SESSION – 3

RIVER AND DRAINAGE SYSTEM IN CMA

Session – III

Waterways in Chennai

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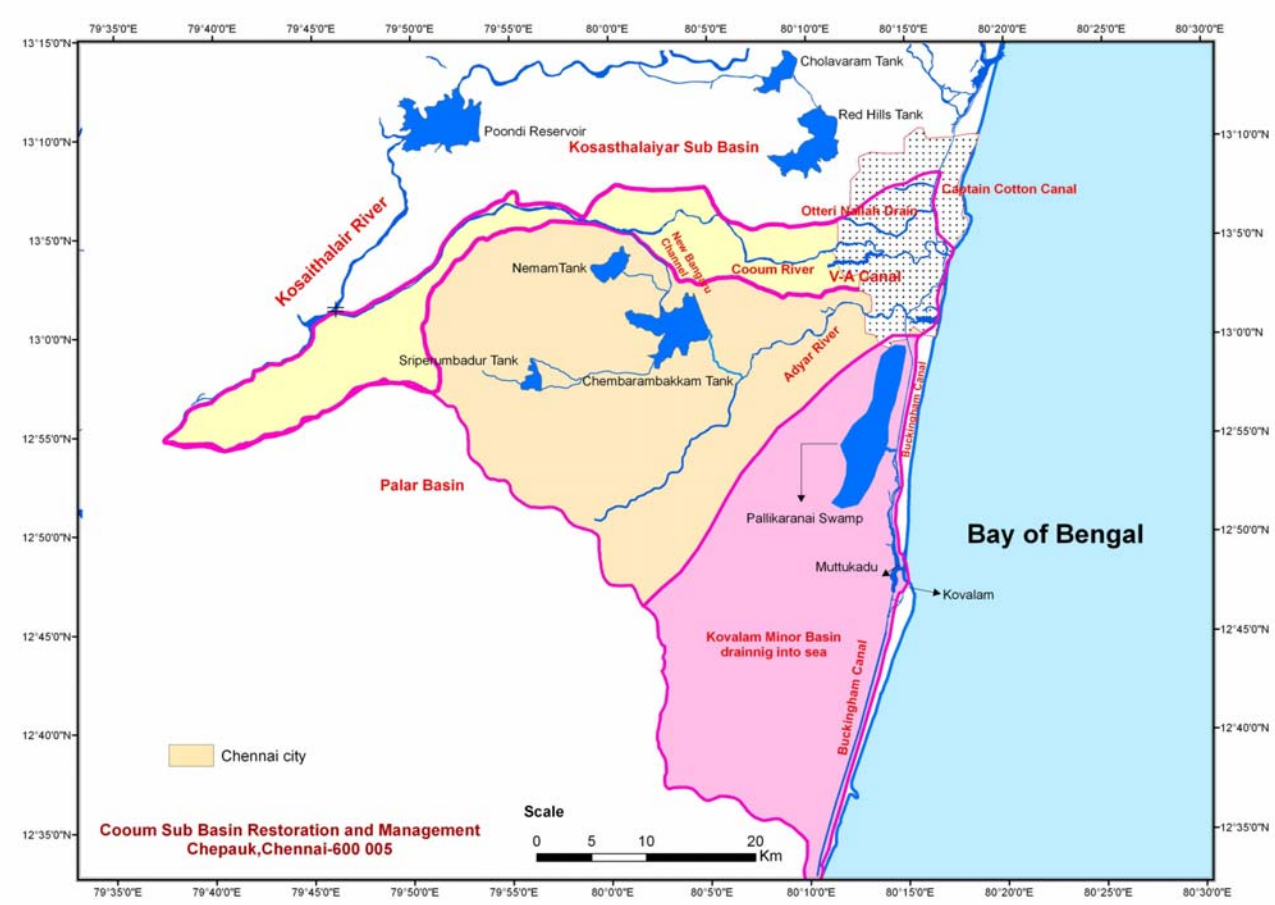
CHENNAI METROPOLITAN AREA

- Chennai Metropolitan Area (CMA) covers 1189 Sq. Km.
  present population about 75 Lakhs
  projected to 98 Lakhs in 2011
- Chennai City covers 176 Sq. Km. having Terrain slope varying from 1 : 5000 to 1 : 10,000
- The City is drained by 2 rivers besides a number of major & minor drains through Buckingham Canal into Sea via Ennore Creek, Cooum mouth, Adyar mouth and Kovalam Creek.
- Major Flood Events in Chennai City experienced during 1943, 1976, 1985,1996 & 2005



RIVERS AND DRAINAGE SYSTEM OF CHENNAI METROPOLITAN AREA

River / Drainage System	Orgin	Location of confluence with Bay of Bengal	Total Length in Km.	Length in City Limits in Km.	Length in CMA in Km.	Total Catchment Area in Sq.Km.	Bed width in M.	Anticipated flood discharge/ Presnet Capacity in C/s	Flood discharge in 2005 in C/s.
RIVERS									
Kosasthalaiyar	Krishnapuram (AP) for nagri am / Kaveripakkam (Vellore District) for Kosasthalaiyar arm	Ennore Creek	136		16	3757	150 to 250	125000/ 110000	90000
Cooum	Cooum Tank (Thiruvallur District) Kesavaram for diversion from Kosasthalaiyar	Cooum Mouth near Napier Bridge	72	18	40	400	40 to 120	22000/ 19500	21500
Adyar	Adanur Tank near Guduvancherry	Adyar Mouth	42.5	15	24	1142	10.50 to 200	60000/ 39000	55000

MAJOR DRAINAGES									
North Buckingham Canal	Ennore Creek	Cooum North Arm	58	7.1	17.1 up to Ennore Creek	89.88	15	10500	9900
Central Buckingham Canal	Cooum South Arm	Adyar Creek	7.2	7.2	7.2	9.75	15	1500	1500
South Buckingham Canal	Adyar Creek	Marakkanam	108	4.2	16.9 up to Kovalam Creek	16.98	15	6000	5660
Otteri Nullah	Padi & Villivakkam Tanks (Abadoned)	Buckingham Canal near Basin Bridge	10.2	10.2	10.2	38.4	4 to 20	1800/600	1800
Virugambakkam - Arumbakkam	Virugambakkam Tank (Abadoned)	Cooum River near Nungambakk-am	6.36	6.36	6.36	13.72	15 to 7.50	2100/600	1700
OTHER DRAINS									
Kodungaiyur Drain	Kolathur Tank, Madhavaram Tank	Buckingham Canal through Kodungaiyur Tank	6.9	6.9	6.9	6.92	6-10m	1060	--
Veerangal Odai	Adambakkam Tank	Pallikaranai Swamp	2.78	--	2.78	6.92	2 X 5.6 m	654	654
Captain Cotton Canal	Vyasarpadi Tank	Buckingham Canal near Tondiarpet	6.9	6.9	6.9	8.14	10-15 m	1950	--
Velachery Drain	Velachery Tank	Pallikaranai Swamp	2.14	2.14	2.14	3.88	5.6	655	750

Linking of Rivers for Chennai City Water needs during the Century

Palar to Kosasthalaiyar : From Palar Anicut near Walajah to Poondi reservoir across Kosasthalaiyar through – Govindavadi channel, Kaveripakkam tank surplus, Cooum River, Kesavaram Anicut, Kosasthalaiyar River, Poondi Reservoir

Palar to Adayar : From Palar Anicut near Walajah to Adyar river (Near Thiruneermalai) through Govindhavadi Cannel-Kambakkal Channel, Sriperumbudur tank and its Surplus, Chembarambakkam tank and its Surplus

Araniyar to Kosasthalaiyar : From Araniyar Syphon across Araniyar river to Poondi reservoir across Kosasthalaiyar river through Kandaleru-Poondi Canal Anicut and in turn to Poondi reservoir.

Cooum to Adayar : From Zamin Korattur Anicut across Cooum River (between Poonamallee and Tiruvallur) to Adyar through New Bangaru channel, Chembarambakkam tank and it's surplus course.

Functions of Rivers and Drainages during Last Half Century

- Strom water & Flood conveyance during monsoon period
- Conveying untreated sullage, sewage and industrial effluents
- Dumping place for all sorts of solid wastes
- Place for Slums by encroachments

Inlets into Rivers and Drainages in CMA

- 512 micro drains falling into rivers & drainages
- 84% infalls are sewage & 11% storm water drainage.
- 27% infalls received by Cooum
- 29% infalls received by Buckingham Canal
- 19% infalls received by Adayar River

Rainfall – Tide and Storm Tide

Average Annual Rainfall	:	N.E.Monsoon 700 mm S.W.Monsoon 400 mm Total = 1100 mm

Max. Rainfall in 27 years 1980-2006 Nungambakkam 2566 mm in 2005

Normal Tide	:	0.60 m
High Tide	:	1.20 m
Storm Tide	:	3.00 m (Ave.)

- In any rainfall more than 20 cm. in 24 hours causes inundation in low lying areas.
- Storm Tide occurs invariably during any North East Monsoon rain
- High Tide with storm reaches 3 m above MSL (eg.1976)

BUCKINGHAM CANAL AND ITS INFLUENCE ON DRAINAGE

- Formed as Drought Relief work in 1806
- Intercepts all the East flowing drains
- Constant Bed level : (-) 1.83 M (Below MSL)
  Length in CMA : 44 km
- Connects Araniyar, Kosasthalaiyar, Cooum and Adayar River
- Major Drains falling in Buckingham Canal : Kodungaiyur Drain, Captain Cotton Canal
  Otteri Nullah, and other Minor Drains between Cooum and Adayar
- Acts as a barrier for arresting sea water intrusion.
- Disrupted by Solid waste and anaerobic growth in sewage
- 25 m wide waterway restricted in many places to 10m due to MRTS stations and pile caps of MRTS pillars. Century old arch bridges across the canal prevent free flood flow (Elephant gate, Ice house, Kutcheri Road, Adams Road).

Flood Experiences during last three decades

1976	Heavy Flood Submergence in Adayar-Kotturpuram TNHB Qtrs. Flood could not enter into sea due to High & Storm tide. Chembarambakkam Tank surplused into Adayar – 28,000 C/s
1985	Floods in Adayar - 63,000 c/s submergence of encroached flood plains
1996	Floods in Adayar, Cooum and Kosasthalaiyar Rivers Poondi Dam surplussed around - 80,000 c/s ,Karanodai Bridge collapsed, Chembarambakkam Tank surplused into Adayar – 20,000 C/s
1998	3 persons Marooned in Thanikachalam Nagar - a residential colony in the flood plains of Kodungaiyur drain
2005	100 year RF 40 cm in a day, Flood in Cooum 19,000 C/S, Adayar 40,000 C/S, Otteri Nullah, Cooum, Adayar, B'Canal Virugambakkam - Arumbakkam Drain over flown, 50,000 people evacuated.

Problems Associated with Waterways

Engineering

- Acute hindrance to hydraulic functions due to restricted vent ways in old arch bridges, causing flood hazards.
- Inadequate tidal influence for periodical flushing
- Formation of sand bars in the river mouths causing stagnation in Cooum and Adayar.
- High Deposits of silt in the tail end reaches, causing restriction of tidal flows into rivers
- Absence of minimum Ecological flows in the rivers
- Reduction in waterways due to encroachments and Solid Waste dumping, causing flood hazards
- Lack of required width to discharge flood due to presence of patta lands within the flood plains of the river (Eg: Stretech of the Adyar River between Nandampakkam and Manapakkam & of Cooum River between Maduravoyal and Thiruverkadu

Environmental

- Inflow of untreated sewage.
- Disposal of solid waste and construction debris.
- Slums in the flood plains directly feed sewage and solid waste.
- The BOD is very High due to direct infall of sewage – 17 to 375 mg / litre
- Presence of disease causing Bacteria & Virus – high, besides mosquito breeding, bad odour etc.

Social

- Eviction of Encroachers along Waterways
- Rehabilitation and resettlement of the both objectionable and un- object able slum dwellers

ZONES OF NEW PROBLEMS

- The recently developing IT corridor should be drained faster by adequate culverts across OMR (Rajiv Gandhi Road) to Discharge into B'Canal.
- The Chennai Bye pass connecting Tambaram to Red hills (NH 45 to NH4) interferes with drainage flowing East eg. Inundation in IRR, Anna nagar, Porur, Vanagaram, Maduravoyal, Mugapppair, Ambattur etc.
- Reduction of flood carrying capacity of the Waterways due to construction of Elevated Transporation corridor along the waterways
- Solid waste and Sewage disposal by the local bodies around Chennai Metropolitan Area into water bodies.
- Interference due to radial roads and new roads across tanks obstruct flood flow.
- Inadequate ventway for culvert in new roads
- Raising the existing top level of road without provision of adequate culverts

SUSTAINED OPENING OF RIVER MOUTHS

1189 Sq.Km. of Chennai Metropolitan Area (Chennai City 175 Sq.Km.) is drained through the mouths of

1.	Kosasthalaiyar at Ennore Creek	:	120 m (Maximum)
2.	Cooum	:	150 m "
3.	Adayar	:	300 m "
4.	Muttukkadu	:	100 m "

- Keeping these four mouths open for adequate width during storms for receiving floods against high storm tide is difficult.
- Hence delay in flood drainage and in turn prolonged inundation.
- Sustaining open river mouth by Groynes and Training wall
- Creation of additional openings by straight cuts from Buckingham canal to Sea wherever technically feasible.

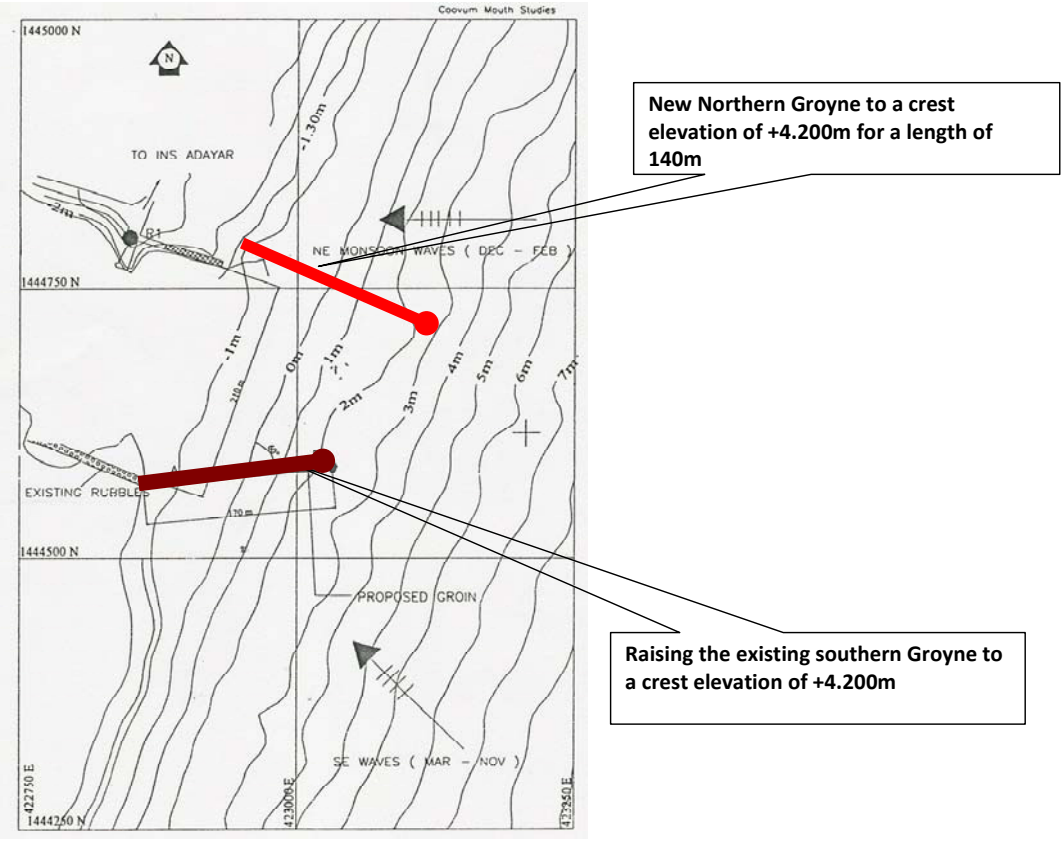
- *So far the River mouths and creeks are opened temporarily prior to monsoon periods and occasionally opened when there is excess stagnation of sewage during low flow periods.*
- *Only for Cooum River mouth attempts by means of both studies and implementation were made in the past*

Suggestions for sustained opening of Cooum mouth

1	1890	Link canal to connect Cooum and Harbour
2	1905	Pumping sea water upto Harris Bridge and Flushing the River
3	1921	Maintaining a deep river course to have tidal effect
4	1922	Construction of 400 m long tidal weir at Napier Bridge
5	1923	Connecting Cooum with the sea through arch culverts, closing the North arm of Cooum
6	1925	To maintain a deep channel from Commander-in-Chief Bridge to Napier Bridge
7	1927	Pumping Scheme from Timber pond at Harbour to Cooum above Wallajah Bridge
8	1933	Removal of shoals in the river bed and a central channel to eliminate local ponds and to give effective flushing.
9	1958	High Power Technical Committee, To stop sewage overflow; a. To relocate slums; b. To improve Cooum stretch between Chetpet Bridge and mouth
10	1976, 1996	P.V. Sahadevan Recommendation, PWD, Formation of reservoir to release artificial floods to flush Cooum.
11	1982	P.V. Indiresan Recommendation, Director-IIT, Introduction of Break water to the South of Cooum mouth to open it.
12	2000	NIOT, IIT for construction of North and South groynes with continous deredging

Works done for Sustained opening of Cooum mouth

1	1968-73	Cooum Improvement Scheme
2	Stage-I	Construction of Tidal weir and Jetty at Mouth; Installation of a sand pump at mouth
3	Stage-II	Improving and Beautifying stretch between Chetpet & Napier Bridge
4	Stage-III	Construction of Regulator
5	1998-99	National Institute of Ocean Technology (NIOT), Construction of groynes in stages at Mouth
6	2000-01	Construction of a 170m long Rubble mound Groyne south of Cooum mouth
7	2003-04	Further studies to extend the Groyne by 170m and formation of another 140m long Groyne North of Cooum mouth
8	2003-04	Developing Cooum River in two stages • Sea Mouth to Periyar Bridge 1.59 Km (Stage –I) • Periyar Bridge to Koyambedu Bridge (Stage – II after evicting the encroachments)
9	2005-07	Construction of a 140m long Rubble Mound Groyne North of Cooum Mouth and raising the South Groyne to (+) 4.200m to prevent sand bye-passing and simultaneous removal of sand bar in mouth



Works to be done for Sustained opening of Cooum mouth

- Initial Dredging of the river from its mouth up to chetpet (Tidal influencing range)
- Continuous Dredging of the River from sea up to off take point of North arm and South arm
- Disposal of the Dredged material in non-hazardous ways

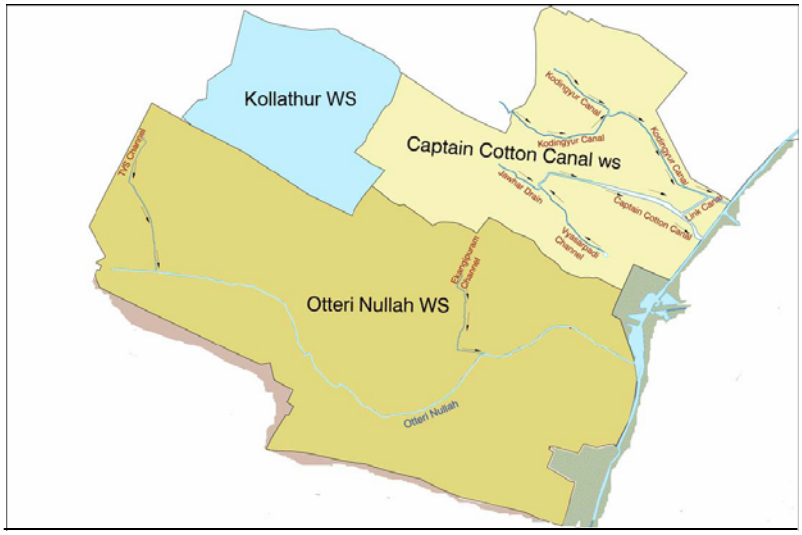
INADEQUACIES IN THE MACRO DRAINAGE

- Width reduced due to encroachment
- Bed Slopes flattened due to siltation and solid waste dumping
- Drains are obstructed by massive construction of inadequate culverts
- Low lying cause ways
- Make shift foot bridges
- Shoals and projecting foundation, toilets of near by houses.
- Vegetations in bed and banks.
- Low level banks weakened by Pedestrian and Cattle walk

WATERSHEDS - IMPROVEMENTS TO MACRO DRAINAGES IN CHENNAI CITY

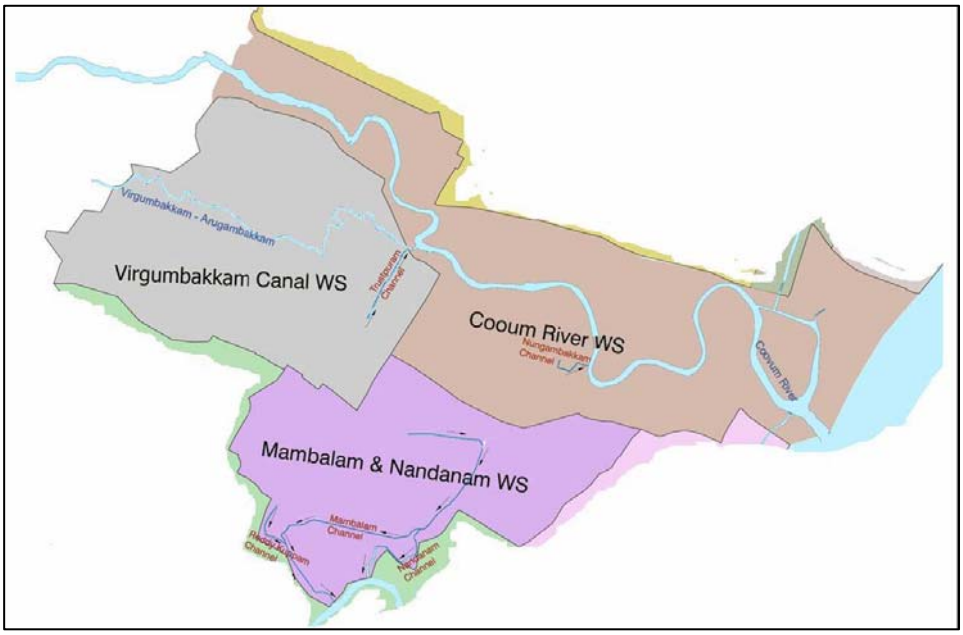
WORKS TO BE TAKEN UP BY PWD UNDER JnNURM FOR STORM WATER DRAIN (MACRO) IMPROVEMENTS (EXCLUDING RIVERS)

I. Northern Basin



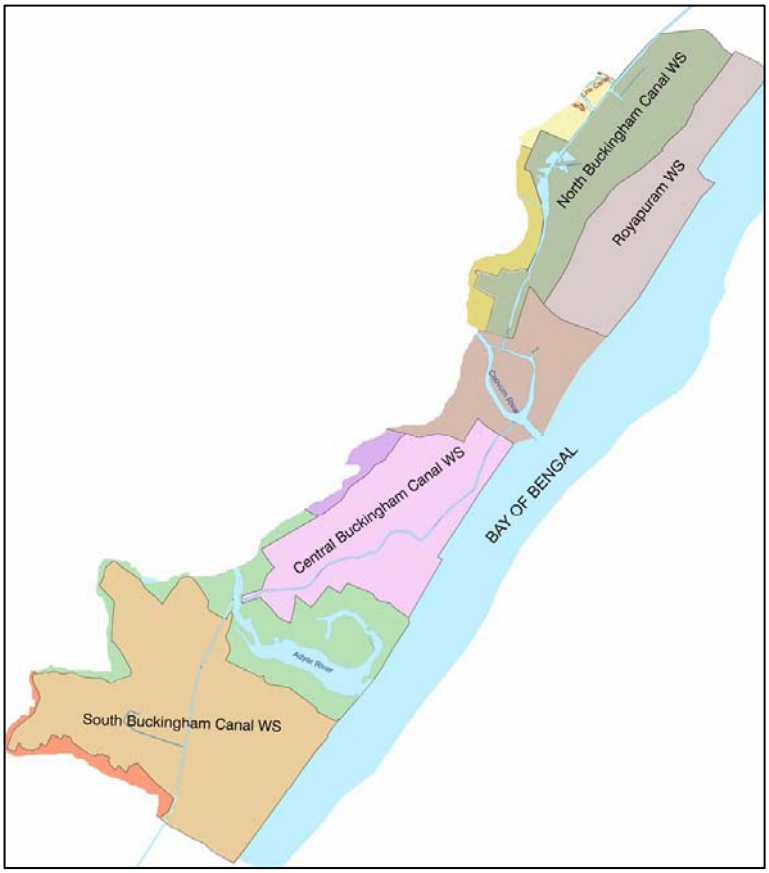
1. Improvement to Kodungaiyur drain @ Ch 3050 m to 3450 m (Below GNT road)
2. Construction of divertion channel (Box culvert) for Kolathur tank surplus to Madhavaram tank left flank surplus course
3. Improvements to the Ambattur tank surplus drainage channel
4. Straight cut diversion channel for directing upstream flood water from Otteri Nullah to Cooum river
5. Improvements for Otteri Nullah like widening and construction of flood protection wall, concrete bed lining with cunnet section fencing, providing access Ramps for maintenance widening the water way of bridges providing intlet arrangement etc.,

II. Central Basin



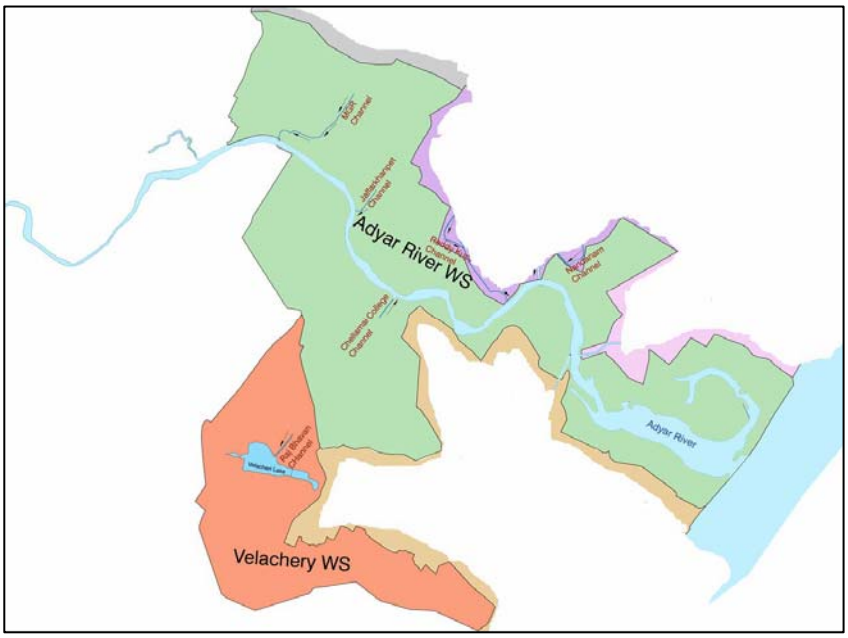
1. Improvements to the outlet, drainage course and construction of diversion channel from Maduravoyal tank to Cooum
2. Short cut diversion drainage canal for Virugambakkam - Arumbakkam drain from 100 ft road bridge to Cooum river at inner ring road bridge
3. Improvements to Virugambakkam - Arumbakkam drain like widening and construction of flood protection wall, concrete bed linning with cunnet section, fencing, providing access ramp for maintenance, widening the water way of existing bridges providing inlet arrangement etc.,

III. Eastern Basin



1. Improvements to North Buckingham canal like widening & deepening, construction of flood protection wall and fencing in vulnerable place, providing access ramp for maintenance, providing inlet arrangement, widening the water ways of bridges etc.,
2. Improvements to Central Buckingham canal like widening and deepening and construction of flood protection walls, bed lining with cunnet section, fencing, providing access ramp for maintenance, providing inlet arrangements, widening the water ways of bridges etc.,
3. Improvements to South Buckingham Canal like widening and deepening, construction of flood protection wall, fencing, providing inlet arrangements, providing access ramp for maintenance, widening the water ways of bridges etc, from Adyar South Lock to Lattice bridge (From Ch.0 m to 4100 m) Reach – I
4. Improvements to South Buckingham Canal like widening and deepening, construction of flood protection wall, fencing, providing inlet arranagements, providing access ramp for maintenance, widening the water ways of bridges etc, from Lattice bridge (Ls 4100 m) to Okkiyam Maduvu (Ls 10500 m) -Reach – II
5. Improvements to South Buckingham Canal like widening & deepening, widening of water ways of bridges etc, from Okkiyam Maduvu to Muttukkadu back water (North Lock from Ls 10500 m to 23500 m) - reach - III

IV . Southern Basin



1. Improvements to Porur tank surplus drainage like weir reconstruction widening & deepening of canal, construction flood protection wall widening the water way of existing bridges etc.,
2. Improvements to Veerangal odai drainage course channel like widening and deepening if canal construction of flood protection wall widening the water ways of exisitng bridges etc.,
3. Short cut diversion drainage channel from Buckingham Canal near Okkiyam Maduvu to Sea
4. Short cut diversion drainage channel for Velachery tank surplus near Velachery bus stand via Velachery OMR by Pass road to South Buckingham Canal near Tidal Park

RESTORATION OF CHENNAI RIVERS

- Macro and Micro drains of Chennai city are being improved under JnNURM Scheme in a time span of 3 years.
- For the Restoration of the Rivers and other drainages in CMA Area, the Government of TamilNadu has reconstituted the "*Adyar Poonga Trust* " to " *Chennai River Restoration Trust " (CRRT)* on 22-01-2010 with the following objectives

Planning
Coordination
Arranging Technical Assistance
Arranging Funds
Monitoring

- A high level committee headed by the Hon'ble Deputy Chief Minister was also constituted by the Government of Tamilnadu on 25-01-2010 with Hon'ble Environmental and Slum Clearance Board Ministers and other higher officials as members

Chennai River Restoration Trust

Planning the Conceptual Master Plan for the River Restoration involves the following aspects in a holistic river basin approach through various Government and non-Governmental Organisations in a co-ordinated way.

Engineering

- Restoring the physical features of the Rivers.
- Finalizing the River hydraulics for effective disposal of floods of 100/50/30 year frequency.
- Identifying the surplus space available along the banks of the river and put them into beneficial use.
- River front Developments.
- Restoration of Irrigation of tanks and its catchment, command area in the upper reaches of the River.
- Restoration of Tanks and other water bodies not having agricultural potential for maintaining the ecological flows in the River.
- Creation of suitable structures like check dams ,barrages across rivers for ground water recharge.
- Creation of sub surface barriers, dykes across the rivers near coastal zones to arrest sea water intrusion.

Environmental

- Arresting the untreated sewage Infall into the river.
- Augmenting the sewage collection network system and capacities of STPs
- Improving the Solid waste collection and its disposal system
- Instream aerators and bubblers for water quality improvements
- Enforcing the Environmental Laws and Acts in force effectively .

Social activates

- Resettlement of slum dwellers along the river banks.
- Public awareness creation
- Community participation in River Restoration.

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Session – III

Overview of Chennai Waterways Rehabilitation Project

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Senior Land Management Specialist, CDIA, Manila

Asia's urban challenge

Another 1.1 billion people will live in Asian cities in the next 20 years

- City Regions serve as magnets for people, enterprise and culture, but with urbanization, poverty also urbanizes
- Urban infrastructure and services lag behind, resulting in problems of pollution, lack of potable water, slums and traffic congestion
- Cities impact heavily on climate change, being responsible for about 75% of GHG emissions globally
- A comprehensive urban management approach is essential for Asian cities to be environmentally and socially sustainable

The infrastructure investment planning & programming gap

A gap often exists between city-level development plans & strategy and their projects

- Cities often have macro-development strategies and – plans to address their issues, but city infrastructure and services projects are generally not related to them.
- Bridging the gap requires city-wide investment planning and pre-feasibility/project structuring.
- Difficult to use IFIs standard feasibility study instruments (PPTAs) for these purposes.
- Cities' government capacity to deal with this needs to be strengthened.

CDIA Approach

CDIA assists cities to implement their development strategies using one or more of the following measures

- Applying a demand-driven and flexible support approach.
- Advisory support to infrastructure investment programming & prioritization.
- Consultancy support to prepare PFS on high priority projects.
- Local institutional capacity strengthening on infrastructure investment planning and programming.
- Identify potential private sector involvement.
- Link cities and their infrastructure investment proposals to investment financiers – both local and international.

Instruments

CDIA offers a number of services to qualifying partner cities

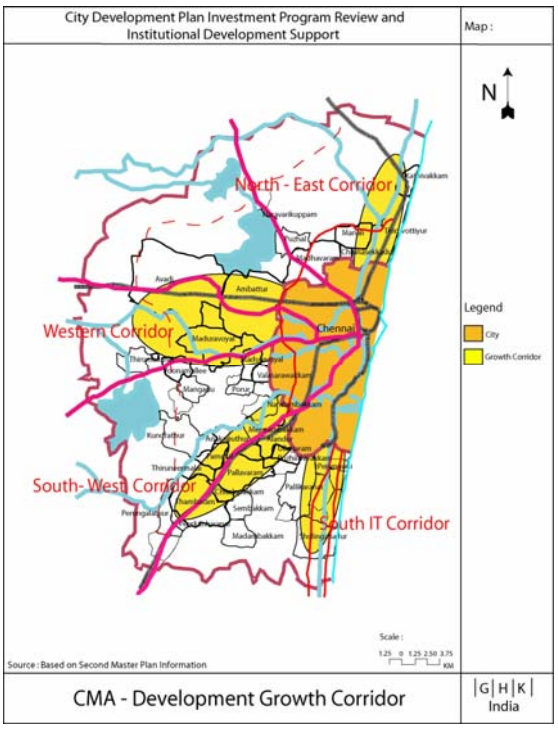
- Regional CDIA core management capacity based in Manila, Philippines
- CDIA city-level assistance teams on demand
- Structural links to ADB operations – also to KfW and others
- Support to regional and international urban management networks

City Application Process

The following steps by CDIA In Chennai

- As CDIA follow demand driven process – Received request from Chennai Municipal Corporation (CMC) for assistance
- CDIA mission deployed to assess the request of CMC and areas require intervention
- Formal Application submitted by CMC requesting CDIA support relating to review of City Development Plan, waterways and solid waste management projects and capacity development program
- Review and approval of applications by CDIA CMT
- Technical Assistance agreement signed with CMC with endorsement from State Government
- Terms of Reference for international consultants procurement
- Pre Feasibility Study for Waterways and Solid waste management including review of City Development Plan.

CDIA linking with Urban Development & Waterways - Chennai



CDIA Linking with Urban Development & Waterways - Chennai

Growth Corridor	Waterway	Areas for future growth
West Corridor	River Coum	Chennai Municipal Corporation Avadi Municipality Ambattur Municipality Valsaravakkam Municipality Poonamalle Municipality Maduravoyal Municipality Porur TP
South-West Corridor	River Adyar	Chennai Municipal Corporation Alandur Municipality Tambaram Municipality Ullagaram-Puzhathivakkam Municipality Pallavaram Municipality Anakaputhur Municipality Pammal Municipality Chitlapakkam TP
North-East Corridor & South IT Corridor	Buckingham Canal	Chennai Municipal Corporation Tiruvottiyur Municipality Kattivakkam Municipality Chinnasekkadu TP Madhavaram Municipality Manali municipality Perungudi TP Pallakaranai TP Sholinganallur TP
North-East Corridor	River Kosasthalayar	Tiruvottiyur Municipality Kattivakkam Municipality

CDIA Linking with On-going efforts in Waterways - Chennai

Integration of On-going efforts

- Efforts through a study on Micro and Macro Drainage System by Chennai Municipal Corporation – under JNNURM for Rs. 1400 crores
- Efforts on Sewage and Sanitation problems by
  - Chennai Metropolitan Water Supply & Sewerage Board
  - Public Works Department
  - Chennai Municipal Corporation
  - Tamil Nadu Pollution Control Board etc.

Rationale for Identification of Waterways Rehabilitation Measures

Rationale for Rehabilitation measures

- Minimise pollution in the waterways;
- Address flood /inundation problems;
- Address the current urban development constraints;
- Address the constraints imposed by the future urban growth;
- Mitigate/ eradicate mosquito menace;
- Improve overall aquatic and biotic environment; and
- Address the problems in holistic manner on integrated water management principles;

Clustering of Projects - Waterways rehabilitation

Principles – Based on integrated water management and adopting water/wastewater catchment concepts in CMA

CMC and ULBs has been divided into 4 catchments

- Cooum river catchment;
- Adyar river catchment;
- Kosasthalayar river catchment; and
- Buckingham canal catchment

Waterways project – Cooum River Catchment

Cooum River Rehabilitation Project

Cooum Reach	Name of Reach	Length of Reach
CR-1	Coastal Reach	0.0 – 6.4 km
CR-2	Central City Reach	6.4 – 9.3 km
CR-3	Outer City Reach	9.3 – 20.0 km
CR-4	CMA Reach	20.0 – 41.0 km

Options explored to flush dry weather flows (treated and untreated sewage entering the river ways):

- by creating fresh water storage to flush the pollutant loads in the river;
- by providing gradient to the river bed and drain the polluted waters by gravity;
- by deepening the river bed in the coastal reaches to flush the polluted river waters making use of possible tidal transactions;
- by maintaining minimum flows in the river and flush the dry weather flows; and
- by exploring the possibility of utilising the reservoir waters meant for other purposes for flushing;

Surface aeration at existing pollution ‘hot spots’ in the rivers.

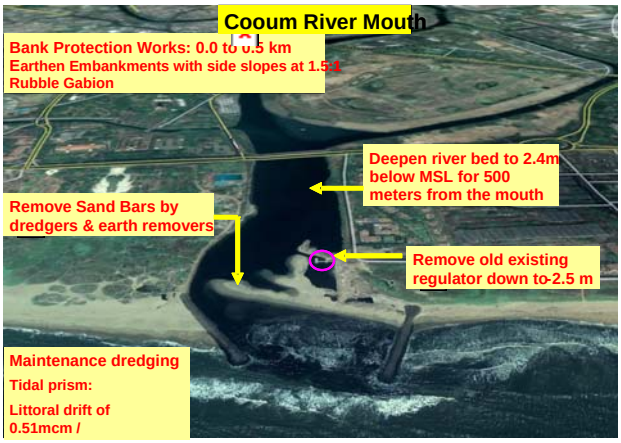
Options explored to address the flood and inundation issues:

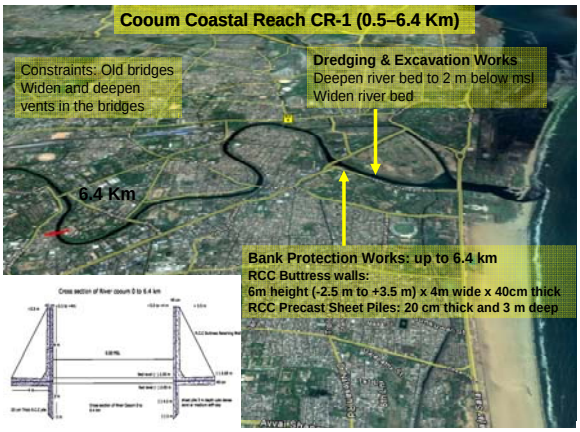
- by deepening the river bed;
- by widening/ restoring the river bed;
- by diverting flood flows partly into new or existing channels;
- by streamlining the river in the bends;
- by removing the obstructions in the river bed;
- by strengthening the bunds;
- by raising the bunds;
- by providing flood protection walls;
- by removing encroachments on the banks; and
- by incorporating possible impacts from the climate change;

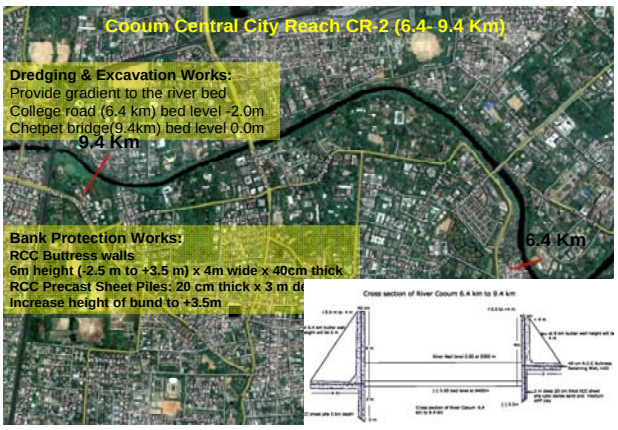
Options explored for viability of the projects:

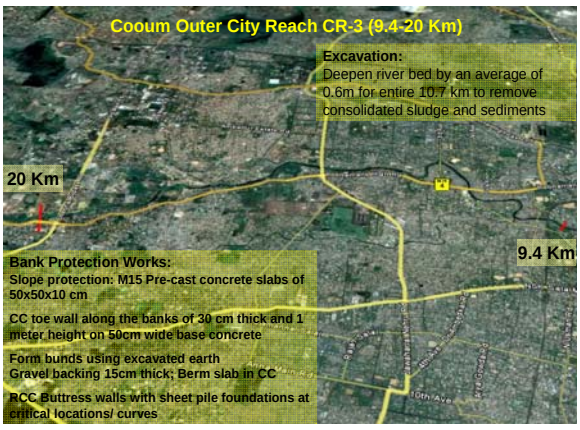
- with river front; and
- without river front.

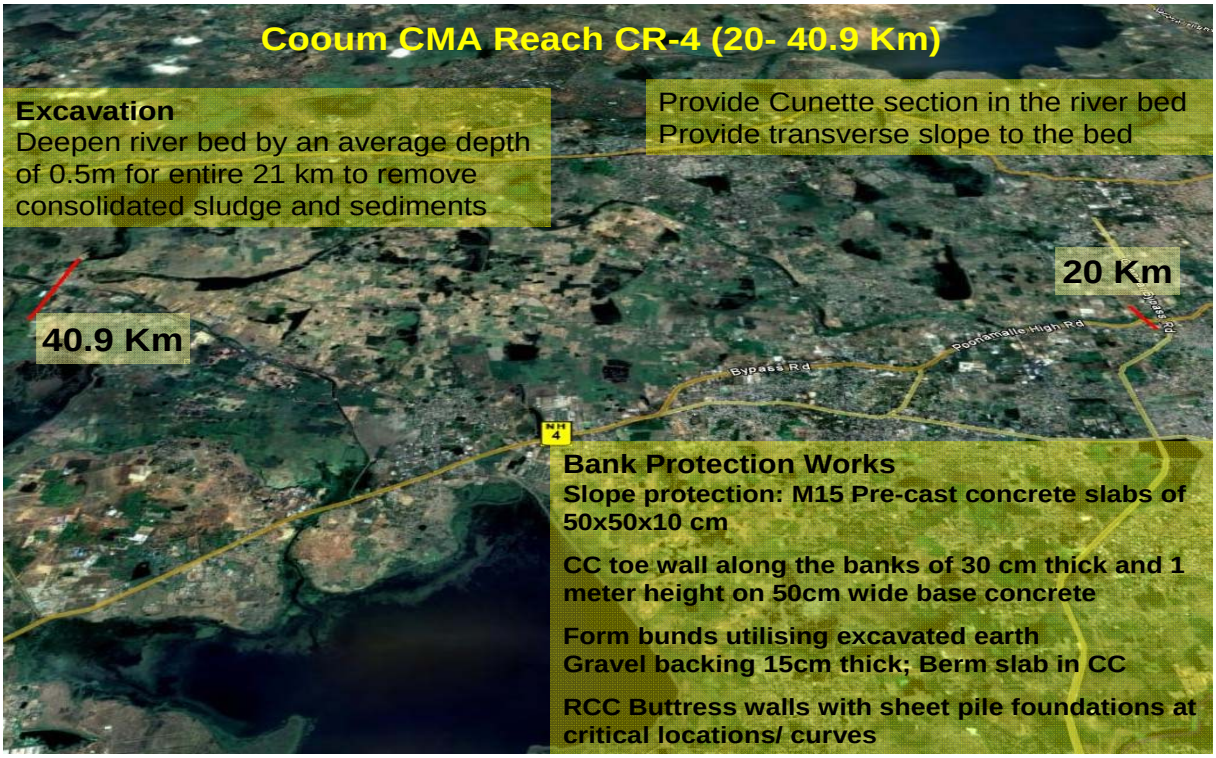
Waterways project - Cooum











Waterways project – Cooum River Catchment

1. Proposals for Coastal Reach – CR1 (0.0 – 6.4 km)
    - specific to River mouth
    - specific to River reach
2. Proposals for Central City Reach –CR2 (6.4 – 9.3 km)
3. Proposals for Outer City Reach –CR3 (9.3 – 20.0 km)
4. Proposals for CMA Reach –CR4 (20 – 41.0 km)

Cost Estimate

The total cost estimate of the Cooum River investment package:

INR 400 Crores (USD $ 81.66 millions)

Waterways project – Adayar River Catchment

Adayar River Rehabilitation Project

Adyar Reach	Name of Reach	Length of Reach
AR-1	Coastal Reach	0.0 – 4.2 km
AR-2	Central City Reach	4.2 – 12.2 km
AR-3	Outer City Reach	12.2 – 24.7 km

1. Proposals for Coastal Reach – AR1 (0.0 – 4.2 km)

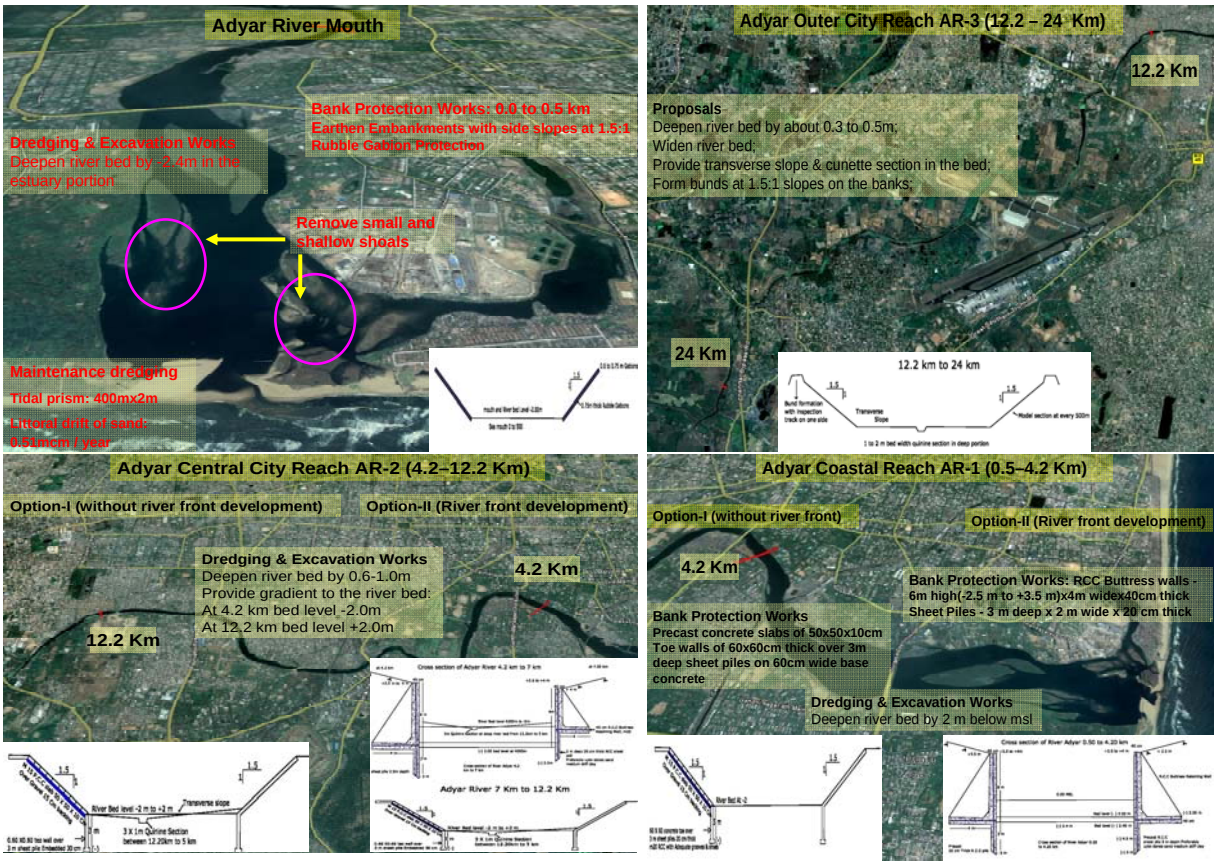
   River Mouth (0.0-0.5 km)
   River Reach (0.5 - 4.2 km)
   - Option-1 without river front
   - Option- 2 with river front

2. Proposals for Central City Reach – AR2 (4.2 – 12.2 km)

   Option-1 without river front (4.2 – 12.2 km)
   Option-2 with river front (4.2 – 7.0 km)
   Option-2 with river front (7.0 – 12.2 km)

3. Proposals for Outer City Reach – AR3 (12.2 - 24 km)

Waterways project – Adayar River Catchment



Adayar River Rehabilitation Project

The total cost estimate of the Adyar River investment package is:

Option I (without river front):

INR 2,150,000,000 (INR 215 Crores / USD 43.89 millions)

Option II (with river front):

INR 2,900,000,000 (INR 290 Crores / USD 59.20 millions)

Waterways project – Kosasthalayar River Catchment

Kosasthalayar Rehabilitation Project

Proposals for Kosasthalayar rehabilitation

- Flood Banks
- Bank Protection
- Flood Protection Walls
- Regulators

The total cost estimate of the Kosasthalayar River Development investment package is INR 16 Crores (USD 3.26 millions).

Waterways project – Buckingham Canal Catchment

Buckingham Canal rehabilitation

Since the projects firmly planned under the JNNURM programme are quite comprehensive and meet the desired objectives of the current PFS for Waterways Rehabilitation.

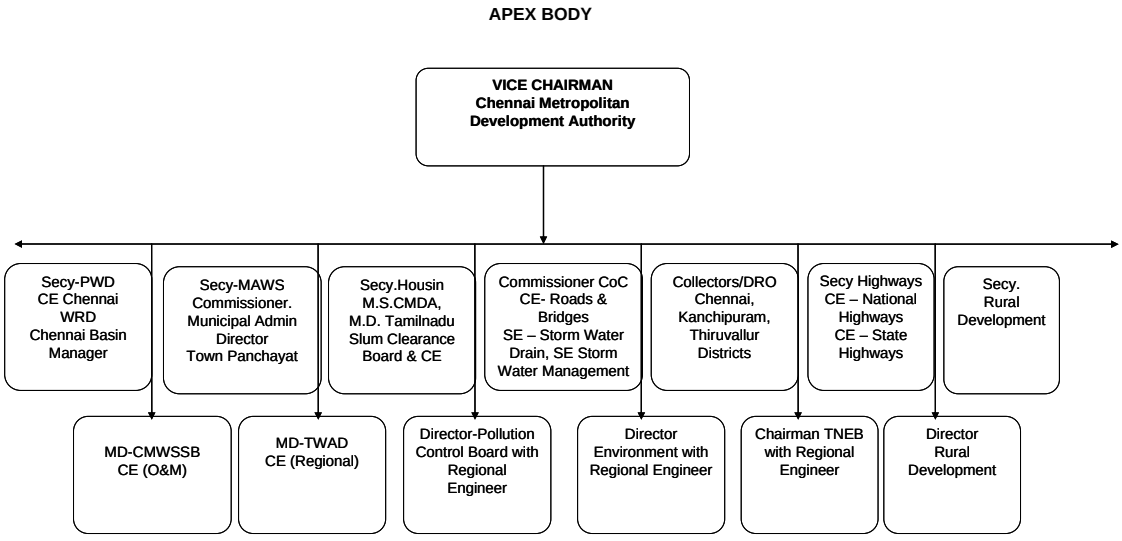
No major proposals are required separately under the study and hence not recommended any new projects.

Opportunities through waterways project

Proposed final outcome of the project

- Financing Plan
- Detailed economic analysis of proposed investment packages
- Project Prioritisation and Implementation Plan
- Inclusive approach through social and economical aspects
- Institutional arrangements (detailed chart follows)

Institutional arrangement



Selected City Interventions

Cochin, India

Focus areas	Urban Transport
CDIA support	USD 370,000 for PFS & Capacity Building
Estimated investment value	USD 100 million
Potential source of financing	Private sector investment, ADB loan

Khulna, Bangladesh

Focus areas	City infrastructure & solid waste management
CDIA support	USD 483,000 for PFS & Capacity Building
Estimated investment value	USD 50 million
Potential source of financing	ADB (pipeline loan) & possible Sida grant

Guiyang, China

Focus areas	Rehabilitate water supply & urban public transport
CDIA support	USD 522,000 for PFS & Capacity Building
Estimated investment value	USD 2 billion
Potential source of financing	Potential ADB pipe-line lending / WB loan

Yangzhou, China

Focus areas	Urban Upgrading & Urban Water supply	
CDIA support	USD 241,000 for PFS & Capacity Building	
Estimated investment value	USD 260 million	
Potential source of financing	Commercial bank loan/ Public Co. PPP	

Kathmandu, Nepal

Focus areas	Bishnumati road corridor & solid waste management	
CDIA support	USD 212,000 for PFS & Cpacity Building	
Estimated investment value	USD 50 million	
Potential source of financing	ADB, JICA and others	

Faisalabad, Pakistan

Focus areas	Urban transport & Industrial Waste management	
CDIA support	USD 535,000 for PFS & Capacity Building	
Estimated investment value	USD 50 million	
Potential source of financing	ADB	



Can Tho, Vietnam

Focus areas	Urban & industrial wastewater	
CDIA support	USD 200,000 for FS	
Estimated investment value	USD 50 million	
Potential source of financing	KfW	



Thanh Hoa, Vietnam

Focus areas	**Water supply & wastewater treatment**	
CDIA support	USD 371,000 for PFS & Capacity Building	
Estimated investment value	USD 40.5 million	
Potential source of financing	ADB, Domestic/ Int. Private Financing, Domestic Infrastructure Funds	



CDIA CONTACTS

Enquiries and support applications may be directed to:

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Sr. Program Specialist
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Cities Development Initiative for Asia (www.cdia.asia)
Suites 202-203, Hanston Building
Emerald Avenue, Ortigas Center, Pasig City 1600
Metro Manila, Philippines
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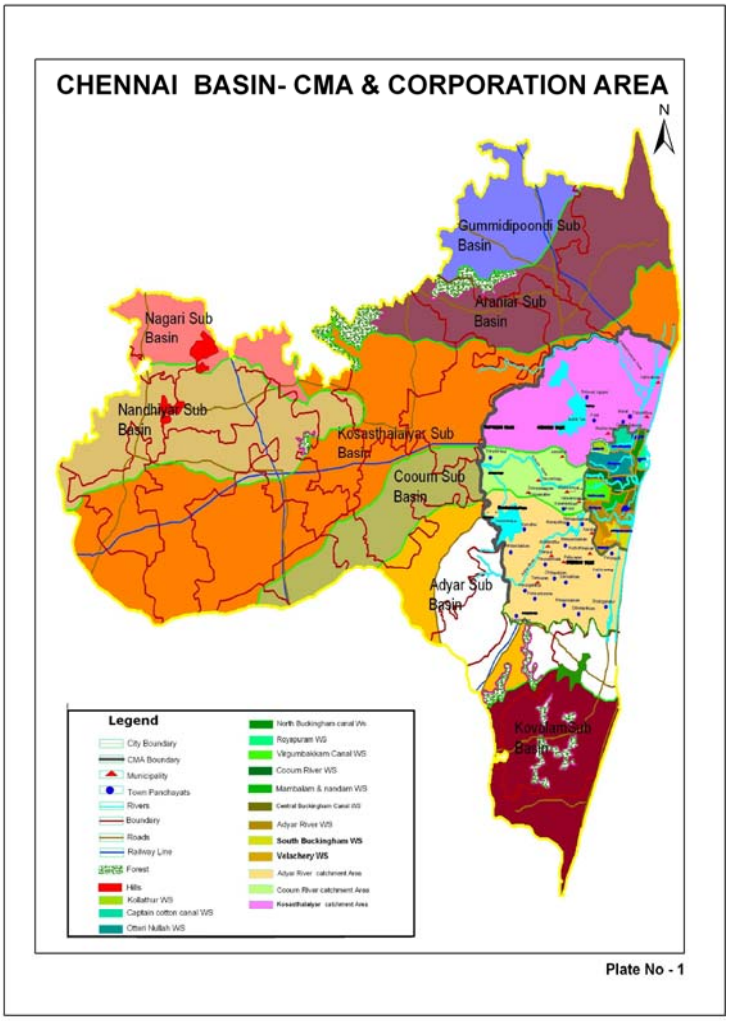
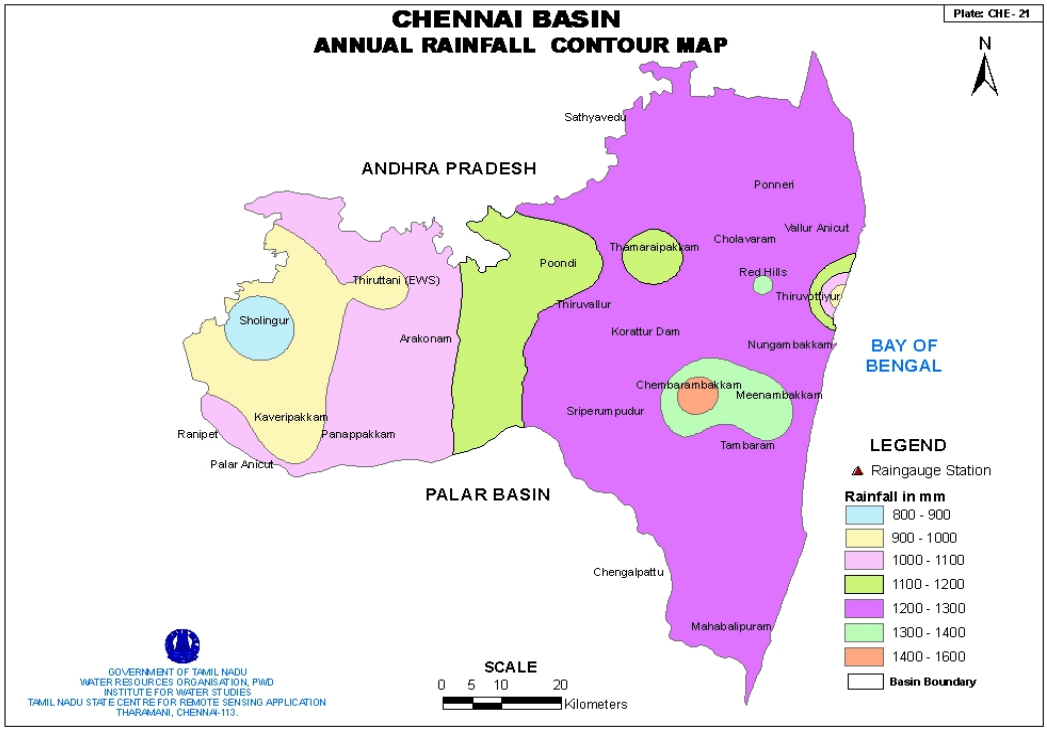
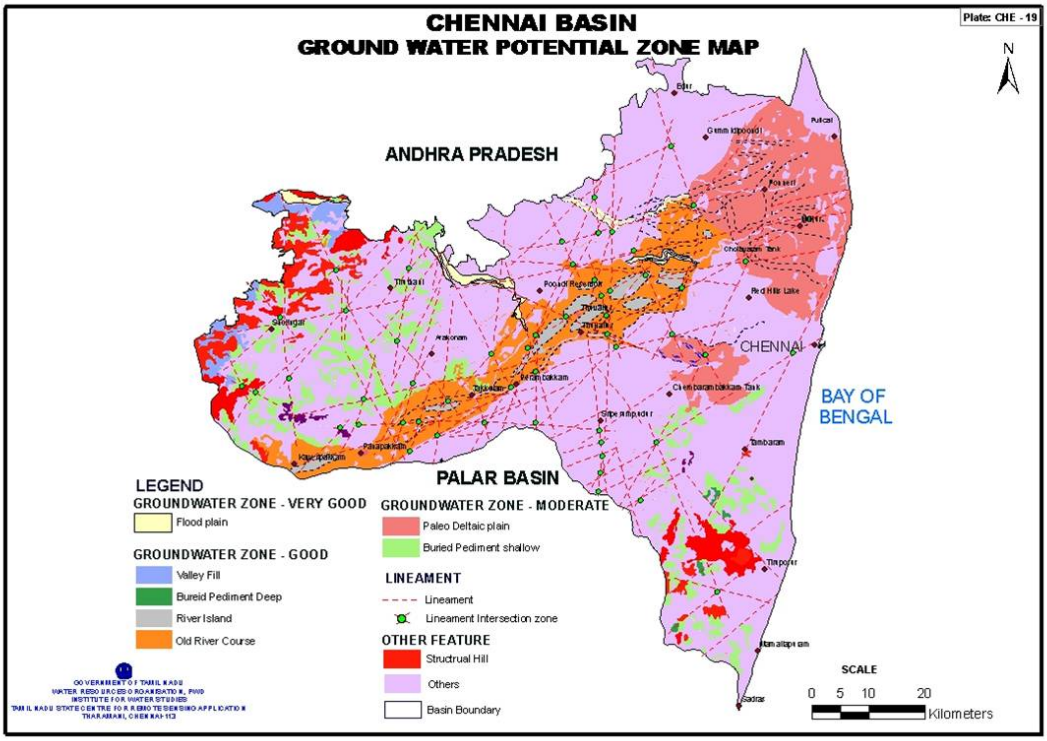
Session – III

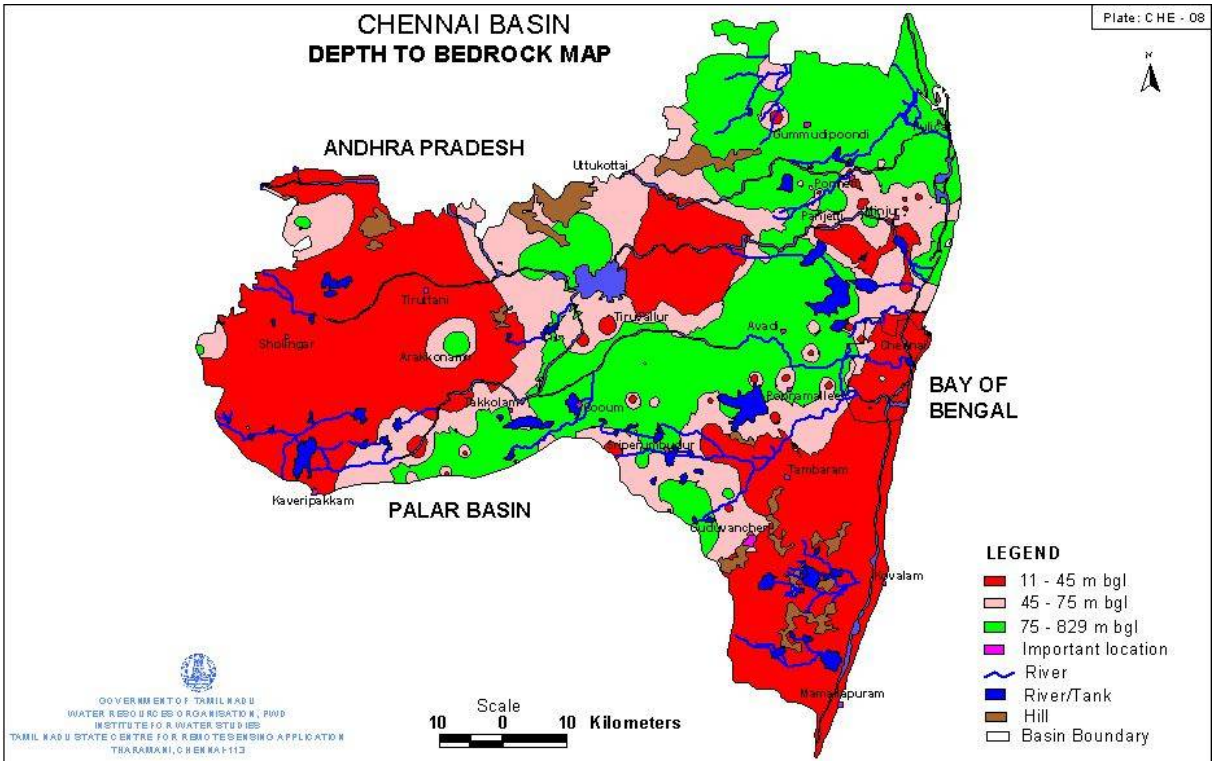
Macro Drainage System in CMA

Er.M.Dheenadhayalan
Former Advisor to Govt. of Tamil Nadu (Schemes),
Senior Consultant, Institute of Remote Sensing, Anna University, Chennai – 25.



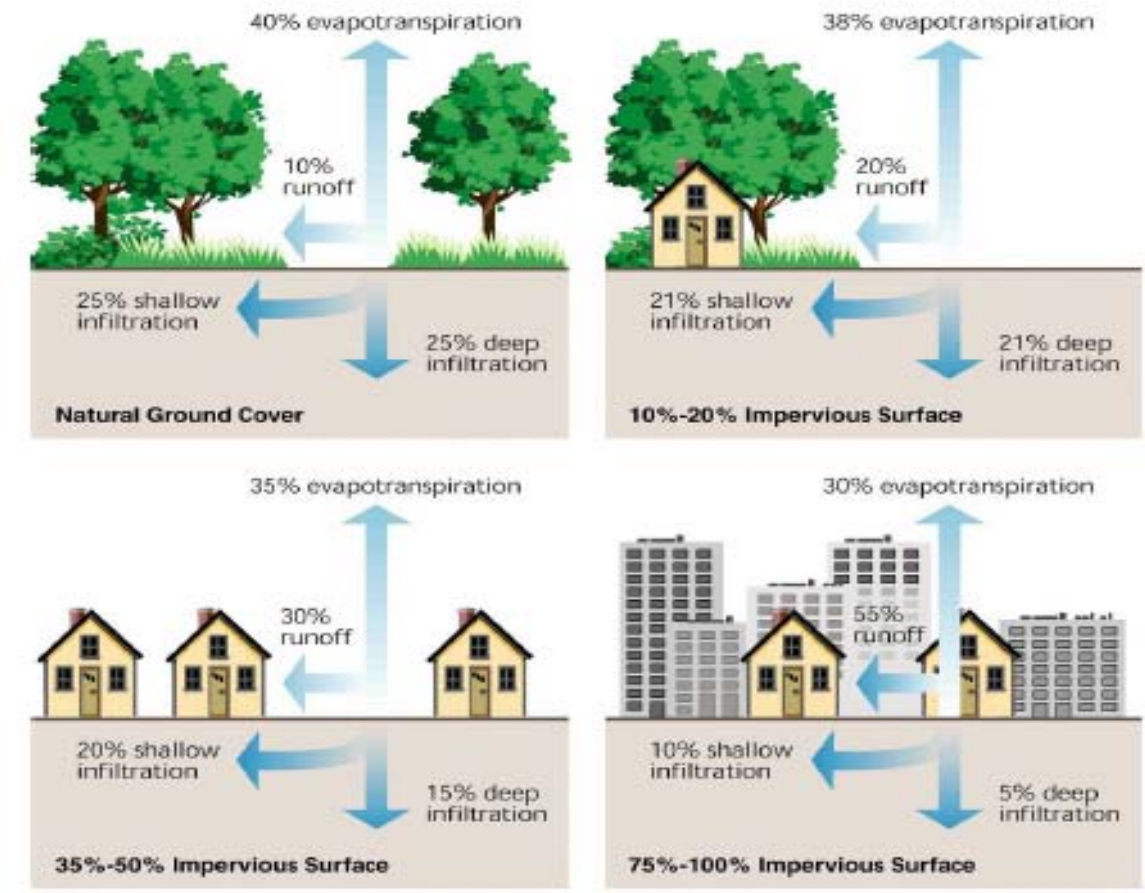

CHENNAI BASIN
ANNUAL RAINFALL CONTOUR MAP
Plate: CHE - 21
N
Sathyavedu
ANDHRA PRADESH
Ponneri
Vallur Anicut
Cholavaram
Thamaraipakkam
Poondi
Red Hills
Thiruvottiyur
Thiruvallur
Thiruttani (EWS)
Sholingur
Korattur Dam
Arakonam
Nungambakkam
BAY OF BENGAL
Chembarambakkam
Meenambakkam
Sriperumpudur
Kaveripakkam
Ranipet
Panappakkam
Tambaram
Palar Anicut
PALAR BASIN
LEGEND
Raingauge Station
Rainfall in mm
800 - 900
900 - 1000
1000 - 1100
1100 - 1200
1200 - 1300
1300 - 1400
1400 - 1600
Basin Boundary
Chengalpattu
Mahabalipuram
GOVERNMENT OF TAMIL NADU
WATER RESOURCES ORGANISATION, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-113.
SCALE
0 5 10 20
Kilometers


CHENNAI BASIN
GROUND WATER POTENTIAL ZONE MAP
Plate: CHE - 19
N
ANDHRA PRADESH
CHENNAI
BAY OF BENGAL
PALAR BASIN
LEGEND
GROUNDWATER ZONE - VERY GOOD
Flood plain
GROUNDWATER ZONE - GOOD
Valley Fill
Bureid Pediment Deep
River Island
Old River Course
GROUNDWATER ZONE - MODERATE
Paleo Deltaic plain
Buried Pediment shallow
LINEAMENT
Lineament
Lineament Intersection zone
OTHER FEATURE
Structrual Hill
Others
Basin Boundary
SCALE
0 5 10 20
Kilometers



Madras city 1909

Influence of urbanization



Overview of Existing Issues

- Increase in Flood level in rivers & drains besides inundation prone zones.
- Reduction in number & capacity of water bodies, change in land use increase flood intensity.
- Augmenting Krishna water in CMA reservoirs during July to October reduces flood absorbing capacity in Chennai basin.
- Raising road levels & forming new road embankments across water bodies without adequate culverts, causes afflux and in turn inundation.
- Increase in point outlets, untreated sewage and effluents entry into rivers and drains.
- Solid waste dumping obstructs waterways, chocks culverts & pollutes water.
- Ponding of polluted water in waterways & drains breeds mosquitoes causing health hazards.
- Deposition of hazardous heavy sludge in swamps, backwater and urban water bodies.

- Encroachment by Government projects, affluent sections & slums in water bodies.
- Absence of base flow in waterways & in turn environmental imbalance.
- Sand bar at river mouths obstructing outflow to sea & tidal inflow.
- Absence of integrated planning using up-to-date tools & techniques.

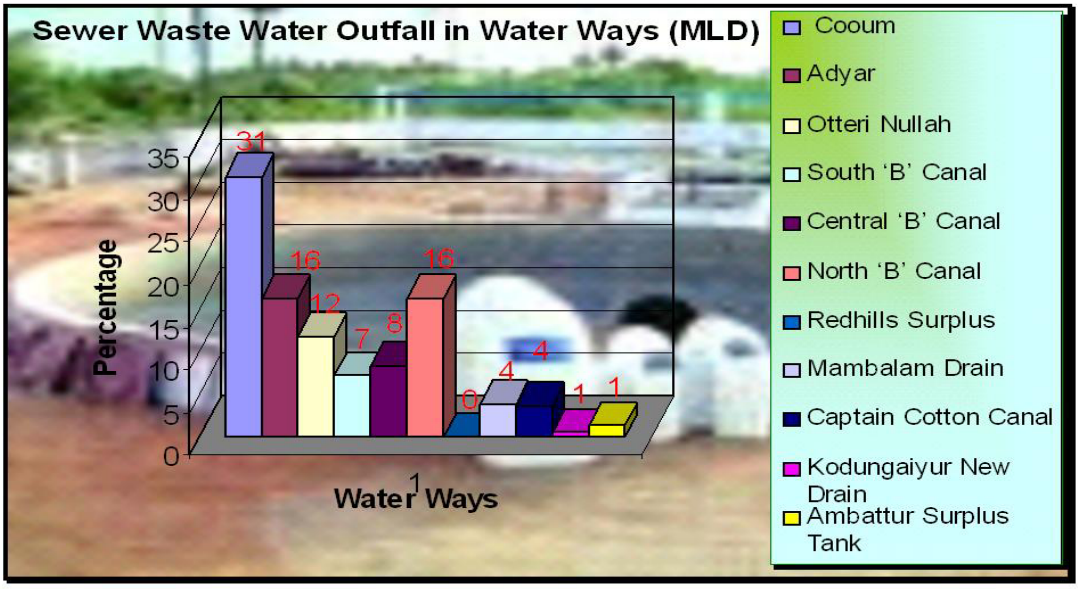
Identified Gaps

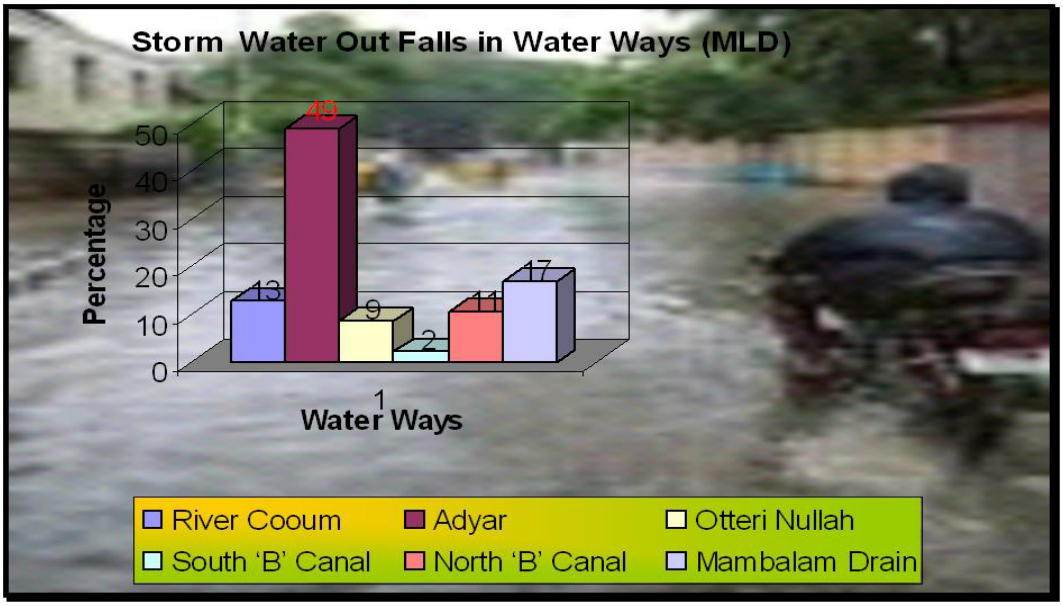
Institutional Gaps

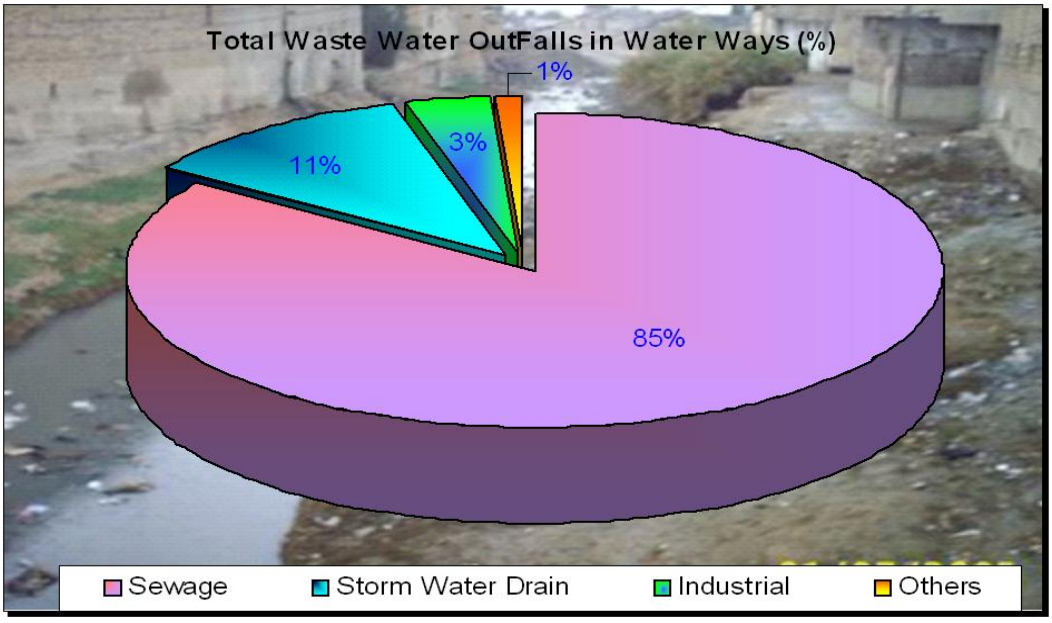
- Planning of individual sector oriented projects without involving connected disciplines Absence of Ready reckoners for anticipating flow / flood in drains, rivers and tanks based on rainfall.
- conceptual planning of surplus releases from city affecting reservoirs based on rainfall in city.
- Critical identification & cure for bottlenecks causing afflux in all waterways& in turn inundation
- Diversion of surface flood in drains to larger waterways is not feasible due to non availability of Land.
- Absence of accurate contour Map for designing Storm water network, collector drains and infall points

Structural Gaps

- Reduction in storage capacities due to solid waste dumping, encroachments, and siltations.
- Diversion of water from other basins without increasing storage capacity causes intensification of flood. (For e.g. Krishna water)
- Rising road levels without adequate culverts increases floods& inundation.
- Absence of base flow in rivers due to over exploitation of Groundwater.
- Stagnation of polluted water in water ways and in low lying lands causing mosquito menace.
- Alarming rate of dumping solid waste & construction debris in waterways & water bodies.
- Intensive and unregulated use of government lands in and around water ways/ water bodies for development projects.
- Sand bars obstruct river outflows to sea & tidal transaction to the river during 10 months in a year.


Sewer Waste Water Outfall in Water Ways (MLD)
Percentage
35
30
25
20
15
10
5
0
31
16
12
7
8
16
0
4
4
1
1
1
Water Ways
Cooum
Adyar
Otteri Nullah
South 'B' Canal
Central 'B' Canal
North 'B' Canal
Redhills Surplus
Mambalam Drain
Captain Cotton Canal
Kodungaiyur New Drain
Ambattur Surplus Tank


Storm Water Out Falls in Water Ways (MLD)
Percentage
50
40
30
20
10
0
13
49
9
2
11
17
1
Water Ways
River Cooum
Adyar
Otteri Nullah
South 'B' Canal
North 'B' Canal
Mambalam Drain


Total Waste Water OutFalls in Water Ways (%)
1%
3%
11%
85%
Sewage
Storm Water Drain
Industrial
Others

FLOODS IN ADYAR RIVER DURING 1943, 1976, 1985, 2005 & 2008.

No	Location	Flood								
		1943			1976			1985	2005	2008
		MFL	Max Flood c/s	Afflux in m	MFL	Flood c/s	Afflux in m	MFL	MFL	MFL
1	Nandampakam-Porur	+10.7	NA	NA	9.46	39,0	NA	9.75	9.4	5.45
2	Jaffarkhanpet	NA	NA	NA	2.40 above	NA	NA	7.85	NA	NA
3	Kattipara cause way	8.04	NA	NA	NA	NA	NA	NA	NA	NA
4	Railway Bridge	7.91	55200	0.45	6.71	63,0	0.22	Na	NA	NA
5	Maraimalai Adigal	7.40	55000	0.53	6.23	63,0	0.21	7.00	5.6	5.7
6	Veeranam pipe	2.90	NA	NA	NA	NA	.12	NA	NA	NA
7	Adyar North Lock	NA	NA	NA	3.26	NA	NA	3.75	NA	NA
8	Thiru vi ka Bridge	2.83	60600	0.36	3.02	72,0	0.41	NA	NA	NA

FLOODS IN COOUM DURING 1943 & 1976

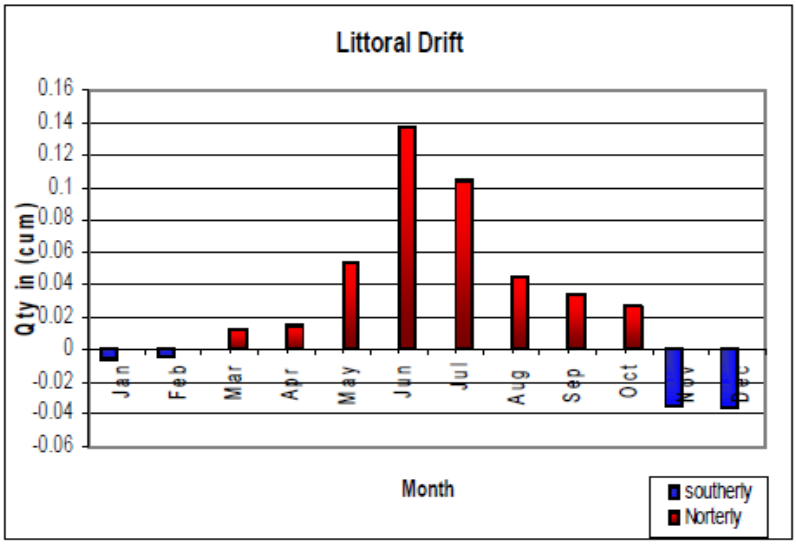
No	Location	Chainage	1976 floods MFL			1943 floods MFL		
			Discharge c/s	MFL (m)	Afflux	Discharge c/s	MFL (m)	Afflux in m
1	Anna Nagar Bridge	12.2Km	16600	7.670	0.230	NA	NA	NA
2	Aminjikarai Bridge	11.4Km	13150	7.440	0.270	19200	7.71	0.46
3	Munroe Bridge	8.3Km	15630	4.510	0.105	23000	5.88	0.40
4	College Bridge	6.7Km	10210	4.405	0.100	16500	5.21	0.37
5	Commander in chief Bridge	5.4Km	11520	4.310	0.270	14300	4.60	0.24
6	Harris Bridge	4.28Km	17780	4.020	0.270	21000	4.09	0.30
7	Andrew's Bridge	3.32Km	14430	3.525	0.300	17500	3.51	0.34
8	Col-Law's Bridge	2.55	23500	3.260	0.380	25900	2.99	0.43
9	Wellington/ Quoidhe Milleth Bridge.	1.40 Km	12000	2.230	0.370	15800	2.07	0.24
10	Hutton Bridge	North arm	10660	NA	NA	4500	2.50	NA
11	Wallajah Bridge	North arm	10660	NA	0.310	15100	2.10	NA
12	Napier Bridge	0.45 Km	27000	1.545	0.260	34300	1.59	0.37

DETAILS OF BRIDGES ACROSS RIVER COOUM (CITY LIMIT)

Sl. No.	Name of Bridge	Chainage (m)	Length (m)	Breadth of the Pier	Number of Span	Span width (m)	Pier Thickness	Soffit Level	Deck Level	Sill Level	Remarks
1	Napier Bridge	450	138	20.0	6.0	23.0	2.25	+ 2.27	+ 3.45	-0.53	
2	Periyar Bridge	1590	134	32.4	9.0	8.9	2.30	3.93	5.65	-0.87	
3	Col. Laws Bridge	2550	80	9.5	5.0	13.0	2.70	2.60	6.35	-0.16	
4	St. Andrews Bridge	3320	65	9.2	6.0	9.5	2.75	2.90	4.10	-1.05	

5	Harris Road Bridge	4280	64	12.2	3.0	19.5	2.30	3.65	5.40	-1.00	
6	Commander in Chief Road Bridge	5450	69	4.1	5.0	11.6	2.30	4.20	5.50	-0.80	
7	College Road Bridge	6700	62	21.5	5.0	11.5	1.20	4.15	5.90	-0.70	
8	Munroe Bridge	8300	75	18.3	6.0	11.4	5.60	5.60	6.60	0.00	
9	Chetpet Railway Bridge	9355	78	23.8	4.0	17.0	3.30	5.89	7.05	1.00	
10	Choolaimedu Bridge	9470	--	--	--	--	--	--	--	1.24	
11	Aminjikarai Bridge	11400	50	14.5	3.0	14.4	2.40	9.44	11.44	3.44	
12	Anna Nagar Bridge	12200	50	19.0	6.0	7.3	1.15	8.14	9.14	3.44	
13	Naduvangari Bridge	13320	--	--	--	--	--	--	--	4.09	
14	Inner Ring Road Bridge	14740	131	18.9	8.0	15.7	0.80	10.57	12.37	4.97	
15	Padikuppam Causeway	15940	--	--	--	--	--	--	--	--	
1	Quaid-E-Milleth Bridge North Arm	--	41	31.0	3.0	12.5	1.25	2.79	3.89	-0.36	
2	Hutton Bridge	--	43	20.5	2.0	20.0	0.90	11.50	12.50	0.30	

MONTHLY LITTORAL DRIFT IN CHENNAI COAST



Total Northern drift: 0.43MM3 During Non monsoon period of East coast i.e., March to October.
Total Southern drift: 0.0793 MM3 During four months November to February

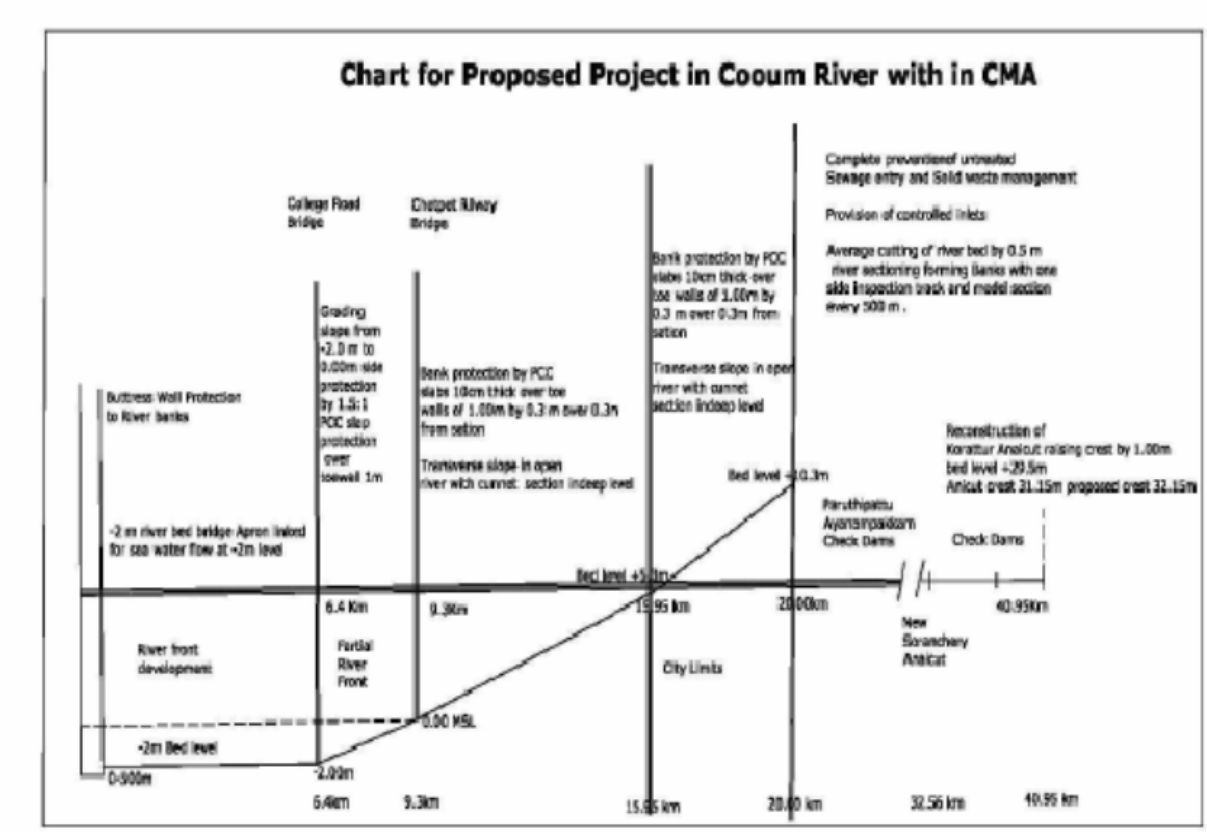
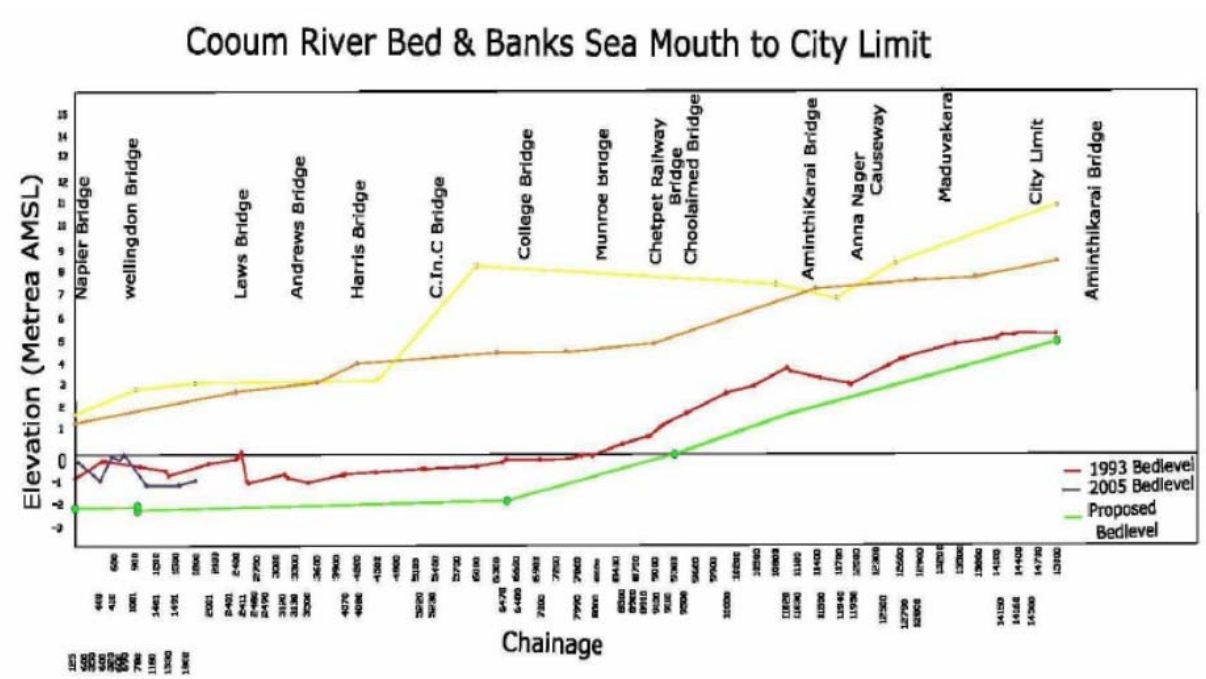
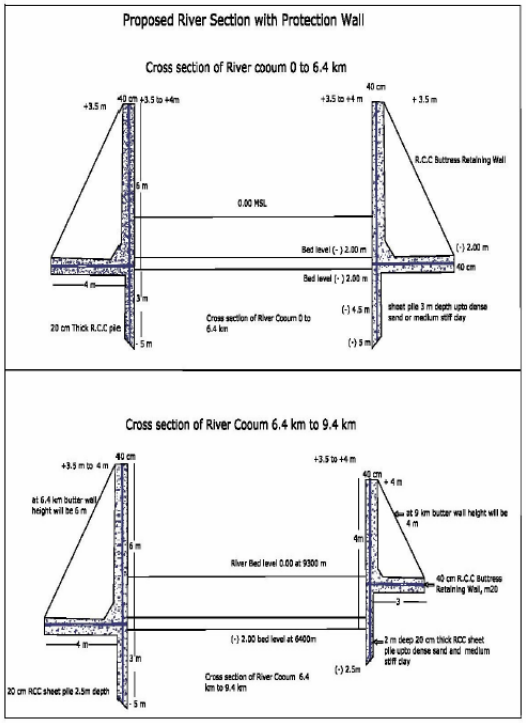
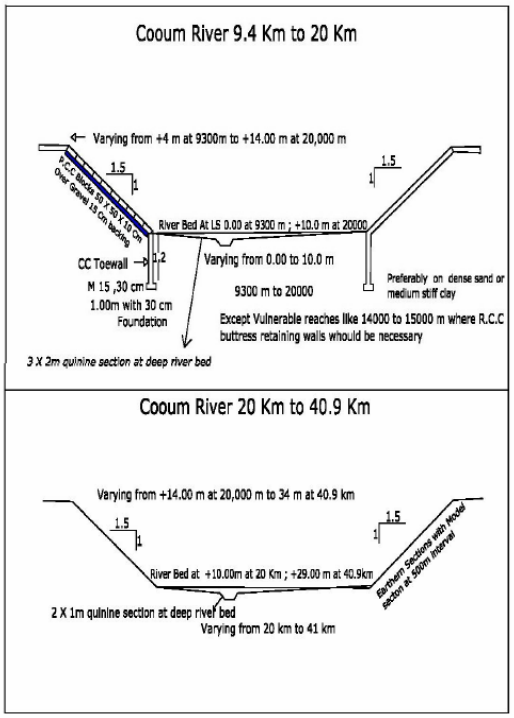
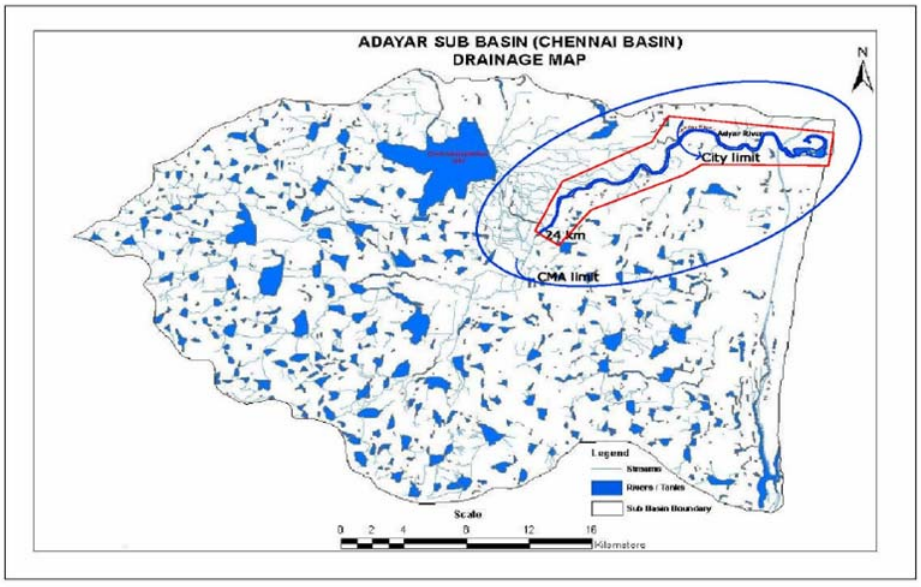


Chart for Proposed Project in Coum River with in CMA
College Road Bridge
Chetpet Railway Bridge
Grading slope from +2.0 m to 0.00m side protection by 1.5:1 PCC slop protection over toewall 1m
Bank protection by PCC slabs 10cm thick over toe walls of 1.00m by 0.3 m over 0.3m from setion
Transverse slope in open river with cunnet section lindeep level
Complete prevantionof untreated Sewage entry and Solid waste management
Provision of controlled inlets
Average cutting of river bed by 0.5 m river sectioning forming banks with one side inspection track and model section every 500 m .
Buttress Wall Protection to River banks
+2 m river bed bridge Apron inlend for sea water flow at +2m level
Bed level +0.3m
Paruthipattu Ayanambakkam Check Dams
Reconstruction of Korattur Anicut raising crest by 1.00m bed level +29.5m Anicut crest 31.15m proposed crest 32.15m
Check Dams
Bed level +5.0m
6.4 Km
9.3Km
15.95 km
20.00km
40.95km
New Sorancheri Anicut
River front development
Fortlal River Front
City Limits
0.00 MSL
+2m Bed level
-2.00m
0-900m
6.4km
9.3km
15.95 km
20.00 km
32.56 km
49.95 km

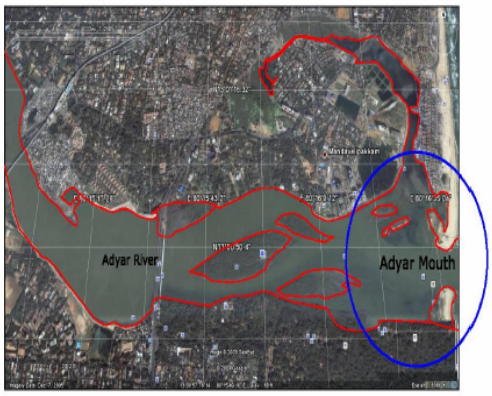

Coum River Bed & Banks Sea Mouth to City Limit
Elevation (Metrea AMSL)
Napier Bridge
wellingdon Bridge
Laws Bridge
Andrews Bridge
Harris Bridge
C.In.C Bridge
College Bridge
Munroe Bridge
Chetpet Railway Bridge
Choolaimed Bridge
AminthiKarai Bridge
Anna Nager Causeway
Maduvakera
City Limit
Aminthikarai Bridge
1993 Bedlevel
2005 Bedlevel
Proposed Bedlevel
Chainage


Proposed River Section with Protection Wall
Cross section of River cooum 0 to 6.4 km
+3.5 m
40 cm
+3.5 to +4m
+3.5 to +4 m
+3.5 m
R.C.C Buttress Retaining Wall
6 m
0.00 MSL
Bed level (-) 2.00 m
(-) 2.00 m
40 cm
4 m
3 m
(-) 4.5 m
sheet pile 3 m depth upto dense sand or medium stiff clay
20 cm Thick R.C.C pile
5 m
Cross section of River Cooum 0 to 6.4 km
(-) 5 m
Cross section of River Cooum 6.4 km to 9.4 km
+3.5 m to 4 m
+3.5 to +4 m
40 cm
+ 4 m
at 6.4 km butter wall height will be 6 m
at 9 km butter wall height will be 4 m
River Bed level 0.00 at 9300 m
40 cm R.C.C Buttress Retaining Wall, m20
(-) 2.00 bed level at 6400m
2 m deep 20 cm thick RCC sheet pile upto dense sand and medium stiff clay
20 cm RCC sheet pile 2.5m depth
Cross section of River Cooum 6.4 km to 9.4 km
(-) 2.5m

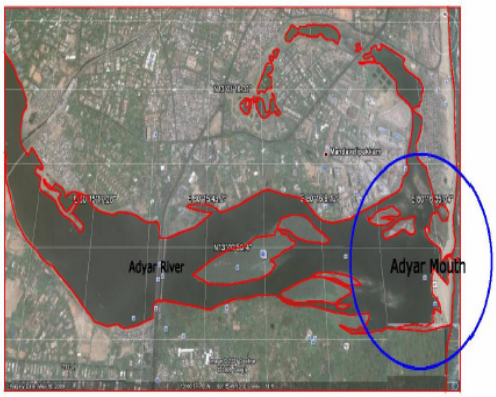

Cooum River 9.4 Km to 20 Km
Varying from +4 m at 9300m to +14.00 m at 20,000 m
1.5
1
R.C.C Blocks 30 X 30 X 10 cm Over Geonet 10 cm backing
River Bed At LS 0.00 at 9300 m ; +10.0 m at 20000
CC Toewall
M 15 ,30 cm
1.00m with 30 cm Foundation
0.2
Varying from 0.00 to 10.0 m
9300 m to 20000
Preferably on dense sand or medium stiff clay
Except Vulnerable reaches like 14000 to 15000 m where R.C.C buttress retaining walls whould be necessary
3 X 2m quinine section at deep river bed
Cooum River 20 Km to 40.9 Km
Varying from +14.00 m at 20,000 m to 34 m at 40.9 km
River Bed at +10.00m at 20 Km ; +29.00 m at 40.9km
Earthern Sections with Model section at 500m interval
2 X 1m quinine section at deep river bed
Varying from 20 km to 41 km


ADAYAR SUB BASIN (CHENNAI BASIN)
DRAINAGE MAP
N
City limit
24 km
CMA limit
Legend
Streams
Rivers / Canals
Sub Basin Boundary
Scale
0 2 4 8 12 16
Kilometers

Adyar River Mouth

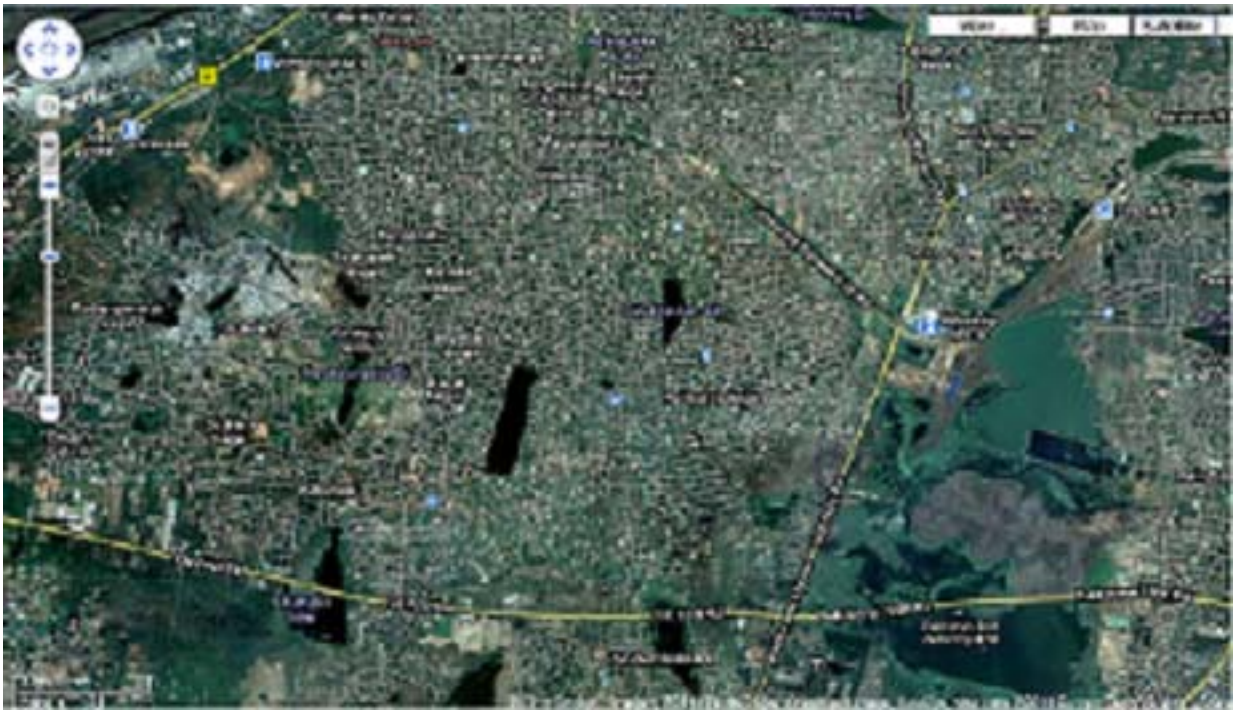


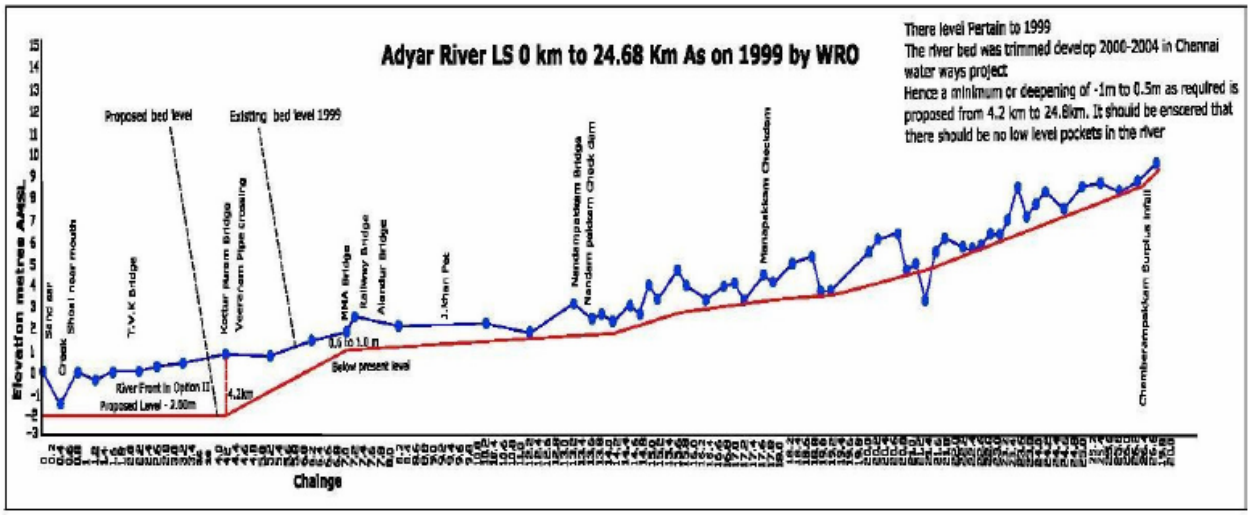
After floods 7-12-2005



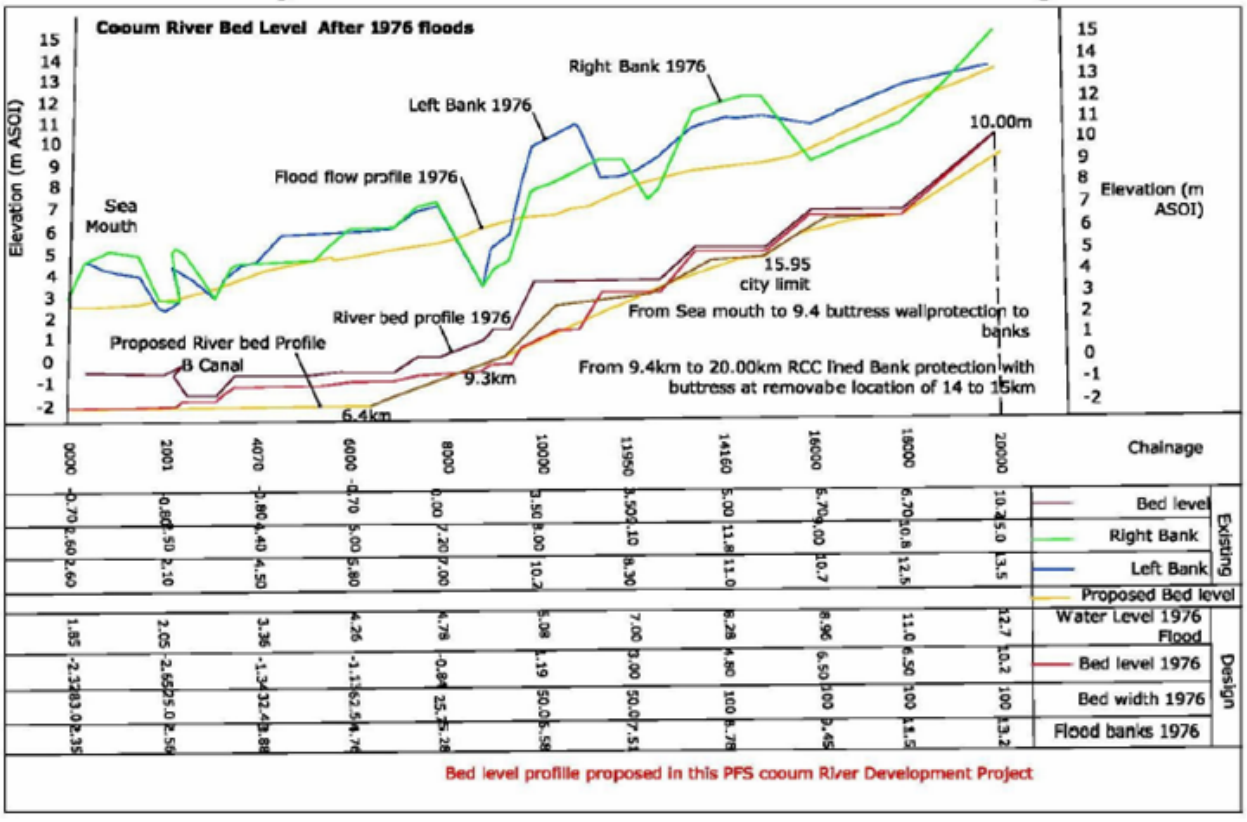
Adyar River 18-5-2009

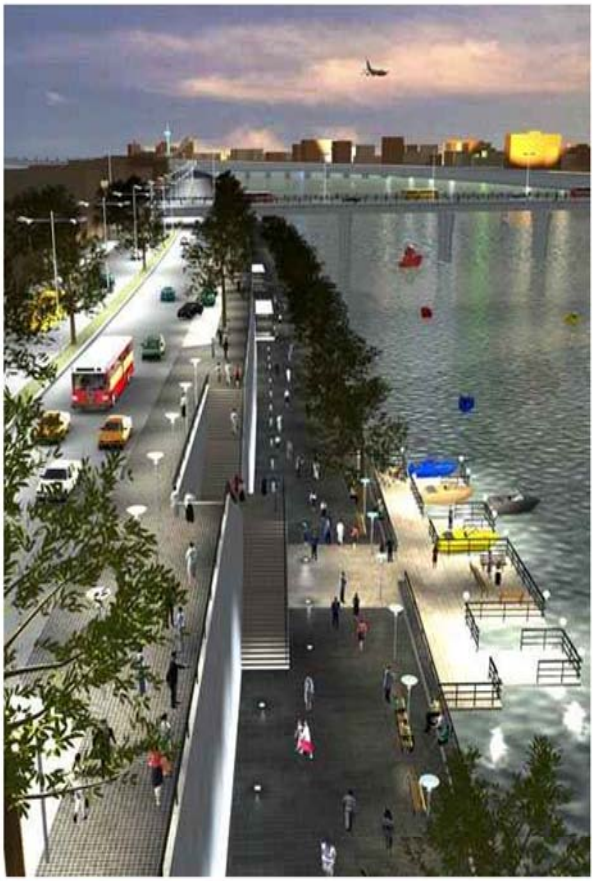
PALLIKARANAI MARSH AND AROUND





Longitudinal Section : Cooum - Flood Banks and Resectioning





IF NOT NOW !
THEN WHEN ?

Thank You

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Session – III

Flood Risk Mapping of Chennai City and its Suburbs using ALTM Technology

Prof. Dr. M. Ramalingam,
Director, Institute of Remote Sensing, Anna University, Chennai

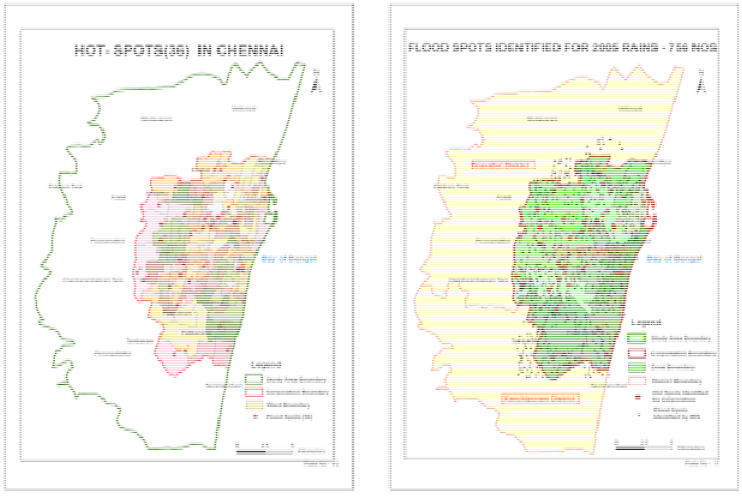
Introduction

- Impact of taking over and converting water bodies for housing development.
- Heavy growth of multistoried complexes, expanded Industries.
- Change of land use pattern, creation of concrete jungle and road surface resulted increase in flood.
- Solid waste dumping affected no. of promising water bodies.
- Unmindful raising of existing Road levels and creation of new embankments across water bodies.
- Encroachments in the banks and reeds of waterways.
- Degradation of storm water drainage system and flood conveying capacity of water ways.
- The one hundred year rainfall occurred during 2005 created heavy flooding and inundation.

Objectives of the Study

- Flood Risk Mapping on 1:2000 scale using digital aerial photographs for 500 sq.km area (part of CMA)
- Generation of 30cm contour using ALTM Technology.
- Studying the lithology of the aquifer and identify suitable sites for artificial recharge by using part of surplus flood discharge.
- Preparation of thematic maps required for generating action plan by different user departments using GIS.
- Recommendation for flood mitigation by expert groups by developing flood inundation models.

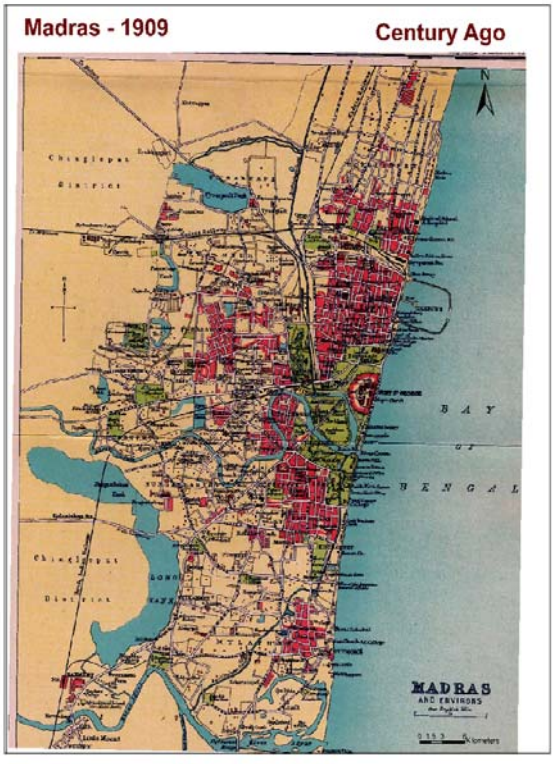
Study area map showing the Drainage, Hot spots and Flood spots

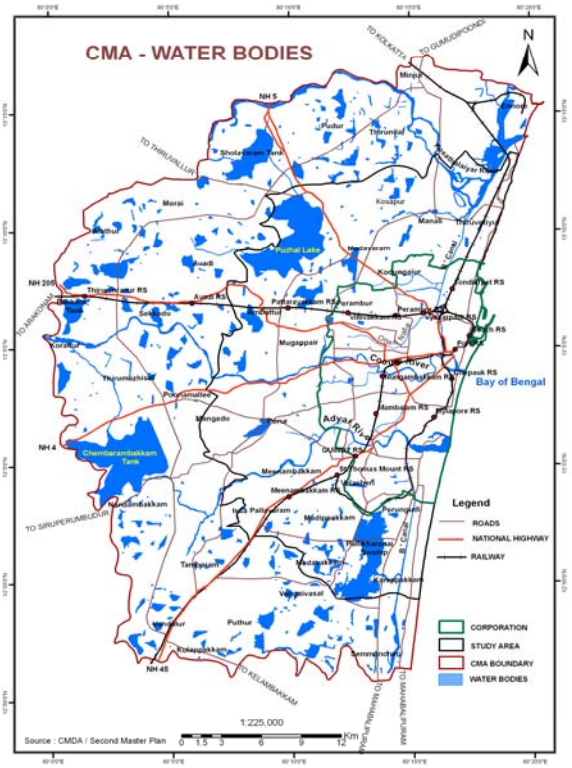


List of 36 hot spots in Chennai city (2005 Flood)

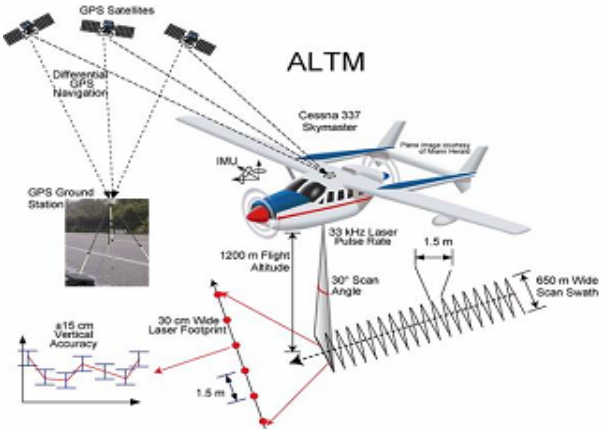
1	Muthamil Nagar	19	Choolaimedu
2	Kannadasan Nagar	20	Trustpuram
3	MKB Nagar	21	Valluvarkottam
4	Sathyamoorthy Nagar	22	Mirshahibpet
5	Kolathur	23	Ice house
6	Tondiarpet	24	Fore shore estate
7	Royapuram	25	Adyar
8	Pulianthope	26	East Velachery
9	Kosapet	27	West Velachery
10	Purasawakkam	28	Saidapet
11	Choolai	29	Virugambakkam
12	Periamedu	30	KK Nagar
13	Nammalwarpet	31	Ashok nagar
14	SS puram	32	Thiruvanmiyur
15	Ayanavaram	33	Mambalam
16	Anna Nagar	34	Rangarajapuram
17	Villivakkam	35	Perambur
18	Arumbakkam	36	Thandavaraya chatram

Water bodies (Past and Present)





Generation of DEM using ALTM technology
(First of it's kind in India)

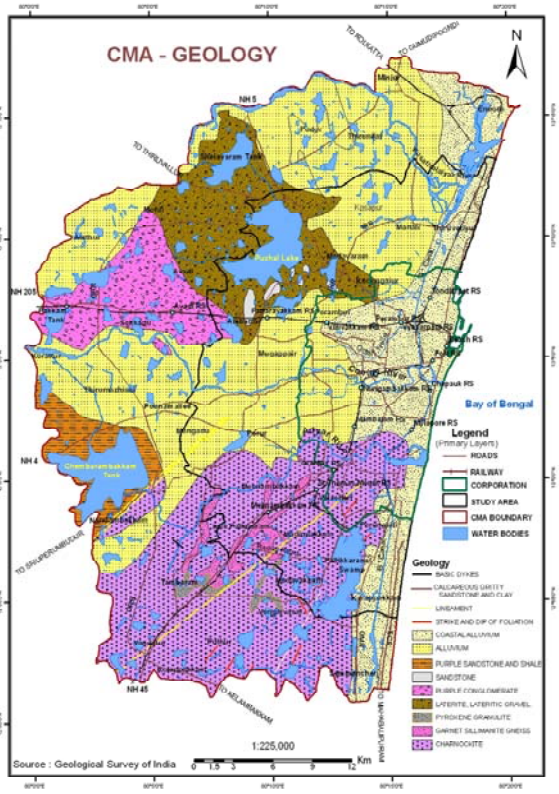


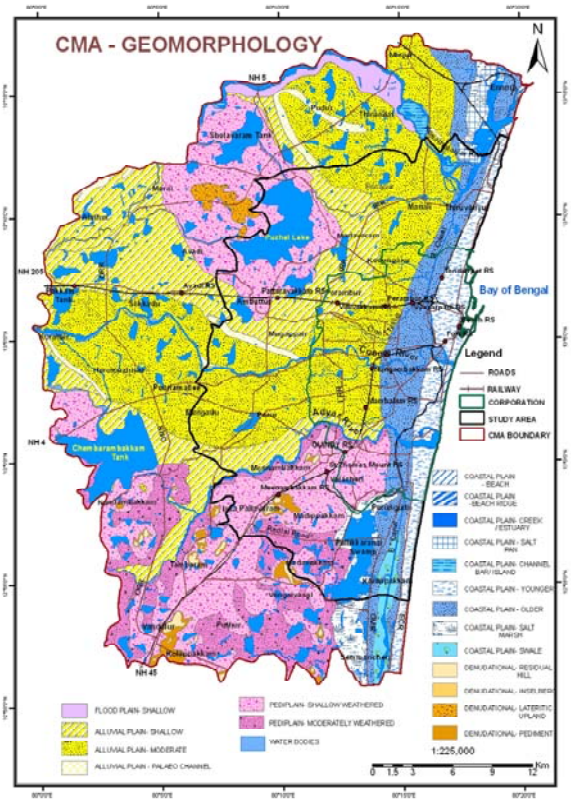
Airborne Laser Terrain Mapping (ALTM)

Helicopter used for flying operation

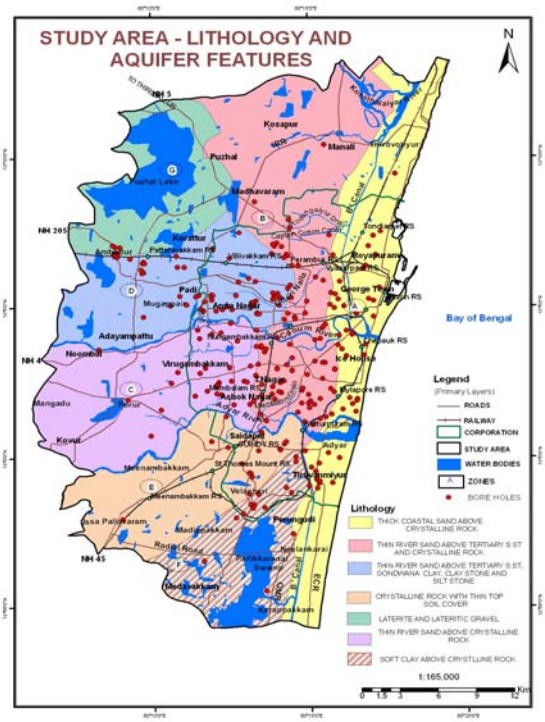
Helicopter used for flying operation

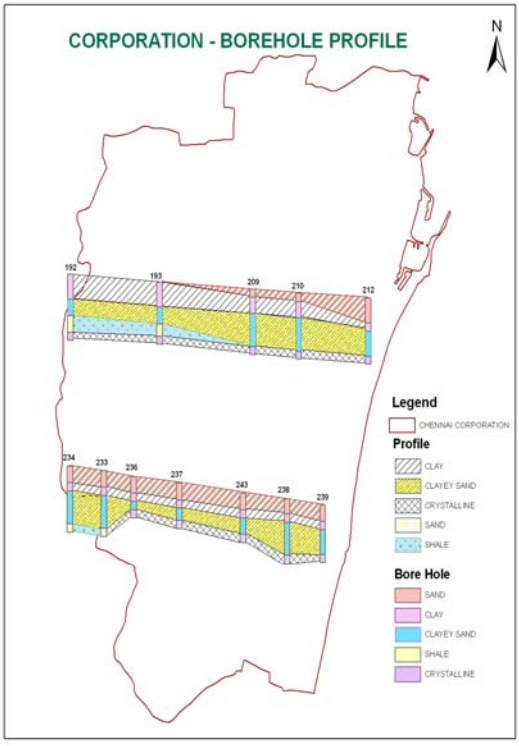
Recharging of Aquifers through Flood waters





Study of Lithology and Aquifer features



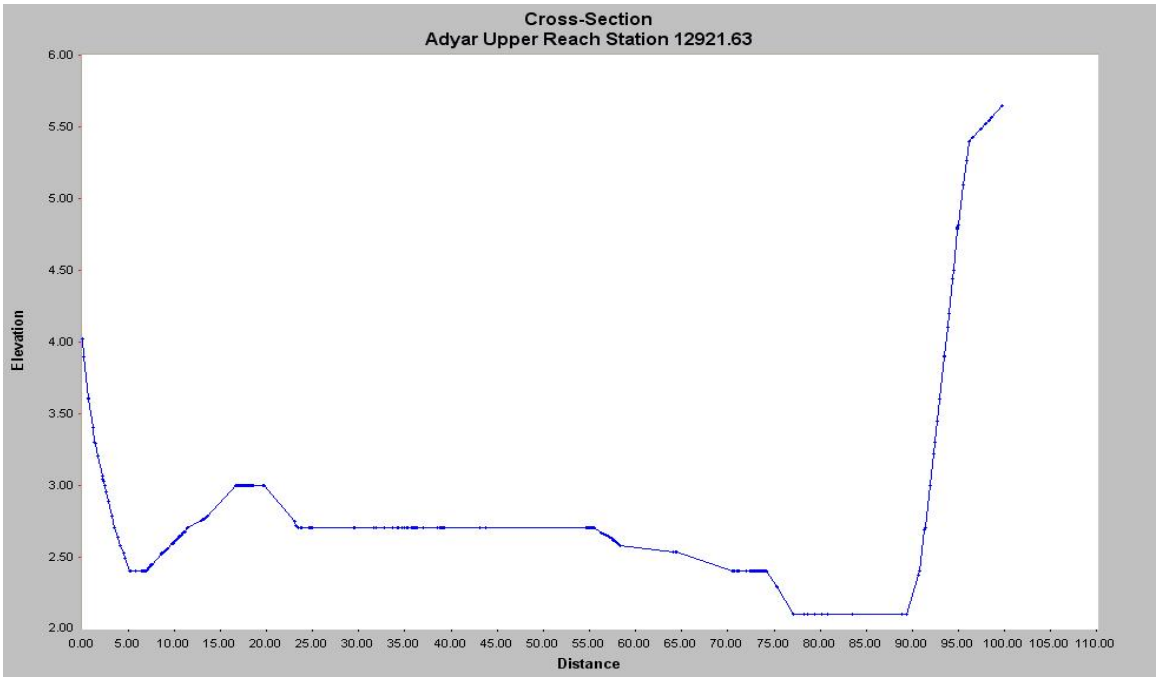


Flood Modeling for Chennai and it's suburbas

Software used

- D8 ALGORITHM
- HEC – HMS
- HEC – RAS
- MIKE – 21
- MIKE-URBAN
- PIPE FLOW MODEL
- STORM NET

Cross section near by Nandampakkam



Modeling by Simulation of floods

POSSIBLE OUT COME

- Quantify the volume of flood inundation in each flood spot.
- Identify the size of storm water drain and its capacity to carry the flood water.
- Estimate the excess flood water under inundation.
- Explore the possibility of recharging the aquifer with the portion of the flood after detailed analysis of the aquifer.
- Examine the possibility of providing straight cut to the sea to relive the excess flood water.
- Any other site specific suitable solution to avoid the flood inundation

Conclusion

- DEM generated with 30 cm contour interval using ALTM is first of its kind in India.
- Fine resolution DEM helps us to suggest efficient flood mitigation measures.
- Digital orthophoto provide parcel level information for infrastructure planning.
- Digital database created will be useful for variety of applications.
- Using the DEM 3D city modelling can be generated.
- Possible future flood inundations can be simulated using the model developed under this project.

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