Chapter 10
Environmental Impact Assessment and Environmental Management Plan

10.0 General

Water is an essential element in all the sustenance and developmental activities of the mankind and is required throughout the year. Water is also required for sustenance of the surrounding environment. Precipitation is the only source of fresh water supply which is however unevenly distributed both in space and time confined to mainly monsoon season i.e. June to October in the Indian Continent. As such, storages such as reservoirs/barrages to store flood waters along with the linking canal systems are necessary so that the availability of water could be ensured throughout the year for various requirements including drinking water. Though, such interventions increase the water availability to various developmental activities and lead to prosperity in the area, some adverse impacts attributable to them on the environment are also likely. As such, it is necessary to identify the adverse impacts along with the positive benefits of the link projects so as to draw appropriate plans to mitigate or ameliorate the anticipated adverse impacts on the environment while enhancing the beneficial impacts.

Major impact of the proposed Cauvery (Kattalai) -Vaigai - Gundar link project could be on account of land acquisition for construction of canal, rehabilitation and resettlement of the displaced population in the affected villages due to construction of the link canal, environmental impact due to formation of canal water body and introduction of irrigation in the command area enroute of the link canal. In order to identify both positive and adverse environmental impacts with their economic evaluation due to the proposed link project and to suggest appropriate measures to mitigate or ameliorate the anticipated adverse impacts on the environment, the Environmental Impact Assessment (EIA) study of the link project is required to be carried out. EIA is to be undertaken to ensure that the project is in compliance with the national environmental and social requirements. The comprehensive EIA study of the link project is planned to be carried out at pre-construction stage. Therefore, for the present, based on the available information for similar projects, general description and the proposed approach for EIA of the project, environmental

Management Plan and Environmental Monitoring Plan along with the tentative costs to implement the Environmental Management Plan are presented in the following paragraphs:

10.1 The proposed project

10.1.1 Project background

The scheme of linking the surplus river basins of Mahanadi and Godavari to the deficit basins of Krishna, Pennar, Cauvery and Vaigai comprising 9 link canals is the most important part of the Peninsular Rivers Development component of the National Perspective Plan formulated by the Govt. of India. Cauvery (Kattalai) - Vaigai-Gundar link project is the concluding link of the scheme. It envisages diversion of 2252 Mcum of water from Cauvery river at the proposed Kattalai barrage for providing domestic, industrial and irrigation benefits to basins south of Cauvery including Vaigai and Gundar in the districts of Karur, Tiruchirappalli, Pudukkottai, Sivaganga, Ramanathapuram, Virudhunagar and Thoothukudi in the State of Tamil Nadu.

The pre-feasibility report of the link project had been prepared by NWDA in 1996 followed by a feasibility report in 2004 which were circulated to the concerned States.

10.1.2 Project justification

Tamil Nadu is a southern Indian State wherein water scarcity is often felt in its various parts from year to year. For long, Tamil Nadu has been urging for early implementation of the interlinking of rivers proposals under National Perspective Plan to provide relief to its water scarce areas. As per the water balance studies carried out by NWDA for (i) various sub-basins of the Cauvery basin, (ii) the basin covering streams between Cauvery and Vaigai, (iii) Vaigai basin, (iv) the basin covering streams between Vaigai and Vaippar, (v) Vaippar basin and (vi) the basin covering streams between Vaippar and Kanyakumari concerning the State of Tamil Nadu covering the districts of Madurai, Dindigul, Karur, Tiruchirappalli, Pudukkottai, Thanjavur, Ramanathapuram, Sivaganga, Virudhunagar and Thoothukudi, it is found that almost all these areas are water short in the ultimate development scenario.

The link canal will provide irrigation to an extent of 448340 ha besides providing drinking and industrial water supply in the districts of Karur, Tiruchirappalli, Pudukkottai, Sivaganga, Ramanathapuram, Thoothukudi and Virudhunagar in Tamil Nadu. Thus, the link project will certainly help in improving the irrigation development and thereby economic prosperity in this region.

10.1.3 Project description

The Cauvery (Kattalai) -Vaigai – Gundar link project comprises of the following components:

i) An existing barrage at Kattalai across the river Cauvery with pond level 101.20 m.
ii) A head regulator on the flank of the extreme right bank with a designed discharge of 180.30 cumec.
iii) A link canal of length 256.82 km taking off from the proposed head regulator with FSL of 100.75 m and designed capacity of 108.30 cumec.
iv) Four tunnels for a cumulative length of 15.54 km located at RD 82.30 km (3.94 km), RD 104.10 km (6.04 km), RD 148.10 km (3.63 km) and RD 156.30 km (1.93 km).
v) 12 branch canals & 25 direct sluices to facilitate irrigation in the command area.
vi) Cross drainage (254) /cross masonry (162) and regulating works (48) across the link canal (Total 464 nos.). The regulating works include 12 branch canal regulators, 25 direct sluice regulators, 7 cross regulators & 4 canal escapes.
vii) Command area development of about 448340 ha in Karur, Tiruchirappalli, Pudukkottai, Sivaganga, Ramanathapuram, Thoothukudi and Virudhunagar districts.

10.2 Study area

The study area to be considered for the Environmental Impact Assessment study and preparation of Environmental Management Plan for the proposed Cauvery (Kattalai) - Vaigai - Gundar link project is given as under:

i) Area to be acquired for various project appurtenances

ii) 10 km on either side of the link canal.
iii) Command area of the project.

10.3 Legal status of the project

Water Resources Projects, when implemented provides immense benefits to the society in the form of increased availability of water for irrigation, domestic, industrial and other uses. On the other hand, these projects will have impacts, both positive and negative on the environment of the project area and in the vicinity and also affect the socio-economic conditions of the population in the region. Therefore, the project before implementation requires statutory clearance from the Ministry of Environment and Forests and Climate Change (MoEF&CC), Govt. of India. As stipulated in the Environmental Impact Assessment Notification of 14th Sept 2006, the Terms of Reference (ToR) for carrying out the Comprehensive Environmental Impact Assessment (CEIA) study of the project are required to be submitted to the MoEF&CC. In accordance with the approved ToRs, CEIA studies for the project are to be carried out to evaluate its beneficial and adverse impacts and draw appropriate Environmental Management Plan and Environmental Monitoring Plan.

As far as Cauvery (Kattalai) - Vaigai - Gundar link project is concerned, no new dam/reservoir is contemplated for diversion of water. The existing Kattalai barrage across Cauvery river will be utilised as off-taking structure. Therefore, no submergence issues are involved in the link project. However, some habitations get affected due to land acquisition for the link canal. These projects affected families are required to be resettled at the new locations. Therefore, with a view to compensate the Project Affected Families (PAFs) and ensure proper amenities in the resettlement colonies, an appropriate Rehabilitation and Resettlement (R&R) Plan is required to be evolved. A detailed R&R package shall be prepared in accordance with the 'National Rehabilitation & Resettlement Policy-2007 (NRRP-2007)' and the 'Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Bill, 2013' formulated by Department of Land Resources, Ministry of Rural Development (MoRD), Govt. of India. Due weightage shall also be given to the R&R Policy / Act of Tamil Nadu State and best of the provisions from the National/State Acts shall be adopted in the R&R package. The possibility of detouring the canal alignment to avoid its traverse through the affected habitations will however be studied at pre-construction stage.

The Cauvery (Kattalai) - Vaigai – Gundar link project requires about 107 ha of forest land and as such forest clearance under Forest (Conservation) Act, 1980 is required. A provision for afforestation in double the area in degraded forests of the region shall be kept as per the Forest (Conservation) Act, 1980. The project will also require techno-economic clearance from Central Water Commission; investment clearance from Ministry of Jal Shakti and consent to establish from Tamil Nadu Pollution Control Board under Water (Prevention and Control of Pollution) Act 1974 and the Air (Prevention and Control of Pollution) Act 1981.

10.4 Baseline environmental data

It is essential that the baseline levels of environmental parameters which could be significantly affected by the implementation of the project are to be ascertained before implementation of the project so that the project induced effects on these parameters can be properly estimated. The baseline status shall involve both field work and review of data collected from secondary sources. The baseline studies will consist of 3 seasonal studies (Pre monsoon, monsoon and winter) to cover the entire annual cycle accommodating seasonal variations on various parameters.

The baseline survey planning shall focus on short listing of impacts and identification of parameters for which the data needs to be collected. Baseline status will be ascertained for air environment, water environment, land environment, public health and biological (terrestrial and aquatic) environment.

10.4.1 Air environment

10.4.1.1 Ambient air quality

The likely sources of air pollution in the study area are emissions from vehicles, burning of fossil fuels, dust arising from unpaved village roads, construction activities and domestic fuel burning. The pollutants are either absorbed by the atmosphere or dispersed effectively. The prime objective of the baseline air quality study is to establish the existing ambient air quality of the area. The Central Pollution Control Board (CPCB)is executing a nation-wide programme of ambient air quality monitoring known as National Air Quality Monitoring Programme (NAMP)with the objective of assessing the status and

trend in the ambient air quality, evaluate air pollution levels, understand natural cleansing process and to develop ways and means for taking preventive and corrective measures. Under NAMP, four air pollutants viz., Sulphur Dioxide (SO_2), Oxides of Nitrogen as NO_2, Respirable Suspended Particulate Matter (RSPM / PM_{10}) and Fine Particulate Matter ($PM_{2.5}$/SPM) have been identified for regular monitoring. The major sources of SPM include soil borne dust, dust from construction activities, etc. NO_2 is formed in the atmosphere due to reaction of nitric oxide with ozone and hydrocarbons. Areas with high population and vehicular traffic give rise to high levels of NO_2. Sulphur dioxide (SO_2) is found in emissions of industries, diesel vehicles and domestic emissions from fossil fuel burning. The major sources of Respirable Suspended Particulate Matter (PM_{10}) are emissions from diesel vehicles and industries where combustion processes take place.

The testing methods that shall be followed for monitoring various ambient air quality parameters and their permissible levels at 24 hourly or 8 hourly monitored values as specified in 'National Ambient Air Quality Standards, 2009' for industrial, residential, rural and other areas are at **Table 10.1**.

Table 10.1
National Ambient Air Quality Parameters and their Standards

Parameter	Description	Methods of Measurement	Permissible Limit ($\mu g/m^3$)
PM_{10}	Respirable Suspended Particulate Matter	Gravimetric/TOEM/ Beta Attenuation methods	100
$PM_{2.5}$	Suspended Particulate Matter	Gravimetric/TOEM/ Beta Attenuation methods	60
SO_2	Sulphur dioxide	Improved West & Gaeke / Ultraviolet Fluorescence methods	80
NO_2	Oxides of Nitrogen	Modified Jacob & Hochheiser /Chemiluminescence methods	80

Source: 'National Ambient Air Quality Standards, 2009', CPCB

The National Ambient Air Quality Monitoring Programme (NAMP) data of CPCB for the year 2017 for Madurai, Tiruchirappalli and Tuticorin (Thoothukudi) cities in and vicinity of the project area is given in **Table 10.2**.

Table 10.2
NAMP data for 2017 in and vicinity of the project Area

City	Location	SO_2 $\mu g/m^3$	NO_2 $\mu g/m^3$	PM_{10} $\mu g/m^3$	$PM_{2.5}$ $\mu g/m^3$
	Standards	**50**	**40**	**60**	**40**
Madurai	Highway (Project-I) Building	9	17	53	24
	Fenner (I) Ltd., Kochadai	15	24	68	31
	Kunnathur Chatram Avvai Girls HS School	18	27	80	35
Trichy	Gandhi Market	14	21	112	NA
	Main Guard Gate	13	21	121	NA
	Bishop Heber College	10	17	34	NA
	Golden Rock	10	18	42	NA
	Central Bus Stand	13	21	122	NA
Tuticorin	Fisheries College, Tuticorin SIPCOT	14	13	141	NA
	Raja Agencies	15	14	226	NA
	AVM Jewellery Building	13	13	30	NA

Source: Website of Central Pollution Control Board www.cpcb.gov.in

It is observed that the value of PM_{10} is in excess of the allowable limit at a no. of locations in all the three cities, while other parameters (SO_2, NO_2 and $PM_{2.5}$) are well within the permissible standards.

The Tamil Nadu Pollution Control Board (TPCB) under NAMP regularly monitors the ambient air quality at certain locations in the State. The AQI values as measured at Madurai, Tiruchirappalli and Tuticorin (Toothukudi) in and vicinity of the project area in August, 2019 are given below in **Table 10.3**.

Table 10.3
Air Quality Index observed in and vicinity of the project area by TPCB

Location	Date	Type	AQI
Standard			**51-100**
Madurai city			
Pitchai Pillai Chavadi	07.08.19 to 31.08.19	Industrial	61-74
Birla Guest House	02.08.19 to 29.08.19	Mixed	57-87
Hotel Tamil Nadu	01.08.19 to 30.08.19	Residential	60-94
Tiruchirappallicity			
Gandhi Market	01.0819 to 29.08.19	Commercial	58-91
Main Guard Gate	05.0819 to 28.08.19	Traffic inter-section	58-92
Bishop Heber College	01.0819 to 29.08.19	Mixed	45-65
Golden Rock	02.0819 to 30.08.19	Residential	42-70
Central Bus Stand	02.0819 to 30.08.19	Traffic inter-section	45-80
Tuticorin (Thoothukudi) city			
Fisheries College, Sipcot	01.08.19 to 29.08.19	Industrial	90-100
Raja Agencies	03.08.19 to 31.08.19	Industrial	71-109
AVM Jewellery Building	02.08.19 to 30.08.19	Mixed	88-99

Source: Website of Tamil Nadu Pollution Control Board www.tnpcb.gov.in

It is observed that at almost all the locations AQI values are within the prescribed standards, barring one location i.e. Raja Agencies in Tuticorin, where it exceeded marginally.

10.4.1.2 Noise environment

Tamil Nadu Pollution Control Board (TNPCB) is the governing body to monitor and control air, noise, and water pollution in the state of Tamil Nadu. The permissible noise levels specified for day (night) time are (i) for residential area - 55(45) dB(A),(ii) for commercial area - 65 (55) dB(A), (iii)for industrial area –75 (70) dB(A) and (iv) for silence zone –50 (40)dB(A)as per the report titled 'TNPCB & You', December, 2017 of TNPCB. TNPCB has brought out

various norms/guidelines for the Ready-Mix Concrete (RMC) plants, stone crushers, Hot mix plants, M sand units and solid/hollow block manufacturing units on environmental aspects (including those from the perspective of air &noise pollution)

10.4.1.3 Meteorology

Climatologically, the calendar year in the project area can be categorized into:

- Winter — January to February
- Summer — March to May
- Monsoon — June to December

There are six IMD observatories in the project area viz. Tiruchirappalli, Thanjavur, Kudumianmalai, Adirampattinam, Madurai and Tondi. Based on the data for the period from 1981- 2010 at these stations, the meteorology in the project area is described as under.

Temperature: The annual mean maximum temperature varies between 39.1 ^{0}C to 29.5 ^{0}C while the annual mean minimum temperature varies between 27.2 ^{0}C to 19.9 ^{0}C in and around the project area.

Rainfall: The monsoon rainfall occurs during June to December under the influence of South-west as well as North-east monsoons. Maximum rainfall is received in the months of September, October and November. The annual rainfall in and around the command area varies from 1187 mm to 844 mm.

Humidity: The annual mean relative humidity varies between 89% and 36% in and around the command area.

Wind velocity: The annual mean wind speed varies between 10.8 and 6.2 km/hr in and around the command area. The maximum wind speed recorded is about 16.1 km/hr during July.

Evaporation: Out of six, the ET_O data is available for three stations Tiruchirappalli, Madurai and Tondi**.** The annual potential evapo-transpiration at Tiruchirappalli station is 2178 mm as per the report of the IMD 'Estimation of Weekly Potential Evapo-transpiration and Climatic Soil Water Balance for 144

locations in India, 2008'. The same for Madurai and Tondi stations are 1925 mm and 1703 mm respectively as per the IMD Scientific report No. 136 'Potential Evapo-Transpiration over India', February, 1971.

Cloud cover: The annual mean cloud cover varies between 4.9 and 3.7 oktas in and around the command area.

10.4.2 Water quality

10.4.2.1 Surface water quality monitoring

Musiri G&D site maintained by Central Water Commission (CWC) is located about 21 km downstream of Kattalai barrage and is the terminal site in Cauvery river basin. CWC collects the water samples at Musiri G&D site regularly for both chemical and physio-chemical analysis for ascertaining the water quality status. The latest data pertaining to the years 2013 to 2016 on laboratory test results of the water samples at Musiri G&D site have been collected and are presented in **Table 10.4.**

Table 10.4
Test results of water samples at Musiri G& D site of CWC on river Cauvery

Sl. No	Characteristic (Parameter)	unit	Analysis Result				Drinking Water Specifications (IS 10500 : 2012)
			2016	2015	2014	2013	Requirement (Acceptable Limit)
1	pH		7.87	8.2	8.09	8.04	6.5 to 8.5
2	Dissolved Oxygen	mg/l	6.42	6.48	6.66	6.68	6 mg/l Min as per CPCB class A Tolerance limit
3	Total Dissolved Solids	mg/l	334	341	295	276	500 Max
4	Turbidity	NTU	0.73	0.78	0.71	0.71	1 Max
5	Total Alkalinity (as $CaCO_3$)	mg/l	158	176	156	136	200 Max

6	Chloride (as Cl)	mg/l	82	78	72	45	250 Max
7	Sulphate (as SO_4)	mg/l	30	32	27.9	21.1	200 Max
8	Fluoride (as F)	mg/l	0.48	0.51	0.39	0.32	1.0 Max
9	Total Hardness (as $CaCO_3$)	mg/l	171	195	170	150	200 Max
10	Calcium (as Ca)	mg/l	29	31	28.3	28.5	75 Max
11	Magnesium (as Mg)	mg/l	23.7	28.3	23.8	18.9	30 Max
12	Boron (as B)	mg/l	0.09	0.12	0.05	0.05	0.5 Max
13	Nitrate as NO_3	mg/l	0.5	2.55	1.38	0.28	45 Max
14	BOD	mg/l	2.23	1.97	2.4	2.34	2 mg/l Max as per CPCB class A Tolerance limit
15	Silica	mg/l	14.33	17.45	17.5	NA	----
16	Iron (as Fe)	mg/l	0.01	0.02	0.05	0.10	0.3 Max

Source: Central Water Commission

It is observed that the pH level of water in Cauvery river ranges between 7.87 to 8.2 during the period. The pH level indicates slightly alkaline nature of the water and the values are within acceptable limits of 6.5 to 8.5 as per IS 10500-2012 specified for drinking and domestic uses. The levels of dissolved oxygen in various collected samples are in the range of 6.42 to 6.68 mg/l and fulfil the CPCB class A tolerance limit of 6mg/l Min. The levels of total dissolved solids are well within the acceptable limit of 500 mg/l i.e. ranging from 276 to 341 mg/l. The range of total Alkalinity (as Ca Co_3) is between 136 to 176 mg/l and satisfies the acceptable limit of 200 mg/l Max. It indicates that the water is suitable for drinking and domestic uses. The range of total hardness (as Ca Co_3) of the above water samples is from 150 to 195 mg/l which is well within the acceptable limit of 200 mg/l specified for drinking water. The concentration of sulphate is in the range of 21.1 to 32 mg/l which is within the acceptable limit of 200 mg/l. The concentration of Chlorides (as Cl) is in the range of 45 to 82 mg/l which is within the acceptable limit of 250 mg/l as per IS 10500-2012 for drinking water quality standards. The concentration of Calcium also is within the acceptable limit of 75 mg/l, ranging from 28.3 to 31 mg/l. Other parameters such as Fluoride, Magnesium, Boron, Nitrate, Silica and Iron are also within the respective acceptable limits as per IS 10500-2012. The turbidity is also within the permissible limit of 1.0, varying from 0.71 to 0.78.

Though the water is suitable for drinking and domestic uses, it is suggested to be supplied with proper filtration and chlorination.

As per the test results of water samples from Cauvery river at Musiri G&D site, the pH is within the limits of 6.5 to 8.5 indicating slightly alkaline nature of water and is fit for irrigation use. As the levels of total dissolved solids in various samples collected are well below the acceptable limits of less than 500 mg/l, the same is 'Excellent to Good-Class-1' for irrigation. The range of Chlorides in the water is less than 250 mg/l which indicates it as 'Excellent to Good-Class-1' for irrigation. Also, the other parameters such as Alkalinity, Total hardness, Calcium/Magnesium/Sulphates etc. are within the limits prescribed for irrigation water. Hence, the water proposed for diversion from Cauvery (Kattalai)-Vaigai-Gundar link canal is found to be suitable for irrigation purpose and with proper treatment for drinking and domestic use as well.

TNPCB is also monitoring the inland water quality under two major programmes namely Global Environmental Monitoring System (GEMS) from 1984 and Monitoring of Indian National Aquatic Resources (MINARS) from 1988 at 32 stations along the four major rivers i.e. Cauvery, Tamiraparani, Palar and Vaigai and three lakes i.e. Ooty, Kodaikanal and Yercaurd in Tamil Nadu. Subsequently, CPCB has sanctioned 23 additional water quality monitoring stations under the 11^{th} plan period during November 2010 and the monitoring was started from December 2010. At present 55 stations are being monitored by TNPCB. The programmes are funded by the CPCB, Delhi.

The Cauvery river, which drain more than one third of the State has been identified as a major river for studying the impact of pollution caused by various activities of the domestic and industrial sectors. Out of the 55 stations, the quality of Cauvery river water is being monitored at 33 stations along the river under GEMS (4 stations) and MINARS (29 stations). These stations were selected on the basis of the location of outfalls of industrial effluents, municipal domestic sewage and other outfalls.

The physico-chemical and biological parameters are analyzed for all the monitoring stations. Sampling is carried out based on the frequency prescribed by Central Pollution Control Board, Delhi and analysis is done at the Advanced Environmental Laboratory, Salem.

10.4.2.2 Ground water quality monitoring

Central Ground Water Board has been monitoring the quality of ground water in all the seven districts viz. Karur, Tiruchirappalli, Pudukkottai, Sivaganga, Ramanathapuram, Virudhunagar and Thoothukudi pertaining to the project command area. As per the latest district ground water brochures of CGWB (2008/2009) as available on the net, the information on no. of monitoring wells, quality, water table, discharge, storativity, transmissivity, pre and post monsoon levels are presented in **Table 10.5**.

Table 10.5
District wise ground water information in the command area

Sl. No	Parameter	Karur	Tiruchirappalli	Pudukkottai	Sivaganga	Ramanathapuram	Virudhunagar	Thoothukudi
1	**Monitoring wells**							
a.	Dug wells	8	19	21	14	23	12	24
b.	Piezometers	5	7	9	6	3	11	12
2	**Depth to water level (m bgl)**							
a.	Pre-monsoon	1.97 to 7.80	N.A	0.85 to 9.50	1.18 to 10.10	0.95 to 8.80	0.67 to 12.12	1.2-12.2
b.	Post-monsoon	1.35 to 6.83	1.60 to 15.15	0.58 to 6.88	0.86 to 18.25	0.76 to 8.42	0.49 to 8.78	0.33-9.24
3	**Groundwater Exploration**							
a.	Wells drilled EW- OW- PZ-	 48 09 05	 19 09 07	 39 12 9	 29 6 6	 43 13 03	 26 05 11	 16 05 12
b.	Depth range (m bgl)	115 to 200	92 to 200	CR 62-200 SR 349-545	CR 65-200 SR 150-325	26 to 777	120 to 200	26-200
c.	Discharge (lps)	0.50-14	<1 to 9	CR <1 to 5 SR 9-67	CR <1 to 5 SR 5-25	2.8-75	0.004- 1.142	0.7-3.9
	Specific capacity (LPm/m)	6.89–117.92	NA	NA	NA	NA	NA	NA
d.	Storativity	NA	$1.6x10^{-4}$ to $9.6x10^{-4}$	SR $4.9x10^{-6}$ to $4.4x10^{-4}$	SR $7.6x10^{-5}$ to $3.6x10^{-4}$ CR $2.2x10^{-5}$ to $4.9x10^{-5}$	$2.72x10^{-5}$ to $8.0x10^{-3}$	$3.41x10^{-5}$ to $0.7x10^{-2}$	$1.3x10^{-4}$ to $4.7x10^{-1}$
e.	Transmissivity (m^2/day)	11.42-669.12	<1 to 45	CR <1 to 50 SR 600-4500	CR <1 to 45 SR 100-500	7-630	1–518.3 (Basalt)	<1 to 296

Source: Ground Water Brochures of the Districts, 2008/2009, CGWB

Quality-wise, the ground water is saline in areas near the sea coast. The ground water is good and potable in other areas of the command. In general, ground water is deep. Hence, seepage from canal and irrigated fields may not cause water level to rise to such an extent to create water logging problem generally. However, in very limited areas near coastal region there is a possibility of rising level, which may lead to water logging and salinity conditions. In such areas suitable schemes should be devised to use the additional water accrued from seepage as a part of command area development programme. One such option is to provide enough drainage facilities so as to flush out the excess water accumulated by way of rise in under ground water level.

Ground water assessment has been made for the proposed command area on pro rata basis based on 'National Compilation on Dynamic Ground water Resources of India, 2017' publication of Central Ground Water Board (CGWB)brought out in July, 2019 and is presented at **Table 10.6**.

Table 10.6
Ground water potential and draft in the project command area

District	Whole district		Within the project region		
	Potential	Draft	Potential	Draft	Balance
Karur	279	286	3	3	0
Pudukkottai	922	432	249	116	133
Ramanathapuram	554	71	277	36	241
Sivaganga	896	163	447	81	366
Thoothukudi	495	213	8	4	4
Tiruchirappalli	619	554	8	7	1
Virudhunagar	525	342	58	38	20

Source: National Compilation on Dynamic Ground Water Resources of India, 2017, CGWB (published in July, 2019)

As per CGWB district brochures, Karur district is underlain entirely by archaean crystalline formations with recent alluvial deposits occurring along the river and streams courses. Weathered, fissured and fractured crystalline rocks and the recent alluvial deposits constitute the important aquifer systems in the district. The major aquifer systems in Pudukkottai district are constituted by (1)

weathered and fractured crystalline rocks consisting mainly hornblende gneisses, granitic gneisses and pink granites and (2) sedimentary formations ranging in age from cretaceous to recent, consisting of sand stones, lime stones, shales and unconsolidated alluvium.

Ramanathapuram, Thoothukudi and Virudhunagar districts are underlain by both porous and fissured formations. The important aquifer systems in these districts are constituted by i) unconsolidated & semi consolidated formations and ii) weathered and fractured crystalline rocks. Two-third area of Sivaganga district is underlain by sedimentary formations while rest by Archaean crystalline metamorphic complex. The important aquifer systems encountered in the district are classified into i) Porous formations, viz., alluvium, sandstone etc and ii) weathered and fractured crystalline formations consisting of Charnockite and Granite. The major part of Tiruchirappalli district is underlain by Archaean crystalline metamorphic complex. The important aquifer systems encountered in the district are classified into i) Fissured, fractured and weathered crystalline formations consisting of charnockites, Granite Gneisses and ii) Unconsolidated and semi-consolidated formations.

CGWB is regularly monitoring the ground water quality of all the seven districts pertaining to the project area through its established monitoring wells. The parameters analysed include pH, Electrical Conductivity (EC), Total Alkalinity (TA), Total Hardness (TH), Nitrate (NO_3) and Fluoride (F).

The suitability of ground water for drinking purpose is determined keeping in view the effects of various chemical constituents in water on the biological system of human being. The standards proposed by the Bureau of Indian Standards (BIS) for drinking water (IS-10500-91 Revised in 2012) are used to decide the suitability of ground water.

Ground water in phreatic aquifers in the project area is in general colorless, odorless and predominantly alkaline in nature. It is observed that in Karur district, only in selected places the ground water is suitable for drinking and domestic uses in respect of all the constituents. There is an incidence of high total hardness, fluoride and nitrate in a no. of places in the district. In case of Pudukkottai, Ramanathapuram and Virudhunagar districts also, it is observed that the ground water is suitable for drinking and domestic uses in respect of all

the constituents except total hardness and nitrate. The incidence of high total hardness can be attributed to the composition of litho-units constituting the aquifers, whereas nitrate pollution is most likely due to the use of fertilizers and improper waste disposal.

In case of Sivaganga district, it is observed that the ground water is suitable for drinking and domestic uses in respect of all constituents except in and around Chettinadu. Major parts of the Thoothukudi district are having multiplayer aquifer system. Hence the water quality varies with respect to depth of tapping and therefore depth of the well should be properly designed. As regards to Tiruchirappalli district, it is observed that in general the ground water is suitable for drinking and domestic uses in respect of all the constituents except fluoride of higher concentration at Siruganallur (1.85 mg/L) and there is higher concentration of NO_3 than BIS permissible limit.

The water used for irrigation is an important factor in productivity of crop, its yield and quality of irrigated crops. The quality of irrigation water depends primarily on the presence of dissolved salts and their concentrations. With regard to irrigation suitability based on specific electrical conductance and sodium Absorption Ratio (SAR), it is observed that ground water in the phreatic zone in the project area may cause high to very high salinity hazard and medium to high alkali hazard when used for irrigation. Proper soil management strategies are to be adopted in the major part of the project area while using ground water for irrigation.

10.4.3 Land environment

10.4.3.1 Land use

The land use particulars in respect of the seven districts pertaining to the Project area as available for the year 2016-17 & 2017-18 are presented in **Table 10.7**.

Table 10.7
Land use particulars of the districts in the project area Unit: '00' ha

Sl. No	Category	Karur	Pudukkottai	Tiruchirappalli	Sivaganga	Ramanathapuram	Virudunagar	Thoothukudi	Total		% of GA
		2016-17	2016-17	2016-17	2017-18	2017-18	2017-18	2017-18			
1	Forest land	62	235	368	165	45	265	110	1250		4.3
2	Barren & Uncultivable land	28	99	126	47	45	45	199	589		2.0
3	Land under Non Agri.Use	376	1371	853	1226	866	705	765	6162		21.1
4	Permanent Pastures	108	35	7	14	2	8	51	225		0.8
	Sub-total	**574**	**1740**	**1354**	**1452**	**958**	**1023**	**1125**	**8226**		**28.2**
5	Land under Misc.Trees & Grooves	23	203	31	61	312	25	356	1011		3.5
6	Culturable Waste	651	97	108	180	34	94	408	1572		5.4
7	Current Fallows	455	125	637	77	547	105	114	2060		7.0
8	Other Fallows	723	1329	1080	1373	458	1778	664	7405		25.4
9	Net Area Sown	469	1169	1194	1046	1781	1218	2040	8917		30.5
	Sub-Total	**2321**	**2923**	**3050**	**2737**	**3932**	**3220**	**3582**	**20965**		**71.8**
10	Area Sown more than once	6	27	79	2	0	20	8	142		0.5
11	Gross Cropped Area	475	1196	1273	1048	1781	1238	2048	9059		31.0
12	**Geographical area (As per village records)**	**2895**	**4663**	**4404**	**4189**	**4090**	**4243**	**4707**	**29191**		**100**

Source: District Statistical Handbooks

10.4.3.2 Mineral deposits

The Cauvery (Kattalai) - Vaigai – Gundar link alignment passes through Karur, Tiruchirappalli, Pudukkottai, Sivaganga, and Virudhunagar districts of Tamil Nadu state. No significant economic mineral deposit/prospect is noticed during the topographical survey of the link project. Detailed mineral surveys will be got carried out through Geological Survey of India during pre-construction stage.

10.4.3.3 Historic/archaeological monuments

Prima facie, there is no adverse impact on central as well as state protected monuments located in the districts of Karur, Tiruchirappalli, Pudukkottai, Sivaganga, Ramanathapuram, Virudhunagar and Thoothukudi. Detailed studies will be got carried out through Archaeological Survey of India (ASI) during pre-construction stage to ascertain the presence of any archaeological sites and monuments of historical significance likely to be affected on account of the link project.

10.4.3.4 Geology

The project area of the Cauvery (Kattalai) - Vaigai- Gundar link project is located in Cauvery basin, Streams between Cauvery and Vaigai, Vaigai basin and the Streams between Vaigai and Vaippar.

The Cauvery basin consists largely of charnockites, high grade schists, migmatites, green stone belts and consolidated gneiss of archaean age. In the upper part of the basin upto Grand Anicut, sand stone is generally lateritised and ferruginous and occurs in wide stretch in southern parts of the basin.

In the basin area of the streams between Cauvery and Vaigai, the geological formations comprise mainly of the hard rocks of archaean age and river alluvium. The main rock types found in the basin are charnockites and khondalites of Archaean age. The charnockite group of rocks consist of the acid charnockite and related migmatites with bands of basic granulite and magnetite quartzite. The khondalite group of rocks consist of crystalline lime stone, colegneiss, calegranulite, garnet - sillimanite gneiss, hornblende and biotite gneiss and related migmatites with bands of quartzite. River alluvium of recent

age are found in the districts of Madurai, Tiruchirappalli and Ramanathapuram. The Upper Gondwanas and Cuddalore sand stones capped by laterite are found in the central part of Ramanathapuram district. Ramanathapuram and Pudukkottai districts are chiefly occupied by crystalline rocks in the western part.

The Vaigai basin area is underlain by geological formations ranging from Archaean to recent. The Archaean formations comprise of khondalite and charnockite group and garnetiferrous granulite biotite gneisses. The charnockites occur as massive out crops in the hills and plains of the area. The garnetiferrous sillimanite gneiss occurs as isolated lenses within the biotite gneiss. Quartzites are found in prominent hills, ridges, low lying mounts in the area. The recent alluvium consists of clay, sand and gravels or their admixture confined to Vaigai river course.

The area covering the streams between Vaigai and Vaipparis underlain by geological formations ranging in age from the archaean to recent. The Archaean rocks mainly belong to composite gneisses, quartzites, charnockite, khondalite and unclassified gneisses. The composite gneisses comprise biotite gneisses, hornblende biotite gneisses and garnet biotite sillimanite gneisses. The geological formations met within the basin in Madurai district comprise of Precambrian charnockites. The basin area is chiefly occupied by crystalline rocks in the western, upper Gondwanas and Cuddalore sandstone capped by laterites in the central part and alluvium in the eastern part. Recent and tertiary sediments occur along the coast and a narrow belt of alluvium along the river course.

During the feasibility study stage, the Geological Survey of India (GSI) was entrusted with the work of carrying out preliminary regional geological survey of the proposed link canal. GSI reported that in the initial 130 km of the canal, the main geological formation observed is metamorphic hard rock and the remaining stretch is dominated by sedimentary domain consisting of sand, clay and shale, capped by laterite. In metamorphic terrain, top soil and weathered migmatitic gneiss form the media. The sedimentary formations consisting of sand and clay exposed in canal route appear to have poor shear strength. Based on the finding of GSI that this formation may pose stability problems in deep cuttings, the canal was realigned, from RD 210 km to till its tail end. In general, no adverse geological features are noticed by GSI along the canal alignment.

10.4.3.5 Soils

Soil is the product of geological, chemical and biological interactions. The command area of the link project falls in Karur, Pudukkottai, Tiruchirappalli, Sivaganga, Ramanathapuram, Virudhunagar and Thoothukudi districts. Karur district has mostly fine to coarse loamy soils. Black soil, red loamy, sandy coastal alluvium, red sandy soil is found in Pudukkottai, Ramanathapuram district. Red loamy soil is predominantly found in Tiruchirappalli district. The district has sandy alluvial soil also in some parts. Red loam, laterite soil, Black and Red soils are mostly found in Sivaganga district. Virudhunagar district has Black soil, Red loamy soil, Lateritic soil and Sandy coastal alluvium. Black loam, Red sandy and alluvium soils are found in Thoothukudi district. Acidic, alkaline and saline soils are also found in the district. The quality of various types of soils in the project area shall be monitored during the CEIA study of the link project.

10.4.4 Terrestrial ecology

10.4.4.1 Delineation of flora in study area

The project region has great biodiversity of flora with many economically and medicinally important plants.A great variety of plant species that include tamarind (Tamarindusindica), coconut (Cocos nucifera), Jamun (Syzigiumcumini), Jack fruit (Artocarpusheterophyllus), Drumstick (Moringa Oleifera), Neem (Azardiractaindica), Teak (Tectonagrandis), Mango (Mangiferaindica), Awala (Emblica officinalis), Kadamba (Anthocephaluscadamba), Moha, orange etc are found in this region. A rapid reconnaissance survey will initially beconducted to understand the existing ecosystem types and to identify the presence of ecologically sensitive areas in the study area during the CEIA study of the link project. In intensive survey, status of flora will be assessed using circular plot of various sizes for trees, shrubs, herbs and grass species.

10.4.4.2 Status of fauna

Wildlife species such as tiger, lion tailed macaque, langur, sambar, sloth bear, elephant, flying squirrel, panther, wild dog, wild pig, boar, jungle cats, butterflies, python, crocodile, wolves, fishes and migratory species are found in

and the vicinity of the project area. Vettangudi bird sanctuary located in Sivaganga district is a natural habitat of winter migratory birds. It is a breeding habitat for grey herons, darters, spoonbills, witeibis, Asian open bill stork and night herons. Vallanadu wildlife sanctuary in Thoothukudi district is created for the protection of black buck antelope. There is a Mayurathottam (peacock garden) in the district as well.

10.4.4.3 Status of fish fauna

As far as economic importance is concerned, the scope of fish and fisheries in Tamil Nadu is of prime interest. There is a rich diversity of fish in Tamil Nadu. The fresh water fish resource of the state constitutes 13 orders, 34 families and 93 genera. Tamil Nadu constitutes 43% of endemic fresh war fishes of India and 40% of total endemic fish diversity of western ghats. There are many species like dugong, grass carp, common carp, silver carp, etc. that have been introduced in the inland and coastal waters of Tamil Nadu. During CEIA study, the fish fauna specific to the project area will be detailed.

10.4.5 Public health

10.4.5.1 Medical and health facilities in the project command area

The medical and health facilities available in the project area (2014-15) are given below at **Table 10.8.**

Table 10.8
Govt. run medical and health facilities available in project area

Name of District	Hospital	Dispensary	Urban Health Post	PHC	Health Sub-Centre	Other Medical Institutes
Karur	7	-	-	32	159	-
Pudukkottai	14	17	-	77	242	-
Tiruchirappalli	24	2	-	117	301	98
Sivaganga	30	4	4	75	275	1
Ramanathapuram	11	-	-	54	244	-
Virudhunagar	16	7	-	78	245	-
Thoothukudi	19	3	-	93	257	-

Source: District Statistical Hand Books (2016-17 & 2017-18)

10.4.5.2 Drinking water supply

National Rural Drinking Water Programme (NRDWP), a flagship programme of Govt. of India, is being implemented in Tamil Nadu state. This programme aims at providing safe and adequate drinking water in rural areas. Drinking water sustainability, a component of NRDWP, is being implemented with an objective of conservation of water by conventional and non-conventional measures. Under this programme, measures of strengthening sources of drinking water such as rooftop rain water harvesting, construction and rejuvenation of tanks for storage of rainwater, recharge shaft, recharge trench, well deepening, etc. for availability of drinking water on sustainable basis are undertaken. The State has taken various measures in order to tackle scarcity situation such as rejuvenation of bore wells and other water sources, water supply by tankers, etc. for scarcity affected villages. The Tamil Nadu Water Supply & Drainage Board (TWAD Board) is assigned with the task of implementing all water supply and sewerage schemes in the state of Tamil Nadu.

The villagers in the project area fetch drinking water from different sources viz. taps, wells, hand pumps, bore wells, tanks and rivers. The different sources of drinking water for the people in the region are presented in **Table 10.9**. A predominant portion of the region gets tap water supply as is evident from the table.

Table 10.9
Different sources of drinking water

Unit : %

Name of district	Tap	Wells	Hand pumps	Bore wells	Other sources
Karur	87	3	2	7	1
Pudukkottai	77	3	3	7	10
Tiruchirappalli	87	2	3	7	1
Sivaganga	69	7	4	11	9
Ramanathapuram	58	18	4	4	16
Virudhunagar	84	1	5	7	3
Thoothukudi	86	2	5	5	2

Source: District Census Hand books, 2011

10.4.5.3 Sanitation

Adequate sanitation is essential for the protection & promotion of individual's and community health. Various schemes are being implemented by the State to improve sanitation conditions. The Government of India runs Total Sanitation Campaign (TSC) to provide sanitation facility. Rural sanitation has always been on priority for Government of Tamil Nadu. The State has achieved the status of free from open defecationby 2nd October 2019 as part of 'Nirmal Bharat Abhiyan' (renamed as Swachh Bharat Mission). The objectives of this mission are to ensure cleanliness in rural areas, to stop the practice of open defecation, construction and utilisation of latrine at household level.

10.4.5.4 Water borne and communicable diseases

The outbreak of water borne diseases like Cholera, Gastro, Acute Diarrhoea/dysentery, Infective hepatitis, Typhoid, etc occurs sporadically in the project region. Outbreaks as well as sporadic cases of these water borne diseases are monitored by the State and to control occurrences and deaths due to these diseases, containment measures are taken.

10.5 Environmental impact assessment

Environmental Impact Assessment is a process of assessment of both positive and negative impacts on the environment due to implementation of the developmental projects. The primary objective of environmental impact assessment (EIA) is to include all the plausible environmental considerations in planning and decision making so as to ultimately arrive at appropriate actions that are environmentally more compatible. Based on the project details and the baseline environmental status, potential impacts as a result of the construction and operation of the proposed Cauvery (Kattalai) - Vaigai – Gundar link project will be identified. Wherever possible, impacts will be quantified or otherwise, qualitative assessment shall be undertaken using predictive modelling techniques. The impacts on various aspects of Environment will be assessed for construction as well as operation phases of project.

10.5.1 Impacts on air environment

10.5.1.1 Impact on air quality

i) Construction Phase: The air pollution Impact on surroundings shall be mainly during construction phase-

a) Pollution due to fuel combustion in various equipments: The operation of various construction equipment requires combustion of fuel. Normally, diesel is used in such equipment. The major pollutant which gets emitted as a result of diesel combustion is SO_2. The SPM emissions are minimal due to low ash content in diesel. The short-term increase in SO_2 even assuming that all the equipment is operating at a common point is quite low i.e. of the order of less than 1µg/m^3. Hence, no major impact is anticipated on this account.

b) Fugitive emissions from various sources: During construction phase, there will be increased vehicular movement and a lot of construction material like sand, fine aggregate is stored at various sites. Normally, due to blowing of winds, especially when the environment is dry, some of the stored material can get entrained in the atmosphere. Some emissions will occur from crushing plants and the DG sets. However, such impacts are normally visible only in and around the construction sites. The impacts on this account are generally, insignificant in nature.

c) Impacts due to vehicular movement: During construction phase, increase in number of vehicles is anticipated for transportation of construction material. However, no major impact on ambient air quality is anticipated due to increase in vehicular movement during construction phase.

ii) Operation Phase: During operation phase, no major impacts are envisaged.

10.5.1.2 Impacts on noise environment

i) Construction phase: The impacts on ambient noise levels are expected during the project construction phase only due to earth moving machinery, crushing equipment, DG sets, increased vehicular movement etc. There could be

impact on the population residing in the proximity to the canal alignment during construction phase as a result of various activities. However, based on past experience in similar projects, the impact however, is not expected to be significant.

ii) Operation Phase: Noise pollution occurs mainly during project construction phase. During project operation phase, no major impacts are envisaged.

10.5.2 Impacts on water resources and quality

i) Construction phase

a) Impacts due to sewage generation from labour camps

The major sources of water pollution during project construction phase are the sewage generated from the labour camps/colonies. The project construction is likely to last for a period of 5 years. A large number of workers and technical staff are likely to migrate during project construction phase. Presently, the employment opportunities in the area are limited. Therefore, during the project construction phase, many of the locals may get employment. It has been observed during construction phase of many such projects that the major works are contracted out and they bring their own skilled labour. Mostly, it is only in the unskilled category, that locals get employment. The disposal of sewage without treatment could lead to adverse impacts on land environment or water environment in which the effluent from the labour camps/colonies are disposed.

Disposal of sewage water is an essential part of the EMP. Sufficient no. of community toilets needs to be provided in the labour camps/colonies. The wastewater generated from the colonies will have to be collected and disposed in specifically designed soak pits and septic tanks. The wastewater and sewage generated should not be allowed to flow into the rivers and streams of the area. Efforts shall be made to ensure that treated effluent is disposed only in such water bodies, which are not used for meeting domestic water requirements.

(b) Impacts due to runoff from construction sites

Substantial quantities of water would normally be used in the construction activities. With regard to water quality, waste water from

construction activities would mostly contain suspended impurities. Adequate care should be taken so that excess suspended solids in the waste water are removed before these are disposed into water body or overland. Similarly, effluents due to washing from truck parking area, workshop etc. would have high concentration of oil and grease. The effluent quality on account of this may be too small to cause any adverse impact. It can, however, be treated by oil and separator unit, so as to ameliorate even the marginal adverse impacts likely to accrue on this account.

ii) Operation phase

a) Impacts on downstream users

A total quantity of 2252 Mcum is proposed for diversion through the Cauvery (Kattalai) - Vaigai - Gundar link project from Kattalai barrage across Cauvery river. It is planned to utilise the water in the command area situated along the canal alignment in Karur, Pudukkottai, Tiruchirappalli, Ramanathapuram, Sivaganga, Virudhunagar and Thoothukudi districts in the state of Tamil Nadu for domestic, irrigation and industrial water supply to the tune of about 79 Mcum, 1931 Mcum and 139 Mcum respectively.

The diversion of water for meeting irrigation and other requirements could lead to following impacts:

- Modification of hydrologic regime
- Impacts on drainage system due to canal network
- Impacts due to siltation

b) Impacts on water logging and soil salinity

The main causes of water logging in a command area due to irrigation could be as follows:

- Developmental activities such as construction of roads, bridges, railway lines, buildings etc. resulting in choking of natural drainage.
- Poor natural drainage as a consequence of topography or unfavourable sub-soil geology like existence of hardpan at shallow depths.
- Heavy storm and rainfall coupled with poor natural drainage.
- Heavy loss of water due to seepage from water courses.

- Excess application of water particularly in the initial years when the command is not fully developed.
- Poor on-farm water management resulting in poor application efficiencies.
- Inadequate drainage and poor maintenance of existing drainage system and outlets.
- Lack of conjunctive use of surface and ground water.

The imbalance of air and water in root zone leads to adverse impacts on crop growth and are listed as under:

- Depletion of oxygen in the root zone and increase/saturation of carbon dioxide due to water logging. This anaerobic condition will have an adverse effect on the growth of useful micro-organisms. Besides, harmful organisms may proliferate and create several problems in the plant growth.
- Physico-chemical and biological activities in the soil on account of low temperature. This may create the problem of increase in pests and diseases.
- Field operations may also become either impossible or difficult in such soils.

c) Changes in water quality due to increased use of fertilizers

The fertilizer dose is likely to increase once irrigation is introduced in the command area. Under the best farming practices, only 40-50% of the applied fertilizers is used by the crop and the balance finds its way into the aquatic environment through drainage runoff. An unexpected intense shower immediately after the spread of fertilizers may bring even greater amount of nutrients as a part of the runoff into the receiving water body.

To compensate the nutrient removal by crops, additional dose of nutrients, i.e. fertilizers dosing may need to be given. Wash down of fertilizers and organic matter rich in nutrients from the surrounding agricultural fields cause eutrophication of water bodies. Overgrowth of aquatic weeds affects the survival of aquatic organisms through depletion of oxygen, change in odour and taste of water. With the introduction of irrigation, the drainage system (natural or

man-made) is likely to contain much higher level of nutrients. The climatic conditions in the project area may also supplement the proliferation of eutrophication in the project area. Thus, in the project operation phase, there will be increased probability of eutrophication in the water bodies receiving agricultural runoff.

d) Impacts due to effluent from project colony

During project operation phase, due to absence of any large-scale construction activities, the cause and source of water pollution will be much different. Since, only a small number of O&M staff will reside in the area in a well-designed colony which will have a sewage treatment plant and other infrastructure facilities, the problems of water pollution due to disposal of sewage may not be anticipated.

d) Recharge of ground water

There will be recharge of ground water en-route the 256.82 km long link canal. This will be a positive impact of the project.

10.5.3 Impacts on land environment

i) Construction phase

The construction of the proposed Cauvery (Kattalai) - Vaigai – Gundar link project is expected to be completed in about 5 years. Majority of the environmental impacts during construction phase are temporary in nature, lasting mainly during the construction phase and for small duration beyond the construction period. The major impacts anticipated on land environment during construction phase will be as follows:

- Environmental degradation due to immigration of labour population.
- Impacts due to Operation of construction equipment.
- Soil erosion.
- Impacts due to construction of roads.

a) Environmental degradation due to immigration of labour population:

There is likely a huge influx of construction labour, technical and other work force for construction and related activities and service providers including

their families in the project area. Congregation of labour force is likely to create problems of sewage disposal, solid waste management and cutting of trees for meeting their fuel requirements etc.

b) Operation of construction equipment:

During construction phase, various types of equipment will be brought to the site. These include batching plant, earth movers, etc. The siting and storage of these construction equipment would require significant amount of space. The site for storage of construction material and equipment will have to be selected in such a way that it causes minimum adverse impact on various aspects of environment. Efforts shall be made that such facilities are located on government or panchayat land only, so that hardships caused as a result of land acquisition, though temporarily on this account are minimized to the extent possible.

c) Soil erosion: Due to various construction activities such as construction of colonies / houses / toilet blocks etc. soil erosion in the project area is bound to increase. During construction activities, the share of the forest cover will be adversely affected which in turn will cause loosening of the soil particles, thus increasing the rate of soil erosion and hence degradation of land environment. Substitute plantation will have to be planned to mitigate the adverse effect of soil erosion.

d) Impacts due to construction of roads: The transport routes are the main arteries of the economy. The status of village roads and cart tracks in the vicinity of the project area will have to be improved and new approach roads to quarries, labour colony, stores and construction sites will have to be constructed. Frequent movement of heavy vehicles loaded with construction material is likely to cause air pollution in terms of SPM, noise and gases. To mitigate the pollution effects, preventive measures such as sprinkling of water, plantation of trees etc. may have to be taken.

(ii) Operation phase

Acquisition of Land: The land to be acquired for Cauvery (Kattalai) - Vaigai –Gundar link canal is 4938 ha as detailed below:

(i)	Link canal right of way	- 3141 ha
(ii)	Borrow area for canal	- 299 ha
(iii)	Office & colony	- 5 ha
(iv)	Housing for R&R	- 50 ha
(v)	Branch canals	- 1443 ha
	Total	**- 4938 ha**

The various categories of land to be acquired for the link canal are as under:

(i)	Residential area	- 230 ha
(ii)	Barren/Govt. Land	- 493 ha
(iii)	Forest	- 107 ha
(iv)	Rainfed area	- 2900 ha
(v)	Irrigated land	- 1210 ha
	Total	**- 4940 ha**

10.5.4 Impact on biological environment

10.5.4.1 Terrestrial environment

10.5.4.1.1 Impacts on forest cover

i) Construction phase: During project construction phase, labour population is likely to congregate near various construction sites. The workers and other population groups residing in the area may use fuel wood (if no alternate fuel is provided). To minimize impacts, community kitchens will have to be provided. These community kitchens shall use liquefied petroleum gas or kerosene as fuel.

ii) Operation phase: Total forest land to be acquired in the canal alignment is 107 ha. The impacts due to acquisition of forest land shall be mitigated through compensatory afforestation measures and implementation of a detailed set of bio-diversity conservation measures that will be outlined in the Environmental Management Plan of the proposed CEIA study.

10.5.4.2 Impacts on wildlife

i) Construction phase

The area to be brought under irrigation within the command area is devoid of forests. The project area is interspersed with settlements and agricultural land. In such settings, large scale of annual population is usually not observed. Thus, no significant impact on wild life is anticipated due to the project.

ii) Operation phase

The following impacts on account of forest land acquisition for the canal alignment shall be studied:

a) Impact due to habitat change having effect like corridor loss and loss of migratory path for wild life including birds.
b) Impact on breeding grounds of species.
c) Impacts on access of animals to food and shelter.
d) Impacts on rare, endangered, threatened and endemic species.

10.5.4.3 Impacts on aquatic ecology

i) Construction phase

Impact due to excavation of construction material from river bed:

During the construction phase, a large quantity of construction material like stones, pebbles, gravel and sand would be extracted from the borrow areas in the river bed. The extraction of construction material may affect the river water quality due to increase in the turbidity levels. This may be mainly because the dredged material gets released during one or all the operations mentioned below:

- Excavation of material from the river bed.
- Loss of material during transport to the surface.
- Overflow from the dredger while loading.
- Loss of material from the dredger during transportation.

The dredging and deposition of dredged material may affect the survival and propagation of benthic organisms. The macro-benthic life which remains attached to the stones, boulders etc. may get dislodged and is carried away downstream by turbulent flow. In the areas from where construction material is excavated, benthic fauna may get destroyed. In due course of time, however, the area is likely to get re-colonized, with fresh benthic fauna. The density and diversity of benthic fauna will, however, be less as compared with the pre-dredging levels.

The second important impact is on the spawning areas of fishes. The spawning areas of various fish species are found amongst pebbles, gravel, sand etc. The eggs are sticky in nature and remain embedded in the gravel and subsequently get hatched. Any disturbance of stream bottom may result in adverse impact on fish eggs.

Thus, significant adverse impacts on aquatic ecology can be anticipated for which adequate precautions during dredging operations are required to be undertaken.

ii) Operation phase

a) Impacts due to bunding of streams

The micro and macro benthic biota likely to be affected as a result of the proposed project will be duly assessed in the CEIA study.

b) Impacts on migratory fish species

The obstructions created by the bunds would hinder migration of various migratory species. Appropriate measures may have to be devised for conservation of fish species in the CEIA study.

10.5.4.4 Impacts on socio- economic environment

i) Construction phase

a) Impact of influx or migration of labour:

The construction phase will last for about 5 years. There is likely to be a huge influx of labour force and technical staff (along with their families) to the

project area. The project will open a large number of jobs to the local population. Job opportunities drastically improve in this area. The adequacy of infrastructure will generally be a problem during the initial construction phase. Though the construction workers can be subsidized for certain facilities like health, education etc, the facilities of desired quality cannot often be made available in the initial stages. The adequacy of water supply, sewage treatment, housing, etc should therefore, be ensured before and adequate measures will have to be taken at the very start of the project.

b) Impacts on public health due to water borne diseases:

Construction phase: The construction phase of the project can lead to increase in incidence of various water borne and vector borne diseases. Therefore, adequate precautions / control measures are to be undertaken. The health risk specific to water resources projects usually emanate from congregation of labour at various construction sites. During construction phase, new groups come and go constantly keeping the human population in a flux. These groups are usually housed in temporary dwellings without proper sanitary conditions and water supply. Only, in the final stages, colonies for project maintenance, town ships etc. are built. Population migration indicated by actual or possible opportunity for work can aggregate problems as a result of housing difficulties, overcrowding, rise in cost of living and some un-predicted social problems as well as introduction of new sources of diseases. Immigrants immunologically may become susceptible to the endemic diseases prevalent in the areas of development.

Many of the immigrant population could be reservoirs of infection for various communicable diseases. Once they settle in labour camps / colonies, there could be increased incidence of various diseases. This aspect needs to be looked into with caution, and efforts may have to be made to ensure that a thorough check up of the labour population congregating in the area is conducted. Those affected by any ailments need to be properly quarantined, particularly if they are suffering from communicable diseases.

Operation phase: Improvement in availability of water for various uses, increased agricultural production, availability of diversified food, strengthening of educational and health facilities significantly improve public health in

project area. On the other hand, water resources development also has negative impacts, since it could increase the habitat of certain vectors like mosquitoes. The project may create favourable conditions for breeding of new pathogens or vectors such as mosquitoes, etc. Most of the water borne diseases can largely be prevented by adequate hygiene. With the increased water availability, quality of water being supplied is expected to improve and the incidence of water borne diseases is likely to reduce. However, adequate measures in the form of strict public health measures shall be proposed in the EMP.

10.5.5 Impacts on micro climate

The increase in surface area of water, irrigation and vegetation cover in the project area may on a local level moderate the temperature, i.e., lead to reduction in the number of days of high temperature, if not in the maximum temperature itself. The higher humidity as a result of high evapo-transpiration is likely to raise the minimum temperature and increased occurrence of fogs during the cooler months.

10.5.6 Green house gas emissions

The major Green House Gases (GHGs) are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). These gases are emitted from both natural aquatic (lakes, rivers, estuaries, wetlands) and terrestrial ecosystems (forest, soils) as well as from anthropogenic sources. CO_2 emissions account for the largest share of GHGs equivalent of ±80-85% of the emissions. Fossil fuel combustion for transportation and electricity generation are main source of CO_2 which normally contribute to more than 50% of the emissions.

Of late, emissions from freshwater reservoirs/ponds/tanks and their contribution to the increase of GHGs in the atmosphere are also being considered as a source of greenhouse gas emissions. In the case of reservoirs, it is known that the amount of GHGs emitted at the air water interface varies over time. In fact, there is an initial peak which occurs immediately after impoundment. The increase of GHG emissions in reservoirs shortly after flooding is related to the release of nutrients, enhanced bacterial activity and decomposition of liable carbon. Magnitude of emissions for both reservoirs and

natural aquatic systems depend on physico-chemical characteristics of the water body and on the incoming carbon from the watershed.

The issue of GHG emissions from reservoirs has been recognized at the international level by the Clean Development Mechanism Executive Board (UNFCCC, 2006) as well as the Intergovernmental Panel for Climate Change-2006. Beyond such preliminary developments, progress in the policy remains at a very nascent stage and is generally held back by a number of scientific uncertainties.

10.6 Environmental Management Plan (EMP)

Based on environmental impact assessment, mitigation of adverse impacts and enhancement of beneficial impacts are specified in the EMP.

10.6.1 Pollution control at construction sites

10.6.1.1 Air pollution control

Control of emissions: Minor air quality impacts are likely to be caused by emissions from construction vehicles, equipment and DG sets, and emissions from transportation traffic. Frequent truck trips will be required during the construction period for removal of excavated material and delivery of construction equipment and material.

The following measures can be recommended to control air pollution:

- The contractor can be made responsible for maintaining and proper functioning of construction equipment to minimize exhaust.
- Construction equipment and vehicles can be turned off when not used for extended periods of time.
- Unnecessary idling of construction vehicles can be prohibited.
- Effective traffic management can be undertaken to avoid significant delays in and around the project area.
- Road damage caused by sub-project activities can be promptly attended to with proper road repair and maintenance work.

Air pollution control due to DG sets: The Central Pollution Control Board (CPCB) has issued emission limits for generators upto 800 KW. Details are given at **Table 10.10**:

Table 10.10
Emission limits for DG sets prescribed by CPCB

Parameter	Emission limits (gm/kwh)
NO_x	9.2
HC	1.3
CO	2.5
PM	0.3
Smoke limit*	0.7

***Note:** *Light absorption co-efficient at full load (M^{-1})*

The above standards can be followed by the contractor while operating the DG sets. The other measures are recommended as below:

- Location of DG sets and other emission generating equipment can be decided keeping in view the predominant wind direction so that emissions do not affect nearby residential areas.
- Stack height of DG sets can be kept in accordance with CPCB norms, which prescribes the minimum height of stack to be provided with each generator set to be calculated using the following formula:

$H = h+0.2 \times \sqrt{KVA}$
H = Total height of stack in metre
h= Height of the building in metres where the generator set is installed
KVA = Total generator capacity of the set in KVA

Dust control: The authorities can work closely with representatives from the community living in the vicinity of project area to identify areas of concern and mitigate dust-related impacts effectively (e.g. through direct meeting, utilization of construction management and inspection program, and / or through the complaint response program).

- Identification of construction limits (minimal area required for construction activities).

- When practical, excavated spoils can be removed as the contractor proceeds along the length of the activity.
- When necessary, stockpiling of excavated material can be covered or staged offsite location with muck being delivered as needed during the course of construction.
- Excessive soil on paved areas can be sprayed (wet) and / or swept and unpaved areas can be sprayed and / or mulched. The use of petroleum products or similar products for such activities may be strictly prohibited.
- Contractors may be required to cover stockpiled soils and trucks hauling soil, sand and other loose materials (or required to maintain load in the truck with at least two feet of freeboard).
- Contractor may ensure that there is effective traffic management at site. The number of trucks / vehicles to move at various construction sites can be fixed.
- Dust sweeping - The construction area and vicinity (access roads and working areas) can be swept with water sweepers on a daily basis or as necessary to ensure that there is no visible dust.

  A lump sum provision of Rs. 40 lakh is made towards air pollution control.

10.6.1.2 Noise control measures

i) Noise generation from construction equipments: The construction equipments, vehicles, DG sets etc. shall be properly maintained and occupational safety and health standards shall be complied. The construction equipment will be required to use available noise suppression devices and properly maintained mufflers.

- Vehicles are to be equipped with mufflers as recommended by the vehicle manufacturer.
- Staging of construction equipment and unnecessary idling of equipment within noise sensitive areas to be avoided whenever possible.
- Notification can be given to residents within 100 m of major noise generating activities. The notification can also describe the noise abatement measures that will be implemented.

- Noise levels can be regularly monitored during the construction phase of the project.
- A proper routine and preventive maintenance procedure for the DG set can be in place which can be followed in consultation with the manufacturer which would help prevent noise levels from its deterioration with use.

ii) Noise generation from controlled blasting operations

- Controlled blasting may be done as per the provisions of Indian Explosives Act.
- Blasting may not be undertaken in night hours.
- Workers at blasting sites may be provided with proper ear plugs and helmets.
- Explosives used for controlled blasting can be kept in safe custody under lock and key as per the provisions of Indian Explosives Act

iii) Noise due to crusher

The exposure of labour operating with crushers may be restricted upto 30 minutes on a daily basis. Alternatively, the workers can be provided with ear muffs or plugs, so as to attenuate the noise level near the crusher by at least 15 dB(A). The exposure to noise level in such a scenario may have to be limited upto 4 hours per day. A Provision of Rs. 5.00 lakh has been kept for noise control measure.

10.6.2 Water pollution

Sewage generated from various labour camps during project construction phase can be treated in a sewage treatment plant prior to disposal. Efforts may be made to discharge the treated effluent only in those water bodies, which are not used for meeting domestic water requirements.

The effluent generated from the crushers will have high-suspended solids and needs to be treated before disposal. Settling tanks of appropriate size for treatment of effluent from various crushers can be provided. The sludge

from various settling tanks can be collected once in 15 days and disposed at the site designed for disposal of municipal solid wastes from the labour camps. The sludge after drying can be used as cover material for landfill disposal site. A lump sum amount of Rs. 20 lakhs are provided for construction of settling tanks.

10.6.3 Land management plan

10.6.3.1 Disposal of muck and reclamation of muck disposal sites

The Cauvery (Kattalai) - Vaigai – Gundar link project envisages construction of 256.82 km long link canal and large number of CD/CM structures. A large quantity of muck is expected to be generated as a result of tunnelling operations and excavations for foundation of the canal. Based on the geological nature of the rocks and engineering properties of the soil, a part of the muck can be used as construction material and balance muck requires to be suitably disposed to the muck disposal sites in the project area. The muck disposal sites can be planned along the river course and in low level areas or depressions. The dumping of muck will be done in a scientific manner by providing appropriate protection walls with deep foundations so that muck will not flow and washed away in the river. Protection structures in the form of masonry work, crate work and check dam will also have to be provided wherever necessary in order to avoid the chances of soil erosion and to ensure flow of silt free water. Besides these engineering measures, proper plantation will be done at the dumping sites for reclamation of the dumping areas.

Muck generally lacks nutrients and therefore, is difficult to re-vegetate. However, if no attempts to vegetate the slopes are made, the muck could slide lower down during rain and may eventually wash off the check bunds also. Bio-fertilizer technique developed by National Environmental Engineering Research Institute, Nagpur can be adopted in the proposed project. Unused excavated material can be piled and stacked with proper slopes at the designated muck disposal sites. The slopes are broken up by creating benches across them. This is done to provide stability to the slopes and also to provide ample space for planting of trees that would further help in holding and consolidating bio-technological approach. The afforestation with suitable plant species will have to be done in consultation with the forest department of Tamil Nadu. A lump sum provision of Rs. 350 lakh has been kept towards restoration of muck disposal sites.

10.6.3.2 Restoration plan for quarry sites

The proposed Cauvery (Kattalai) - Vaigai – Gundar link project would involve construction of canal, colonies for staff and labourers and other various components. During construction, these activities could result in accumulation of large amount of unused material at various sites which require proper restoration measures. This also includes areas likely to be disturbed due to quarries and dumping of unused muck in the project area. The existing landscape is likely to be totally modified or changed due to proposed project. Therefore, all areas disturbed by construction activity will be landscaped to reflect natural contours and encourage the re-establishment of vegetation.

Disturbed sites and their restoration: Construction activities like roads, quarry sites, project colonies, workshops, offices etc. will change the existing land use / land cover in the region. After completion of the construction work, it is required to restore the disturbed areas to their original condition wherever possible. Various engineering and biological measures will be undertaken for the restoration of these areas which inter alia may help arrest soil erosion in the region.

Quarrying operation: A project of this magnitude would require significant amount of construction material. The aggregate requirement for concrete is proposed to be met from the quarries in the vicinity along the link alignment. The proposed project would require significant amount of fine material, which shall be met from the nearby sand quarries. The CSMRS, New Delhi has carried out the construction materials survey of coarse and fine aggregates for the link project during FR stage. Based on physical & chemical tests and ASR test conducted by CSMRS, it was found that out of the 17 locations, quarries at 8 locations are suitable for coarse aggregate in concrete for both wearing and non-wearing surfaces, whereas quarries at 15 locations are suitable for non-wearing surfaces only. The coarse aggregate samples from two locations are not suitable for use in concrete as the abrasion loss is more than the specified limit in IS 383-1970. Out of the 11 natural sand quarries, samples from eight quarries other than Mayanur, Musiri and Ariyar river, were found to be susceptible to alkali aggregate reaction due to high strained quartz content. Therefore, these have to be used with cement having alkali content not more than 0.6% for controlling alkali aggregate reaction.

The quarrying operations are semi-mechanised in nature. Quarrying is normally done by cutting a face of the hill. A permanent scar is likely to be left, once quarrying activities are over. With the passage of time, the rock from the exposed face of the quarry under the action of wind and other erosion forces may get slowly weathered and after some time, it may become a potential source of landslide. Thus, it may be necessary to implement appropriate slope stabilisation measures to prevent the possibility of soil erosion and landslides in the quarry sites. After excavation of the required material, these quarry sites will require restoration. Appropriate engineering, bio-engineering and biological methods will be proposed for effective restoration of the quarry sites.

Engineering and bio-engineering measures: Opening of the quarries will cause visual impacts because they remove a significant part of the hills. Other impacts will be the noise generated during aggregate acquisition through explosive and crushing, dust produced during the crushing operation to get the aggregates to the appropriate size and transport of the aggregates and material to the nearby project sites. The quarrying for rock material in the proposed project may lead to removal of vegetation cover and top soil and leave the area barren. After the completion of mining activity, these areas will have to be restored to their normal habitat conditions.

Standard mitigation measures against erosion and sedimentation, noise and air pollution will be taken in particular for the use of explosives. At the end of the exploitation, quarries will be rehabilitated adopting such measures as re-establishment of vegetation, restoration of natural watercourses, avoidance of flooding of the excavated areas, achievement of stable slopes and avoidance of features. Otherwise these may constitute a risk to health and safety or a source of environmental pollution.

The measures that will be adopted for landscaping of the quarry sites and borrow areas have been described in the following paragraphs.

Measures to be adopted before quarrying: The top soil (top 6 – 12-inch soil) shall be removed before excavating the sand or rocks from the quarry sites. This soil contains all microbes (including earthworms) and important nutrients and organic matters which will be required at the time of restoration of these quarry sites.

Measures to be adopted after quarrying:

- **Diversion of run-off:** Effective drainage system shall be provided to avoid the infiltration of run-off and surface waters into the ground of quarry sites.

- **Filling of depressions:** The craters formed at the quarry sites shall be filled with dumping materials consisting of boulders, rocks, gravels and soil from the nearby sites. After filling these craters, the top soil collected prior to quarrying shall be spread as top layer. The top soil then can be covered with geo-textiles like coir, jute or by other locally available bio-degradable material so as to protect it from erosion.

- **Construction of retaining walls:** Retaining walls shall be constructed at the filled-up depressions of quarry sites to provide necessary support.

- **Rocks for landscaping:** After the quarrying activities are over, these sites will get splattered with the leftovers of rocks and boulders. These boulders and rocks can support the growth of mosses and lichens, which will act as ecological pioneers and initiate the process of succession and colonization. The boulders of moderate size will therefore be used to line the boundary of a path.

- **Laying of the top soil:** The depressions / craters filled up with rock aggregates shall be covered with top soils. Fungal spores naturally present in top soil will aid plant growth and natural plant succession. The top soil will be further enriched by organic manure, which will help in the process of soil reclamation and the early establishment of seedlings.

- **Re-vegetation:** Re-vegetation of the dumping sites through 'Integrated Biological and Biotechnological Approach' shall be practised.

A lump sum provision of Rs. 200 lakh have been earmarked for restoration of quarry sites and borrow area.

10.6.3.3 Restoration of colony and office complex

Labour colony and Project colony areas will be developed for beautification of the project area after construction is over. There would be sufficient open space in the colony area. The beautification in the colony area will be carried out by development of flowering beds for plantation of ornamental plants, creepers, flower garden, small park, construction of benches for sitting, resting sheds, walk way and fountains. A lump sum provision of Rs. 100 lakh are made for beautification & landscaping of the colonies & office complex and all along the link canal.

Implementing Agency: The restoration of the construction sites and implementation of various reclamation measures shall be part of the scope of work of the contractor.

10.6.4 Biodiversity conservation and management plan

10.6.4.1 Compensatory afforestation

About 107 ha of forest area will have to be acquired for the link canal. No rare, endangered and threatened species are reported in the project area. The afforestation will be done in 214 ha (double the area of forest land of 107 ha likely to be affected) in degraded forest land as per the provisions of Forest (Conservation) Act, 1980. The afforestation work is to be done by the forest department of Tamil Nadu. A provision of Rs. **3235** lakh shall be kept for compensatory afforestation @ Rs. **6.72** lakh/ha and adopting escalation factor as **2.25.** In addition, the NPV and cost of trees will be paid to the Forest Department, which shall be estimated by the forest department, as a part of Forest clearance.

10.6.4.2 Biodiversity Management Plan

i) Forest protection plan: As stated above, about 107 ha of forest area is proposed to be acquired for Cauvery (Kattalai) - Vaigai – Gundar link project. The following measures can be proposed as a part of Forest Protection Plan on the lines of similar link projects for which CEIA studies have been carried out:

- Under the reward for informer's programme, workers who are well acquainted with the area and will be resourceful in gathering information

for anti-poaching and better vigilance shall be engaged on contractual basis.

- An office to monitor the activities shall be arranged
- Public awareness programmes shall be organized; training camps shall be conducted; pamphlets, brochures, hoardings etc. shall be prepared for distribution/display.
- Fire lines within critical areas to protect the forest from accidental fires shall be provided.
- Check posts and watch towers equipped with camera, wireless, binoculars and other minor equipment (spot scope, search lights, sleeping bags, health kits etc) shall be set up for better vigilance to check poaching.
- Construction of bridges, roads, inspection paths for more effective and meaningful patrolling of the staff shall be undertaken.
- Field vehicles and motorbikes shall be provided for effective vigilance.
- Creation of veterinary facilities and rescue camps for healthcare of wild animals and for controlling diseases with a mobile-rescue-cum-publicity-van and adequate stock of medicines shall be planned.

ii) Safeguards during construction phase: During the construction phase, various adverse impacts on the forests and wildlife are anticipated in the concerned reaches of the proposed project in terms of increased noise levels, land vibrations during controlled blasting, air pollution etc. In order to avoid or minimize the negative impacts from these activities, project authorities can formulate strict guidelines as follows:

- Strict restrictions shall be imposed on the workers at project sites to ensure that they do not harvest any species / produce from the forests and cause any danger or harm to animals and birds in wilderness area.
- The fuel wood to the labourers shall be provided by the project proponents so that there is no pressure for cutting of trees to meet fuel wood requirements.
- The interference of human population can be kept to a minimum in the adjacent forest areas and it may be ensured that the contractors do not set up labour colonies / camps in the vicinity of forests and wilderness areas.

- Only well maintained / new equipment that produces lesser noise shall be installed at the work sites.

- The best way to control the noise is at source. Certain equipment that needs to be placed permanently at one place like generators etc. shall be housed in enclosed structures to cut off the noise.
- The heavy equipment like rotating or impacting machines shall be mounted on anti-vibration mountings.
- Wherever combustion engines are required they shall be fitted with silencers.
- The machinery (trucks etc) used for the project works shall be managed to produce a smooth flow instead of a noise producing stop and start flow. Necessary training / orientation shall be provided to the traffic operators / drivers. Sounding of loud horns etc. in the forest areas shall be banned. Project authorities shall use water sprinklers on the road to avoid the dust from constructions activities.
- While clearing the land of vegetation for any project work, the project authorities shall ensure that the work area has sufficient layer of tree cover around it. It will act as an effective noise absorber and dust barrier. The tree layer will act as buffer zone and these are known to cut off noise by about 5 – 20 dB at a site depending upon the density of vegetation. These measures shall be planned in advance and well before starting operation at any site.

iii) Measures to improve habitat of avi-fauna: Forests are vital for survival, foraging, breeding and nesting of avifauna. Natural forests provide a variety of food material to birds not only in the form of nectar of flowers, fruits, seeds etc. in the trees, shrubs, herbs and grasses but they also contain a large number of insects eaten by birds. In the forests, food is always available for the faunal component. Although most floral species flower during spring through summer but fruit maturation and seed ripening takes place in them throughout the year. Therefore, first strategy of improvement of habitat for birds is avoiding nest predation or brood parasitism through maintenance of large contiguous forest tract.

iv) Anti-poaching measures: There are no ecologically sensitive areas around the project sites. However, the forests in the vicinity serve as a habitat for wildlife. Due to construction activities and increased human interferences, as a result of immigration of large labour population and their family members, some adverse impacts may take place on wildlife during construction phase in

the concerned reaches of the project area, which will be assessed during the CEIA studies of the link project.

10.6.5 Green belt development plan

Forest loss due to acquisition under the link canal and other project appurtenances is compensated as a part of compensatory afforestation. However, in addition to above, it will be proposed to develop greenbelt around the periphery of various project appurtenances etc. The greenbelt development plan aims to overall improvement in the environmental conditions of the region. The plan with a five-fold objective will address issues such as prevention of land degradation due to activities during construction phase; enhancing the forest cover for increasing the biodiversity of the region; providing aesthetic value to the project area and consequently inviting a proportionate tourist flux; enhancing the ecological equilibrium of the area; and to a large proportion in combating soil erosion. The plantation for this purpose shall be carried out by Forest Department of Tamil Nadu. A provision of Rs. 200 lakh for green belt plantation along the link canal has been kept.

10.6.6 Environmental management in labour camps

The aggregation of large number of workers about 2500 in the project area during the construction phase is likely to put considerable stress on the prevailing biotic and abiotic environment of the area. The total number of people including the family members of workers may be about 6000. The stress could be on account of increased water demand, sewage and solid waste generation, fuel wood requirements etc. The aim of the Environmental Management Plan is therefore to minimize these stresses. A community toilet must be provided for 20 persons. A lump sum provision of Rs. 200 lakh towards providing sanitation facilities in the labour camps is made.

The construction activities are likely to be concentrated at various locations at storage sites and along the canal alignment. Community kitchens shall be provided to worker families and the kerosene / Liquefied Petroleum Gas will be provided at subsidised rates. The provision for supply of subsidised kerosene/LPG to the labour is about Rs. 300 lakh.

Adequate facilities for housing and water supply shall also be provided. The wastewater generated from the colonies shall be collected and disposed in specifically designed soak pits and septic tank. The wastewater and sewage generated shall not be allowed to flow into the rivers and streams of the area. Efforts shall be made to ensure that treated effluent is disposed only in those water bodies, which are not used for meeting domestic water requirements. Adequate facilities for collection and conveyance of municipal wastes generated to the disposal site shall be developed. At each labour camp, covered trailers to collect the solid waste from the common collection point and transfer it to the disposal site will need to be put to service. A lump sum provision of Rs. 150 lakh is made for solid waste management.

All necessary safety appliances such as helmets, masks, ear plugs, etc. shall be provided to the workers and staff. The regulations regarding working platforms, excavations, trenches and safe means of entry and exit shall be strictly complied. Efficient lighting and safety signs shall be installed on temporary roads during construction and adequate traffic regulations shall be adopted and implemented. All facilities to be constructed shall be fully equipped with the fire protection equipment as per IS standards. Thus, a total provision of Rs. 650 lakh is kept for Environmental Management in labour camps.

10.6.7 Public health

i) Control of malaria: Increase in water fringe area provides suitable habitats for the growth of vectors of various diseases, which is likely to increase the incidence of water-related diseases. Malaria could be the major incidence in the months of Sept and March. The preferred habitat is stagnant or slow-moving fresh water open to vector-borne disease in the area. The main breeding reasons of the anopheline mosquito (malaria vector) are sunshine or moderate shade. Mosquito control and mosquito proofing measures shall be taken up to control malaria. The anti-malarial operations will be coordinated by various Primary Health Centres located in villages close to the link canal.

ii) Development of Medical Facilities: It is proposed to develop first-aid posts manned by a doctor each and supporting staff during construction phase. The first-aid posts shall be located close to major construction sites. The doctor

posted at the first-aid posts shall also coordinate the anti-malarial campaign to be carried out. A systematic campaign shall be conducted in the months of March and Sept which are usually the breeding months of mosquito. There shall be regular fumigation and sprays of insecticides in the areas where water is likely to be stagnant, to prevent the growth of malarial larvae.

iii) Health extension activities: The health extension activities will be carried out in the villages situated close to the storages being developed as a part of the project. There would be possibility of the transmission of communicable diseases due to migration of labour population from other areas at the construction site. The doctors from the dispensaries to be set up as part of the project and other dispensaries in various villages in the project area shall make regular visits to the villages and organize health promotional activities with the active participation of the local village leaders, Non-Governmental Organisations and available local health functionaries.

iv) Water-borne diseases: Following measures will be implemented for control of water-borne diseases:

- Details of incidence of various water-borne diseases in the project areas are collected and analysed to detect any particular trend.
- A detailed water quality monitoring programme is designed and implemented. In areas showing incidence of water-borne diseases, intensive water quality monitoring shall be done.

v) Disposal of bio-medical waste: The Bio-medical waste generated from Health Care Facilities (HCFs) like hospitals, clinics, dispensaries, blood banks, health camps, medical or surgical camps, vaccination camps, blood donation camps and first aid rooms shall be treated and disposed of in compliance with the standards of the prevailing bio-medical waste management rules of the state.

A lump sum provision of Rs. 100 lakh are made towards public health, health delivery system and disposal of bio medical waste.

10.6.8 Catchment area treatment plan

10.6.8.1 Data acquisition

Due to the spatial variability of site parameters such as soils, topography, land use and rainfall, all areas may not contribute equally to the erosion problems. Satellite data shall be used for deriving latest and accurate land use data and ground truth studies shall be conducted.

The various data layers of the catchment area useful for the study are as follows.

- Catchment area map
- Location map
- Project layout map
- Slope map
- Soil map
- Land use classification map
- Current management practices

10.6.8.2 Estimation of soil loss using silt yield index (SYI)method

The Silt Yield Index is defined as the yield per unit area and silt yield index (SYI) value for a hydrologic unit is obtained by taking the weighted arithmetic mean over the entire area of the hydrologic unit by using suitable empirical equation. Details are given at **Table 10.11.**

Table 10.11
List showing priority categories and SYI Values

Priority categories	SYI Values
Very high	>1300
High	1200 – 1299
Medium	1100 – 1199
Low	1000 – 1099
Very low	<1000

10.6.8.3 Catchment area treatment measures

The Objective of the SYI method is to prioritize sub-water shed in a catchment area for treatment. The erosion category of various watersheds in the catchment area as per SYI index for the catchment of Kattalai barrage proposed enroute storages shall be arrived at in the CEIA study of the link project and areas under different erosion categories shall be identified accordingly. Various engineering and biological measures shall be suggested in EIA studies for catchment area treatment categorized in the high erosion category of watersheds in the catchments upto the respective storages.

10.6.8.4 Silt transfer

The yield received from rains in the catchment area would be tapped at Kattalai barrage and let out into the link canal through the head regulator. Normally, the silt transported from the catchment area would settle down into the lower layers and finally to the bottom and the top silt free water would be admitted into the link canal. However, during monsoon season the flood waters due to heavy rain fall would be laden with more suspended silt which would require mitigative measures. Silt excluders need to be built at the head regulator of main canal and branch canals. The silt excluders shall extract silt from the water and lead it to the river.

Silt escape or bed escapes, provided with vents and gates, need to be provided on the link canal nearer to the streams or rivers at suitable locations. Even after providing silt excluders and silt escapes, some quantity of suspended silt shall still get deposited on the bed of link canal. Every year during the closure period of the canal, the deposited silt will have to be removed from the bed of the canal in order to avoid growth of weeds. Since the bed of the canal shall be entirely lined, desilting can be done with ease.

10.6.9 Command area development/management

Cauvery (Kattalai) - Vaigai – Gundar link project envisages to provide irrigation to an extent of 448340 ha of new area in seven districts of Tamil Nadu viz. Karur, Pudukkottai, Tiruchirappalli, Ramanathapuram, Sivaganga, Virudhunagar and Thoothukudi in Cauvery, Streams between Cauvery &

Vaigai, Vaigai and Streams between Vaigai &Vaippar basins. Topography of the command area is undulating and is of moderate slope with isolated hill tops dominating the command area.

The command area development would include land leveling, shaping, construction of field channels and drainage systems. Land leveling is essential in undulating area of the command for equitable distribution of water and prevention of soil loss due to erosion. To prevent stagnation of water in the command, field drains would drain into subsidiary drains to be constructed at right angle to natural drains. The field boundaries will be made use of in digging these subsidiary drains. Field drains shall be at least 30 cm deep with side slope ranging between 4:1 and 8:1. Drains shall be as straight as possible with cross section of trapezoidal shape.

A provision of Rs. 27017 lakh have been kept in the estimate towards improvement of existing drains and construction of new drains in the command area @ Rs. 8000/- per ha of CCA. At the time of implementation of the link project, detailed survey of each command will be done and based on the actual requirement, appropriate land development works will be taken up by the state Govt.

10.6.10 Impact on water quality downstream of Kattalai barrage

There will be no adverse impact on the water quality downstream of Kattalai barrage, as only a part of the available water is diverted into the link canal and the remaining water flows down the river. Also, a no. of rivers/streams join Cauvery downstream of the barrage.

10.6.11 Disaster management plan

Since the link project is envisaged from the existing barrage at Kattalai on river Cauvery and no major storage dam is involved, no dam break management plan is required.

10.6.12 Energy conservation measures

Various construction and other activities of the proposed Cauvery (Kattalai) - Vaigai – Gundar link project would lead to increased demand for fuel wood in the project area and its vicinity and would therefore exert pressure

on forest areas located around the project. The major source of energy in the villages of the project area is fuel wood, acquirement of which is one of the main causes of ecological degradation and human drudgery. It is estimated that during the construction of the project, which would last for about 5 years, a large influx of labour will be at the project site. Majority of the labour force will be outsiders and it will be very important to meet their energy requirement in an ecologically sustainable manner.

To provide an alternate for the energy requirement of the workers, contractor/s shall be made responsible to provide subsidized kerosene/LPG to their workers which will in turn discourage them from illegal tree felling and removal of fuel wood and timber from the adjoining forests. Further, community kitchen facilities shall also be provided to the labourers by the contractors. In addition to above, efforts can be made towards energy conservation by installing non-conventional energy sources. Energy conservation measures shall be implemented to ensure that the use of non-renewable resources is minimized. A key component of achieving energy conservation would be the development of an energy management action plan. This plan can be included as part of the construction and operational EMPs. The energy management action plan shall be consistent with the energy conservation measures during both construction and operation phases.

10.6.12.1 Energy conservation during construction phase

The following energy conservation measures can be undertaken during construction works:

- Efficient work scheduling and methods that minimize equipment idle time and double handling of material
- Throttling down and switching off construction equipment when not in use
- Switching off truck engines while they are waiting to access the site and while they are waiting to be loaded and unloaded
- Switching off site office equipment and lights and using optimum lighting intensity for security and safety purposes.
- Careful design of temporary roads to reduce transportation distance

- Regular maintenance of equipment to ensure optimum operation and fuel efficiency.
- The specification of energy efficient construction equipment.

10.6.12.2 Energy conservation during operation phase

The following energy conservation measures would be implemented during operation phase:

- Use of CFL lights up to maximum possible extent.
- Awareness about the use of CFL lights by locals.
- Development of heating, cooling and lighting use in buildings through climate-responsive design and conservation practices.
- Employing renewable energy sources such as day lighting and passive solar heating.
- Optimizing building performance and system control strategies, such as controlling lights with occupancy sensors and controlling comfort.
- Maximizing the use of solar power for signage and pedestrian lighting.
- Designing roads on site to reduce transportation distances.

An amount of Rs. 150 lakh have been earmarked for implementation of energy conservation measures.

10.6.13 Environmental monitoring programme

Environmental monitoring is an essential tool in relation to environmental management as it provides the basis for rational management decisions regarding impact control. Environmental monitoring shall be performed during construction, commissioning and operation phases to ensure that the adverse impacts have been mitigated efficiently and to verify the impact predictions. The monitoring program will indicate where changes to procedures or operations are required, in order to reduce impacts on the environment or local population. The monitoring program will be undertaken to meet the following objectives:

- To monitor the environmental conditions of areas benefited and impacted by the project

- To check whether mitigation and benefit enhancement measures have actually been adopted, and are proving effective in practice
- To provide information on the actual nature and extent of key impacts
- Effectiveness of mitigation and benefit enhancement measures which, through a feedback mechanism, can improve the planning and execution of future similar projects.

From the monitoring point of view, the important parameters are water quality, air quality, noise, erosion and siltation, afforestation, fishery, etc. An attempt can be made to establish early warning of indicators of stress on the environment. Suggested environmental monitoring plans are described in the following sections. The environmental monitoring programme during construction phase shall be as in **Table 10.12.**

Table 10.12
Environmental monitoring programme during construction phase

Sl. No.	Particulars	Parameters	Frequency	Location
1	Treated wastewater from STPs	pH, BOD, COD, TSS and Oil and Grease	Once in a month	Before and after treatment from STPs at various labour camps
2	Ambient Air quality	SPM, RPM, SO_2, NOx and CO	Once in a season	Major Construction sites
3	Noise	Equivalent noise level (Leq)	Every month	Major Construction sites
4	Water-related diseases	Identification of water related diseases, adequacy of local control and curative measure, etc.	Once in a season	Labour camps and nearby settlements

As indicated above, the parameters to be monitored in water are pH, BOD, COD, total dissolved solids. A provision of Rs. 70 lakh is made for environmental monitoring programme during construction phase.

The Environmental monitoring programme during project operation phase can be as at **Table 10.13.**

Table 10.13

Environmental monitoring programme during project operation phase

Sl. No.	Particulars	Parameters	Frequency	Location
1	Water	pH, turbidity, total dissolved solids, calcium, magnesium, chlorides, sulphate, nitrates, iron, DO, BOD, COD etc.	Pre and Post monsoon seasons	Storages
2	Treated waste water from STP	pH, BOD, COD, TSS and Oil and Grease.	Once in a month	Before and after treatment from STP
3	Ecology	Status of afforestation Programmes	Once in 5 years	-
4	Fisheries	Phytoplanktons, zooplanktons, benthic life, fish composition	Twice in a year	Storages
5	Incidence of water-related diseases	Cause and control measures for various diseases.	Once in a year	Settlements around storages and in command area
6	Meteorological parameters	Temperature, rainfall, humidity, cloud cover, wind speed and direction, solar insulation, evaporation rate	Continuous	At a location close to each of the two storage sites

A provision of Rs. 100 lakh are made towards implementing environmental monitoring programme during operation phase. Further, a provision of Rs. 10 lakh are made for monitoring meteorological parameters.

Thus, a total of Rs. 110 lakh are provided for implementation of the above listed activities in the environmental monitoring programme during construction as well as operation phases.

10.6.14 Cost of environmental management plan

The total estimated cost for implementation of environmental management plan is Rs. 5160 lakh (excluding the cost of R&R Plan). Details are given at **Table 10.14.**

Table 10.14

Details of cost for implementation of environmental management plan

Sl. No.	Item	Total (Rs lakh)
1	Compensatory afforestation	3235
2	Green belt development on reservoir periphery and along link canal	200
3	Environmental Management in Labour camps including storages and canal	650
4	Public health and health delivery system and disposal of Bio medical waste	100
5	Restoration of Quarry sites and land scaping including restoration of Colony and Office Complex	200
6	Stabilisation of Muck disposal management / Land management	350
7	Land scaping of colonies and offices	100
8	Implementation of water pollution control measures	20
9	Implementation of Air pollution control measures	40
10	Implementation of Noise pollution control measures	5
11	Implementation of Energy conservation measure	150
12	Implementing Environmental Monitoring Programme	110
	Grand total	**5160**