

## **Chapter 4**

### **Surveys and investigations**

#### **4.0 General**

Surveys and Investigations provide field data required for planning and designing of various components of a Water Resources Development project. A project can be designed optimally and economically, only when the necessary field data of specified standards are available. NWDA has carried out field surveys and investigations in the project area for collection of the data required for the preparation of Feasibility Report of Cauvery (Kattalai) - Vaigai – Gundar link project during the period from 1998 to 2003 as per norms and guidelines prescribed for preparation of feasibility report.

Topographical surveys, geological and geotechnical investigations including foundation investigations i.e. drilling bore holes at identified major CD/CM structures & Tunnel for obtaining rock cores, construction materials investigations, geophysical investigations, geotechnical investigations including borrow area surveys and command area surveys are carried out through departmentally as well as through various specialized organizations in order to examine the feasibility of the project.

The Feasibility Report (FR) of Cauvery (Kattalai) - Vaigai – Gundar link project was prepared by NWDA during the year 2004.

The link project comprises the following components at F. R. stage:

- 1) An existing barrage at Kattalai across the river Cauvery with pond level of 101.200 m.
- 2) A head regulator from the foreshore on the right side at Kattalai barrage with a designed discharge capacity of 180.3 m<sup>3</sup>/sec.
- 3) A 256.82 km long link canal taking off from the proposed head regulator with FSL at 100.75 m and discharge capacity of 180.30 m<sup>3</sup>/sec at head.
- 4) A total number of 204 CD/CM works.

The Kattalai bed regulator was constructed in 1933 and in operation till the new Kattalai barrage was constructed by Government of Tamil Nadu and commissioned in 2014. The various components of the Kattalai barrage are furnished below:

- 1) 1233.20 m long barrage with 7.5 m wide carriage way to pass maximum flood discharge of 13,111 Cumec
- 2) 86 nos. of barrage vents of which 82 nos. are of size 11.00 X 4.90 m and 4 nos. are of 10.20 x 4.90 m with sill level of 96.300 m to pass maximum flood discharge of 11,305 Cumec
- 3) 12 nos. of scour vents of size 11.00 X 5.50 m with sill level of 95.700 m to pass maximum flood discharge of 1806 Cumec

The field inspection for the CVG canal alignment was carried out during 29<sup>th</sup> July to 1<sup>st</sup> August, 2019 by the Chief Engineer (S), NWDA, Hyderabad accompanied by the officers of NWDA and WRD, PWD, Government of Tamil Nadu, in view of the urbanization and developmental activities that has taken place after the circulation of feasibility report in 2004. In the light of field inspection and other technical studies, the link canal is re-aligned between RD 62.60 km and 69.00 km to avoid the institutional areas (Indian Institute of Management, Trichy, Bharathidasan University and Anna University, Trichy campus). Apart from this, tunnels are introduced to negotiate the deep cut reaches along the canal alignment.

The link project comprises the following components at DPR stage:

- 1) Existing barrage at Kattalai in Mayanur village in Krishnarayapuram taluk of Karur district with full pond level of 101.20 m.
- 2) A head regulator on the right bank of Kattalai barrage with a designed discharge capacity of 180.3 m<sup>3</sup>/sec.
- 3) A 256.82 km long lined canal off taking from Kattalai barrage with FSL at 100.75 m and discharge capacity of 180.3 m<sup>3</sup>/sec at head.
- 4) 25 nos. of direct sluices and 12 nos. of branch canals off taking from the main canal to feed the command area lying east of the link alignment.

- 5) 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).
- 6) Cross drainage/ cross masonry and regulating works across the link canal (464 nos).
- 7) Command area development for about 448340 ha in Karur, Tiruchirappalli, Pudukkottai, Sivaganga, Virudhunagar, Ramanathapuram and Thoothukudi districts of Tamil Nadu.

The surveys and investigations in respect of the link canal, canal structures etc., undertaken departmentally and through various specialized organizations at FR stage have been considered for preparation of Detailed Project Report. The relevant details in respect of Kattalai barrage is collected from the Water Resources Department, Government of Tamil Nadu and incorporated in the report.

The various surveys and investigations work carried out at FR stage are described in the following paragraphs.

#### 4.1 Topographical survey

The Great Trigonometrical Survey (GTS) Bench Marks (BMs) of Survey of India (SoI) located in the vicinity of link canal have been transferred and connected at various locations along the canal alignment by conducting Double Tertiary (DT) levelling of about 149 km. Adequate number of Temporary Bench Marks (TBMs) at different locations along the alignment were established with reference to the above GTS Bench Marks. The details of various GTS Bench Marks connected to the link alignment is furnished in **Table 4.1**.

**Table 4.1**

#### **GTS Bench Mark details of Cauvery -Vaigai-Gundar link project**

Sl. No.	Description	Distance	RD of CVG link
	SOI	NWDA	
1	G.T.S. Bench Mark -58 J/1 at Mayanur Railway Station	On top of stone fixed by NWDA on right side Kattur to Malaipatti Road.	2.000 km 1.500 km

2	G.T.S.BM at Kulithalai Railway Station.	On top of stone fixed by NWDA at the corner of Road junction in front of Vinayagar Temple at Satyamangalam Village.	7.40 km	46.785 km
3	G.T.S.BM situated in Executive Engineer's Office, PWD, Trichy.	On top of stone fixed by NWDA at left side of Road junction in front of Dendayudhapani Koil at Mandaiyur Village.	19.100 km	64.150 km
4	BM at Ganapathy Temple at North end of Karambagudi Village.	On top of stone fixed by NWDA near North West side of Basement of High-Power line near North East Corner of Kavinad Tank at Tiruvappur Village.	46.100 km	110.750 km
5	G.T.S Temple at out strikes of Karaikudi Town.	On top of stone fixed by NWDA at corner of Sharath Industries on Karaikudi to Nachiyapuram Road at Managiri Village.	7.600 km	155.735 km
6	G.T.S. Standard Bench Mark 1907 at Madurai situated in Civil station.	On top of stone fixed by NWDA in front of Police Station, within the Compound at Thirupachetty Village.	32.500 km	222.775 km
7	G.T.S. Bench Mark at Thirumangalam Railway Station	On top of stone fixed by NWDA under the over head Water tank at Dharmapuram Village.	34.000 km	255.600 km

The line diagram of GTS BMs connected with the link alignment is shown in **Plate 4.1**

### 4.1.1 Rivers

Cauvery (Kattalai)-Vaigai-Gundar link project takes off from the existing Kattalai barrage on Cauvery. The pond level of the barrage is 101.20 m against the off take FSL of 100.75 m. The flood protection banks top level in the upstream of the barrage is 103.0 m. As such additional topographical survey for river is considered as nil.

### 4.1.2 Reservoirs

No reservoir surveys have been conducted, since no new dam is proposed across any of the intermediate rivers that the link canal crosses.

### 4.1.3 Head works

The link canal takes off from the right side of Kattalai barrage just u/s of the off take of Kattalai High Level canal. A head regulator is proposed to divert the regulated water from the barrage to the link canal. The head regulator is proposed at river protection bund on foreshore far away from the submergence area which necessitate an approach channel up to the regulator. The off take FSL of canal is at 100.75 m. The head regulator with 4 bays of 4.25 m wide each is proposed.

The crest level of the regulator is at 96.50 m. Identical vertical lift type fixed wheel service gate in each bay for opening size of 4.25 m X 4.70 m are proposed to control the discharge into the canal. The gate is designed for water head corresponding to pond level of 101.20 m. The layout plan, elevation and bottom plan of existing Kattalai barrage are appended at **Plate 4.2**.

### 4.1.4 Plant and colony layout

The Plant and colony layout survey for the link canal are proposed to be carried out at Pre-construction stage of the project. There are suitable locations available for installation of various plants and colonies in the vicinity of the link canal.

#### **4.1.5 Canal and water conductor system and canal structures**

##### **i) Link canal and water conductor system**

The total length of Cauvery (Kattalai) -Vaigai-Gundar link canal is about 256.82 km. It is designed to divert 2252 Mcum of water from Kattalai barrage during June to January for irrigation requirement and throughout the year for domestic and industrial use. The topographical surveys have been carried out departmentally during the period from February 1999 to January 2003.

The centre line of the link canal marked on the 1:50000 scale toposheets of Survey of India, is transferred to the ground first by measuring the bearings of the alignment in the toposheets and then setting them in ground with the help of compass / theodolite after applying correction on account of magnetic variation. Alignment of the link canal was fixed on the ground by taking into account the actual site conditions such as that forest patches, developed areas and valuable lands were avoided as far as possible. Centre line stones of size 75 cm X 15 cm X 15 cm have been fixed all along the alignment at 500 m interval up to the tail end. In addition, centre line stones are also fixed along the alignment at road crossings, at locations of important CD works and at all the turns / bends indicated by change in the bearings of the link canal alignment. All the above pillars were painted blue and chainage along with name of the project were written with red paint.

Longitudinal Profile surveys of the link canal have been carried out by Double Tertiary (DT) levelling using auto levels by taking levels at every 100 m interval. Cross sectional profile surveys of the link canal were carried out at every 400 m interval along the alignment by Single Tertiary (ST) levelling using auto levels by taking levels at every 50 m interval extending up to 200 m on either side of the alignment. Whenever appreciable change in topography is noticed along the cross-sectional lines, levels are taken at closer intervals.

The link canal alignment proposed at Feasibility Report stage was reviewed using the images of google earth for ascertaining the extent of developmental activities that have taken place around the urban areas of Pudukkottai and Karaikudi. The link canal alignment proposed during feasibility stage has been deviated from RD 62.60 km to RD 69.10 km to avoid

passing through Indian Institute of Management and Bhrathidasan University near Trichy. The topographical investigation carried out at feasibility stage was limited and not in conformity with DPR guidelines and required to be carried out fresh. Due to time constraint, the topographical condition of the link alignment was analysed using Remote Sensing Technology. The accuracy for elevation was compared with the natural surface elevation of 46 locations along the link alignment and elevation of GDSM/DEM as obtained from Bhuvan (India) and Jaxa Global Alos (Japan) web portals. The accuracy for elevation in respect of GDSM obtained from Jaxa Global Alos web portal was found better than DEM obtained from Bhuvan web portal. The contours at 2 m interval along the link canal covering 500 m on either side have been generated using the Global Digital Surface Model (GDSM) of 1 arc obtained from Jaxa Global Alos web portal. The actual topographical survey will be carried out at pre construction stage.

The maps showing link alignment drawn on toposheets of 1:50000 scale is given at **Plates 4.3.1 to 4.3.12**. The strip contour plan and L - section of the link canal alignment generated 2.0 m contour interval using the GDSM of 1 arc obtained from Jaxa Global Alos web portal and appended at **Plates 4.4.1 to 4.4.26**.

## ii) Canal structures

The link canal on its way crosses a number of rivers / streams/ tributaries/ nallas besides National/ State/ District highways and village roads / Railway lines. In total there are 464 canal structures, consisting of 6 aqueducts, 10 syphon aqueducts, 36 canal syphons, 12 super passages, 7 cross regulators, 4 canal escapes, 25 direct sluices, 12 canal regulators, 95 under tunnels, 95 over passes, 110 single lane bridges, 35 double lane bridges, 11 four lane bridges and 6 railway bridges. Details of the CD/CM structures across the link canal is furnished in **Annexure 4.1**.

The strip contour maps cover 500 m on either side of centre line which is more than norms prescribed in the DPR guidelines. The actual topographical survey will be carried out at pre construction stage.

#### **4.1.6 Power house, switch yard, surge shaft, tail race etc.**

The hydro power house is not proposed in the link project.

#### **4.1.7 Tunnel, adits and penstock**

Four tunnels of total length 15.54 km are proposed i.e. at RD 82.3 km, 104.1 km, 148.1 km and 156.3 km with length of 3.94 km, 6.04 km, 3.63 km and 1.93 km respectively. The strip contour maps cover 500 m on either side of centre line which is sufficient as per the norms prescribed in the DPR guidelines. The actual topographical survey will be carried out at pre construction stage.

#### **4.1.8 Command area**

The Cauvery (Kattalai) -Vaigai-Gundar link project envisages diversion of 2252 Mcum of waters of Cauvery river from Kattalai barrage to serve water deficit areas in seven districts of Tamil Nadu for irrigation, domestic and industrial use. It is planned to provide irrigation to an extent of 448340 ha in Karur, Tiruchirappalli, Pudukkottai, Sivaganga, Virudhunagar, Ramanathapuram and Thoothukudi districts utilizing 1931 Mcum of water. Besides, the link project will provide 218 Mcum of water for domestic and industrial use. The command area survey has been done to an extent of 2392 ha under the proposed command area under Narangiyanpatti branch canal (Alangudi br. canal) in 2006-07 (after circulation of FR in 2004), which constitutes only 0.71 per cent of the culturable command area of 448340 ha. The detailed surveys in the likely command area are proposed to be carried out at pre-construction stage.

### **4.2 Other surveys**

#### **4.2.1 Archaeological survey in the canal area**

No major archaeological site has been noticed on the proposed canal alignment and a buffered area of 200 m on both banks of the canal during the topographical surveys carried out by NWDA. However, detailed archaeological surveys in the command area and the link alignment is



proposed to be carried out at Pre-construction stage to ensure that the project area is devoid of Central / State protected archaeological sites and monuments.

#### **4.2.2 Mineral survey in the canal area**

No minerals of economic importance have been found along Canal alignment. Sporadic sulphide mineralization in the form of Pyrite and rare incidence of Chalcopyrite is reported in the granites of Nartamalai area. White clay of refractory grade occurs in Karaikudi and Sivaganga taluks. Some of the best-known deposits of graphite occur near Sivaganga. Yellow Shale and ferruginous material used as mineral pigment occurs below laterite west of Puvali and Pudupatti near Sivaganga. Ochre occurs as buff, mauve, yellow and pink coloured shale exposed near Sivaganga. Minor occurrence of Baryte is noticed north of Tiruppuvanam.

#### **4.2.3 Right of way surveys for the reservoir**

No right of way survey has been carried out since only the existing Kattalai barrage is planned to be used as head works of the proposed link canal.

#### **4.2.4 Communication surveys**

The Cauvery (Kattalai) - Vaigai - Gundar Link project is proposed to pass through Karur, Tiruchirappalli, Pudukkottai, Sivaganga and Virudhunagar districts of Tamil Nadu. The existing Kattalai barrage functions as the head works of the link canal. The barrage is located at about 5 km from Krishnarayapuram town in Karun district and is approachable from NH 81 connecting Coimbatore and Chidambaram via Karur and Tiruchirappalli. The head works is also connected by Erode -Tiruchirappalli BG railway line and the nearest railway station is at Mayanur hardly 200 m from the barrage. The nearest airport in the vicinity of the off-take point is located at Tiruchirappalli at about 65 km.

The link canal crosses Musiri- Manapparai SH 71 at RD 19.45 km, Tiruchirappalli-Dindigul NH 83 at RD 47.03 km, Tiruchirappalli- Madurai NH 38 at RD 53.40 km, Tiruchirappalli-Rameswaram NH 526 at RD 67.94 km,

RD 112.44 km, RD 116.85 km and RD 123.81 km, Thanjavur-Manamadurai NH 36 at RD 153.98 km, RD 155.42 km and RD 206.19 km, Kochi -Thondi NH 85 at RD197.06 km, Melur-Ilaiyankudi SH 34 at RD 204.49 & RD 206.56 km and Madurai -Rameswaram NH 87 at RD 222.44 km.

The link canal alignment crosses Tiruchirappalli - Madurai at RD 48.99 km, Tiruchirappalli - Rameswaram BG railway line at RD 67.71 km, RD 127.59 km, RD 148.05 km, RD 194.44 km &RD 205.69 km and Madurai - Rameswaram BG railway line at RD 227.70 km.

Thus, the entire link canal traverses in the vicinity of many villages and towns. The head works and the canal alignment are very well approachable by means of railway line, National Highways, State Highways, major district roads and all-weather village roads. The existing road and railway networks can be used during the period of construction activities of the link project.

The map showing the communication network in the vicinity of the link canal project is appended at **Plate. 4.5**.

#### **4.2.5 Drainage surveys**

The link project envisages transfer of water through lined canals to extend irrigation benefits in the water short areas of Tamil Nadu. The enroute command area is well drained by rivers / streams like Ariyar, Pungar, Napiliar, Koraiyar, Agniar, Virisalar, Vellar, Manimuttar, Uppar, Vaigai and Gundar and also by a number of minor drains. As such, no water logging / drainage problems are anticipated in the command area. Suitable provision is, however, made in the cost estimate towards providing good drainage network.

#### **4.2.6 Soil surveys**

No systematic soil surveys in the command area has been carried out. However, the the details available from Department of Agriculture, Government of Tamil Nadu, the soils in the proposed command area are mainly falling under five soil classification groups viz. Haplustalfs, Rhodustalfs, Ustifluvents, Chromusterts and Ustropepts. Details on

Physiography and classification of soils, in the proposed command area of the link canal is given in **Annexure 4.2**.

Red sandy loam soil, brown clay loam soil, black clay loam soil, alluvial soil etc. are the predominant soil available in the command. Soil map of the command area is appended at **Plate 4.6**.

#### **4.2.7 Cadastral surveys**

The Department of Land Records, Chennai and Tamil Nadu e – governance Agency, Department of IT, Chennai were approached to supply Geo referenced cadastral maps of taluks falling under the link alignment for assessing the survey numbers and extent of different types of land acquisition involved under the link canal. The Department of Land Records, Chennai have informed that they do not have geo referenced cadastral maps. Tamil Nadu e – governance Agency, Department of IT, Chennai declined to share the data on the ground that they are only the central repository of all digital maps of all the departments of the State and not the owner of the data. Due to time constraint, it is proposed to assess the land acquisition with cadastral maps during the pre-construction stage of the project.

### **4.3 Geology and seismic investigations**

#### **4.3.1 Regional geology**

Crystalline rocks of Archaean to late Proterozoic age occupy over 80 % of the area of the Tamil Nadu State, while the rest is covered by Phanerozoic sedimentary rocks mainly along the coastal belt and in a few inland River valleys. The hard rock terrain comprises predominantly of Charnockite and Khondalite groups and their Migmatitic derivatives, supracrustal sequences of Satyamangalam and Kolar groups and Peneinsular Gneissic Complex (Bhavani Group), intruded by ultramafic- mafic complexes, basic dykes, granites and syenites. The sedimentary rocks of the coastal belt include fluviatile, fluvio-marine and marine sequences, such as Gondwana Supergroup (Carboniferous to Permian and Upper Jurassic to Lower Cretaceous), marine sediments of Cauvery basin (Lower Cretaceous to Paleogene), Cuddalore / Panambari Formation (Mio – Pliocene) and sediments of Quaternary and Recent age. The Crystalline rocks of the State are derived through a complex evolutionary

history during Archaean and Proterozoic times with multiple deformations, anatexis, intrusions and polyphase metamorphic events.

The area around the link canal alignment from Kattalai barrage to Gundar river is predominantly occupied with the rock formations ranging in age from Archaean to Early to Middle Pleistocene. Migmatite complex, Khondalite Group, Late Jurassic to Early Cretaceous and Early to Middle Pleistocene occupy the major south and eastern part of the alignment and command area of the project. The south eastern part of the command is represented by Quaternary Alluvium, Fluvial, Fluvio-marine and Aeolian.

The broad and tentative succession of the area, as worked out in 1: 250000 Geological Resources Maps of Geological Survey of India is given at Table 4.2 below:

**Table 4.2**  
**Geological formation and rock type**

<b>Age</b>	<b>Super group</b>	<b>Group</b>	<b>Formation</b>	<b>Rock type</b>
Recent to Late Pleistocene				Alluvium, Fluvial, Fluvio-Marine and Aeolian
Mio-Pliocene			Cuddalore Formation	Sandstone, Pebbly Sandstone, Mottled Sandstone and Clay
Early to Middle Pleistocene				Laterite
Late Jurassic to Early cretaceous			Sivaganga Formation	Boulder bed Conglomerate, Micaceous Sandstone and Clay
Proterozoic		Acid Intrusives		Pink Granite and Granite Gneiss
Archaean		Migmatite Complex		Granite, Garnet granulite, Grey migmatite /

				Hornblende – biotite gneiss
		Khondalite		Quartzite

### 4.3.2 Local geology

The Cauvery (Kattalai) -Vaigai-Gundar link canal traverses for its entire length of 256.82 km through Karur, Tiruchirappalli, Pudukkottai, Sivaganga and Virudhunagar districts. The lithotypes broadly belongs to Migmatite Complex, Khondalite, Acid Intrusives, Sivaganga Formation and Cuddalore Formation along the proposed link canal alignment.

In the initial reach of link canal alignment Alluvium covers about 800 meters followed by Migmatite Complex represented by Hornblende – biotite gneiss up to RD 53.45 km. The Acid intrusive of Proterozoic era represented by Pink Granite and Granit Gneiss covers the alignment from RD 53.45 to 54.77 km, RD 93.90 to 95.40 km and RD 97.24 to 101.33 km. The Hornblende – biotite gneiss covers the alignment from RD 56.85 to 59.85 km, RD 67.65 to 74.63 km, RD 116.29 to 132.98 km, RD 134.35 to 136.31 km, RD 162.11 to 168.14 km, RD 176.04 to 187.50 km, RD 203.90 to 215.73 km and RD 254.87 to 256.51 km. The Migmatite complex represented by Grey migmatite, Graygranolite and Garnet granolite covers the alignment from RD 54.77 to 56.85 km, RD 59.85 to 67.65 km, RD 74.63 to 93.90 km, RD 95.40 to 97.24 km and RD 101.33 to 114.33 km. The Cuddalore Formation of Mio-pliocene represented by Sandstone, Pebbly sandstone, Mottled sandstone and clay covers the alignment from RD 114.33 to 116.29 km, RD 132.98 to 134.35 km, RD 136.31 to 138.27 km, RD 141.11 to 162.11 km, RD 199.23 to 203.90 km and RD 239.73 to 254.87 km. The Laterite covers the alignment from RD 138.27 to 141.11 km. The Sivaganga Formation of Late Jurassic to Early Cretaceous represented by Boulder bed conglomerate micaceous sandstone and clay covers from RD 187.50 to 199.23 km. The Alluvium covers from RD 215.73 to 239.73km.

### 4.3.3 Geological and geotechnical investigations

The objective of the geological investigations is to find out type of rock, major joints, shear zones, fault and fractured zones if any, in the project area.

The Geological Investigations for the link project was carried out by Engineering Geology Division, GSI, Chennai in 2001-02.

As per the Preliminary Report of the GSI based on limited field checks, the link canal alignment falls in two contrasting geological domains of which, from off take to RD 130 km the alignment passes through Archaean metamorphic terrain consisting of migmatite and hornblende biotite gneiss and beyond RD 130 km, Passes through sedimentary formation of Upper Gondwana (Sivaganga Formation) and Mio – Pliocene (Cuddalore Formation) ages.

At off take, weathered gneiss is exposed in Kattalai canal cutting at about 700 m away from the site. From off take to Koraiyar river (at RD 60.0 km) there is 1 to 3 m thick soil cover followed by a moderately weathered migmatitic gneiss of about 10 m thickness. From RD 35 km to 50 km and 57 km to 60 km, the thickness of alluvium and soil appears to be higher at 5 to 7 m. The alignment continues to traverse the migmatitic terrain up to RD 128 km. The soil and weathered rock thickness are 2-3 m and 5-7 m respectively up to RD 110 km. Towards Pudukkottai the overburden thickness tapers to 2 m. The thickness of soil/alluvial cover is higher and it could be about 10 m at Vellar river crossing at RD 114 km.

From RD 128 to 158 km, the canal runs in Karaikudi area and passes through laterite cover, which appears to be more than 10 m at places, below which sand, sandstone and clay stone of Cuddalore formation occur.

From RD 158 to 163 km, there is an inlier of gneisses in this stretch of sedimentary terrain. In the segment of RD 163 to 182 km, the canal passes through a narrow off - shoot of sedimentary basin forming a valley and drained by two rivers namely, Virisalar and Manimuttar. The Virisalar section is occupied by over 20 m thick sedimentary sequence consisting of alluvium, sand and clay formations. At Manimuttar river bed, weathered rock appears at a shallow depth overlain by clay formation. From RD 182 to 207 km, the canal re-enters the sedimentary terrain of sand and clay formations capped by laterite. In the short reach of RD 207 to 211 km, migmatitic gneiss is expected at shallow depth. A thick alluvial cover of Vaigai river over the sedimentary formations consisting of gravel, sand, clay, limestone etc. occurs between RD

211 and 234 km of canal alignment. Sedimentary formation continues along the last segment of the canal but the basement rock is probably present at a shallow depth.

In addition, Geotechnical investigations including drilling were carried out by Department of Geology, College of Engineering (COEP), Pune at proposed major Cross Drainage (CD) works and in deep cut reaches to evaluate the depth and nature of bed rock, overburden and bed characteristics. The COEP carried out sub surface exploration at 15 nos. of bore holes by double tube barrel diamond core drilling, core logging and assessment of the cores. The location of drill hole details is furnished at **Table 4.4**. The rock types encountered in the mapped reaches include Hornblende – Biotite gneiss, Pink Granite, Granite Gneiss and Migmatite.

The report on the Geological Investigations and Geotechnical Investigations of the link project received from GSI and COEP are at **Appendix 4.1** and **Appendix 4.2** respectively.

#### **4.3.4 Laboratory investigation of rock samples**

Department of Geology, College of Engineering (COEP), Pune has been assigned with laboratory investigations of rock samples for the Cauvery (Kattalai) – Vaigai - Gundar Link Project. The core samples collected from exploratory drill holes were got tested at COEP Laboratory, Pune. The following tests were carried out on rock samples.

- Wet and dry density
- Specific gravity
- Water content
- Porosity
- Unconfined compressive strength

All the above tests were carried out in accordance with the recommendations of the relevant Indian Standard Codes and other standard procedures. The test results are furnished in **Appendix 4.2**.

### **4.3.5 Geophysical Investigations**

The geophysical investigations along the canal alignment to determine the sub-surface lithology, encountered between the Natural Soil Level (NSL) and Canal Bed Level (CBL) was entrusted to the Geology Department of Pune Institute of Engineering and Technology (PIET), formerly known as College of Engineering, Pune. The PIET conducted Geophysical investigations for the entire length of link alignment at an interval of 1000 m to a depth of 2 m below the CBL and at 200 m interval at major CD location to a depth of 20 m below the NSL at 269 locations using the “Electrical Resistivity Method” (ERM). Based on these ERM profiles 12 nos. of longitudinal cross sections were generated depicting the sub-surface geological features with reference to the CBL. The sub-surface vertical lithological sections along the link alignment is appended at **Plate 4.7.1 to 4.7.7.**

The report on Geophysical Investigations is at **Appendix 4.3.**

### **4.3.6 Seismic investigations**

No new dams/ reservoirs are proposed in the present study, since the existing Kattalai barrage is planned as head works of the link project. The proposed project area falls in the Zone II (least active) as per the Bureau of Indian standards (IS: 1893 - 2002). The preparation of DPR of the project comprises only the water conductor system but not water retaining structures. Therefore, seismic studies are not conducted in this study.

## **4.4 Geotechnical investigations (soils)**

The Geotechnical investigations (Soils) involve:

- 1) Soil investigations along the canal alignment.
- 2) Laboratory Investigations on soil samples from Borrow area along the canal alignment.
- 3) Foundation investigations of Cross Drainage structures.



#### 4.4.1 Soil investigations along the canal alignment

To ascertain the suitability of the borrow area material as construction material in filling reaches of canal alignment, disturbed / undisturbed soil samples from trial pits were collected from borrow areas and laboratory investigations were conducted by National Institute of Technology (NIT), Tiruchirappalli.

A total of 13 sites located along the proposed link canal alignment and at each location pits of size 1.5 X 1.5 X 1.2 m (minimum) were dug and the soil profile were recorded and disturbed & undisturbed soil samples were collected. The location of soil pits is given in **Table 4.3**.

**Table 4.3 Location of soil pits along the canal**

Sl. No	RD (km)
1	23.7 - 24.0
2	29.0 - 31.5
3	36.7 - 39.4
4	50.0 - 51.2
5	60.6 - 66.3
6	96.5 - 97.2
7	110.2 - 111.0
8	131.7 - 132.4
9	149.5 - 150.9
10	160.2 - 162.4
11	238.4 - 243.0
12	243.0 - 247.1
13	254.4 - 255.6

#### 4.4.2 Laboratory investigation on soil samples from borrow area along the canal alignment

Samples collected at 13 sites were preserved and sent to the NIT, Tiruchirappalli for carrying out the laboratory investigations. The soil samples collected as above were subjected to the following investigation:

- Grain size analysis
- Atterberg limits

- Proctor density
- Specific Gravity
- Direct Shear
- Triaxial Shear
- Chemical analysis
  - pH value
  - Calcium Tri-carbonate ( $\text{CaCO}_3$ )
  - Organic matter
  - Total Suspended Solids
  - Water Soluble Sulphate
  - Water Soluble Chloride

All the above tests were carried out in accordance with the recommendations of the relevant Indian Standard and other standard procedures.

Based on the findings of the laboratory investigations carried out on soil samples collected along the canal alignment, following conclusions have been arrived at:

- ❖ The grain size analysis indicate that the tested soil samples possess predominantly medium sand sizes followed by fine sand sizes, Gravel sizes and coarse sand sizes.
- ❖ The plasticity index of the tested soil samples indicates that all the 13 soil samples posses the low to medium plasticity characteristics.
- ❖ Bases on the results of grain size distribution and Atterberg limit test, out of 17 soil samples tested, 10 soil samples fall under SP (Poorly graded sand), 2 soil samples fall under SW ( Well graded sand ) and one sample fall under GW ( Well graded gravel) group of Bureau of Indian Standard Soil classifications (BIS : 1498-1970).

- ❖ Based on Standard Proctor Compaction tests, it is inferred that the soil samples are capable of achieving very good compaction densities.

The report on laboratory investigations on soil samples along the alignment received from NIT, Tiruchirappalli is at **Appendix - 4.4**. The map showing the location of soil samples collected for along the canal alignment is at **Plate 4.8**.

#### **4.4.3 Foundation investigations of CD structures**

Foundation investigation at major CD structures and deep cut stretches involve drilling the drill holes at each site and conducting the Standard Penetration Test (SPT) and In-situ permeability tests alternatively at every 1.5 m interval, besides, collection of undisturbed soil samples in Shelby tubes and SPT samples from the drill holes. A total of 14 bore holes were drilled at 11 different locations viz. at five deep cut reaches and 5 CD works apart from the location of Kattalai barrage.

14 SPT samples collected from the 11 bore hole locations in the link canal alignment was subjected to the following engineering properties of soil:

- Wet and dry density
- Specific gravity
- Water content
- Direct Shear test
- SPT

All the above tests were carried out in accordance with the recommendations of the relevant Indian Standard Codes and other standard procedures. The recommendations at the proposed location are given in **Table 4.4**.

**Table 4.4**  
**Recommendation on the type of foundations**

BH. No	Name of river/ location	Type of structure	Location of Drill hole	R.D/ chainage in Km	Suggested Depth of the Foundation RL wise	Suggested Depth of the Foundation in M	Type of FoundationReco mm-ended	Type of Densification Methods
1L	Cauvery river	Proposed barrage	250 m from the left bank within Cauvery river		91.716	7.1916	Well foundation	@
1C	Cauvery river	Proposed barrage	Centre of Cauvery river		91.716	7.1916	Well foundation	@
1R	Cauvery river	Proposed barrage	83m from the right bank within Cauvery river		91.716	7.1916	Well foundation	@
2	Napalli river	Aqueduct	Centre	33.830	76.930	12.7221	Well foundation	@
3	Koraiyar river	Aqueduct	Centre	58.475	68.700	18.2088	Friction Pile	Dynamic compaction
4	Deep cut	-	-	83.000	86.650	23.8174	Friction Pile	Dynamic compaction
5	Deep cut	-	-	104.000	84.38	21.1364	Friction Pile	Dynamic compaction
6L	Vellar river	Aqueduct	Left	113.890	68.865	13.6416	Well foundation	@
6C	Vellar river	Aqueduct	Centre	113.915	68.865	13.6416	Well foundation	@
6R	Vellar river	Aqueduct	Right	113.940	68.865	13.6416	Well foundation	@
7	Deep cut	-	-	135.215	66.860	28.6066	Friction Pile	Dynamic compaction
8	Deep cut	-	-	147.000	59.720	53.1669	Friction Pile	Dynamic compaction
9	Virisalar river	Aqueduct	Centre	163.580	51.925	25.1730	Well foundation	@
10	Deep cut	-	-	209.000	73.040	18.6317	Friction Pile	Displacement grout
11	Gundar river	Aqueduct	Centre	255.600	60.120	9.3289	Pile Foundation	Dynamic compaction

@Since we are recommending Well foundation for these bore holes, the soil here need not be densified, hence no Densification methods are suggested

The map showing the location of drill holes at Cross Drainage structures and deep cut reaches is at **Plate 4.9**.

## 4.5 Construction material survey

The CSMRS, New Delhi has carried out the construction materials survey of coarse and fine aggregates for the link alignment in the vicinity of the project area along with laboratory investigations for assessing their suitability to use as coarse and fine aggregates in concrete during construction of the project.

### 4.5.1 Rock and aggregates

The CSMRS team inspected the rock quarry sites which are located in the vicinity of the project during 05<sup>th</sup>- 09<sup>th</sup> August, 2002. The list of 22 rock quarry sites identified by CSMRS team in Karur, Tiruchirappalli, Pudukkottai, Sivaganga and Virudhunagar districts for coarse aggregate are furnished in **Annexure 4.3.1**.

All these quarries located in the proximity of link alignment have sufficient quantity of rock for use as coarse aggregate for the construction of the project.

The samples from the 22 quarries were collected by the CSMRS team during 28<sup>th</sup>- 31<sup>st</sup> August, 2002 and carried out the following tests as per BIS: 2386-1963 for assessing the suitability of these samples as coarse aggregate for use in concrete.

- Specific gravity
- Water absorption
- Soundness (5 cycles)
- Aggregate Impact Value
- Aggregate Crushing Value
- Aggregate Abrasion Value (Los-Angeles)
- Petrographic Examination

Based on physical and chemical tests and ASR (Alkali Silica Reaction) test conducted, it is found that out of 22 representative rock samples collected from 17 locations, the samples collected at following 8 locations are confirming to the codal requirements for use as coarse aggregate in concrete for both wearing as well as non-wearing surfaces as per BIS: 383-1970.

- 1) Sandhaipettai
- 2) Nedumalai
- 3) Pardi – Tuliyanur
- 4) Malayandipatti
- 5) Punnavayal
- 6) Mallampatti - Valvengai
- 7) Pillayarpati
- 8) Mallakottai

Further, the following seven samples are suitable for use as coarse aggregate in concrete for non-wearing surfaces only as these samples are prone to AAR.

- 1) Sukkaliyur – Unnachatram
- 2) Thogamalai – Kodapatty
- 3) Kavalkaranpatti
- 4) Kunnathur – Sandanakurichi
- 5) Lembalakudi
- 6) Ammachatram
- 7) Northamalai

Rock samples collected from Thirumalai quarry, Johilpatty quarry and Vakkanagundu quarry have been found to be unsuitable for use as coarse aggregate in concrete as the abrasion loss was more than the specified limit as per BIS: 383-1970.

On the petrographic examination carried out on the rock samples from Thogamalai, Kodapatty, Malaiyandipatti, Ammachatram and Northamalai quarries, it is found that rocks from these quarries are suitable for use as coarse aggregate in concrete for wearing surface as well as non-wearing surfaces. Rock materials from quarries other than those mentioned above are found to be susceptible to Alkali Aggregate Reaction due to the presence of high percentage of strained quartz. In view of the above, the aggregate from these quarries have to be used with cement containing alkali content not more than 0.6% as sodium oxide equivalent or pozzolanic cement for controlling alkali aggregate reaction.

## 4.5.2 Sand

The CSMRS team inspected the sand quarry sites which are located in the vicinity of the project during 05<sup>th</sup> - 09<sup>th</sup> August, 2002. The list of 11 sand quarry sites identified by CSMRS team along the course of the river Cauvery, Ariyar, Vaigai and Gundar for sand are furnished in **Annexure 4.3.2**.

One natural sand sample from each sand quarry have been collected by CSMRS team during 28<sup>th</sup>-31<sup>st</sup> August, 2002 for ascertaining the suitability for use as fine aggregate in concrete for the construction of the proposed link project. The Physical and Chemical tests viz. specific gravity, grading and fineness modulus, organic impurities, silt and clay content, Alkali Aggregate Reactivity and Petrographic analysis were conducted on the representative sand samples as per BIS: 2386-1963 for ascertaining their suitability for use in concrete as fine aggregate.

Based on the Physical, chemical and AAR test results the silt and clay content for all the 11 sand samples varies between 0.20% and 2.10% indicating that the presence of silt and clay are well below the maximum permissible limit as per BIS: 383-1970. The grading of the fine aggregate samples conforms to the requirement of the grading zones given in BIS: 383-1970. Fine aggregates of Mayanur and Musiri sand quarries should not be used in rain forced concrete unless prior tests are carried out to ascertain the suitability of proposed mix proportions. Specific gravity varies from 2.64 to 2.70. Fineness modulus varies between 1.794 and 3.061 indicating that sand samples are medium to coarse grained. The organic impurities are present only in 3 samples. It is recommended that sand samples especially from Ariyar river quarries are thoroughly washed with water and examined again for organic impurities before putting in to use as construction material in concrete.

Natural sand material from quarries other than that mentioned above have been found to be susceptible to Alkali Aggregate Reaction due to high strained quartz content. In view of the above, the aggregate from these quarries have to be used with cement having alkali content not more than 0.60% as sodium oxide equivalent or pozzolanic cement for controlling alkali aggregate reaction.

The report on Construction Materials Survey and Laboratory Testing of Rock and Sand samples for use as coarse and fine aggregates in concrete for Cauvery (Kattalai) - Vaigai – Gundar Link project received from CSMRS, New Delhi is given at **Appendix 4.5**. The map showing the location of quarry sites is at **Plate 4.10**.

#### **4.5.3 Bricks and tiles**

Cement bricks/hollow concrete bricks/ Red Bricks and tiles are available locally in the vicinity of the project area.

#### **4.5.4 Pozzolana**

The pozzolana materials are not considered to be used in the construction of the project.

#### **4.5.5 Cement**

A number of Cement Industries are located in the vicinity of Project area. To name a few, "TNPL cement, Kagithapuram", "Chettined cement Uliyur" and "Cheran cement, Karur" in Karur district, "Dalmia cement (Bharat) Ltd, T. Pudupatti" in Tiruchirappalli district, "Ramco cements, RR Nagar" in Virudhunagar district and "Maha cement" in Thoothukudi are some of the cement manufacturing units located near to the project area. Thus, the required cement for construction of the project is available in the project area.

#### **4.5.6 Steel**

The steel required for the project construction can be procured from the plants located in Tiruchirappalli (Amman - Try Steels (P) Ltd), Coimbatore, Salem and other districts of Tamil Nadu.

#### **4.5.7 Scarce material**

No scarce materials are anticipated to be used in the project which may cause hindrance to the construction of the project.



#### **4.5.8 Any other material**

Apart from the above, there will be many other items such as iron rods/ Pillars, iron sheets, CGI sheets, coal tar, wood, paint, ropes etc., which are required for construction of temporary sheets/ rooms etc. All such items are available in Karur, Tiruchirappalli, Pudukkottai, Sivaganga, Madurai and Virudhunagar districts within the vicinity of the project area.

#### **4.6 Hydrological and meteorological investigation.**

In Cauvery (Kattalai) - Vaigai – Gundar Link project, no dams/ storage reservoirs are contemplated and the existing Kattalai barrage across Cauvery river facilitates the off take of link canal. As such, hydrological and meteorological investigations are not required for this link project. However, the hydrological and meteorological aspects are dealt in "**Chapter 5: Hydrology and Water Assessment**".