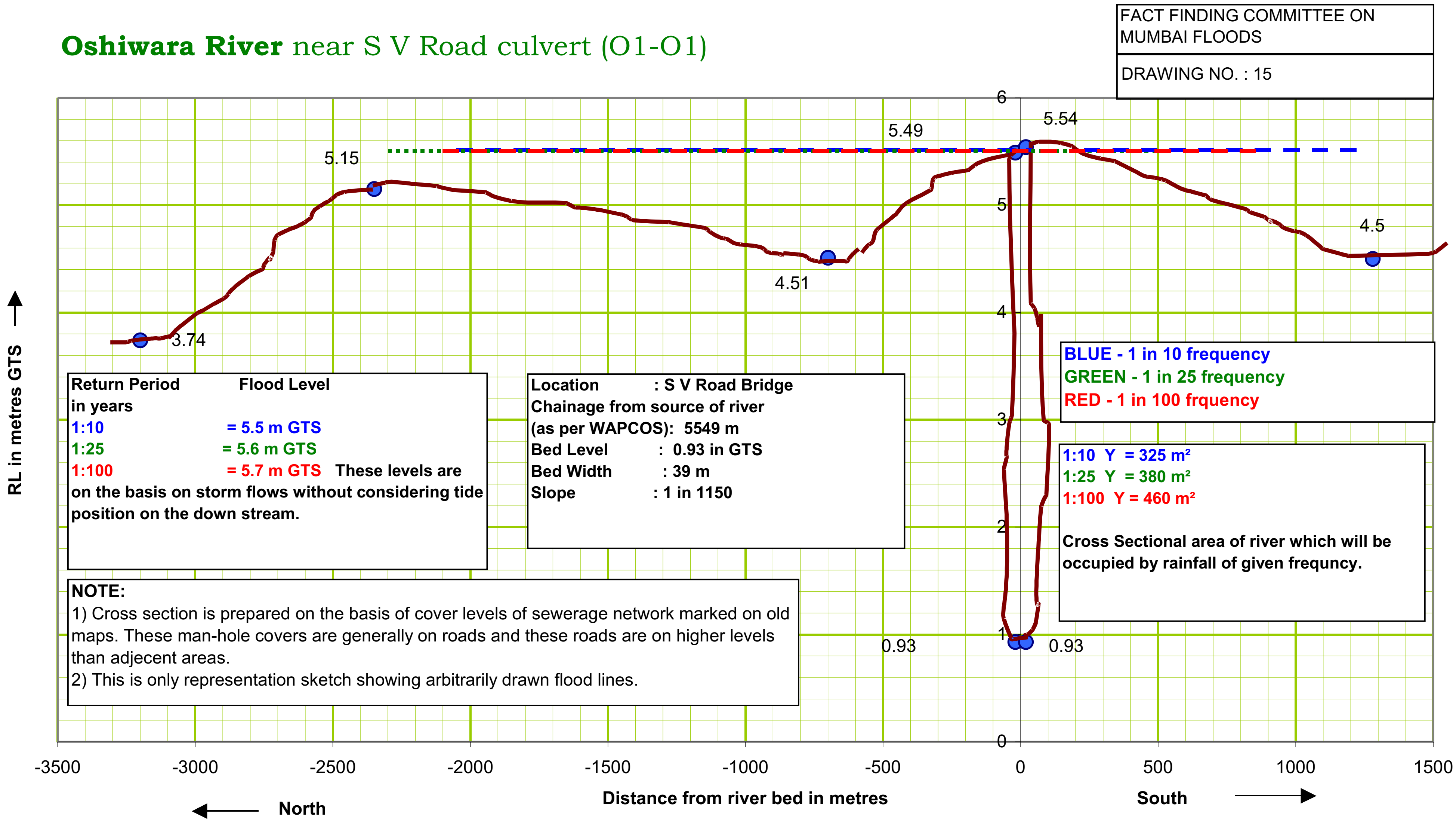
CONTOURS & CROSS SECTIONS OF DAHISAR RIVER

DRAWING NUMBER : 13

FACT FINDING COMMITTEE ON MUMBAI FLOODS
DRAWING NO. : 14

Oshiwara River near Jawahar Nagar



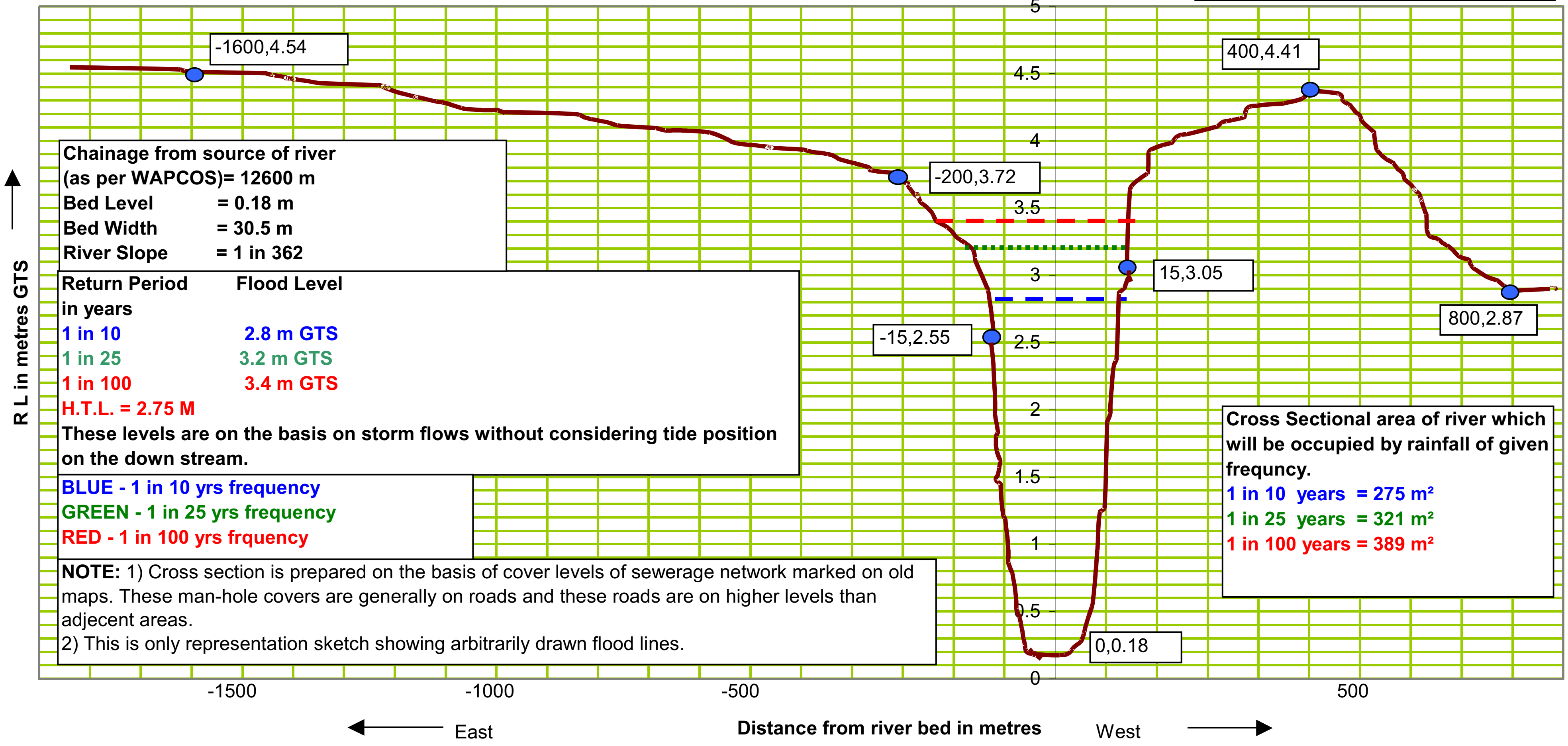


Oshiwara River near S V Road culvert (O1-O1)
FACT FINDING COMMITTEE ON MUMBAI FLOODS
DRAWING NO. : 15
5.15
5.49
5.54
3.74
4.51
4.5
0.93
0.93
Return Period in years
Flood Level
1:10 = 5.5 m GTS
1:25 = 5.6 m GTS
1:100 = 5.7 m GTS These levels are on the basis on storm flows without considering tide position on the down stream.
Location : S V Road Bridge
Chainage from source of river (as per WAPCOS): 5549 m
Bed Level : 0.93 in GTS
Bed Width : 39 m
Slope : 1 in 1150
BLUE - 1 in 10 frequency
GREEN - 1 in 25 frequency
RED - 1 in 100 frquency
1:10 Y = 325 m²
1:25 Y = 380 m²
1:100 Y = 460 m²
Cross Sectional area of river which will be occupied by rainfall of given frequncy.
NOTE:
1) Cross section is prepared on the basis of cover levels of sewerage network marked on old maps. These man-hole covers are generally on roads and these roads are on higher levels than adjecent areas.
2) This is only representation sketch showing arbitrarily drawn flood lines.
RL in metres GTS
0
1
2
3
4
5
6
-3500
-3000
-2500
-2000
-1500
-1000
-500
0
500
1000
1500
Distance from river bed in metres
North
South

FACT FINDING COMMITTEE ON MUMBAI FLOODS

DRAWING NO. : 16

Dahisar River at West near Kandarpada (D1-D1)



1 : 10 Flood Plain Boudary

1 : 25 Flood Plain Boudary

1 : 100 Flood Plain Boudary

NOTE:

This is only a representative sketch showing arbitrarily drawn flood plain boundary. After the contour plans are ready flood levels will have to be calculated with the help of mathematical model. These boudaries are for frequencies of rain fall 1 in 10, 1 in 25 and 1 in 100 years rain fall intensities.

Spillway Discharges :
(Tulsi, Vihar & Powai Lakes)

1) Tulsi Lake : The FSL (full supply level) of the lake is 114.74 mtr. GTS. The dam is having ungated spillways. One spillway at crest level of 115.42 mtr. GTS. This spillway discharges into Dahisar River. The first spillway discharges into Vihar Lake.

2) Vihar Lake : The FSL of the lake is 80.68 mtr. THD i.e. 56.21 mtr. GTS. This dam is also having ungated (i.e. Unregulated) spillway. The Vihar Lake spillway discharges flows into Mithi River.

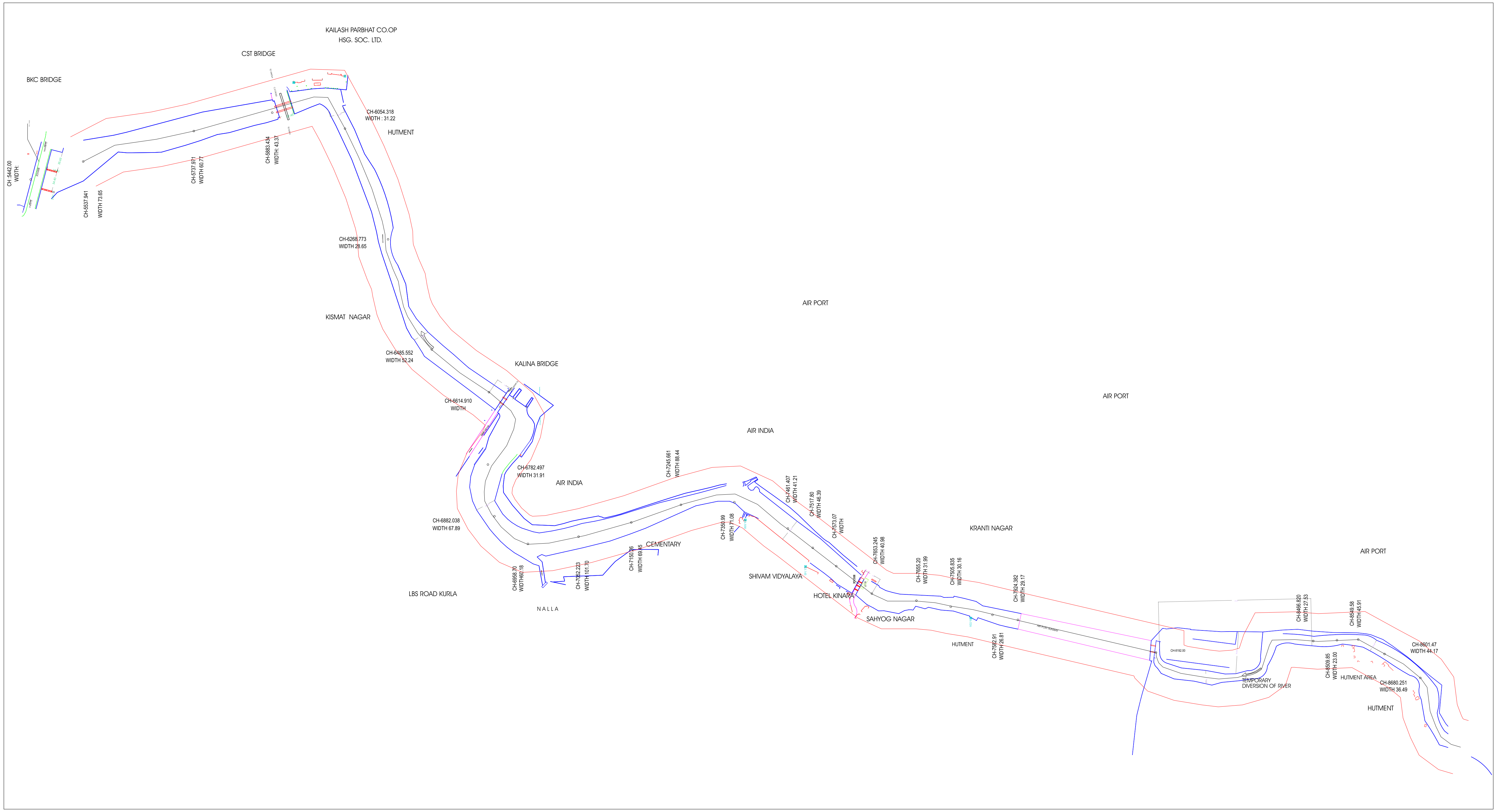
3) Powai Lake : The FSL of the lake is 34.97 mtr. GTS. The spillway discharge meets Mithi River.

RIVER FLUSHING SYSTEM :

Without sacrificing the potable water contents of Vihar Lake, if the spillway is regulated / gated, alongwith Powai Lake, we can get an additional storage of about 2,733 ML if 0.6 mtr. gates are provided at these two dams i.e. Vihar & Powai.

FACT FINDING COMMITTEE ON MUMBAI FLOODS
SCHEMATIC SKETCH TO REPRESENT FLOOD RISK LINES FOR DIFFERENT FREQUENCIES
DRAWING NO.:- 17

courtesy - Mumbai Eicher Map, Eicher Goodearth Ltd., New Delhi.



REFERENCE : CWPRS REPORT - JAN 2006

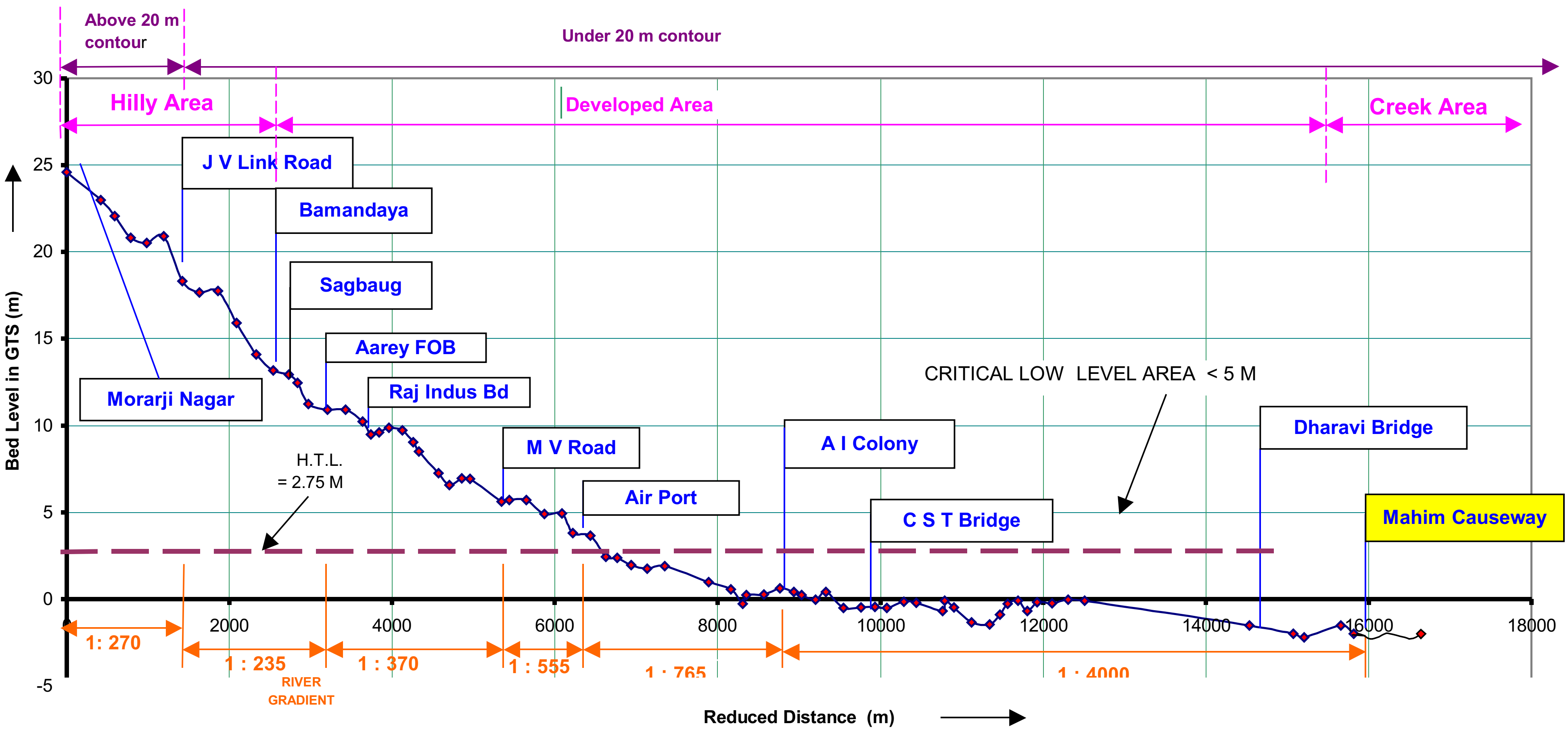
EXISTING MITHI RIVER BOUNDARY

PROPOSED MITHI RIVER BOUNDARY

FACT FINDING COMMITEE
ON MUMBAI FLOODS

WIDTH OF MITHI RIVER -
AIRPORT TO BKC BRIDGE

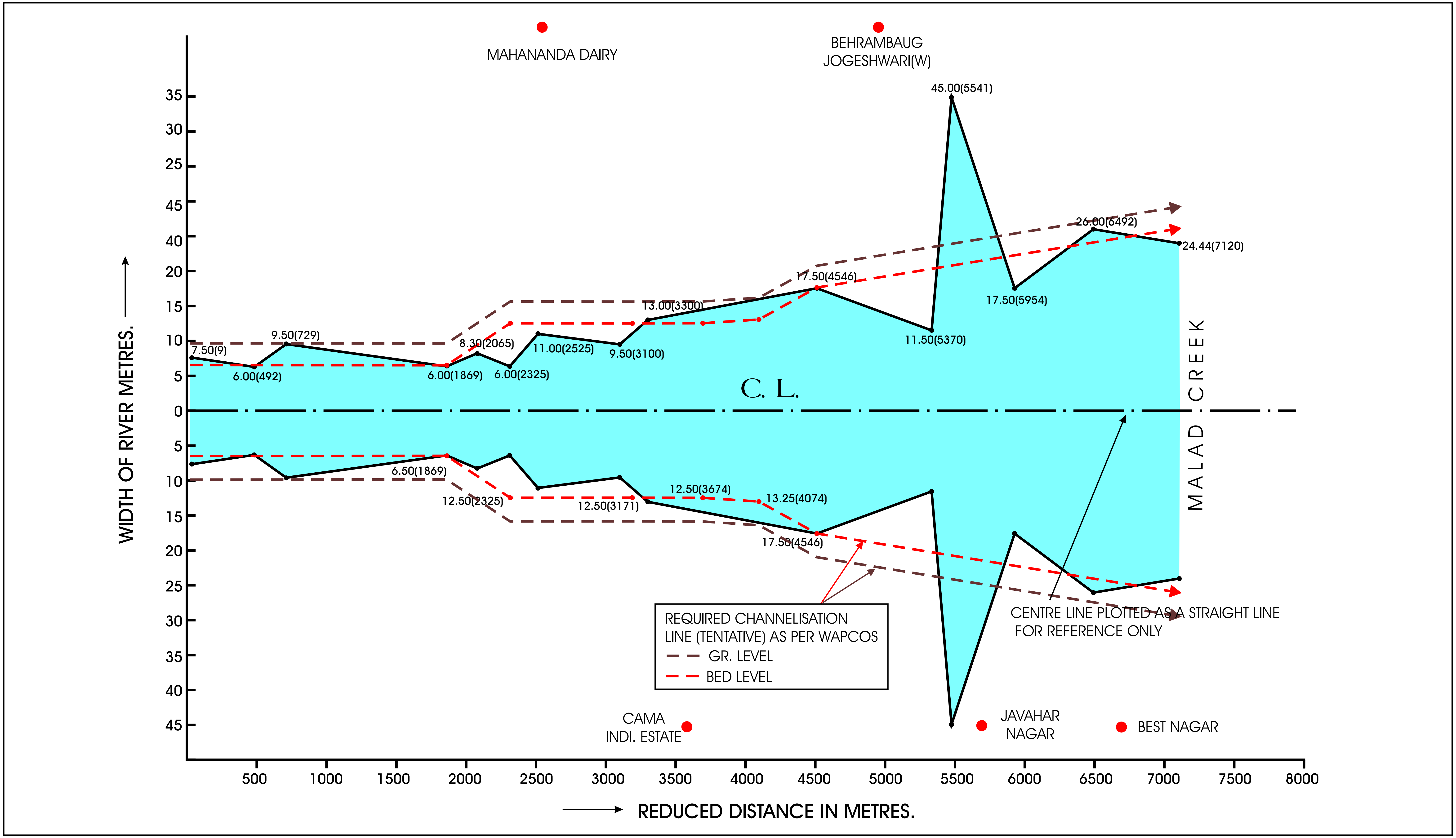
DRAWING NO 18



Through Corridor

Data Source : C W & P R S - Interim Report Oct 2005

FACT FINDING COMMITTEE ON MUMBAI FLOOD
LONGITUDINAL SECTION OF **MITHI RIVER**
DRAWING NO. 19



OSHIWARA RIVER

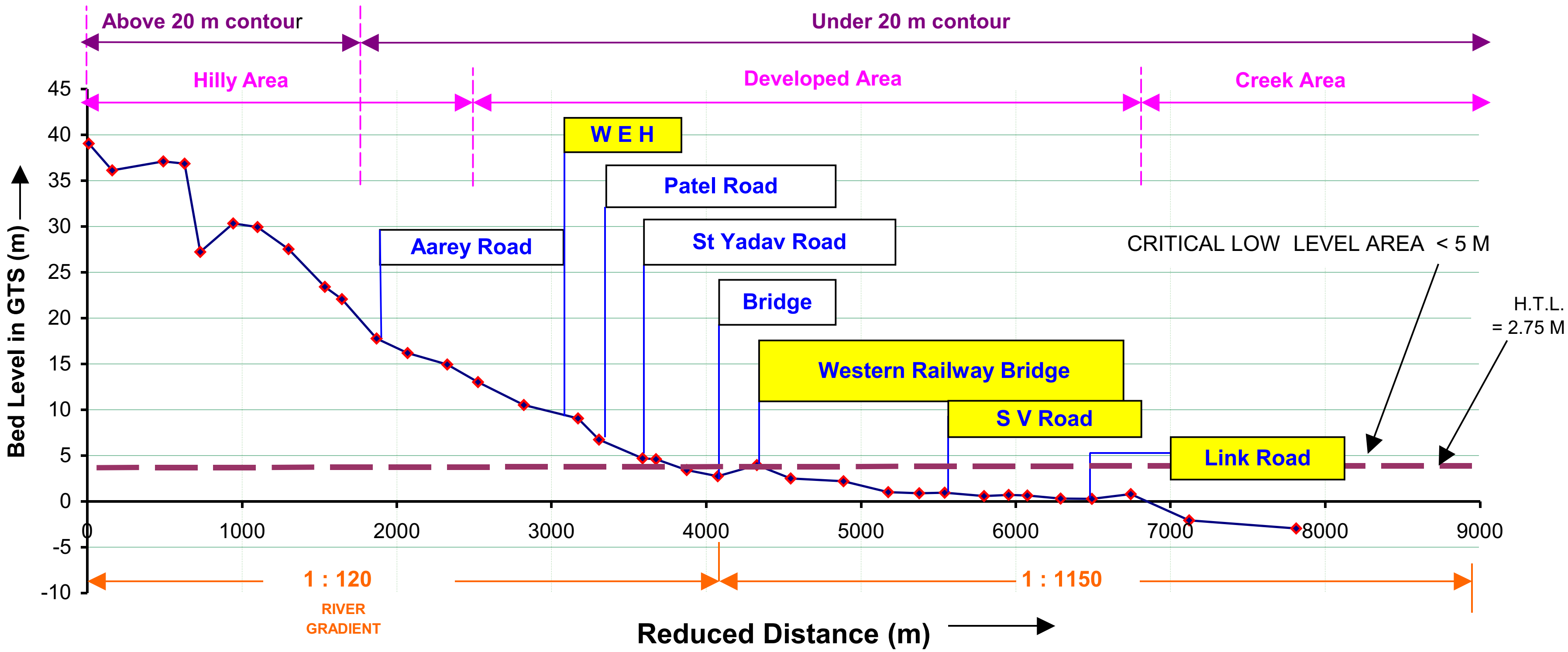
WIDTH →1 UNIT = 5 Metres.
LENGTH →1 UNIT = 500 Metres.
(REF:WAPCOS REPORT : DEC 2005)

● LOCATIONS AFFECTED BY MAJOR FLOODS ON 26/07/2005

FACT FINDING COMMITTEE ON MUMBAI FLOODS

WIDTHS OF OSHIWARA RIVER - GRAPHICAL REPRESENTATION

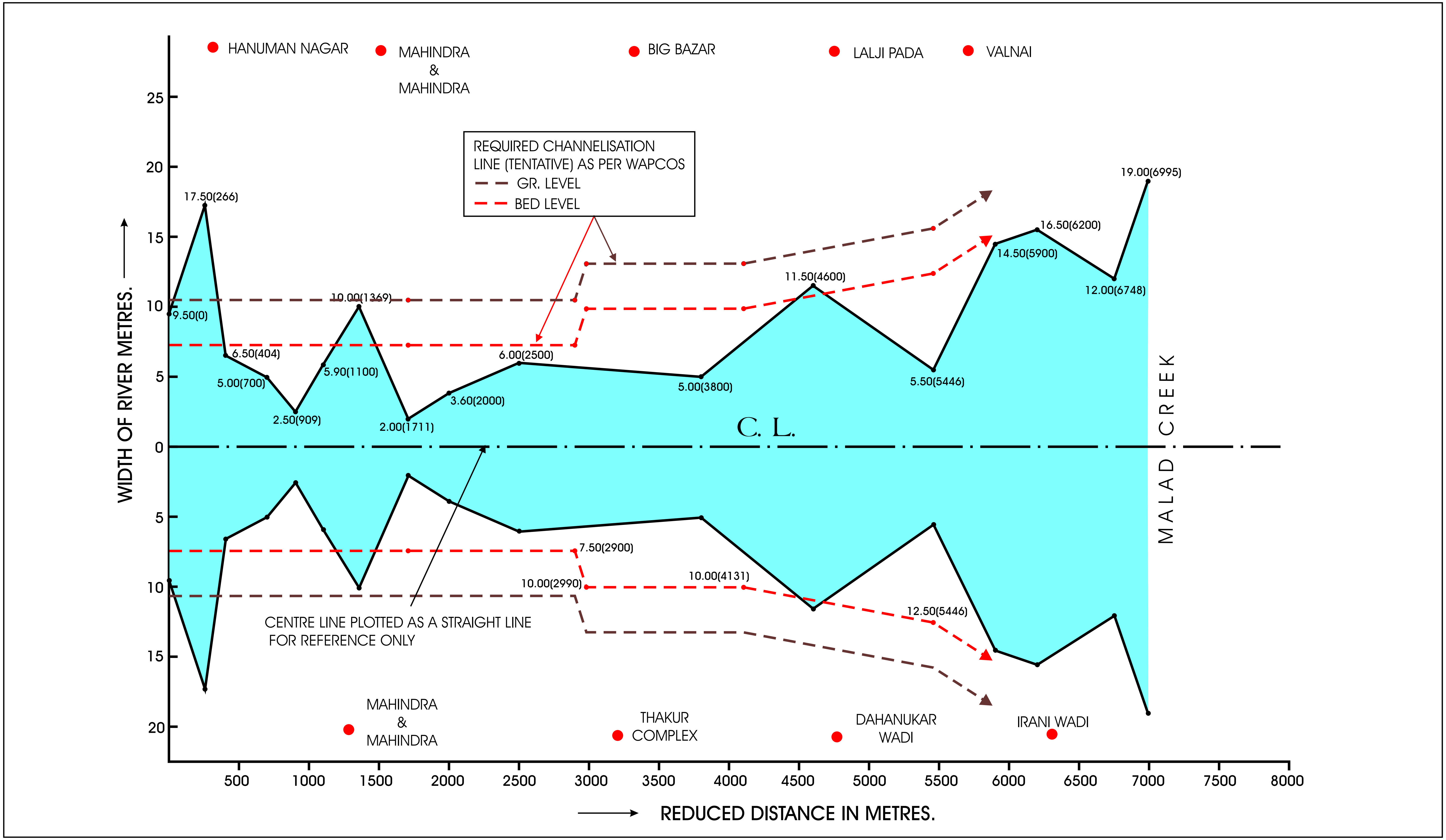
DRAWING NUMBER : 20



Through Corridor

Data Source : WAPCOS - Interim Report Dec 2005

FACT FINDING COMMITTEE ON MUMBAI FLOOD
LONGITUDINAL SECTION OF **OSHIWARA RIVER**
DRAWING NO. 21



POISAR RIVER

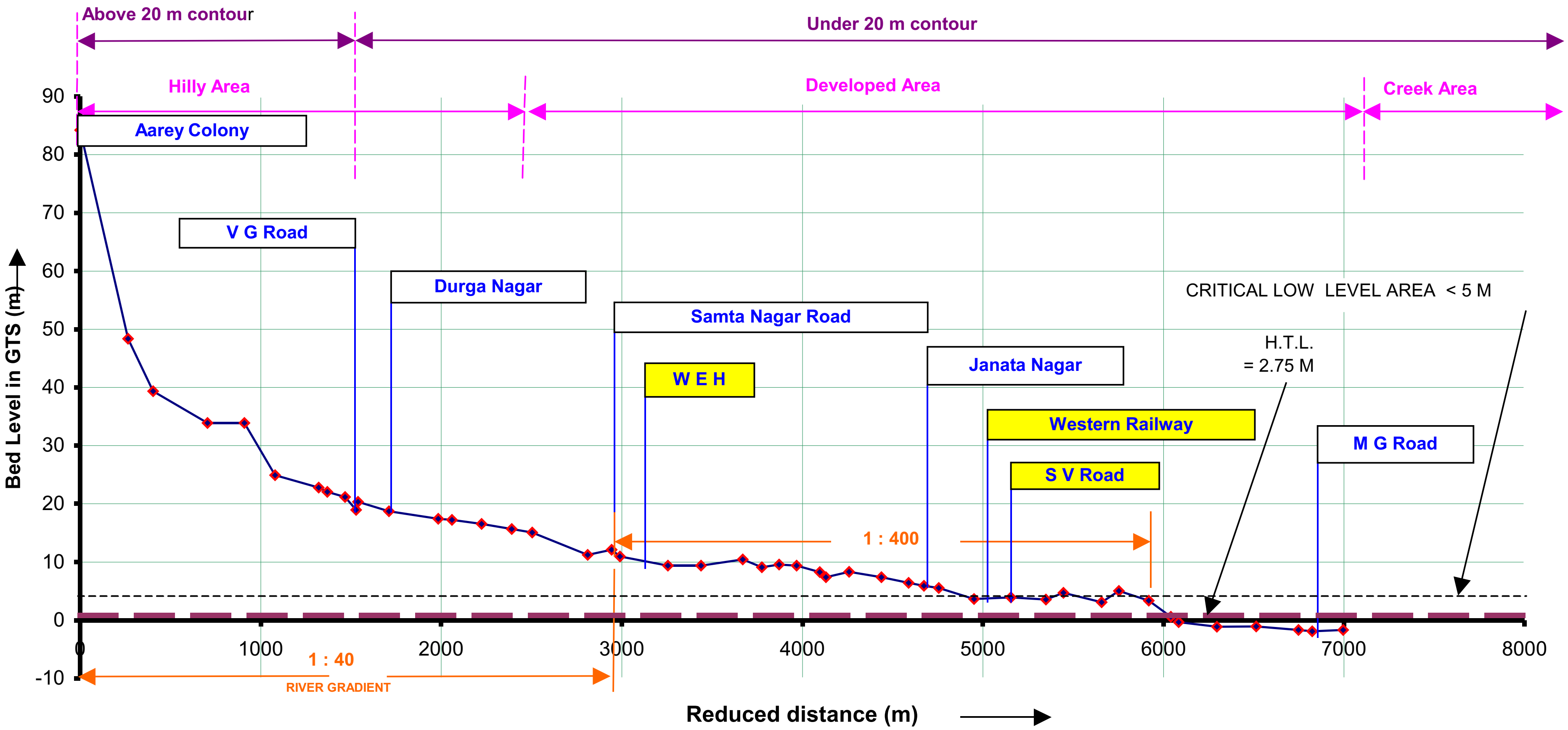
WIDTH →1 UNIT = 5 Metres.
LENGTH →1 UNIT = 500 Metres.
(REF:WAPCOS REPORT : DEC 2005)

● LOCATIONS AFFECTED BY MAJOR FLOODS ON 26/07/2005

FACT FINDING COMMITTEE ON MUMBAI FLOODS

WIDTHS OF POISAR RIVER - GRAPHICAL REPRESENTATION

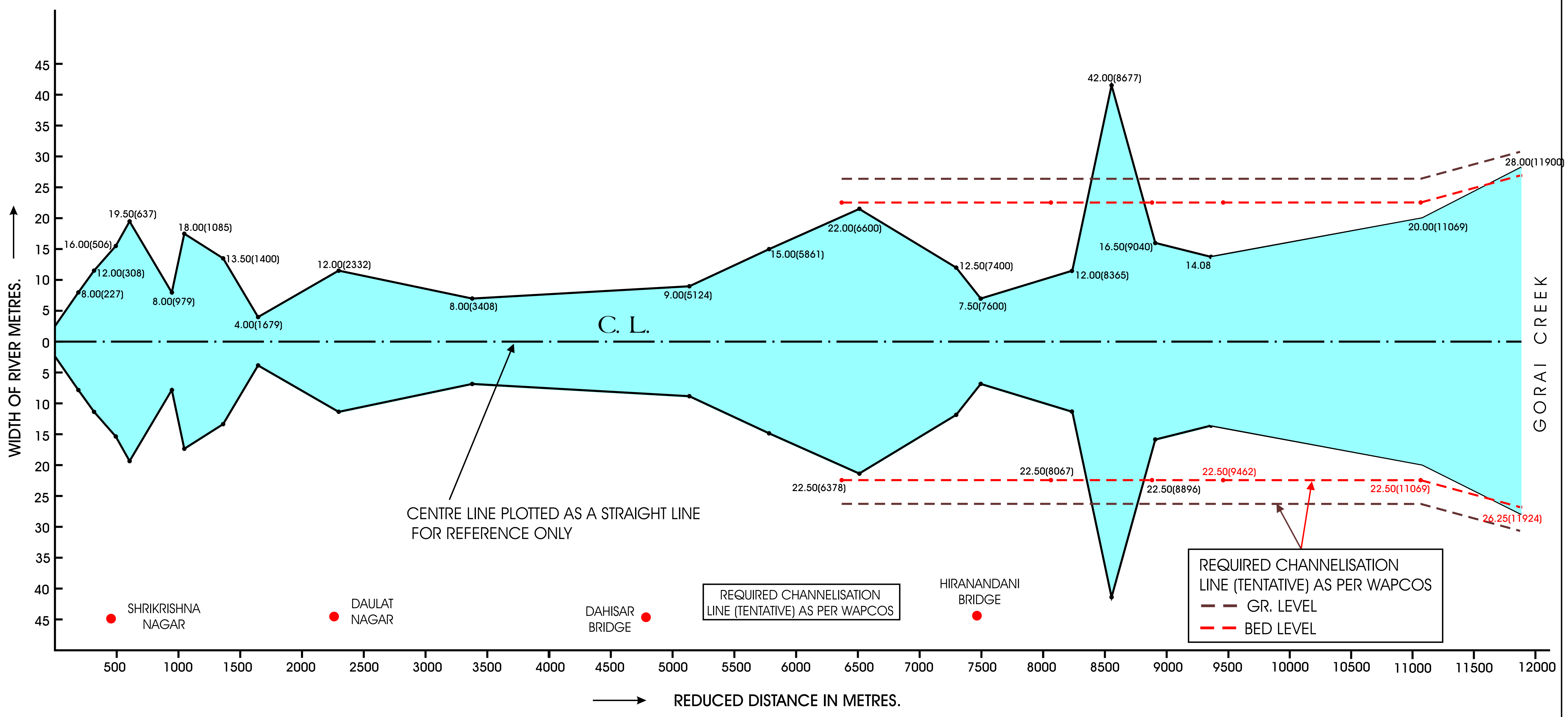
DRAWING NUMBER : 22



Through Corridor

Data Source : WAPCOS - Interim Report Dec 2005

FACT FINDING COMMITTEE ON MUMBAI FLOOD
LONGITUDINAL SECTION OF **POISAR RIVER**
DRAWING NO. 23



DAHISAR RIVER

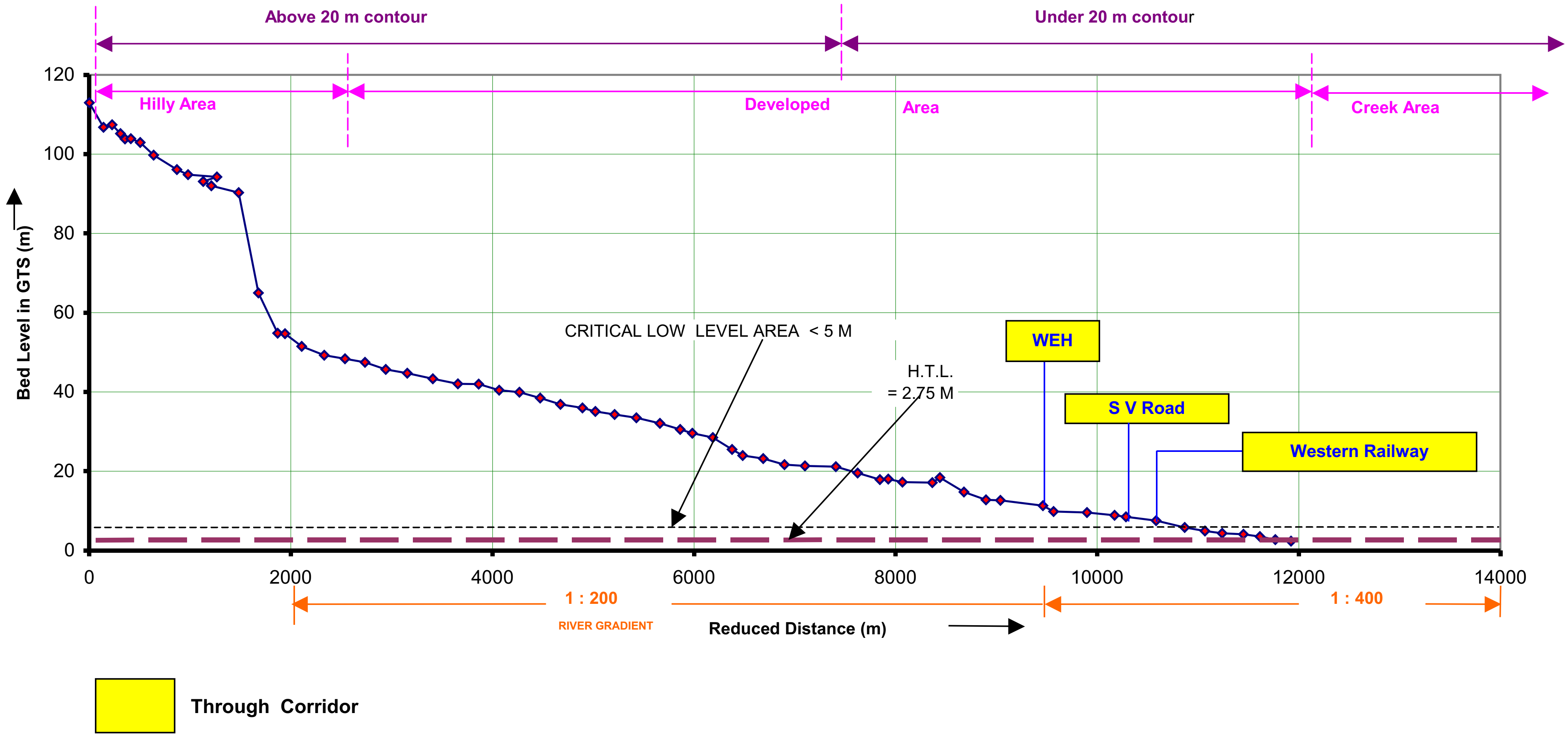
WIDTH →1 UNIT = 5 Metres.
LENGTH →1 UNIT = 500 Metres.
(REF:WAPCOS REPORT : DEC 2005)

● LOCATIONS AFFECTED BY MAJOR FLOODS ON 26/07/2005

FACT FINDING COMMITTEE ON MUMBAI FLOODS

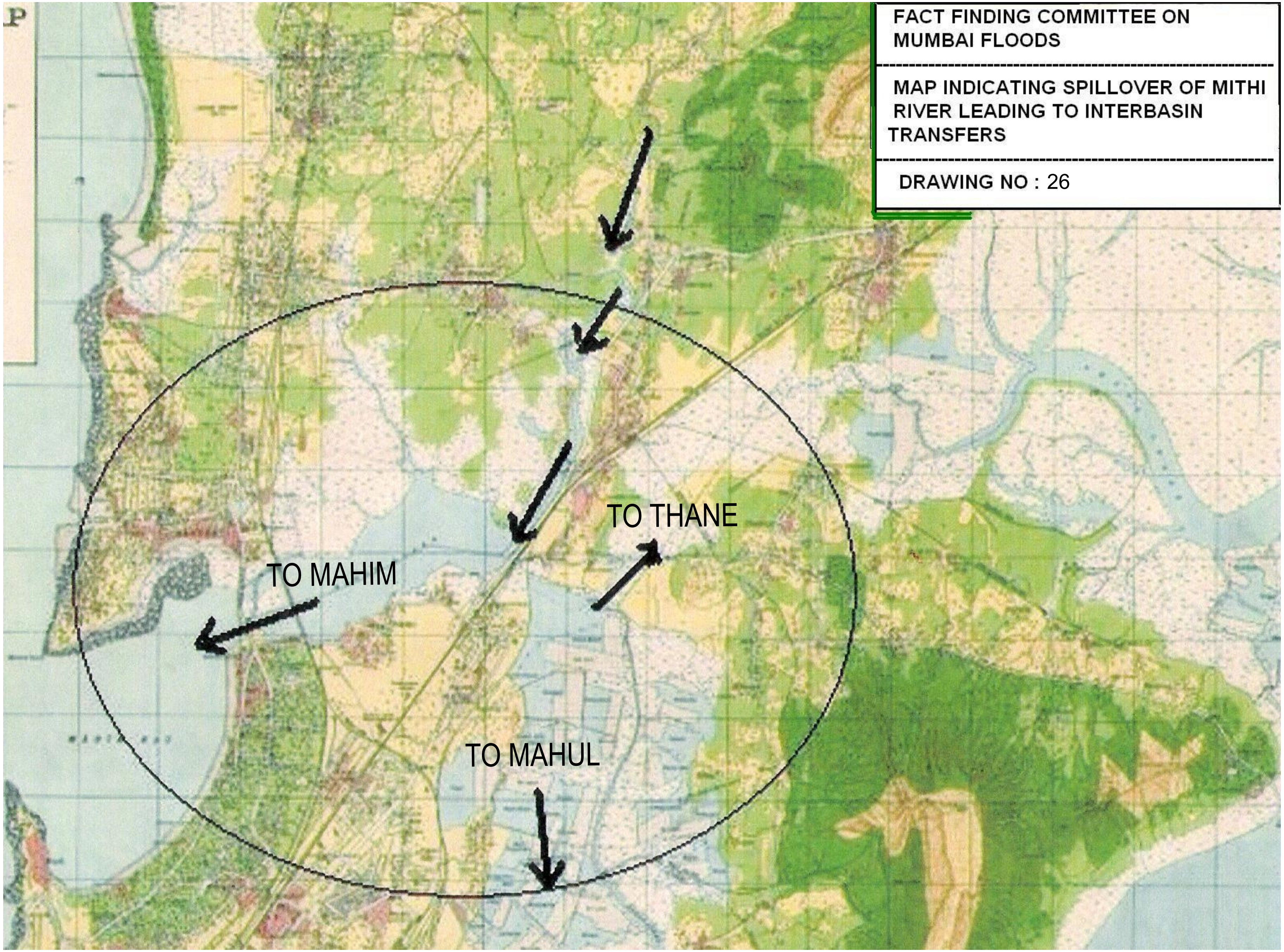
WIDTHS OF DAHISAR RIVER - GRAPHICAL REPRESENTATION

DRAWING NUMBER : 24

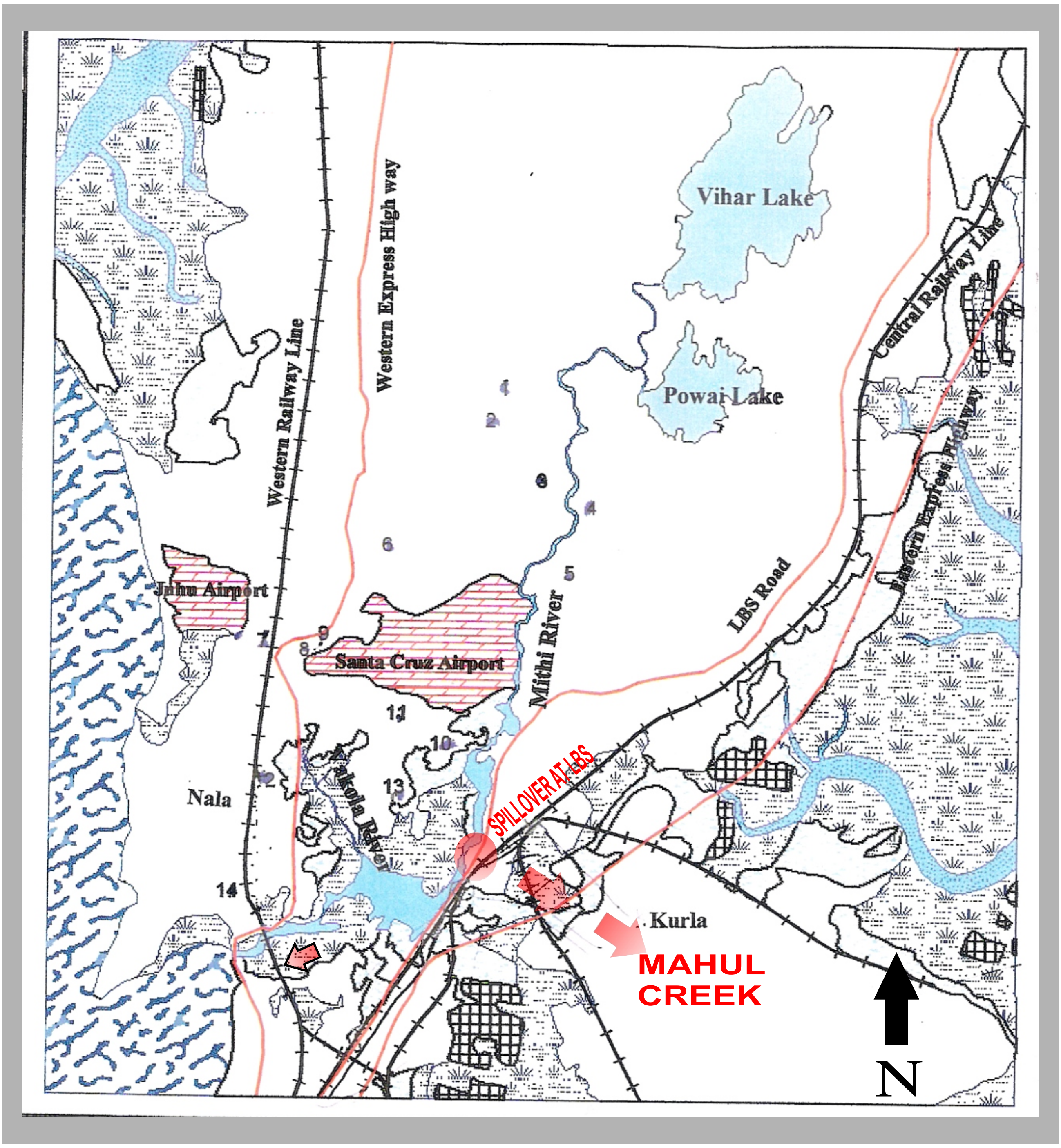


FACT FINDING COMMITTEE ON MUMBAI FLOOD
LONGITUDINAL SECTION OF **DAHISAR RIVER**
DRAWING NO. 25

Data Source : WAPCOS - Interim Report Dec 2005



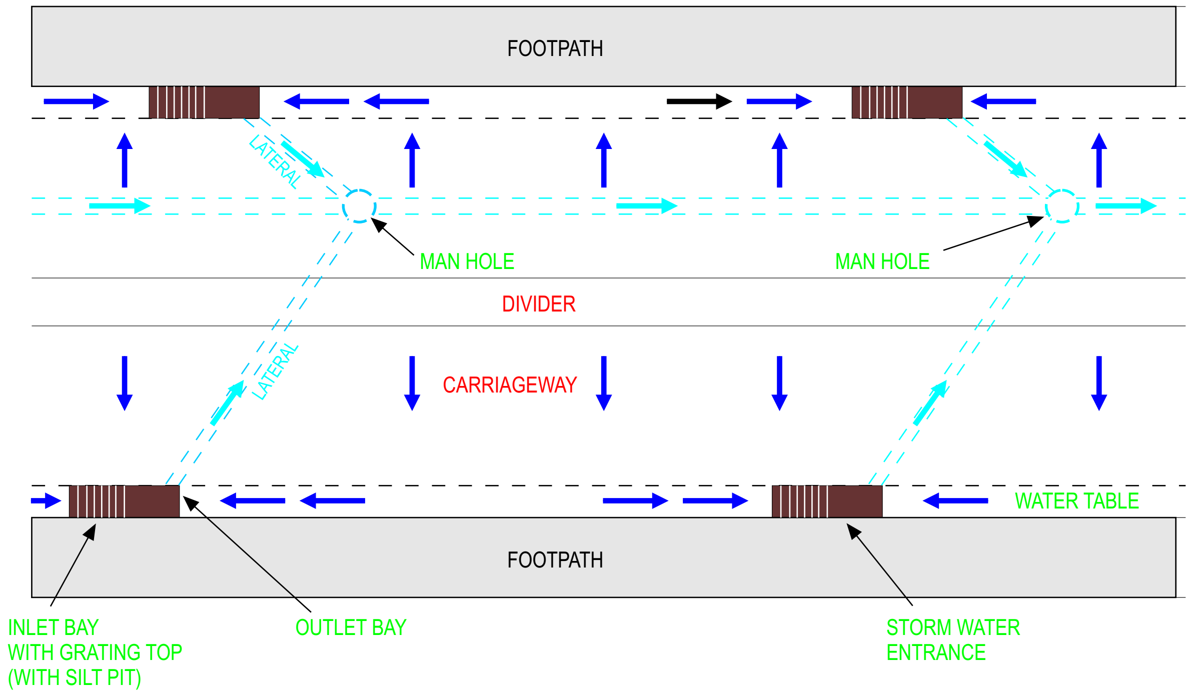
Reference : Survey of India Map 1946



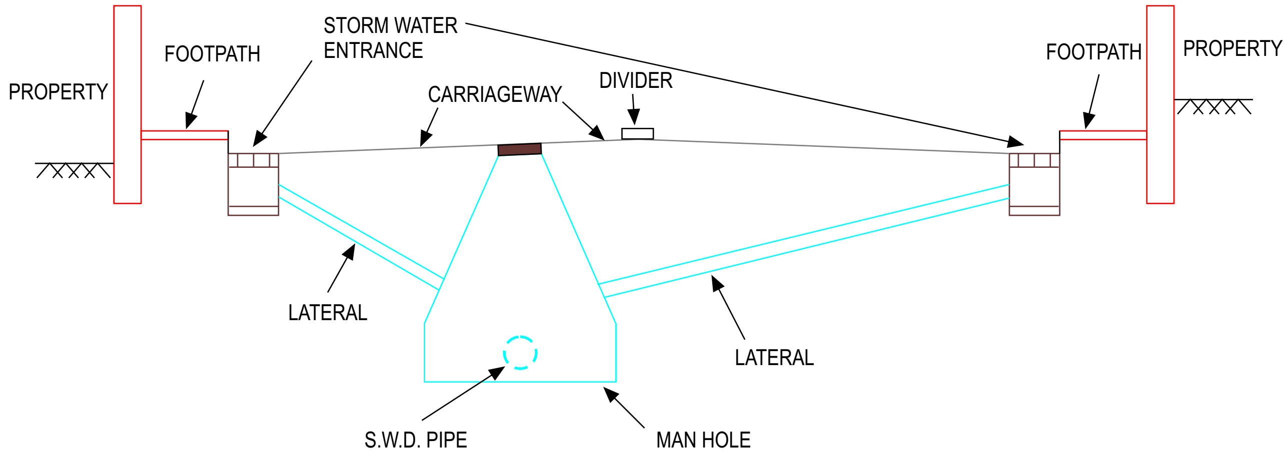
REFERENCE:CESE REPORT NOVEMBER 2005

NOT TO SCALE

FACT FINDING COMMITTEE ON MUMBAI FLOODS
TOPOGRAPHICAL FEATURES IN SADDLE AREA EAST OF MITHI RIVER (1976)
DRAWING NUMBER : 27



P L A N

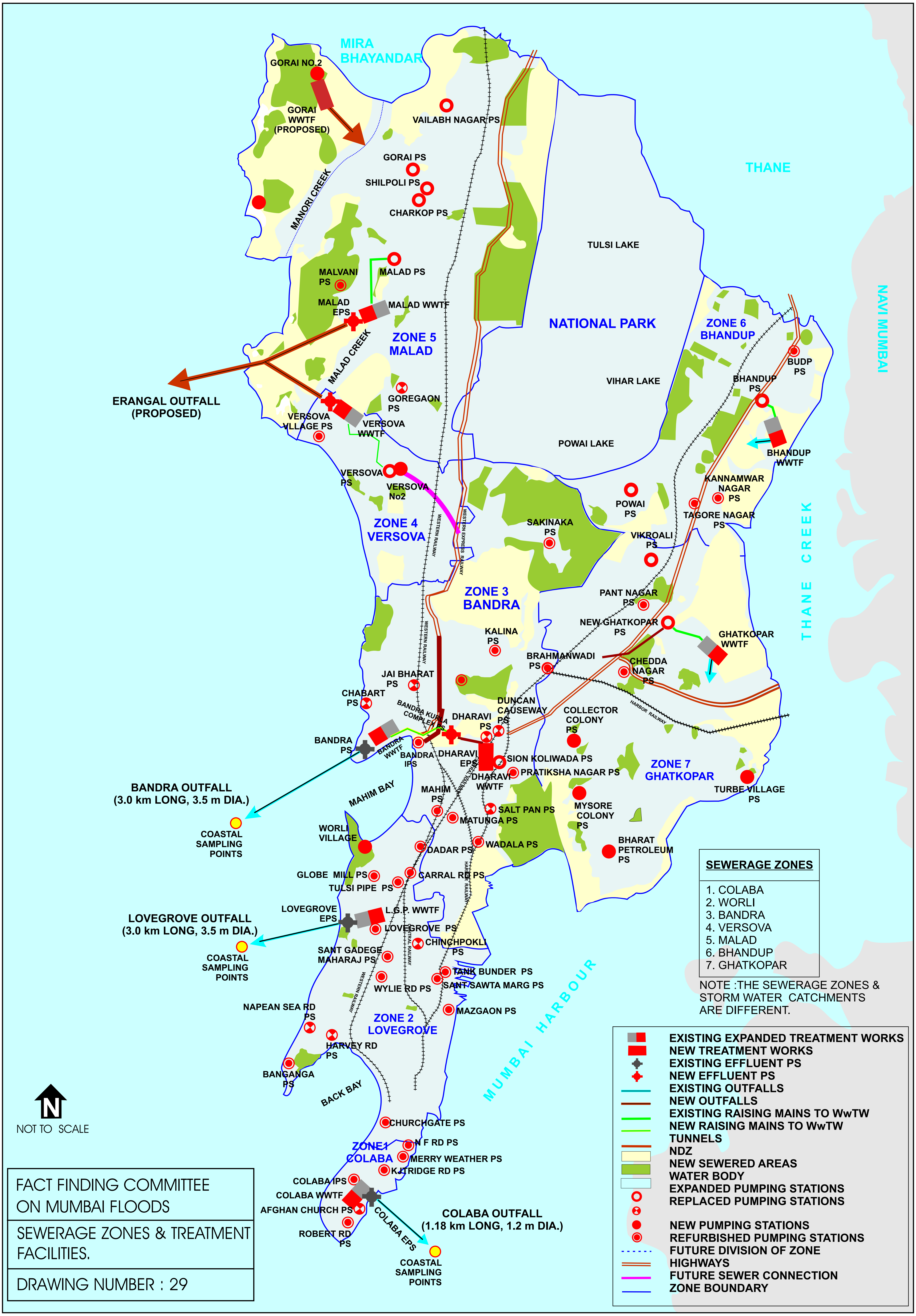


S E C T I O N

FACT FINDING COMMITTEE
ON MUMBAI FLOODS

GENERAL ARRANGEMENT OF UNDER
GROUND STORM WATER DRAIN NETWORK

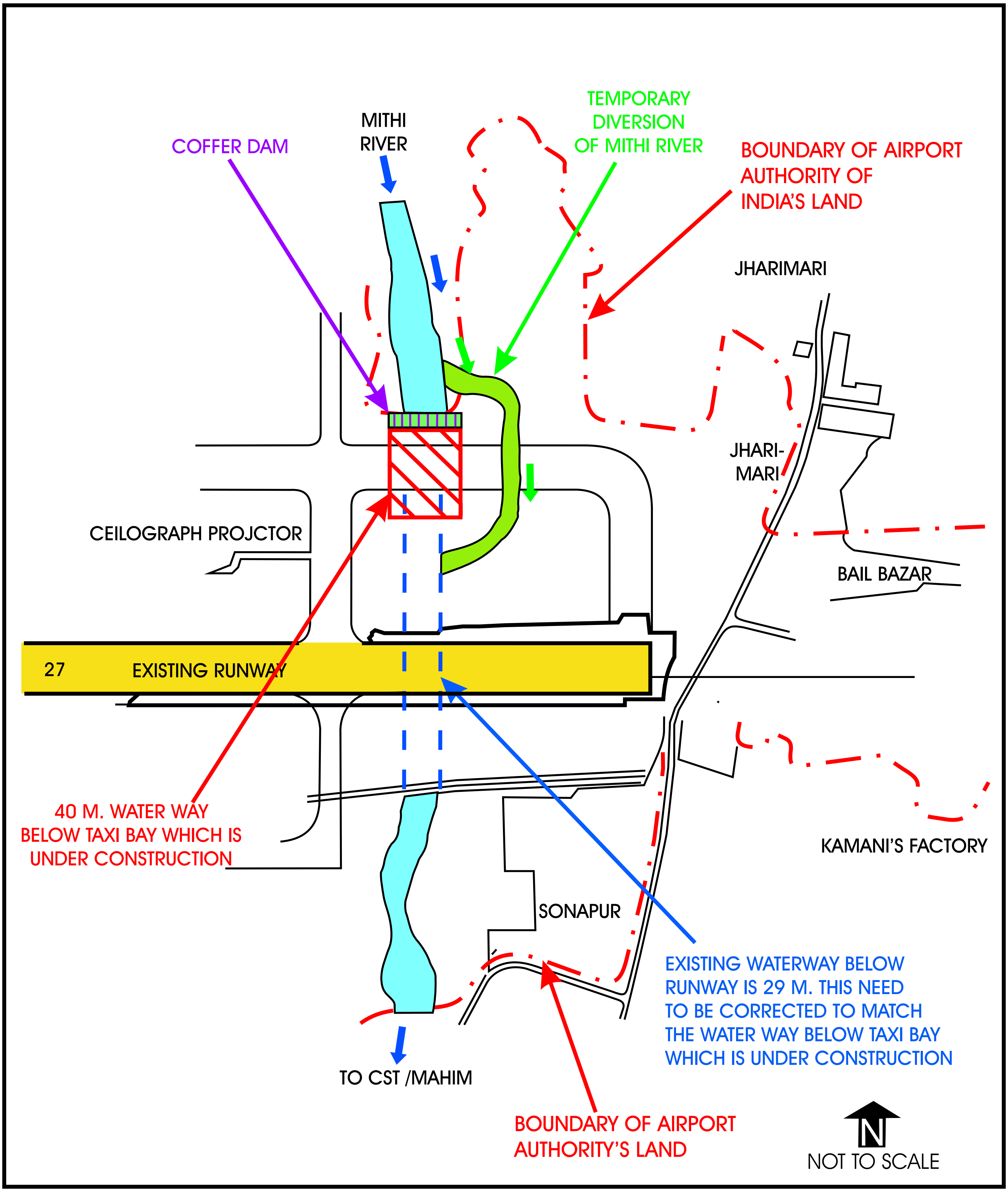
DRAWING NO.:- 28



FACT FINDING COMMITTEE ON MUMBAI FLOODS

SEWERAGE ZONES & TREATMENT FACILITIES.

DRAWING NUMBER : 29



Reference : Drawing of A.A.I.

FACT FINDING COMMITTEE ON MUMBAI FLOODS
MITHI RIVER BELOW TAXI BAY & RUNWAY OF THE AIR PORT
DRAWING NUMBER : 30

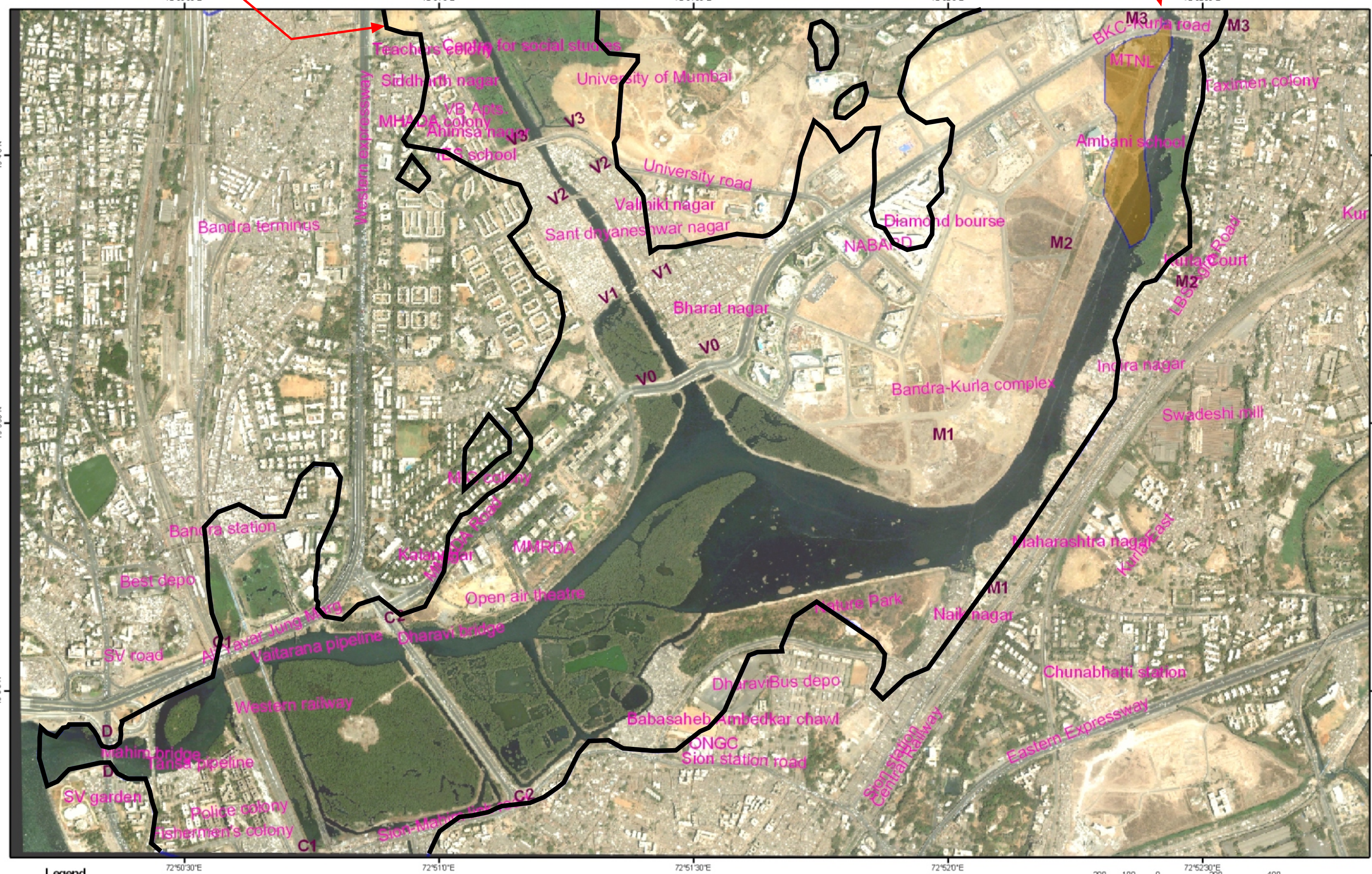
Image Temporary diversion of Mithi River course for construction of box culvert under proposed taxi-bay extension (north of runway) as revealed by the QuickBird satellite image of 8 April 2005 (before flood situation)

FACT FINDING COMMITTEE ON MUMBAI FLOODS
TEMPORARY DIVERSION OF MITHI RIVER COURSE BY A.A.I.(APRIL 2005)
DRAWING NUMBER : 31

EARLIER CREEK BOUNDARY

MITHI RIVER

Change in Mithi River estuary between 1976 and 2005



Legend

Island (1976)

Earlier Creek Boundary

(Data Source :- Survey of India Topographic sheet , 1976. Scale 1:63,360 and Quickbird satellite image of 8 April, 2005 at 9:30 am IST.)

200 100 0 200 400 Meters

1:11,611

FACT FINDING COMMITTEE ON MUMBAI FLOODS
CHANGE IN MITHI RIVER ESTUARY BETWEEN 1976 AND 2005
DRAWING NUMBER : 32