# Urban Floods:
# Case Study of Mumbai

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## Abstract
*Mumbai city having an area of 437 sq km with a population of 12 million came to a complete halt due to the unprecedented rainfall of 944 mm during the 24 hours starting 0830 on 26 July 2005. More than 419 people (and 16,000 cattle) were killed due to the ensuing flash floods and landslides in Mumbai municipal area, and about 216 people died due to flood related illnesses. Over 100,000 residential and commercial establishments and 30,000 vehicles were damaged. The paper describes Mumbai's drainage system, the details of the flooding, and the measures being taken by the city to mitigate such floods in the future. The Mumbai experience would be helpful for the other metropolitan cities to make panned response strategies to cope-up with similar disasters in the future.*
***Keywords:*** *Extreme rainfall, Urban flooding, Mumbai drainage system, Flood resilience*

## Introduction and City Profile
Mumbai, formerly called Bombay, (lat 18 N to 19.20 N, long. 72 E to 73 E) is the capital of Maharashtra state of India and the commercial and financial centre of India. It generates about 5% of India's GDP and contributes to over 25 % of the country's tax revenues. During the past 5 years, Mumbai has also become a centre for BPOs (Business Process Outsourcing) for major international organizations. Thus, any disaster in Mumbai has roll-on effects affecting the global economy. Mumbai is located on the windward side of the Western Ghats of India and receives high rainfall due to orographic effect from strong westerly/southwesterly flows over the Arabian Sea. The average annual rainfall of Mumbai City is 2050 mm as recorded by the Colaba meteorological station of IMD located at the southernmost tip of the city while that for the suburbs is 2300 mm as recorded at Santa Cruz, located 27 km away to the north. Monsoon rainfall occurs primarily during June to October and about 70 % of the

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average annual rainfall occurs in July and August and 50 % of this occurs in just 2 or 3 events. During these 2-3 events, it usually rains uniformly over the city and severe flooding occurs in many parts of the city. Mumbai is administered by the Municipal Corporation of Greater Mumbai and is divided into two revenue districts, viz. Mumbai city district (which has been formed due to the merging of seven islands by massive reclamation from the sea during 1784-1845) (Figure 1). Historically, these 7 islands were ceded to King Charles II of England as dowry in 1661 by the Portuguese. In 1668, the islands were leased to the East India Company for a sum of £10.  In 1877, the control passed to the British crown. The land reclamations have continued and in 1961 the Mumbai suburban district was formed which comprise the erstwhile island of Salsette and the former Trombay Island. A small part in the north Salsette Island, however, lies with the Thane Municipal Corporation. The Salsette-Mumbai creek and the Thane creek together separate Mumbai from mainland India. Thus, Mumbai is surrounded by the Thane creek and the Arabian Sea.

There has been a rapid and uncontrolled all round growth of the city - the influx of migrant workers have seen the population rise from 9.9 million in 1981 to 13.0 million in 1991 and to 17.7 million in 2001. However, the area under the Greater Mumbai Municipal Corporation covers an area of 437.71 sq km (excluding 200 sq km green belt) and is divided into 24 municipal wards (Figure 2). The average population density is 27,209 persons per sq km while some areas, for example Ward 'A' has a daytime (floating) population density as much as 394,390 persons per sq km and the night-time population is 200,000 persons with a density of 17,528 persons per sq km.

There are a large number of vulnerable informal settlements, many of them located on the flood plains of the Mithi River and the open storm water drains. About 65% of the Mumbaites live in informal settlements and over 2,768,910 structures - residential, commercial and industrial are listed with the Municipal Corporation of Greater Mumbai (MCGM). The Mumbai population is projected to reach 25 million before 2025.

The municipal area is highly susceptible to frequent flooding and witnesses severe disruptions annually. In addition, this area falls in an active seismological zone. The city is strongly oriented in a north-south direction. A majority of the population resides in the suburbs in the north and commutes to the City located in the south. The rail network constitutes the lifeline of the city and over 6 million people are transported daily by Mumbai's suburban railway system alone- this is almost 50% of the total number of passengers travelling daily by train in India. Thus, any disruption due to flooding results economic and social disruption - loss of livelihood to the individuals and loss of business to commerce and industry.

A new authority called the Mumbai Metropolitan Regional Development authority was set up in 1975 as an apex body for planning and co-ordination of development activities in the Region. The jurisdiction covers Mumbai and the neighbouring municipalities of Thane, Kalyan, Navi Mumbai, Bhiwandi, Virar and other municipal councils in the geographical area (Figure 3).

## City Infrastrucutre with Reference to Drainage

The drainage system of Mumbai is a mix of simple drains and complicated network of rivers, creeks, drains and ponds. A network of closed drains below the roads has evolved in the city - the roads have evolved by covering the old drains in the city whilst there are open drains in the suburbs (Figure 4). The southern city area has long complex networks which drains relatively large low-lying areas, while short drains from small areas drain directly to the sea. During 1870 to 1930 many royal commissions of enquiry were set up and they found that due to lack of knowledge of the monsoon rainfall and expertise during the 1870s, sanitation designs were based on empirical considerations and a system of "trial and error" was used. The history of drainage of the south city area is exceptional due to its unique history of reclamation of the area in between the original seven separate islands (James, 1917). In 1672, Mumbai consisted of seven separate islands. During 1672-1845, the municipal interests of the city were looked after by the Board of Conservancy and intensive reclamation of the spaces between the islands was undertaken with the reclaimed ground being below high-water level. This is one of the main reasons why many parts of Mumbai still experience severe flooding during intense rainfall, particularly at times of high tide. Water usually recedes during low tide, but if the rainfall persists for 7-10 hours and the next tidal cycle starts, then it becomes difficult for the water to recede and compounds the flooding. Most detention ponds have been lost to development and it is estimated that urbanisation has contributed to increased runoff by 2-3 times.

However, an open ditch was left for drainage purposes - known as the old main drain- from the town centre to the Flats where it emptied itself into a tidal estuary. In 1824, arching over this drain was started and completed in phases by 1856. The arching and the walls of the drains consisted mostly of roughly dressed stone; there was no foundation in many parts, but where it existed it was of rubble. The width of the old drain varied from 2 ft to 20 ft 3 in while the height varied from 2 ft to 9ft 10 in and the gradients were from 1 in 450 to 1 in 5000. This drain carried all the surface water in the monsoon, and all the year round sewage which was discharged into it by gravity or by hand. Due to the inadequate slopes, it functioned as a vast elongated cess-pool during the non-monsoon months.

In 1866, Mr Rusell Aitkin, then Municipal Engineer proposed that the sewage should be discharged into a reservoir at Colaba (southernmost point of Mumbai) near the lighthouse and pumped into the sea at ebb-tide. He proposed a main sewer from Null Bazaar to Colaba with large branch sewers from different districts. The main sewer was designed to carry only two inches of rainfall per day and Mr Aitkin proposed to retain the existing open main drain to receive the surplus when more than two inches of rainfall fell in a day.

In 1890, it was shown by Mr Baldwin Latham that the arrows indicating the directions of the floats were wrongly shown in the plan - they pointed to the north instead of the south and thus erroneously led to the conclusion that the current during the low tide set into the harbour instead of flowing to the open sea (These observations were again confirmed by another set of float observations by Mr Santo Crimp in 1899). This extraordinary mistake has no doubt been the principal cause of Bombay having its outfall on its western foreshore with all the consequent nuisances.

Hence, Mr Russell's scheme therefore remained in abeyance; however, Mr Aitkin constructed a low-level sewer system from the city which intercepted all the sewage from the old main drain and conveyed it to a pumping station at Love Grove, where it was lifted by two centrifugal pumps into the sea. In subsequent years, in most areas of Mumbai, brick-sewers and pipe-sewers were substituted for open drains.

By 1877, the nuisances due to lack of drainage increased, and the report of Hunter Commission marked the commencement of an entirely new era regarding the drainage history of Bombay. The Commission recommended the adoption of a scheme of pumping of sewage into the sea at Love Grove outfall. This scheme consisted of laying a main ovoid sewer from the east city passing through the city centre and the Flats to Love Grove on the west coast. A pumping station was to be set up at Love Grove to pump the sewage into the sea. The commission strongly recommended free ventilation of all sewers and the separation of storm water from drainage. The work commenced in December 1878 and was completed in May 1881. During 1881-1917, several other areas of Mumbai were also sewered. The drainage of Bombay, as laid out in the Island City at the beginning of the 20th century has mainly followed these recommendations.

The last major study was taken up in 1993, called the BRIMSTOWAD project (Brihanmumbai Storm water Drainage Project) and it recommended the augmentation of the drainage network. However, on grounds of economy, it recommended the augmentation of the drainage network for a rainfall intensity of 50 mm/hr which allowed two flooding per year. This scheme was implemented only partially due to limited funds. However, recent data analysis for the years 1999 to 2004 show that the peak rainfall intensity for the time of concentration of 15 minutes exceeded 72 mm/h over 80 % of the times (Table 1).

## Major Floods in the City – 26th July 2005 Extreme Rainfall of 944 mm in 24 hours

Flooding has been a regular feature during the monsoon and several earlier committees have identified the main causes of the flooding and these are summarised in Table 2.

The 26th July 2005 event has been classified as "very heavy" (> 200mm/day as per the rainfall classification of IMD). The Santa Cruz observatory at Mumbai airport recorded 944 mm during the 24 hours ending 0830 am on 27th July 2006 while the Colaba observatory recorded only 74 mm of rain (Jenamani, et al., 2006). The event has been attributed to a highly localized "offshore vortex". The rainfall hyetograph for the 26th July 2005 event is shown in Figure 6. From the figure it can be seen that at Santa Cruz, heavy rainfall started at 1430 with 481.2 mm falling in just 4 hours between1430 to 1830 and hourly rainfall exceeding 190 mm/h during 1430 to 1530. This has exceeded the rainfall record of Cherrapunji, which has been considered the world's wettest place. The already inadequate drainage system was unable to drain out because of the highest high tide level of the month of 4.48m at 1550.

### Extent of Flooding and it's Effects

Over 60 % of Mumbai was inundated to various degrees on 26th July 2005 as shown in Figures 7 and 8 (FFC, 2006). 107 low lying areas were severely flooded and the northern suburbs were severely affected.

The Indian Meteorological Department was unable to issue advance warnings of this event. Even when there was heavy rainfall in the northern suburbs, the IMD was unable to monitor the rainfall and issue warnings in real time. This has been attributed to the lack of state-of-the-art equipment like tipping bucket rain gauges with the IMD. IMD has only two rain gauges in Mumbai and both are of the syphonic type which record data on graph paper attached to clockwork driven drums. These are read only at 0830 daily.

The immediate impact of the heavy rainfall was that there was a total collapse of the transport and communication system. Both the main Mumbai Santa Cruz airport and Juhu airport used mainly for helicopter operations had to be closed down for two days on 26-27 July, 2006. The runways were waterlogged, the terminal buildings were flooded and crucial navigation and landing aids damaged, thus forcing over 750 flights to be either diverted or cancelled. Both the major roads linking the northern suburbs to the city, namely the western expressway and the eastern expressway were submerged. Most arterial roads and highways in the suburbs were severely affected due to waterlogging and traffic jams resulting in breakdown of vehicles in deep waters. Intercity train services had to be cancelled for over a week, while suburban trains, which are the lifeline of the city, could not operate from 1630 onwards for the next 36 hours. Many people were stranded in their offices while students had to spend the night at their respective colleges and schools. Others spent the night in the trains and buses and some even on top of the buses. The mobile phone network also collapsed- the transmitters had diesel generators to last only two hours and the fuel could not be replenished due to failure of transport; over 2 million landline phones were also affected. Electricity was cut off in most parts of Mumbai- this resulted in the failure of sewage pumps and further led to backflow of sewage into the stormwater. Excessive rainfall resulted in waterlogging in several areas of the suburbs with water entering even the first floor flats in some areas. Almost 419 people lost their lives including 65 killed in the several landslides. 216 people died due to the various deluge-related epidemics. Animals too were not spared; around 6307 animal carcasses were disposed off.

A substantial number of buildings were damaged- 2000 residential buildings were fully damaged while 50,000 were partially damaged and 40,000 commercial establishments suffered heavy losses. 30,000 vehicles were damaged and 850 buses of the Mumbai Transport were damaged. Some vehicle occupants lost their lives because they could not open their power windows as their car engines went dead after being submerged in flood waters.

## Post-Flood Measures

As thousands of people had to wade through sewage waters on 26-27 July, 2005, the risk of epidemics of water-borne diseases such as gastroenteritis, hepatitis, leptospirosis, malaria and possible cholera was high. To prevent an outbreak of epidemics, 6307 carcasses were disposed of on a priority basis by the staff of the Mumbai Corporation of Greater Mumbai (MCGM) - these included 1307 buffaloes and 5000 sheep and goats. The removal of the carcasses was facilitated by employing 27 cranes, 87 dumpers and 24 bulldozers during 27-30 July 2005. In addition, extensive spraying of disinfectants and insecticides to control pests and minimize flies and mosquitoes was undertaken. MCGM also provided comprehensive healthcare services through 130 specially constituted medical teams and over 300,000 patients were treated virtually at their doorstep through health camps and outreach camps. 253,612 metric tones of solid waste which had accumulated in various parts of the city was removed by employing 107 bulldozers, 438 dumpers and 511 compactors during 29th July to 21st August 2005.

### Chitale Committee (2006)

A fact finding committee was also set up by the Government of Maharashtra to identify the cause of floods and to suggest measures for the future. Earlier reports by the Natu committee (1974), CWPRS - Central Water Power Research station (1978), BRIMSTOWAD (1993) and IIT Bombay (Gupta, 2005) were also placed before the Chitale committee. The Chitale committee reiterated the causes of the flooding as mainly the inadequate drainage system, rapid developments and loss of holding ponds, encroachment by the slums on and over the existing drains and decrease in the coastal mangrove areas. The Mithi River in the north has been reduced to an open drain due to severe encroachments and discharge of industrial effluents into the river. Nearly 54 percent of the original river flow has been lost to slums, roads and new developments. The new sea-link has also reclaimed the mouth of the river by about 27 hectares of landfill. Other rivers in the northern suburbs which overflowed are the River Dahisar and the River Poisar.

The committee recommended detailed contour maps of all watersheds, stream gauging, installation of automatic rain gauges by the IMD, regular maintenance and desilting of the existing drains, removal of obstructions and provision of additional gated outfalls/ pumping stations and holding ponds. Further, it recommended that the BRIMSTOWAD report be revised to take into account 100 mm/hr rainfall for the major roads and critical structures in the city.

## Enhancement of the Flood Response Mechanism During 2006–09

### Institutional mechanisms

Several institutional mechanisms have been strengthened - the Mumbai Disaster Management Committee headed by a very senior bureaucrat, the MCGM Disaster Management Committee headed by the Municipal commissioner and the Ward Disaster Management Plan headed by the Assistant Commissioner of the ward. A new Mithi River Development Authority has been set up to look exclusively into the restoration of the Mithi River to pre-development conditions. In addition, all construction works in the city which are carried out by central government organizations would require clearance from the MCGM. Rainwater harvesting has been made compulsory for development on areas greater than 1000 sq. m. - this would ensure that no additional runoff reaches the drains from new developments.

## Emergency Control Centre

The emergency control centre of the MCGM has been upgraded at an estimated cost of Rupees 5 crore and now has been made self-sufficient to withstand and handle most disaster situations. It has an array of communications systems, television sets tuned to major news channels, networked computer systems with disaster management related software, video conferencing setup, conference and press rooms, emergency water supplies and rations, uninterruptible power supply with standby generators.

## Automatic Weather Stations

Independent of the recommendations of the Chitale committee, the MCGM had already initiated the procurement and completed the installation of 30 automatic weather stations by June 2006. The weather station included tipping bucket rain gauges capable of giving rainfall data every minute. The weather station also has a console capable of giving an audible alarm at preset rainfall intensity values (in this case when the rainfall exceeded 40 mm/hr). The weather stations have been spread out on a more or less uniform basis in the city so as to provide representative rainfall data over most of the catchments in Mumbai. Considering the safety of the instrument (protection from vandals) and the fact that the fire and rescue services are the first respondents, the weather stations have been sited on the top of the fire stations in each area. The other weather stations have been located at the MCGM headquarters where the emergency control centre is located, and one each in the catchments of Powai Lake (at IIT Bombay), Vihar Lake (MCGM water intake) and Tulsi Lake (MCGM water intake). The data for the monsoon of 2006 is presently under compilation and work is under progress to study the spatial and temporal pattern of rainfall in Mumbai.

During monsoon 2006 and 2007, it has been possible for the duty officer at each location to monitor the rainfall every 15 minutes and issue alert too the central control room. As compared to earlier years when real time data for rainfall was not available, this has resulted in a substantially enhanced response mechanism and judicious deployment of resources to the waterlogged areas. It has also enabled the MCGM to issue warnings to the public through mass media. The schematic for the early warning system is shown in Figure 9.

The procurement of flow gauges and identification of suitable sites is currently in process and is targeted to be implemented before monsoon 2008.

## Removal of Solid Waste from Stormwater Drains

To prevent clogging of the stormwater inlets, a ban on plastic bags less than 50 microns has been enforced. Enhanced desilting of drains, clearing og blocked inlets and deployment of manpower at critical locations on 24 hour basis has also been carried out. A significant achievement has been the restoration of the width of the Mithi River to between 7 m to 35 meters at various locations through removal of encroachments from the river banks.

### Response Mechanisms

For enhancing the search and rescue operations, six fire brigade control rooms have been upgraded to command centres with state-of-the-art equipment and manpower of 30 personnel. MCGM has also constituted three search and rescue) "ask Force One" comprising of 26 members each from various disciplines. They have undergone training in collapsed structure search and rescue, confined space search and rescue, rope rescue and medical first response. Their training has been based on INSARAG and ADPC guidelines. These teams have also been equipped with 6 inflatable boats, 12 kayaks. In addition, there has been an agreement with the navy to deploy boats in seven low-lying areas.

The hospitals form the backbone of any emergency response and measures like shifting of medical equipment and wards to higher floors, deployment of additional medical and paramedical staff and establishment of additional trauma care centres at various hospitals in the city have been implemented.

The following additional measures have also been implemented:

- To prevent a recurrence of stranded vehicles which was seen during July 2005, 84 parking spots have been demarcated for people to park their cars in the event of severe rainfall.
- 120 temporary shelters for stranded people have been identified as temporary shelters for stranded people - these comprise of 5 schools in each of the 24 wards.
- Additional pumps have been installed in 40 high risk flood prone areas with manpower on 24 hour standby.
- Involvement of home guards, various voluntary organizations has been enhanced.

## Strategies for the Future

The extreme rainfall event of 944 mm on 26th July 2005 has been a lesson for Mumbai and has resulted in Mumbai setting up a much better response mechanism based on real-time monitoring of rainfall at 27 locations in the city during 2006. During 2007-

2008, the number of rain gauges has been increased to 32 and an ultrasonic flow gauge has also been installed to better monitor the rainfall and flow level in the Mithi River. In 2008-2009, the rainfall density is further being intensified and 30 more additional weather stations are proposed to be installed. In addition, 4 more flow gauges are being installed at major locations to monitor the flow levels and improve the response mechanism.

During 2009-2010, the budget provisions of Rs. 2058.43 crore has been made for improving storm water drainage and sewerage as shown in Table 3. It has focused on the improvement of storm water drains to minimize water logging. Construction of storm water pumping stations has been proposed at various locations including Britannia Outfall, Gazdarband, Mogra Nalla and Mahul Creek. Under the JNNURM, the BMC has also been working on the replacement and rehabilitation of city's ancient sewerage system to increase the life and capacity of the pipelines.

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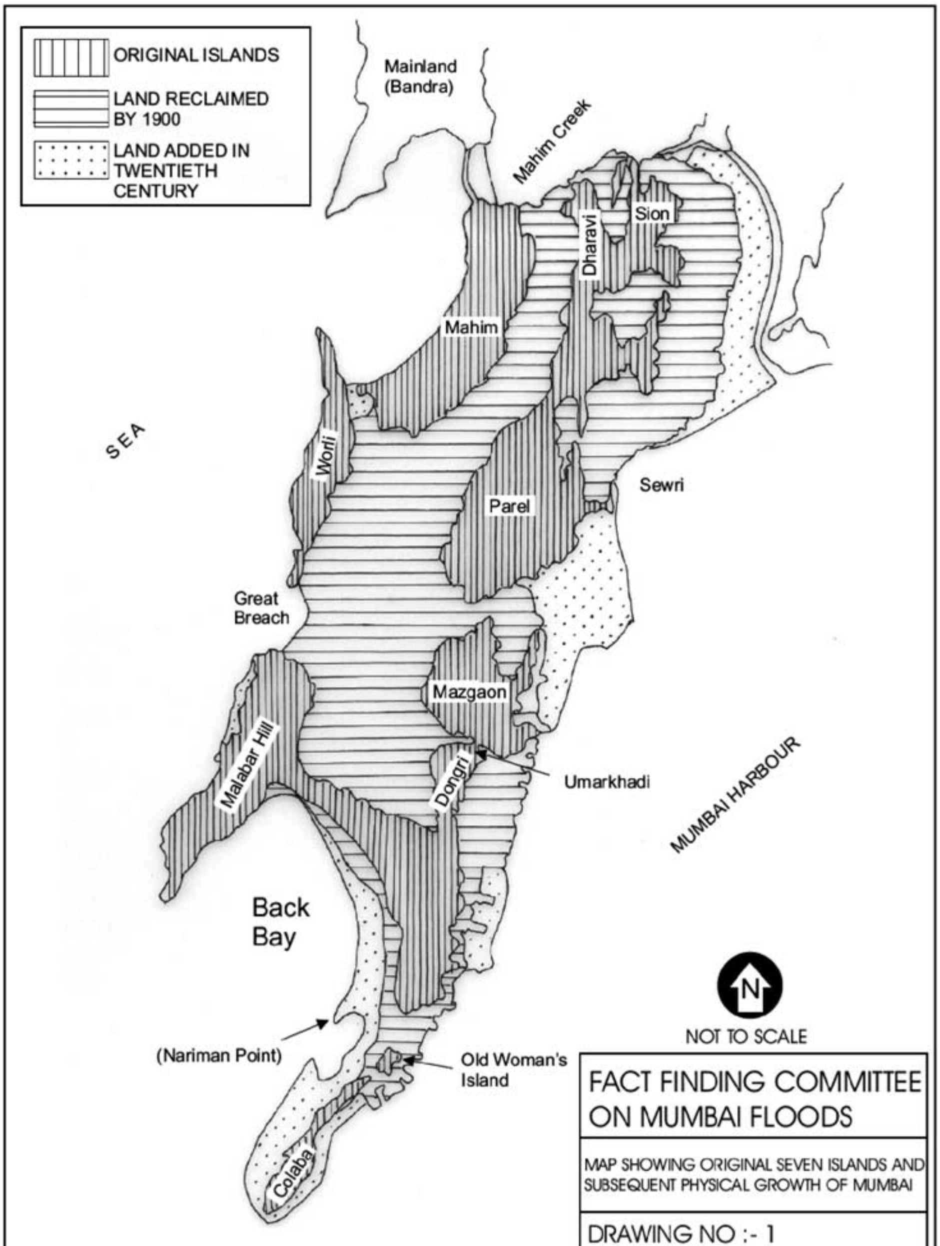


Reference - Gazetteer of India, Maharashtra State, History of Bombay, Modern Period 1987

Figure 1. The Mumbai city district showing the original seven islands and subsequent physical growth of Mumbai (Gazetteer of India, 1987)

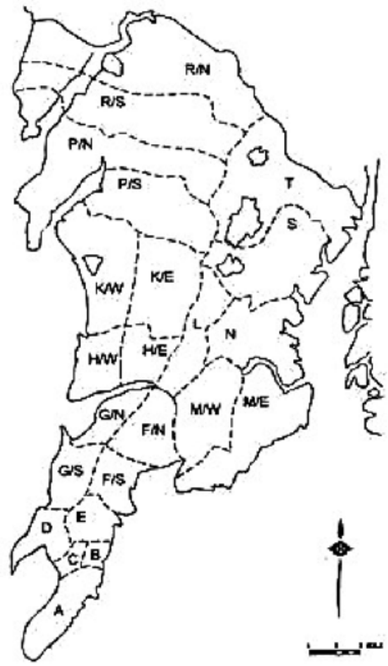


Figure 2: 24 municipal wards of Mumbai

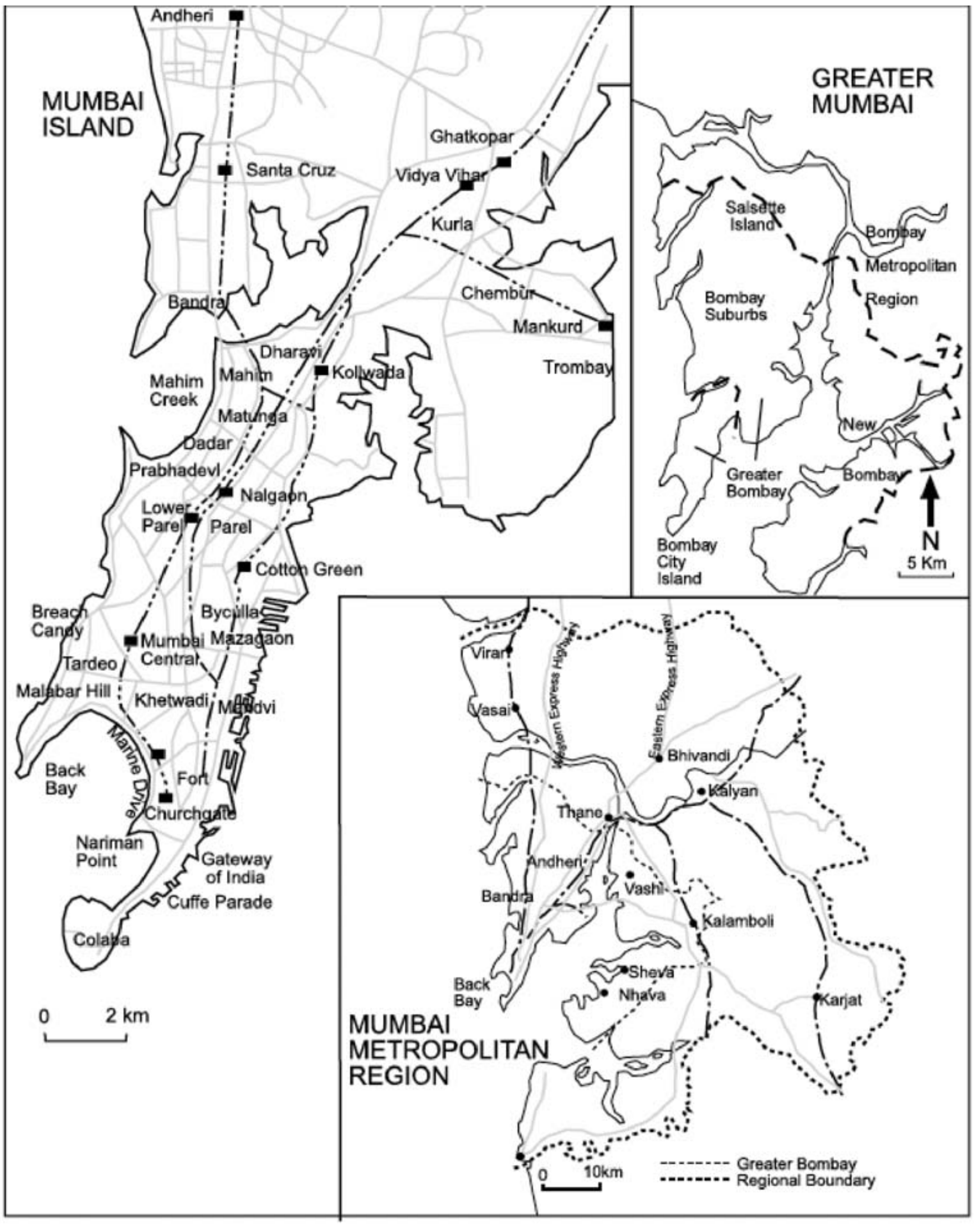


Figure 3: Area under MMRDA

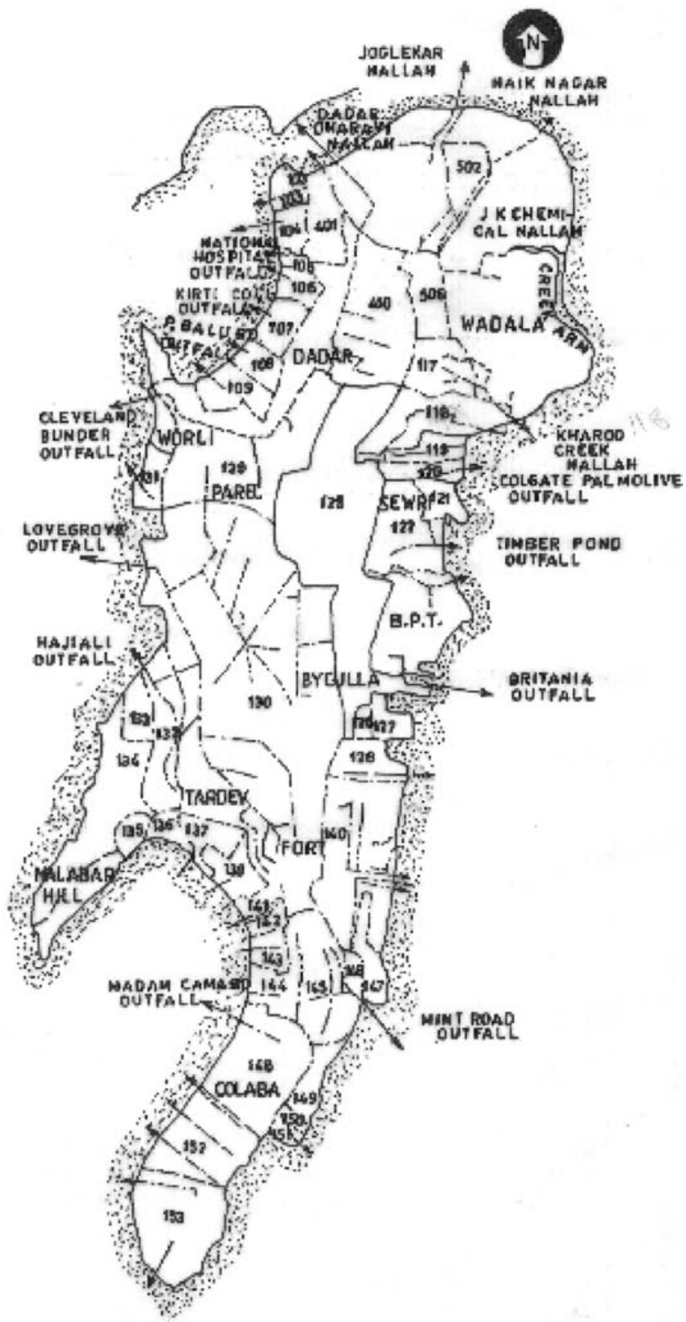


Figure 4. Drainage of Mumbai City area (MCGM, 1993)

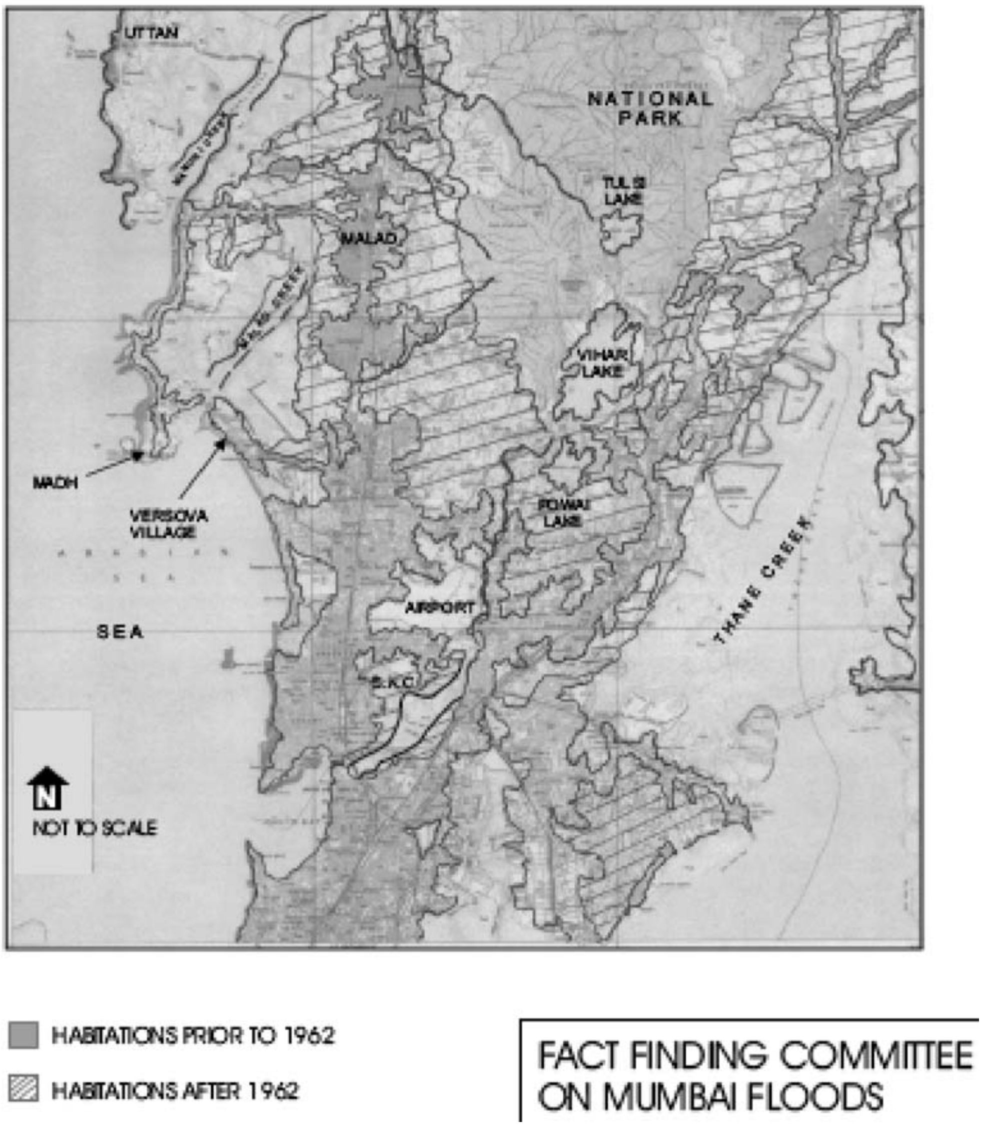


Figure 5. Drainage of northern suburbs (FFC, 2006)

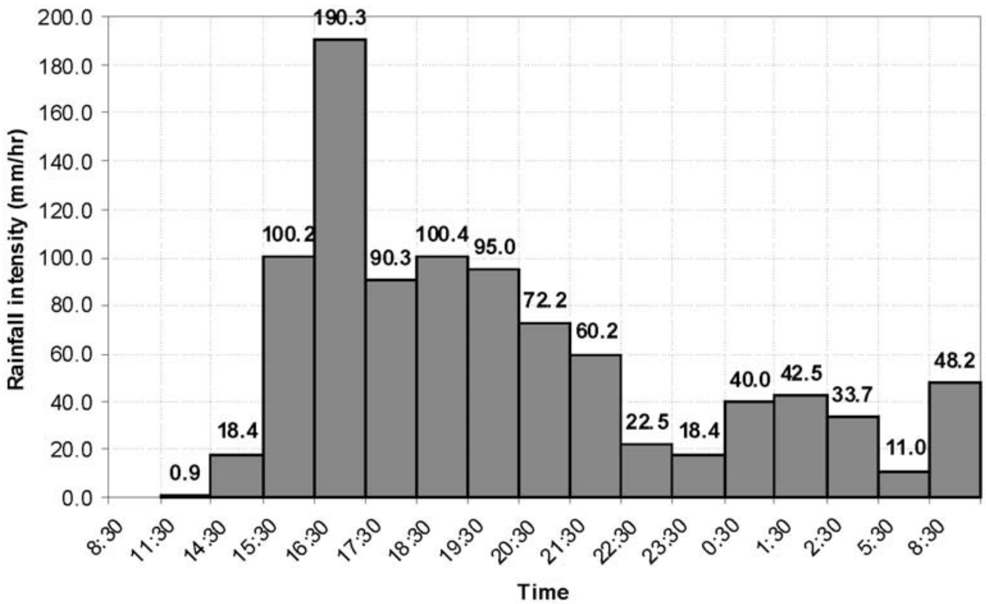


Figure 6. Hyetograph of 26th July 2005 rainfall- 24 hours ending 0830 on 27th July 2005 (source: IMD, 2005)

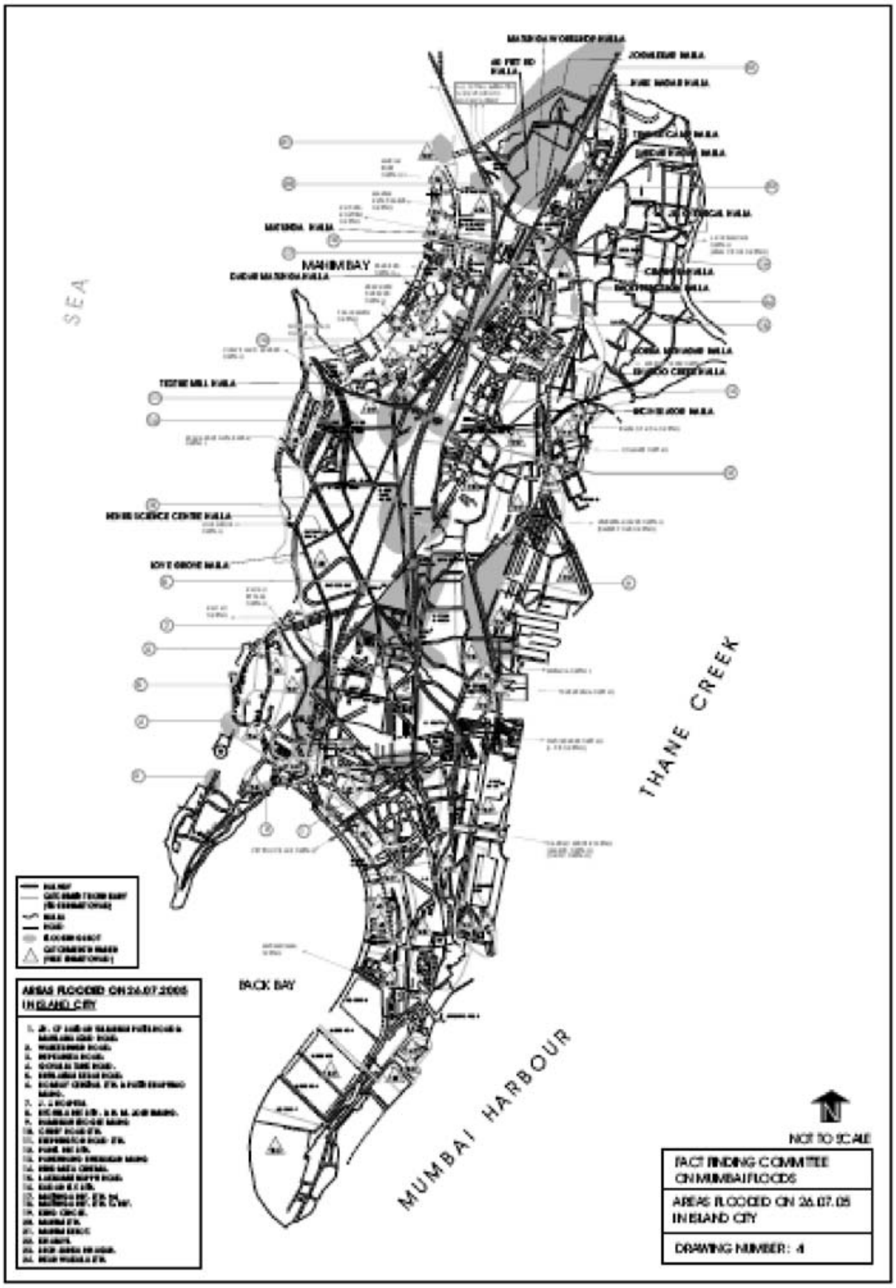


Figure 7. Inundated areas in City area (Fact Finding Committee, 2006)

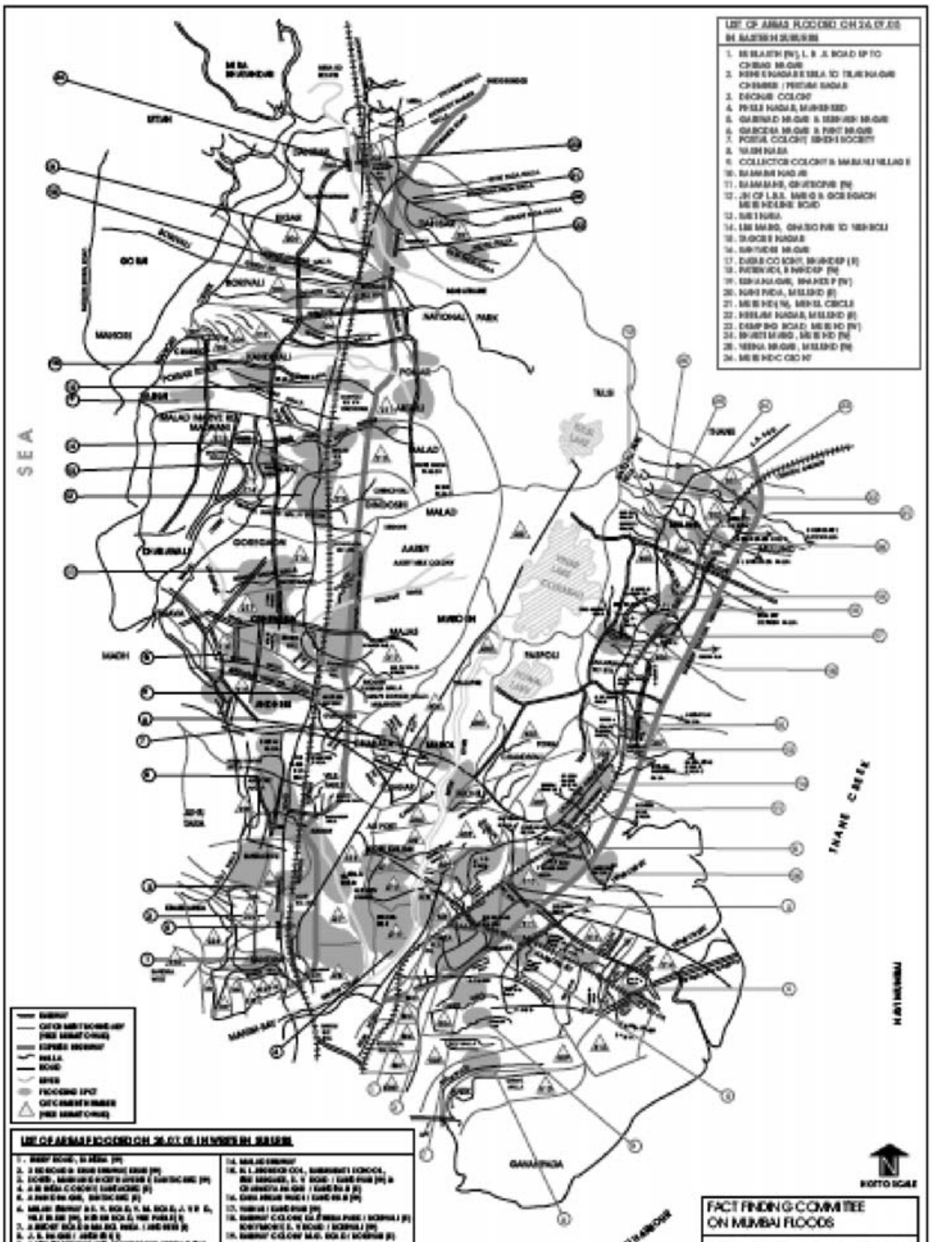


Figure 8. Inundated areas in the northern suburbs of Mumbai (FFC, 2006)

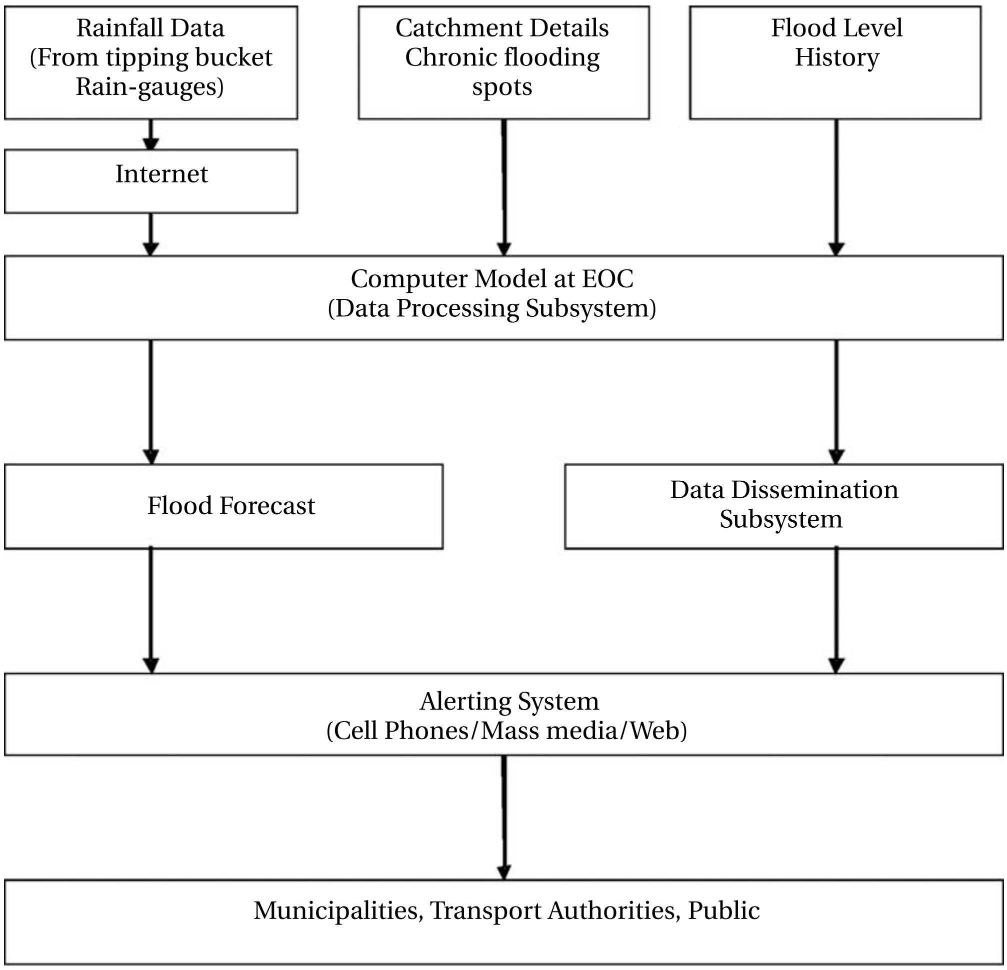


Figure 9. A flood warning system for mitigating urban flooding in Mumbai

Table 1: Peak 15-min rainfall intensities on flooding days (compiled from BMC/IMD)

| | | 15-min (mm/h) | rainfall | intensity | Yearly intensity) | maximum mm/h | (15 min rainfall |
|---|---|---|---|---|---|---|---|
| Year | Flooding date | | Santa Cruz | Colaba | | Santa Cruz | Colaba |
| **1999** | 23.05.1999 | - | 48 | | 116 | 76 | |
| | 16.06.1999 | 72 | - | | | | |
| | 23.06.1999 | - | 76 | | | | |
| | 07.07.1999 | - | 56 | | | | |
| | 16.07.1999 | 70 | - | | | | |
| | 10.09.1999 | 72 | - | | | | |
| | 12.09.1999 | - | 48 | | | | |
| | 07.10.1999 | 116 | | | | | |
| **2000** | 18.05.2000 | 116 | 60 | | 116 | 88 | |
| | 08.06.2000 | 100 | 68 | | | | |
| | 03.07.2000 | - | 76 | | | | |
| | 12.07.2000 | 104 | - | | | | |
| | 24.08.2000 | - | 88 | | | | |
| | 22.09.2000 | 50 | - | | | | |
| **2001** | 08.06.2001 | 68 | - | | 80 | 96 | |
| | 17.06.2001 | - | 80 | | | | |
| | 08.07.2001 | 80 | 96 | | | | |
| | 08.08.2001 | - | 43.2 | | | | |
| | 16.08.2001 | 69.2 | - | | | | |
| | 27.09.2001 | 40 | - | | | | |
| **2002** | 14.06.2002 | 60 | - | | 64 | 80 | |
| | 26.06.2002 | - | 56 | | | | |
| | 06.08.2002 | 64 | - | | | | |
| | 09.08.2002 | - | 52 | | | | |
| | 23.09.2002 | - | 48 | | | | |
| **2003** | 18.06.2003 | - | 80 | | 64 | 80 | |
| | 19.06.2003 | 64 | - | | | | |
| | 07.07.2003 | 64 | - | | | | |
| | 14.07.2003 | - | 88 | | | | |
| | 23.08.2003 | 64 | - | | | | |
| | 30.08.2003 | - | 53.6 | | | | |
| | 10.09.2003 | - | 72 | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 26.09.2003 | 56 | - | | | |
| **2004** | 18.05.2004 | 88 | - | 120 | 75.2 | |
| | 17.06.2004 | 48 | - | | | |
| | 18.06.2004 | - | 62 | | | |
| | 04.07.2004 | 74 | - | | | |
| | 29.07.2004 | - | 60 | | | |
| | 01.08.2004 | - | 75.2 | | | |
| | 04.08.2004 | 120 | - | | | |
| | 05.08.2004 | 80 | - | | | |
| | 20.09.2004 | 70.8 | - | | | |
| | 30.09.2004 | - | 40.4 | | | |
| | **Maximum 15 -min peak intensity (mm/h) during 1999-2004** | | | | **120** | **96** |

Table 2. Main causes of flooding in Mumbai (FFC, 2006)

| S No | City area | Suburban areas |
|---|---|---|
| 1 | Low ground levels | Low ground levels |
| 2 | Siltation of drains/ nallas | Siltation of drains/ nallas |
| 3 | Obstructions of utilities | Obstructions of utilities |
| 4 | Low Level of outfalls | Encroachment along nallas |
| 5 | Dilapidated drains | Slums along outfalls |
| 6 | Urbanisation and loss of holding ponds | Garbage dumping in SWDs/Nallas mainly in slums |
| 7 | Increased runoff coefficients | No access for desilting |

Table 3: Funds allocated for improving stormwater in Mumbai during 2008-09

| S.No. | Particulars | Rs. (crore) |
|---|---|---|
| 1 | Maintenance of storm water drains (SWD) | 248.10 |
| 2 | Infrastructure projects under Brimstowad | 1,576.82 |
| 3 | Widening and cleaning or Mithi River | 40.00 |
| 4 | Laying of 5.95 km sewage lines with the help of micro-tunnelling | 25.00 |
| 5 | Construction of sewage treatment plants at Colaba, Worli and Malad and a recycling plant at Versova | 55.00 |
| 6 | Rehabilitating old sewer lines across city | 70.51 |
| 7 | ISO 9001-2000 certification for sewage installations | 0.90 |
| 8 | Construction and repair of public toilets under the slum sanitation programme | 42.10 |
| | TOTAL | 2058.43 |