



National River Conservation Directorate
Ministry of Jal Shakti,
Department of Water Resources,
River Development and Ganga Rejuvenation
Government of India

Management Plan for Industrial Wastewater Cauvery River Basin



June 2026



© cCauvery, cGanga and NRCD, 2026

Management Plan for Industrial Wastewater

Cauvery River Basin



© cCauvery, cGanga and NRCD, 2026

National River Conservation Directorate (NRCD)

The National River Conservation Directorate, functioning under the Department of Water Resources, River Development and Ganga Rejuvenation, and the Ministry of Jal Shakti, provides financial assistance to the State Government for conservation of rivers under the Centrally Sponsored Schemes of 'National River Conservation Plan (NRCP)'. National River Conservation Plan to the State Governments/ local bodies to set up infrastructure for pollution abatement of rivers in identified polluted river stretches based on proposals received from the State Governments/ local bodies.

www.nrcd.nic.in

Centres for Cauvery River Basin Management Studies (cCauvery)

The Centres for Cauvery River Basin Management Studies (cCauvery) is a Brain Trust dedicated to River Science and River Basin Management. Established in 2024 by IISc Bengaluru and NIT Tiruchirappalli, under the supervision of cGanga at IIT Kanpur, the centre serves as a knowledge wing of the National River Conservation Directorate (NRCD). cCauvery is committed to restoring and conserving the Cauvery River and its resources through the collation of information and knowledge, research and development, planning, monitoring, education, advocacy, and stakeholder engagement.

www.ccauvery.org

Centre for Ganga River Basin Management and Studies (cGanga)

cGanga is a think tank formed under the aegis of NMCG, and one of its stated objectives is to make India a world leader in river and water science. The Centre is headquartered at IIT Kanpur and has representation from most of the country's leading science and technology institutes. cGanga's mandate is to serve as a think-tank in the implementation and dynamic evolution of the Ganga River Basin Management Plan (GRBMP) prepared by the Consortium of 7 IITs. In addition, it is responsible for introducing new technologies, innovations, and solutions to India.

www.cganga.org

Acknowledgment

This report is a comprehensive outcome of the project jointly executed by IISc Bengaluru (Lead Institute) and NIT Tiruchirappalli (Fellow Institute) under the mentoring of cGanga at IIT Kanpur. It was submitted to the National River Conservation Directorate (NRCD) in 2024. We gratefully acknowledge the individuals who provided information and photographs for this report.

Team

Praveen C Ramamurthy, cCauvery, IISc Bengaluru
Shekhar M, cCauvery, IISc Bengaluru
Nagesh Kumar Dasika, cCauvery, IISc Bengaluru
Srinivas VV, cCauvery, IISc Bengaluru
Lakshminarayana Rao, cCauvery, IISc Bengaluru
Rajarshi Das Bhowmik, cCauvery, IISc Bengaluru
Bramha Dutt Vishwakarma, cCauvery, IISc Bengaluru
Debsunder Dutta, cCauvery, IISc Bengaluru

S Saravanan, cCauvery, NIT Trichy
R Manjula, cCauvery, NIT Trichy
Nisha Radhakrishnan, cCauvery, NIT Trichy
Aneesh Mathew, cCauvery, NIT Trichy
Laveti Satish, cCauvery, NIT Trichy
Prabu P, cCauvery, NIT Trichy
Vinod Tare, cGanga, IIT Kanpur

Preface

Industrial wastewater is a significant pressure on the Cauvery River Basin because industrial clusters, treatment infrastructure, receiving-water conditions, and regulatory responsibilities span several states and sub-basins. This management plan sets out a basin-oriented framework for pollution prevention, wastewater treatment, reuse, hazardous waste management, monitoring, compliance, and coordinated implementation.

The report identifies priority industrial clusters and describes collective wastewater management approaches, CETP requirements, the conditional role of Zero Liquid Discharge, the management of hazardous residues, continuous monitoring, and policy interventions. It should be read together with the quantified baseline, implementation schedule, financing plan and regulatory compliance matrix introduced in this revision.

Where verified basin-level data are not currently available, the document uses clearly highlighted data requirements rather than inferred values. These fields should be completed using validated inventories from the relevant Pollution Control Boards, industrial development agencies, CETP operators, authorised laboratories, and other competent authorities.

Implementation should follow a risk-based and adaptive approach. Priority should be given to interventions that reduce the largest pollutant loads and exposure risks, protect sensitive river reaches and groundwater, improve treatment reliability, and provide measurable benefits in water reuse and resource recovery.

This plan is intended to support coordinated decisions by regulators, industries, local authorities, infrastructure agencies, research institutions and communities. Progress should be reviewed annually against defined baselines, targets, budgets, responsibilities and independently verifiable performance indicators.

Centres for the Cauvery River Basin
Management Studies (cCauvery)
IISc Bengaluru (Lead Institute), NIT Tiruchirappalli (Fellow Institute)

Contents

Preface	v
List of Figures	xi
List of Tables	xiii
Abbreviations and Acronyms	xv
Executive Summary	1 – 3
1. Introduction	5 – 5
1.1. Objectives	5
2. Industrial Cluster Analysis	6 – 11
2.1. Industrial Clusters and CETP Requirements	6
2.2. Strategy for Collective Waste Management in the CRB	7
2.2.1. Collective Waste Management Strategy	7
2.2.2. Cluster-Based Wastewater Management Framework	8
2.2.3. Industrial Cluster Categorization	10
2.2.3.1. Category I: High-Priority Clusters	10
2.2.3.2. Category II: Moderate-Priority Clusters	10
2.2.3.3. Category III: Emerging Industrial Clusters	10
2.2.4. Integrated Wastewater Collection and Conveyance System	11
2.2.5. CETP Infrastructure	11
3. ZLD Implementation	11 – 19
3.1. Feasibility and Roadmap for ZLD	12
3.1.1. Current Status of ZLD in the CRB	12
3.1.2. Feasibility Assessment Framework	13
3.1.3. Roadmap for ZLD Implementation	14
3.2. Sector-Specific ZLD Guidelines	15
3.3. ZLD Gaps and Strategic Recommendations	17
4. Hazardous Waste Management	20 – 27
4.1. Treatment and Secure Landfill Needs	20
4.1.1. Hazardous Waste Characterization	21

4.1.2. Treatment Infrastructure Requirements	22
4.1.3. Secure Landfill Requirements	23
4.2. Strategy for Toxic Liquid Waste	23
4.2.1. Source Segregation and Waste Minimization	24
4.2.2. Treatment Strategy	24
4.2.3. Toxic Liquid Waste Storage and Transportation	25
4.2.4. Emergency Response and Risk Management	26
4.2.5. Monitoring and Compliance	26
4.2.6. Strategic Recommendations	27
5. Plan for Continuous Monitoring	27 – 32
5.1. Industrial Effluent Monitoring	28
5.2. CETPs and ZLD monitoring	29
5.3. River Water Quality Monitoring	30
5.4. Watershed Development and Soil Conservation	31
6. Policy Interventions	32 – 37
6.1. Regulatory Interventions	33
6.2. Economic and Financial Interventions	33
6.3. Institutional and Governance Interventions	34
6.4. Technology and Innovation Policies	34
6.5. Wastewater Reuse and Circular Economy Policies	34
6.6. Compliance and Enforcement Policies	35
6.7. Research, Capacity Building and Public Participation	36
6.8. Expected Outcomes	36
7. Summary	37 – 37
8. Recommendations and Role of Stakeholders	37– 37
9. Significance of the Report	40 – 40
10. Implementation Framework and Data Requirements	40 – 65
10.1. Scope, Method and Limitations	40
10.2. Cluster Baseline and Gap Assessment	41
10.3. Risk-Based Prioritisation	46

10.4. Time-Bound Implementation Programme	50
10.5. Financing and Cost Recovery	52
10.6. Monitoring, Data Quality and Enforcement	54
10.7. ZLD and Water-Reuse Decision Protocol	56
10.8. Climate, Emergency and Social Safeguards	57
10.9. Governance, Review and Change Control	58
10.10. Regulatory Compliance Matrix	59
10.11. Source and Evidence Quality Requirements	63
References	64 – 65

List of Figures

Fig. 1.	Primary objectives of the continuous monitoring program	28
Fig. 2.	Major objectives of the proposed policy interventions for industrial wastewater management in the CRB	33

List of Tables

Table E1. Baseline status and data requirements for industrial wastewater management in the CRB	1
Table 1. Major industrial clusters and typical wastewater characteristics in the	6
Table 2. Priority industrial clusters for industrial wastewater management in the	9
Table 3. Sector-specific ZLD guidelines for major industries in the CRB	16
Table 4. Key challenges and strategic recommendations for ZLD implementation in the CRB	18
Table 5. Major industrial clusters and typical hazardous waste streams in the CRB	21
Table 6. Major categories of hazardous waste generated in the CRB	21
Table 7. Recommended treatment strategies for major toxic liquid waste streams	24
Table 8. Recommended monitoring parameters for industrial effluent compliance	28
Table 9. Key performance indicators for CETPs and ZLD facilities	29
Table 10. Recommended monitoring frequency for key performance indicators	30
Table 11. Priority river stretches for water quality monitoring in the CRB	31
Table 12. Components of a groundwater quality monitoring programme	32
Table 13. Roles and responsibilities of key stakeholders in industrial wastewater management in the CRB	38
Table 14. Cluster-level baseline and treatment gap assessment for priority industrial clusters in the CRB	42
Table 15. Criteria and weighting framework for industrial cluster risk	48
Table 16. Time-bound implementation programme for industrial wastewater management in the CRB	51
Table 17. Indicative financing and cost-recovery framework for industrial wastewater management	53
Table 18. KPIs and verification framework for industrial wastewater management	55
Table 19. Governance, review and change-control framework for industrial wastewater management	58
Table 20. Regulatory compliance matrix for industrial wastewater management	60

Abbreviations and Acronyms

AI	Artificial Intelligence
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
BOD	Biochemical Oxygen Demand
CAPEX	Capital Expenditure
CEPI	Comprehensive Environmental Pollution Index
CETP	Common Effluent Treatment Plant
CGWB	Central Ground Water Board
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CRB	Cauvery River Basin
CWC	Central Water Commission
CWMA	Cauvery Water Management Authority
CWRCCauvery	Water Regulation Committee
DPR	Detailed Project Report
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
ETP	Effluent Treatment Plant
GIS	Geographic Information System
GPS	Global Positioning System
GRBMP	Ganga River Basin Management Plan
IIT	Indian Institute of Technology
IISc	Indian Institute of Science
IoT	Internet of Things
KIADB	Karnataka Industrial Areas Development Board
KINFRA	Kerala Industrial Infrastructure Development Corporation
KPI	Key Performance Indicator
KSPCB	Karnataka State Pollution Control Board
MLD	Million Litres per Day
MoT	Ministry of Textiles
MSMEs	Micro, Small, and Medium Enterprises
NABL	National Accreditation Board for Testing and Calibration Laboratories
NIT	National Institute of Technology

NMCG	National Mission for Clean Ganga
NPC	National Productivity Council
NRCD	National River Conservation Directorate
NRCP	National River Conservation Plan
O&M	Operation and Maintenance
OCEMS	Online Continuous Effluent Monitoring System
OPEX	Operating Expenditure
PCC	Pollution Control Committee
PIB	Press Information Bureau
QA/QC	Quality Assurance/Quality Control
RO	Reverse Osmosis
SIPCOT	State Industries Promotion Corporation of Tamil Nadu
SPCB	State Pollution Control Board
TDS	Total Dissolved Solids
TNPCB	Tamil Nadu Pollution Control Board
TSDF	Treatment, Storage and Disposal Facility
TSS	Total Suspended Solids
ZLD	Zero Liquid Discharge

Executive Summary

Purpose and decision context

This management plan provides a basin-wide framework for reducing industrial pollutant loads, improving treatment reliability, increasing safe water reuse, managing hazardous residues and strengthening regulatory accountability across the Cauvery River Basin (CRB). It is a technical and management-planning document; it does not create or modify statutory discharge standards, interstate water allocations, water rights, or the legal powers of any State or Central authority. The current baseline assessment and the principal data requirements for establishing a validated implementation baseline are summarised in Table E1.

Table E1. Baseline status and data requirements for industrial wastewater management in the CRB

Baseline component	Current assessment / information available	Information required for final baseline and implementation
Industrial inventory	Major industrial clusters and sectors have been identified across the CRB, including Bengaluru, Nanjangud, Mysuru, Mandya, Tiruppur, Erode, Karur, Salem, Namakkal–Pallipalayam, Mettur and Tiruchirappalli. The identified sectors include textiles, pharmaceuticals, chemicals, engineering, food processing, sugar and distilleries, paper, poultry, electroplating and other manufacturing activities.	A validated unit-level inventory of operating industries, including industry name/location, state, cluster, sector, regulatory category, production capacity and operational status, with source and reference year.
Water use	The report recognises industrial water consumption and water conservation/reuse as important components of basin-scale wastewater management. However, a consolidated quantitative water-use	Freshwater abstraction and purchased-water volumes by industry/cluster and sector, preferably in MLD, together with source, reference year and validation status. Industrial water

	baseline for the identified clusters is not established in the present report.	audits should be used where direct measurements are unavailable.
Wastewater and pollutant load	Industrial wastewater characteristics have been qualitatively characterised by sector. Textile clusters are associated with high TDS, colour, dyes and COD; pharmaceutical and chemical industries with high COD, TDS, toxic organics and sector-specific contaminants; sugar and distillery industries with high BOD, COD, nutrients and spent wash; and metal-finishing activities with heavy-metal-bearing wastewater.	Quantified wastewater generation and pollutant loads by cluster/sector, including flow, BOD, COD, TSS, TDS, nutrients, heavy metals and sector-specific toxicants. Concentration data should be accompanied by flow measurements so that pollutant loads can be calculated.
Treatment infrastructure	The report proposes cluster-based ETP/CETP infrastructure, integrated collection and conveyance systems, treatment upgrades and advanced treatment where required. Existing treatment infrastructure is discussed, but a validated basin-wide inventory of design capacity, actual utilisation, downtime and compliance is not yet established.	ETP/CETP inventory with design capacity, operational capacity, actual flow, utilisation, treatment technology, inlet/outlet quality, bypass incidents, downtime, sludge generation and compliance performance.
Reuse and residues	Wastewater reuse and resource recovery are identified as core components of the management framework. Zero Liquid Discharge (ZLD) systems are discussed as a site- and sector-specific option rather than a universal requirement. The report also identifies sludge, RO concentrates,	Quantified treated-water reuse, internal recycling, RO reject/concentrate generation, sludge and recovered-salt quantities, together with the authorised destination and disposal/recovery pathway for each residue stream.

	evaporator salts and other treatment residues as important management streams.	
Receiving environment	The report identifies the potential for industrial wastewater to affect the Cauvery River and tributaries, groundwater resources and sensitive receiving environments. Priority assessment should consider proximity to rivers, groundwater vulnerability, low-flow conditions and sensitive receptors.	Georeferenced discharge/outfall locations; receiving river/tributary and groundwater receptors; affected river stretches/aquifers; seasonal flow conditions; downstream drinking-water intakes; ecologically sensitive areas; and existing receiving-water quality data.

Priority outcomes and commitments

- Reduce untreated and non-compliant industrial wastewater discharges through source control, strengthening of ETPs/CETPs, and improved regulatory compliance.
- Reduce pollutant loads from priority industrial clusters by establishing cluster-specific pollution-load baselines and implementing targeted interventions for identified receiving-water stretches.
- Improve ETP/CETP performance, operational uptime and compliance through performance monitoring, process optimisation and periodic verification.
- Reduce freshwater dependence and increase fit-for-purpose treated-water reuse through industrial water audits, recycling, cleaner production and cluster-level reuse planning.
- Ensure the complete, traceable, and authorised management of sludge, concentrates, and hazardous residues generated by industrial processes and wastewater treatment systems.

Implementation summary

Implementation shall proceed through verified baseline development, risk-based cluster prioritisation, preparation of bankable infrastructure projects, time-bound execution, performance verification and annual adaptive review. The detailed responsibilities, budgets, milestones and evidence requirements are provided in Section 10.

1. Introduction

The Cauvery River Basin (CRB) is one of India's most important river systems, supporting domestic water supply, irrigation, industrial development, hydropower generation, and ecological services across Karnataka, Tamil Nadu, Kerala, and Puducherry. Rapid industrialisation within the basin has resulted in an increasing generation of industrial effluents, posing significant risks to river water quality, groundwater resources, aquatic ecosystems, and public health.

Major industrial activities within the basin include textile processing, leather industries, electroplating units, food processing industries, pharmaceutical manufacturing, paper and pulp mills, sugar industries, chemical industries, distilleries, engineering industries, and industrial estates located in urban and peri-urban regions (Brema et al., 2021; Manoj & Padhy, 2015; Rajalakshmi et al., 2013). Several industrial clusters are situated in proximity to the Cauvery River and its tributaries, increasing the risk of direct and indirect pollution through wastewater discharge, runoff, and groundwater contamination (Chidambaram et al., 2018; RamyaPriya & Elango, 2022).

The industrial wastewater management plan aims to establish a comprehensive framework for pollution prevention, wastewater treatment, resource recovery, monitoring, and regulatory compliance across the CRB.

1.1. Objectives

- a) Minimise industrial pollution loads entering the Cauvery River and its tributaries.
- b) Promote basin-wide adoption of cleaner production technologies and wastewater recycling.
- c) Identify industrial pollution hotspots and prioritise interventions.
- d) Strengthen the Common Effluent Treatment Plant (CETP) infrastructure in industrial clusters.
- e) Promote Zero Liquid Discharge (ZLD), minimum-liquid-discharge and other advanced water-recovery systems where required or justified by applicable regulations and site- and sector-specific feasibility assessment.
- f) Ensure environmentally sound management of hazardous industrial wastes.
- g) Establish continuous monitoring and compliance mechanisms.

2. Industrial Cluster Analysis

2.1. Industrial Clusters and CETP Requirements

Major industrial activity within the CRB is concentrated, among other areas, in the Bengaluru-Mysuru industrial corridor in Karnataka and the Tiruppur-Erode-Karur-Namakkal-Salem belt in Tamil Nadu. Available literature identifies sector-specific risks, including high-TDS and dye-bearing textile effluents in the Noyyal, Bhavani and Amaravathi sub-basins and chemical/heavy-industry risks around Mettur (Sellamuthu et al., 2011; Ramesh Kumar & Anbazhaan, 2018). However, the present report does not contain a harmonised, flow-weighted and contemporaneous pollutant-load baseline that would support a legally or scientifically defensible ranking of one State's clusters as the basin's 'most significant' hotspots. Priority for CETP/ETP strengthening, ZLD, or other advanced treatment, OCEMS, and enforcement should therefore be determined using the verified risk-based framework in Section 10.3, applied consistently across the basin.

The CRB contains several major industrial clusters that generate significant industrial wastewater. The type and characteristics of wastewater vary across industrial sectors, necessitating sector-specific treatment and management approaches. Table 1 presents the major industrial clusters in the basin, their dominant industrial sectors, typical wastewater characteristics, and the principal references used to identify them.

Table 1. Major industrial clusters and typical wastewater characteristics in the CRB

State	Industrial Cluster	Dominant Industrial Sectors	Typical Wastewater Characteristics
Karnataka	Bengaluru Metropolitan Industrial Region (Peenya, Bommasandra, Electronic City, Whitefield)	Electronics, pharmaceuticals, biotechnology, engineering	Heavy metals (sector-specific), solvents, pharmaceutical residues, organic pollutants
	Nanjangud Industrial Area	Pharmaceuticals, chemicals, food processing	High Chemical Oxygen Demand (COD), toxic organics, solvents, process chemicals
	Mandya Industrial Region	Sugar, distilleries, agro processing	High Biochemical Oxygen Demand

			(BOD), COD, nutrients, spent wash
	Mysuru Industrial Area	Engineering, manufacturing, food processing	Mixed industrial wastewater, suspended solids, organic pollutants
Tamil Nadu	Tiruppur Textile Cluster (Noyyal Basin)	Textile dyeing, bleaching, garment processing	High TDS, colour, COD, dissolved salts
	Erode Textile Cluster (Bhavani Basin)	Textile processing and dyeing	High TDS, colour, dyes, organic pollutants
	Karur Textile Cluster (Amaravathi Basin)	Home textiles and textile processing	High TDS, colour, dyes, organic pollutants
	Salem Industrial Region	Steel, engineering, chemicals	Heavy metals (sector-specific), industrial chemicals, suspended solids
	Namakkal–Pallipalayam Industrial Region	Paper, poultry processing, textile processing	Organic pollutants, nutrients, suspended solids
	Mettur Industrial Complex	Chemicals, fertilizers, thermal power	Chemical residues, high TDS, hazardous process wastewater
	Tiruchirappalli Industrial Region	Heavy engineering, fabrication	Metal-bearing wastewater, oils and grease, suspended solids
Source: Compiled from official information and sectoral/regulatory documents of KIADB, KSPCB, TNPCB, SIPCOT, CPCB and the Ministry of Textiles. Sector-specific wastewater characteristics represent typical characteristics reported for the respective industrial activities and are not intended as verified cluster-level pollutant-load measurements.			

2.2. Strategy for Collective Waste Management in the CRB

2.2.1. Collective Waste Management Strategy

The CRB comprises numerous industrial clusters encompassing textile processing, pharmaceuticals, distilleries, food processing, engineering, chemical manufacturing, paper and pulp, leather processing, and other agro-based industries. A substantial proportion of these

industries, particularly Micro, Small, and Medium Enterprises (MSMEs), face significant financial, technical, and land constraints that limit their ability to establish and operate individual wastewater treatment facilities. Consequently, a basin-wide collective waste management strategy is required to ensure effective pollution control, optimise infrastructure investments, improve regulatory compliance, and promote sustainable industrial development. The proposed strategy advocates establishing cluster-based wastewater treatment systems, shared infrastructure facilities, resource recovery mechanisms, and coordinated institutional frameworks to minimise industrial pollution entering the Cauvery River and its tributaries while enhancing water reuse and circular economy practices.

2.2.2. Cluster-Based Wastewater Management Framework

The CRB encompasses a diverse range of industrial activities distributed across metropolitan regions, industrial estates, special economic zones, and rural industrial corridors. These industries generate wastewater with varying physicochemical characteristics and pollution loads, contributing to the deterioration of surface water and groundwater quality. Since decentralised treatment systems are often economically unviable for MSMEs, a cluster-based wastewater management framework is proposed to facilitate collective treatment, optimise infrastructure utilisation, strengthen environmental compliance, and reduce cumulative pollutant loads entering the basin.

The proposed framework groups industries by geographical proximity, industrial sector, wastewater characteristics, pollution potential, and hydrological connectivity. Each industrial cluster functions as an integrated management unit in which wastewater collection, conveyance, treatment, monitoring, sludge management, and resource recovery are undertaken through shared infrastructure and coordinated governance mechanisms. This integrated approach aims to minimise untreated industrial discharges into the Cauvery River system, promote cost-effective wastewater treatment through common facilities, enhance water reuse and resource recovery, facilitate the adoption of ZLD technologies in priority sectors, strengthen environmental monitoring and regulatory compliance, and reduce cumulative pollution impacts at the sub-basin scale.

Industrial clusters should be identified through an integrated assessment combining geospatial analysis, industrial inventory databases, land-use information, and hydrological characteristics. Delineation should consider the spatial concentration of industries, industrial production profiles, wastewater generation rates, effluent characteristics, existing treatment infrastructure,

proximity to the Cauvery River and its tributaries, groundwater vulnerability, and the potential for pollution of environmentally sensitive ecosystems. These criteria will facilitate the identification of priority industrial clusters requiring collective wastewater management interventions and support strategic planning for basin-wide pollution control.

Based on the distribution of industrial activities, major manufacturing sectors, and hydrological connectivity, several industrial clusters were identified within the CRB. These clusters represent the principal sources of industrial wastewater and form the basis for basin-scale wastewater management planning. Classifying industrial clusters according to their dominant industrial sectors and associated sub-basins facilitates the identification of region-specific pollution sources. It supports the development of targeted wastewater treatment and monitoring strategies. Table 2 presents the major industrial clusters, their dominant industrial sectors, and the corresponding sub-basins within the CRB.

Table 2. Priority industrial clusters for industrial wastewater management in the CRB

Cluster	Dominant Industrial Sectors	Sub-Basin
Bengaluru Industrial Corridor	Electronics, pharmaceuticals, engineering	Arkavathi–Vrishabhavathi
Nanjangud Industrial Cluster	Chemicals, pharmaceuticals, food processing	Kabini
Mysuru Industrial Region	Engineering and manufacturing	Kabini
Mandya Industrial Cluster	Sugar and distillery industries	Upper Cauvery
Tiruppur Textile Cluster	Textile dyeing and bleaching	Noyyal
Erode Textile Cluster	Textile processing and weaving	Bhavani
Karur Textile Cluster	Textile processing and home furnishings	Amaravathi
Salem Industrial Cluster	Steel, chemicals and engineering	Thirumanimuthar
Namakkal–Pallipalayam Cluster	Poultry, paper and textile industries	Cauvery Main Stem
Mettur Industrial Complex	Chemicals, fertilizers and power generation	Cauvery Main Stem
Tiruchirappalli Industrial Cluster	Heavy engineering and fabrication	Cauvery Main Stem

2.2.3. Industrial Cluster Categorisation

To facilitate risk-based planning and targeted wastewater management interventions, industrial clusters within the CRB should be categorised according to wastewater generation, pollution potential, industrial composition, and their potential impact on receiving water bodies. This classification will assist regulatory agencies in prioritising investments, strengthening environmental monitoring, and implementing appropriate wastewater treatment and pollution control measures.

2.2.3.1. Category I: High-Priority Clusters

For planning purposes, Category I should be treated as a provisional screening category rather than a statutory classification or a final inter-State ranking. A cluster should be confirmed as high priority only after verified data demonstrate material wastewater volume and/or pollutant load, hazardous constituents, repeated non-compliance, vulnerable receiving waters, drinking-water or irrigation exposure, groundwater risk, or other high-consequence factors under the Section 10.3 scoring framework. Bengaluru and Nanjangud in Karnataka, and Tiruppur, Erode, and Mettur in Tamil Nadu, may be screened for early verification due to their industrial profiles. Still, the final category and intervention package shall be based on comparable, flow-weighted evidence and applicable regulatory requirements. ZLD shall be required only where mandated or technically and environmentally justified; high-priority status by itself shall not create a ZLD obligation.

2.2.3.2. Category II: Moderate-Priority Clusters

Moderate-priority clusters are characterised by moderate wastewater generation and manageable pollution loads but require improvements in treatment infrastructure, operational efficiency, and environmental compliance. These clusters should focus on upgrading CETPs, expanding wastewater reuse, and strengthening monitoring systems to prevent future environmental degradation. Examples include Karur, Salem, Namakkal–Pallipalayam, and Mandya.

2.2.3.3. Category III: Emerging Industrial Clusters

Emerging clusters comprise developing industrial areas that currently generate relatively low wastewater volumes but are expected to undergo significant industrial expansion. Proactive planning, including the provision of wastewater treatment infrastructure, pollution prevention measures, and environmental monitoring, should be undertaken to prevent future deterioration

in water quality. Such clusters include peripheral industrial areas of Mysuru and smaller industrial estates located throughout the basin.

2.2.4. Integrated Wastewater Collection and Conveyance System

An integrated wastewater collection and conveyance system should be established for each industrial cluster to ensure the safe and efficient transport of industrial effluents to centralised treatment facilities. The system should comprise dedicated industrial sewer networks, pumping stations, equalisation facilities, flow measurement systems, emergency storage tanks, and separate conveyance pipelines for hazardous wastewater streams where required. Attention should be given to preventing the mixing of industrial effluents with municipal sewage, especially in major urban centres such as Bengaluru, Mysuru, Salem, and Tiruchirappalli, where combined sewer systems can compromise treatment efficiency and increase environmental risks. The design of these systems should consider projected industrial growth, hydraulic capacity, operational reliability, and resilience to extreme rainfall events.

2.2.5. CETP Infrastructure

CETPs should constitute the core infrastructure for collective wastewater management in industrial clusters, particularly for Micro, Small, and Medium Enterprises (MSMEs) that may lack the technical or financial capacity to operate individual treatment facilities. Existing CETPs should be upgraded to meet current environmental standards, while new facilities should be established in clusters lacking adequate treatment capacity. Depending on wastewater characteristics, CETPs should incorporate preliminary screening, equalisation and neutralisation units, primary clarification, biological treatment processes, tertiary polishing systems, membrane filtration technologies, reverse osmosis (RO) where appropriate, and sludge dewatering and safe disposal or resource recovery facilities. The design capacity of CETPs should be established using verified current wastewater generation, projected industrial growth, water-use efficiency, treatment requirements, and an appropriate design horizon, as determined through the project-specific DPR and applicable design guidelines.

3. ZLD Implementation

ZLD is an advanced wastewater management approach that aims to eliminate liquid effluent discharge from industrial facilities through comprehensive wastewater treatment, recovery, recycling, and reuse. Under ZLD systems, wastewater is treated using a combination of physical, chemical, biological, and membrane-based technologies, enabling maximum water

recovery while converting residual contaminants into solid waste streams suitable for safe disposal or resource recovery.

Given the increasing water stress within the CRB and the need to reduce industrial pollution loads entering the Cauvery River and its tributaries, ZLD represents a critical strategy for sustainable industrial water management. The approach is particularly relevant in industrial clusters characterised by high wastewater generation, elevated TDS, toxic pollutants, and limited assimilative capacity of receiving water bodies. The implementation of ZLD aligns with the broader objectives of the CRB management program by promoting water conservation, pollution prevention, circular economy practices, and long-term ecological restoration.

3.1. Feasibility and Roadmap for ZLD

3.1.1. Current Status of ZLD in the CRB

The most clearly documented large-scale implementation of Zero Liquid Discharge (ZLD) within the CRB is associated with the textile dyeing and processing industry in the Tiruppur cluster of Tamil Nadu. Historical records indicate that ZLD-based treatment was progressively adopted by individual industrial units and Common Effluent Treatment Plants (CETPs) in response to regulatory and judicial requirements. The Ministry of Textiles reported in 2012 that 16 of the 18 CETPs in Tiruppur were operational and that treated water was being reused within industrial processes (MoT, 2012). In 2016, the Ministry reported that more than 450 dyeing units had established 18 ZLD-enabled CETPs, with a reported project investment of ₹1,013 crore. It documented the financial and technical challenges associated with their operation (MoT, 2016).

More recent records from the Tamil Nadu Pollution Control Board (TNPCB) confirm the continued importance of ZLD-based treatment in the textile sector. The TNPCB Annual Report 2024 states that 19 textile CETPs in Tamil Nadu, comprising 18 in Tiruppur and 1 in Perundurai, had implemented tertiary treatment incorporating reverse osmosis, multiple-effect evaporation, and agitated thin-film drying to achieve ZLD. The same report identifies additional CETPs that were under closure due to an inability to achieve the required ZLD performance.

TNPCB's 2024 documentation also provides facility-level information for the Tiruppur CETPs, including treatment configuration and reported effluent characteristics, providing a more recent basis for updating the cluster-level ZLD inventory.

These records demonstrate that ZLD is well established in the Tiruppur textile cluster; however, the existence of ZLD infrastructure should not be interpreted as evidence of uniform operational performance. The current management plan, therefore, requires facility-level verification of design capacity, actual wastewater flow, water recovery, energy consumption, concentrate and salt generation, operational uptime, compliance status, and residue management pathways. These parameters shall be incorporated into the verified baseline during the initial implementation phase.

The Tiruppur experience also demonstrates that ZLD implementation involves significant technical, energy, financial and residue-management requirements. Accordingly, ZLD should not be treated as a uniform requirement for all industrial clusters in the CRB. Applicable regulatory requirements and the site should determine its application- and sector-specific assessments of wastewater characteristics, water stress, reuse demand, lifecycle costs, energy requirements, concentrate management, and operator capability.

3.1.2. Feasibility Assessment Framework

The feasibility of ZLD should be evaluated through a structured assessment of wastewater characteristics, treatment requirements, water-recovery potential and implementation constraints. The assessment should initially characterise wastewater quantity and quality, including wastewater generation, TDS, salinity, organic and inorganic pollutants and other constituents relevant to treatment selection. This is important because textile and other industrial wastewaters can vary substantially in composition, and no single treatment configuration is universally suitable for all industrial effluents (Jahan et al., 2022).

The assessment should subsequently consider the existing effluent-treatment infrastructure and the additional treatment processes required to achieve the intended level of water recovery. Depending on wastewater characteristics, ZLD systems may involve combinations of conventional treatment, membrane processes, and concentrate management processes. The feasibility assessment should therefore consider the availability of suitable land and utilities, energy requirements, technical capability for operation and maintenance, capital expenditure and recurring operating costs. The relatively high energy, investment and maintenance requirements reported for ZLD systems should be explicitly incorporated into the economic assessment rather than assuming that ZLD is automatically the most appropriate treatment option (Jahan et al., 2022).

Water availability and opportunities for treated-water reuse should also be incorporated into the assessment. The National Framework on Safe Reuse of Treated Water, prepared by the National Mission for Clean Ganga (NMCG), guides the development of state-level policies for the safe reuse of treated water and promotes the consideration of treated water as a resource within a circular water-management approach (NMCG, 2022). The Ministry of Jal Shakti subsequently launched the framework in January 2023.

For the CRB, ZLD feasibility should therefore be assessed using a multi-criteria framework covering: (i) wastewater quantity and characteristics, (ii) existing treatment infrastructure, (iii) freshwater availability and water-stress conditions, (iv) achievable water-recovery and reuse potential, (v) energy and land requirements, (vi) regulatory requirements, (vii) capital and operating costs, (viii) resource-recovery opportunities, and (ix) operational and maintenance requirements. The outcome should be a sector- and site-specific determination of whether ZLD, partial water recovery, enhanced conventional treatment, or another treatment configuration provides the most technically feasible and environmentally appropriate solution.

3.1.3. Roadmap for ZLD Implementation

The implementation of ZLD in the CRB should follow a phased, evidence-based approach, beginning with an assessment of industrial water use, wastewater generation, existing treatment capacity, and opportunities for water recovery and reuse. Industrial water audits can establish water balances, identify losses and inefficiencies, quantify wastewater generation, and identify opportunities for water conservation, recycling and reuse (NPC, 2023). Such assessments should be complemented by an evaluation of existing effluent treatment plants (ETPs) and CETPs, their treatment performance, residual streams, and the additional treatment requirements to achieve ZLD.

The first phase should therefore focus on baseline assessment and prioritisation, including industrial water audits, wastewater characterisation, assessment of existing treatment infrastructure, identification of units or industrial sectors subject to ZLD requirements, and evaluation of technical and economic feasibility. Regulatory compliance and monitoring should be integral to this phase. This approach is particularly relevant because the implementation experience in Tiruppur demonstrates that ZLD infrastructure can entail substantial investment and may face technical and financial challenges during implementation (MoT, 2016).

The second phase should focus on improving the performance of existing treatment systems and increasing water recovery and reuse. Depending on site-specific wastewater characteristics and treatment requirements, this may include upgrading existing CETPs/ETPs, improving process controls, integrating appropriate membrane-based treatment and concentrate-management systems, and developing reliable infrastructure for internal recycling and reuse. CPCB documentation of ZLD systems in Tiruppur demonstrates the use of treatment and recovery processes designed to facilitate recycling of recovered water within industrial operations (CPCB, 2014).

The third phase should involve the selective implementation or extension of ZLD to additional industrial units where technically feasible and environmentally justified. Such decisions should consider wastewater characteristics, regulatory requirements, freshwater availability, achievable recovery, energy requirements, land requirements, capital and operating costs, and the capacity of industries or CETPs to operate and maintain the systems reliably. ZLD should therefore not be treated as a uniform requirement across all industries; rather, its application should be determined by applicable regulatory provisions and site- and sector-specific conditions. CPCB provisions indicate that ZLD can be mandated for specified industrial circumstances, such as environmentally sensitive or critical areas, rather than being a universal requirement for all industrial units.

Across all phases, continuous monitoring and periodic performance evaluation should be maintained to verify water recovery, treated-water quality, concentrate management, energy consumption and compliance with applicable consent conditions. Where treated water can be safely reused, reuse opportunities should be incorporated into industrial water-management plans. The National Framework on Safe Reuse of Treated Water provides a broader policy basis for promoting safe reuse of treated wastewater and developing appropriate reuse approaches (NMCG, 2022).

3.2. Sector-Specific ZLD Guidelines

Given the diversity of industries within the CRB, sector-specific implementation strategies are necessary, with recommended ZLD components and primary objectives varying by industry type and wastewater characteristics (Table 3).

Table 3. Sector-specific advanced treatment and ZLD options for major industries in the CRB

Industry Sector	Representative Locations	Typical Wastewater Characteristics	Recommended ZLD Components	Primary Objective	References
Textile processing	Tiruppur, Erode, Karur	High TDS, colour, COD, dye residues, dissolved salts	Equalization → Biological treatment → Ultrafiltration → RO → Multiple-Effect Evaporator / Mechanical Vapour Recompression → Crystallizer → Salt management	Maximize treated water reuse and minimize liquid discharge ; recover salts where technically feasible	https://cpcb.gov.in/ , Rajakumari & Kanmani (2008)
Pharmaceutical industries	Bengaluru, Nanjangud	High COD, high TDS, solvents, recalcitrant organic compounds, pharmaceutical residues	Equalization → Physicochemical treatment → Biological treatment → Advanced Oxidation Processes → RO → Evaporation/Crystallization (where required)	Water reuse, reduction of pharmaceutical residues, compliance with discharge standards	https://www.pcbassam.org/Report_on_Classification_of_Sectors_2025_1737901761.pdf ; https://cpcb.gov.in/ , Shetty et al., 2023
Chemical industries	Mettur, Nanjangud	High salinity, toxic organics, inorganic chemicals, heavy metals (sector-dependent)	Neutralization → Chemical precipitation (where applicable) → Biological treatment (where applicable) → RO → Evaporation/Crystallization	Minimize hazardous liquid waste and maximize water recovery	https://www.greentribunal.gov.in/sites/default/files/news_updates/OA%2033%20of%202023%20Annexures%20by%20R7.pdf ; *
Electroplating and metal finishing	Bengaluru, Mysuru	Heavy metals, cyanide (where applicable),	Segregation → Chemical precipitation → pH adjustment → Metal recovery	Metal recovery, water reuse, reduction	https://www.greentribunal.gov.in/sites/default/files/news_update

		acidic/alkaline wastewater	Membrane polishing (where feasible)	of hazardous sludge	s/OA%2033%20of%202023%20Annexures%20by%20R7.pdf
Sugar and distillery industries	Mandya and other sugar-processing areas	High BOD, COD, colour, spent wash/process condensate	Anaerobic treatment → Aerobic polishing → Condensate polishing → Evaporation/incineration or other approved ZLD systems (where applicable)	Process water reuse and reduction of freshwater demand; compliance with applicable CPCB/State Pollution Control Board (SPCB) requirements	https://cpcb.gov.in/ngriba/chapter_distillery.pdf https://moef.gov.in/uploads/2017/06/FNO-Q1701-11-2014-CPW-22-11-2016_0.pdf

***Note:**

Government of India, 2018. Cauvery Water Management Scheme, notified on 1 June 2018 pursuant to the Cauvery Water Disputes Tribunal Award as modified by the Supreme Court.

Supreme Court of India, 2018. State of Karnataka v. State of Tamil Nadu, Civil Appeal No. 2453 of 2007 and connected matters, judgment dated 16 February 2018; implementation Scheme considered by order/judgment dated 18 May 2018.

Supreme Court of India, 2025. The State of Karnataka by its Chief Secretary v. State of Tamil Nadu by its Chief Secretary & Others, 2025 INSC 1343, judgment dated 13 November 2025.

Government of India, Ministry of Law and Justice, 2024. Water (Prevention and Control of Pollution) Amendment Act, 2024 (Act No. 5 of 2024), including its State-application clause under Article 252.

Government of India, Ministry of Environment, Forest and Climate Change, 2026. Control of Water Pollution (Grant, Refusal or Cancellation of Consent) Amendment Guidelines, 2026, G.S.R. 63(E), dated 23 January 2026, to be applied subject to the operative legal position in the concerned State.

Government of India, Ministry of Environment, Forest and Climate Change, 2024. Hazardous and Other Wastes (Management and Transboundary Movement) Amendment Rules, 2024, together with the principal Rules of 2016 and subsequent amendments.

3.3. ZLD Gaps and Strategic Recommendations

Despite its environmental benefits, the widespread implementation of ZLD in the CRB is constrained by several technical, economic, institutional, and regulatory challenges (Table 4). High energy requirements, membrane fouling, management of concentrate and recovered salts, substantial capital investment, limited technical expertise, and inconsistent regulatory compliance remain significant barriers to large-scale adoption. Addressing these challenges through technological innovation, cluster-based infrastructure, financial incentives, capacity building, and strengthened regulatory oversight will be essential for expanding ZLD implementation and improving industrial wastewater management across the basin.

Table 4. Key challenges and strategic recommendations for ZLD implementation in the CRB

Gaps	Description
Technical Gaps	a) High Energy Consumption Evaporation and crystallization systems require substantial energy inputs, increasing operational costs. b) Membrane Fouling High concentrations of suspended solids and scaling compounds reduce treatment efficiency and membrane lifespan. c) Management of Recovered Salts Safe reuse and disposal of recovered salts remain a significant challenge, particularly in textile clusters. d) Limited Technical Expertise Many industries, especially MSMEs, lack trained personnel for operating advanced ZLD systems.
Economic Gaps	a) High Capital Investment ZLD systems require significant upfront investment, often exceeding the financial capacity of small and medium industries. b) High Operating Costs Energy consumption, membrane replacement, chemical usage, and maintenance contribute to elevated operational expenditures. c) Limited Financial Incentives Existing financial support mechanisms are insufficient to accelerate basin-wide ZLD adoption.
Infrastructure Gaps	a) Inadequate Common ZLD Facilities Several industrial clusters lack centralized facilities for wastewater concentration, evaporation, and resource recovery. b) Insufficient Hazardous Waste Disposal Capacity

	Increased adoption of ZLD will generate additional solid residues requiring secure treatment and disposal facilities. c) Limited Water Reuse Networks Infrastructure for distributing recovered water to industries remains underdeveloped.
Institutional and Regulatory Gaps	a) Inconsistent Compliance Monitoring Monitoring mechanisms vary significantly among industrial clusters and states within the basin. b) Limited Basin-Wide Coordination Industrial wastewater management is currently fragmented among multiple agencies and jurisdictions. c) Lack of Standardized Performance Indicators There is no unified framework for evaluating ZLD effectiveness across the basin.

Achieving sustainable ZLD implementation in the CRB requires a phased, sector-specific, and economically feasible approach that addresses both technological and institutional challenges. A basin-wide ZLD strategy should be developed to guide implementation across priority industrial sectors, with particular emphasis on water-intensive and high-polluting industries. Financial incentives, low-interest financing, and technical assistance should be provided to MSMEs to facilitate technology adoption and compliance. The establishment of cluster-level ZLD systems and shared treatment infrastructure can improve cost-effectiveness and operational efficiency, particularly in industrial estates with numerous small-scale units. Capacity-building programmes should strengthen technical expertise among industry personnel, treatment-plant operators, and regulatory agencies to ensure effective operation and maintenance of advanced treatment systems.

Policy measures should also promote the recovery and beneficial utilisation of salts and other by-products to improve the economic viability of ZLD systems, while expanding hazardous waste treatment and disposal facilities to safely manage concentrated residues generated during treatment. Priority should be given to high-risk industrial clusters based on pollution potential, water stress, and environmental sensitivity to maximise environmental benefits and optimise resource allocation. Collectively, these measures can facilitate the wider adoption of ZLD technologies, reduce industrial pollution, enhance water reuse, and contribute to the long-term restoration and sustainable management of the CRB.

4. Hazardous Waste Management

Industrial development within the CRB has contributed significantly to economic growth; however, it has also generated substantial quantities of hazardous waste and toxic liquid effluents. Industries such as textiles, chemicals, pharmaceuticals, electroplating units, distilleries, engineering industries, pulp and paper mills, fertiliser plants, and metal processing facilities generate hazardous residues that pose serious risks to water resources, soil quality, ecosystem health, and public health.

Improper handling, storage, treatment, and disposal of hazardous waste can contaminate surface water bodies, groundwater aquifers, agricultural lands, and ecologically sensitive zones. Given the basin's dependence on river water and groundwater for drinking water supply, irrigation, and industrial use, establishing a comprehensive hazardous waste management framework is essential to achieving the environmental objectives of the CRB management program. The proposed framework focuses on minimising hazardous waste generation, ensuring environmentally sound treatment and disposal, strengthening monitoring systems, and promoting resource recovery wherever feasible.

4.1. Treatment and Secure Landfill Needs

Industrial activities within the CRB generate hazardous waste from manufacturing processes and wastewater treatment operations, which require environmentally sound collection, treatment, storage, and disposal in accordance with the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016. The quantity and characteristics of hazardous waste vary by industrial sector and production process, with chemical manufacturing, pharmaceuticals, textile processing, engineering, and electroplating industries as the principal sources. Furthermore, the adoption of advanced wastewater treatment technologies, including ZLD systems, may increase the generation of treatment residues, such as chemical sludge and concentrated salts, that require appropriate management. Therefore, identifying major hazardous waste-generating industrial clusters is essential for planning treatment, storage, and secure landfill facilities across the basin. Table 5 summarises the major industrial clusters within the CRB and the typical hazardous waste streams associated with their principal industrial activities. It highlights the sector-specific waste characteristics that should inform appropriate treatment, handling, and disposal strategies.

Table 5. Major industrial clusters and typical hazardous waste streams in the CRB

Industrial Cluster	Major hazardous and potentially hazardous treatment/process residues
Tiruppur Textile Cluster	Salt residues, dye sludge, RO reject concentrates
Erode Textile Cluster	Dye sludge, chemical residues, recovered salts
Karur Textile Cluster	Sludge, evaporator salts, chemical residues
Mettur Industrial Complex	Chemical sludge, heavy metals, hazardous process waste
Bengaluru Industrial Corridor	Pharmaceutical waste, solvents, heavy metals
Nanjangud Industrial Cluster	Chemical residues, pharmaceutical waste, sludge
Salem Industrial Region	Metal-bearing sludge, chemical wastes
Electroplating Units	Chromium, nickel, zinc-containing sludge
Distillery and Chemical Industries	Process sludge, spent catalysts and residues

4.1.1. Hazardous Waste Characterisation

Hazardous wastes generated within the CRB originate from industrial manufacturing processes, pollution control systems, wastewater treatment facilities, and ancillary operations. The nature and composition of these wastes vary depending on the industrial sector and production processes (Table 6). Broadly, the hazardous wastes generated within the basin can be categorised into inorganic residues, organic wastes, process residues, spent chemicals, and contaminated materials, all of which require appropriate handling, storage, transportation, treatment, and disposal in accordance with the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.

Table 6. Major categories of hazardous waste generated in the CRB

Hazardous Waste	Description
Inorganic waste	Heavy metal-bearing sludge, electroplating residues, chemical precipitates, contaminated salt, and incinerator ash.
Organic waste	Solvent residues, pharmaceutical intermediates, organic sludge, and process chemicals.

ZLD and treatment residues requiring characterisation	The regulatory classification of individual treatment residues shall be established through waste characterisation and applicable provisions of the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, as amended.
--	---

4.1.2. Treatment Infrastructure Requirements

An integrated hazardous waste management system should be established across the CRB to ensure the environmentally sound collection, transportation, treatment, storage, recovery, and disposal of hazardous wastes generated by industrial activities. The treatment infrastructure should be planned based on hazardous waste generation, industrial distribution, transportation logistics, and the availability of existing treatment facilities, while complying with the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.

Existing Treatment, Storage and Disposal Facilities (TSDFs) serving the basin should be strengthened, and additional capacity should be developed where necessary to meet future hazardous waste management requirements. TSDFs should include facilities for hazardous waste reception and inspection, waste characterisation laboratories, temporary storage, stabilisation and solidification of hazardous wastes, engineered secure landfill cells, leachate collection and treatment systems, and environmental monitoring infrastructure to ensure safe operation and regulatory compliance.

Hazardous waste with high organic content, high calorific value, or constituents unsuitable for landfilling should be treated in authorised hazardous waste incineration facilities equipped with high-temperature combustion systems, air pollution control devices, and continuous emission monitoring systems. Incineration should be undertaken only for waste streams approved under applicable regulatory guidelines and where material recovery or recycling is not technically or environmentally feasible.

Resource recovery should be prioritised wherever technically and economically feasible to promote circular economy principles and reduce the quantity of hazardous waste requiring final disposal. Depending on the characteristics of the waste stream, dedicated facilities may be established to recover solvents, metals, chemicals, and other reusable materials using environmentally sound technologies. The selection of resource recovery technologies should be based on waste composition, recovery efficiency, economic viability, and compliance with applicable environmental regulations.

4.1.3. Secure Landfill Requirements

Secure landfills are an essential component of hazardous waste management for waste that cannot be prevented, reused, recycled, recovered, co-processed, or treated using environmentally sound technologies. The planning, design, operation, and closure of secure landfill facilities within the CRB should comply with the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 and relevant CPCB guidelines to ensure the long-term protection of surface water, groundwater, and surrounding ecosystems.

The selection of secure landfill sites should be based on comprehensive environmental, geological, and logistical assessments. Key considerations include maintaining adequate separation from rivers, reservoirs, wetlands, and environmentally sensitive areas; minimising risks to groundwater resources; ensuring geological and geotechnical stability; avoiding flood-prone areas; maintaining reasonable proximity to major hazardous waste-generating industrial clusters; and providing reliable transportation access to facilitate safe waste movement while minimising environmental risks.

Secure landfills should incorporate engineered containment systems to prevent the release of hazardous contaminants into the surrounding environment. Essential design features include double composite liner systems, leachate collection and treatment facilities, groundwater monitoring wells, stormwater drainage and diversion systems, landfill gas venting arrangements where applicable, and environmental monitoring infrastructure for long-term surveillance of groundwater, surface water, and landfill performance throughout the operational and post-closure periods.

The capacity of secure landfill facilities should be determined using comprehensive hazardous waste inventories, projected industrial development, expected waste-generation trends, and anticipated treatment-residue generation from advanced wastewater treatment systems, including ZLD facilities. Capacity planning should incorporate periodic reviews and allow for future expansion to accommodate changes in industrial activity, regulatory requirements, and waste management practices while ensuring the continued availability of environmentally sound disposal infrastructure across the CRB.

4.2. Strategy for Toxic Liquid Waste

Toxic liquid waste is one of the most significant environmental threats in the CRB's industrialised regions. These waste streams often contain hazardous chemicals, heavy metals, toxic organics, solvents, pharmaceutical compounds, and high concentrations of dissolved

solids that can severely impact aquatic ecosystems and groundwater resources if not properly managed. A dedicated strategy for toxic liquid waste management is therefore required to prevent accidental releases and eliminate direct discharge into the river system.

4.2.1. Source Segregation and Waste Minimisation

Source segregation is the foundation of effective toxic liquid waste management, as it prevents the mixing of incompatible waste streams, improves treatment efficiency, facilitates resource recovery, and reduces the amount of hazardous waste that requires treatment and disposal. Industries should implement dedicated collection and conveyance systems for different wastewater categories based on their physicochemical characteristics and pollution potential. Separate handling should be provided for high-TDS streams, heavy-metal-bearing effluents, solvent-containing waste streams, pharmaceutical process wastewater, acidic and alkaline waste streams, and relatively clean streams such as cooling water and non-contact process water to maximise opportunities for reuse and recycling. In addition to source segregation, industries should adopt waste-minimisation measures through process optimisation, cleaner production techniques, raw material substitution, improved housekeeping practices, and water conservation to reduce both wastewater generation and pollutant loads. These practices are consistent with the principles of cleaner production and environmentally sound hazardous waste management and contribute to improved regulatory compliance and sustainable industrial operations within the CRB.

4.2.2. Treatment Strategy

The selection of treatment technologies for toxic liquid waste should be based on wastewater characteristics, pollutant composition, regulatory requirements, and opportunities for resource recovery. A combination of physical, chemical, biological, and advanced treatment processes may be required, depending on the nature of the contaminants and the intended reuse or disposal pathway. Typical treatment strategies for major toxic liquid waste streams generated within the CRB are presented in Table 7.

Table 7. Recommended treatment strategies for major toxic liquid waste streams

Wastewater	Typical Sources	Recommended Treatment
Heavy Metal-Bearing Wastewater	a) Electroplating industries b) Metal finishing units c) Engineering industries	a) Chemical precipitation b) Ion exchange systems c) Electrochemical treatment

		d) Metal recovery units
Toxic Organic Wastewater	a) Pharmaceutical industries b) Chemical manufacturing units	a) Advanced oxidation processes b) Activated carbon absorption c) Membrane bioreactors d) Thermal destruction
High-TDS Waste Streams	a) Textile processing b) Chemical industries c) ZLD facilities	a) RO b) Multiple Effect Evaporators c) Crystallizers d) Salt recovery systems
Acidic and Alkaline Waste Streams	a) Chemical manufacturing industries b) Electroplating and metal finishing units c) Textile and dyeing industries d) Pulp and paper industries	a) Neutralization systems b) pH balancing units c) Controlled discharge of downstream treatment facilities

4.2.3. Toxic Liquid Waste Storage and Transportation

The safe storage and transportation of toxic liquid waste are critical to preventing accidental releases and minimising risks to human health and the environment. Industries should establish dedicated storage facilities designed in accordance with applicable regulatory requirements, incorporating adequate secondary containment, chemically resistant and impermeable flooring, leak detection systems, spill collection arrangements, appropriate ventilation where necessary, and emergency response equipment to manage accidental spills or leaks safely. Storage areas should be clearly labelled, regularly inspected, and designed to ensure the segregation of incompatible waste streams. The transportation of toxic liquid waste should be undertaken only by authorised transporters using suitable containers and vehicles that comply with the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 and the Central Motor Vehicles Rules, 1989. A manifest system should be maintained to ensure traceability of waste from the point of generation to its final treatment or disposal facility. At the same time, digital record management and Global Positioning System (GPS) enabled vehicle tracking may be adopted to improve operational efficiency, transparency, and regulatory oversight.

4.2.4. Emergency Response and Risk Management

Industrial facilities handling toxic liquid wastes should establish comprehensive emergency response and risk management systems to minimise the consequences of accidental releases and protect human health and the environment. Emergency response plans should identify potential hazards, define roles and responsibilities, establish communication protocols, and specify procedures for responding to chemical spills, fires, explosions, transportation accidents, accidental releases to surface water bodies, and extreme weather events such as flooding that may affect hazardous waste storage or treatment facilities.

Industries should maintain appropriate spill containment equipment, fire protection systems, emergency shutdown procedures, and first-aid facilities, and conduct regular emergency preparedness training, mock drills, and periodic reviews of emergency response procedures. High-risk industrial clusters and CETPs should strengthen coordination with State Pollution Control Boards (SPCBs), District disaster management authorities, fire and emergency services, and other relevant agencies to ensure timely and effective emergency response. Integrating emergency planning with on-site and off-site disaster management measures will improve preparedness, reduce environmental risks, and enhance the resilience of industrial wastewater management systems within the CRB.

4.2.5. Monitoring and Compliance

Effective monitoring and regulatory compliance are essential to minimising the environmental risks associated with managing toxic liquid waste in the CRB. A comprehensive monitoring programme should include continuous monitoring of industrial effluent discharge points; periodic groundwater quality monitoring around major industrial clusters and hazardous waste treatment facilities; leachate monitoring at TSDFs; and regular surveillance of river water quality at strategically located monitoring stations.

Geospatial technologies, including Geographic Information Systems (GIS) and remote sensing, should be utilised to identify pollution hotspots, assess spatial trends, and support environmental planning and decision-making. Monitoring data should be integrated with the existing digital environmental monitoring systems of the CPCB and the respective SPCBs (KSPCB and TNPCB) to strengthen compliance assessment, improve transparency, facilitate timely regulatory action, and support adaptive management of industrial pollution within the CRB.

4.2.6. Strategic Recommendations

Strengthening hazardous and toxic liquid waste management in the CRB requires an integrated approach that combines improved infrastructure, regulatory oversight, and resource-efficient waste management practices. Priority should be given to developing a comprehensive basin-wide inventory of hazardous waste generation and movement to support evidence-based planning and regulatory decision-making. Existing TSDFs and secure landfill infrastructure should be strengthened and expanded, as needed, to accommodate current and future hazardous waste generation. Industries should adopt waste-minimisation measures, implement source segregation of toxic liquid waste streams, and promote the recovery and recycling of materials wherever technically and economically feasible, in accordance with circular economy principles.

Regulatory agencies should strengthen monitoring, inspection, and compliance programmes through risk-based surveillance, environmental audits, and digital reporting systems to ensure adherence to applicable environmental standards. Industrial facilities should also establish comprehensive emergency preparedness and response mechanisms to address accidental spills, leaks, fires, and other pollution incidents in coordination with relevant regulatory and disaster management authorities. These measures should be integrated into the broader framework of sustainable industrial wastewater management and river restoration initiatives within the CRB to reduce environmental risks, protect surface water and groundwater resources, improve industrial environmental performance, and support the long-term ecological sustainability of the basin.

5. Plan for Continuous Monitoring

Continuous monitoring forms the cornerstone of effective industrial wastewater management and river restoration within the CRB. While wastewater treatment infrastructure, ZLD systems, and hazardous waste management facilities are essential for pollution control, their effectiveness depends on robust monitoring systems that provide timely, accurate, and actionable information.

The CRB encompasses diverse industrial sectors distributed across Karnataka, Tamil Nadu, Kerala, and Puducherry. Industrial activities within the basin generate a wide range of pollutants, including organic matter, nutrients, dissolved solids, heavy metals, toxic chemicals, pharmaceuticals, dyes, solvents, and emerging contaminants. Continuous monitoring is therefore necessary to assess compliance, identify pollution hotspots, detect unauthorised

discharges, evaluate treatment performance, and support evidence-based management decisions. The primary objectives of the continuous monitoring program are shown in Fig. 1.

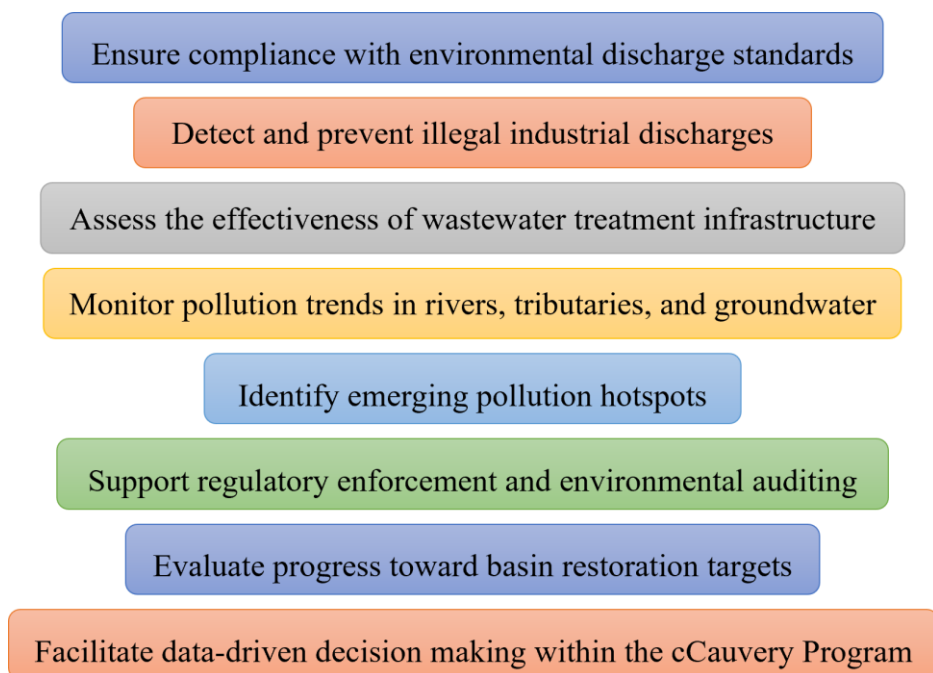


Fig. 1. Primary objectives of the continuous monitoring program

5.1. Industrial Effluent Monitoring

Continuous environmental monitoring is essential to ensure compliance with industrial effluent discharge standards and to strengthen pollution control within the CRB (Table 8). In accordance with the directions of the CPCB, Online Continuous Effluent Monitoring Systems (OCEMS) should be installed in applicable Red Category industries, CETPs, and other facilities identified by the respective SPCBs. Periodic laboratory analyses should complement continuous monitoring to verify online measurements and assess parameters that cannot be reliably monitored using online instrumentation.

Table 8. Recommended monitoring parameters for industrial effluent compliance

Monitoring Type	Parameter	Typical Frequency*
Online OCEMS	Effluent flow	Continuous
	pH	Continuous
	Total Suspended Solids (TSS)**	Continuous (where applicable)
	COD**	Continuous (where applicable)

	Ammoniacal Nitrogen**	Continuous (where applicable)
Periodic Laboratory Monitoring	BOD	As prescribed by SPCB/CPCB consent conditions
	TDS	As prescribed by SPCB/CPCB consent conditions
	Heavy metals	As prescribed by SPCB/CPCB consent conditions
	Oil and grease	As prescribed by SPCB/CPCB consent conditions
	Chlorides, sulphates and other industry-specific pollutants	As prescribed by SPCB/CPCB consent conditions
*Monitoring frequency depends on the applicable consent to operate, industrial sector, and CPCB/SPCB requirements. **Online monitoring parameters vary depending on the industrial sector and CPCB directions.		

5.2. CETPs and ZLD monitoring

Continuous performance assessment of CETPs and ZLD facilities is essential to ensure compliance with prescribed discharge standards, maintain treatment efficiency, optimise resource utilisation, and improve operational reliability (Tables 9-10). Performance evaluation should include hydraulic loading, treatment efficiency, operational stability, energy consumption, sludge generation, water recovery, and resource recovery, as applicable. Monitoring programmes should combine online instrumentation with routine laboratory analyses and periodic performance audits in accordance with the consent conditions prescribed by the respective SPCBs.

Table 9. Key performance indicators for CETPs and ZLD facilities

Performance Category	Key Performance Indicators
Hydraulic Performance	Influent flow rate, effluent flow rate, hydraulic loading, treatment capacity utilization
Treatment Performance	pH, COD removal, BOD removal, TSS removal, nutrient removal (where applicable), compliance with discharge standards

Operational Performance	Energy consumption, chemical consumption, sludge generation, equipment availability, plant uptime
ZLD Performance*	Water recovery efficiency, RO recovery, evaporator performance, crystallizer performance, management of recovered salts and treatment residues
*Applicable only to industries or CETPs operating ZLD systems.	

Table 10. Recommended monitoring frequency for key performance Indicators

Parameter	Recommended Monitoring Frequency
Flow rate	Continuous (OCEMS/flow meters where applicable)
pH	Continuous (where applicable)
COD, TSS and other online parameters	Continuous, where mandated under CPCB/SPCB requirements
Laboratory analysis of effluent quality	As specified in consent to operate conditions
Energy consumption	Periodic operational review
Chemical consumption	Periodic operational review
Sludge generation and disposal records	Periodic operational review
Water recovery and RO recovery (ZLD facilities)	Periodic operational review
Plant performance audit	Periodic internal review and regulatory inspection
Note: Monitoring frequencies should be determined in accordance with the consent to operate conditions, applicable CPCB/SPCB directions, and the operational requirements of the treatment facility.	

5.3. River Water Quality Monitoring

River water quality monitoring is essential for assessing the cumulative impacts of industrial wastewater discharges on the Cauvery River and its tributaries and for evaluating the effectiveness of pollution control measures. The existing monitoring network operated by the CPCB, Central Water Commission (CWC), and the respective SPCBs should be strengthened by establishing additional monitoring stations in industrially influenced reaches. Monitoring locations should include upstream and downstream sections of major industrial clusters,

confluences of major tributaries, drinking water abstraction points, and ecologically sensitive river stretches to enable a comprehensive assessment of industrial pollution and its downstream impacts (Table 11).

Table 11. Priority river stretches for water quality monitoring in the CRB

River Stretch	Major Industrial Influence
Vrishabhavathi River	Bengaluru metropolitan and industrial region
Arkavathi River	Urban and industrial activities in the Bengaluru metropolitan region
Kabini River	Mysuru–Nanjangud industrial region
Cauvery River (Mandya)	Sugar, distillery and agro-processing industries
Noyyal River	Tiruppur textile processing industries
Bhavani River	Textile processing and manufacturing industries in the Erode region
Amaravathi River	Textile processing and allied industries in the Karur region
Cauvery River (Mettur)	Chemical and manufacturing industries
Cauvery River (Tiruchirappalli)	Mixed urban and industrial activities

5.4. Groundwater Quality Monitoring

Groundwater quality monitoring is essential for assessing the potential impacts of industrial activities, hazardous waste handling, and wastewater disposal on aquifer systems within the CRB. A comprehensive monitoring network should be established around major industrial estates, CETPs, TSDFs, secure landfill facilities, and other high-risk industrial clusters to enable early detection of contaminant migration and support timely corrective actions. The monitoring network should include appropriately designed observation wells located upgradient, downgradient, and at background reference locations based on site-specific hydrogeological investigations to distinguish natural groundwater quality from contamination resulting from industrial activities. Groundwater monitoring should include measurements of water levels and analyses of key physicochemical parameters, such as pH, electrical conductivity (EC), TDS, major cations and anions, fluoride, nitrate, and heavy metals, as well as industry-specific contaminants where relevant. Monitoring programmes should be

implemented in accordance with the authorisation conditions prescribed by the respective SPCB and the applicable CPCB guidelines, with the monitoring frequency determined by pollution risk, hydrogeological characteristics, and regulatory requirements (Table 12).

Table 12. Components of a groundwater quality monitoring programme

Monitoring Component	Description
Monitoring Locations	Industrial estates, CETPs, TSDFs, secure landfill facilities, and other high-risk industrial clusters
Monitoring Network	Observation wells located at upgradient, downgradient, and background reference locations based on hydrogeological assessment
Water Level Monitoring	Periodic measurement of groundwater levels to evaluate groundwater flow patterns and potential contaminant migration
Water Quality Parameters	pH, EC, TDS, major ions, fluoride, nitrate, heavy metals, and industry-specific contaminants where applicable
Monitoring Frequency	Determined by site-specific risk assessment, regulatory requirements, and authorization conditions prescribed by the respective SPCB

6. Policy Interventions

Industrial wastewater management within the CRB requires a combination of technological solutions, institutional strengthening, economic incentives, and regulatory enforcement. While treatment infrastructure, such as CETPs, ZLD systems, and hazardous waste management facilities, is critical, their effectiveness depends on supportive policy frameworks and robust governance mechanisms.

The CRB spans multiple States and administrative jurisdictions, creating a need for coordination in monitoring, data quality and pollution-abatement planning. A basin-scale policy framework should therefore facilitate comparable methods, interoperable data and cooperative action while preserving the statutory powers, territorial jurisdiction and decision-making responsibility of each competent authority. The framework may support inter-State coordination, but it cannot substitute for KSPCB, TNPCB, Kerala SPCB, Puducherry PCC or other authorities exercising powers conferred by law, nor can it alter the Cauvery water-sharing regime. Proposed interventions should reduce industrial pollution, promote safe reuse and

resource recovery, strengthen compliance, encourage cleaner production and improve water security within this legal boundary (Fig. 2).

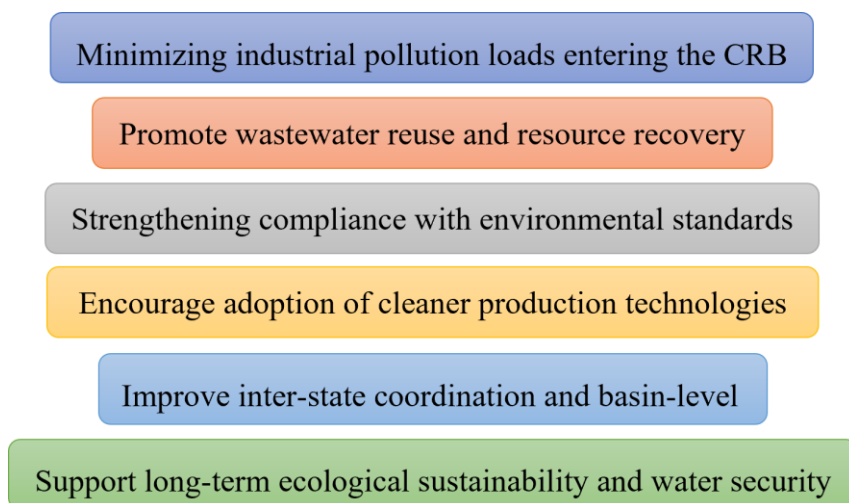


Fig. 2. Major objectives of the proposed policy interventions for industrial wastewater management in the CRB

6.1. Regulatory Interventions

Industrial wastewater management in the CRB requires coordinated planning to address cumulative water-quality impacts, while enforcement remains with the competent statutory authorities within their respective jurisdictions. Bengaluru, Mysuru-Nanjangud, Mandya, Mettur, Erode, Tiruppur, Karur, and Namakkal are among the clusters requiring verified assessment due to their industrial profiles and hydrological connectivity; the report should not state that any cluster contributes a 'significant' load unless supported by contemporaneous flow-weighted monitoring. KSPCB should lead consent, inspection, enforcement and corrective action for Karnataka facilities, while the corresponding regulator should do so in each other State/Union Territory. Basin-level coordination should support, not supersede, these functions and should rely on official action plans, consent records, OCEMS/validated laboratory data and documented non-compliance rather than secondary descriptions.

6.2. Economic and Financial Interventions

Economic instruments play a critical role in complementing regulatory measures by creating financial incentives for pollution prevention, water conservation, and resource recovery. In the CRB, the adoption of market-based mechanisms can encourage industries to minimise wastewater generation, invest in cleaner production technologies, and increase the reuse of

treated wastewater. Such approaches support the transition from conventional end-of-pipe pollution control to resource-efficient and circular water management.

6.3. Institutional and Governance Interventions

Effective industrial wastewater management in the CRB requires strong institutional coordination, integrated governance, and stakeholder participation in addition to regulatory and economic instruments. Given the interstate nature of the basin and the diversity of industrial sectors, governance mechanisms should facilitate coordinated planning, information sharing, compliance monitoring, and adaptive management. Institutional strengthening at both basin and industrial cluster levels would improve regulatory effectiveness and support long-term water quality management.

6.4. Technology and Innovation Policies

The adoption of advanced treatment technologies and digital water management systems is essential for improving industrial wastewater management in the CRB. A phased implementation of ZLD should be prioritised for water-intensive and high-polluting industries, particularly textile processing, pharmaceuticals, chemicals, and electroplating, where wastewater contains high concentrations of dissolved solids and hazardous contaminants. Simultaneously, industries should progressively adopt best available technologies, including advanced oxidation processes, membrane-based treatment systems, biological nutrient removal, and resource recovery technologies, to enhance treatment efficiency, promote water reuse, and reduce energy consumption.

The transition towards digital water governance should also be accelerated through the integration of OCEMS, Internet of Things (IoT)-enabled sensors, GIS-based decision-support platforms, and artificial intelligence (AI) based predictive analytics to enable real-time compliance monitoring, pollution forecasting, and evidence-based regulatory decision-making. Together, these technological interventions can significantly reduce industrial pollutant loads, improve resource efficiency, strengthen regulatory compliance, and support the long-term restoration and sustainable management of water quality across the CRB.

6.5. Wastewater Reuse and Circular Economy Policies

Wastewater reuse and resource recovery should be integral components of industrial water management in the CRB to reduce dependence on freshwater resources and enhance water security. Water-intensive industries should maximise the reuse of treated wastewater by

adopting advanced treatment and recycling technologies, consistent with the Government of India's policy initiatives promoting circular water management.

Under AMRUT 2.0, the Government has envisaged reusing treated wastewater to meet 40% of the aggregate industrial water demand at the state level. At the same time, the National Framework for Safe Reuse of Treated Wastewater encourages the safe reuse of treated wastewater and the recovery of valuable resources wherever technically and economically feasible. Industries should therefore integrate water reuse with the recovery of salts, nutrients, energy, and other by-products, where applicable, to improve resource efficiency, reduce waste generation, minimise environmental impacts, and support the transition towards a circular economy in the CRB.

6.6. Compliance and Enforcement Policies

Strengthening compliance and enforcement is essential for improving industrial wastewater management and protecting water quality in the CRB. Regulatory authorities should adopt a risk-based inspection framework that prioritises industries according to their pollution potential, compliance history, wastewater characteristics, proximity to environmentally sensitive river reaches, and potential impacts on downstream water users. Rather than relying on uniform inspection schedules, high-risk industries and facilities with repeated non-compliance should be subjected to more frequent inspections and continuous surveillance. In contrast, consistently compliant industries may be inspected at longer intervals, thereby optimising regulatory resources.

In parallel, a basin-wide environmental performance rating system should be established to evaluate industries using objective indicators, including compliance with effluent discharge standards, operational performance of effluent treatment plants, water-use efficiency, reuse of treated wastewater, adoption of cleaner production technologies, and resource recovery practices. The annual public disclosure of environmental performance through industry rankings, compliance status, and pollution performance scorecards would enhance transparency, encourage voluntary compliance, improve corporate environmental accountability, and provide stakeholders with reliable information on industrial environmental performance across the CRB.

6.7. Research, Capacity Building and Public Participation

Strengthening research, institutional capacity, and stakeholder participation is fundamental to achieving sustainable industrial wastewater management in the CRB. Collaborative research should be promoted among leading academic and research institutions, including the Indian Institute of Science, Bengaluru, the National Institute of Technology, Tiruchirappalli, and state universities, with emphasis on emerging contaminants, advanced wastewater treatment technologies, resource recovery, industrial water reuse, and AI-based water quality monitoring and pollution forecasting. Regular capacity-building programmes should be organised for industry personnel, CETP operators, regulatory agencies, and urban local bodies to strengthen technical expertise in wastewater treatment, environmental monitoring, regulatory compliance, and digital data management.

Furthermore, a basin-wide stakeholder engagement framework should promote transparent environmental governance through public access to water quality and compliance data, citizen-based reporting mechanisms, structured dialogue among industries, regulatory agencies, local governments, and civil society organisations, and community awareness programmes to foster public participation in river conservation. Such collaborative and participatory approaches are consistent with the principles of integrated water resources management. They are essential for improving environmental compliance, strengthening institutional coordination, and ensuring the long-term ecological sustainability of the CRB.

6.8. Expected Outcomes

The implementation of the proposed policy interventions is expected to substantially improve industrial wastewater management and contribute to the long-term ecological sustainability of the CRB. Strengthened regulatory enforcement, adoption of advanced wastewater treatment technologies, enhanced water reuse and resource recovery, and basin-wide digital monitoring systems are anticipated to reduce industrial pollutant loads entering the river and its tributaries, thereby improving compliance with prescribed effluent discharge standards. Increased adoption of water-efficient technologies and circular economy practices will reduce industrial freshwater abstraction, enhance water security, and improve resource efficiency across major industrial clusters.

Risk-based inspections, real-time monitoring, and transparent environmental performance assessments are expected to strengthen regulatory compliance, increase industrial accountability, and facilitate evidence-based decision-making. Furthermore, collaborative

research, institutional capacity building, and active stakeholder participation will foster innovation, strengthen governance, and promote integrated river basin management. Collectively, these interventions will contribute to improved river water quality, enhanced ecosystem health, sustainable industrial development, and greater resilience of the CRB, while supporting national objectives for water conservation, pollution prevention, and sustainable development.

7. Summary

The industrial wastewater management plan for the CRB provides a basin-scale framework for reducing industrial pollutant loads, improving wastewater treatment and compliance, increasing safe reuse of treated water, strengthening hazardous-residue management, and improving monitoring and institutional accountability. Implementation should follow a risk-based and adaptive approach, beginning with the establishment of a verified industrial and wastewater baseline and progressing through treatment and collection-system improvements, water reuse, advanced treatment where justified, strengthening of residue management, and periodic performance evaluation. Given the interstate nature of the basin, effective implementation requires coordinated action among regulatory authorities, industries, infrastructure agencies, local authorities, research institutions and communities. Progress shall be assessed against verified baselines, approved targets, defined responsibilities and measurable environmental outcomes.

8. Recommendations and Role of Stakeholders

The successful implementation of the industrial wastewater management plan for the CRB requires coordinated participation by multiple stakeholders across the basin, state, district, cluster, and industry levels (Table 13). Effective wastewater management cannot be achieved solely through regulatory enforcement; it requires collective action involving industries, government agencies, local authorities, research institutions, financial organisations, civil society groups, and local communities.

Given the interstate nature of the CRB, stakeholder coordination is particularly important to ensure harmonised policies, consistent monitoring, effective compliance mechanisms, and equitable sharing of responsibilities. The stakeholder framework proposed under the cCauvery program seeks to establish clear institutional roles while promoting accountability, transparency, and collaborative decision-making.

Table 13. Roles and responsibilities of key stakeholders in industrial wastewater management in the CRB

Agencies	Key Responsibilities
CPCB	a. Formulation of industrial discharge standards b. Development of monitoring protocols and guidelines c. Oversight of OCEMS d. Coordination with SPCBs e. Environmental compliance assessment f. Periodic performance audits of CETPs and ZLD facilities g. Technical support for pollution control initiatives h. Development of national-level pollution databases
KSPCB	a. Monitoring industrial compliance in Karnataka b. Inspection of industrial facilities c. Consent management and enforcement d. Monitoring of industrial clusters in Bengaluru, Mysuru, and Mandya e. Management of OCEMS data f. Coordination with local authorities and industries
TNPCB	a. Monitoring of industrial clusters in Tiruppur, Erode, Karur, Salem, Namakkal, Mettur, and Tiruchirappalli b. Regulation of CETPs and ZLD facilities c. Industrial wastewater compliance assessment d. Hazardous waste management oversight
Kerala State Pollution Control Board (Kerala SPCB)	a. Monitoring industrial activities within the Kerala portion of the basin b. Groundwater quality surveillance c. Industrial wastewater compliance monitoring d. Coordination with basin-level authorities
Karnataka Industrial Areas Development Board (KIADB), State Industries Promotion Corporation of Tamil Nadu (SIPCOT), Kerala Industrial	a. Development of industrial infrastructure b. Provision of land for CETPs and TSDFs c. Promotion of environmentally sustainable industrial development d. Facilitation of wastewater management projects

Infrastructure Development Corporation (KINFRA)	e. Support for industrial symbiosis and resource recovery initiatives
Municipal Corporations, Municipal Councils, District Collectorates, District Environmental Committees	a. Coordination of industrial and municipal wastewater systems b. Land allocation for environmental infrastructure c. Support for pollution monitoring programs d. Emergency response coordination
CWC	a. River flow monitoring b. Hydrological assessments c. Support for environmental flow evaluations d. Integration of water quantity and quality assessments
State Water Resources Departments	a. River basin planning b. Water allocation management c. Integration of pollution control measures into water resource planning
Central Ground Water Board (CGWB)	a. Groundwater quality monitoring b. Aquifer vulnerability assessments c. Contamination risk evaluation d. Development of groundwater protection strategies
State Groundwater Departments	a. Regional groundwater surveillance b. Groundwater quality assessments near industrial clusters c. Monitoring of landfill and hazardous waste facilities
Indian Institute of Science, Bengaluru, National Institute of Technology Tiruchirappalli, State Universities and Research Centres	a. Technology development and validation b. Water quality modelling c. AI and GIS applications d. Emerging contaminant studies e. Capacity building and training
Civil Society Organizations and Communities	a. Community-based monitoring b. Reporting pollution incidents c. Public awareness and education d. Participation in stakeholder consultations e. Support for river conservation initiatives

The active participation of all stakeholders will create a collaborative governance framework for industrial wastewater management within the CRB. Clearly defined roles, coordinated monitoring, transparent information sharing, and shared accountability will facilitate effective pollution control, increased wastewater reuse, improved compliance, and long-term protection of the basin's water resources. Through this stakeholder-driven approach, the cCauvery Program can achieve its objectives of river restoration, ecological sustainability, and water security while supporting responsible industrial development across the basin.

9. Significance of the Report

This report focuses on the assessment and management of industrial wastewater within the CRB. It covers industrial clusters and wastewater-generating activities across Karnataka, Tamil Nadu, Kerala and Puducherry that may affect the Cauvery River, its tributaries or connected groundwater. For Karnataka, the immediate planning value is to establish defensible baselines and targeted measures for the Arkavathi-Vrishabhavathi/Bengaluru corridor, the Kabini-Mysuru-Nanjangud region, and the Mandya-Cauvery reach, with a focus on treatment reliability, pollutant load reduction, safe reuse, and hazardous residue traceability. The same evidence standards should be applied across the basin so that inter-State comparisons are based on like-for-like monitoring. The report provides a practical pollution-control roadmap but does not adjudicate water-sharing rights, determine return-flow accounting, or create cross-border enforcement powers.

10. Implementation Framework and Data Requirements

10.1. Scope, Method and Limitations

The implementation boundary shall include industrial units, industrial estates, CETPs, ETPs, ZLD facilities, authorised recyclers, TSDFs, secure landfills and industrial discharge pathways that can affect surface water or groundwater within the CRB. The analysis shall distinguish industrial pollution from municipal sewage while assessing cumulative impacts on receiving waters. Implementation under this plan shall be without prejudice to the Cauvery Water Disputes Tribunal Award as modified by the Supreme Court, the Cauvery Water Management Scheme and the statutory jurisdiction of the party States, CPCB/SPCBs/PCC and other competent authorities. No pollution-control recommendation in this report shall be used, by itself, to infer or alter any State's allocated share, water entitlement, release obligation or accounting treatment of return flows.

All quantitative values shall state the source, reference year, unit, spatial coverage and confidence or validation status. Estimates shall be identified separately from measured data and shall document the calculation method.

10.2. Cluster Baseline and Gap Assessment

The priority industrial clusters identified in the CRB were further assessed using their priority category, wastewater generation, treatment capacity gap, compliance status, and major pollutants of concern. The cluster-level assessment framework is presented in Table 14. The assessment is intended to provide a common basis for identifying treatment deficiencies, compliance risks, and pollutant management priorities across industrial clusters. Where validated quantitative data on wastewater generation, treatment gaps, and compliance are not currently available, these parameters are identified as unavailable. They should be established through the verified baseline assessment described in Section 10.1.

The present industrial cluster assessment primarily identifies candidate priority clusters in Karnataka and Tamil Nadu. Still, the existing evidence is insufficient for a final comparative ranking because verified wastewater flows, treatment gaps, compliance rates and flow-weighted pollutant loads are incomplete. During the 0-12-month baseline phase, Karnataka should establish a KSPCB-led, verified inventory for the Bengaluru/Arkavathi-Vrishabhavathi, Nanjangud-Kabini, Mysuru-Kabini, and Mandya-Cauvery clusters, using consent records, OCEMS where applicable, accredited laboratory data, water balances, and treatment-plant performance records. This Karnataka baseline should be completed on the same data template used for other States, enabling defensible comparison without prejudging relative responsibility. Kerala and Puducherry remain within the implementation boundary, and their industrial units, discharge pathways and treatment infrastructure should likewise be verified before assigning any additional priority category.

Karnataka implementation priority: the first-year programme should produce a public, auditable Karnataka industrial wastewater baseline covering unit inventory; permitted and actual water use; wastewater generation; ETP/CETP design and effective capacity; bypass/downtime incidents; OCEMS availability where mandated; flow-weighted pollutant loads; groundwater risk; and authorised residue destinations. This will strengthen the regulatory position by replacing assumptions with verified evidence and by demonstrating measurable pollution-abatement performance without conceding any issue of interstate water entitlement.

Table 14. Cluster-level baseline and treatment gap assessment for priority industrial clusters in the CRB

Cluster	Priority Category	Wastewater (MLD)	Treatment Gap (MLD)	Compliance (%)	Priority Pollutants / Load (kg/day)
Bengaluru Industrial Corridor (Peenya, Bommasandra, Electronic City, Whitefield) Sub-basin: Arkavathi–Vrishabhavathi	Category I (High Priority)	To be established in the 0–12-month verified baseline phase.	To be calculated from verified wastewater generation and effective operational treatment capacity.	To be established from SPCB inspection, OCEMS and consent-compliance records.	Heavy metals (sector-specific — electronics, pharma, engineering); solvents; pharmaceutical residues; organic pollutants. Pharmaceutical waste; solvents; heavy metals. Quantified loads (kg/day): to be established from flow-weighted monitoring.
Nanjangud Industrial Cluster Sub-basin: Kabini	Category I (High Priority)	To be established in the 0–12-month verified baseline phase.	To be calculated from verified wastewater generation and effective operational treatment capacity.	To be established from SPCB inspection, OCEMS and consent-compliance records.	High COD; toxic organics; solvents; process chemicals. Chemical residues; pharmaceutical waste; sludge. Quantified loads (kg/day): to be established from flow-weighted monitoring.
Mysuru Industrial Region	Category III (Emerging)	To be established in the 0–12-month	To be calculated from verified	To be established from SPCB inspection,	Mixed industrial wastewater; suspended

Sub-basin: Kabini		verified baseline phase.	wastewater generation and effective operational treatment capacity.	OCEMS and consent-compliance records.	solids; organic pollutants. Quantified loads (kg/day): to be established from flow-weighted monitoring.
Mandya Industrial Cluster (Sugar and Distillery) Sub-basin: Upper Cauvery	Category II (Moderate Priority)	To be established in the 0–12-month verified baseline phase.	To be calculated from verified wastewater generation and effective operational treatment capacity.	To be established from SPCB inspection, OCEMS and consent-compliance records.	High BOD; COD; nutrients; spent wash (distilleries). Quantified loads (kg/day): to be established from flow-weighted monitoring.
Tiruppur Textile Cluster Sub-basin: Noyyal	Category I (High Priority)	To be established in the 0–12-month verified baseline phase.	To be calculated from verified wastewater generation and effective operational treatment capacity.	To be established from SPCB inspection, OCEMS and consent-compliance records.	High TDS; colour; COD; dissolved salts. Salt residues; dye sludge; RO reject concentrates. Quantified loads (kg/day): to be established from flow-weighted monitoring.
Erode Textile Cluster Sub-basin: Bhavani	Category I (High Priority)	To be established in the 0–12-month verified baseline phase.	To be calculated from verified wastewater generation and effective operational treatment capacity.	To be established from SPCB inspection, OCEMS and consent-compliance records.	High TDS; colour; dyes; organic pollutants. Dye sludge; chemical residues; recovered salts. Quantified loads (kg/day): to be established from flow-

					weighted monitoring.
Karur Textile Cluster Sub-basin: Amaravathi	Category II (Moderate Priority)	To be established in the 0–12-month verified baseline phase.	To be calculated from verified wastewater generation and effective operational treatment capacity.	To be established from SPCB inspection, OCEMS and consent-compliance records.	High TDS; colour; dyes; organic pollutants. Sludge; evaporator salts; chemical residues. Quantified loads (kg/day): to be established from flow-weighted monitoring.
Salem Industrial Cluster (Steel, Chemical, Engineering) Sub-basin: Thirumanimuthar	Category II (Moderate Priority)	To be established in the 0–12-month verified baseline phase.	To be calculated from verified wastewater generation and effective operational treatment capacity.	To be established from SPCB inspection, OCEMS and consent-compliance records.	Heavy metals (sector-specific — steel and engineering); industrial chemicals; suspended solids. Metal-bearing sludge; chemical wastes. Quantified loads (kg/day): to be established from flow-weighted monitoring.
Namakkal–Pallipalayam Cluster (Poultry, Paper, Textile) Sub-basin: Cauvery Main Stem	Category II (Moderate Priority)	To be established in the 0–12-month verified baseline phase.	To be calculated from verified wastewater generation and effective operational treatment capacity.	To be established from SPCB inspection, OCEMS and consent-compliance records.	Organic pollutants; nutrients; suspended solids. Quantified loads (kg/day): to be established from flow-weighted monitoring.

Mettur Industrial Complex (Chemical, Fertilizer, Power) Sub-basin: Cauvery Main Stem	Category I (High Priority)	To be established in the 0–12-month verified baseline phase.	To be calculated from verified wastewater generation and effective operational treatment capacity.	To be established from SPCB inspection, OCEMS and consent-compliance records.	Chemical residues; high TDS; hazardous process wastewater. Chemical sludge; heavy metals; hazardous process waste. Quantified loads (kg/day): to be established from flow-weighted monitoring.
Tiruchirappalli Industrial Cluster (Heavy Engineering, Fabrication) Sub-basin: Cauvery Main Stem	Category II (Moderate Priority)	To be established in the 0–12-month verified baseline phase.	To be calculated from verified wastewater generation and effective operational treatment capacity.	To be established from SPCB inspection, OCEMS and consent-compliance records.	Metal-bearing wastewater; oils and grease; suspended solids. Quantified loads (kg/day): to be established from flow-weighted monitoring.

^aWastewater generation volume not available. Required from KSPCB (Karnataka clusters: Bengaluru, Nanjangud, Mysuru, Mandya) or TNPCB (Tamil Nadu clusters: Tiruppur, Erode, Karur, Salem, Namakkal–Pallipalayam, Mettur, Tiruchirappalli) consent-and-compliance records and CETP/ETP operational data returns. Data shall state reference year, spatial coverage (all regulated units within the cluster boundary), collection method (metered flow or water-balance audit) and validation status. Deadline: 0–12-month baseline phase, Section 10.4 Action 1.

^bTiruppur cluster - wastewater: MoT (2012) documents 450+ dyeing units and 16 of 18 CETPs operational; MoT (2016) documents ₹1,013 crore invested in 18 ZLD-enabled CETPs. Neither source states the cluster's wastewater generation volume in MLD. This footnote supplements ^a and does not replace the data-collection requirement stated therein.

^cTreatment gap not available and cannot be derived independently. Computable only after both inputs are established from SPCB-verified records: (i) wastewater generation volume (MLD), and (ii) CETP/ETP design and operational capacity (MLD) from CETP operators confirmed by the relevant SPCB. Formula: Treatment gap = Wastewater generation (MLD) - Effective operational treatment capacity (MLD). Deadline: 0–12-month baseline phase, Section 10.4 Action 1.

^dTiruppur cluster - treatment gap: MoT (2016) documents financial and technical difficulties with CETPs, indicating a treatment gap exists. However, neither MoT (2012), MoT (2016) nor CPCB (2014) quantifies this gap in MLD. This footnote supplements ^e and does not replace the data-collection requirement stated therein.

^eEffluent-standard compliance rate not available. Required from KSPCB or TNPCB inspection records, OCEMS validated data reports and consent-condition assessments for each cluster. Data shall state reference period, number of monitoring events, number of exceedances and applicable consent limits. Deadline: 0–12-month baseline phase, Section 10.4 Action 1.

^fTiruppur cluster - compliance: MoT (2016) documents financial and technical difficulties with CETPs; the TNPCB action plan (cited in this report) records non-compliance in the Noyyal basin. Neither source states a cluster-level effluent-standard compliance percentage. This footnote supplements ^e and does not replace the data-collection requirement stated therein.

^gPriority pollutant types are reproduced verbatim from Tables 1 and 5 of this report and represent the only cluster-level pollutant information currently available. Load quantities (kg BOD/day, kg COD/day, kg TDS/day, kg metals/day and sector-specific toxicants) are not available. Required from OCEMS flow-weighted mass-load calculation and NABL-accredited laboratory analysis at each cluster's effluent discharge points. Deadline: 0–12-month baseline phase, Section 10.4 Action 1.

10.3. Risk-Based Prioritisation

Clusters and projects shall be ranked using a documented multi-criteria risk-prioritisation assessment. Scores shall be supported by traceable evidence and reviewed by the competent state and basin-level authorities. The framework is informed by the CPCB Comprehensive Environmental Pollution Index (CEPI) and adapted to the specific requirements of industrial wastewater management in the CRB. The criteria and weights also reflect the explicit priority hierarchy established in the Preface, namely reducing major pollutant loads and exposure risks, protecting sensitive river reaches and groundwater, improving treatment reliability, and ensuring practical implementation.

Pollutant load and toxicity (25%) and compliance and treatment gap (25%) together form 50% of the total weight, corresponding precisely to CEPI's 50-point PE allocation. They are weighted equally because both determine the actual pollutant load delivered to the receiving water: the first captures the intrinsic toxicity and volume of what is generated at source, including the presence of heavy metals, persistent organics, dyes and pharmaceutical residues; the second captures the operational dimension, the fraction of that generated load that fails to be adequately treated, either because treatment capacity is insufficient or because installed treatment plants are underperforming or bypassed. A cluster generating a moderate load with a severe treatment gap poses the same river-quality risk as a high-load cluster with functioning

treatment; this pairing of criteria ensures that both risks are scored. Both directly align with the Preface priorities of reducing the largest pollutant loads and improving treatment reliability.

Receiving-water sensitivity (20%) corresponds to CEPI's ES component and to the Preface priority of protecting sensitive river reaches. It is set at 20% rather than CEPI's 25% ES allocation for reasons explained below. Still, it receives a 5% uplift over the residual share it would otherwise carry, reflecting the CRB's role as a multi-state source of drinking water, irrigation supply and ecological services across Karnataka, Tamil Nadu, Kerala and Puducherry, making receiving-water sensitivity a stronger discriminator here than in a generic national industrial-cluster assessment. The nine-priority river stretches identified in Table 11, including the Noyyal at Tiruppur, the Cauvery at Mettur and the Vrishabhavathi at Bengaluru, provide the spatial reference against which each cluster is scored on this criterion.

Groundwater and flood vulnerability (10%) is treated as a distinct ES sub-component rather than being subsumed within receiving-water sensitivity. This separation is justified by the fact that the CRB's alluvial and hard-rock aquifer systems, monitored through the CGWB programme and the observation-well network specified in Table 12 of this report, represent an independent exposure pathway from surface-water impact: contamination can reach groundwater through leachate migration from TSDFs and secure landfills without producing a detectable surface-water signal. Flood vulnerability is included in this criterion because the siting and design requirements for secure landfills in Section 4.1.3 and the emergency storage obligations in Section 10.8 of this report explicitly link flood inundation risk to the integrity of hazardous waste containment. Together, receiving-water sensitivity and groundwater and flood vulnerability sum to 30%, a deliberate 5% uplift over CEPI's combined 25% ES allocation, which is justified by the basin-wide ecological and public-health significance described above. This combined allocation corresponds to the Preface priority of protecting sensitive river reaches and groundwater.

Human exposure (15%) corresponds to CEPI's Population component and to the Preface's reference to exposure risks. It is set at 15% rather than CEPI's 25% P allocation because 5% has been reallocated to groundwater and flood vulnerability, which represents a distinct aquifer-dependent exposure pathway that warrants its own scoring criterion given Table 12's groundwater monitoring requirements, and another 5% has been assigned to implementation readiness, a planning constraint that is not present in the CEPI framework but is necessary in a multi-state, multi-agency programme of this scale. The primary scoring evidence for this criterion is the location and capacity of downstream drinking-water intakes and irrigation

abstractions identified for each cluster in Table 11 and the river monitoring framework in Section 5.3.

Implementation readiness (5%) has no equivalent in the CEPI framework. It is added as a practical planning constraint specific to the context, where sequencing investments across Karnataka and Tamil Nadu requires explicit consideration of land availability, existing approvals, operator technical capacity and the time between project preparation and the realisation of measurable environmental benefit. Without this criterion, risk scoring alone could direct the earliest resources to clusters that are technically the highest priority but practically the furthest from implementation, undermining the adaptive approach required by the Preface. At 5%, it is the least-weighted criterion and cannot alter the rank order of any cluster on pollution load or environmental sensitivity grounds alone.

The six criteria collectively provide a 100-point prioritisation framework for the CRB. The weights are intended to provide a transparent basis for comparing industrial clusters and proposed interventions after the verified baseline is completed. Until quantitative baseline data and criterion-specific scores are established, the Category I, II and III classifications presented in Section 2.2.3 shall be treated as provisional implementation priorities based on the current qualitative assessment. The final quantitative ranking shall be undertaken during the baseline phase using verified data on wastewater generation, pollutant loads, treatment performance, compliance, receiving-environment sensitivity, exposure, and implementation readiness.

Table 15. Criteria and weighting framework for industrial cluster risk prioritisation

Criterion	Weight	Relationship to CEPI Framework	Alignment with Report Preface
Pollutant load and toxicity	25%	Addresses the source-side pollution burden, including pollutant quantity, toxicity and sector-specific contaminants. It is informed by the source/pollution dimension of the CEPI framework but is adapted for industrial wastewater risk assessment in the CRB.	Directly supports the Preface priority of reducing the largest pollutant loads.

Compliance and treatment gap	25%	Addresses treatment adequacy, operational performance and the proportion of wastewater or pollutant load not adequately treated. It is related to the compliance and pollution-control dimensions of the CEPI framework but is adapted to cluster-level wastewater management.	Directly supports the Preface priority of improving treatment reliability.
Receiving-water sensitivity	20%	Represents the environmental receptor and receiving-water dimension, including proximity to sensitive river stretches, drinking-water sources, irrigation abstractions and ecologically important reaches.	Directly supports the Preface priority of protecting sensitive river reaches.
Human exposure	15%	Represents potential exposure of downstream populations through drinking-water abstraction, irrigation use and other relevant pathways. It is informed by the population/exposure dimension of environmental risk assessment.	Directly supports the Preface priority of reducing exposure risks.
Groundwater and flood vulnerability	10%	Represents an additional CRB-specific vulnerability pathway covering aquifer contamination, flood exposure and the vulnerability of hazardous-waste/treatment infrastructure.	Directly supports the Preface priority of protecting groundwater and reducing environmental vulnerability.

Implementation readiness	5%	Not a CEPI component. Added as a planning criterion to assess feasibility of implementation, including land, approvals, institutional capacity and infrastructure readiness.	Supports the Preface requirement for measurable and implementable interventions and adaptive implementation.
Total	100%		

Note: The above weighting framework is a CRB-specific risk-prioritisation approach informed by the principles of the CPCB Comprehensive Environmental Pollution Index (CEPI) and the management priorities established in the Preface. It is not intended to reproduce or replace the official CPCB CEPI scoring methodology. Implementation readiness is an additional planning criterion introduced specifically for prioritising interventions under this management plan.

10.4. Time-Bound Implementation Programme

Implementation shall proceed through a phased, time-bound programme, beginning with the development of a verified baseline and progressing through treatment and collection-system improvements, water reuse, strengthening of residue management, selective application of advanced treatment, and periodic outcome evaluation. The sequencing is intended to ensure that infrastructure and regulatory interventions are based on verified wastewater generation, treatment capacity, compliance status, pollutant loads and receiving-environment risks. Each action shall have an identified accountable lead, an approved financing mechanism, a defined milestone and documentary evidence of completion.

The first 12 months shall focus on establishing the verified baseline, including industrial inventory, industrial water use, wastewater generation, discharge locations, treatment performance and compliance. The subsequent 1–3-year period shall prioritise the rehabilitation of underperforming Effluent Treatment Plants (ETPs) and Common Effluent Treatment Plants (CETPs), the closure of collection and conveyance gaps, treated-water reuse, and the strengthening of authorised residue-management capacity. During years 3–5, ZLD or minimum-liquid-discharge projects shall be implemented selectively where site-specific

feasibility, applicable regulatory requirements and environmental benefits justify such interventions. Beyond five years, infrastructure capacity and environmental outcomes shall be reviewed against industrial growth, climate risks, river response and revised regulatory standards.

Progress shall be reviewed periodically using the performance indicators specified in Section 10.6, with independent outcome evaluation at appropriate intervals. Where baseline values or quantitative targets are not yet available, these shall be established during the initial baseline phase and formally incorporated into the implementation monitoring framework.

Table 16. Time-bound implementation programme for industrial wastewater management in the CRB

Period	Action	Accountable lead	Cost/funding	Milestone/evidence
0–12 months	Complete verified industrial inventory, water audits, discharge/outfall mapping and ETP/CETP treatment-performance audits.	KSPCB/TNPCB with industrial agencies, CETP/ETP operators and relevant local authorities.	Regulatory programme budgets; industry/CETP contributions; approved public financing where applicable.	Validated baseline database, water-use/wastewater inventory and priority hotspot register approved.
0–12 months	Establish OCEMS and laboratory QA/QC protocols and a non-compliance response workflow.	CPCB and KSPCB/TNPCB.	Regulatory monitoring budgets; applicable industry/service charges.	Approved monitoring and QA/QC protocol; designated responsible officers; documented escalation workflow.
1–3 years	Rehabilitate underperforming ETPs/CETPs and close priority wastewater collection and conveyance gaps.	Relevant SPCB, industrial development agency and ETP/CETP operator.	Industry contributions/user charges; approved public financing mechanisms for eligible	Treatment capacity and operational performance aligned with verified cluster demand and applicable consent requirements.

			infrastructure.	
1–3 years	Implement fit-for-purpose treated-water reuse and water-efficiency projects in priority clusters.	Industries/CET P operators with SPCBs and industrial development agencies.	Industry investment; treated-water tariff/offtake arrangements; approved financing mechanisms.	Verified water balance, defined reuse end uses and progressive increase in treated-water reuse from the established baseline.
1–3 years	Strengthen authorised storage, transport, TSDF and treatment/recovery capacity for hazardous residues.	SPCBs, authorised facility operators and waste generators.	Generator charges, operator investment and approved financing mechanisms.	Adequate authorised capacity, manifest-based traceability and verified treatment/recovery/disposal pathways.
3–5 years	Implement selective ZLD or minimum-liquid-discharge projects where feasibility, environmental risk and applicable regulation justify them.	Industries/CET P operators with SPCB oversight.	Project-specific industry/CETP investment and approved financing mechanisms.	Verified water/recovery balance, residue-management plan and compliance performance for each approved project.
5–10 years	Review infrastructure and management measures against industrial growth, climate risk, river response and revised environmental standards.	Designated basin coordination mechanism with CPCB, SPCBs and state agencies.	Approved basin programme budget and participating agency/industry financing.	Five-year independent outcome evaluation and revised implementation plan.

10.5. Financing and Cost Recovery

Each proposed intervention shall be supported by a lifecycle financial assessment covering capital expenditure (CAPEX), operation and maintenance expenditure (OPEX), energy consumption, chemical requirements, membrane replacement, staffing, laboratory monitoring,

sludge and residue management, maintenance, contingency requirements, and, where applicable, closure or rehabilitation costs. The financial assessment shall be prepared at the project or facility level, using site-specific engineering designs, verified wastewater flows, and treatment requirements, rather than applying a uniform cost estimate across industrial clusters.

The financing framework shall distinguish between pollution-control infrastructure that is primarily the responsibility of industrial generators and public-good infrastructure that provides broader environmental monitoring, basin-level information, or protection of the receiving environment. Industrial units and CETP operators shall bear applicable treatment, compliance, operation and maintenance costs in accordance with the relevant regulatory and institutional arrangements. User charges, treated-water offtake agreements, and generator charges may be used to support cost recovery for shared wastewater treatment, water reuse, and residue management infrastructure. Public financing mechanisms may be considered for eligible public-good components, subject to applicable government schemes, approvals and funding guidelines.

For each proposed investment, the project implementing agency shall prepare a detailed project report (DPR) or an equivalent engineering and financial assessment that establishes the CAPEX, annual OPEX, financing requirement, expected cost recovery, implementation period, and long-term financial sustainability. Cost estimates shall be updated at the project-preparation stage and reviewed periodically to account for changes in construction costs, energy prices, treatment technology, regulatory requirements and industrial wastewater characteristics.

The proposed financing and cost-recovery framework for the principal investment packages is presented in Table 17.

Table 17. Indicative financing and cost-recovery framework for industrial wastewater management

Investment package	CAPEX	OPEX	Proposed funding/cost recovery
CETP/collection upgrade	Site-specific DPR and detailed engineering estimate	Annual O&M estimate from DPR	Industry contribution/user charges; approved public financing mechanisms for eligible public-good components.
Monitoring and data platform	System design, sensors/OC	Annual monitoring, connectivity,	Regulatory programme budgets; applicable service fees; other approved sources.

	EMS integration and data-platform DPR	calibration, QA/QC and maintenance cost	
Reuse network	Site/cluster-specific water-reuse network DPR	Annual pumping, treatment, monitoring and maintenance cost	Treated-water tariff/offtake agreement; industry investment; other approved sources.
TSDF/residue capacity	Facility-specific feasibility study and DPR	Annual operation, monitoring, residue handling and closure provision	Waste-generator charges and authorised operator investment; other approved sources.

10.6. Monitoring, Data Quality and Enforcement

Effective monitoring, data quality assurance and enforcement are essential for ensuring that industrial wastewater management measures are implemented consistently and that reported environmental performance is reliable and verifiable. The monitoring and compliance framework shall therefore cover the following key requirements:

- Monitoring plans shall define sampling points, parameters, analytical methods, minimum frequency, responsible laboratory, reporting deadline and escalation threshold for each industry and facility.
- Quality assurance shall cover instrument calibration, laboratory accreditation, detection limits, blanks, duplicates, chain of custody, data validation, OCEMS downtime, tamper detection and independent audit.
- The data platform shall retain raw and validated data, maintenance logs, exceedance events, corrective actions and final closure evidence. Public disclosure shall protect legitimately confidential information while reporting compliance status and environmental performance.
- Alert, warning, and action thresholds, response times, responsible officers, escalation procedures, and appeal/review arrangements shall be defined in the approved compliance before implementation.

The implementation programme shall be monitored using a defined set of Key Performance Indicators (KPIs) covering monitoring-system performance, effluent compliance, pollutant-load reduction, treatment-plant operation, freshwater withdrawal, treated-water reuse and hazardous-residue management. The baseline, time-bound targets, monitoring frequency and verification mechanisms for these indicators are presented in Table 18.

Table 18. KPIs and verification framework for industrial wastewater management

KPI	Baseline	Time-bound target	Frequency	Verification
OCEMS data availability	Baseline established during 0–12-month phase.	Annual target approved from validated baseline; progressive improvement in data availability and reduction of unexplained downtime.	Monthly	Validated uptime/downtime logs, calibration and connectivity records.
Effluent-standard compliance	Cluster/facility baseline established from consent and validated monitoring records.	Progressive improvement to full compliance with applicable consent and statutory standards, subject to regulatory requirements.	Monthly/quarterly	Validated samples, OCEMS records and consent-condition assessment.
Pollutant-load reduction	Flow-weighted cluster pollutant-load baseline established.	Cluster-specific reduction target approved after baseline and risk assessment.	Quarterly/annual	Flow-weighted mass-load calculation and accredited laboratory data.
CETP/ETP uptime	Facility-specific operational baseline established.	Facility-specific uptime target approved after performance audit; sustained reliable operation and	Monthly	Operating logs, maintenance records and independent audit.

		documented downtime.		
Freshwater withdrawal	Cluster/industry water balance established.	Progressive reduction from baseline through water efficiency, recycling and fit-for-purpose reuse.	Monthly/annual	Calibrated meters, water balance and audit records.
Treated-water reuse	Verified treated-water reuse baseline established.	Progressive increase from baseline based on safe, fit-for-purpose demand and applicable quality requirements.	Monthly/annual	Water-quality records, reuse/offtake records and water balance.
Hazardous residue traceability	Baseline traceability system established.	Complete traceability from generation through authorised storage, transport, treatment/recovery and disposal.	Monthly/annual	Manifest reconciliation, authorised receipts and facility records.

10.7. ZLD and Water-Reuse Decision Protocol

ZLD shall not be applied as a uniform default. Selection among enhanced conventional treatment, partial recovery, minimum liquid discharge, and ZLD shall be based on applicable regulations and a site- and sector-specific assessment of pollutant characteristics, water stress, reuse demand, energy, land, lifecycle cost, concentrate management, and operator capability.

For each proposed ZLD facility, the approved feasibility assessment shall document the complete water and contaminant mass balance, expected RO recovery, evaporator/crystalliser yield, energy use, greenhouse-gas implications, salt quality and potential end use, non-recoverable residue quantity, authorised disposal route, backup storage, financial sensitivity and contingency arrangements.

Reuse projects shall specify the intended end use, applicable quality criteria, additional treatment or disinfection, storage and distribution controls, occupational/public-health safeguards, monitoring and responsibility at the point of use.

For stakeholder States, treated-water reuse targets under this plan are pollution-control and water-efficiency measures only. They shall not assume how recycled, regenerated, non-consumptive or return flows are to be counted for inter-State Cauvery allocation purposes. Questions concerning implementation or accounting under the Cauvery Award/Scheme should be placed before the legally competent CWC/CWMA/CWRC mechanisms, consistent with the Supreme Court's 13 November 2025 judgment (2025 INSC 1343), while KSPCB and other environmental regulators continue to determine compliance with treatment and discharge standards within their statutory remit.

10.8. Climate, Emergency and Social Safeguards

Industrial wastewater management infrastructure shall be designed and operated to remain resilient to climate-related hazards, operational emergencies and potential impacts on workers, downstream users and affected communities. The implementation framework shall therefore incorporate the following climate, emergency-response and social safeguards:

- Facilities shall assess flood inundation, extreme rainfall inflows, drought and low-flow conditions, heat, power interruptions, and access disruptions. Designs shall provide appropriate hydraulic reserve, emergency storage, backup power and controlled shutdown capability.
- Each high-risk facility and cluster shall maintain a spill-response plan covering detection, isolation, containment, notification, downstream warning, mutual aid, recovery, remediation, incident investigation and drill frequency.
- The emergency plan shall document emergency contacts, notification time limits, available containment volume, sensitive downstream receptors, alternative water-supply arrangements and the annual drill schedule.
- Implementation shall address worker health and safety, downstream drinking water and irrigation users, vulnerable communities, land or livelihood impacts, grievance reporting, and public disclosure of material pollution incidents.

10.9. Governance, Review and Change Control

The stakeholder roles and functional responsibilities described in Section 8 provide the institutional basis for implementation. The governance framework in Section 10.9 is intended to coordinate information, investment, and performance reviews; it does not confer new regulatory powers on cCauvery, NRCD, or any basin coordination forum. Project approvals, consent decisions, enforcement, penalties and directions remain with the authorities legally competent to exercise those functions. Issues concerning the implementation of the Cauvery water-sharing award or Scheme remain within the legally established Cauvery/Central water-management mechanisms. They are not to be decided by this industrial wastewater plan.

The basin-level mechanism should therefore issue recommendations, common data templates and annual performance summaries rather than purport to exercise consent, enforcement, allocation or adjudicatory powers. Participation in basin coordination shall not constitute a waiver by any state of statutory, constitutional or adjudicated right, contention or remedy.

Table 19. Governance, review and change-control framework for industrial wastewater management

Level	Core responsibility	Accountable body	Review frequency
Basin coordination	Recommend basin-wide pollution-control priorities for consideration by the competent authorities; facilitate inter-State coordination and common data standards; collate verified performance information; and publish an annual basin performance report. The basin forum shall not approve State projects, issue consents, impose penalties or alter water allocations.	NRCD/CPCB with participating SPCBs/PCC and designated State/basin agencies, each acting within its legal mandate	At least annually
State implementation	Within the State's jurisdiction, approve or implement projects through the legally competent department/agency, enforce consent conditions, maintain verified industrial and compliance inventories, and take corrective/enforcement action under applicable law.	Respective SPCB/PCC and relevant State departments; for Karnataka, KSPCB and competent Karnataka departments/agencies	Quarterly
Cluster delivery	Operate shared infrastructure, maintain treatment and monitoring records, implement corrective actions and report performance.	Cluster entity/CETP operator and	Monthly

		participating industries	
Independent verification	Audit monitoring data, treatment performance, residue traceability and environmental outcomes.	Independent competent technical/audit body appointed through the approved governance mechanism	At least annually and as required for major projects/incidents

The management plan shall be reviewed annually and comprehensively revised at least once every five years, or earlier following a major pollution incident, material regulatory change, significant industrial expansion, failure to meet approved targets, or new evidence of environmental or public-health risk. Each revision shall maintain a documented change log specifying the section or provision modified, the reason for the change, the approving authority, the date of revision, the affected target or budget, and the supporting evidence.

10.10. Regulatory Compliance Matrix

Industrial wastewater management shall comply with the Water (Prevention and Control of Pollution) Act, 1974, as legally applicable in the concerned State, the Environment (Protection) Act, 1986 and Rules, applicable industry-specific effluent standards, valid consent conditions, hazardous-waste requirements, binding directions/orders and other applicable environmental and safety laws. This management plan is not a substitute for statutory consent, environmental clearance, authorisation or case-specific judicial/tribunal directions. Subsequent amendments and Central guidelines must be checked for commencement, territorial or State-specific applicability and any conditions of adoption before they are relied upon for a facility in the basin.

The compliance matrix shall therefore be reviewed against the latest applicable legal instruments before approval and at each major revision of the management plan. Particular attention shall be given to amendments to the Water (Prevention and Control of Pollution) Act, 1974, current consent-management requirements, amendments to the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016, applicable industry-specific effluent standards, online continuous monitoring requirements and emergency/chemical-safety provisions.

The following matrix provides the principal regulatory areas to be verified for implementation. The exact notification, amendment, consent conditions, and sector-specific standard applicable to each facility shall be confirmed by the competent authority before implementation.

Table 20. Regulatory compliance matrix for industrial wastewater management

Regulatory area	Principal legal/regulatory instrument	Facility-level requirement to be verified	Competent authority	Evidence/status
Water pollution and consent	Water (Prevention and Control of Pollution) Act, 1974, as amended; applicable consent guidelines and current consent conditions	Consent to Establish/Consent to Operate, discharge conditions, monitoring requirements, authorised discharge point and applicable standards	KSPCB/TNPCB, as applicable	Consent order; applicable fee/validity record or legacy renewal record, where relevant; inspection/verification record; monitoring data; and compliance status
Current consent framework	Control of Water Pollution Grant of Consent Amendment Guidelines, 2026, G.S.R. 63(E), dated 23 January 2026, as applicable	Confirm whether and to what extent the 2026 consent framework is legally operative for the concerned State/facility, including any State-specific adoption or applicability issue, and apply the current consent conditions actually issued by the competent Board.	CPCB/SPCB, as applicable	Applicable notification and consent documentation
Environmental standards	Environment (Protection) Act, 1986; Environment (Protection) Rules, 1986;	Parameter-wise discharge limits and applicable receiving-	MoEFCC/CPCB/SPCB	Applicable notification/standard and compliance assessment

	applicable industry-specific effluent standards and subsequent amendments	environment requirements		
CETP requirements	Applicable Environment (Protection) Rules/CETP standards, consent conditions and CPCB directions	Inlet and outlet standards, member-unit responsibilities, monitoring, conveyance and operational performance	CPCB/SPCB	CETP consent, monitoring data, inspection and performance records
Hazardous and other wastes	Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016, as amended, including the 2024 amendment	Authorisation, waste classification, storage, packaging, manifest, transport, treatment/recovery/disposal and record keeping	SPCB	Authorisation, manifests, receipts, facility records and annual returns
Online monitoring	Applicable CPCB/SPCB directions and consent conditions	OCEMS parameters, connectivity, uptime, calibration, data transmission, data validation and response to exceedances	CPCB/SPCB	OCEMS records, calibration certificates and validated data
ZLD and advanced treatment	Applicable sector-specific standards, consent conditions and	Applicability of ZLD, treatment configuration, water recovery, concentrate/residue	SPCB/CPCB, as applicable	Approved design, consent conditions, performance records

	CPCB directions	management and reuse		
Emergency and chemical safety	Applicable provisions of the Manufacture, Storage and Import of Hazardous Chemical Rules, 1989; Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996; Public Liability Insurance Act, 1991; applicable occupational-safety law; consent/authorisation conditions; and subsequent amendments	Emergency response plan, containment, notification, drills, worker protection and incident reporting	Competent state/district authorities and SPCB, as applicable	Approved emergency plan, drill records and incident reports

The legal and regulatory instruments listed above shall be verified against the latest Gazette notifications, official CPCB/SPCB/PCC directions, sector-specific standards and State-level applicability before approval of individual projects. Where a national amendment has differential State applicability, the operative position for Karnataka, Tamil Nadu, Kerala or Puducherry shall be separately confirmed by the competent authority. The compliance review should also check, where applicable, environmental-clearance conditions under the EIA Notification, 2006; the Manufacture, Storage and Import of Hazardous Chemical Rules, 1989; the Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996; the Public Liability Insurance Act, 1991; and binding orders of the Supreme Court, High Courts and National Green Tribunal. Any use of the precautionary principle, polluter-pays principle,

or environmental compensation must be tied to applicable law, binding precedent, and competent-authority action, and not treated as an automatic basin-level levy.

10.11. Source and Evidence Quality Requirements

Primary legal notifications, official CPCB/SPCB directions, applicable consent documents, audited facility records, accredited laboratory data and basin-specific peer-reviewed studies shall be preferred as sources of evidence. Homepage links, secondary document-sharing sites and sources not directly relevant to the CRB shall not be used as the principal basis for regulatory or quantitative claims.

References

1. Brema, J., Trivedi, S., Sherin, M., Dhotrad, D.S., Raj, K.G. and Samal, D., 2021. Urban growth impact on Cauvery river: a geospatial perspective. In *Geo-intelligence for sustainable development* (pp. 127-147). Singapore: Springer Singapore.
2. Chidambaram, S., Sarathidasan, J., Srinivasamoorthy, K., Thivya, C., Thilagavathi, R., Prasanna, M.V., Singaraja, C. and Napolian, M., 2018. Assessment of the hydrogeochemical status of groundwater in a coastal region of the Southeast coast of India. *Applied Water Science*, 8(1), p.27.
3. CPCB, 2014. Annual Report 2013–14. New Delhi: Ministry of Environment, Forest and Climate Change, Government of India.
4. Jahan, N., Tahmid, M., Shoronika, A.Z., Fariha, A., Roy, H., Pervez, M.N., Cai, Y., Naddeo, V. and Islam, M.S., 2022. A comprehensive review on the sustainable treatment of textile wastewater: zero liquid discharge and resource recovery perspectives—sustainability, 14(22), p.15398.
5. Manoj, K. and Padhy, P.K., 2015. Discourse and review of environmental quality of river bodies in India: an appraisal of physico-chemical and biological parameters as indicators of water quality—current World Environment, 10(2), p.537.
6. MoT, 2012. Tirupur First to Arrive at Zero Liquid Discharge Technology. Press Information Bureau, Government of India, 6 December 2012.
7. MoT, 2016. Central Government sanctions of Rs. 200.00 Crores for the Tirupur Dyeing Industry. Press Information Bureau, Government of India, 28 December 2016.
8. NMCG, 2022. National Framework on Safe Reuse of Treated Waste Water. New Delhi: Ministry of Jal Shakti, Government of India.
9. NPC, 2023. Water Audit – The Need of the Hour. New Delhi: National Productivity Council, Department for Promotion of Industry and Internal Trade, Ministry of Commerce and Industry, Government of India.
10. Rajakumari, S.P. and Kanmani, S., 2008. Environmental life cycle assessment of zero liquid discharge treatment technologies for textile industries, Tirupur--A case study. *Journal of Scientific and Industrial Research*, 67(6), p.461.
11. Rajalakshmi, D., Jagannathan, R. and Geethalakshmi, V., 2013. Uncertainty in seasonal climate projection over Tamil Nadu for 21st century. *African Journal of Agricultural Research*, 8(32), pp.4334-4344.

12. Ramesh Kumar, K. and Anbazhagan, V., 2018. Analysis and assessment of heavy metals in soils around industrial areas in Mettur, Tamil Nadu, India. *Environmental monitoring and assessment*, 190(9), p.519.
13. RamyaPriya, R. and Elango, L., 2022. Geogenic and anthropogenic impacts on the water quality of the Cauvery River. In *Riverine Systems: Understanding the Hydrological, Hydrosocial and Hydro-Heritage Dynamics* (pp. 149-170). Cham: Springer International Publishing.
14. Sellamuthu, K.M., Mayilswami, C., Valliammai, A. and Chellamuthu, S., 2011. Effect of textile and dye industrial pollution on irrigation water quality of Noyyal river basin of Tamil Nadu.
15. Shetty, P., Sophia, S. and Kodialbail, V.S., 2023. Zero liquid discharge technology strategies in Indian distilleries and pharmaceutical industries—a paradigm shift toward sustainability. In *Concept of Zero Liquid Discharge* (pp. 347-372). Elsevier.
16. PIB.
<https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=1985040&lang=2®=48> (Accessed 19 May 2026)
17. TNPCB. https://tnpcb.gov.in/PDF/About_Us/projects/PR-Stretches/Water-QA-MN-report/actionplan/PrsCauvery24919.pdf (Accessed 7 April 2026)
18. <https://cpcb.gov.in/> (Accessed 10 May 2026)
19. https://www.pcbassam.org/Report_on_Classification_of_Sectors_2025_1737901761.pdf (Accessed 21 May 2026)
20. https://www.greentribunal.gov.in/sites/default/files/news_updates/OA%2033%20of%202023%20Annexures%20by%20R7.pdf (Accessed 15 June 2026)

