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EXECUTIVE SUMMARY



Project

INTEGRATED COOUM RIVER ECO-RESTORATION PLAN

FINAL REPORT

EXECUTIVE SUMMARY

TNUIFSL **CRRT**

Date

November 2014



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ABBREVIATIONS

BOD	Biochemical Oxygen Demand
C in C	Commander in Chief
CMA	Chennai Metropolitan Area
CMDA	Chennai Metropolitan Development Authority
CMWSSB	Chennai Metropolitan Water Supply and Sewerage Board
CoC	Corporation of Chennai
COD	Cemical Oxygen Demand
Col.	Colonel
CPCB	Central Pollution Control Board
CPHEEO	he Central Public Health and Environmental Engineering Organisation
CRRT	Chennai Rivers Restoration Trust
CRZ	Coastal Regulation Zone
Cu.m	Cubic. Metre
DHI	Danish Hydraulic Institute
DO	Dissolved Oxygen
DPR	Detailed Project Report
DRD	Directorate of Rural Development
ft	Feet
Ha	Hectare
HEC HMS	Hydrologic Engineering Center - Hydrologic Modeling System
HEC RAS	Hydrologic Engineering Center - River Analysis System
IS	Indian Standard
ISD	Insitu Development
ISR	Insitu Reconstruction
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
kfw	Kreditanstalt für Wiederaufbau
Kg	Kilogram
LARR	Land Acquisition, Rehabilitation and Resettlement
m	Metre
M/s	Messers
m/s	Metre Per second
m ²	Square Metre
m ³	Cubic Metre
m ³ /s	Cubic Metre Per Second
MCM	Million Cubic Metre
mg	Milligram
mg/l	Milligram Per Litre
MLD	Million Litres Per Day
mm	Millimetre
MPN	Most Probable Number
MSW	Municipal Solid Waste
MT	Metric Tonne
NGRBA	National Ganga River Basin Authority
NIOT	National Institute of Ocean Studies

NRCP	National River Conservation Plan
NRRP	National Rehabilitation and Resettlement Policy
Pvt Ltd.,	Private Limited
PWD	Public Works Department
R & R	Resettlement & Rehabilitation
RAY	Rajiv Awas Yojana
Rd	Road
ROW	Right of Way
RP	Return Period
Rs	Rupees
RST	Resettlement
RTFCTLARR	The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement
RVA	Range of Variability Approach
Sq. ft	Square Feet
Sq. Km	Squar kilometre
St	Street
STP	Sewage Treatment Plant
SW	Solid Waste
SWD	Storm Water Drain
SWM	Solid Waste Management
TKN	Total Kjehldahl nitrogen
TNPCB	Tamil Nadu Pollution Control Board
TNSCB	Tamil Nadu Slum Clearance Board
TNUIFSL	Tamil Nadu Urban Infrastructure Financial Services Limited
UGSS	Underground Sewerage System
ULB	Ulrbn Local Bodies
WRCRC	Water Resources Control and Review Council

EXECUTIVE SUMMARY

I.1. PREAMBLE

Water is the most precious renewable natural resource for maintaining all forms of life on Earth. It is much more than just an economic productive resource and main foundation for many economic structures.

Functions and values associated with water are related to environment and ecology, along with social, recreational, cultural and emotionally sensitive issues. Understanding water not only as a single resource but integrating previously defined functions and values together with productive utilities may entail a change in mindset.

Rivers are a natural and cultural heritage beyond their physical and ecological functions. Rivers are a constituent part of the soul of the territories, as they structure them and remain as a landmark in people's memory.

In recent decades, urban development has caused a progressive deterioration of the environmental quality of the water and has also diluted linkages that traditionally humans have had with the rivers.

However, due to its own idiosyncrasies, water management usually brings together diverse conflicts emerging from different vested interests.

The Cooum River Eco Restoration Plan in Chennai is designed as a tool with strategies to create a change in the water management. It will provide the guidelines to improve the value of water as natural resource and create new opportunities with the development of the river front.

I.2. BACKGROUND

CRRT is an umbrella government organisation with the prime objective of restoring rivers and waterways. The Government of Tamil Nadu has visualized the concept of restoration of rivers and water bodies and instructed CRRT to appoint consultants for developing an Integrated Eco Restoration Master Plan for Cooum River in Chennai. In turn, CRRT had requested TNUIFSL for technical assistance for the preparation of the Master Plan for Cooum River.

TNUIFSL, after following the KfW Banks procurement guidelines had appointed M/s. LKS India Pvt Ltd., as the consultants in October 2012 for the preparation of Integrated Cooum River Eco-Restoration Plan.

The Government announced the project in State Assembly during the budget session in 2014-15.

I.3. INTRODUCTION

Cooum River, once a fresh water source is today a drainage course collecting surpluses of 75 small tanks of minor basin. It was once a fishing & boat racing river which has borne the brunt of the city's population explosion.

Cooum is a heavily polluted river which drains into the Bay of Bengal. It originates from a village with the same name in Tiruvallur district, about 70 km upstream of Chennai, although its main course begins at Satharai village, which is 65 km from Chennai.

Flowing through Poonamallee, it enters Chennai District at Nolambur meandering for more than 50 km. It then runs for another 20 km through Choolaimedu, Chetpet, and Egmore. Near Egmore, just before Col. Laws Bridge the river splits into two creating the Northern and Southern arms that meet again before Napier Bridge, forming the famous Island Grounds. The river finally drains in the Bay of Bengal, south of Fort St George, just downstream of Napier Bridge. The sub basin area is 453 sq.km.

The Cooum River flows through the following administrative jurisdiction:

- 3 Districts: Chennai, Thiruvallur and Vellore
- 1 Metro Corporation: Chennai
- 4 Municipalities: Avadi, Poonamallee, Thiruverkadu and Thiruvallur
- 3 Town Panchayats: Thiruninravur, Thakkolam and Thirumazhisai.
- 2 Panchayat Unions: Poonamallee and Villivakkam
- 148 Villages

I.4. OBJECTIVES

The objectives of Cooum River Integrated Eco Restoration Master Plan are as follows:

- To ensure effective abatement of pollution and protection of river by adopting a sustainable approach promoting inter-sectorial co-ordination through comprehensive integrated planning and management.
- To maintain minimum ecological flows in the rivers with the aim of ensuring water quality and sustainable development.
- To improve and maintain the flood-carrying capacity of the river.
- To create a River front development within urbanised areas, wherever possible.
- To identify projects / sub projects for pollution abatement with cost estimates.
- To explore the possibility of navigation purposes and other future uses of the River after restoration.

I.5. NEED FOR RESTORATION

Growth of urbanisation without associated facilities led to pollution of the existing rivers. The major pollution contribution factors are: sewage, solid waste, industrial discharges and encroachments. There is an urgent need to undertake measures to stop the pollutants from reaching the river.

I.6. VISION

I.6.1. VISION TAMIL NADU 2023

Nurturing a rich heritage and preserving the ecology

Environmental preservation would encompass the entire ecological footprint of human activity and would include increasing forest cover, protection of wetlands, conserving groundwater and rivers and other water bodies, protection of the coastal zones and fragile ecosystems, conservation of the zoological and botanical diversity of the state, protection of soil and other natural formations from abuse on account of human activity, efficient recycling of solid waste ensuring minimal impact of the environment, minimising atmospheric pollution and in general maintaining the ecological balance across the entire state.

Tamil Nadu Infrastructure Development Board

- In the meeting held on February 4, 2013, it was resolved to place Restoration of Chennai Water Ways Project worth Rs.10,000 crores on fast track.
- Directed the concerned agencies to take necessary follow up action including preparation of detailed feasibility studies, wherever required, to ensure speedy implementation within strict time frame.

Restoration of Chennai rivers and waterways

Subsequently, the State committed to restore the ecological health of these waterways and water bodies by upstream treatment, desiltation, plugging of polluting outfalls, sewage treatment, scientific solid waste management, embankment protection and development of parking areas, walkways and parks. It was proposed to restore Cooum, Adyar and Kosasthalaiyar rivers, the Buckingham canal along with other smaller canals for a total length of 214 km and 42 water bodies in the Chennai Metropolitan Area which are highly degraded due to severe pollution. This project will be implemented under the aegis of Chennai Rivers Restoration Trust (CRRT).

I.6.2. PROJECT VISION

தூய்மையான கூவும் துப்புறவான சென்னை

CLEAN COOUM, CLEAN CHENNAI

I.7. GUIDELINES AND STANDARDS

The Report was prepared based on the following guidelines and standards:

RIVER RESTORATION - GUIDELINES:

- Guidelines for preparation of project reports under National River Conservation Plan and National Ganga River Basin Authority, Ministry of Environment & Forests, December 2010 (NRCP & NGRBA)

SEWERAGE AND SANITATION SECTOR - GUIDELINES:

- Central Public Health And Environmental Engineering Organisation (CHPEEO) manuals
- Water sampling and testing: Protocol for water quality monitoring notified by the Govt. of India.
- Tamil Nadu Pollution Control Board (TNPCB)
- Water Quality criteria and Goals, MINARS 17/2002 CPCB

SOLID WASTE MANAGEMENT PLAN - GUIDELINES:

- Municipal Solid Waste Management Rules 2000
- Hazardous Waste Management Rules 2008
- Biomedical Waste Management Rules 1998

SOCIAL ASSESSMENT FRAMEWORK – POLICIES:

- National Rehabilitation and Resettlement Policy (NRRP)
- Jawaharlal Nehru National Urban Renewal Mission (JNNURM)
- Rajiv Awas Yojana (RAY)
- Tamil Nadu Slum Clearance Board policy (TNSCB)
- The right to fair compensation and transparency in Land Acquisition and Resettlement & Rehabilitation, 2013 (LARR)

RIVER FRONT DEVELOPEMENT- GUIDELINES:

- Coastal Regulation Zone Notification (CRZ), 2011
- Second Master Plan for Chennai Metropolitan Area, 2006

I.8. PROJECT BENEFITS

The solutions proposed for the restoration of the Cooum river will help bring life back to the Cooum River as well as improve the living conditions of the people residing along the riverside. It will also provide the city with a green corridor where citizens will be able to enjoy nature by walking, cycling and running along the walkways and cycle tracks of the new river front.

The creation of a large new green space in the city along the river will help increase the rain water harvesting and the number of permeable areas in the city. Furthermore, the creation of walkways and cycletracks where motor vehicles are separated from bicycles and pedestrians will result in important accident risk depletion, improving considerably human safety conditions in the area.

Waterborne diseases like mosquito borne dengue fever and malaria, or others like cholera, leptospirosis, typhoid, diarrhoea, that can be transmitted through unhygienic conditions and contaminated water, will be drastically reduced, benefiting both the citizens and Government.

Besides, damages that may occur in the rainy season due to floods under different estimated return periods, affecting both people and infrastructures, will be reduced by improving the flood carrying capacity of the river. This will positively affect the human safety of the people living in the riverine neighbourhoods as well as those whose workplace is near a flood prone area.

I.9. ASSESSMENT: CURRENT STATE OF COOUM RIVER BASIN

The current status of Cooum basin has been analysed from multiple points of view in order to understand its problems. Every problem has been thoroughly analysed and a brief summary of the same is highlighted in the following sections.

The study area of the assignment comprises the stretch from Paruthipattu anicut to the river mouth in the Bay of Bengal. It was proposed to take up the restoration from Parthipattu as the major sources of pollution have been observed to be downstream of Paruthipattu, in the densely populated urban area. The water quality has been observed to change as the river flows through the urban area: transparency is lost, colour changes and the odour becomes highly objectionable. Besides, the flora and fauna surveys conducted show a good number of phytoplankton and zooplankton species in the upstream stretch of the studied area, along with an interesting number and variety of trees, herbs and climbers, indicating a better quality of water compared to that downstream.

In the following table, the list of drains flowing into the Cooum river in the studied stretch is given:

No	Drains flowing into Cooum	Location	Length (km)
1	North Buckingham Canal	Central Railway Station	17.1 in CMA limit
2	Central Buckingham Canal	Near Napier Bridge - behind Madras University	7.2 in CMA limit
3	Nungambakkam Canal	Opp. To Police quarters / Asan Mem. Hr. School - Greams Road - behind Sewage Pumping Station	1.5
4	Virugambakkam - Arumbakkam Drain	Nelson Manickam Road - Near Shoban Babu Statue - below the bridge	6.9
5	Padi Kuppam Canal	Behind Vee care Hospital - Anna Nagar	2.2
6	Mogappair Drain (Nolambur Canal)	Beside MGR University (Thaimoogambikai Dental College & hospital) - Near Nerkundram Bridge	2.4

Table 1. Details of drains in the study area

I.9.1. ENVIRONMENTAL QUALITY

The origin of the pollutants in different sections of the river has been assessed. The information gathered during site visits has been verified against lab results and desk studies. This allowed the team to define hypotheses, draw conclusions and give recommendations.

The water quality standards adopted follow the standards set by the Central Pollution Control Board (CPCB), as well as those indicated in the Guidelines for Preparation of Project Reports under the National River Conservation Plan, National Ganga River Basin Authority (NRCP and NGRBA, 2010) and the Indian Standards. The bench marks shown in Table 1. This criterion the Designated Best Use for establishing the benchmarks. According to the CPCB designated best use criteria water quality **B Class Outdoor bathing (organised)** is the objective of the Cooum River restoration.

Parameters	CPCB Guidelines
pH	6.5 – 8.5
BOD ₅ (mg/l), max.	3
DO (mg/l), max.	5
Faecal Coliform (MPN/100ml), max.	500

Table 2. Water quality Standard benchmarks

26 water samples were taken and analysed, from what it was observed that the river has very poor water quality as it contains high levels of oxygen demanding material, both biochemical and chemical (BOD¹ and COD²) with almost zero dissolved oxygen values. Low DO levels

¹ BOD: Biochemical Oxygen Demand

along with substantial presence of faecal coliforms effectively transform the river into an open sewer. Ammoniacal Nitrogen levels are very high as well, and Faecal Coliforms are above desired levels in all cases. This indicates that uncontrolled sewage discharges reach the river on a regular basis. Besides, heavy metals such as Lead, Zinc and Cadmium are also present.

Parameter	BOD	DO ³	F. Coliforms
Standard for Class B	< 3 mg/L	> 5 mg/L	<500 (MPN/100ml)
Mouth	124	< 1	>1600
Koyambedu	34	< 1	> 1600
Paruthipatu	10	< 5	1600

Table 3. Current state in test results in key points

The ECO Lab module of Mike 21 has been used to predict how different hypothetical pollution and hydraulic conditions could affect water quality. A bespoke model has been built based on information gathered on site, conversations with the client and desk studies.

The results have been used to define potential solutions for water quality improvement in the Cooum River.

I.9.1. SEWAGE & SANITATION

Various surveys were conducted along Cooum river such as a Water Quality Survey, where 26 water samples were collected and different parameters identified and an Outfall Survey, where 118 outfalls were located and analyzed.

Within Cooum basin, several areas remain uncovered by UGSS, particularly, in the recently added areas of Chennai Corporation and ULB's⁴.

The whole stretch of the river was studied, and solutions have been proposed based on that analysis in depth. To start with, outfall surveys and water quality surveys were conducted and information was collected from the stakeholders involved in this sector, such as CMWSSB⁵. Based on the study of the information and the analysis of the results of the surveys, the description of the current state of river within Chennai and outside Chennai, is given in the following sections:

² COD: Chemical Oxygen Demand

³ DO: Dissolved Oxygen

⁴ ULB: Urban Local Body

⁵ CMWSSB: Chennai Metro Water Supply and Sewerage Board

I.9.1.1. OUTFALL SURVEY

During the course of this study, raw sewage outfalls which let sewage directly into the Cooum River were identified and recorded. The outfalls are mainly storm water drains carrying sewage, overflows from the sewerage network and direct flows from various premises and buildings.



Picture 1. Raw sewage flow to the river in Metha Nagar

A summary of the sewage outfalls and its classification is given in the following table.

COOUM RIVER	TOTAL	City	ULBs
Flow through SWD	73	67	6
Sewerage outfall	19	14	5
Flow from Premises	16	15	1
SWD dry	9	9	0
STP	1	1	0
TOTAL	118	106	12
Total without Premises or STP (total to plug with Interception & Diversion)	101	90	11

Table 4. Summary of the existing outfalls

I.9.1.2. SEWERAGE SCHEMES IN CHENNAI CORPORATION AREA:

According to the published table in the CMWSSB⁶ website and the data collected, 100% of the former city limits has been covered by Under Ground Sewage System. With a total length of 2,677 km of sewers, the system connects about 15,460 streets of the Corporation covering an area of 174 Sq. Km. The entire system is operationally supported by 218 pumping stations.

On the other hand, the recently added areas of Chennai Corporation, i.e. Zones I, II, III, VII, XI, XII, XIV and XV, are not completely covered under UGSS and Sewage Treatment facilities. CMWSSB is developing all the necessary designs, supervision, works and management for covering all the new areas with an adequate system in a phased manner.

⁶ CMWSSB: Chennai Metropolitan Water Supply and Sewerage Board

The current state of the newly added areas within the Cooum basin is given in the Table 5 below.

	DPR status	Works status
within Chennai Corporation		
Ambattur	Completed	Ongoing
Valasaravakkam	Completed	Completed
Maduravoyal	Completed	Ongoing
Nerkundram	Under preparation	Not started
Porur	Completed	Ongoing
Ramapuram	Completed	Ongoing
Nolambur	Completed	Not started
Karambakkam	Under preparation	Not started

Table 5. Current State of the Newly Added Areas to Chennai Corporation

Furthermore, there is no sanitation infrastructure in the slums located along the waterways. Therefore, people settled along the river banks contribute to pollution by discharging sewage directly into the waterways.

I.9.1.3. SEWERAGE SCHEMES OUTSIDE CHENNAI CORPORATION

The sewerage network is currently being developed in the Municipalities, Town and Village Panchayats. The works and DPRs are in different stages. The summary is enclosed in the following Table 6. Great efforts are being carried out to introduce and improve the given networks.

Area	DPR status	Works status
Municipalities		
Avadi	Completed	Ongoing
Poonamallee	Completed	Not started
Thiruverkadu	Completed	Not started
Others		
Ayapakkam (Villivakkam PU)	Completed	Not started
Adayalapattu (Villivakkam PU)	Under preparation	Not started
Vanagaram (Villivakkam PU)	Completed	Not started
Sennerkuppam (Poonamallee PU)	Completed	Not started

Table 6. Current state outside Chennai Corporation

I.9.2. SOLID WASTE

Currently, there are two landfills within CoC⁷: Kodungaiyur with 182 Ha and Perungudi with 142 Ha. Waste disposal along Cooum river is extensively done by the nearby residing population. According to the field survey carried out to measure the volume of solid waste

⁷CoC: Corporation of Chennai

disposed along the riverbanks, there are around 62,000 cum within Corporation limit and 8,000 cum outside Corporation of Chennai.

More than hundred soil samples were collected at different locations and depths in order to find out the quality of the soil. From the results, it is concluded that the soil is not categorized as hazardous, and thus it can be safely disposed in dump yards.

The study of SWM⁸ on the Cooum Basin is divided into three zones with very distinct characteristics and structures of management. These zones are Upper zone (283.89 sq. Km), part of Thiruvallur district, where most of the village panchayats are located, the Middle zone (103.8 sq. Km) includes municipalities of Thiruvallur district's south-eastern area, as well as sections of Chennai Metropolitan Area (CMA) which are not administered by the Corporation of Chennai (CoC) and the Lower zone (139.69 sq. Km) is the Metropolitan area of Chennai that is all managed by the CoC.

The Municipal Solid Waste (Management and Handling) Rules, 2000, lay down the steps to be followed by all the municipal authorities to ensure management of solid waste according to best practice.

Currently, the landfills at Kodungaiyur and Perungudi, with 182 and 142 hectares of land available, are the only locations within CoC where Solid Waste is dumped in a constant manner, although these are open ground dumping sites, with no scientific methods used. Additionally, vacant/open areas, such as those found along the river and other areas along Thiruverkadu, and other municipalities used as dumping areas are neither controlled, nor monitored properly by any agency.

Presently, Solid Waste dumping along the Cooum River is done indiscriminately. This procedure however, poses serious concerns, since it is an extended habit throughout the population living along the Cooum River. As such, this situation is a high source of pollution, encroachment and source of diseases due to the increased presence of disease carrying vectors.



Picture 2. Solid Waste Dumping along Cooum River near Periyar Bridge(source: Field visit, January 2013)

Several field visits were done in order to survey the quantity of solid waste and construction debris deposited on the riverbanks. The summary of the quantities is enclosed in the tables below.

⁸SWM: Solid Waste Management

The surveys measured the following quantities within Chennai city limits

Quantities in m³

COC ⁹	SHORT	MEDIUM	LONG	TOTAL
MSW ¹⁰ (m3)	13,977	6,430	11,388	31,765
C.DEBRIS ¹¹ (m3)	23,141	3,163	4,250	30,554
TOTAL	37,118	9,593	15,638	62,319

The following quantities were found outside of the city:

	Solid waste m ³
DRD	
Adayalapattu	682.5
Vanagaram	2,400
Seneerkuppam	1,500
CMA	
Thiruverkadu	3,146.5

Table 7. Solid waste and constructions debris on the riverbanks

The Solid Waste and Construction Debris accumulated along the river were classified between that which fell within the Chennai City Limits, therefore becoming the responsibility the cleanup and Disposal the Corporation of Chennai, and that which fell outside the city limits, falling under the responsibility of the corresponding Municipality/ Administrative body in which the material is found.

1.9.2.1. SOIL QUALITY

Sampling stations were fixed within the whole length of scope of the project. The sampling stations were selected based on the survey conducted to identify the possible areas of plantation. More than 100 samples were taken at different locations and depths in order to find out the quality of the soil. The depths of the sampling points were selected based on the debris height and width of the existing dumps, assuming the waste dumps to be dredged out during the execution of the works. Soil characteristics are the most important environmental factors directly affecting mangrove productivity and structure.

The soil samples were analysed for physicochemical parameters such as pH @25°C, electrical conductivity@25°C, Magnesium, phenolic compounds as C₆H₅OH, TKN, Nitrogen as N, Phosphorous as P, Sodium as Na, Potassium as K, Sulphate, Chloride, Cadmium, Molybdenum, Selenium, Nickel as Ni, Manganese as Mn, Copper as Cu, Zinc as Zn

⁹ COC: Corporation of Chennai

¹⁰ MSW: Municipal Solid Waste

¹¹ C.DEBRIS: Construction Debris

Chromium as Cr, Mercury as Hg, Arsenic as As and Lead as Pb. These test results are utilized for the restoration plan as well as for post restoration management.

The soil samples were analysed following Indian Standard (IS) testing methods. The Hazardous Wastes Management, Handling and Transboundary Movement Rules 2008, establishes the permissible limits of various elements which determined the toxicity of soil samples are as given below:

Main Parameters	Concentration Limit
Calcium Carbonate	50,000 mg/kg
Soluble Calcium	50,000 mg/kg
Phosphorous	5,000 mg/kg
Sodium	50,000 mg/kg
Potassium	50,000 mg/kg
Sulphate	50,000 mg/kg
Chloride	50 mg/kg
Cadmium	50 mg/kg
Nickel	5,000 mg/kg
Manganese	5,000 mg/kg
Copper	5,000 mg/kg
Zinc	20,000 mg/kg
Chromium	CrIII 5,000 mg/kg / CrVI 50 mg/kg
Mercury	50 mg/kg
Arsenic	50 mg/kg
Lead	5,000 mg/kg

Table 8. Main Parameters measured for soil quality

From the results it is concluded that the soil is not categorised as hazardous material and thus it can be safely disposed to dump yards.

1.9.3. RIVER CHANNEL

The river channel has undergone major changes from its natural conditions due to rapid urbanization growth mainly across the city. The river has been narrowed due to encroachments in many parts of the city.

The maximum discharge and flood carrying capacity was worked out using a Hydrologic and Hydraulic Model in a specific software. This software has also helped in finding the solutions to prevent floods.

The first step to analyse the current condition of the river was to work out the maximum discharge it carries during rainy season. For that purpose, a topographical survey was carried out; rainfall data and drain discharge data were collected and with this data a Hydrologic

Model was created. A hydrologic model is designed to simulate the rainfall-runoff process of dendritic watershed systems.

From the discharge obtained using the hydrologic model is known, hydraulic model is created to find out how those discharges flow along the river and assess its carrying capacity.

I.9.3.1. HYDROLOGIC MODEL

For this study the HEC-HMS¹² model has been selected to determine the flood discharge for the 2, 10, 100 and 200 years return period rainfall events.

The Table 9, shows the peak discharges in several zones for those rainfall events.

	Chainage	DISCHARGE		VELOCITY		WATER LEVEL (msl)		Current bed level
		2 year	100 year	2 year	100 year	2 year	100 year	(msl)
	M	m ³ /s	m ³ /s	m/s	m/s	m	M	m
Napiers	500	161	640	0.22	0.81	1.53	1.87	-1.37
Bypass Rd	19700	119	490	0.89	1.81	9.70	11.58	7.88
Paruthipattu	27400	115	480	1.93	2.5	18.26	19.54	16.38

Table 9. Hydraulic properties of the Cooum river - Current State.

I.9.3.2. HYDRODYNAMIC MODEL

The hydrodynamic behaviour of the Cooum River has been analysed through two different software. The first one analyses one-directional flows: HEC-RAS¹³, which has been developed by the US Army Corps of Engineers. The second software, MIKE-21, developed by the Danish Hydraulic Institute (DHI), analyses two-directional flows.

The 1-dimensional model has been developed for the analysis of the current status and for the design of the riverbed modification proposals.

The 2-dimensional model was used to characterize the floodplains for the 4 return period years: 2, 10, 100 and 200 years. This model has also been the base for the water quality modeling in conjunction with Ecolab model for water quality evolution.

The next figure shows the floodplain delineation near Adayalampattu.

¹² HEC-HMS: Hydrologic Engineering Center -Hydrologic Modeling System; is the name of the world-wide known and used program for hydrological modelling. It is developed by the US Army Corps of Engineers.

¹³HEC-RAS: Hydrologic Engineering Center – River Analysis System; is the name of the world-wide known and used program for river modelling. It is developed by the US Army Corps of Engineers.



Figure 1. Floodplain delimitation for 2, 10, 100 and 200 year return periods.

I.9.3.3. ANALYSIS ON THE CURRENT STATE

The fluvial corridor of the Cooum river from Paruthipattu bridge to its mouth has undergone a major alteration from its natural conditions, turning from a shallow and wide river in the peri urban zone into a narrow, deep and wall protected channel within the city limits of Chennai.

All along the stretch analysed, there is the so-called back water effect, because the river has a subcritical flow regime, implying that any contraction or control structure at a certain point will have an impact upstream.

From Paruthipattu anicut to the city limit, the flood carrying capacity is reduced by several contractions due to encroachments and transverse structures (causeways) with insufficient hydraulic capacity. The narrowed zones and the transverse structures which are limiting the flood carrying capacity of the river are highlighted in the following table. Although there are several causeways along this stretch which are flooded for low return period events, only two of them produce a considerable backwater effect.

Chainage	Type	AREA
26000	Causeway	Thiruverkadu
22800-22200	Section shrunk	Perumalagaram
21000-20300	Section shrunk	Adayalapattu
18250	Causeway	Nolambur
17800-16600	Section shrunk	Nerkundram

Table 10. Zones and structures limiting flood carrying capacity.

From the city limits to the mouth, the river is completely channelized and has suffered accretion of the river bed due to a progressive sedimentation originated by low velocities in the flow and the tidal influence. Consequently the river has lost hydraulic area and diminished its

flood carrying capacity. All the bridges except Commander in Chief Bridge have sufficient hydraulic capacity to carry the 100 year flood events, whether in free flow or orifice regimes.

1.9.3.4. ECOLOGICAL FLOWS

According to its hydrological cycle, Cooum River can be defined as a non-perennial waterway, and more precisely as a seasonal river. It may appear that variable flows and intermittency have largely negative effects, adversely affecting the water quality during the drying phase and limiting the diversity of water plants, invertebrates and fish. Yet, the significance of the comparison is not that “permanent” is better, but that river systems with high variable flow regimes are different and call for a different approach in their management. Efforts to reduce this flow variability in order to increase biodiversity or to “restore” the river system to one that better fits a “perennial healthy” river may not be the best ecological option.

Therefore it’s judged suitable to define a minimum ecological flow that varies throughout the year (monthly variation) following the trend of the historical flow regime, which has a marked seasonal pattern. For the quantification of the regime of monthly minimum ecological flow, the "Range of Variability Approach" (RVA) method has been applied. This approach is based on the fundamental role of hydrologic variability on aquatic ecology related to coordination, frequency, duration, and rate of change with the maintenance of ecosystems.

The following table shows the quantification of the monthly minimum ecological flow using the RVA method.

Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
0.69	1.43	1.14	2.05	3.16	2.58	0.09	0.00	0.00	0.00	0.00	0.12

Table 11. Quantification of monthly minimum ecological flow (m³/s)

The minimum ecological flow represents a total annual runoff of 29.7 MCM¹⁴. During the dry season due to the non-perennial nature of Cooum the expected flow comes from the installed modular treatment plants, and the minimum expected flow in the dry season is as follows:

Month	Jan	Feb	Mar	Apr
Min Flow (in m³/s)	0.473	0.473	0.473	0.473

Table 12. Expected minimum flow during dry season (m³/s) from STPs

1.9.3.5. WATER BALANCE

Water balance can be defined as a balancing of water between availability and amount of water required for various needs. In this study, the water balance is considered in a drainage basin level.

¹⁴ MCM: Million Cubic Metre

Taking 2020 as horizon year, the total amount of water (surface water and ground water - calculated by PWD) available in basin level is 220 MCM (Million Cubic Meter), out of this 83 MCM is from surface water resources and the remaining 137 MCM is from ground water resources. Whereas the total amount of water available is required for various needs like domestic water demand, industrial demand, water required for livestock, irrigation demand and the water required for ecological flow in the river.

- The domestic water demand is calculated based on the projected population and the norms set by the Water Resources Control & the Review Council for per capita water demand.
- The water required for minimum ecological flow is calculated from the 34 years average monthly flow.
- The industrial water demand is calculated as per the Department of Industries and Commerce recommendations (industries are classified into small, medium & large).
- The livestock water demand is calculated based on the livestock population collected from the Department of Economics and Statistics & the Animal Husbandry Department and the norms set by the Indian Council of Agriculture and Research for the livestock per capita water requirement.
- The irrigation water demand is calculated with the help of crop water requirement for various crops and the data collected from the Department of Economics and Statistics for the irrigated area and the types of crops.

The following table summarizes the water balance simulation for the horizon year 2020:

Water sources Potential in MCM	Total	220
	Surface water	83
	Ground water	137
Total gross Demand in MCM	Total	849
	Domestic	167
	E-flow	30
	Industries	456
	Livestock	14
	Irrigation	182
Deficit in MCM		629
Percentage		73%

Table 13. Annual water balance - Horizon year: 2020

Given the water deficit in the basin, it is up to the pertinent authorities, mainly PWD and Water Resources Control and Review Council (WRCRC) to prioritize the use of water.

Source: "Study of Chennai River Basin" by Institute of Water Studies - Water Resources Department / Public Works Department - 2007

I.9.3.6. CURRENT STATE OF THE TANKS

According to the current land use, the whole Cooum basin is divided into three different zones, and 80 tanks are located just in the upper and middle zones:

1. Upper zone (from the uppermost watershed of the basin to Korrattur anicut) has 54 irrigation tanks with registered ayacut of 6558.34 Ha.
2. Middle zone (from Korattur anicut up to Koyambedu bridge) has 26 tanks with registered ayacut of 3379.20 Ha.
3. Lower zone (from Koyambedu bridge to mouth) has no tanks.

From those 80 registered tanks only 61 tanks have full or partial ayacut. The main functionality of those tanks is irrigation purposes and from the total registered ayacut of 9,937.54 Ha only 6,629.52 Ha are currently available.

I.9.4. SOCIAL ASSESSMENT

Data on slums was collected from TNSCB¹⁵, RAY¹⁶ visor and the ROW¹⁷ was identified with the help of PWD. According to this data, 58 slums will be affected by the Cooum River Project as they are located within the ROW line defined by PWD¹⁸.

Every area was individually surveyed in order to find the best solution within the Eco-restoration plan of the river.

The current urban development data used for this report has been extracted from three different sources, mainly:

- **Second Master Plan For Chennai Metropolitan Area, 2026**
- Unplanned settlements or slums, have been delimited using the **RAY (Rajiv Awas Yojana)**
- **Right of way line** (provided by PWD)

Survey information on slums along Cooum riverbanks has been provided by Tamil Nadu Slum Clearance Board. The main documents provided are:

- **Cooum Restoration Plan** - Tamil Nadu Slum Clearance Board. July 2012.
- **Updated slum list along Cooum River Banks** (Tamil Nadu Slum Clearance Board).

According to these documents, 76 slum areas have been identified along the Cooum River banks. From the slums that have been identified and located, 65 slums are within the Eco-

¹⁵ TNSCB: Tamil Nadu Slum Clearance Board

¹⁶ Rajiv Awas Yojana

¹⁷ ROW: Right of Way

¹⁸PWD: Public Works Department

restoration Plan area and 7 have already been resettled. Therefore, 58 slum areas would be affected by the Eco-restoration Plan.

	%	FAMILIES	SLUMS
TOTAL IN TNSCB DATA	100%	14,972	65
ALREADY RESETTLED	5%	715	7
AFFECTED IN THE PROJECT	95%	14,257	58
Within Chennai		13,232	49
Outside Chennai		1,025	9

Table 14. Summary of slums in the Cooum river

Every slum area has been analysed according to the following parameters in order to determine the current conditions and select the action that should be taken in order to achieve the Eco-restoration plan's objectives.

- Areas included totally or partially (P) in the Right of Way Line provided by PWD¹⁹.
- Areas included totally or partially (P) in the Fluvial Corridor defined in the CMA²⁰ Masterplan developed by CMDA²¹.
- Need of urban regeneration in order to obtain lands inside ROW²² line.
- Need of river front improvement.
- Areas presenting full or partial (P) high (two year return period), medium (ten year return period) or low (one hundred year return period) flooding risk, or very low (two hundred year return period) flooding risk.
- Current status is not compatible with a proper urban river front.

Options have been studied as per Indian policies. The **first option** is aimed at finding areas where in-situ development (ISD) is possible, focusing on providing basic facilities. As a **second option**, the report explores in situ re-construction (ISR) to create new residential areas through urban renewal. Finally, and as **third option** the resettlement (RST) is studied.

Definitions of the solutions within each option:

- **In situ Development** - Provision of Basic Infrastructure amenities such as water supply, roads, sanitation, solid waste management policies in the slums.
- **In situ Reconstruction** – Construction of dwelling units, construction of tenements without any relocation within the slum area.
- **Resettlement & Rehabilitation** – provision of houses, infrastructure, and livelihood programmes, etc., with a holistic approach in the TNSCB relocation areas.

¹⁹ PWD: Public Works Department

²⁰ CMA: Chennai Metropolitan Area

²¹ CMDA: Chennai Metropolitan Development Authority

²² ROW: Right of Way



Picture 3. Quith E Millet Bridge to Old Jail slum on Island Grounds

I.9.5. BIODIVERSITY

A survey was conducted to understand the current status of the flora and fauna along the river. 21 tree species were found, out of which 14 are native species, and 34 species of herbs and climbers. The fauna analysis recorded less number of species compared to healthy rivers. The biodiversity was found to be in a degraded but not irreversible status. With a proper restoration plan, vegetation can abundantly grow again along the riverbanks.

I.9.5.1. EXISTING FLORA

Seven locations were selected based on richness of vegetation which is thought to be a good representation of Cooum floral ecosystem.

A complete sampling of flora was carried out, identifying all the species of the Cooum River. The location details of surveyed sites are listed below:

- Site I - River mouth
- Site II - Chindatripet
- Site III - Ethiraj bridge
- Site IV - Chetpet bridge
- Site V - Choolaimedu
- Site VI - Koyambedu
- Site VII - Paruthipattu

The occurrence and distribution of plant species were recorded on both sides of the aforementioned sites.

- **TREES:** Under this study, a total of twenty one tree species belonging to twenty genera and seventeen families were recorded in seventy plots of each 10 m x 10 m size (100 m²) along the Cooum river banks. Of these, four families namely, *Caesalpiniaceae*, *Fabaceae*, *Mimosaceae* and *Moraceae* were represented by two species each, while thirteen families including *Annonaceae*, *Boraginaceae*, *Bignoniaceae*, *Meliaceae* were represented by a

single species each. A total of fourteen native tree species were recorded through quantitative floristic survey.

- **HERBS & CLIMBERS:** Furthermore, a total of thirty four herbs and climber species belonging to thirty genera and sixteen families were recorded in seventy plots of each 1m x 1m (1 m²) along the Cooum river banks. The most dominant species belonging to the family of *Amaranthaceae* (six species) followed by *Asteraceae* (five species) and *Cucurbitaceae* (three species). While nine families including *Apocynaceae*, *Asclepiadaceae* and *Polygonaceae* were represented by a single species each.



Figure 2. *Catharanthus roseus L*



Figure 3. *Coccinia indica L*



Figure 4. *Tamarindus Indica*

1.9.5.2. EXISTING FAUNA

A complete survey of the Cooum River was carried out from the mouth to Paruthipattu. The stretch was divided into four representative locations comprising of different landscapes namely: (1) undisturbed area, (2) developed area, (3) water bodies with riparian cover and (4) sandy area with meagre vegetation for inventory of aquatic organisms along with Mammals, Birds, Reptiles, Amphibians and butterflies etc.

The representative landscape covers the following sites:

1. Chepauk River Mouth,
2. Downstream from Chindadripet Bridge
3. Downstream from Ethiraj College Bridge
4. Downstream from Chetpet Bridge
5. Downstream from Nungambakkam Bridge
6. Downstream from Koyembedu – Anna Nagar Bridge
7. Downstream from Paruthipattu Bridge

This stratified survey fetched no significant quantum of biological diversity starting from microscopic organisms up to mammals in the Cooum River.

- There was no representation of Fish fauna during sampling.

- Diversity of butterflies is significant. The representations from the insect families are four species of butterflies identified as Dainaid egg fly - female (*Hypolimnas misippus*), Plain tiger, Common migrant or Lemon Emigrant – (*Catopsilia pomona*) and *Phalantaphalantha* - common Leopard were recorded.
- One species of snail was also reported along the Cooum River.
- Other insects namely Jewel beetle, Damsel fly, dragonfly and spiders were observed.
- Birds like Pond Heron, Egret and Kingfisher were seen on both sides of the river banks. Among these birds more quantities of Egret and Pond Heron were observed.
- In case of mammals, domestic animals like cows and goats were browsing the vegetation present on the banks.
- When compare to plankton diversity other organisms normally expected to inhabit any water body, were found in low numbers in the river Cooum.



Figure 5. Image of a Plain Tiger



Figure 6. Image of a Egret

I.10. BRIEF OF SECTOR WISE PROPOSED SOLUTIONS

After assessing the current status of the river, several solutions have been designed within the Cooum River Eco-restoration Plan. The solutions are divided into different fields, namely: Sewage & Sanitation, Solid waste management, Inundation Plan, Social Assessment and Riverfront Development.

I.10.1. SEWAGE & SANITATION

The project has differentiated the Sanitation proposals inside and outside the city.

Within Chennai Corporation, CMWSSB²³ must continue with the enlargement and rehabilitation of the existing network and finalization of the UGSS²⁴ in the newly added areas to Chennai. Sewage outfalls will be plugged through interventions comprising: 16 km of interception and diversion pipelines, new pumping stations to divert the raw sewage to the existing network, and 6 modular sewage treatment plants in those places where the existing network has not enough capacity to handle the excess flow.

Outside Chennai Corporation the implementation of the sewerage network must be launched, but as this is a long process, as a complementary solution 1 modular Sewage Treatment Plant will be located.

The poor quality of the water found in the river has been confirmed in a number of ways: in field visits done by experts team, through surveys where soil and water samples were taken and analysed, checking several earlier studies and bibliography, as well as the numerous water sample analysis historically made by TNPCB²⁵. All the studies come to the conclusion that the high levels of oxygen demanding material, along with the low dissolved oxygen values nearing zero and the substantial presence of faecal coliforms effectively transform the Cooum into an open sewer that can support no life.

As it is concluded in the Water Quality analysis model, due to the low flow running nature of the river during most of the year, all the raw sewage outfalls letting into the Cooum must be plugged. Otherwise, the challenge of having a healthy and lively water body will not be fulfilled. This is important not only for the health of all the inhabitants of the city, but also for the benefits that a clean and integrated river can offer to the whole city.

In order to find out the current state of the sewerage system in the basin, the expert team held numerous meetings with the involved stakeholders such as CMWSSB, and collected all the available information regarding the current network as well as the details of on-going projects, plans and works.

From the analysis of the current and the projected state, a complex mixture of problems was noted. These problems include highly populated areas without proper sewerage system, e.g. Ambattur, Avadi or Thiruverkadu; severe treatment capacity shortfall in the operating systems; saturation of the existing infrastructure, consisting of lots of undersized or blocked drains

²³ CMWSSB: Chennai Metropolitan Water Supply and Sewerage Board

²⁴ UGSS: Under Ground Sewage System

²⁵ TNPCB: Tamil Nadu Pollution Control Board

overflowing directly to the waterways or storm water drains, or sewage pumping stations that are not working properly and letting out daily raw sewage into the river system.

In addition to the aforementioned problems, thousands of sewage pipes are illegally connected to the storm water drains, creating a new issue of untreated sewage directly reaching the waterways.

Finally, all these problems could be mitigated enforcing the adequate by-laws and regulations which should enforce discipline and socially responsible behaviour.

I.10.1.1. COLLECTION SYSTEM

The complete enlargement and reinforcement of the network will require long time whereas the task to avoid all the outfalls must be done as soon as possible. Thus, interception and diversion systems have been designed, to convey the outfalls to the current sewers and STPs reducing the pollution until the raw sewage that reaches the Cooum is completely eliminated. The designed solutions include 16 km of pipelines with diameters ranging from 300 to 1500 mm. These mains will end in sewage pumping stations, with storm water tanks to store the first flush water. The pumping stations will divert the sewage to the existing network. Where the current network cannot handle the diverted flow, interception mains will convey the flow directly to a modular STP²⁶ set on the river bank. Besides, weirs for the excess runoff flow and storm water tanks will be installed since the proposed interceptor is a combined sewer.

I.10.1.2. TREATMENT FACILITIES

As stated earlier, in those areas where the existing network does not have enough capacity to handle the additional flow, in situ treatment is proposed. For this purpose six treatment plants are proposed. Each of the plants requires a different treatment capacity, depending on the outfalls collected.

The selected modular STP's²⁷ treatment is based on Moving Bed Bio Reaction principle and includes tertiary treatment that allows reusing the treated water. Modules of 0.2 MLD²⁸, 0.3 MLD and 0.40 MLD are available. The system is prebuilt, pre-piped and skid mounted. The modules are very easy to set up, transportation is done by road and installation in situ.

²⁶ STP: Sewage Treatment Plant

²⁷ STP: Sewage Treatment Plant

²⁸ MLD: Millions Litres per Day



Picture 4. STP built with modules

To meet the required treatment capacity different combinations of modules are used. In the following table a summary of the approved proposals is enclosed.

S. No.	Action ID	Proposed location	Treatment Cap required in MLD	installed Cap. In MLD	Used modules
1	SWL7&8	Left bank, downstream Munnore bridge, Chetpet	0.901	1.00	2x0.3+1x0.4MLD
2	SWR8	Right bank, downstream Nungambakkam MRTS bridge	1.167	1.20	3x0.40MLD
3	STP-Out-3	Upstream Chennai Bypass road, between Poonamallee HR & cemetery	0.6	0.60	2x0.3 MLD
4	SWL4&3	Inside Langs Garden SPS premises	1.550	10.00	25x0.40 MLD
	SWL5		0.523		
5	SWR4&5	Right bank, behind Mount Road Dhargas Bus stop in Dams road	1.085	1.20	3X0.40 MLD
6	SWL11	Left bank, upstream of Metha Nagar bridge	0.537	0.60	2x0.3 MLD

Table 15. STP proposed

I.10.2. SOLID WASTE MANAGEMENT

This study proposes cleaning-up all the areas along the riverbanks consisting of a total of 62,319 cum of solid waste and construction debris within Chennai Corporation and 7,800 cum outside city. Furthermore, the river will be fenced to avoid new solid waste dumping along the riverbanks

The solid waste Management Plan analysed the existing situation found at the Banks of the Cooum, as well as the whole river basin to understand the dumping of municipal solid waste (MSW) along its banks, as well as for the garbage found along the roadways. The first-hand visits by the team of experts confirmed this problem and revealed that large amounts of solid waste ended up being dumped along the river banks, as well as along many roadways. This serious situation presents numerous problems, which includes stink and hazardous gases that are released during the decomposing of the waste, as well as providing breeding grounds for

disease carrying pests and vectors. In order to reduce these problems, and improve the environment within the Cooum river basin, the current legislature, as well as the programme planned for its proper management have been analysed and reviewed.

Literature reviews of publications mentioning the problems related to Solid Waste Management, as well as the measures undertaken to provide solutions have been studied. Similarly, by carrying out meetings with stakeholders and officials from agencies such as the Corporation of Chennai (CoC), Tamil Nadu Pollution Control Board (TNPCB) and the Municipalities within the Cooum River Basin, information regarding the generation, treatment and disposal methods, as well as the pertaining procedures in place were obtained, in addition to the major concerns expressed by the officials.

Through this process, it is revealed that the key factors in reducing the amount of MSW²⁹ disposed are: lack of proper facilities capable of handling the solid waste generated, inappropriate handling of the solid waste generated, the inefficiency in enforcing the law pertaining to littering and the dumping of solid waste.

These include open dumping disposal methods laid by Corporation of Chennai Solid Waste Management, illegal dumping of MSW along the river and other open areas by private businesses and individuals, lack of appropriate recycling process and facilities and inability of law enforcing agencies to prevent and penalize those responsible for littering. It is important to point out that due to the lack of enforcement, approximately 62,319 cum of Solid Waste and Construction Debris is to be collected from the Cooum river bank within Chennai city limits, and other 7,729 cum in the stretch up to Paruthipattu.

This Study proposes the clean-up of all the areas along the river where indiscriminate dumping of SW³⁰ and Construction Debris has occurred, and introducing a layer of soil in those areas to provide a healthy ground for the growth of green areas. Similarly, as preventive measure for further dumping, these areas will be fenced as per the specifications given in the Riverfront Development section. Furthermore, in order to provide disposal facilities for those who disposed their waste along the riverbanks, waste disposal bins will be installed near the areas exposed to Waste dumping.

The existing Solid Waste, non-reusable Construction Debris and Silt extracted from the riverbed will be diverted to the COC³¹ Disposal Facilities, for what falls within the limits of the

²⁹MSW: Municipal Solid Waste

³⁰ SW: Solid Waste

³¹ COC: Corporation of Chennai

Corporation of Chennai Administration, and which falls in other municipalities, such as Thiruverkadu, will need to be dealt by the corresponding Local Body.

Besides collecting the waste, it is proposed to provide solid waste management facilities such as dumpsters, dustbins and a long fence all along the river, in order to prevent future waste disposal that could pollute the river.

I.10.2.1. SILT FROM THE RIVERBED

The Cooum River Eco-Restoration Plan proposes the desiltation of the riverbed to improve the flood carrying capacity of the river. Such works will be implemented by PWD³² and the excavated volume is 8,27,715 cum.

The main concern was to provide usage to part of the silt extracted from the Riverbed. The toxicity test conducted indicated that the parameters measured are within the permissible limit, therefore no remediation works were required for the reuse or disposal of the material.

With regards to the potential use of the extracted material, the team was keen on finding use to the silt within the Riverine system, in order to reduce potential cost derived from its transportation to other locations. A portion of the amount of Silt extracted is reused along the river as per sections. Further plans for the use of the material in other locations nearby proved fruitless, as issues such as leveling of low laying areas is executed using other materials such as construction Debris. As such, it was established that the remaining silt needs to be transported to the corresponding dumping facilities, where if the facility has capacity, the material can be piled until a use can be found for it.

I.10.2.2. BOOM SYSTEM

In order to collect the floating elements on the river surface, it is proposed to install boom systems in 10 points along the river, within Chennai Corporation area.

I.10.3. INUNDATION PLAN

The proposals to improve the flooding have been divided into three stretches:

- From Paruthippatu to Virugambakkam. Regularization of the riverbed's slope and creation of a 3 m wide baby canal. The main function of the baby canal is to convey water during low flow season and avoid the stagnation of water.
- From Virugambakkam to Aminjikai. Regularization of the riverbed's slope and creation of a 8 m wide baby canal.
- From Aminjikai to mouth (zone of tidal influence). Regularization and deepening of the riverbed.

³² PWD: Public Works Department

The volume to be excavated to increase the hydraulic section of the river and to build the baby canal is around 827,715 m³.

To achieve a comprehensive approach to flood control issues along the Cooum River, some hydrologic and hydraulic models were developed to update flood plain maps throughout the basin, and to help identify and prioritize the most beneficial capital projects to address flooding issues.

Due to the hydrological characteristics and the lack of space within the Cooum River peri-urban and urban basin, flood protecting measures such as flood ways or retarding basins have been discarded and only river channel improvement solutions have been adopted. Nevertheless, advices concerning projects in the upper part of the river have been incorporated. Those solutions consist of:

- From Paruthippattu to Virugambakkam. Regularization of the riverbed's slope and creation of a 3 m wide baby canal. The main function of the baby canal is to convey water during low flow season and avoid stagnation along the river.
- From Virugambakkam to Aminjikari. Regularization of the riverbed's slope and creation of 8 m wide baby canal.
- From Aminjikari to mouth (zone of tidal influence). Regularization and deepening of the riverbed

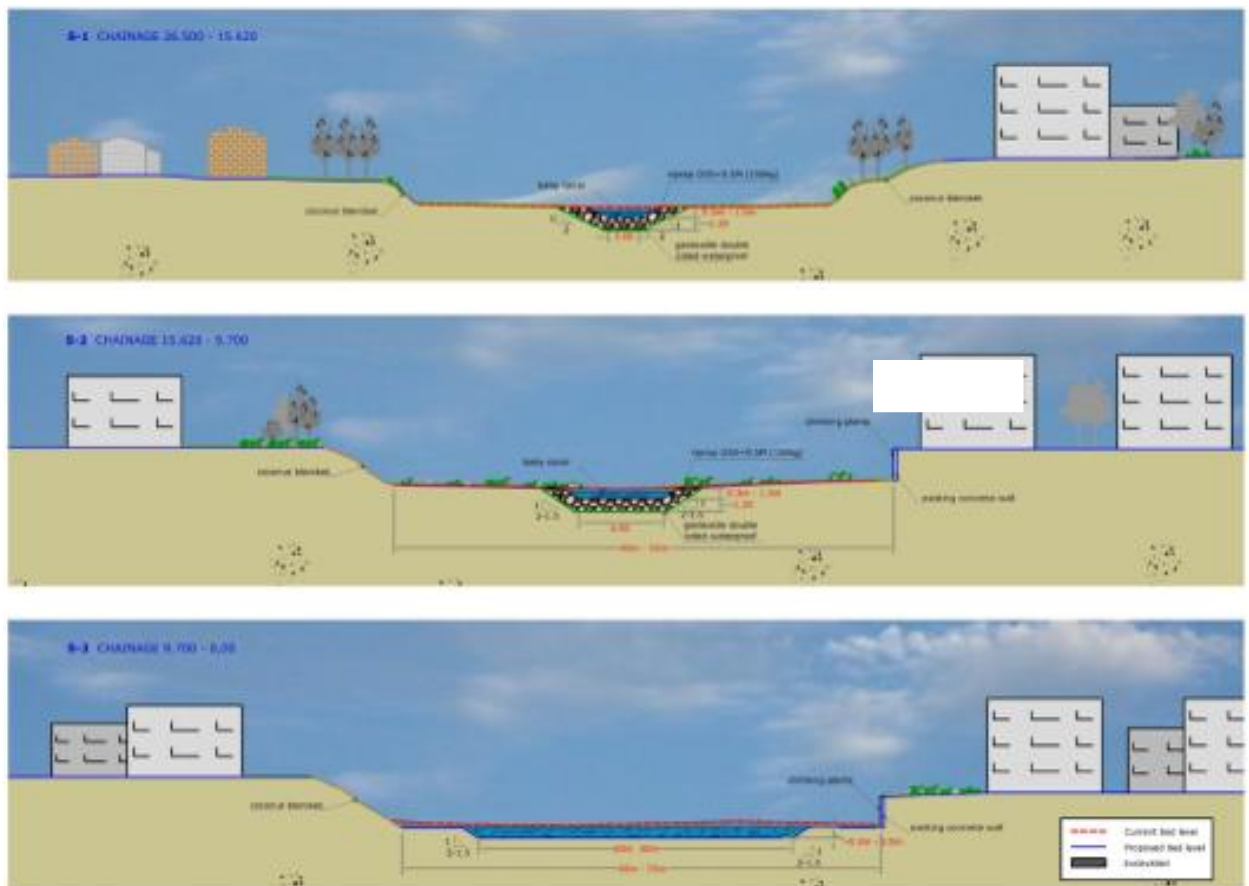


Figure 7. Sketches of the solution for improving flood carrying capacity

The following table shows a comparison of the current and future water levels after implementing the solutions.

Bridge Name	Location chainage	Q Total (m ³ /s)	100 year RP - Maximum Flood Level (m)				Improvement (m)	
			Current		Proposed		High Tide	Low Tide
			High Tide	Low Tide	High Tide	Low Tide		
Bypass Road	19700	480	11.88	11.88	11.73	11.73	0.15	0.15
Aminjikarai Bridge	11470	485	8.03	8.02	7.05	7.04	0.98	0.98
C & C Bridge	5490	485	6.18	6.17	4.47	4.43	1.71	1.74
Periyar Bridge	1600	640	2.64	2.6	2.3	2.16	0.34	0.44
Napier Bridge	470	640	1.92	1.79	1.64	0.93	0.28	0.86

Table 16. Current and future hydraulic capacity comparison.

The total volume to be excavated to increase the hydraulic section of the river and to build the baby canal with riprap revetment is around 827,715 m³. The material will be disposed in the municipal dumpsites. The total volume has been obtained using the cross-section method with detailed measurements every 50 m.

I.10.3.1. MAJOR DRAINS

From the major drains located within the city limits, Virugambakkan - Arumbakkam and the Oterri Canal, tributary of the North Buckingham canal, they currently have insufficient hydraulic capacity for routing flood events. PWD has initiated works to improve the flood carrying capacity of those drains. Works consist of raising the concrete walls of the canals, cleaning the beds, and making deviations.

It is important to state that those works for improving the flood carrying capacity of the drains must be accompanied with the interception of sewage outfalls flowing into these drains. Similarly, this Master Plan is also defining the interception of the sewage outfalls flowing directly to the Cooum River.

No	Drains flowing into Cooum	Location	Length (km)	Pollution abatement proposal
1	North Buckingham Canal	Central Railway Station	17.1 in CMA limit	Confluence treatment not possible due to tidal influence
2	Central Buckingham Canal	Near Napier Bridge - behind Madras University	7.2 in CMA limit	Confluence treatment not possible due to tidal influence
3	Nungambakkam Canal	Opp. To Police quarters / Asan Mem. Hr. School - Greams Road - behind Sewage Pumping Station	1.5	Confluence treatment not possible due to tidal influence
4	Virugambakkam - Arumbakkam Drain	Nelson Manickam Road - Near Shoban Babu Statue - below the bridge	6.9	Diversion and treatment in modular STP proposed
5	Padi Kuppam Canal	Behind Vee care Hospital - Anna Nagar	2.2	Not required, CMWSSB schemes ongoing

6	Mogappair Drain (Nolambur Canal)	Beside MGR University (Thaimoogambikai Dental College & hospital) - Near Nerkundram Bridge	2.4	Not required, CMWSSB schemes ongoing
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Table 17. Drains flowing into Cooum

I.10.3.2. MINOR DRAINS

As for the major drains, PWD and CoC have prepared DPRs for the improvement of minor drains connecting to major drains or Cooum River itself.

Works consist of improvement of current drains, construction of new drains, reconstruction of drains and desilting.

I.10.3.3. COASTAL MANAGEMENT

The mouth of the Cooum river gets clogged due to the periodical sand bar formation which restricts the river draining into the sea and reduces the tidal influence in the river. This leads to water stagnation at the river mouth.

As per NIOT study report around 1,75,000 m³ of sea sand is deposited annually in Cooum mouth. In the same report it suggested to enlarge the existing north and south groynes. PWD has undertaken part of these works, but formation of sand bar still persists.

To overcome this issue and for the effective functioning of the river mouth, Cooum river mouth needs to be regularly desilted by the respective department.

I.10.4. SOCIAL ASSESSMENT

Identification of the slum areas, the ROW³³ line, encroachments and floodplains was done all along the studied stretch of the Cooum River. The study inferred that 14,257 families will be affected by this project.

Different options of relocation were studied under the social assessment section, such as in situ development or in situ re-construction.

The resettlement option was studied in the areas identified by TNSCB, that is, Perumbakkam and Okkiyam-Thoraipakkam. This third option was the one approved by TNSCB.

The social assessment has been developed according to the existing social key policies in central, state and local level. The main objective of these policies consists in improving the quality of life of those living in informal settlements.

³³ ROW: Right of Way

Taking into consideration the existing social policies and the environmental and social framework, the social assessment provides a balance between the proposed solutions and the potential social impacts. This phase analyses several alternatives for minimizing the social impacts, identifies the potential impacts such as PAFs³⁴, affected lands, existing current regulations and finally presents the Resettlement Action Plan options taking into account policy provisions and entitlements available in the National R&R³⁵ Policy 2007/ RTFCTLARR Act 2013³⁶ entitlement matrix.



Figure 8. Riverfront improvement proposal in Bharathipuram area near Anna Nagar bridge

Every slum has been analysed with regard to flooding risk, affection and encroachment on the Right of Way Line and compatibility with a new river front development, through site visits and multi criteria integral analysis. From the above analysis it is concluded that some land currently encroached may be reclaimed to develop the riverfront, always with a proper resettlement of the affected people.

Options have been studied as per Indian policies. The **first option** is aimed at finding areas where in-situ development (ISD) is possible, that is, areas where there is no flooding risk and there is compatibility with the creation of a river front. In situ development actions are focused on providing basic facilities. It is inferred that this can affect the ROW line.

As a **second option**, the report explores in situ re-construction (ISR) to create new residential areas through urban renewal. In order to assess in situ re-construction possibilities, 20 vacant areas were identified and surveyed for Ownership details with Revenue department. The problem involved for its development includes the requirement of an amendment to the Coastal Regulation Zone notification, since CRZ³⁷ does not allow the construction of new buildings, affecting the areas identified up to Chetpet. For other zones the available land is as

³⁴ PAF: Project Affected Family

³⁵ R&R: Resettlement and Rehabilitation

³⁶ ESF: Environment and Social Framework

³⁷ CRZ: Coastal Regulation Zone

per the CMDA³⁸ land use for open space and recreational use only, forbidding the construction of new houses.

Finally, and as **third option** the resettlement (RST) is studied, where the families will be relocated in TNSCB houses.

As a summary, the following numbers give the Project Affected Families in each option.

SUMMARY	%	PAFS
Option 1: Partial RST+ISD	87%	12,459
Option 2: Partial RST+ISD+ISR	47%	6,681
Option 3: Complete RST**	100%	14,257

RST: Resettlement
 ISD: In situ Development
 ISR: In situ Reconstruction

**** option approved by TNSCB**

Table 18. PAF in studied options

The exploration of different options of relocation has been developed within the scope of this project as stated in the Terms of Reference. All the 3 options were presented to the TNSCB in several meetings and as an immediate remedy for the affected people, only option 3 is possible as the tenements are built and ready for occupation.

It has been estimated a total resettlement cost of **Rs 1087.63 Crores**.

I.10.5. RIVER FRONT DEVELOPMENT

Based on the profile of the river and the adjoining land uses, the proposals have been designed to maintain the connectivity as well as enriching the river's natural charm. The proposals consist of more than 9.6 kms of maintenance ways, 24 km of walkways, 19 km of cycle tracks and more than 6,63,788 sq.mt in 24 parks. Within these areas there will be recreational spaces, children playgrounds and food courts.

Landscape and river bank restoration plan should be the last step in the Cooum River eco-restoration process. No river front development or improvement would make sense before improving the water quality and flooding risk related problems.

Landscape and restoration plan has analysed the current land uses in Chennai city and its metropolitan area all along the Cooum river banks and has also analysed the proposed land

³⁸ CMDA: Chennai Metropolitan Development Authority

uses as per **CMDA**³⁹ masterplan to identify the continuous open spaces and recreational areas along the river from the mouth to Paruthipattu Anicut.

Encroachments on the Right of Way line and Coast Regulation Zone have also been analysed together with the data provided by CMDA, PWD⁴⁰ and TNSCB⁴¹. After a number of site visits and a multi criteria analysis, four different categories have been set on the river banks, trying to identify similarities along the 32 km of the river. These categories depend on the action to be developed and they are river front development, river front improvement, urban renewal & urban regeneration.



Figure 9. Park development proposal near Choolaimedu bridge

According to the aforementioned analysis, the whole riverfront area has been redefined as a system, on a holistic analysis, as regards hydraulics, urban and environmental issues. All along the riverbanks, a new landscape has been defined and redesigned, preserved or improved, defining several parks, walkways and cycle tracks. This way, twenty four new parks have been located and designed along the river banks with twenty two new walkways connecting the parks.

Under the riverfront activities certain developments have been proposed. Based on the profile of the river and adjoining land uses, the proposals are integrated so that it maintains the throughout connectivity and also enriches the river natural charm. The summary of the proposals under riverfront are given below.

³⁹CMDA: Chennai Metropolitan Development Authority

⁴⁰ PWD: Public Works Department

⁴¹TNSCB: Tamil Nadu Slum Clearance Board

S.NO	CATEGORY	QUANTITY	LENGTH (in KM)	AREA (sq.mt)
1.	MAINTENANCE WAYS	11	9.6	
2.	WALKWAYS	22	24.02	
3.	CYCLETRACKS	17	19.26	
4.	PARKS	24		6,63,788

Table 19. Summary of riverfront proposals

Main characteristics of the proposed development are as follows: Walkways and maintenance ways (walkways for maintenance), parks and cycle tracks.

The river front system is completed with a 19 km long cycle track that will provide a new infrastructure for non-motorised mobility along the Cooum river banks.



Figure 10. Walkway development proposal near Munroe bridge

Proposals are completed with almost fifty areas of river bank vegetation improvement. Parks, walkways, maintenance ways and cycle tracks to be developed. River banks where river vegetation is improved and conserved will be fenced in order to avoid new encroachment and solid waste dumping.



Figure 11. Riverfront regeneration through Mangroves development on Island Grounds

I.10.6. BIODIVERSITY

Plantation of different species along the riverbanks is included within the project. The plantation area comprises 24.5 kilometers on both sides of the Cooum River. The width of the plantation ranges from 2m to a maximum of 18 m.

Under the tidal influence, mangrove associates (*Thespesia Populnea*, *Pongamia Pinnata*, *Terminalia Arjuna*, and others) and terrestrial tree species (*Melia Azedarach*, *Lannea Coromandelica*, *Morinda Tinctoria* and others) will be planted. From Chetpet to Paruthipattu more than 10 different terrestrial tree species will be planted such a *Parkinsonia Aculeata*, *Ficus Benjamina*, *Lawsonia Inermis*, *Phoenix Sylvestris*, etc.

After conducting a flora survey consisting of recording the occurrence and distribution of the plant species on both banks all along the riverbanks, it was observed that despite the polluted state of the river, 21 tree species and 34 herb and climber species were found, out of which 14 tree species are native.

It was also observed that the soils along the banks are highly polluted due to anthropogenic activities. Therefore it is not recommended to grow vegetable/medicinal plants along the banks, since the contaminants could be accumulated in the plants. Replacement of the existing soil for a fertile soil would be too expensive; therefore it is concluded to cultivate only timber yielding plants of commercial value.

The plantation area comprises 24,576 running metres on both sides of the Cooum River. The width of the plantation ranges from 2m to a maximum of 18 m differentiating two plantation strategies: strip plantations, consisting of a plantation of 2-5m at the edge of the riverbank; and major plantations, consisting of wider areas where vegetation can be planted up to a width of 18 metres.

The following species will be planted up to Chetpet, where the riverbanks are under the tidal influence.

Mangrove Associates	Terrestrial Tree Species
<i>Thespesia Populnea</i>	<i>Melia Azedarach</i>
<i>Pongamia Pinnata</i>	<i>Lannea Coromandelica</i>
<i>Terminalia Arjuna</i>	<i>Morinda Tinctoria</i>
<i>Barringtonia Acutangula</i>	<i>Bauhinia Variegata</i>
<i>Hibiscus Tiliaceus</i>	

Table 20. Plant species up to Chetpet

From Chetpet to Paruthipattu, the following terrestrial species are proposed:

Terrestrial Tree Species	
<i>Melia Azedarach</i>	<i>Ficus Benjamina</i>
<i>Lannea Coromandelica</i>	<i>Lawsonia Inermis</i>

<i>Morinda Tinctoria</i>	<i>Phoenix sylvestris</i>
<i>Bauhinia Variegata</i>	<i>Terminalia arjuna</i>
<i>Parkinsonia aculeata</i>	

Table 21. Plant species from Chetpet to Paruthipattu

In addition, a specific Mangrove Development Plan has been created for the mouth of the Cooum River and surrounding the Island Grounds due to the favourable environmental characteristics of these areas. Mangroves act as flood buffers, and as a bio-barrier against storms and high tides, saving the coast. They are specially adapted to withstand salinity, wave action and can grow in poor soils, preventing ground water pollution. They have the ability to slowly restore the quality of soil by reducing the lethal impacts on it.

I.10.7. STAKE HOLDERS AND PUBLIC PARTICIPATION

As the study is intended to be undertaken in a participatory manner, an operational working group has been assigned by CRRT⁴², in which, representatives from the main agencies involved (CMWSSB⁴³, PWD⁴⁴, CRRT, CoC⁴⁵, CMA⁴⁶, CMDA⁴⁷, TNPCB⁴⁸, TNSCB⁴⁹) as well as civil society representatives has participated.

I.10.8. PHASING PLAN

After having many meetings with the line departments, a phasing plan was prepared. The plan approved includes 60 subprojects in the short term, 7 in the medium term and 2 in the long term. The description of the subprojects is given in the following table:

SHORT TERM PLAN PROPOSALS

I	PUBLIC WORK DEPARTMENT	
1	CO-PWD-2014-STP-01	Dredging the Cooum River from River mouth to upstream side of napier Bridge Chainage 0-700m
	CO-PWD-2014-STP-01A	Desilting (167898 cum)
	CO-PWD-2014-STP-01B	Coveying the excavated silt to disposal point
2	CO-PWD-2014-STP-02	Improvement to North Arm of Cooum River From Hutton Bridge to Napier Bridge (Chainage 0-2040)
	CO-PWD-2014-STP-02A	Desilting (40000 cum)
	CO-PWD-2014-STP-02B	Coveying the excavated silt to disposal point
	CO-PWD-2014-STP-02C	Coconut Blanket for 15200m ²
3	CO-PWD-2014-STP-03	Improvement to Cooum River From upstream side of Napier Bridge to Chetpet Bridge (Chainage 700-9677m).

⁴² CRRT: Chennai Rivers Restoration Trust

⁴³ CMWSSB: Chennai Metropolitan Water Supply and Sewerage Board

⁴⁴ PWD: Public Works Department

⁴⁵ COC: Corporation of Chennai

⁴⁶ CMA: Commissionerate of Municipal Administration

⁴⁷ CMDA: Chennai Metropolitan Development Authority

⁴⁸ TNPCB: Tamil Nadu Pollution Control Board

⁴⁹ TNSCB: Tamil Nadu Slum Clearance Board

	CO-PWD-2014-STP-03A	Desilting (377034 cum)
	CO-PWD-2014-STP-03B	Coveying the excavated silt to disposal point
	CO-PWD-2014-STP-03C	Coconut Blanket for 15200m ²
4	CO-PWD-2014-STP-04	Improvements to Cooum River From upstream side of Chetpet Bridge to Padikuppam causeway desilting baby canal formation and other necessary provisions which includes warthwork, Rip Rap, Geotextile covering and providing coconut blanket.(Chainage 9677-15940m)
5	CO-PWD-2014-STP-05	Improvements to Cooum River From upstream side of padikuppam causeway to Vanagaram Bridge including desilting baby canal formation and other necessary provisions which includes warthwork,Rip Rap, Geotextile covering and providing coconut blanket.(Chainage 15940-22337m)
6	CO-PWD-2014-STP-06	Improvements to Cooum River From upstream side of padikuppam causeway to Vanagaram Bridge including desilting baby canal formation and other necessary provisions which includes warthwork,Rip Rap, Geotextile covering and providing coconut blanket.(Chainage 22337-27336)
7	CO-PWD-2014-STP-07	Continuous Dredging of Cooum Mouth
8	CO-PWD-2014-STP-08	Demarcation and fixing Boundary stones at chainage of 0-15940m
9	CO-PWD-2014-STP-09	Biometric Survey From Chainage 0-15940m
II	CHENNAI CORPORATION	
10	CO-COC-2014-STP-01	BoomSystem for a total length of 700 Rm, with Anchorage at ten locations: 1. Napiers Bridge.2.Col.Laws Bridge, 3. C and C Bridge 5. Choolaimedu Bridge 6. Virugambakkam Bridge 7. Naduvakkarai Bridge 8. Thirumarsalam Bridge 9. Golden bdge Bride and 10.Nolambur Bridge
11	CO-COC-2014-STP-02	Solid Waste Removal in the River bank
12	CO-COC-2014-STP-03	Boundary Fencing along the Cooum River banks for a total length of 23.92Km on either sides
13	CO-COC-2014-STP-04	Developing park at right bank upstream to central bucking canal Napier Bridge - periyar Bridge (Chainage 700 - 1000m)
14	CO-COC-2014-STP-05	Developing park at right bank from C in C road bridge to college road bridge (Chainage 6100-6550m)
15	CO-COC-2014-STP-06	Developing park at right bank from Munroe Bridge to Chetpet railway bridge (Chainage 9100-9450m)
16	CO-COC-2014-STP-07	Developing park at left bank from Maduravoyal Golden George Rathinam salai bridge (Chainage 17050-17450m)
17	CO-COC-2014-STP-08	Constructing Maintenance Walkway at right bank from River mouth to Napier Bridge (chainage 0-400m)
18	CO-COC-2014-STP-09	Constructing Maintenance Walkway at right bank from Napier Bridge to Periyar Bridge (chainage 1000-1600m)
19	CO-COC-2014-STP-10	Consutructing Maintenance walkway at Right Bank from Harris Bridge to C in C road Bridge, Behind EB Office parking lot proposed in two places (Chainage 4600-5500m)
20	CO-COC-2014-STP-11	Consutructing Maintenance walkway at Right Bank from Munroe Bridge to Chetpet railway bridge (Chainage 8300-9100m)
21	CO-COC-2014-STP-12	Nature Trail park at Right bank form college road bridge to Mounroe bridge
III	COMMISSIONER OF MUNICIPAL ADMINISTRATION	
22	CO-CMA-2014-STP-01	Solid Waste Removal in the river banks
23	CO-CMA-2014-STP-02	Fencing over both sides of river banks for 10.80km
24	CO-CMA-2014-STP-03	Providing Childern's parks and play Fields at the bund of Cooum river at Rajankuppam
25	CO-CMA-2014-STP-04	Providing Childern's parks and play Fields at the bund of Cooum river at Kaduvetti

26	CO-CMA-2014-STP-05	Providing Children's parks and play Fields at the bund of Cooum river at sundarasolapuram
IV	DIRECTOR OF RURAL DEVELOPMENT	
27	CO-DRD-2014-STP-01	Solid Waste Removal from left River bank in Adayalapattu (Chainage 19600-21100m)
28	CO-DRD-2014-STP-02	Solid Waste Removal from Right River bank in Seneerkuppam (Chainage 24000-25080m)
29	CO-DRD-2014-STP-03	Solid Waste Removal from Right River bank in Vanagaram (Chainage 20100-20500m)
30	CO-DRD-2014-STP-04	Fence at Adyalampattu (Chainage 19600-21100m)
31	CO-DRD-2014-STP-05	Fence at Seneerkuppam (Chainage 24100-25100m)
32	CO-DRD-2014-STP-06	Fence at Vanagaram(Chainage 19600-20450m)
33	CO-DRD-2014-STP-07	Vegetation at Vanaagaram (Chainage 19600-20450m)
V	CMWSSB	
34	CO-CMW-2014-STP-01	A Main pipeline that converge into a SPS the swage is pumped to the Napier park SPS. A new pumpset in the Napier park SPS
35	CO-CMW-2014-STP-02	Two Newinterception mains along Spurtank Road will convey the collected sewage from outfalls to an STP
36	CO-CMW-2014-STP-03	Two main pipelines in nungambakkam bank convergence into an STP
37	CO-CMW-2014-STP-04	A interception main collecting the sewage outfalls of metha nagar to pumping station and pumping to a discharge chamber connecting to the main pipeline in the area.
38	CO-CMW-2014-STP-05	New main pipeline connected to the existing SPS
39	CO-CMW-2014-STP-06	Two Main along langas garden road that convey the sewage to a new STP at Langs garden
40	CO-CMW-2014-STP-07	Two New Inteception mains along south cooum road will convey the sewage collected from outfalls to a new STP at langas garden
41	CO-CMW-2014-STP-08	Two mains along Amijikarai river bank and conveyed to bharathipuram pumping station.
42	CO-CMW-2014-STP-09	A main along NSK Nagar area and Conveyed to anna nagar 'B' pumping station and then to Koyambedu STP
43	CO-CMW-2014-STP-10	A main along Anna Nagar bank to a SPS and to Anna Nagar 'B' pumping station and then to Koyambedu STP
44	CO-CMW-2014-STP-11	Modular STP at Left Bank in Chetpet - college Road
45	CO-CMW-2014-STP-12	Modular STP at Right Bank in Choolaimedu railway bridge.
46	CO-CMW-2014-STP-13	Modular STP at Chennai Bye Pass Road between PH Road and Cemetery Road.
47	CO-CMW-2014-STP-14	Modular STP at West Cooum Road and south cooum road to be expanded to 10 MLD capacity at langas garden road with MBBR and UF Technology.
48	CO-CMW-2014-STP-15	UGSS for Nerkundram & Karambakkam (Newly added areas to Chennai corporation)
VI	TAMIL NADU SLUM CLEARANCE BOARD	
49	CO-TNS-2014-STP-01	Shifting allowance at Rs.5000 per person
50	CO-TNS-2014-STP-02	Subsistence allow @Rs.2500/month for 1 year
51	CO-TNS-2014-STP-03	Beneficiary contribution are 10 % of the cost of construction
52	CO-TNS-2014-STP-04	EB Service Connection
53	CO-TNS-2014-STP-05	Community Development programme
54	CO-TNS-2014-STP-06	Impact Assessment study
55	CO-TNS-2014-STP-07	Project Management Group
56	CO-TNS-2014-STP-08	Land cost at auto nagar(300sp ft @ Rs.638 per sq ft for 458 families)
57	CO-TNS-2014-STP-09	Notional cost of construction at Rs. 6.5 Lakhs per family
VII	CHENNAI RIVERS RESTORATION TRUST	

58	CO-CRR-2014-STP-01	Mangrove Development along the river bank
59	CO-CRR-2014-STP-02	Flora -Plantation along the river bank
60	CO-CRR-2014-STP-03	Community Education programme and Monitoring of project implementation and its sustainability

MEDIUM TERM PLAN PROPOSALS

I	CHENNAI CORPORATION	
1	CO-COC-2014-MTP-01	Solid waste removal in the riverbank
2	CO-COC-2014-MTP-02	Development of Parks at 17 different locations
3	CO-COC-2014-MTP-03	Construction of Maintenance Pathway, cycle tracks, lawn, etc. At 23 different locations
II	CMWSSB	
4	CO-CMW-2014-MTP-01	Interception and Diversion at remaining 8 locations
III	CRRT	
5	CO-CRR-2014-MTP-01	Mangrove Development Plan
6	CO-CRR-2014-MTP-02	Flora plantation along the river bank
7	CO-CRR-2014-MTP-03	Community education programme and monitoring of project implementation and its sustainability

LONG TERM PLAN PROPOSALS

I	CHENNAI CORPORATION	
1	CO-COC-2014-LTP-01	Solid waste removal in the riverbank
II	CRRT	
5	CO-CRR-2014-LTP-01	Flora plantation along the river bank

I.10.9. CLEARANCES

The Clearances required for the implementation of project are as follows:

- **CoC:** Permission for **disposal in landfill** of the silt material. Expected time: 1 month. Expected cost: 4.72 Rs/MT (private sector cost for disposal).
- **TNPCB:** Permission for letting the treated water of the modular STP into the river. Expected time: 3 months maximum. Expected cost: 3,000 Rs.
- **MoEF: Coastal Regulation Zone** affects the River front development works, construction of path ways & cycle tracks, installation of STP's. The CRZ⁵⁰ will affect all interventions up to the chainage 9,700, as shown in the following table. Expected time: 1 year.

Table 22. Subprojects under the Coastal Regulation Zone

S.No	Sub-Project Code	Project Description	Chainage
CORPORATION OF CHENNAI			
1	CO-COC-2014-STP-04	Developing park at right bank upstream to central bucking canal Napier Bridge - periyar Bridge (Chainage 700 - 1000m)	0,700 - 1,000

⁵⁰ CRZ: Coastal Regulation Zone

2	CO-COC-2014-STP-05	Developing park at right bank from C in C road bridge to college road bridge (Chainage 6100-6550m)	6,100 - 6,550
3	CO-COC-2014-STP-06	Developing park at right bank from Munroe Bridge to chetpet railway bridge (Chainage 9100-9450m)	9,100 - 9,450
4	CO-COC-2014-STP-08	Constructing Maintenance Walkway at right bank from River mouth to Napier Bridge (chainage 0-400m)	0,000 - 0,400
5	CO-COC-2014-STP-09	Constructing Maintenance Walkway at right bank from Napier Bridge to Periyar Bridge (chainage 1000-1600m)	1,000 - 1,600
6	CO-COC-2014-STP-10	Consutructing Maintenance walkway at Right Bank from harris Bridge to C in C road Bridge, Behind EB Office parking lot proposed in two places (Chainage 4600-5500m)	4,600 - 5,500
7	CO-COC-2014-STP-11	Consutructing Maintenance walkway at Right Bank from Munroe Bridge to Chetpet railway bridge (Chainage 8300-9100m)	8,300 - 9,100
8	CO-COC-2014-STP-12	Nature Trail park at Right bank form college road bridge to Mounroe bridge	6,800 - 8,300
CMWSSB			
9	CO-CMW-2014-STP-01	A Main pipeline that converge into a SPS the swage is pumped to the Napier park SPS. A new pumpset in the Napier park SPS	1,300-1,600
10	CO-CMW-2014-STP-02	Two Newinterception mains along spurtank road will convey the collected sewage from outfalls to an STP	7,550-8,350
11	CO-CMW-2014-STP-03	Two main pipelines in nungambakkam bank converge into an STP	8,650 - 9,400
12	CO-CMW-2014-STP-06	Two Main along langas garden road that convey the sewage to a new STP at Langs garden	2,500 - 4,200
13	CO-CMW-2014-STP-07	Two New Inteception mains along south cooum road will convey the sewage collected from outfalls to a new STP at langas garden	4,400 - 5,500
14	CO-CMW-2014-STP-11	Modular STP at Left Bank in Chetpet - college Road	8,100
15	CO-CMW-2014-STP-12	Modular STP at Right Bank in Choolaimedu railway bridge.	9,100
PWD			
1	CO-PWD-2014-STP-01	Dredging the Cooum River from River mouth to upstream side of napier Bridge Chainage 0-700m	0-700
	CO-PWD-2014-STP-01 A	Desilting (167898 cum)	
	CO-PWD-2014-STP-01 B	Coveying the excavated silt to disposal point	
2	CO-PWD-2014-STP-02	Improvement to North Arm of Cooum River From Hutton Bridge to Napier Bridge (Chainage 0-2040)	0 - 2,040 Northern Arm
	CO-PWD-2014-STP-02A	Desilting (40000 cum)	
	CO-PWD-2014-STP-02B	Coveying the excavated silt to disposal point	
	CO-PWD-2014-STP-02C	Coconut Blanket for 15200m ²	
3	CO-PWD-2014-STP-03	Improvement to Cooum River From upstream side of Napier Bridge to Chetpet Bridge (Chainage 700-9677m).	700 - 9,677
	CO-PWD-2014-STP-03A	Desilting (377034 cum)	
	CO-PWD-2014-STP-03B	Coveying the excavated silt to disposal point	
	CO-PWD-2014-STP-03C	Coconut Blanket for 15200m ²	

I.11. SUMMARY OF THE COST

The cost of the works and maintenance proposed in this report has been calculated according to the current Schedule of Rates and market rates. A summary of the estimate is shown in further sections of this Report.

The sub projects will be implemented in different terms:

SHORT TERM: 0-3 years; MEDIUM TERM: 4-12 years; LONG TERM: 13-25 years

(Rs in Crores)

S.No	SUBPROJECT SECTOR	SHORT TERM	MEDIUM TERM	LONG TERM	AMOUNT
1	SANITATION SECTOR	161.18	17.1	-	178.28
2	SOLID WASTE MANAGEMENT	9.68	1.29	2.32	10.65
3	INUNDATION PLAN	81.08	-	-	81.08
4	SOCIAL ASSESSMENT*	1087.63	-	-	1087.63
5	RIVERFRONT DEVELOPMENT	107.57	213.3	-	293.67
6	BIODIVERSITY	6.69	15.5	0.13	21.74
	TOTAL	1,453.83	247.19	2.45	1,703.47
	Contingency 2.5%	63.54	6.18	0.06	69.78
	Supervision Charges 2.5%	90.73	6.18	0.06	96.97
	TOTAL COST	1,608.09	259.55	2.57	1,870.22
	ESCALATION 10%	38.45	25.95	0.26	64.66
	TOTAL PROJECT COST	1,646.54	285.50	2.83	1,934.88

(Rs in Crores)

S.No	DEPARTMENT WISE	SHORT TERM	MEDIUM TERM	LONG TERM	AMOUNT
1	CMWSSB	161.18	17.1	-	178.28
2	COC	87.41	214.59	2.32	10.65
3	PWD	81.08	-	-	81.08
4	TNSCB*	1087.63	-	-	1087.63
5	CRRT	6.11	15.5	0.13	21.74
6	CMA	27.24	-	-	27.24
7	DRD	3.18	-	-	3.18
	TOTAL	1,453.83	247.19	2.45	1,703.47
	Contingency 2.5%	63.54	6.18	0.06	69.78
	Supervision Charges 2.5%	90.73	6.18	0.06	96.97
	TOTAL COST	1,608.09	259.55	2.57	1,870.22
	ESCALATION 10%	38.45	25.95	0.26	64.66
	TOTAL PROJECT COST	1,646.54	285.50	2.83	1,934.88

*Contingencies 5% & Supervision Charges 7.5%

The total cost for the Cooum river restoration Master Plan amounts to **Rs.1,934.88 Crores (Rupees One thousand nine hundred and thirty four Crores)** excluding taxes.

I.12. FINANCIAL ANALYSIS

Different cash flows were estimated for the Project under financial plan. In particular, the costs for construction and maintenance are compared with the benefits expected from the damages avoided and other non-market benefits. This comparison provides an annual net benefit, as well as a cumulative net benefit of the project during the established 25 year period. From this net benefit/cash flow, the Economic Internal Rate of Return is established, which for the works designed for the Eco restoration of the Cooum Project is calculated to be 25.24%. This factor is essential in determining the economic feasibility of any project, even more so when considering public funds for projects involving the enhancement of environmental and social aspects.

I.13. CONCLUSION

Cooum River Eco-restoration Plan brings together the task of streamlining existing structures along with creating new ones. The report provides several solutions to be implemented sector wise.

The water quality will improve with the proposed sanitation solutions and the solid waste removal from the riverbanks. Furthermore, the implementation of the suggested activities such as vegetation plantation, riverfront beautification, creation of parks and walkways will provide the Chennai citizens with areas for leisure in a new ecosystem that will see life rising from the River.

The Master Plan Report gives the authorities a comprehensive roadmap as well as Detailed Project Reports in order to set up the strategy, start the tendering process and implementation of the specific projects.

Besides, the engineering and administrative departments in charge of the river will be able to make sure that not only the works are implemented as planned, but also that they maintain the standards up to the required indicators and parameters defined in the guidelines.

If the implementation arrangements are strictly followed, the objectives and challenges of the project will be fully accomplished and will successfully become a reality.