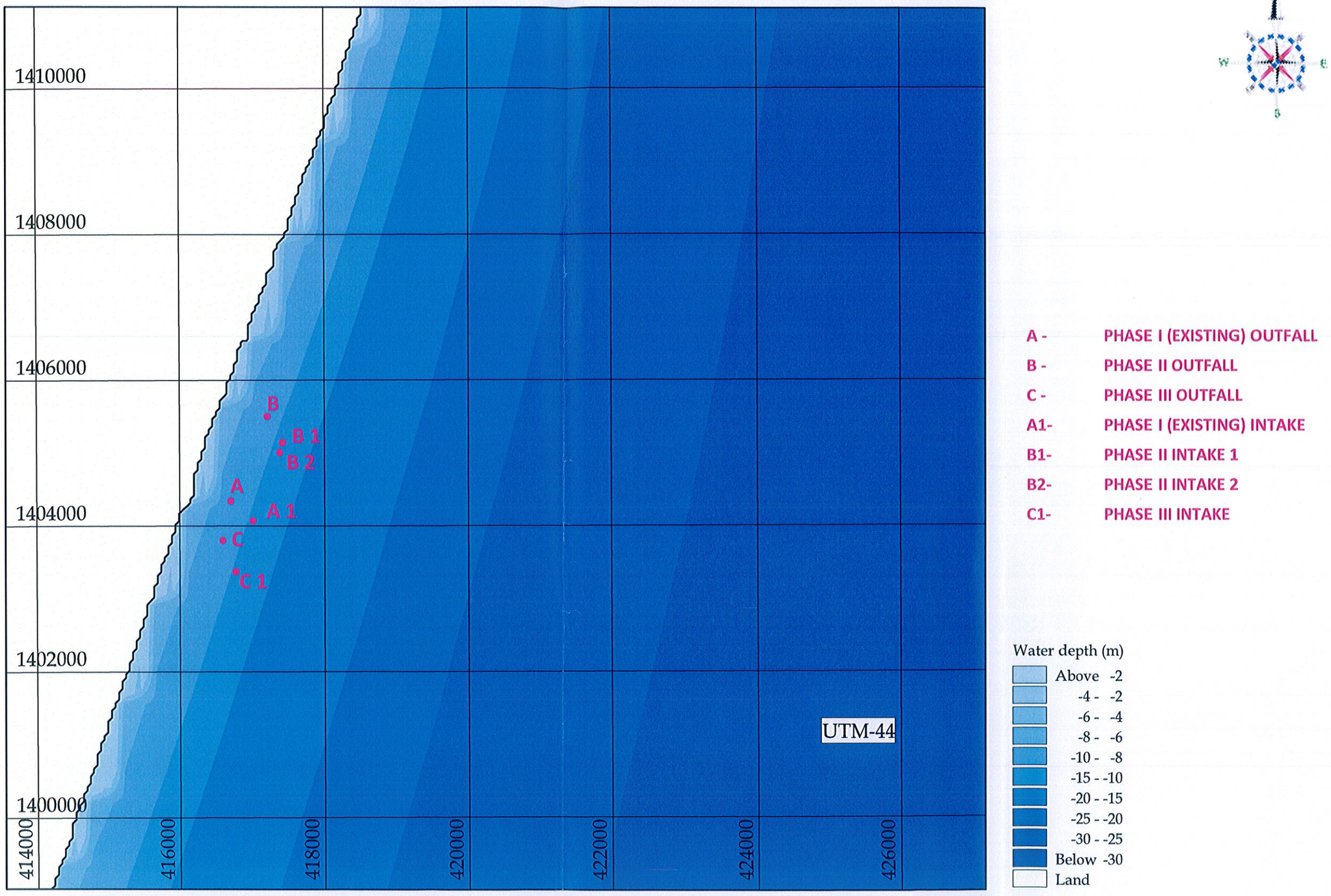
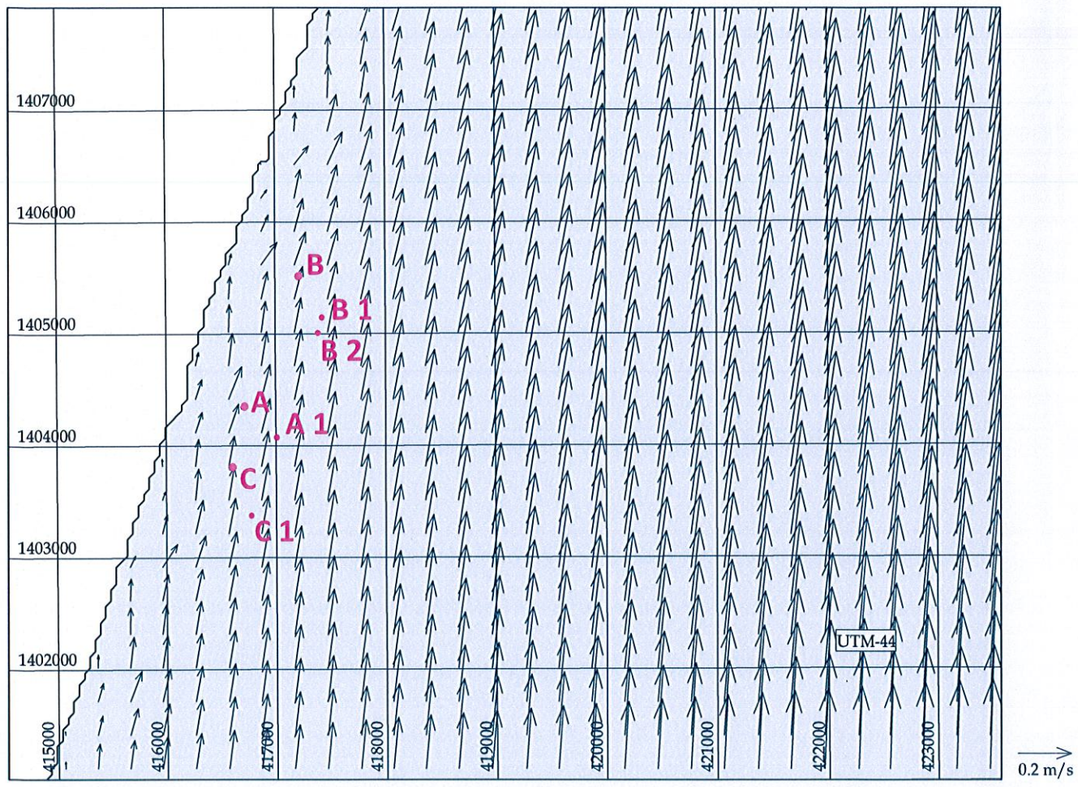


Fig. 7.1. Bathymetry for Mike 21 HD & AD Module

Third Hour during Flooding



Third Hour during Ebbing

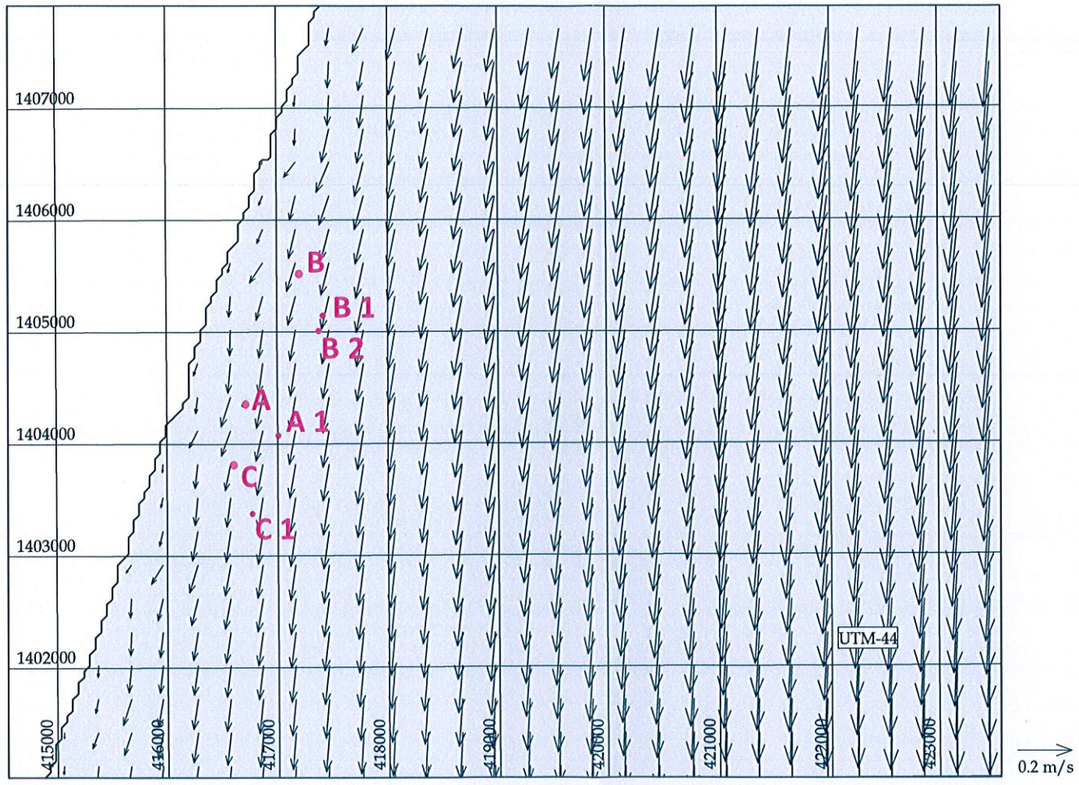
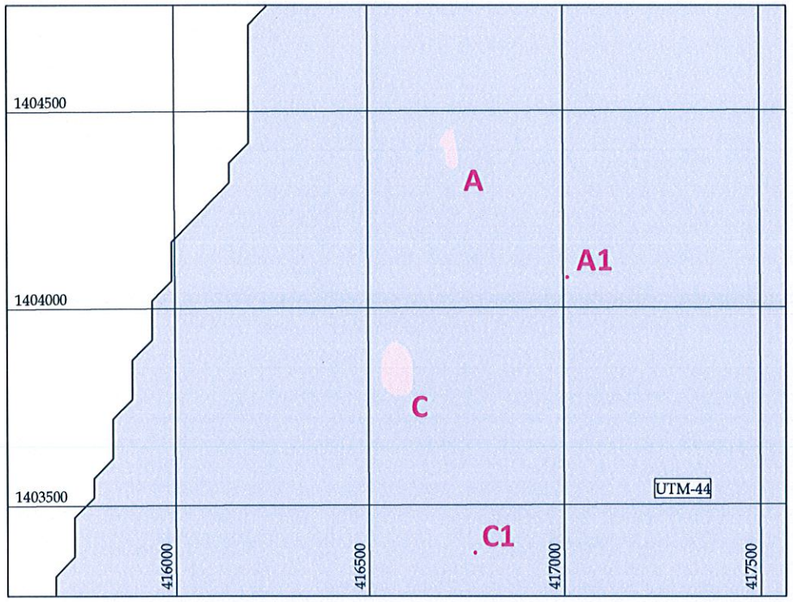


Fig. 8.1. Flow field - Spring tide –Fair weather

A - PHASE I (EXISTING) OUTFALL
B - PHASE II OUTFALL
C - PHASE III OUTFALL
A1- PHASE I (EXISTING) INTAKE
B1- PHASE II INTAKE 1
B2- PHASE II INTAKE 2
C1- PHASE III INTAKE

Third Hour during Flooding



Third Hour during Ebbing

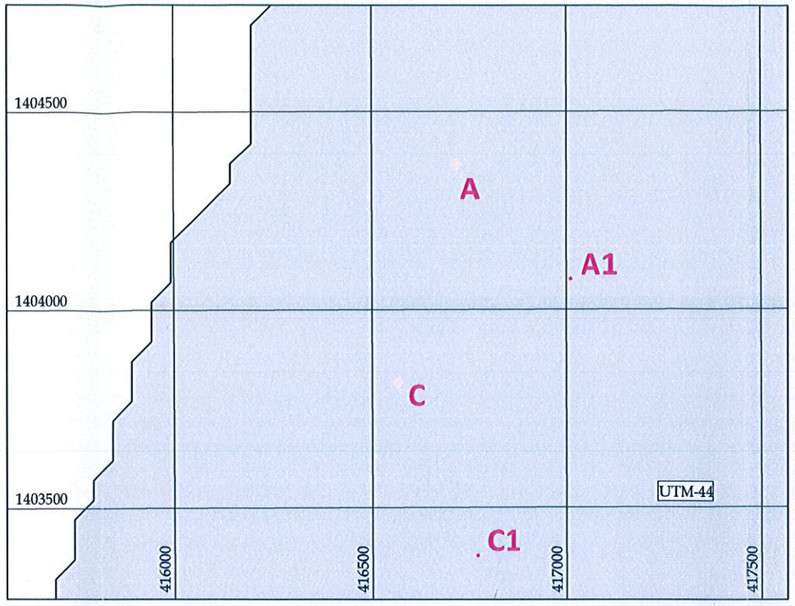
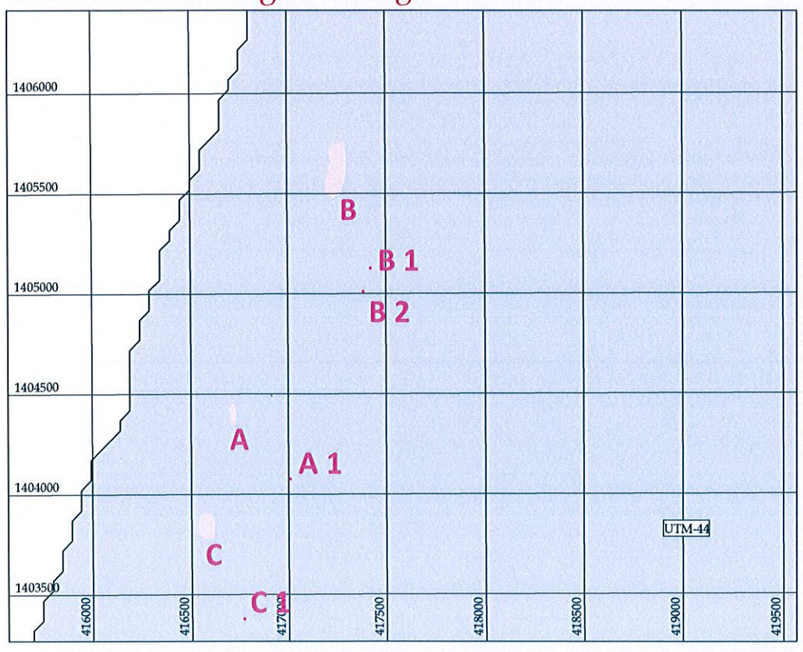
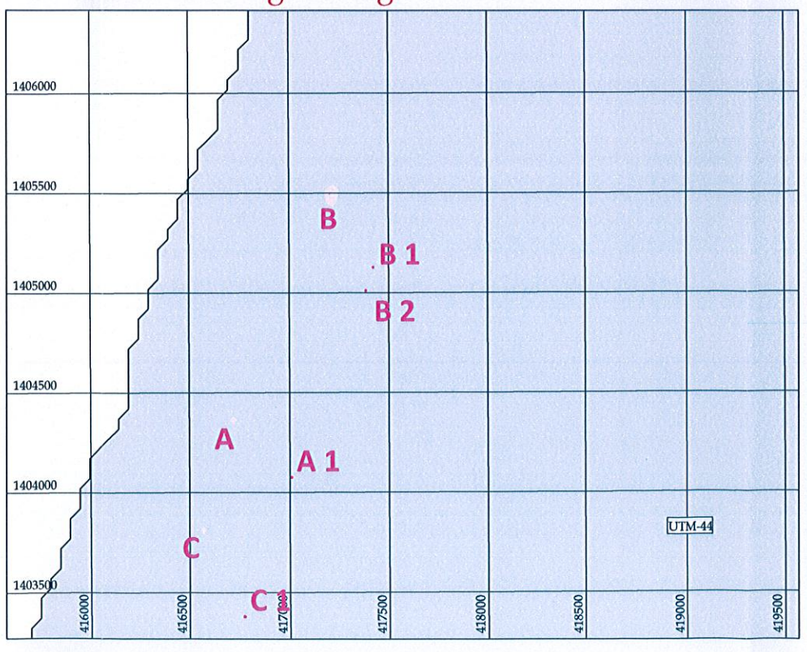


Fig. 8.2. Secondary Dispersion – Spring tide - Fair weather – Phase I (Existing) & Phase III

Third Hour during Flooding



Third Hour during Ebbing

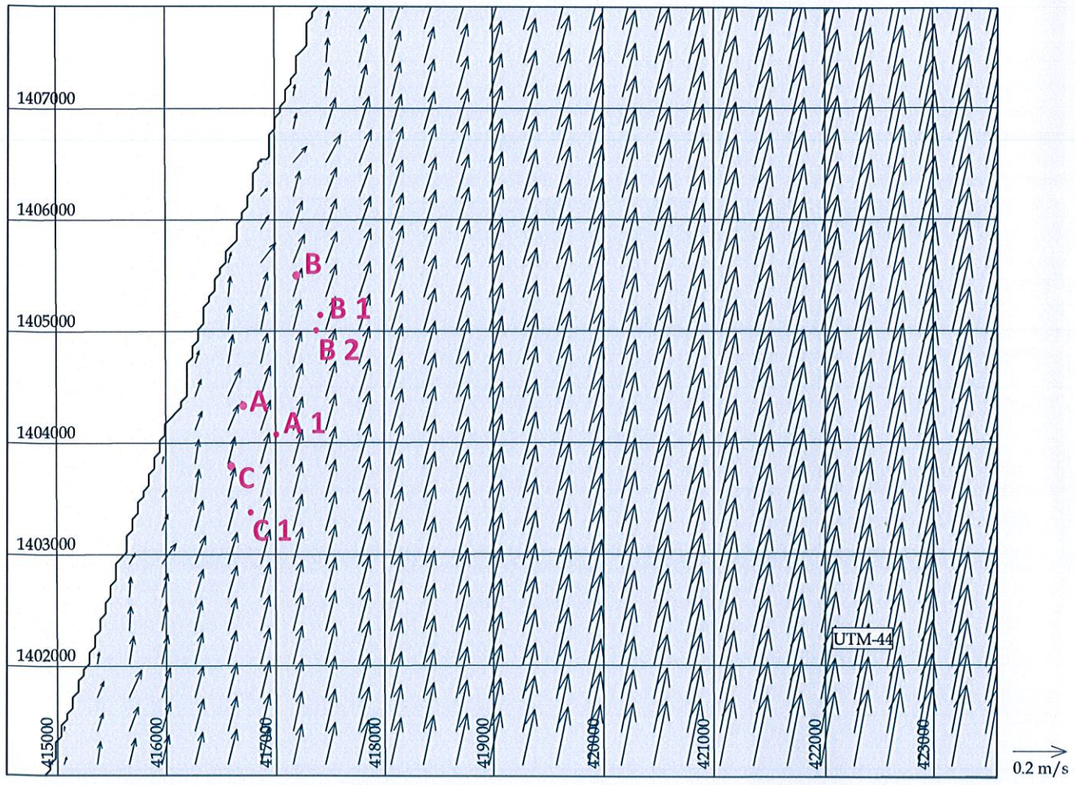


A - PHASE I (EXISTING) OUTFALL
B - PHASE II OUTFALL
C - PHASE III OUTFALL
A1- PHASE I (EXISTING) INTAKE
B1- PHASE II INTAKE 1
B2- PHASE II INTAKE 2
C1- PHASE III INTAKE

Salinity Difference (ppt)
- Above 4
- 3 - 4
- 2 - 3
- 1 - 2
- Below 1

Fig. 8.3. Secondary Dispersion – Spring tide - Fair weather – Phase I (Existing), Phase II & Phase III

Third Hour during Flooding



Third Hour during Ebbing

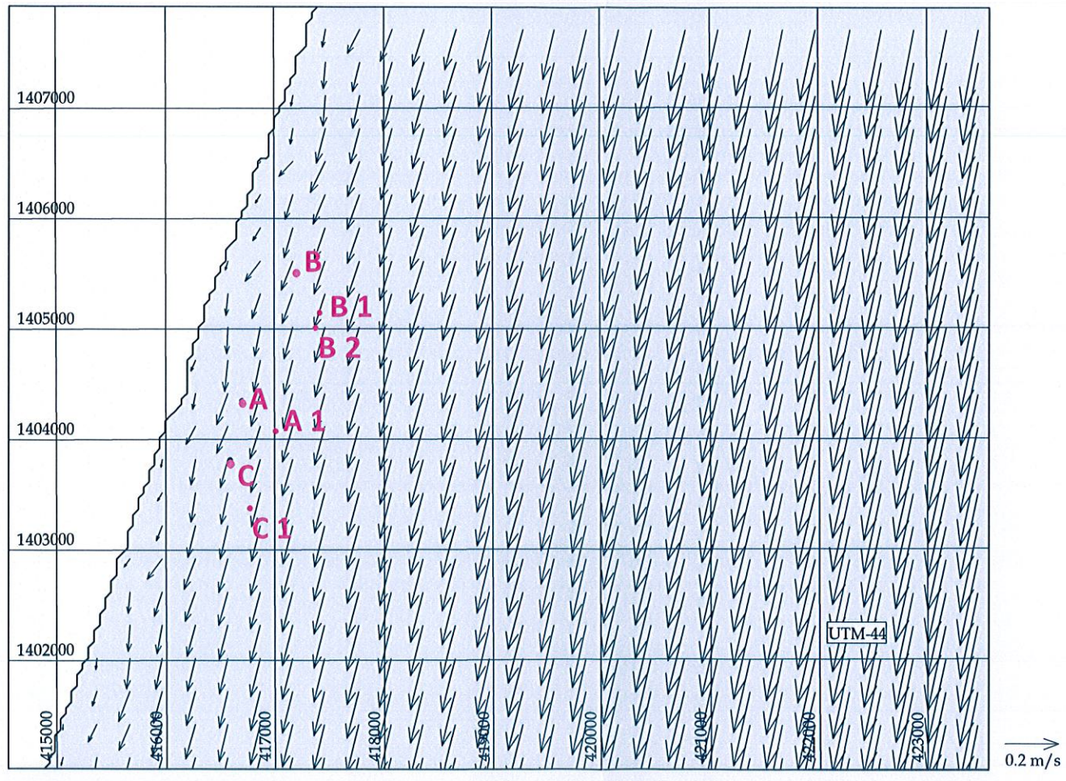
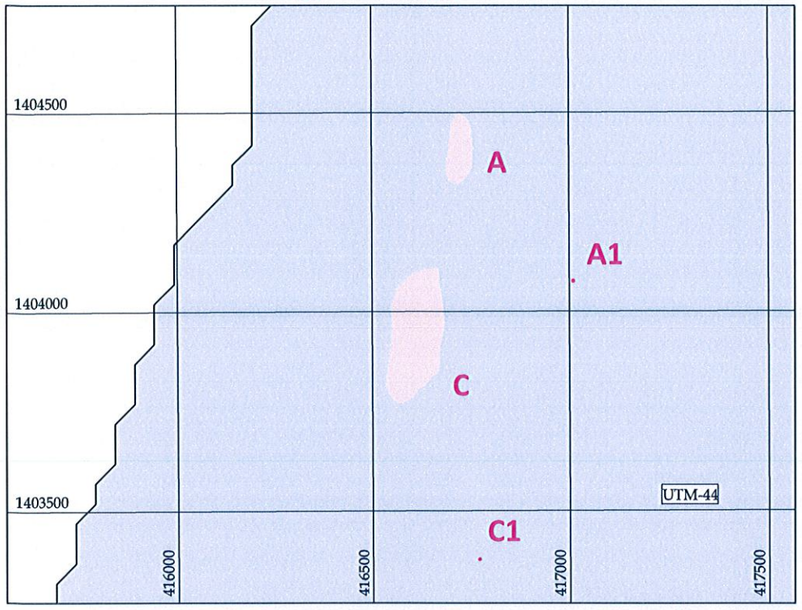


Fig. 8.4. Flow field - Neap tide – Fair weather

A - PHASE I (EXISTING) OUTFALL
B - PHASE II OUTFALL
C - PHASE III OUTFALL
A1- PHASE I (EXISTING) INTAKE
B1- PHASE II INTAKE 1
B2- PHASE II INTAKE 2
C1- PHASE III INTAKE

Third Hour during Flooding



Third Hour during Ebbing

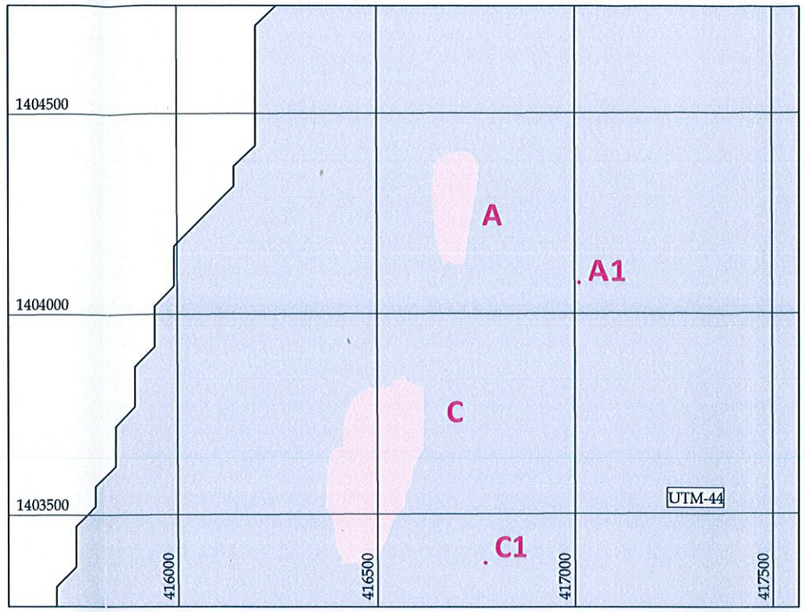
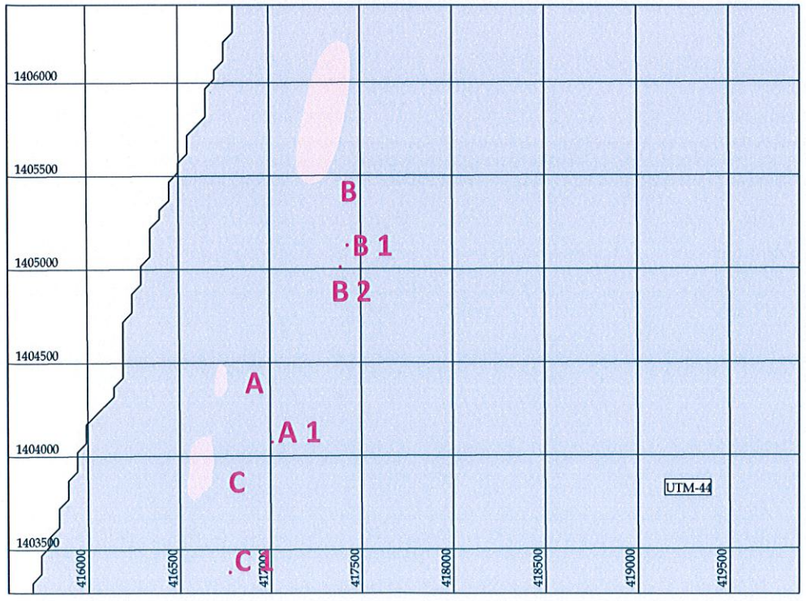


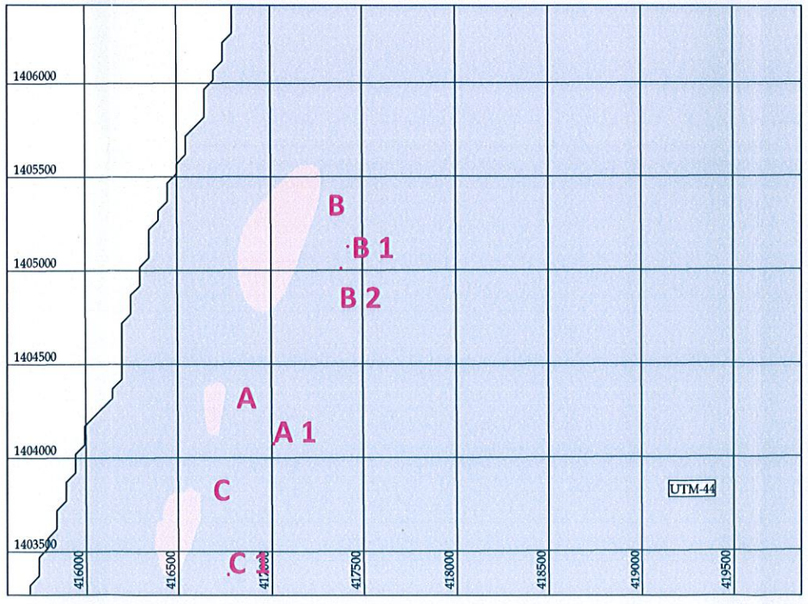
Fig. 8.5. Secondary Dispersion – Neap - Fair weather – Phase I (Existing) & Phase III

A - PHASE I (EXISTING) OUTFALL
B - PHASE II OUTFALL
C - PHASE III OUTFALL
A1- PHASE I (EXISTING) INTAKE
B1- PHASE II INTAKE 1
B2- PHASE II INTAKE 2
C1- PHASE III INTAKE

Third Hour during Flooding



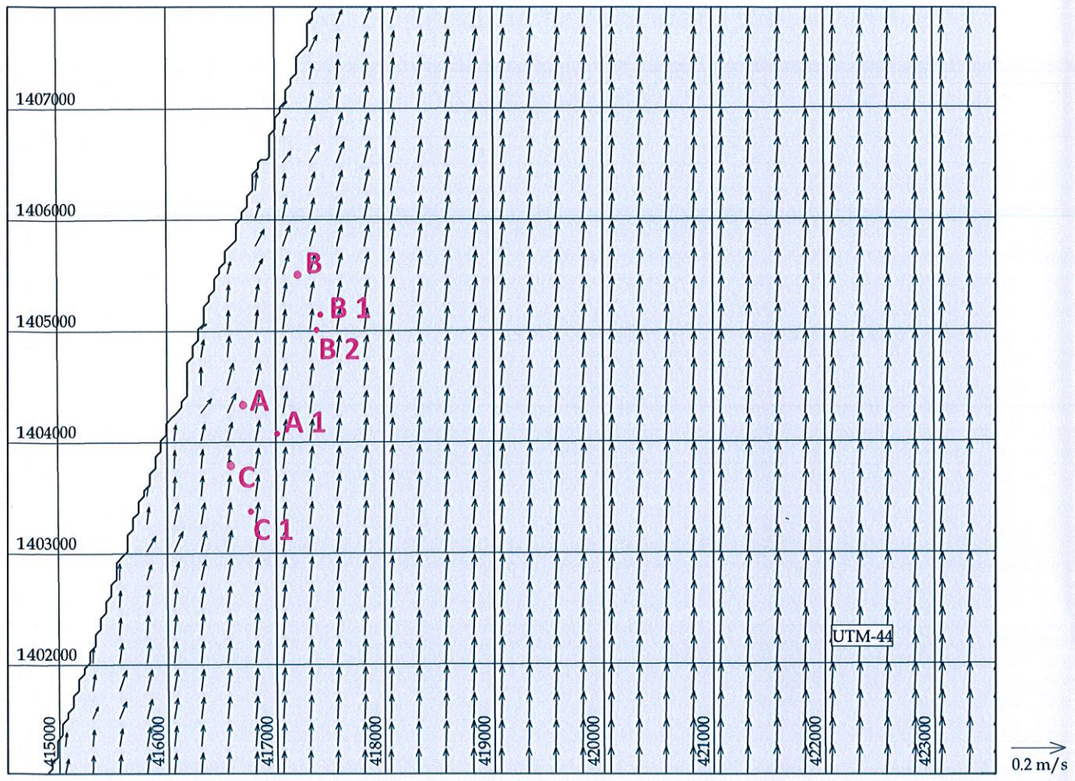
Third Hour during Ebbing



Salinity Difference (ppt)
Above 4
3 - 4
2 - 3
1 - 2
Below 1

Fig. 8.6. Secondary Dispersion – Neap tide - Fair weather – Phase I (Existing), Phase II & Phase III

Third Hour during Flooding



Third Hour during Ebbing

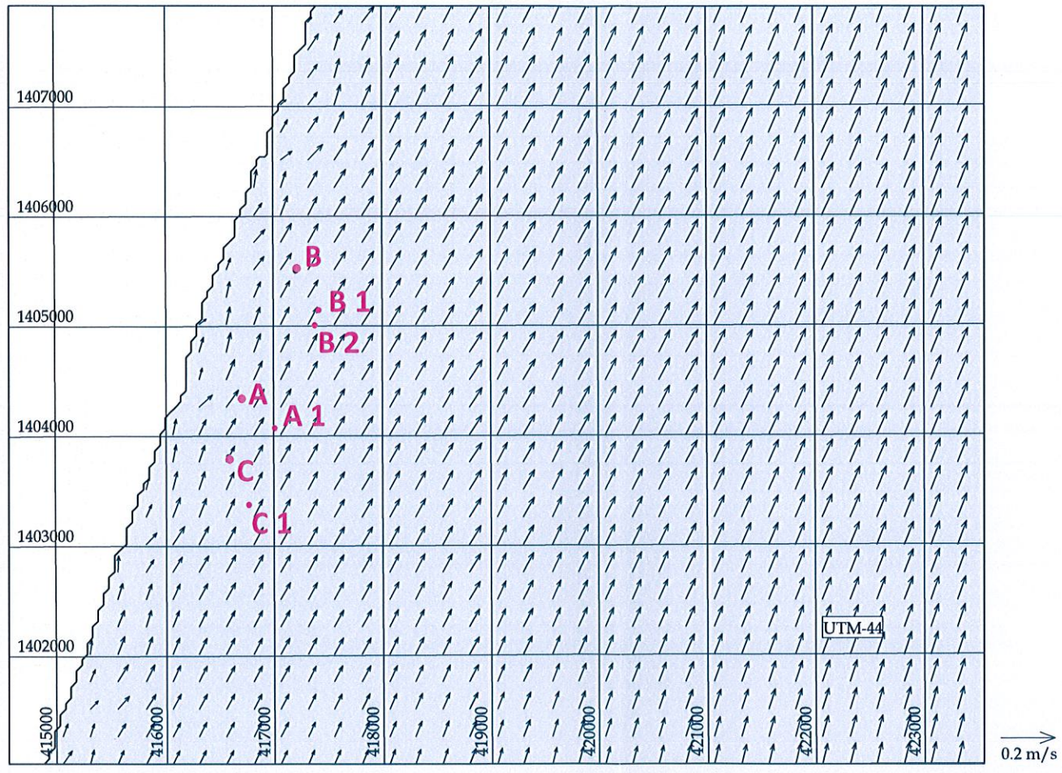
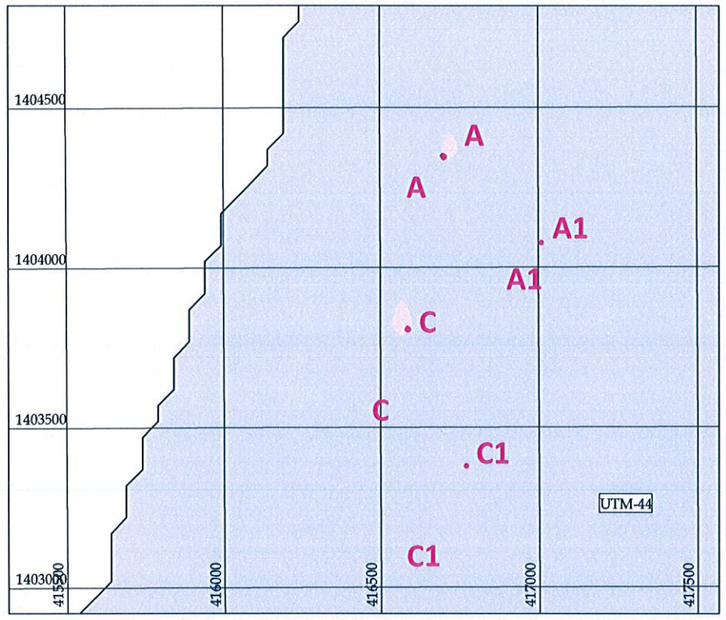


Fig. 8.7. Flow field - Spring tide – SW Monsoon

A - PHASE I (EXISTING) OUTFALL
B - PHASE II OUTFALL
C - PHASE III OUTFALL
A1- PHASE I (EXISTING) INTAKE
B1- PHASE II INTAKE 1
B2- PHASE II INTAKE 2
C1- PHASE III INTAKE

Third Hour during Flooding



Third Hour during Ebbing

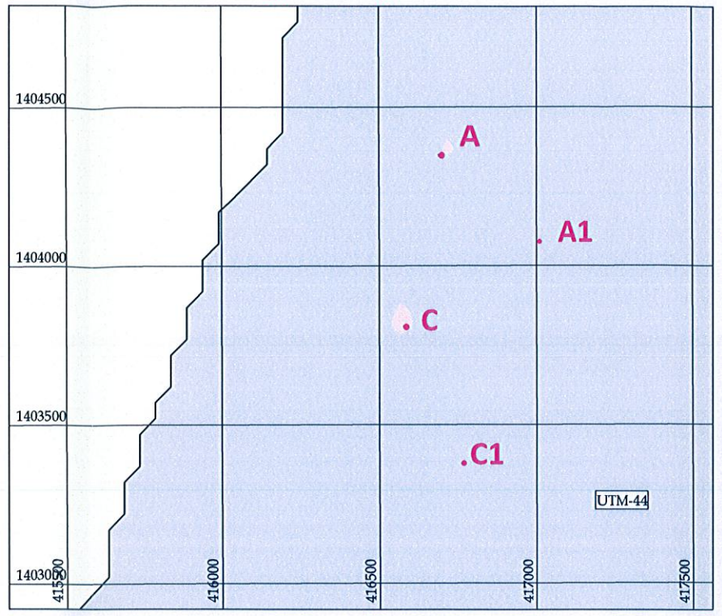
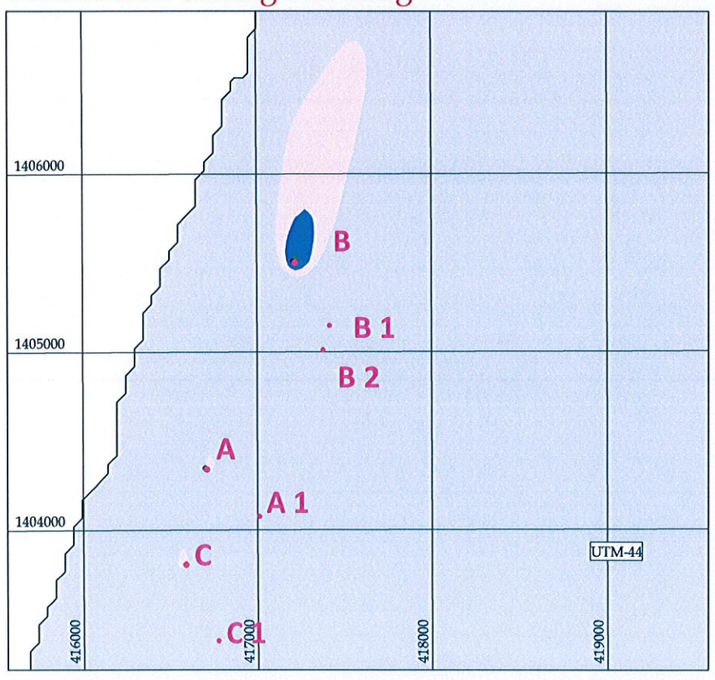
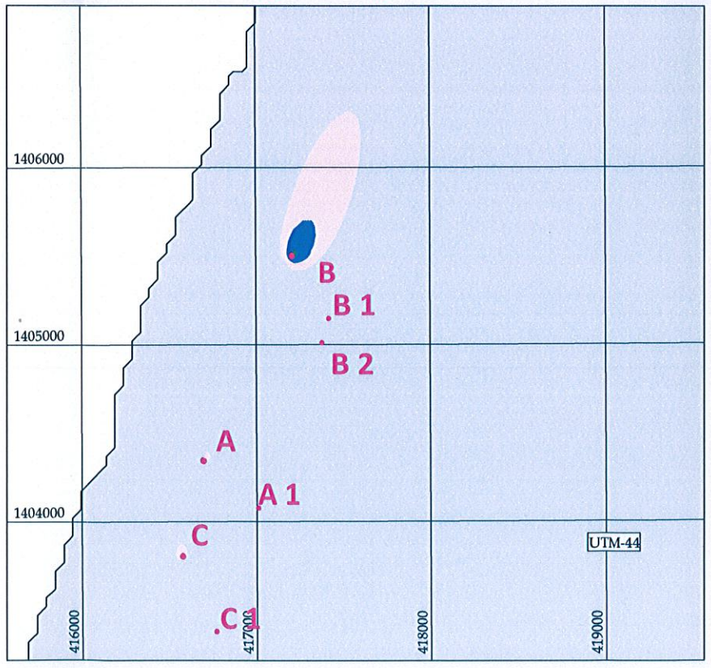


Fig. 8.8. Secondary Dispersion – Spring tide – SW Monsoon – Phase I (Existing) & Phase III

Third Hour during Flooding



Third Hour during Ebbing

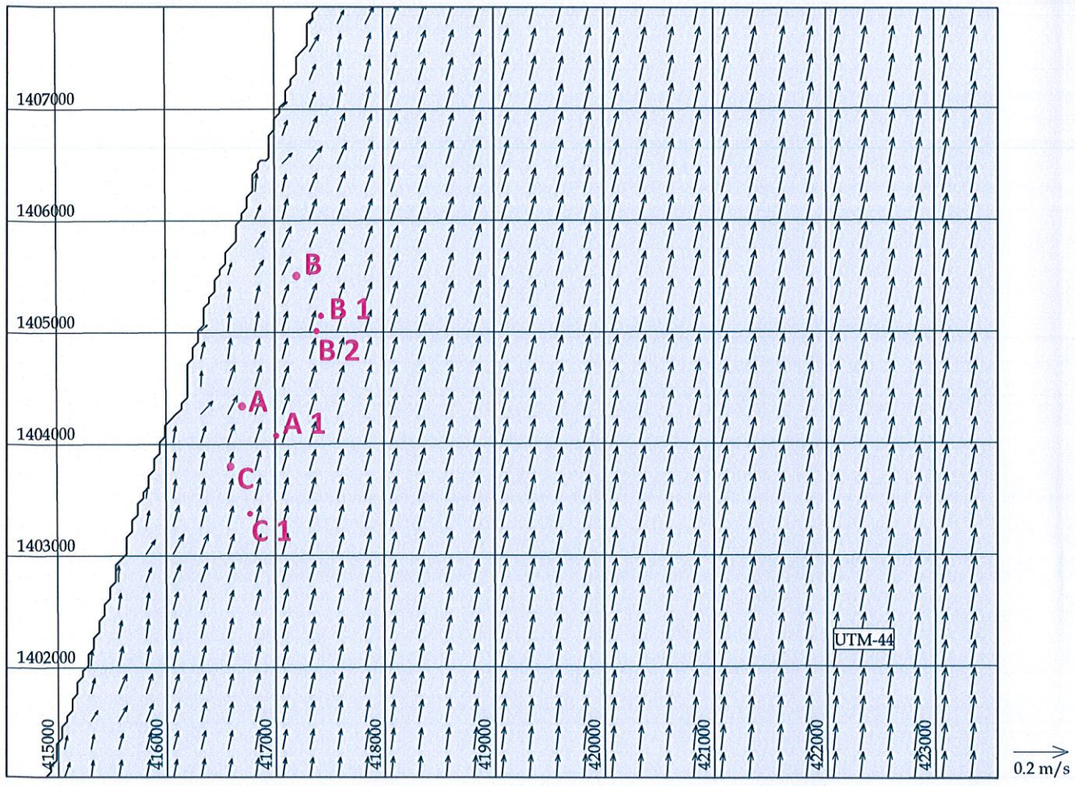


A - PHASE I (EXISTING) OUTFALL
B - PHASE II OUTFALL
C - PHASE III OUTFALL
A1- PHASE I (EXISTING) INTAKE
B1- PHASE II INTAKE 1
B2- PHASE II INTAKE 2
C1- PHASE III INTAKE

Salinity Difference (ppt)
- Above 3.0
- 2.0 - 3.0
- 1.0 - 2.0
- 0.6 - 1.0
- Below 0.6

Fig. 8.9. Secondary Dispersion – Spring tide – SW Monsoon – Phase I (Existing), Phase II & Phase III

Third Hour during Flooding



Third Hour during Ebbing

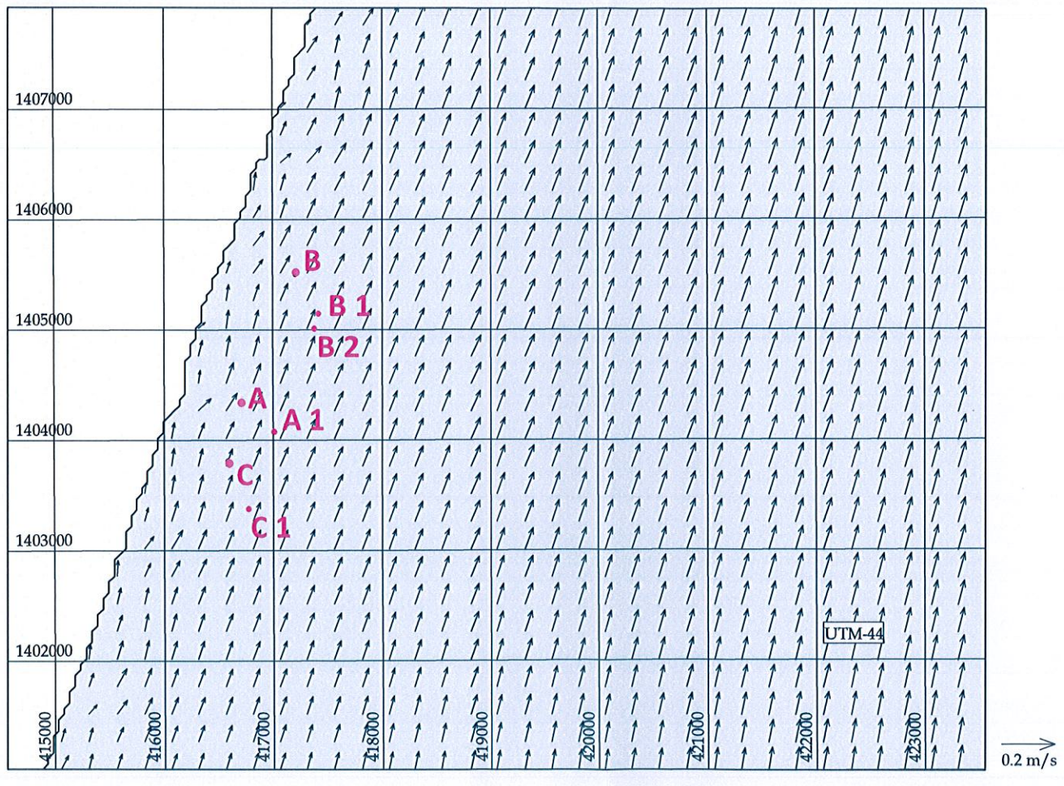
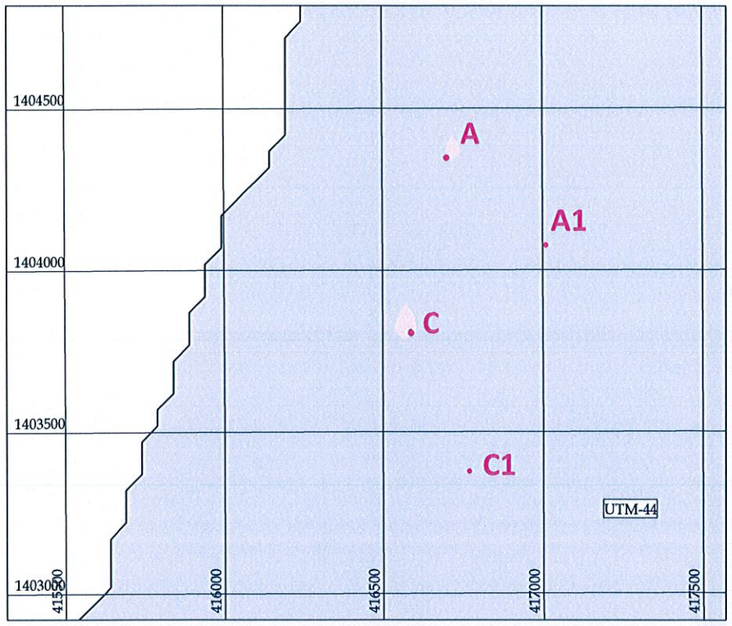


Fig. 8.10. Flow field - Neap tide – SW Monsoon

A - PHASE I (EXISTING) OUTFALL
B - PHASE II OUTFALL
C - PHASE III OUTFALL
A1- PHASE I (EXISTING) INTAKE
B1- PHASE II INTAKE 1
B2- PHASE II INTAKE 2
C1- PHASE III INTAKE

Third Hour during Flooding



Third Hour during Ebbing

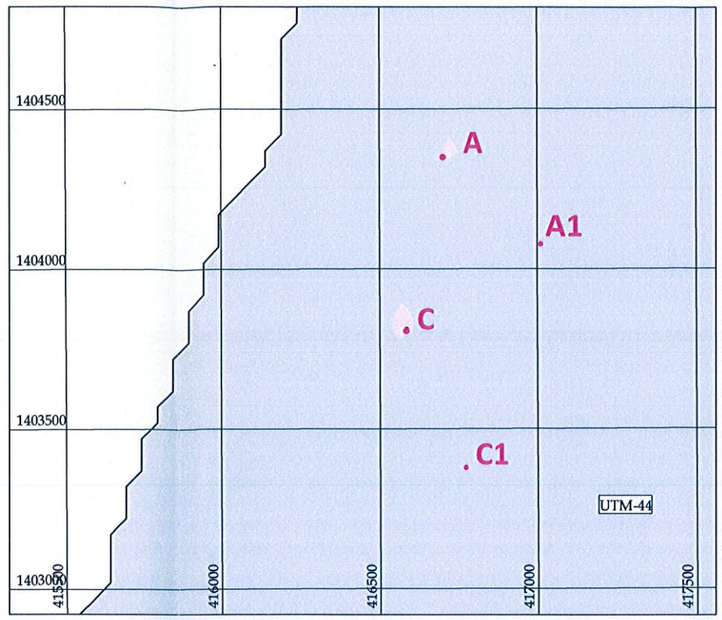
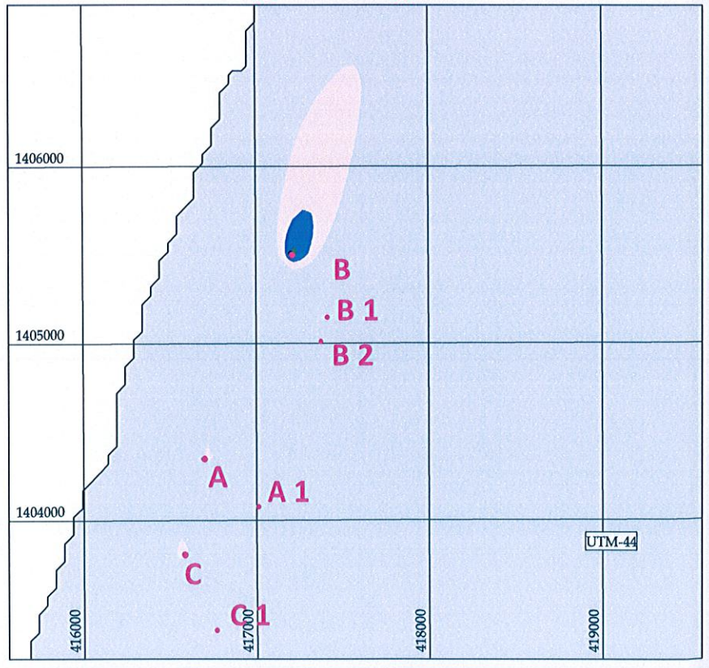


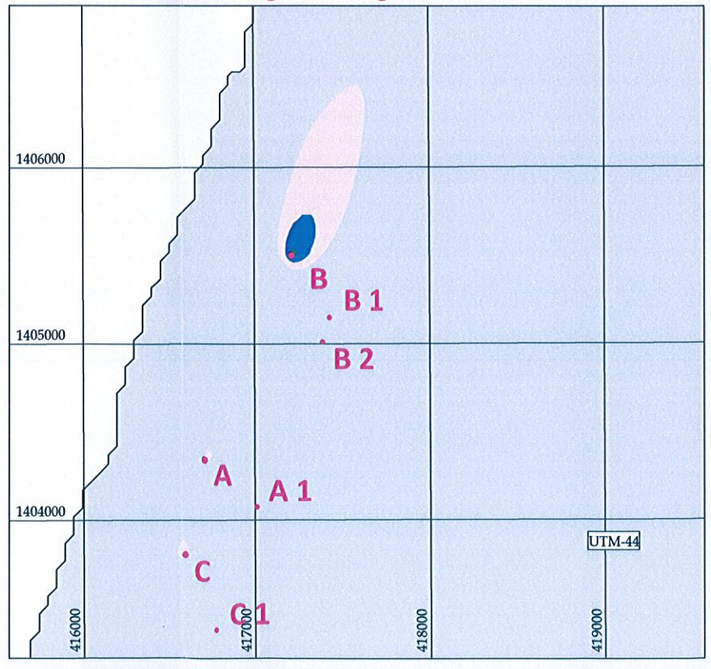
Fig. 8.11. Secondary Dispersion – Neap tide – SW Monsoon – Phase I (Existing) & Phase III

A - PHASE I (EXISTING) OUTFALL
B - PHASE II OUTFALL
C - PHASE III OUTFALL
A1- PHASE I (EXISTING) INTAKE
B1- PHASE II INTAKE 1
B2- PHASE II INTAKE 2
C1- PHASE III INTAKE

Third Hour during Flooding



Third Hour during Ebbing



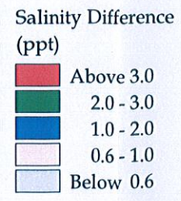
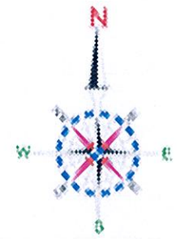
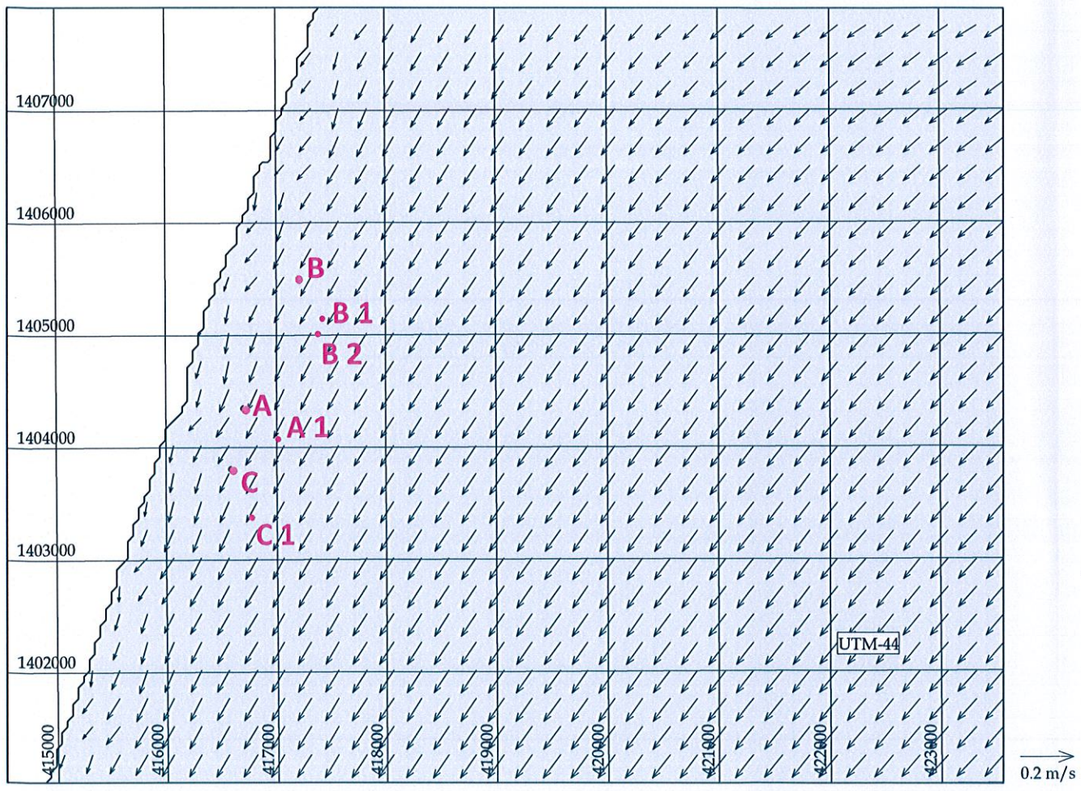


Fig. 8.12. Secondary Dispersion – Neap tide – SW Monsoon – Phase I (Existing), Phase II & Phase III



Third Hour during Flooding



Third Hour during Ebbing

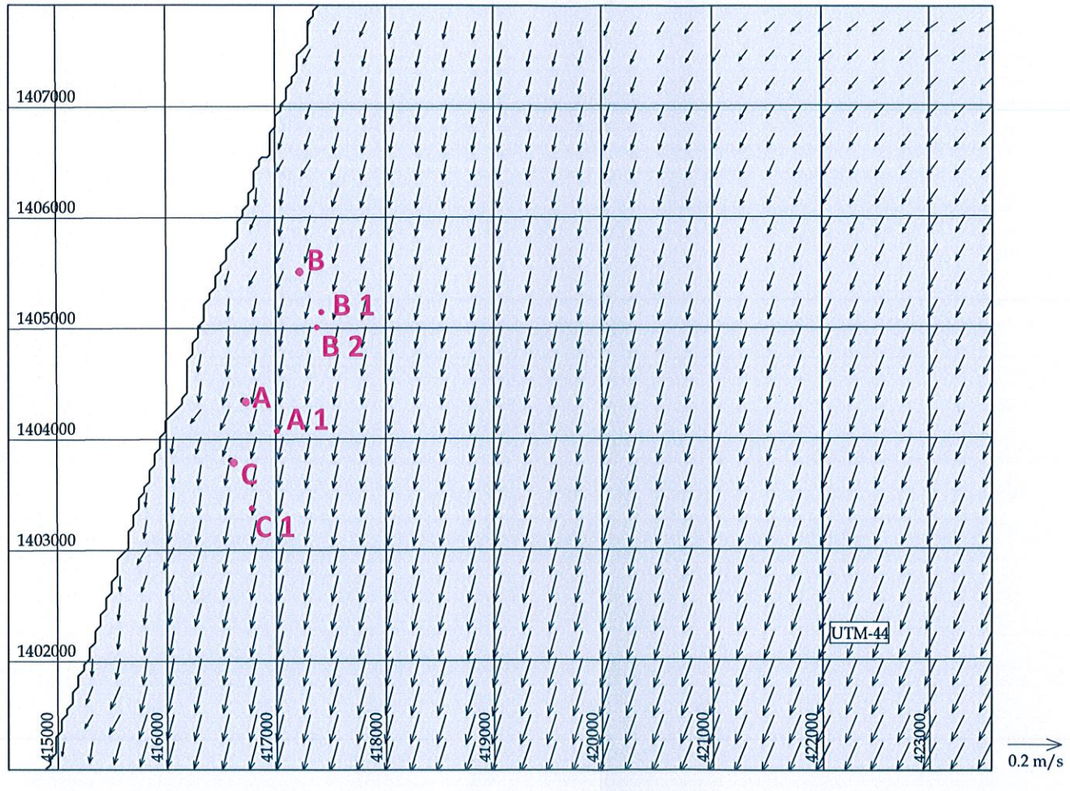
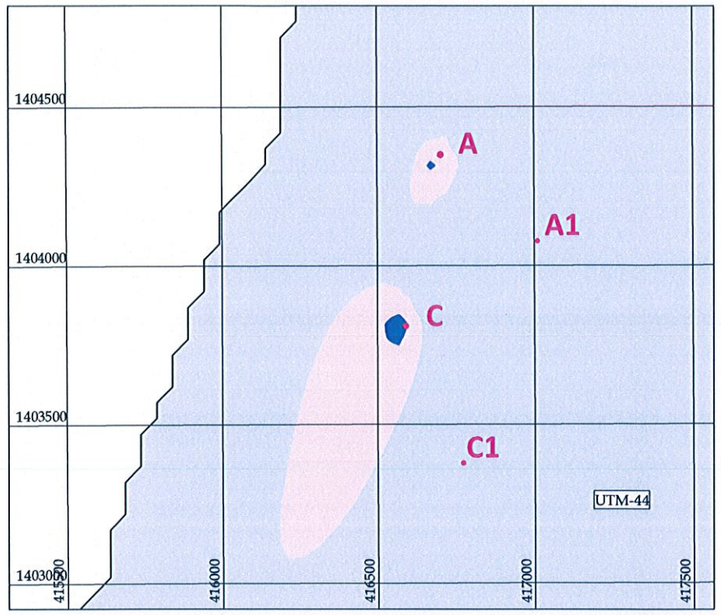


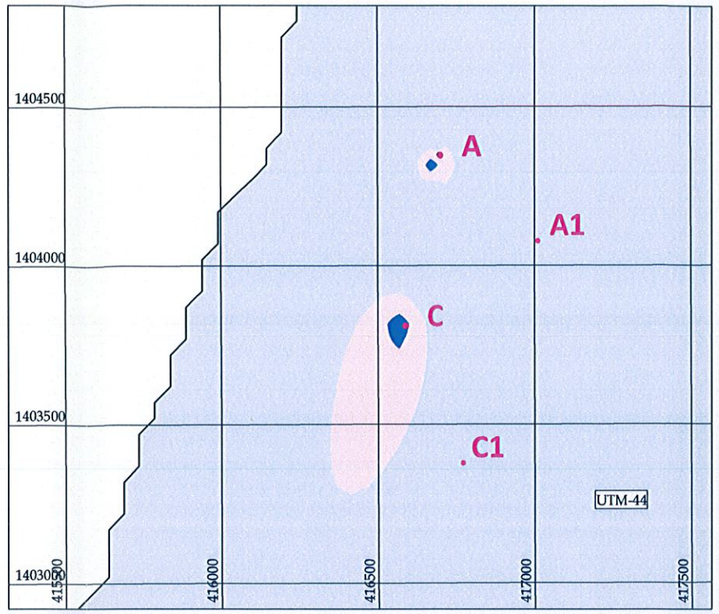
Fig. 8.13. Flow field - Spring tide – NE Monsoon

A - PHASE I (EXISTING) OUTFALL
B - PHASE II OUTFALL
C - PHASE III OUTFALL
A1- PHASE I (EXISTING) INTAKE
B1- PHASE II INTAKE 1
B2- PHASE II INTAKE 2
C1- PHASE III INTAKE

Third Hour during Flooding



Third Hour during Ebbing



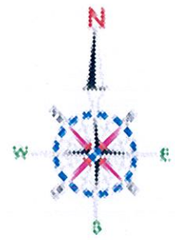
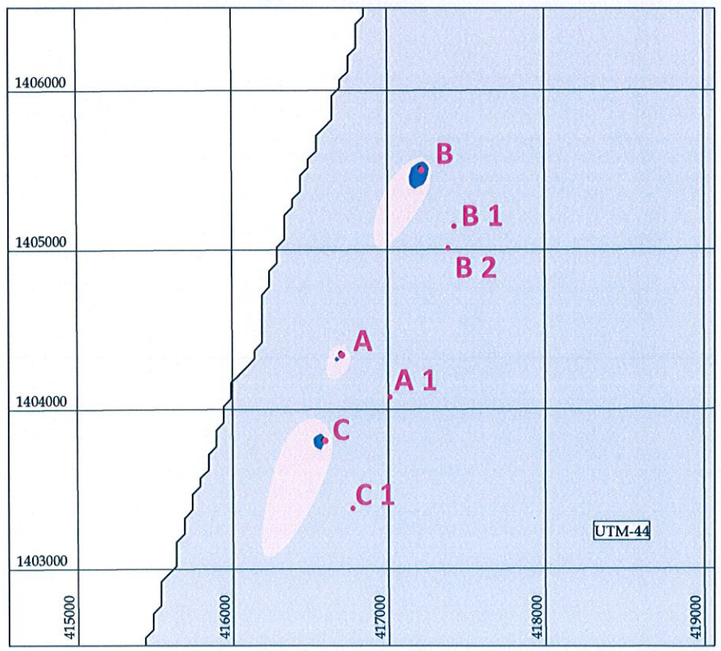
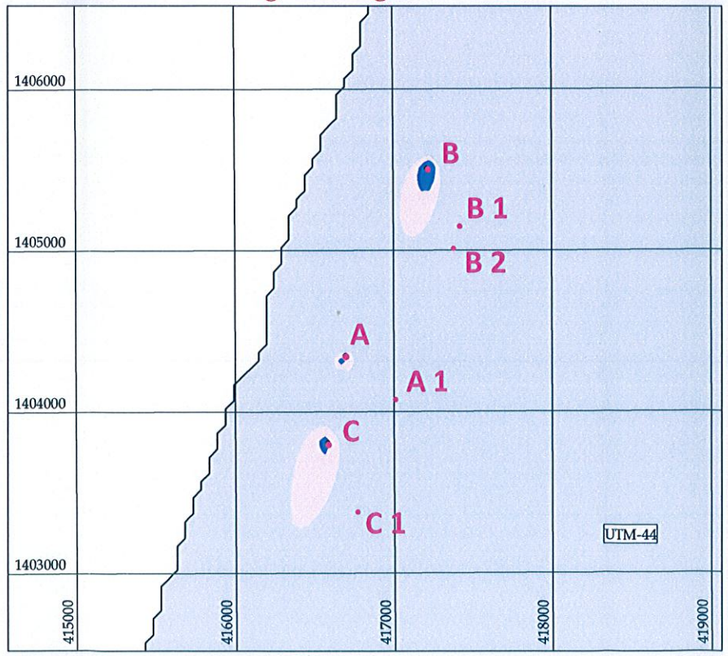


Fig. 8.14. Secondary Dispersion – Spring tide – NE Monsoon – Phase I (Existing) & Phase II

Third Hour during Flooding



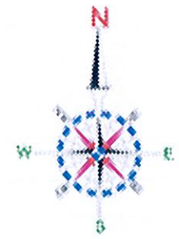
Third Hour during Ebbing



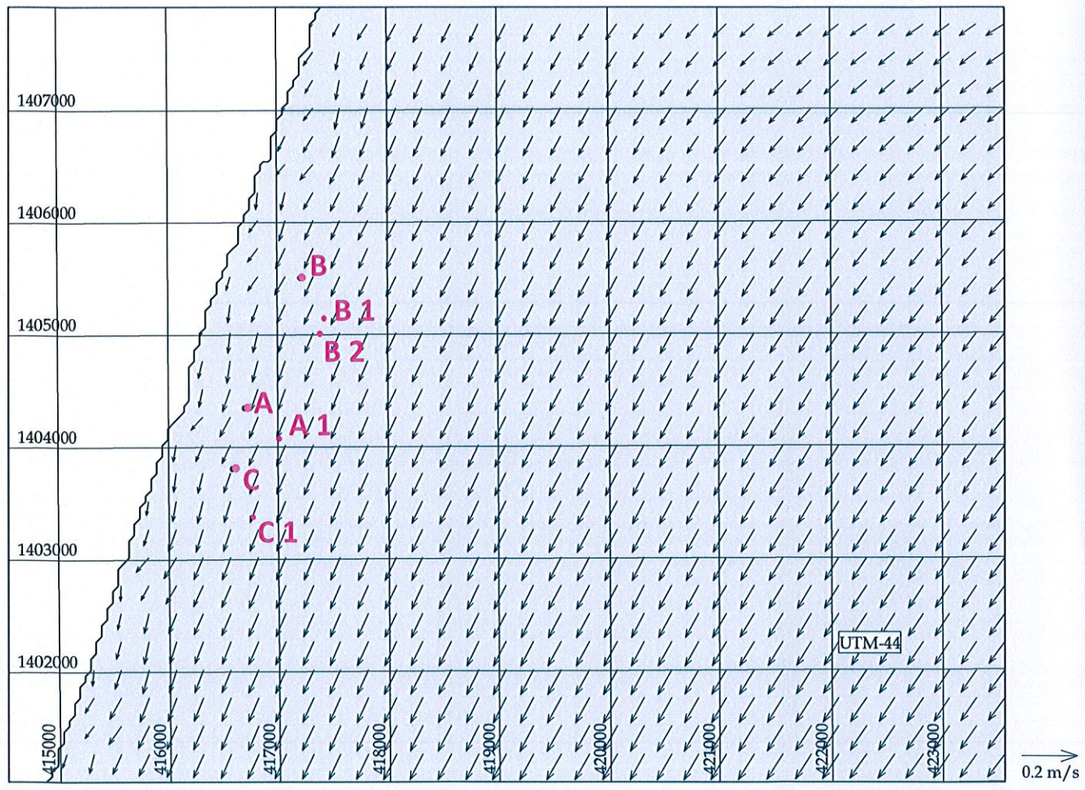
A - PHASE I (EXISTING) OUTFALL
B - PHASE II OUTFALL
C - PHASE III OUTFALL
A1- PHASE I (EXISTING) INTAKE
B1- PHASE II INTAKE 1
B2- PHASE II INTAKE 2
C1- PHASE III INTAKE

Salinity Difference (ppt)
- Above 3.0
- 2.0 - 3.0
- 1.0 - 2.0
- 0.6 - 1.0
- Below 0.6

Fig. 8.15. Secondary Dispersion – Spring tide – NE Monsoon – Phase I (Existing), Phase II & Phase III



Third Hour during Flooding



Third Hour during Ebbing

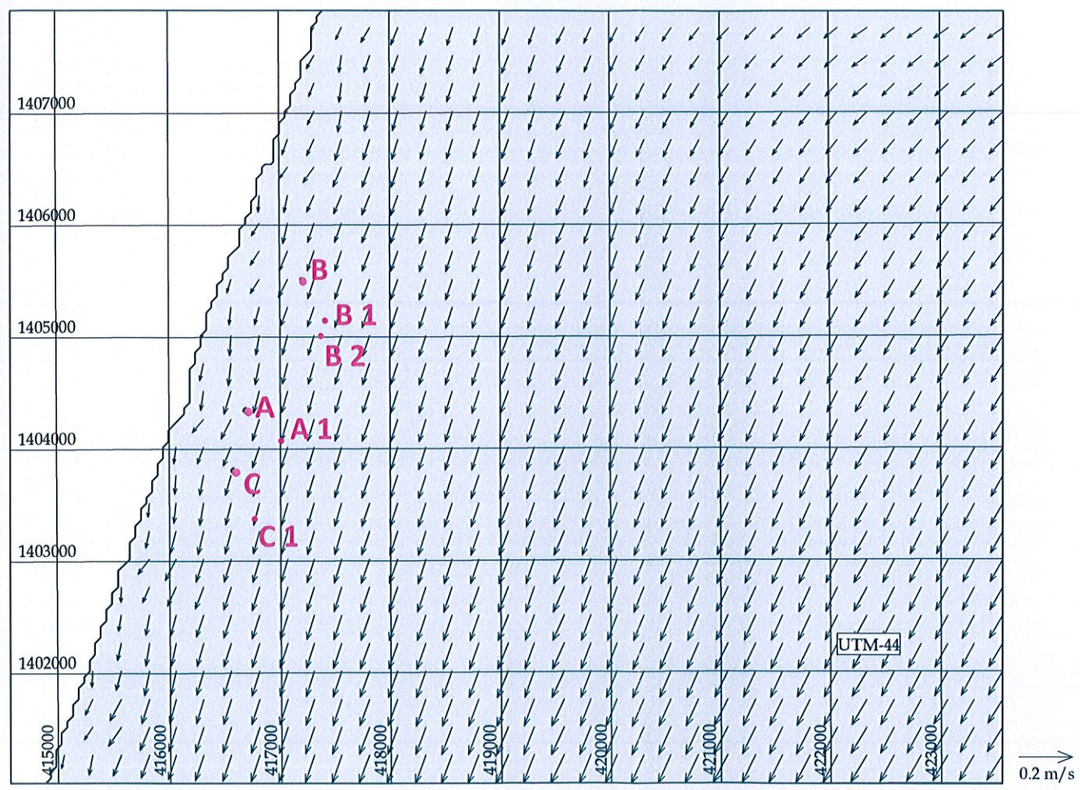
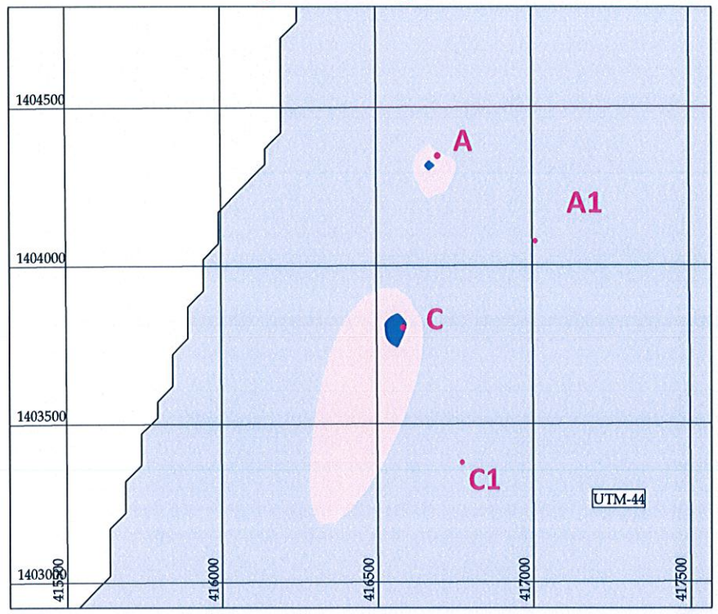


Fig. 8.16. Flow field - Neap tide – NE Monsoon

A - PHASE I (EXISTING) OUTFALL
B - PHASE II OUTFALL
C - PHASE III OUTFALL
A1- PHASE I (EXISTING) INTAKE
B1- PHASE II INTAKE 1
B2- PHASE II INTAKE 2
C1- PHASE III INTAKE

Third Hour during Flooding



Third Hour during Ebbing

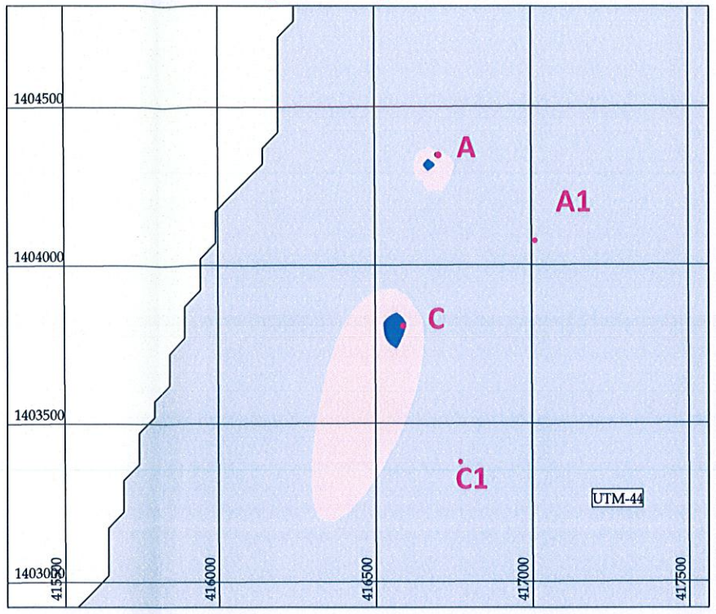
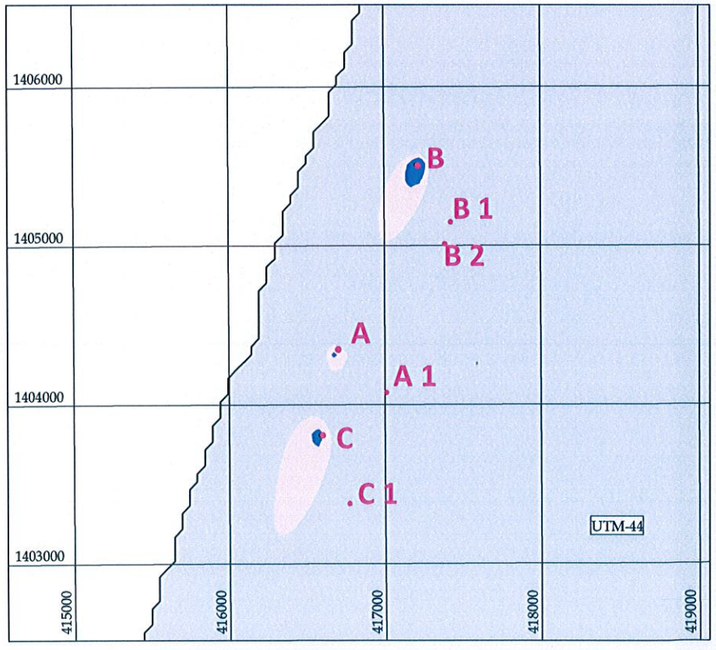
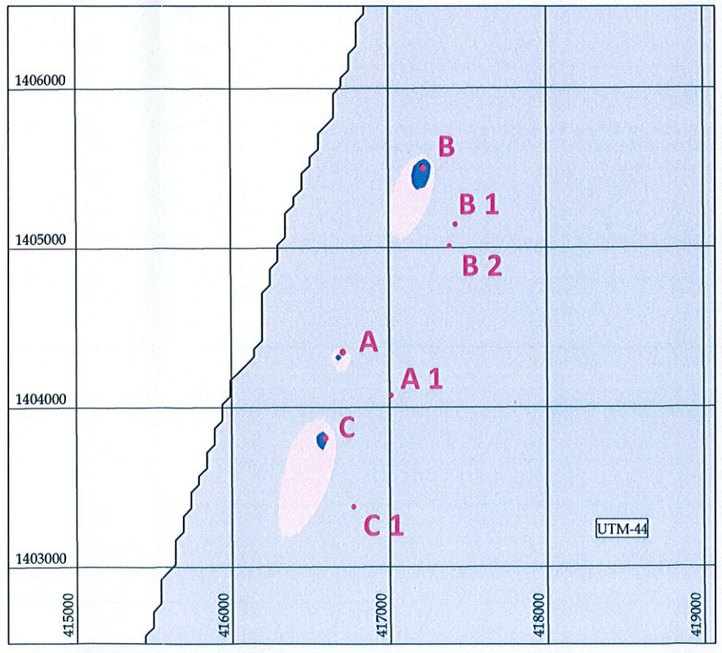


Fig. 8.17. Secondary Dispersion – Neap tide – NE Monsoon – Phase I (Existing) & Phase II

Third Hour during Flooding



Third Hour during Ebbing



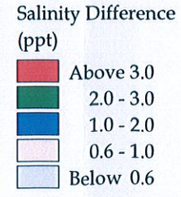


Fig. 8.18. Secondary Dispersion – Neap tide – NE Monsoon – Phase I (Existing), Phase II & Phase III

Annexure-VI

Base Line Collection Data

BASELINE ENVIRONMENTAL STATUS REPORT

FOR

PROPOSED METRO WATER DESALINATION PLANT IN NEMMELI, KANCHEEPURAM DISTRICT, TAMIL NADU

Submitted to:

Indomer Coastal Hydraulics (P) Limited
Chennai – 600 087 for AECOM INDIA P. LTD

Report Prepared by:

VIMTA Labs Ltd., 142, IDA, Phase-II
Cherlapally, Hyderabad – 500 051, India
www.vimta.com

December 2013

1.0 BASELINE ENVIRONMENTAL STATUS

1.1 Introduction

This chapter illustrates the description of the existing environmental status of the study area with reference to the prominent environmental attributes. The study area covers the area falling within 10 km radius from the center of the proposed project site.

The existing environmental setting is considered to adjudge the baseline environmental conditions, which are described with respect to climate, hydro-geological aspects, atmospheric conditions, water quality, soil quality, vegetation pattern, ecology and socio-economic profiles of people and land use. The objective of this section is to define the present environmental status, which would help in assessing the environmental impacts due to the proposed project.

This report incorporates the baseline data generated through primary surveys for three months from 1st August 2013 to 31st October 2013 representing summer season.

1.1.1 Methodology

Appropriate methodologies have been followed in developing the EIA/EMP report. The methodology adopted for the study is outlined below:

- Conducting reconnaissance surveys for knowing the study area; and
- Selecting sampling locations for conducting various environment baseline studies.

The sampling locations have been selected on the basis of the following:

- Predominant wind directions recorded by the India Meteorological Department (IMD) Meenambakkam, Chennai observatory;
- Existing topography;
- Drainage pattern and location of existing surface water bodies like lakes/ponds, rivers and streams;
- Location of villages/towns/sensitive areas; and
- Areas, which represent baseline conditions.

The field observations have been used to:

- Assess the positive and negative impacts due to the proposed project; and
- Suggest appropriate mitigation measures for negating the adverse environmental impacts, if any; and
- Suggesting post-project monitoring requirements and suitable mechanism for it.

1.2 Geology and Hydrogeology

The Geographical area of the Kancheepuram district is 4470.25 (Sq. km). The elevation of the area ranges from 100 m amsl in the west to a sea level in the east. The major part of the area is characterized by an undulating topography with innumerable depressions, which are used as irrigation tanks. Three beach

terraces ranging in elevation between 4m mark the coastal tract and 12 m with broad inter terrace depressions. The coastal plain displays a fairly low level or gently rolling surface and only lightly elevated above the local water surfaces on rivers. The straight trend of the coastline is a result of development of a vast alluvial plain. There are a number of sand dunes in the coastal tract. The coastal landforms include estuarine tidal, mud flats or lagoons and salt marsh etc.

1.2.1 Drainage

The drainage pattern in the area is developed by River Palar and Cheyyar and its tributories. The drainage pattern in general is sub-dendritic and radial. All the rivers are seasonal and carry substantial flows during monsoon period. River Palar, a major river course, which drains this district originates from Western Ghats in Karnataka state, and discharges in Bay of Bengal near Pudupattinam. The Cheyyar, a tributary of Palar originates from the Jawadu Hills of Tiruvannamalai district. It has a northeasterly flow in Kancheepuram district and confluences with the Palar near Pazhaiyaseevaram. Other seasonal river like Korattalaiar and Tandiar drain this district partly on the northern and southern part respectively.

1.2.2 Geology

Geologically the Tamilnadu state is comprises of Crystalline rocks of Archaean to late Proterozoic age occupy over 80% of the area of the 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 Sathyamangalam and Kolar groups and Peninsular 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/ Panambarai Formation (Mio-Pliocene) and sediments of Quaternary and Recent age.

Geologically the study area comes under Charnokite gneiss and Pyroxene granulites and also Coastal sediments and Alluvium.

1.2.3 Hydrogeology

Hydro geologically the district is underlain by both sedimentary and fissured formations. The important aquifer system in the district are constituted by 1) unconsolidated and semi consolidated formations and 2) weathered, fissured and fractured crystalline rocks.

Hydro geologically the study area underlain by Sedimentary and fissured formations. The important aquifer system in the study are constituted by consolidated and semi consolidated formations of Granite, Gneisses, Charnokite and Sandstones, conglomerate, Clay, shale types of rocks. Ground water occurs

under unconfined to semiconfied and Discontinuous, Restricted to weathered residuum and fracture zones.

CGWB was determined by recording the water levels in the Tamilnadu state of Kancheepuram District during pre and post-monsoon periods. The depth to water levels in the study area were observed ranges from 2 to 5 m bgl during premonsoon may-2006 and 0-5 m bgl during post monsoon January-2007. The specific yield ranges from <1 to 2 lps and yield restricted to shallow depth (50 m bgl) and 50 cu.m/d near weathered divides and high grounds 50-200 cu.m/d near third order steams and low grounds.

1.2.4 Present Status Of Ground Water Development

The state ground water organizations jointly with Central Ground Water Board (CGWB) determine the status of ground water development for each tehsil every year and publish the findings once in four years after monitoring the key wells.

The findings of the CGWB have been released in the Ground Water report-2007. The status of ground water development as on March 2004 of Thiruporur black, Kancheepuram District, Tamil Nadu state as 81% of long term ground water recharge have been declared as semi critical area for future ground water development.

1.3 Land Use Studies

Studies on land use aspects of eco-system play important roles for identifying sensitive issues, if any, and taking appropriate actions for maintaining the ecological balance in the development of the region.

1.3.1 Objectives

The objectives of land use studies are

- To determine the present land use pattern;
- To analyze the impacts on land use due to plant activities in the study area; and
- To give recommendations for optimizing the future land use pattern vis-a-vis growth of plant activities in the study area and its associated impacts.

1.3.2 Methodology

For the study of land use, literature review of various secondary sources such as District Census Handbooks, regional maps regarding topography, zoning settlement, industry, forest etc., were taken. The data was collected from various sources like District Census Handbook, Revenue records, state and central government offices and Survey of India (SOI) Top sheets and also through primary field surveys.

1.3.3 Land use Based on Secondary Data

Based on the census report, 10-km radial distance around this Plant Centre has been considered in the study. These areas were studied in detail to get the idea of land use pattern in the study area. The land use census data 2011 is not available and the land use pattern of the study area as per 2001 Census is presented in **Table-1.3.1.** The village wise land use data is presented in **Annexure-X.**

TABLE-1.3.1
LAND USE PATTERN IN THE STUDY AREA

S .No	Particulars of Land use	0-3 km	3-7 km	7-10 km	0-10 km	%
1	Forest Land (ha)	0	390	1151	1541	12.73
2	Land under Cultivation					
	a) Irrigation Land (ha)	238	1188	1611	3037	25.09
	b) Un Irrigated Land (ha)	164	1389	1073	2626	21.69
3	Cultivable Waste Land (ha)	208	1016	554	1779	14.70
4	Area not Available for Cultivation (ha)	528	1244	1350	3122	25.79
	Total Area	**1138**	**5228**	**5740**	**12105**	**100.00**

Source: District Census Hand Book -2001

- ***Forest***

The revenue forestland under the study area consists 1541 ha (12.73%) of the total geographic area.

- ***Land under Cultivation***

Altogether 5663 ha cultivable land (irrigated and un-irrigated) was observed in the study area. The irrigated land admeasures to about 3037 ha in the study area which works out to be 25.09 % of total study area. The un-irrigated land admeasures about 2626 ha and works out to about 21.69 % of the total study area.

- ***Cultivable Waste***

This land includes that land, which was cultivated sometime back and left vacant during the past 5 years in succession. Such lands may either be fallows or covered with shrubs, which are not put to any use. Lands under thatching grass, bamboo bushes, other grooves useful for fuel etc., and all grazing lands and village common lands are also included in this category. The study area comprises about 14.70% cultivable wastelands.

- ***Land not available for Cultivation***

The land not available for cultivation is 25.79 % of the total study area.

1.4 Soil Characteristics

It is essential to determine the potentiality of soil in the area and to identify the impacts of urbanization on soil quality. Accordingly, the soil quality assessment has been carried out.

1.4.1 Data Generation

The sampling locations have been identified with the following objectives:

- To determine the baseline soil characteristics of the study area;
- To determine the impact of proposed project on soil characteristics; and
- To determine the impact on soils more importantly from agricultural productivity point of view.

For studying soil characteristics of the region, soil sampling locations were selected to assess the existing soil conditions in and around the project area representing various land use types. The physical, chemical and heavy metal concentrations were determined. The samples were collected using ramming a core cutter into the soil up to a depth of 90 cm.

The present study on the soil profile establishes the baseline characteristics. Eight soil samples were collected from the study area. At each location, soil samples were collected from three different depths viz. 30 cm, 60 cm and 90 cm below the surface and homogenized. The homogenized samples were analyzed for physical and chemical characteristics.
The details of the soil sampling locations are given in **Table-1.4.1** and shown in **Figure-1.4.1**.

TABLE-1.4.1
DETAILS OF SOIL SAMPLING LOCATIONS

Code No.	Location	Distance w.r.t. Proposed Site (Km)	Direction w.r.t Proposed Site
S1	Near-Plant Site	--	--
S2	Thiruporur	4.7	NW
S3	Aalathur	5.0	SW
S4	Pudunellikuppam	1.9	SSW
S5	Thiruvidanthai	6.9	NNE
S6	Kelambakkam	9.2	NNW
S7	Nemmeli	1.2	NW
S8	Thandalam	3.2	W

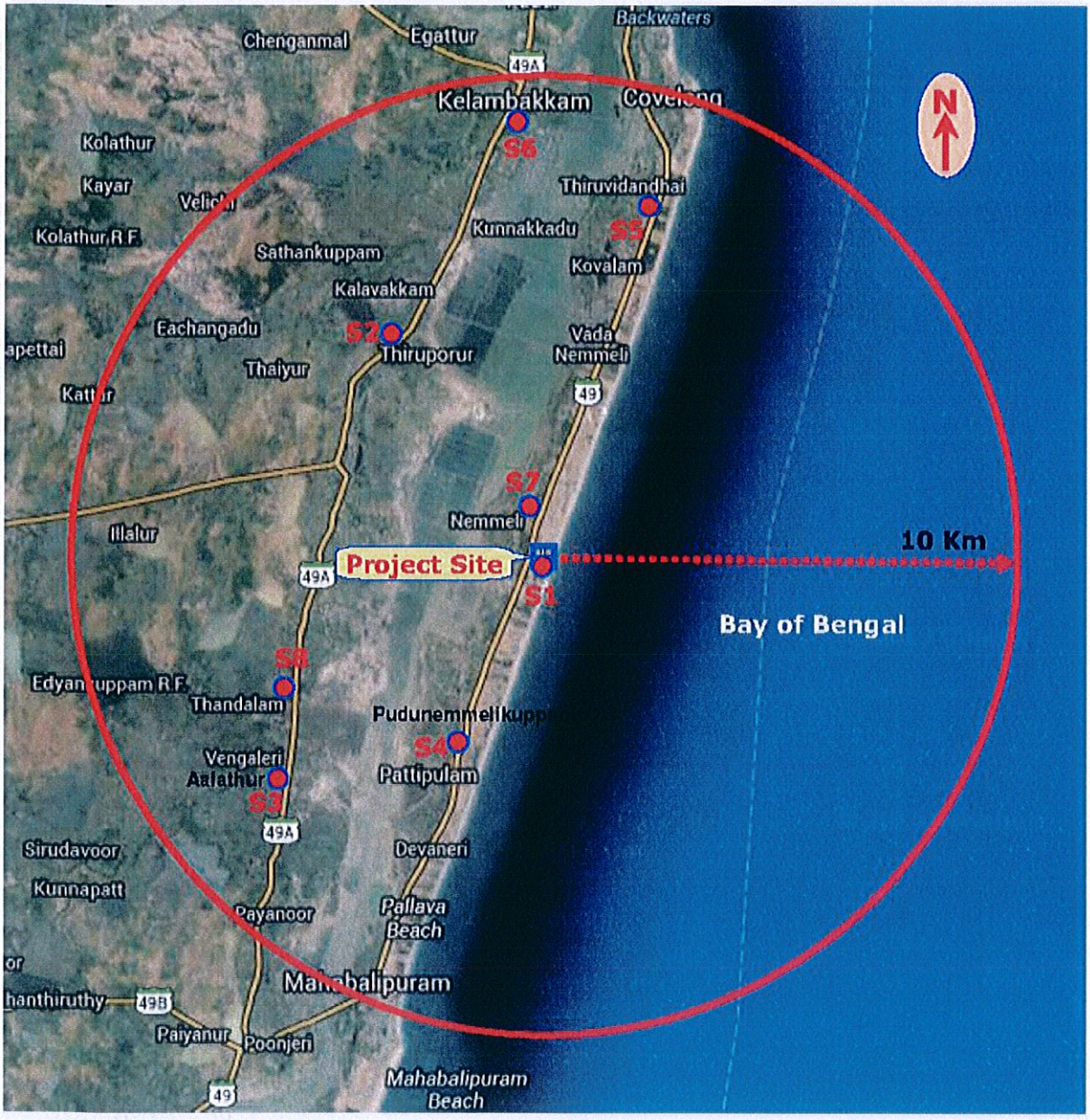


FIGURE-1.4.1
SOIL SAMPLING LOCATIONS

1.4.2 Baseline Soil Status

The soil characteristics are shown in **Table-1.4.2**.The results are compared with standard soil classification given in **Table-1.4.3.**

TABLE-1.4.2
SOIL ANALYSIS RESULTS

Sr. No.	Parameter	UOM	S1	S2	S3	S4
1	pH (1:5 Aq. Extract)	----	7.9	8.0	8.1	7.9
2	Conductivity (1:5 Aq. Extract)	mS/cm	245	192	280	144
3	Texture	----	Sandy Clay	Sandy Clay	Sandy Clay	Sandy Clay
4	Sand	%	45	48	46	45
5	Silt	%	15	10	09	13
6	Clay	%	40	42	45	42
7	Bulk Density	mg/cc	1.1	1.1	1.2	1.1
8	Exchangeable Calcium as Ca	mg/kg	4387	2924	2276	3217
9	Exchangeable Magnesium as Mg	mg/kg	296	592	608	279
10	Exchangeable Sodium as Na	mg/kg	97.5	69.2	91.9	90.4
11	Available Potassium as K	Kg/ha	0.17	0.13	0.20	0.19
12	Available Phosphorous as P	Kg/ha	56.0	52.0	56.0	52.0
13	Available Nitrogen as N	Kg/ha	46	58	52	46
14	Organic Matter	%	180	186	320	250
15	Organic Carbon	%	0.086	0.100	0.028	0.085
16	Water Soluble Chloride as Cl	mg/kg	0.148	0.172	0.049	0.147
17	Water Soluble Sulphate as SO_4	mg/kg	320	260	320	275
18	Sodium Absorption Ratio	----	128	98	120	106
19	Aluminum	%	0.86	1.02	0.48	0.68
20	Total Iron	%	1.24	0.96	0.64	0.97
21	Manganese	mg/kg	280	240	360	260
22	Boron	mg/kg	14	28	19	36
23	Zinc	mg/kg	74	82	87	68

TABLE-1.4.2 (Conti...)
SOIL ANALYSIS RESULTS

Sr. No.	Parameter	UOM	S5	S6	S7	S8
1	pH (1:5 Aq. Extract)	----	7.8	8.1	8.0	7.9
2	Conductivity (1:5 Aq. Extract)	mS/cm	158	168	220	236
3	Texture	----	Sandy Clay	Sandy Clay	Sandy Clay loam	Sandy Clay loam
4	Sand	%	65	63	54	55
5	Silt	%	20	22	12	13
6	Clay	%	15	15	34	32
7	Bulk Density	mg/cc	1.3	1.3	1.1	1.1
8	Exchangeable Calcium as Ca	mg/kg	2437	1889	3284	2925
9	Exchangeable Magnesium as Mg	mg/kg	652	918	627	711
10	Exchangeable Sodium as Na	mg/kg	35.1	29.3	57.2	66.3
11	Available Potassium as K	Kg/ha	0.07	0.06	0.11	0.12
12	Available Phosphorous as P	Kg/ha	42.0	28.2	78	72
13	Available Nitrogen as N	Kg/ha	38	42.0	72	65
14	Organic Matter	%	280	198	360	380
15	Organic Carbon	%	0.014	0.028	0.513	0.357
16	Water Soluble Chloride as Cl	mg/kg	0.024	0.049	0.885	0.617
17	Water Soluble Sulphate as SO_4	mg/kg	214	196	216	218
18	Sodium Absorption Ratio	----	82	76	78	82
19	Aluminum	%	0.76	0.96	0.88	0.74
20	Total Iron	%	1.06	1.06	1.16	0.98
21	Manganese	mg/kg	384	410	380	270
22	Boron	mg/kg	44	48	32	26
23	Zinc	mg/kg	74	62	56	58

1.4.2.1 Observations

- It has been observed that the pH of the soil in the study area varied from 7.8 to 8.1. The maximum pH value of 8.1 was observed at S3 and S6 where as the minimum value of 7.8 was observed at S5.
- The electrical conductivity was observed to range from 144 µmhos/cm to 280 µmhos/cm, with the maximum observed at S3 with the minimum observed in S4.
- The nitrogen value varies from 28.2-78.0 kg/ha. The nitrogen content in the study area falls in very less to less category.
- The phosphorus values varies from 38.0 to 72.0 kg/ha, indicating that the phosphorus content in the study area falls in medium to sufficient category.
- The potassium values varies from 180 to 380 kg/ha. The potassium content in the study area falls in less to more than sufficient category.
- The organic carbon value varies from 0.014 % to 0.513 %. The organic carbon content in the study area falls in very less to on an average sufficient category.

TABLE-1.4.3
STANDARD SOIL CLASSIFICATION

Sr. No.	Soil Test	Classification
1	pH	<4.5 Extremely acidic 4.51- 5.50 Very strongly acidic 5.51-6.0 moderately acidic 6.01-6.50 slightly acidic 6.51-7.30 Neutral 7.31-7.80 slightly alkaline 7.81-8.50 moderately alkaline 8.51-9.0 strongly alkaline 9.01 very strongly alkaline
2	Salinity Electrical Conductivity (mmhos/cm) (1 ppm = 640 mmho/cm)	Upto 1.00 Average 1.01-2.00 harmful to germination 2.01-3.00 harmful to crops (sensitive to salts)
3	Organic Carbon	Upto 0.2: very less 0.21-0.4: less 0.41-0.5 medium, 0.51-0.8: on an average sufficient 0.81-1.00: sufficient >1.0 more than sufficient
4	Nitrogen (Kg/ha)	Upto 50 very less 51-100 less 101-150 good 151-300 Better >300 sufficient

Sr. No.	Soil Test	Classification
5	Phosphorus (Kg/ha)	Upto 15 very less 16-30 less 31-50 medium, 51-65 on an average sufficient 66-80 sufficient >80 more than sufficient
6	Potash (Kg/ha)	0 -120 very less 120-180 less 181-240 medium 241-300 average 301-360 better >360 more than sufficient

Source: Handbook of Agriculture

1.5 Meteorology

The meteorological data recorded during the monitoring period is very useful for proper interpretation of the baseline information as well as for input prediction models for air quality dispersion. Historical data on meteorological parameters will also play an important role in identifying the general meteorological regime of the region.

The year may broadly be divided into four seasons:

- Winter season : December to February
- Pre-monsoon season : March to May
- Monsoon season : June to September
- Post-monsoon season : October to November

1.5.1 Methodology

The methodology adopted for monitoring surface observations is as per the standard norms laid down by Bureau of Indian Standards (IS : 8829) and India Meteorological Department (IMD). On-site monitoring was undertaken for various meteorological variables in order to generate the site-specific data. The generated data is then compared with the meteorological data generated by IMD.

1.5.1.1 Methodology of Data Generation

The automatic meteorological instrument was installed on top of a building near to the project site to record wind speed, direction, relative humidity and temperature. Cloud cover is recorded by visual observation. Rainfall is monitored by rain gauge. Hourly average, maximum, and minimum values of wind speed, direction, temperature, relative humidity and rainfall have been recorded continuously at this station during 1st August 2013 to 31th October 2013.

1.5.1.2 Sources of Information

Secondary information on meteorological conditions has been collected from the nearest IMD station at Chennai Airport.

India Meteorological Department has been monitoring surface observations at Chennai since 1891. Pressure, temperature, relative humidity, rainfall, wind speed and direction are measured twice a day viz., at 0830 and 1730 hr. The wind speed and direction data of IMD, Chennai has been obtained for the past available 10 years. The data for the remaining parameters has been collected for the last 10 years and processed.

1.5.2 Synthesis of Data on Climatic Conditions

1.5.2.1 Analysis of the Data Recorded at IMD-Chennai

1) Temperature

The winter season starts from December and continues till the end of February. January is the coldest month with the mean daily maximum temperature at 33.3°C with the mean daily minimum temperature at 17.0°C. Both the day and night temperatures increase rapidly during the onset of Pre-monsoon season. During Pre-monsoon the mean maximum temperature (May) is observed at 43.4°C with the mean minimum temperature at 21.6°C. The mean maximum temperature in the Monsoon season was observed to be 42.8°C whereas the mean minimum temperature was observed to be 21.2°C. By end of September with the onset of Northeast monsoon (October), day temperatures decrease slightly with the mean maximum temperature at 35.9°C with the mean minimum temperature at 22.4°C. The monthly variations of temperatures are presented in **Table-1.5.1.**

2) Relative Humidity

The air is generally very humid in the region especially during monsoon when the average relative humidity is observed around 67% with a maximum and minimum of 100% and 35% respectively. In the pre-monsoon period the relative humidity is 63%. During the pre-monsoon season the mean maximum humidity is observed at 100%, with the mean minimum humidity at 39% in the month of May and April respectively. During winter season the humidity is found to be in line with the values recorded during the Pre-monsoon season. The mean maximum humidity recorded during winter season, which is the driest part of year with an average of 66% relative humidity. The mean maximum relative humidity is observed to be 100% with mean minimum humidity at 38%. The monthly mean variations in relative humidity are presented in **Table-1.5.1**.

3) Atmospheric Pressure

The station level maximum and minimum atmospheric pressure levels are recorded during the winter and monsoon seasons. The maximum pressure observed is in the range of 1016.5 to 1003.5-mb, with the maximum pressure (1016.5-Mb) occurring during the winter season, in the month of January. The minimum pressure observed is in the range of 1013.6 to 999.9 Mb, with the minimum pressure (999.9-Mb) occurring during the pre-monsoon season in the month of June. The average pressure levels in all other months are found to be in the range of 1008.5 to 1010.6-mb. The monthly variations in the pressure levels are presented in **Table-1.5.1**.

4) Rainfall

It is observed that the north-east monsoon is more predominant than the south-west monsoon. The southwest monsoon generally sets in during the last week of May. About 30% of the rainfall is received during the southwest monsoon. The rainfall gradually increases after September (and reaches maximum rainfall is recorded in the month of November). The area experiences maximum rainfall (308.0 mm) in the month of November. The Northeast monsoon rain occurs between October to December and contributes to the rainfall by about 60% of the total rainfall. Monthly variations in the rainfall for past available 10 years are given in **Table-1.5.1**.

5) Cloud Cover

Generally light clouds are observed during winter mornings. During pre-monsoon and the post-monsoon evenings the skies are either clear or lightly clouded. But in post-monsoon mornings as well as monsoon morning heavy clouds are commonly observed. Whereas in the evening time the skies are light to moderately clouded through out the year.

6) Wind Speed/Direction

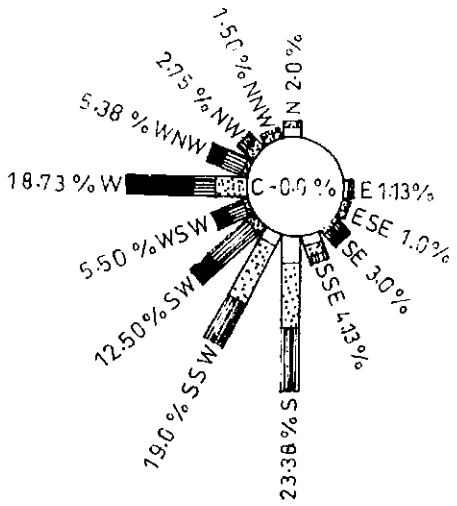
The windrose for the study period representing pre-monsoon, monsoon, post-monsoon and winter season along with annul windrose are shown in **Figure-1.5.1** and presented in **Table-1.5.2.**

TABLE-1.5.1
CLIMATOLOGICAL DATA - IMD, CHENNAI (MINAMBAKAM)

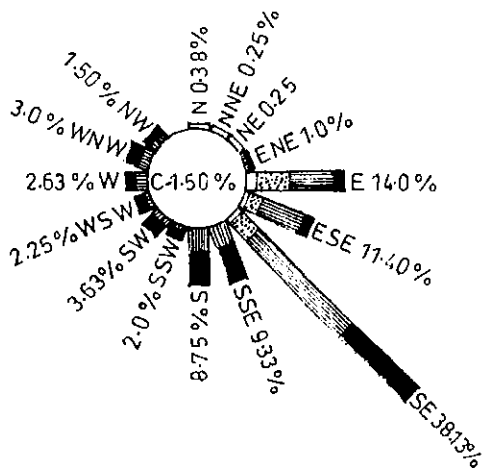
Month	Temperature (^{0}C)			Relative Humidity (%)		Atmospheric Pressure (Mb)		Rainfall (mm)
	Max	Min	Avg.	0830	1730	0830	1730	
January	33.3	17.0	26.1	100	38	1016.5	1013.6	23.8
February	34.9	16.0	25.2	95	31	1012.2	1009.0	6.8
March	38.7	18.2	27.5	91	28	1010.6	1007.1	15.1
April	42.7	21.0	32.0	96	39	1008.4	1004.3	24.7
May	43.4	21.6	32.2	100	15	1004.5	1000.8	51.7
June	42.8	21.2	32.5	100	32	1003.5	999.9	52.6
July	39.5	22.3	31.0	95	35	1004.2	1000.7	83.5
August	39.0	22.0	31.0	98	32	1004.9	1001.1	124.3
September	37.8	21.5	29.5	97	35	1006.3	1002.4	118.0
October	35.9	22.4	28.7	98	46	1008.5	1005.3	267.0
November	34.4	18.0	27.0	99	42	1010.9	1003.1	308.0
December	31.7	17.8	25.0	100	34	1012.9	1010.0	139.1

TABLE-1.5.2
SUMMARY OF WIND PATTERN – IMD, CHENNAI

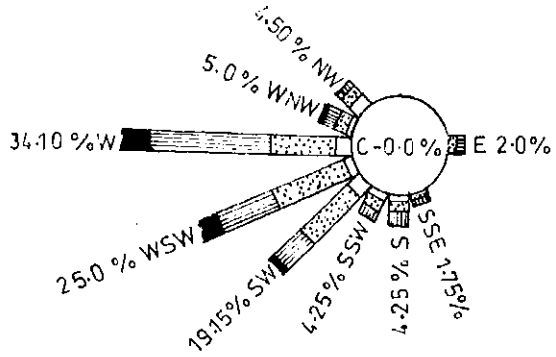
Season	First predominant winds		Second predominant winds		Calm condition in %	
	0830	1730	0830	1730	0830	1730
Pre-monsoon	S (29.0)	S (37.5)	SSW (17.5)	SSW (24.9)	10.3	1.7
Monsoon	SSW (17.3)	SSW (20.3)	SW (16.9)	S (18.1)	10.5	8.2
Post monsoon	NNE (17.0)	E (15.0)	N (15.5)	NE (14.0)	21.0	25.0
Winter	NE (16.7)	S (14.6)	NNE (14.0)	E (11.6)	31.0	16.7
Annual	SSW (12.9)	S (18.9)	SW (10.0)	SSW (14.2)	15.8	12.9

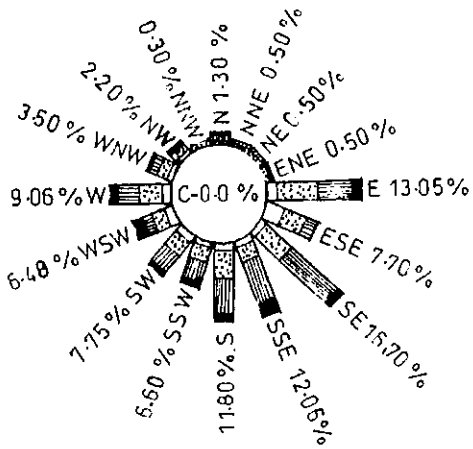


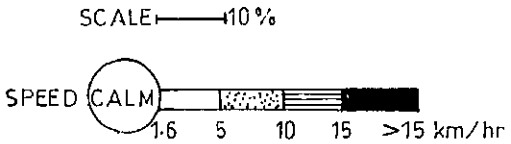
PRE MONSOON SEASON
(0830 hrs)



PRE MONSOON SEASON
(1730 hrs)



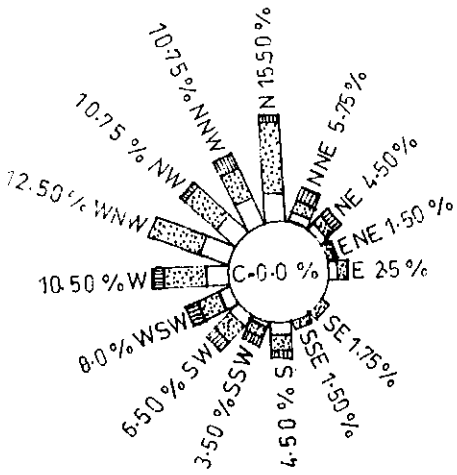




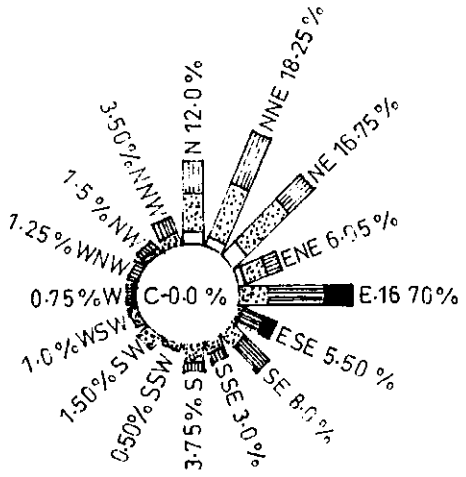
MONSOON SEASON
(0830 hrs)

MONSOON SEASON
(1730 hrs)

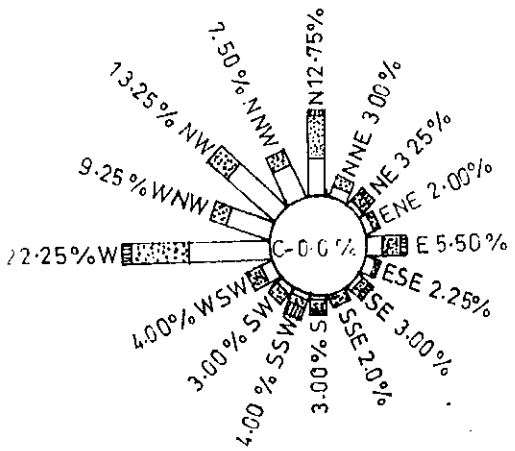
FIGURE-1.5.1 (A)
WINDROSE FOR PRE MONSOON & MONSOON SEASON-IMD, CHENNAI



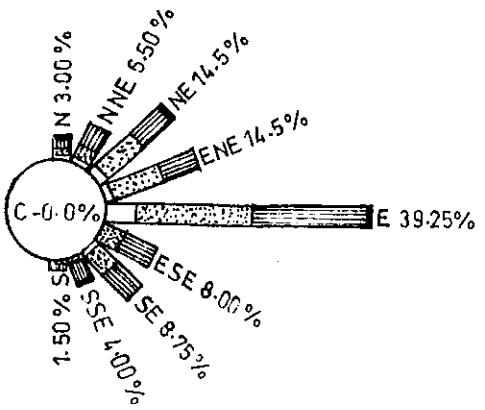
POST MONSOON SEASON
(0830 hrs)

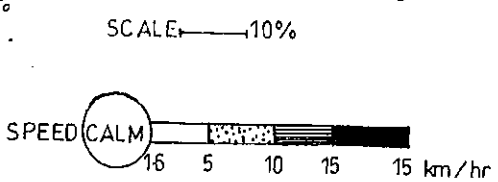


POST MONSOON SEASON
(1730 hrs)



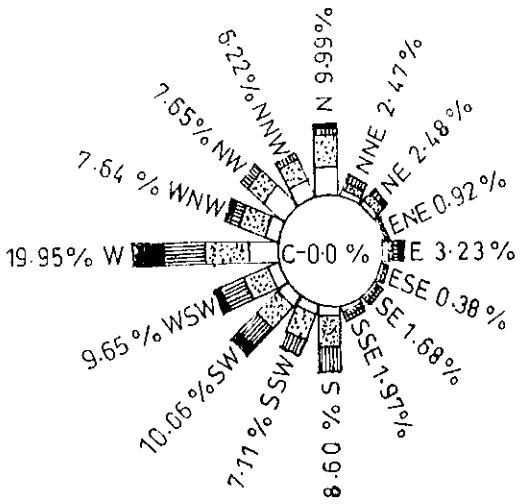
WINTER SEASON
(0830 hrs)



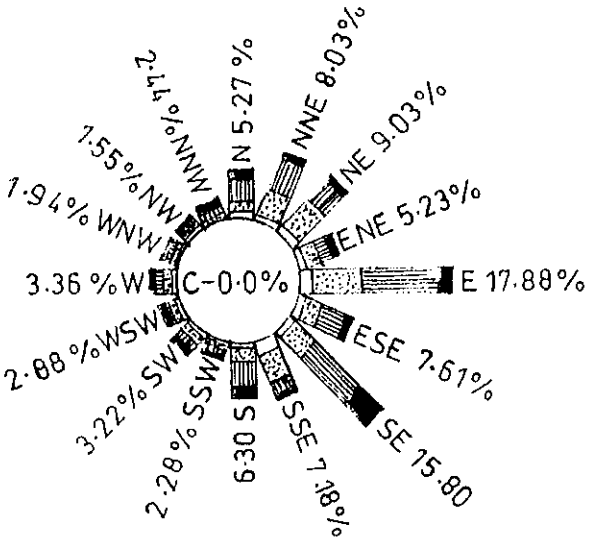


WINTER SEASON
(1730 hrs)

FIGURE-1.5.1 (B)
WINDROSE FOR POST MONSOON & WINTER SEASON-IMD, CHENNAI



08·30 hrs



17·30 hrs

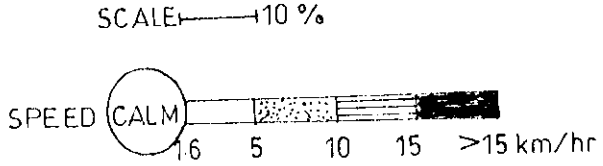


FIGURE-1.5.1 (C)
ANNUAL WINDROSE -IMD, CHENNAI

1.5.2.2Analysis of Meteorological Data Recorded at Project Site

The meteorological data recorded at the project site during the study period (1st August, 2013 to 31st October, 2013) is presented in **Table-1.5.3.**

TABLE-1.5.3
SUMMARY OF THE METEOROLOGICAL DATA AT SITE

Month	Temperature (°C)		Humidity (%)		Total Rainfall (mm)
	Max	Min	Max	Min	
August 2013	37.5	23.7	100	28	73
September 2013	36.8	22.9	100	34	89
October 2013	36.3	22.6	100	21	121

1) Temperature

It was observed that the temperature at the proposed site during study period ranged from 22.9°C to 37.5°C. The monthly variations in the temperatures are presented in **Table-1.5.3.**

2) Humidity

During the period of observation, the humidity ranged from 21.0% to 100.0%. The monthly variations in the humidity are presented in **Table-1.5.3.**

3) Rainfall

A total of 283 mm of rainfall was observed during the study period. The maximum rainfall was recorded in the month of October in study period.

4) Cloud Cover

Mostly clear skies were observed except rainy days during the study period.

5) Wind Speed and Direction

The windrose for the study period representing winter season is shown in **Figure-1.5.2.** A review of the windrose diagram shows that predominant winds are mostly from West (14.4%) and WSW (10.3%) followed by E (8.1%) direction. Calm condition was recorded for 4.5%.

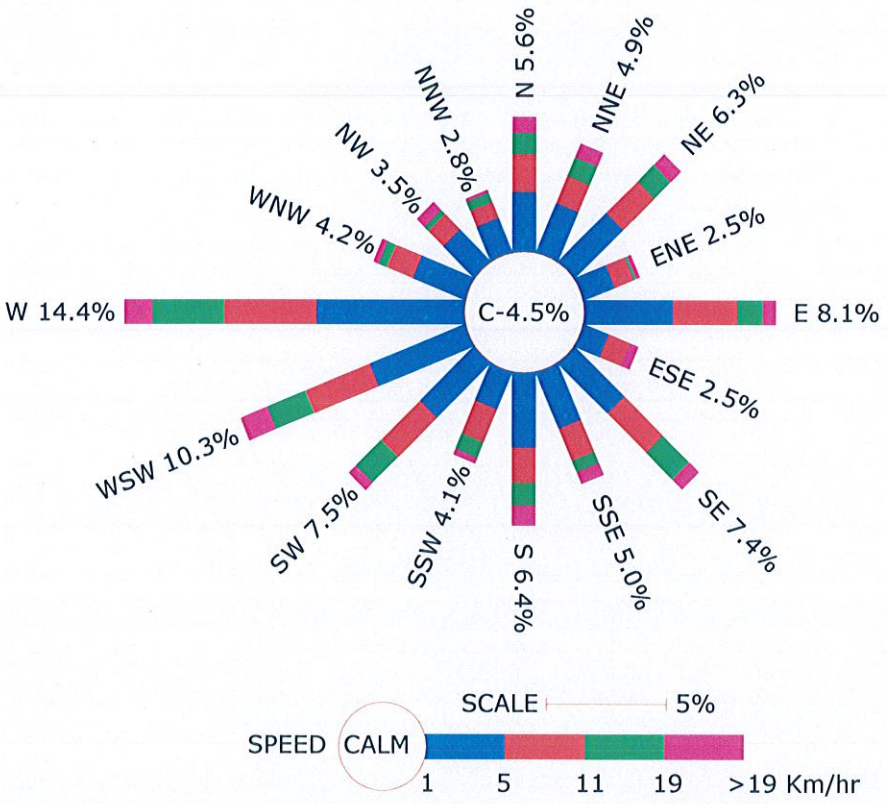


FIGURE-1.5.2
SITE SPECIFIC WINDROSE (AUGUST – OCTOBER 2013)

1.6 Air Quality

The ambient air quality with respect to the study zone of 10-km radius around the project site forms the baseline information. The various sources of air pollution in the region are industries and vehicular traffic. The prime objective of the baseline air quality study was to assess the existing air quality of the area. The study area represents mostly rural environment.

This section describes the selection of sampling locations, methodology adopted for sampling, analytical techniques and frequency of sampling.

1.6.1 Methodology adopted for Air Quality Survey

1.6.1.1 Selection of Sampling Locations

The baseline status of the ambient air quality has been assessed through a scientifically designed ambient air quality-monitoring network. The design of monitoring network in the air quality surveillance program has been based on the following considerations:

- Meteorological conditions on synoptic scale;
- Topography of the study area;
- Representatives of regional background air quality for obtaining baseline status;
- Representatives of likely impact areas.

Ambient Air Quality Monitoring (AAQM) stations were set up at **eight** locations with due consideration to the above mentioned points. **Table-1.6.1** gives the details of environmental setting around each monitoring station. The location of the selected stations with reference to the project site is given in the same table and shown in **Figure-1.6.1**.

TABLE-1.6.1
DETAILS OF AMBIENT AIR QUALITY MONITORING LOCATIONS

Station Code	Name of the Station	Distance w.r.t Project Site (km)	Direction w.r.t Project Site
AAQ1	Near-Plant site	--	--
AAQ2	Thiruporur	4.7	NW
AAQ3	Aalathur	5.0	SW
AAQ4	Pudunemmelikuppam	1.9	SSW
AAQ5	Thiruvidanthai	6.9	NNE
AAQ6	Kelambakkam	9.2	NNW
AAQ7	Nemmeli	1.2	NW
AAQ8	Thandalam	3.2	W

1.6.1.2 Frequency and Parameters for Sampling

The following frequency has been adopted for sampling:

Ambient air quality monitoring has been carried out with a frequency of two days per week at all locations for study period from 1st March 2012 to 31st May 2012. The baseline data of air environment is generated for the following parameters:

- Particulate Matter (PM_{10});
- Particulate Matter ($PM_{2.5}$);

- Sulphur dioxide (SO_2);
- Nitrogen dioxide (NO_2);
- Carbon monoxide (CO);

1.6.1.3 Duration of Sampling

The sampling duration for PM_{10}, $PM_{2.5}$, SO_2 and NO_2 was twenty-four hourly continuous samples per day and CO was sampled for 8–hrs continuous thrice a day. This is to allow a comparison with the present revised standards mentioned in the latest Gazette notification of the Central Pollution Control Board (CPCB) (November 16, 2009).

TABLE-1.6.2
MONITORED PARAMETERS AND FREQUENCY OF SAMPLING

Parameters	Sampling Frequency
PM_{10}	24 hourly sample twice a week for three months
$PM_{2.5}$	24 hourly sample twice a week for three months
Sulphur dioxide (SO_2)	24 hourly sample twice a week for three months
Oxides of Nitrogen (NO_X)	24 hourly sample twice a week for three months
Carbon Monoxide (CO)	08 hourly sample twice a week for three months

1.6.1.4 Method of Analysis

The air samples were analyzed as per standard methods specified by Central Pollution Control Board (CPCB), IS: 5184 and American Public Health Association (APHA).

1.6.2 Instruments used for Sampling

Dust Samplers of Pollutech instruments were used for monitoring PM_{10} (<10 microns), $PM_{2.5}$ and gaseous pollutants like SO_2 and NO_2. Glass tubes were deployed for collection of grab samples of Carbon monoxide. Gas Chromatography techniques have been used for the estimation of CO.

1.6.3 Sampling and Analytical Techniques

The techniques used for ambient air quality monitoring and minimum detectable levels are given in **Table-1.6.3.**

TABLE-1.6.3
TECHNIQUES USED FOR AMBIENT AIR QUALITY MONITORING

Sr. No.	Parameter	Technique	Technical Protocol	Minimum Detectable Limit ($\mu g/m^3$)
1	PM_{10}	Fine Particulate Sampler (Gravimetric Method)	IS-5182 (Part-IV)	5.0
2	$PM_{2.5}$	Fine Particulate Sampler (Gravimetric Method)	IS-5182 (Part-IV)	2.0
3	Sulphur dioxide	Modified West and Gaeke Method	IS-5182 (Part-II)	4.0
4	Oxides of Nitrogen	Jacob & Hochheiser Method	IS-5182 (Part-VI)	9.0
5	Carbon Monoxide (CO)	Gas Chromatography Method	IS:5182 (Part-X)	12.5

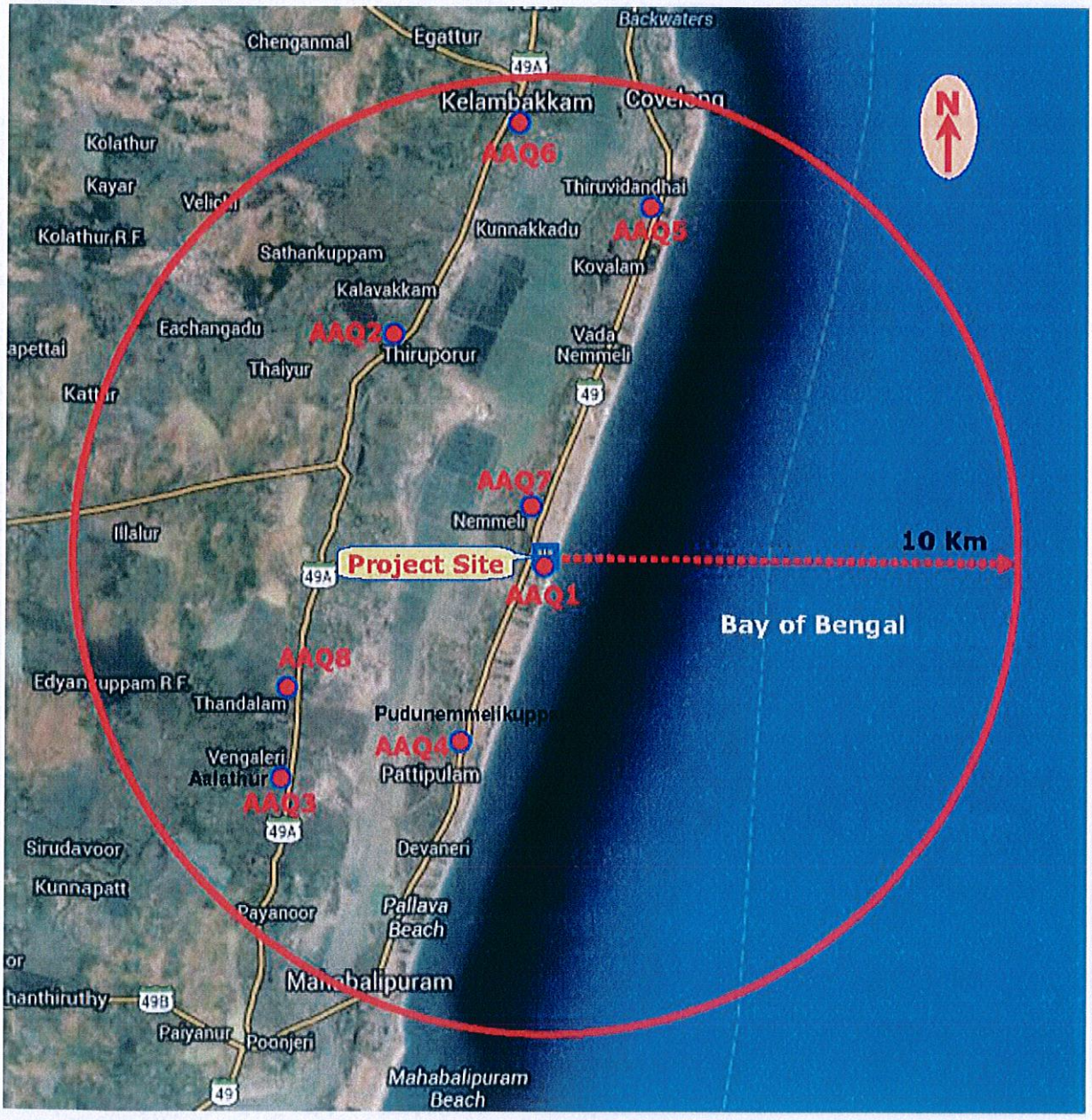


FIGURE-1.6.1
AIR QUALITY SAMPLING LOCATIONS

1.6.4 Presentation of Primary Data

Various statistical parameters like 98th percentile, average, maximum and minimum values have been computed from the observed raw data for all the AAQ monitoring stations. The summary of these results for summer season is presented in **Table-1.6.4.**

TABLE-1.6.4
SUMMARY OF AMBIENT AIR QUALITY RESULTS

Location	PM_{10} ($\mu g/m^3$)				$PM_{2.5}$ ($\mu g/m^3$)				SO_2 ($\mu g/m^3$)			
	Max	Min	Avg	98%	Max	Min	Avg	98%	Max	Min	Avg	98%
Near-Plant Site	49.9	40.9	45.7	49.6	18.5	12.8	15.7	18.0	10.7	8.6	9.5	10.6
Thiruporur	51.5	42.4	47.3	51.2	19.5	13.8	16.3	19.1	10.8	8.2	9.1	10.5
Aalathur	47.3	41.4	44.0	47.1	17.3	13.9	15.1	17.2	9.8	8.3	9.0	9.7
Pudunemmelikuppam	46.0	37.8	42.1	45.7	17.4	12.9	14.5	16.7	9.6	7.5	8.7	9.6
Thiruvidanthai	44.7	36.7	41.0	44.5	16.1	12.4	14.1	15.9	10.2	7.9	8.8	9.8
Kelambakkam	52.5	45.2	49.1	52.2	19.5	15.1	16.9	19.4	10.4	8.6	9.5	10.4
Nemmeli	40.0	32.7	36.7	39.8	14.6	11.0	12.7	14.3	9.9	8.2	9.0	9.8
Thandalam	43.6	36.3	40.2	43.3	15.4	11.8	13.8	15.3	9.8	8.2	8.9	9.8
Range	**32.7-52.5**				**11.0-19.5**				**7.5-10.8**			
Standards	**100**				**60**				**80**			

TABLE-1.6.4 (Cont...)
SUMMARY OF AMBIENT AIR QUALITY RESULTS

Location	NO_2 ($\mu g/m^3$)				CO ($\mu g/m^3$)			
	Max	Min	Avg	98%	Max	Min	Avg	98%
Near-Plant Site	14.2	10.7	12.4	14.0	514	383	448	509
Thiruporur	13.6	11.0	12.1	13.6	527	390	451	520
Aalathur	13.3	10.4	11.9	13.2	481	373	429	477
Pudunemmelikuppam	13.7	9.7	11.5	13.4	495	365	424	480
Thiruvidanthai	13.5	10.0	11.6	13.5	486	371	428	483
Kelambakkam	14.8	11.4	12.6	14.8	536	394	462	521
Nemmeli	13.8	10.2	11.9	13.5	489	368	429	485
Thandalam	13.1	10.4	11.8	13.0	497	377	436	494
Range	**9.7-14.8**				**365-536**			
Standards	**80**				**2000**			

1.6.5 Observations of Primary Data

The three months Ambient Air Quality data is given as **Annexure-3.**

PM_{10}: The maximum and minimum concentrations for PM_{10} were recorded as 52.5 $\mu g/m^3$ and 32.7 $\mu g/m^3$ respectively. The maximum concentration was recorded at Kelambakkam and the minimum concentration was recorded at Nemmeli. The average values were observed to be in the range of 36.7 and 49.1 $\mu g/m^3$.

$PM_{2.5}$: The maximum and minimum concentrations for $PM_{2.5}$ were recorded as 19.5 $\mu g/m^3$ and 11.0 $\mu g/m^3$ respectively. The maximum concentration was recorded at Kelambakkam and the minimum concentration was recorded at Nemmeli. The average values were observed to be in the range of 12.7 and 16.9 $\mu g/m^3$.

SO_2: The maximum and minimum SO_2 concentrations were recorded as 10.8 $\mu g/m^3$ and 7.5 $\mu g/m^3$. The maximum concentration was recorded at Thiruporur and the

minimum concentration was recorded at Pudunemmelikuppam. The average values were observed to be in the range of 8.7 and 9.5 $\mu g/m^3$.

NO_2: The maximum concentration of 14.8 $\mu g/m^3$ for NO_2 was recorded at Kelambakkam and minimum of 9.7 $\mu g/m^3$ observed at Pudunemmelikuppam. The average concentrations were ranged between 11.5 and 12.6 $\mu g/m^3$.

CO: The maximum concentration of 536 $\mu g/m^3$ was recorded at Kelambakkam and minimum of 365 $\mu g/m^3$ observed at Pudunemmelikuppam. The average concentrations were ranged between 424 and 462 $\mu g/m^3$.

The concentrations of PM_{10}, $PM_{2.5}$, SO_2, NO_X, CO and O_3 are observed to be well within the standards prescribed by Central Pollution Control Board (CPCB) for Industrial, Rural, Residential and Other area.

1.7 Water Quality

Selected water quality parameters of ground water and surface water resources within the study area has been studied for assessing the water environment and evaluate anticipated impact of the proposed project. Understanding the water quality is essential in preparation of Environmental Impact Assessment and to identify critical issues with a view to suggest appropriate mitigation measures for implementation.

The purpose of this study is to:

- Assess the water quality characteristics for critical parameters;
- Evaluate the impacts on agricultural productivity, habitat conditions, recreational resources and aesthetics in the vicinity; and
- Prediction of impact on water quality by this project and related activities.

The information required has been collected through primary surveys and secondary sources.

1.7.1 Methodology

Reconnaissance survey was undertaken and monitoring locations were finalized based on:

- Drainage pattern;
- Location of residential areas representing different activities/likely impact areas; and
- Likely areas, which can represent baseline conditions.

Water sources covering 10-km radial distance were examined for physico-chemical, heavy metals and bacteriological parameters in order to assess the effect of industrial and other activities on water. The samples were collected and analyzed as per the procedures specified in 'Standard Methods for the Examination of Water and wastewater' published by American Public Health Association (APHA).

Samples for chemical analysis were collected in polyethylene carboys. Samples collected for metal content were acidified with 1 ml HNO_3. Samples for bacteriological analysis were collected in sterilized glass bottles. Selected physico-chemical and bacteriological parameters have been analyzed for projecting the existing water quality status in the study area. Parameters like temperature,

Dissolved Oxygen (DO), free Chlorine and pH were analyzed at the time of sample collection.

1.7.2 Water Sampling Locations

Water samples were collected from 4 ground water and 2 surface water-sampling locations. These samples were taken as grab samples and were analyzed for various parameters to be compared with the standards for drinking water as per IS:10500. The water sampling locations are listed below in **Table-1.7.1** and are depicted in **Figure-1.7.1**.

TABLE-1.7.1
DETAILS OF WATER SAMPLING LOCATIONS

Code	Location	Distance w.r.t. Project Site (km)	Direction w.r.t. Project Site
Ground Water			
GW1	Alathur	5.0	SW
GW2	Thiruporur	4.7	NW
GW3	Pudunemmelikuppam	1.9	SSW
GW4	Thiruvidanthai	6.9	NNE
Surface Water			
SW1	Pattipulam	2.7	SSW
SW2	Vada Nemmeli	4.6	NNE

1.7.3 Presentation of Results

Four ground water and two surface water samples representing water environment have been considered around the proposed plant within the periphery of 10 km taking in to account the various uses. The results of surface water samples and the ground water quality are presented in **Table-1.7.2 and Table-1.7.3.**

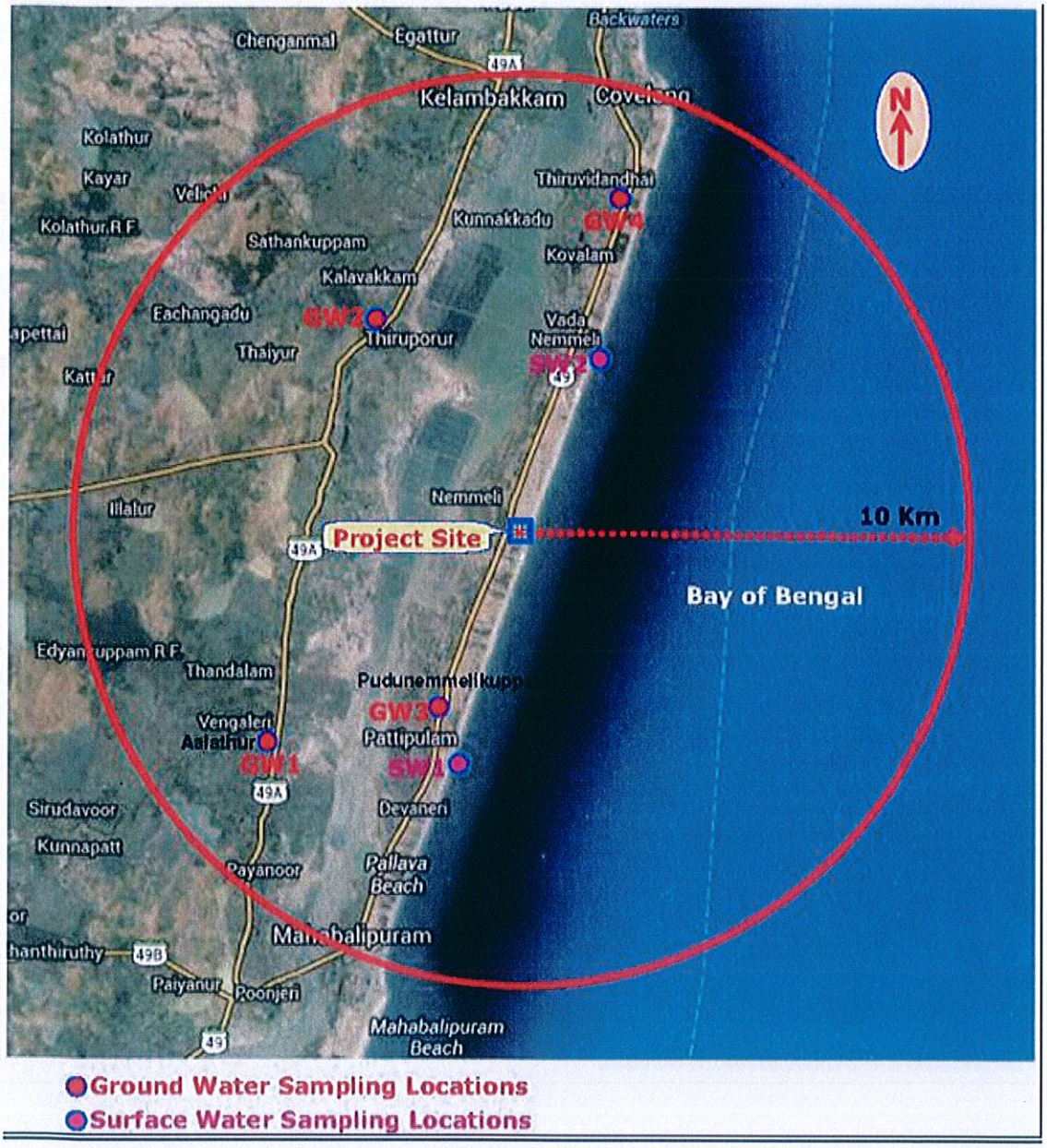


FIGURE-1.7.1
WATER SAMPLING LOCATIONS

TABLE 1.7.2
GROUND WATER QUALITY

Sr. No	Parameters	Unit	IS: 10500 Limits	GW1	GW2	GW3	GW4
1	pH	-	6.5 – 8.5 (NR)	7.4	7.5	7.3	7.6
2	Colour	Hazen	5(25)	2	3	2	2
3	Taste	-	Agreeable	Ag	Ag	Ag	Ag
4	Odour	-	U.O	U.O	U.O	U.O	U.O
5	Conductivity	µS/cm	$	1601.0	1676.0	104.0	1568
6	Turbidity	NTU	5(10)	1	2	1	1
7	TDS	mg/l	500(2000)	1040	1080	65	1015
8	Total Hardness as $CaCO_3$	mg/l	300(600)	473	497	39	640
9	Total Alkalinity	mg/l	200(600)	485.0	350.0	22.0	510.0
10	Calcium as Ca	mg/l	75(200)	160.5	165.0	10.2	85.0
11	Magnesium as Mg	mg/l	30(100)	17.5	20.5	5.3	40.0
12	Residual Chlorine	mg/l	0.2 Min	<0.2	<0.2	<0.2	<0.2
13	Boron	mg/l	1	0.01	0.02	<0.01	0.02
14	Chlorides as Cl	mg/l	250(1000)	140.2	235.0	10.2	85.0
15	Sulphates as SO_4	mg/l	200(400)	86.5	112.2	6.1	120.0
16	Fluorides as F	mg/l	1.0(1.5)	0.9	0.8	0.5	0.7
17	Nitrates as NO_3	mg/l	45(NR)	30.2	35.0	11.2	36.0
18	Sodium as Na	mg/l	$	145.0	150.0	6.2	65.0
19	Potassium as K	mg/l	$	15.6	16.0	0.6	14.0
20	Phenolic Compounds	mg/l	0.001(0.002)	<0.001	<0.001	<0.001	<0.001
21	Cyanides	mg/l	0.05 (NR)	<0.02	<0.02	<0.02	<0.02
22	Anionic Detergents	mg/l	0.2 (1.0)	<0.1	<0.1	<0.1	<0.1
23	Mineral Oil	mg/l	0.01 (0.03)	<0.01	<0.01	<0.01	<0.01
24	Cadmium as Cd	mg/l	0.01 (NR)	<0.01	<0.01	<0.01	<0.01
25	Arsenic as As	mg/l	0.01 (NR)	<0.01	<0.01	<0.01	<0.01
26	Copper as Cu	mg/l	0.05 (1.5)	<0.01	<0.01	<0.01	<0.01
27	Lead as Pb	mg/l	0.05 (NR)	<0.01	<0.01	<0.01	<0.01
28	Manganese as Mn	mg/l	0.1 (0.3)	0.01	0.04	<0.01	0.02
29	Iron as Fe	mg/l	0.3(1.0)	0.06	0.04	0.02	0.05
30	Chromium as Cr^{+6}	mg/l	0.05(NR)	<0.05	<0.05	<0.05	<0.05
31	Selenium as Se	mg/l	0.01(NR)	<0.01	<0.01	<0.01	<0.01
32	Zinc as Zn	mg/l	5(15)	<0.01	<0.01	<0.01	<0.01
33	Aluminum as Al	mg/l	0.03(0.2)	<0.01	<0.01	<0.01	<0.01
34	Mercury as Hg	mg/l	0.001(NR)	<0.001	<0.001	<0.001	<0.001
35	Pesticides	mg/l	Absent	Absent	Absent	Absent	Absent
36	E. Coil	-	Absent	Absent	Absent	Absent	Absent
37	Total Coliforms	MPN/100	10	<2	<2	<2	<2

Note: Values in paranthesis are 'Permissible limit in the absence of Alternate source'. NR: No relaxation, $: *Limits not specified, UO: Un-Objectionable,* Agr-Agreeable

IS: 10500 (the standard prescribes the requirements for the essential and desirable characteristics required to be tested for ascertaining the suitability of water for drinking purpose).

TABLE 1.7.3
SURFACE WATER QUALITY

Sr. No	Parameters	Unit	IS: 10500 Limits	SW1	SW2
1	pH	-	6.5 – 8.5 (NR)	7.9	7.9
2	Colour	Hazen	5(25)	2	2
3	Conductivity	µS/cm	$	51600	51800
4	TDS	mg/l	500(2000)	33540	33670
5	DO	mg/l	$	5.5	5.6
6	BOD	mg/l	$	<3	<3
7	COD	mg/l	$	<5	<5
8	Total Hardness as $CaCO_3$	mg/l	300(600)	7013	7059
9	Total Alkalinity as $CaCO_3$	mg/l	200(600)	145.0	150.0
10	Calcium as Ca	mg/l	75(200)	690.0	700.0
11	Magnesium as Mg	mg/l	30(100)	1285.0	1290.0
12	Chlorides as Cl	mg/l	250(1000)	17359.0	17458.0
13	Residual free Chlorine	mg/l	0.2 Min	<0.2	<0.2
14	Phosphates as PO_4	mg/l	$	0.1	0.1
15	Sulphates as SO_4	mg/l	200(400)	0.1	650.0
16	Fluorides as F	mg/l	1.0(1.5)	620.0	2.0
17	Nitrates as NO_3	mg/l	45(NR)	2.0	3.5
18	Sodium as Na	mg/l	$	3.0	8524.0
19	Potassium as K	mg/l	$	8500.0	350.0
20	Total Boron as B	mg/l	1	0.04	0.05
21	Cyanides	mg/l	0.05 (NR)	<0.02	<0.02
22	Phenolic Compounds	mg/l	0.001(0.002)	<0.001	<0.001
23	Oil and Grease	mg/l	$	<1	<1
24	Cadmium as Cd	mg/l	0.01 (NR)	<0.01	<0.01
25	Arsenic as As	mg/l	0.01 (NR)	<0.01	<0.01
26	Copper as Cu	mg/l	0.05 (1.5)	<0.01	<0.01
27	Lead as Pb	mg/l	0.05 (NR)	<0.01	<0.01
28	Iron as Fe	mg/l	0.3(1.0)	0.03	0.03
29	Chromium as Cr^{+6}	mg/l	0.05(NR)	<0.05	<0.05
30	Selenium as Se	mg/l	0.01(NR)	<0.01	<0.01
31	Zinc as Zn	mg/l	5(15)	<0.01	<0.01
32	Aluminum as Al	mg/l	0.03(0.2)	<0.01	<0.01
33	Mercury as Hg	mg/l	0.001(NR)	<0.001	<0.001
34	SAR	-	$	44.17	44.15
35	Pesticides	mg/l	Absent	Absent	Absent
36	Anionic Detergents	mg/l	0.2 (1.0)	Absent	Absent
37	Total Coliforms	MPN/100	10	<2	<2

Note: Values in paranthesis are 'Permissible limit in the absence of Alternate source'. NR: No relaxation, $: *Limits not specified, UO: Un-Objectionable,* Agr-Agreeable

IS: 10500 (the standard prescribes the requirements for the essential and desirable characteristics required to be tested for ascertaining the suitability of water for drinking purpose).

1.7.4 Observations

Ground Water Quality

- The analysis results indicate that the pH ranges in between 7.3 to 7.6, which is well within the specified standard of 6.5 to 8.5. The minimum pH of 7.3 was observed at GW3 and the maximum pH of 7.6 was observed at GW4.
- Total hardness was observed to be ranging from 39 to 640 mg/l. The minimum hardness (39 mg/l) was recorded at GW3 and the maximum (640 mg/l) was recorded at GW4.
- Chlorides were found to be in the range of 10.2 mg/l to 235.0 mg/l, the minimum concentration of chlorides (10.2 mg/l) was observed at GW3, whereas the maximum value of 235.0 mg/l was observed at GW2.
- Sulphates were found to be in the range of 6.1 mg/l to 120.0 mg/l. The minimum value observed at GW3 (6.1 mg/l) whereas the maximum value observed at GW4 (120.0 mg/l).
- The Total Dissolved Solids (TDS) concentrations were found to be ranging in between 65 to 1080 mg/l, the minimum TDS observed at GW3 (65 mg/l) and maximum concentration of TDS observed at GW2 (1080 mg/l).
- Iron is found in between 0.02 mg/l to 0.06 mg/l and Zinc found <0.01 mg/l.
- The ground water quality in the study area does indicate slightly sea water characteristics influence.

Surface Water Quality

- The analysis results indicate that the pH values were found 7.9, for both the station.
- DO was observed to be in the range of 5.5 to 5.6 mg/l. The TDS was observed in the range of 33540 mg/l to 33670 mg/l, the minimum TDS value was observed at SW1, and where as maximum value was observed at SW2.
- The chlorides and Sulphates were found to be in the range of 17359.0 to 17458.0 mg/l and 620.0 to 650.0 mg/l, respectively.
- Total hardness expressed as $CaCO_3$ ranges between 7013 to 7059 mg/l. The concentration of nitrate fluctuates between 3.0 to 3.5 mg/l.
- The calcium & magnesium were found to be in the range of 690.0 to 700.0 mg/l and 1285.0 to 1290.0 mg/l, respectively. Iron values are found 0.03 mg/l and zinc is found <0.01 mg/l.

1.8 Noise Level Survey

The physical description of sound concerns its loudness as a function of frequency. Noise in general is sound which is composed of many frequency components of various loudness distributed over the audible frequency range. Various noise scales have been introduced to describe, in a single number, the response of an average human to a complex sound made up of various frequencies at different loudness levels. The most common and universally accepted scale is the A weighted Scale which is measured as dB (A). This is more suitable for audible range of 20 Hz to 20,000 Hz. The scale has been designed to weigh various components of noise according to the response of a human ear.

The impact of noise sources on surrounding community depends on:

- Characteristics of noise sources (instantaneous, intermittent or continuous in nature). It can be observed that steady noise is not as annoying as one which is continuously varying in loudness;
- The time of day at which noise occurs, for example high noise levels at night in residential areas are not acceptable because of sleep disturbance; and
- The location of the noise source, with respect to noise sensitive land use, which determines the loudness and period of exposure.

The environmental impact of noise can have several effects varying from Noise Induced Hearing Loss (NIHL) to annoyance depending on loudness of noise. The environmental impact assessment of noise due to construction activity, and vehicular traffic can be undertaken by taking into consideration various factors like potential damage to hearing, physiological responses, annoyance and general community responses. Noise monitoring has been undertaken for 24-hr duration at each location.

1.8.1 Identification of Sampling Locations

A preliminary reconnaissance survey has been undertaken to identify the major noise generating sources in the area. Noise at different noise generating sources has been identified based on the activities in the village area, ambient noise due to industries and traffic and the noise at sensitive areas like hospitals and schools. The noise monitoring has been conducted for determination of noise levels at eight locations in the study area. The environmental settings of each noise monitoring location is given in **Table-1.8.1** and depicted in **Figure-1.8.1**.

1.8.2 Method of Monitoring

Sound Pressure Level (SPL) measurements were measured at all locations; one reading for every hour was taken for 24 hours. The day noise levels have been monitored during 6 am to 10 pm and night levels during 10 pm to 6 am at all the monitoring locations within the study area.

TABLE-1.8.1
DETAILS OF NOISE MONITORING LOCATIONS

Location Code	Location (Village)	Distance w.r.t Project Site (km)	Direction w.r.t Project Site	Zone
N1	Near-Plant site	--	--	Residential
N2	Thiruporur	4.7	NW	Residential
N3	Aalathur	5.0	SW	Residential
N4	Pudunellikuppam	1.9	SSW	Residential
N5	Thiruvidanthai	6.9	NNE	Residential
N6	Kelambakkam	9.2	NNW	Commercial
N7	Nemmeli	1.2	NW	Residential
N8	Thandalam	3.2	W	Residential

1.8.3 Parameters Measured During Monitoring

For noise levels measured over a given period of time interval, it is possible to describe important features of noise using statistical quantities. This is calculated using the percent of the time certain noise levels are exceeding the time interval. The notation for the statistical quantities of noise levels are described below:

- L_{10} is the noise level exceeded 10 per cent of the time;
- L_{50} is the noise level exceeded 50 per cent of the time ; and
- L_{90} is the noise level exceeded 90 per cent of the time.

Equivalent Sound Pressure Level (L_{eq}):

The Leq is the equivalent continuous sound level which is equivalent to the same sound energy as the actual fluctuating sound measured in the same period. This is necessary because sound from noise source often fluctuates widely during a given period of time.

This is calculated from the following equation:

$$L_{eq} = L_{50} + \frac{(L_{10} - L_{90})^2}{60}$$

L_{day} is defined as the equivalent noise level measured over a period of time during day (6 am to 10 pm).

L_{night} is defined as the equivalent noise level measured over a period of time during night (10 pm to 6 am).

A noise rating developed by Environmental protection Agency (EPA) for specification of community noise from all the sources is the Day-Night Sound Level, (L_{dn}).

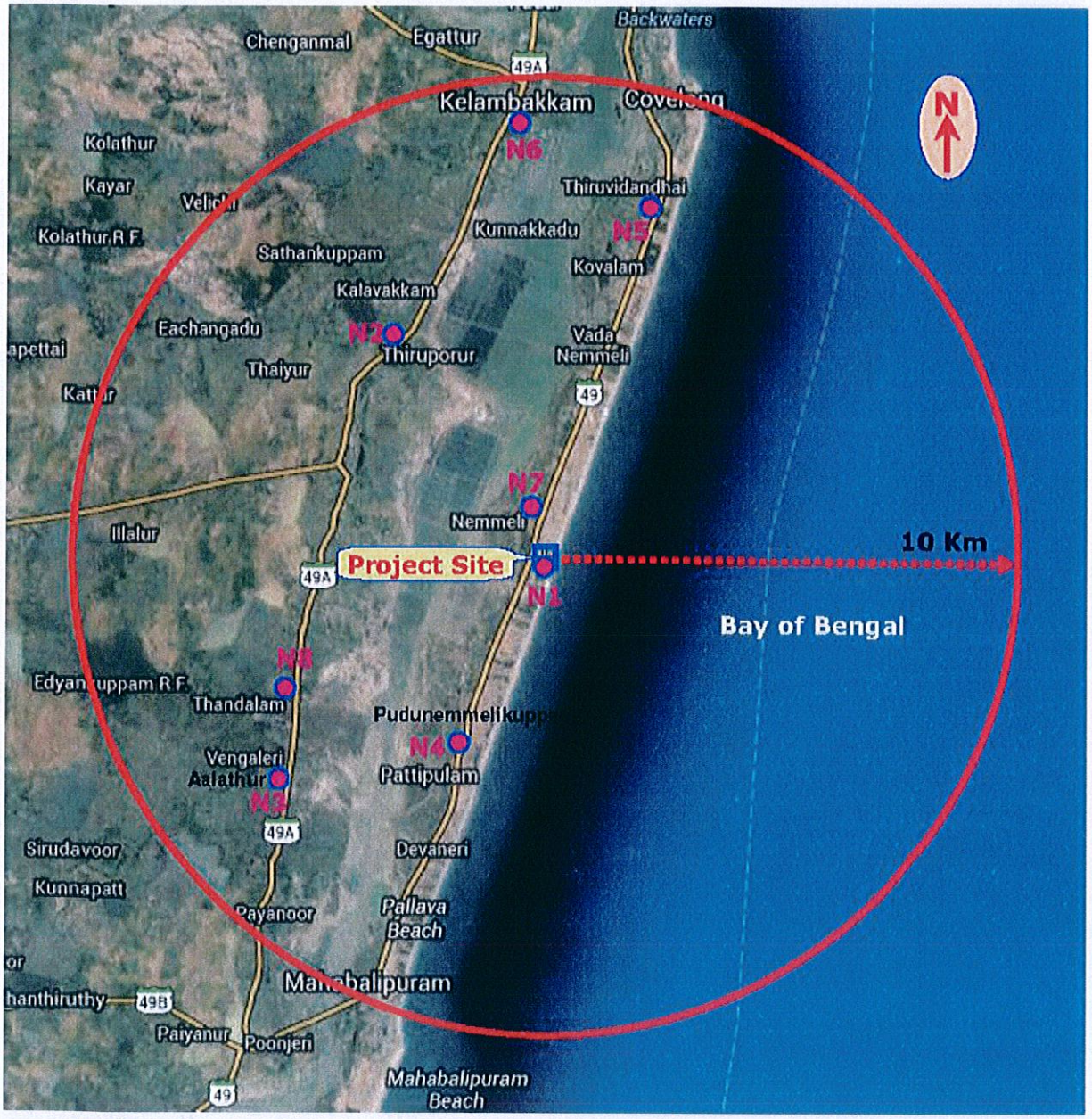


FIGURE-1.8.1
NOISE MONITORING LOCATIONS

Day-Night Sound Level (L_{dn}):

The noise rating developed for community noise from all sources is the Day-Night Sound Level (L_{dn}). It is similar to a 24 hr equivalent sound level except that during night time period (10 pm to 6 am) a 10 dB (A) weighting penalty is added to the instantaneous sound level before computing the 24 hr average.

This night time penalty is added to account for the fact that noise during night when people usually sleep is judged as more annoying than the same noise during the day time.
The L_{dn} for a given location in a community may be calculated from the hourly L_{eq}'s, by the following equation.

$$L_{dn} = 10 \log \{1/24[16(10^{Ld/10}) + 8\,(10^{(Ln+10)/10})]\}$$

Where L_d is the equivalent sound level during the daytime (6 am to 10 pm) and L_n is the equivalent sound level during the nighttime (10 pm to 6 am).

1.8.4 Presentation of Results

The statistical analysis is done for measured noise levels at eight locations for once during study period. The parameters are analyzed for L_{day}, L_{night}, and L_{dn}. These results are tabulated in **Table-1.8.2.**

TABLE-1.8.2
NOISE LEVELS IN THE STUDY AREA

Code	Location	L_{10}	L_{50}	L_{90}	L_{eq}	L_{day}	L_{night}	L_{dn}
N1	Near-Plant site (R)	44.3	40.4	36.7	41.4	42.2	38.6	45.7
N2	Thiruporur (C)	47.7	43.8	40.1	44.8	45.6	42.0	49.1
N3	Aalathur (R)	45.8	41.9	38.2	42.9	43.7	40.1	47.2
N4	Pudunellikuppam (R)	45.1	41.2	37.5	42.2	43.0	39.4	46.5
N5	Thiruvidanthai (R)	46.2	42.3	38.6	43.3	44.1	40.5	47.6
N6	Kelambakkam (C)	48.3	44.4	40.7	45.4	46.2	42.6	49.7
N7	Nemmeli (R)	45.5	41.6	37.9	42.6	43.4	39.8	46.9
N8	Thandalam (R)	44.9	41.0	37.3	42.0	42.8	39.2	46.3

Note: *R- Residential, C- Commercial*

a) Daytime Noise Levels (L_{day})

The daytime noise levels at all the locations are observed to be within the prescribed limits for various zones. The minimum noise level is observed 42.2 dBA at Near-Plant site (N1) and maximum noise level observed 46.2 dB (A) at Kelambakkam (N6).

It is observed that the day time noise levels are in broadly in accordance to the prescribed limit of 55 dB (A) for rural / residential areas and 65 dB (A) for commercial zones.

b) Night time Noise Levels (L_{night})

The night time noise levels at all the locations were found to be within the prescribed limits for various zones. The maximum noise level observed 44.7 dB (A) at Vayor village (N6).

It is observed that the night time noise levels are in broadly in accordance to the prescribed limit of 45 dB (A) for rural / residential areas and 55 dB (A) for commercial zones.

1.9 Flora and Fauna

1.9.1 Introduction

Ecological evaluation aims at developing and applying methodologies to assess the relevance of an area for nature conservation. As such, it is to support the assessment of the impact of a proposed development by providing guidance on how to describe the ecological features within the area affected, how to value them, and how to predict the value losses caused by the development. The evaluation of the ecological significance of an area can be undertaken from different perspectives and consequently with different objectives. One of such perspectives focuses on the conservation of the biological diversity or biodiversity. Among the human activities that pose the highest threat to the conservation of biodiversity are the developmental projects in particular. Such projects represent artificial elements that cut through the landscape and interfere with the natural habitat and its conditions by emissions that may be solid, liquid and or gaseous. This in turn influences the abundance and distribution of plant and animal species, i.e., the biodiversity of the areas impacted.

Most of the data are usually already existing and obtainable from the governmental agencies or the scientific literature. This information is typically complemented by field visit, site surveys and sample collection. The description of the actual ecological assessment provided by the ecological baseline study serves to set a reference for the subsequent impact analysis. Moreover, it helps decision-makers and EIA reviewers to become familiar with the environmental features and the needs of the study area.

1.9.2 Objectives

The present study was undertaken with the following objectives to assess both terrestrial and aquatic habitats of the study area:

- To assess the nature and distribution of vegetation in and around the existing project site.
- To assess the fauna in the study area.
- To understand the ecology of the water bodies.
- To identify and quantify the ethno botanical importance of the plant species.
- To ascertain the migratory routes of fauna, presence of breeding grounds and sensitive habitats in the study area, if any.
- To assess the presence of protected areas in the study area.

- To review the information from secondary sources and discuss the issues of concern with the relevant authority and stakeholders.
- Impact prediction based on primary and secondary data sources to formulate mitigation measures.

1.9.3 Methodology

To achieve the above objectives a detailed study of the area was undertaken with the existing plant as its centre. The different methods adopted were as follows:

- Generation of primary data by undertaking systematic ecological studies in the study area;
- Primary data collection for flora through random sampling method for trees, shrubs and herbs from the selected locations to know the vegetation cover qualitatively.
- Faunal studies by taking transect in the study area to spot the fauna and also to know the fauna through secondary indictors such as pugmarks, scats, fecal pallets, calls and other signs.
- For ecological information, the secondary sources such as local officials, villagers and other stakeholders were interviewed.
- Sourcing secondary data with respect to the study area from published literature.

The locations for terrestrial and aquatic ecological studies are shown in **Figure 1.9.1** and the details are given in **Table 1.9.1.**

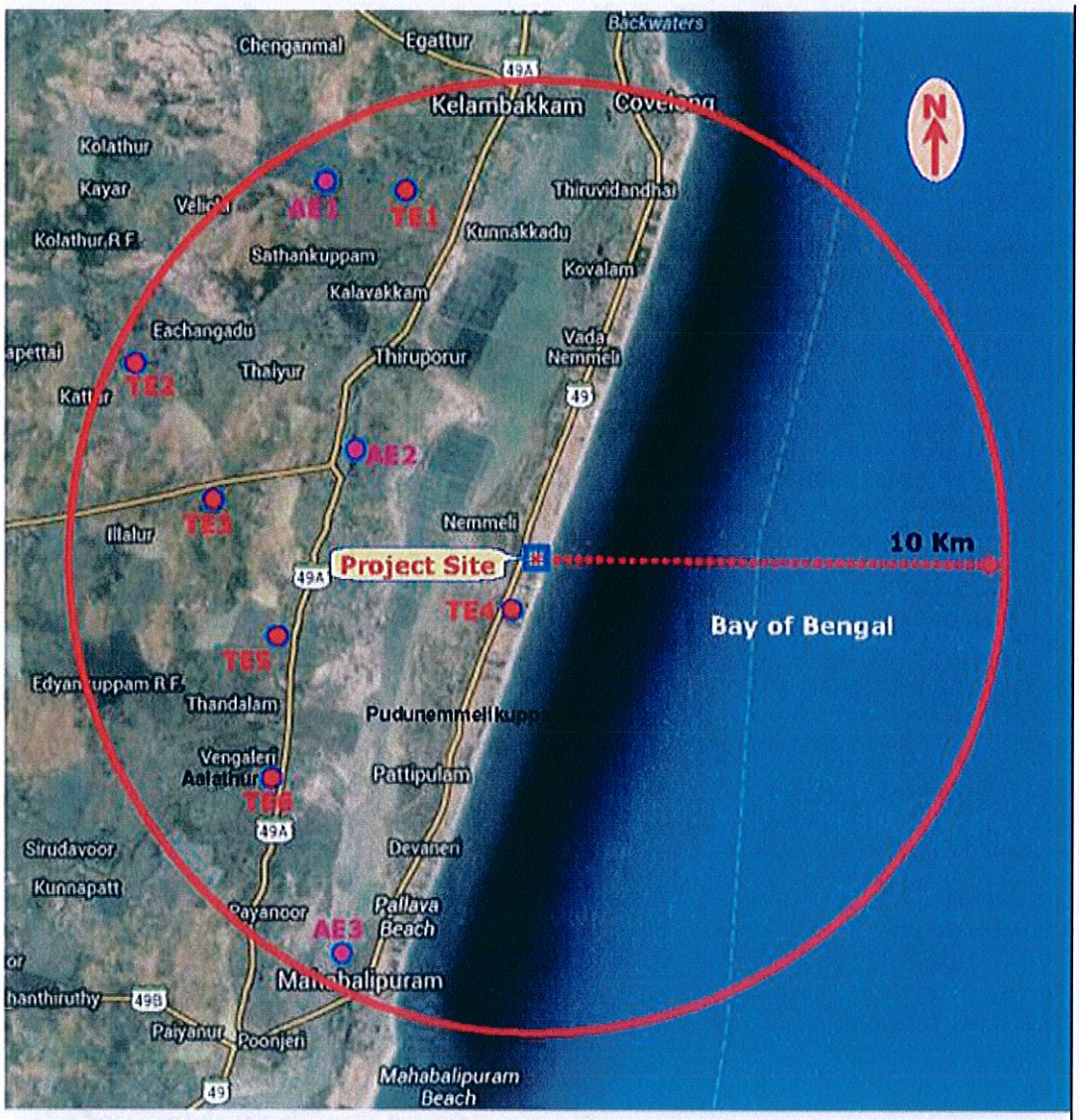


FIGURE-1.9.1
ECOLOGICAL SAMPLING LOCATIONS

TABLE-1.9.1
DETAILS OF SAMPLING LOCATIONS

Code	Location	Distance w.r.t. Project Site (km)	Direction w.r.t. Project Site
Terrestrial			
TE1	Near OMR (North)	8.2	NNW
TE2	Near Kattur	9.5	NW
TE3	Near Illalur	7.0	WNW
TE4	Near Pattipullam	1.2	SSW
TE5	Near OMR (South)	5.8	WSW
TE6	Near Vengaleri	7.3	SW
Aquatic			
AE1	Near Pudupakkam	9.1	NNW
AE2	Kandhaswamy Temple Tank	4.5	NW
AE3	Near Mahabalipuram	9.2	SSW

1.9.4 Type of Habitats in the Study Area

The study area falls in the southern east coast of the subcontinent which receives considerable rainfall in the monsoon. Being a coastal region and intrusion of marine water on the landwards side, the habitat is dominated by backwaters and salt pans. The eastern half of the study area (10km radius) falls under marine subtidal region, coastal habitats comprising of beaches, marshes and estuaries. Towards the west of the coast (landward side) the habitat is mainly represented by dense *Casurina* plantations on the coast and salt pans intermixed with backwaters.

The area in general is well developed with good road network, infrastructure along with many beach resorts and places of interest for tourism and pilgrimage. The two main roads which connect the villages in the region to the major towns and the capital city are East Coast Road (ECR) and Old Mahabalipuram Road (OMR). The other habitats in the study area are mostly represented by pasture lands, grazing lands, agriculture lands, farms and plantations. There are reserve forests (RFs) in the study area which have secondary mixed dry deciduous forest. The study area also has many ephemeral water bodies and manmade water bodies. There are no large rivers flowing through the study region. The land between the ECR and OMR has marine water intrusion (about 50%) hence most of the area is being used as salt pans. The list of reserve forest are given in **Table-1.9.2.**

1.9.5 Terrestrial Flora

The study area is located near the capital city and there are two major roads crossing through the study area which connect Chennai with a major tourist destination that is Mahabalipuram. Owing to this the buffer zone of the study area has very less natural forests remaining which are catagorised as Reserve Forests. Most of the vegetation is in the form of plantation along the bunds of agricultural lands, grazing lands and road side vegetation. The coastal areas in the buffer zone have been planted with *Casurina* which acts as shoreline protection.

There is very little natural vegetation within the study area. The RFs in the buffer zone have low dense mixed scrub forest. The RFs have a well grown under storey

with many shrubs and grasses. Few areas have bamboo and other areas are dominated by *Prosopis juliflora* on uncultivable waste land. *Azadirachta indica* and *Borassus flabelliform* have better adaptability among naturally growing species. The villages in study area have sometimes cashew tree & coconut plantation. Plantation of fruit trees & decorative plants like Guava, Papaya, Banana, China rose, Coconut etc. are seen. Paddy is the main crop but pulses, sugarcane & groundnut are also grown is this area. Many locally available plants are used in traditional medicine. The area along the coast and two major roads have been occupied by many commercial establishments which consist of resorts and hotels. These establishments have maintained and developed good vegetation and green belt which comprise of trees with canopy and ornamental and flowering shrubs.

Significant amount of area in the buffer zone is maintained as grassland which acts as fodder source for cattle **(Figure 1.9.2).** The plantations along the roads are mostly of *Eucaliptus, Azadiracta indica, Casurina* and *Cassia sp.* Many patchy areas have exclusive plantations of *Eucaliptus, Azadirachta indica, Casurina, Cocos nucifera, Tectona grandis* and Palm. Some of the areas have developed dense vegetation of *Prosopis juliflora*. Trees like *Lepisanthes tetraphylla, Buchanania axillaris, Santalum album* and *Manilkara hexandra*, once known to be common are now found only in the protected forests of the region. *Ziziphus xylopyrus, Acacia planifrons, Atalantia monophylla, Canthium parviflorum, Catunaregam spinosa, Scutia myrtina, Benkara malabarica* and *Ziziphus oenoplia* have now started to dominate amongst the vegetation. High anthropogenic pressure, browsing and lopping are the presumable reasons for the occurrence of more number of these thorny species. The genera with high occurrence include *Cassia*, *Crotalaria*, *Erogrostis, Phyllanthus* and *Hedyotis*.

The area shows many algae, fungi, bryophytes and ferns. Algae are present in aquatic bodies and in marshy places. Fungi, particularly from ascomycetes and basidiomycetes are located either on ground or epiphytically. Lichens of crustose, foliose and fruticose types are present on different substrates. Bryophytes occur in wet areas and occasionally on barks of trees and old walls of houses and other structures.

1.9.6 Terrestrial Fauna

No wild lives of Schedule 1 are found in the core zone. The terrestrial fauna consist mostly of avifauna and there are no major animals of conservation importance. Jungle cat, Rhesus macaque, Indian fox etc. are found amongst mammals. The mammals occasionally observed such as Jackal and rodents which stray from the nearby RFs.

The avifauna recorded during the field survey are; Cattle Egret, Pond Heron, Grey Heron, Pale Harrier, Common Babblers, Leaf Warblers, White Throated Kingfisher, Black Drongo, Red Whiskered Bulbul, Indian Roller and House Crow etc. The area is also known to harbour species of Storks, Ibis, Stilt, Plovers, Jacanas along with other wader.

As the region has good rainfall, many common species of herpetofauna occur in the region along with many arthropods. Due to presence of many lentic and lotic water bodies interspersed with small hillocks with rocky habitats the area shows a good representation of reptiles and amphibians viz; Common Indian toad

(*Duttaphrynus melanostictus*), Common tree frog (*Polypedates maculates*), Indian skipper frog (*Euphlyctis cyanophlyctis*), Indian flapshell turtle (*Lissemys punctata*), Southern house gecko (*Hemidactylus frenatus*), Common garden lizard (*Calotes versicolor*), Common skink (*Eutropis macularia*), Indian rat snake (*Ptyas mucosus*), Common bronzeback (*Dendrelaphis tristis*), Bengal monitor (*Varanus bengalensis*).

TABLE-1.9.2
DETAILS OF RESERVE FOREST IN THE STUDY AREA

Sr.No.	Forests	Distance (Km)	Direction
1	Talayur RF	7.6	NW
2	Illalur RF	5.2	NW
3	Madayattur RF	5.7	WNW
4	Kattur RF	8.9	WNW
5	Alattur RF	4.4	W
6	Kulattur RF	10	NW
7	Kayar RF	11.6	NW
8	Sirukunram RF	14.8	WNW
9	Sonallur RF	12.6	NNW
10	Mambakkam RF	14.4	NW

1.9.7 Aquatic Biodiversity

The buffer zone has many freshwater bodies which are mostly ephemeral. There is a canal crossing across the study area which runs parallel to the coast covering large stretch of land from Chennai to Pondicherry. Many water bodies in the study area have submerged and floating hydrophytes such as lotus and water lily (*Nelumbo* sp.), *Ipomea aquatic* and *Hydrilla* sp..

The micro-algae represented by Chlorophyceae and Bacillariophyceae that include *Pediastrum* sp, *Actinastrum* sp, *Synedra* sp, *Navicula* sp, *Pinnularia* sp., *Nitzschia* sp. and *Cymbella* sp., *Chlorella vulgaris, Dunaliella tertiolecta, Tetraselmis suecica.*

The freshwater zooplanktons were significantly represented by Cladocerans, Rotifers, Copepods, Sarcodines and Euglinids. The community composition included *Keratella* sp., *Diaptomus* sp., *Pseudodioptomus* sp., *Branchionus* sp., *Diaphanosoma* sp., *Macrothrix* sp. along with Amoeba and Euglina.

Freshwater benthic fauna was represented by larval and sub adult stages of terrestrial and aquatic arthropods along with molluscs and crustaceans such as aquatic gastropods, crabs other decapods and Oligochaetes. The arthropods were represented by Ephemeroptera, Diptera, Trichoptera, Coleoptera, Odonata and Hemiptera.

Freshwater fishes found in the study area are mostly the result of traditional fishery practices, modern aquacultures and exploitation of fish resources. The species which usually occur are introduced in the region for commercial and economic growth. The species may have sporadic and seasonal occurrence depending on the availability of water in the water bodies across the seasons. The species include *Cirrhina mrigala, Hypophthalmichthys molitrix, Ctenophyaryngodon idella, Cyprinus carpio, Labeo rohita, Catla catla,*

Heteropneustes fossilis, Rita rita, Mystus pseudutropius, Ompok sp., Clarias sp., Wallago sp.

1.9.8 Conclusions

The baseline survey reveals that the study area harbours biodiversity which is mostly aggregated in the reserve forests and plantations and near the water bodies. There are no schedule-I species as per the Wildlife (Protection) Act 1972. There are no Wildlife Sanctuaries, National Parks, Tiger Reserves or Biosphere Reserves in the study area. There are no corridors and routes of migratory fauna. The study core zone of the study area has no flora and fauna and does not involve any tree cutting. The buffer zone has few reserve forests which have secondary grown forest and shows signs of heavy anthropogenic pressure that has resulted in stunted growth, dominance of weeds and more thorny species of shrubs and trees.

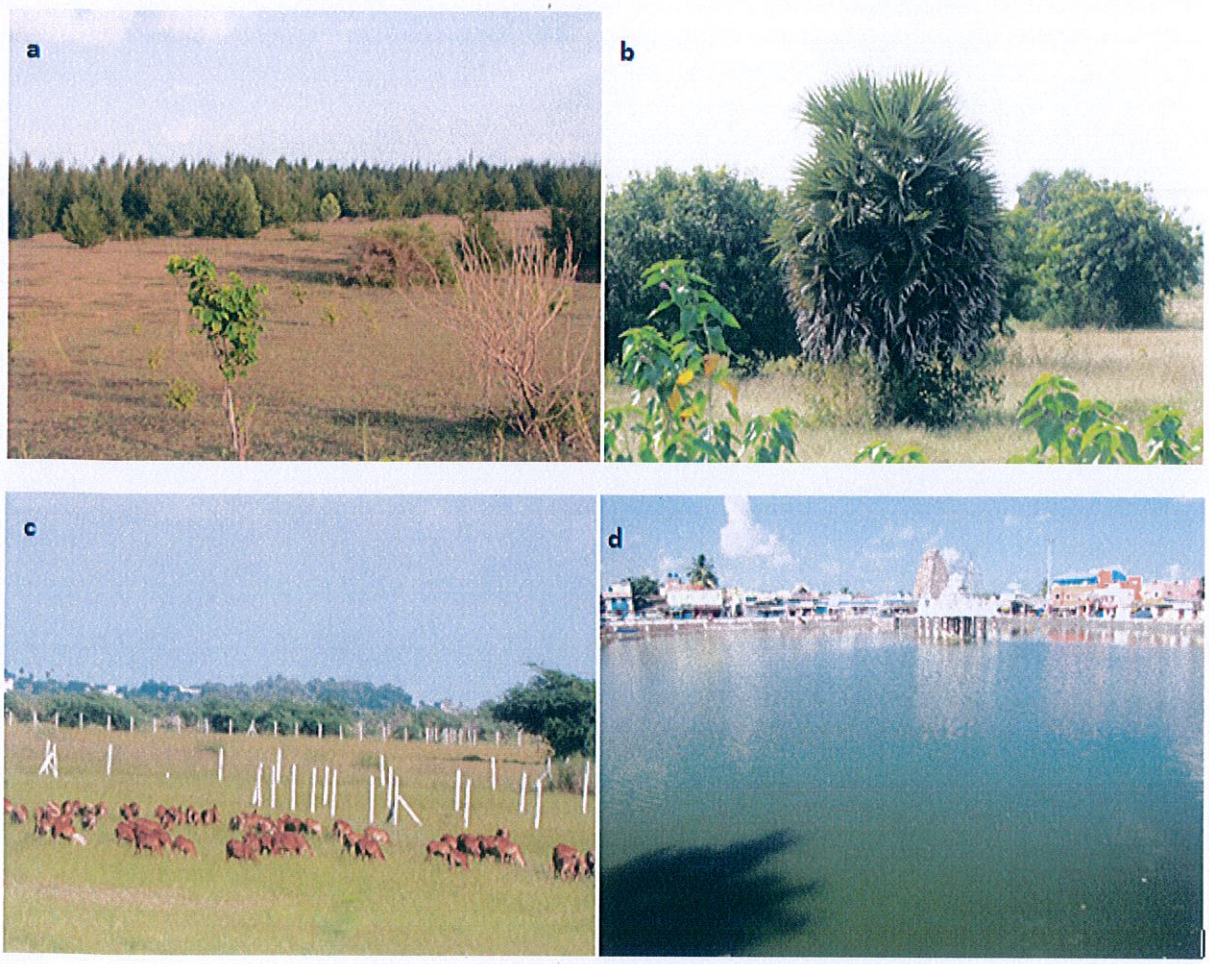


FIGURE 1.9.2
(A) CASURINA PLANTATION NEAR THE COAST
(B) PALM IN THE CULTIVATED GRASSLANDS
(C) CATTLE GRAZING IN THE GRASSLANDS AND
(D) KANDHASWAMY TEMPLE TANK

1.10 Demography and Socio-Economics

In this section, the prevailing socio-economic aspects of people in the study area around the proposed project boundary, which would form the basis for making planning efforts for the socio-economic development of people of the study area, have been described.

1.10.1 Methodology Adopted for the Study

The methodology adopted for the study mainly includes review of latest published secondary data (District Census Statistical Handbooks-2011 and Primary Census Abstract of Census-2011) with respect to population, Social structure, literacy levels and occupational structure available for 10-km radius study area.

1.10.2 Review of Demographic and Socio-Economic Profile-2011

The village wise demographic data for the census year 2011 is given in **Annexure-IX**. The salient features of the demographic and socio-economic details are described in the following sections.

1.10.3 Demography

Almost all villages in the study area are experiencing a rapid growth of population, which may be due to the process of industrialization.

Distribution of Population

As per 2011 census the study area consisted of 73245 souls inhabited in study area. The distribution of population in the study area is shown in **Table-1.10.1.**

TABLE-1.10.1
DISTRIBUTION OF POPULATION

Particulars	0-3 km	3-7 km	7-10 km	0-10 km
No. of Households	1009	9190	7762	17961
Male Population	1974	18994	16031	36999
Female Population	1848	18470	15928	36246
Total Population	3822	37464	31959	73245
Male Population (0-6 years)	250	2179	1871	4300
Female Population (0-6 years)	226	2178	1831	4235
Total Population (0-6 years)	476	4357	3702	8535
Average Household Size	3.79	4.08	4.12	4.08
% of males to the total population	51.65	50.70	50.16	50.51
% of females to the total population	48.35	49.30	49.84	49.49
Sex Ratio (no of females per 1000 males)	936	972	994	980
Density	336	717	557	605

Source: District Census Hand Book -2011

Average Household Size

The study area has a family size of 4.08 as per 2011 census.

Population Density

The density of population reveals that the study area has an overall density of 605 persons per km2 (PP km2) as per 2011 census reports.

Sex Ratio

The configuration of male and female indicates that the males constitute to about 50.51% and females to 49.49% of the total population as per 2011 census records. The sex ratio i.e. the number of females per 1000 males indirectly reveals certain sociological aspects in relation with female births, infant mortality among female children and single person family structure, a resultant of migration of industrial workers. The study area on an average has 980 females per 1000 males as per 2011 census reports.

1.10.4 Social Structure

In the study area, as per 2011 census, 34.19 % of the population belongs to Scheduled Castes (SC) and 1.04 % to Scheduled Tribes (ST). The distribution of population by social structure is shown in **Table-1.10.2.**

TABLE-1.10.2
DISTRIBUTION OF POPULATION BY SOCIAL STRUCTURE

Particulars	0-3 km	3-7 km	7-10 km	0-10 km
Schedule caste	203	14864	9973	25040
% To the total population	5.31	39.68	31.21	34.19
Schedule Tribes	124	398	240	762
% To the total population	3.24	1.06	0.75	1.04
Total SC and ST population	327	15262	10213	25802
% To total population	8.56	40.74	31.96	35.23
Total population	3822	37464	31959	73245

Source: District Census Hand Book -2011

1.10.5 Literacy Levels

The study area experiences a literacy rate of 72.65 % (2011). The distribution of literate and literacy rate in the study area is given in **Table-1.10.3.**

TABLE-1.10.3

DISTRIBUTION OF LITERATE AND LITERACY RATES

Particulars	0-3 km	3-7 km	7-10 km	0-10 km
Male Population	1974	18994	16031	36999
Female Population	1848	18470	15928	36246
Total Population	3822	37464	31959	73245
Male Population (0-6 years)	250	2179	1871	4300
Female Population (0-6 years)	226	2178	1831	4235
Total Population (0-6 years)	476	4357	3702	8535
Male literates	1546	15125	12489	29160
Female literates	1206	12357	10487	24050
Total literates	2752	27482	22976	53210
Male literacy rate (%)	56.18	55.04	54.36	54.80
Female literacy rate (%)	43.82	44.96	45.64	45.20
Average Male Literacy to the total population (%)	40.45	40.37	39.08	39.81
Average female Literacy to the total population (%)	31.55	32.98	32.81	32.84
Total Literacy rate (%)	72.00	73.36	71.89	72.65

Source: District Census Hand Book -2011

The male literacy i.e. the percentage of literate males to the total males of the study area works out to be 54.80 %. The female literacy rate, which is an important indicator for social change, is observed to be 45.20 % in the study area as per 2011 census records.

1.10.6 Occupational Structure

The occupational structure of residents in the study area is studied with reference to main workers, marginal workers and non-workers. The main workers include 10 categories of workers defined by the Census Department consisting of cultivators, agricultural laborers, those engaged in live-stock, forestry, fishing, mining and quarrying; manufacturing, processing and repairs in household industry; and other than household industry, construction, trade and commerce, transport and communication and other services.

The marginal workers are those workers engaged in some work for a period of less than six months during the reference year prior to the census survey. The non-workers include those engaged in unpaid household duties, students, retired persons, dependents, beggars, vagrants etc.; institutional inmates or all other non-workers who do not fall under the above categories.

As per 2011 census records altogether the main workers works out to be 30.51% of the total population. The marginal workers and non-workers constitute to 8.32 % and 61.17 % of the total population respectively. The distribution of workers by occupation indicates that the non-workers are the predominant population. The occupational structure of the study area is shown in **Table-1.10.4.**

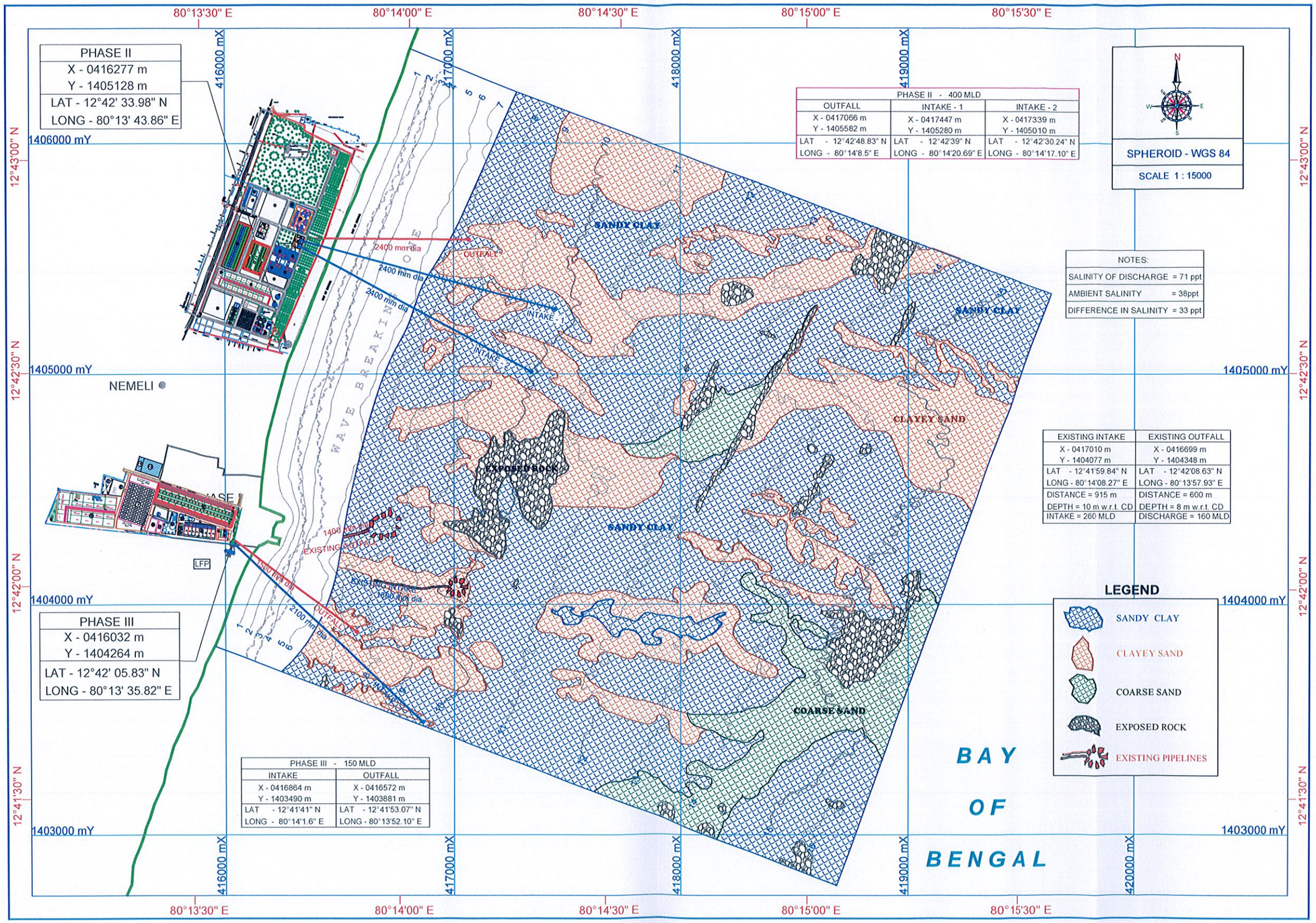
TABLE-1.10.4
OCCUPATIONAL STRUCTURE

Particulars	0-3 km	3-7 km	7-10 km	0-10 km
Total Population	3822	37464	31959	73245
Total workers	1402	14378	12660	28440
Work participation rate (%)	36.68	38.38	39.61	38.83
Total main workers	1319	10588	10440	22347
% of main workers to total population	34.51	28.26	32.67	30.51
Marginal workers	83	3790	2220	6093
% of marginal workers to total population	2.17	10.12	6.95	8.32
Non-workers	2420	23086	19299	44805
% of non-workers to total population	63.32	61.62	60.39	61.17

Source: District Census Hand Book-2011

Annexure-VII

Marine Facilities



DETAILS OF INTAKES & OUTFALLS

REV NO.	DATE	DETAILS	BY	CHKD.	APPD.	PROJ. MGR
0	29.10.14	FOR APPROVAL	M.K.C.	A.R.	P.G.	U.K.

CONSULTANT: AECOM
AECOM INDIA Private Limited

CLIENT:
Chennai Metro Water Supply and Sewerage Board

PROJECT TITLE:- CONSULTANCY TO CONDUCTING PREFEASIBILITY STUDIES,PREPARATION OF DETAILED PROJECT REPORT, BID DOCUMENTS, EVALUATION OF BIDS (BID PROCESSING) FOR SETTING UP OF A 150 MLD CAPACITY SEA WATER REVERSE OSMOSIS DESALINATION PLANT FOR CHENNAI CITY AT NEMMELI ALONG ECR ROAD, CHENNAI, TAMILNADU, INDIA

DRAWING TITLE:- DETAILS OF INTAKES AND OUTFALLS

SCALE:- AS SHOWN

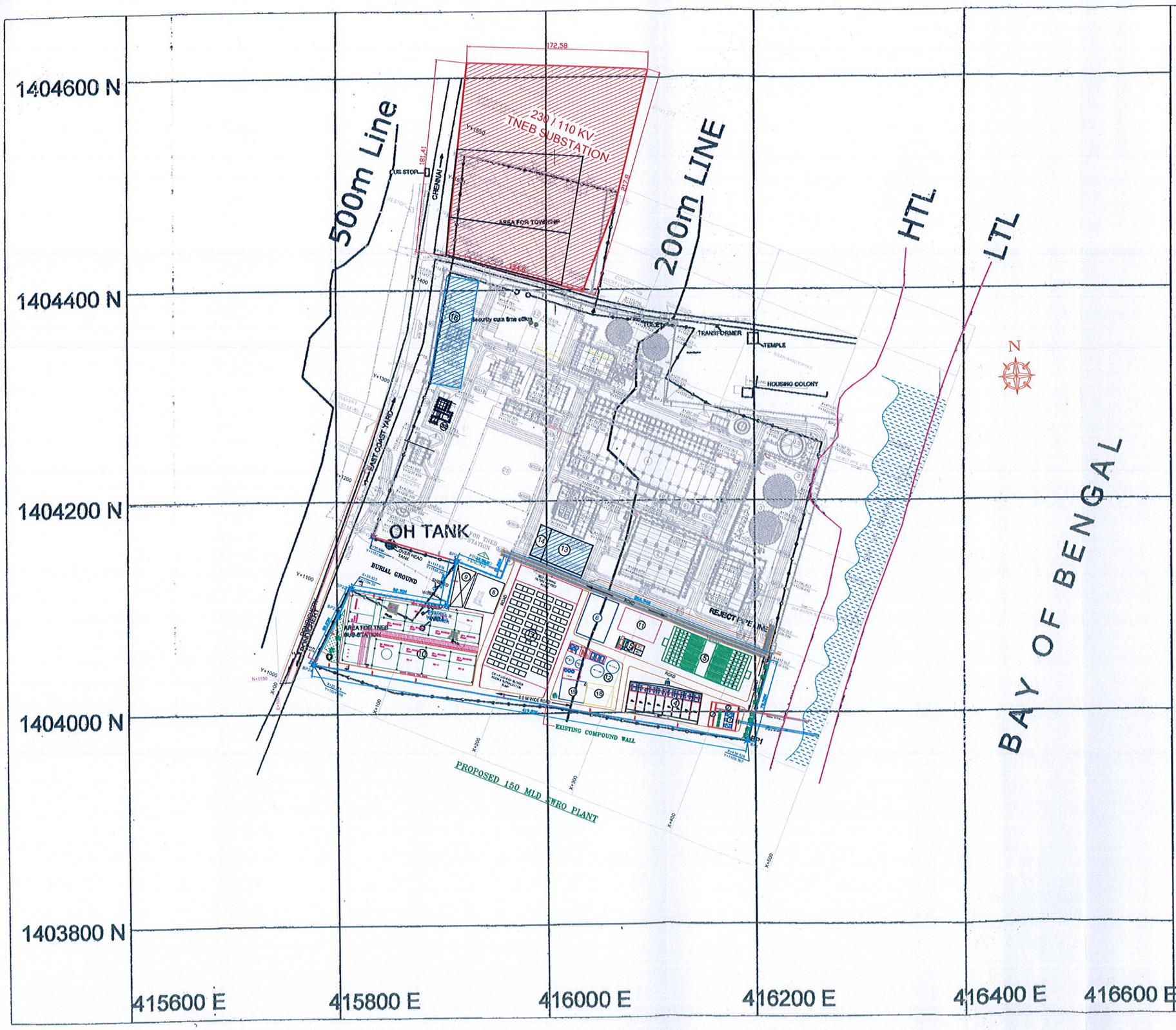
DWG. NO. CMW/SWRO/IND/001

SIZE A1

SHEET 1

Annexure-VIII

HTL /LTL Line Demarcation by Anna University



CRZ Details :

CRZ-I : LTL TO HTL
: LTL
: HTL
CRZ-III : HTL TO 500M
: 200M
: 500M
: PLANT BOUNDARY
: PLANT DETAILS
: ROAD

Geodetic Details :

Spheroid : Everest 1830
Grid Projection : TRANSVERSE MERCATER

Legend:
General
UTM Grid Intersection

Benchmark Details :

Remark	Position		Heights in m w.r.t. MSL of	Location
	Latitude	Longitude		
BENCH MARK RCL	13°18'54" N	80°20'34" E	4.885	CHNL SITE, KATTUPALLI

TIDAL INFORMATION :

Height above Chart Datum

Place	Position		MHWS in Mtrs	MHWN in Mtrs	MLWN in Mtrs	MLWS in Mtrs	MSL in Mtrs
	Latitude	Longitude					
CHENNAI	13° 06 N	80° 18 E	1.15	0.84	-0.43	-0.14	0.65

Survey Period : 26-09-2007 to 27-05-2007

SCALE 1 : 5000

NATIONAL INSTITUTE OF OCEANOGRAPHY
(COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH)
REGIONAL CENTRE,
NO.176, LAWSONS BAY COLONY,
VISAKHAPATNAM - 530017
PHONE : (0891) 2539180
E-MAIL : sircrv@nio.org
URL : http://www.nio.org

CONSULTANT :
INDOMER COASTAL HYDRAULICS (P) LTD.

CLIENT :
CHENNAI METROPOLITION
WATER SUPPLY & SEWERAGE BOARD (CMWSSB)

PROJECT TITLE :
DELINEATION OF LTL, HTL AND CRZ BOUNDARIES NEAR NEMMELI VILLAGE

FIG : 4 - 24

Checked by	Approved by

Annexure-IX

Risk Assessment and Disaster Management Plan

1.0 RISK ASSESSMENT AND DISASTER MANAGEMENT PLAN

1.1 Introduction

Risk involves the occurrence or potential occurrence of some accident consisting of an event or sequence of events resulting into fire, explosion or toxic hazards to human health and environment. Conceptual framework of any quantitative risk analysis is shown in **Figure-1.1.**

Risk Assessment (RA) provides a numerical measure of the risk that a particular facility poses to the public. It begins with the identification of probable potential hazardous events at an industry and categorization as per the predetermined criteria. The consequences of major credible events are calculated for different combinations of weather conditions to simulate worst possible scenario.

1.1.1. Objectives of the Risk Assessment Study

- Identification of vulnerable units with resources to hazard indices
- Generation of release scenarios for escape of Toxic chemicals from facilities
- Estimation of damage distances for the accidental release based on different scenarios
- Suggestion of risk mitigation measures for based on consequence analysis
- Approach to Disaster Management Plan

1.1.2 Scope of Work

The scope of the present chapter is to carry out risk assessment for the following items:

- Storage of chemicals in the Mild Steel Tanks

Standard industry practices of risk assessment are considered in the project. Maximum Credible Accident analysis is carried out to arrive at the hazard distance for the worst case scenario. The consequences of all the scenarios are computed and hazard distances are worked out and listed for flammable materials and possible explosion effects.

1.2 Maximum Credible Accident (MCA) Analysis

MCA stands for Maximum Credible Accident or in other words, an accident with maximum damage distance, which is believed to be probable. MCA analysis does not include quantification of the probability of occurrence of an accident. In practice, the selection of accident scenarios for MCA analysis is carried out on the basis of engineering judgement and past accident analysis.

Risk involves the potential occurrence of some accident consisting of an event or sequence of events. Accidental release of oil and/or gas to the atmosphere from well or processing equipment is studied by visualising scenarios on the basis of their properties and the impacts are computed in terms of damage distances. A disastrous situation is the outcome of fire or explosion of the released gas in

addition to other natural causes, which eventually leads to loss of life, damage to property and/or ecological imbalance.

Depending on the effective hazardous attributes and their impacts, the maximum effect to the surroundings could be assessed.

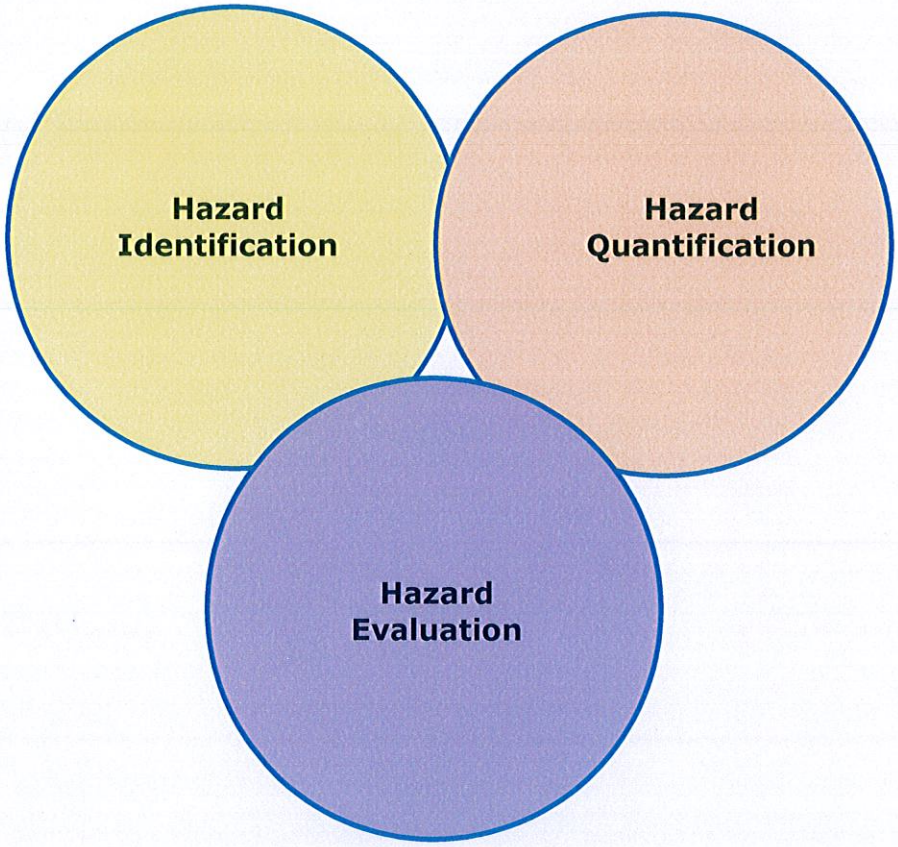


FIGURE-1.1
CONCEPTUAL ACTIVITIES: HAZARD STUDY AND RISK ANALYSIS

MCA analysis encompasses defined techniques to identify the hazards and compute the consequent effects in terms of damage distances due to heat radiation, toxic releases, vapour cloud explosion etc. A list of probable or potential accidents of the major units in the industries arising due to use, storage and handling of the hazardous materials is examined to establish their credibility. Depending upon the effective hazardous attributes and their impact on the event, the maximum effect on the surrounding environment and the respective damage caused can be assessed. **Figure-1.2** depicts the flowchart for MCA analysis.

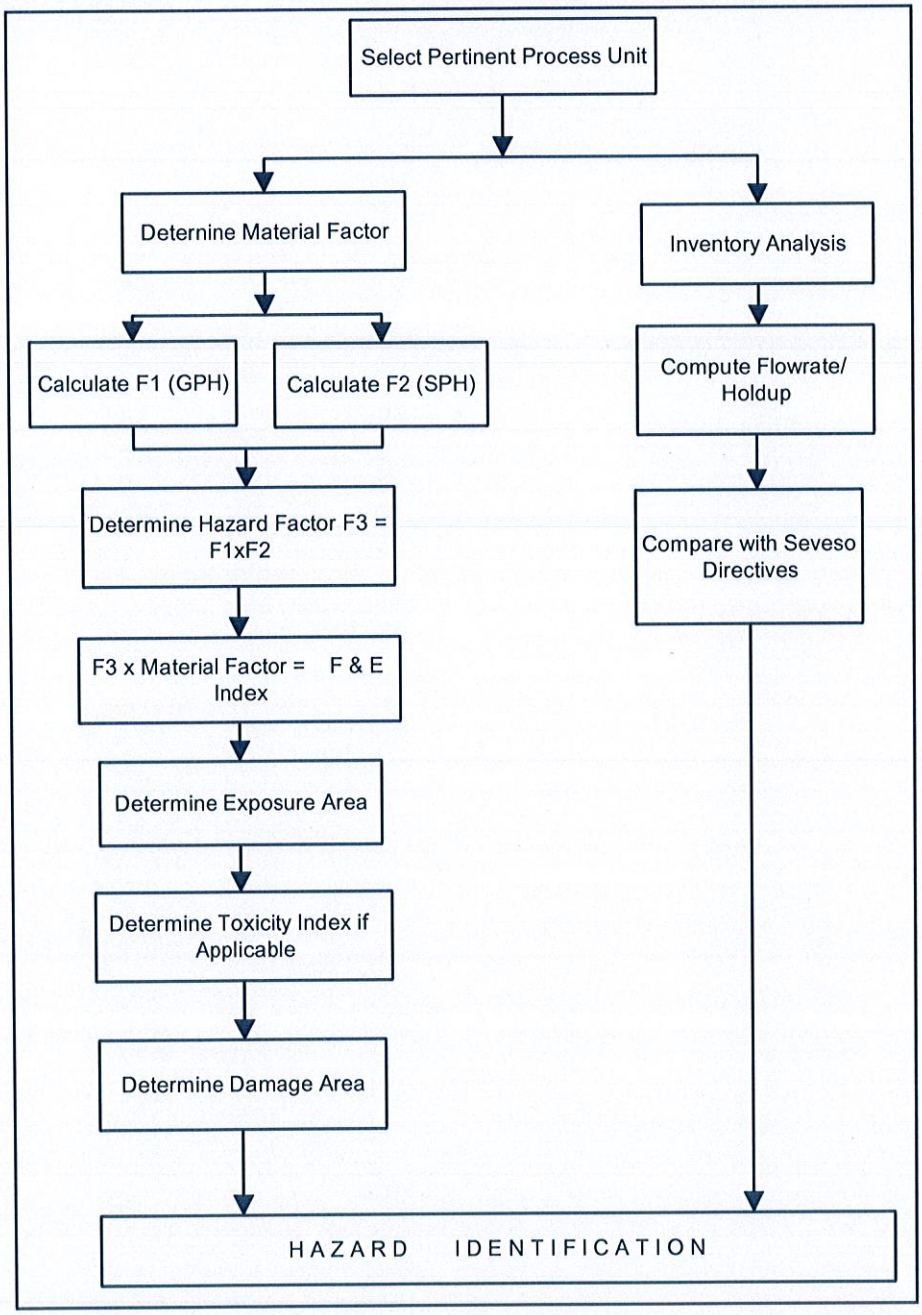


FIGURE-1.2
FLOWCHART FOR MAXIMUM CREDIBLE ACCIDENT ANALYSIS

The proposed hazardous chemical storage details are given in **Table-1.1**

TABLE-1.1 (A)
DETAILS OF FLAMMABLE, EXPLOSIVE AND HAZARDOUS MATERIALS

Sr.No	Materials	Hazardous Properties	Type of Storage	Storages Proposed
1	Chlorine	Toxic	Tanks	900 Kg
2	Ammonia	Toxic	Tanks	---
3	Sulphuric Acid	Toxic	Tanks	---
4	Phosphoric acid	Toxic	Tanks	---
5	Sodium Hydroxide	Toxic	Tanks	---

TABLE-1.1 (B)
APPLICABILITY OF GoI RULES TO CHEMICAL STORAGE

Sr. No	Materials	Listed in Schedule	Threshold Quantity for Application Of Rules (tonnes)	
			5,7,9,13-15	10-12
1	Chlorine	3 (Group 2)	10	25
2	Ammonia	3 (Group 2)	50	500
3	Sulphuric Acid	1 (part 2)	--	--
4	Phosphoric acid	1 (part 2)	--	--
5	Sodium Hydroxide	1 (part 2)	--	--

1.2.1 Methodology

The MCA analysis involves ordering and ranking of various sections in terms of potential vulnerability. The input requirements for MCA analysis are:

- Operating manual
- Flow diagram
- Detailed design parameters
- Physical & chemical properties of all the chemicals
- Detailed plant layout
- Detailed area layout
- Past accident data.

The following steps are involved in MCA analysis:

- Identification of potential hazardous process units, storage sections and representative failure cases from the vessels and pipelines
- Visualization of chemical release scenarios
- Consequence Analysis for computation of damage distances for the release cases through mathematical modeling.

1.2.2 Hazard Identification

Identification of hazards is an important step in Risk Assessment as it leads to the generation of accidental scenarios. The merits of including the hazard for further investigation are subsequently determined by its significance, normally using a cut-off or threshold quantity.

Once a hazard has been identified, it is necessary to evaluate it in terms of the risk it presents to the employees and the neighbouring community. In principle, both probability and consequences should be considered, but there are occasions where it either the probability or the consequence can shown to be sufficiently low or sufficiently high, decisions can be made on just one factor.

During the hazard identification component, the following considerations are taken into account.

- Chemical identities
- Location of facilities that use, produce, process, transport or store hazardous materials.
- The types and design of containers, vessels or pipelines
- The quantity of material that could be involved in an airborne release and

The nature of the hazards are (e.g. airborne toxic vapours or mists, fire, explosion, large quantities stored or processed handling conditions) most likely to accompany hazardous materials spills or releases.

1.2.2.1 Fire and Explosion Index (FEI)

Fire and Explosion Index (FEI) is useful in identification of areas in which the potential risk reaches a certain level. It estimates the global risk associated with a process unit and classifies the units according to their general level of risk. FEI covers aspects related to the intrinsic hazard of materials, the quantities handled and operating conditions. This factor gives index value for the area which could be affected by an accident, the damage to property within the area and the working days lost due to accidents. The method for evaluation of FEI involves following stages:

- Selection of pertinent process unit which can have serious impact on plant safety

- Determination of Material Factor (MF): This factor for a given substance in the process unit gives intrinsic potential to release energy in case of fire or an explosion. Material Factor can be directly obtained from Dow's Fire and Explosion Index Hazard classification Guide of American Institute of Chemical Engineers, New York. The factor can also be evaluated from NFPA indices of danger, health, flammability and reactivity.

- Determination of Unit Hazard Factor: The Unit Hazard Factor is obtained by multiplication of General Process Hazard (GPH) factor and Special Process Hazard (SPH) factor. GPH factor is computed according to presence of exothermic reactions and loading and unloading operations. The penalties due to each of these reactions / operations are summed up to compute GPH factor. Similarly, SPH factor can be evaluated for the operations close to flammable range or pressures different from atmospheric. Penalties of these operations for both factors can be obtained from Dow's EFI index form.

Fire and explosion index is then calculated as the product of Material Factor (MF) and Unit Hazard Factor. Degree of hazards based on FEI is given in the **Table-1.2.**

TABLE-1.2
DEGREE OF HAZARDS BASED ON FEI

FEI Range	Degree of Hazard
0 – 60	Light
61-96	Moderate
97 - 127	Intermediate
128 - 158	Heavy
159 and Above	Severe

1.2.2.2 Toxicity Index (TI)

The TI value is computed from Maximum Allowable Concentration (MAC), General Process Hazard and Special Process Hazard by use of DOW's hazard classification guide. The scale for TI is given in the **Table-1.3.**

TABLE-1.3
DEGREE OF HAZARDS BASED ON TI

TI Range	Degree of Hazard
0 – 6	Light
6 - 10	Moderate
Above 10	High

Based on the category of hazard and preventive and protective system present in the installation, recommendations are made. FEI and TI of various storage tanks are depicted in **Table 1.4** and **Table 1.5** respectively.

TABLE 1.4
FIRE AND EXPLOSION INDEX FOR STORAGE TANKS

Sr. No.	Unit Name	FEI	Category
1	Chlorine	4.50	Light
2	Ammonia	20.73	Light

TABLE 1.5
TOXICITY INDEX FOR STORAGE TANK

Sr. No.	Unit Name	TI	Category
1	Chlorine	22.0	High
2	Ammonia	19.4	High

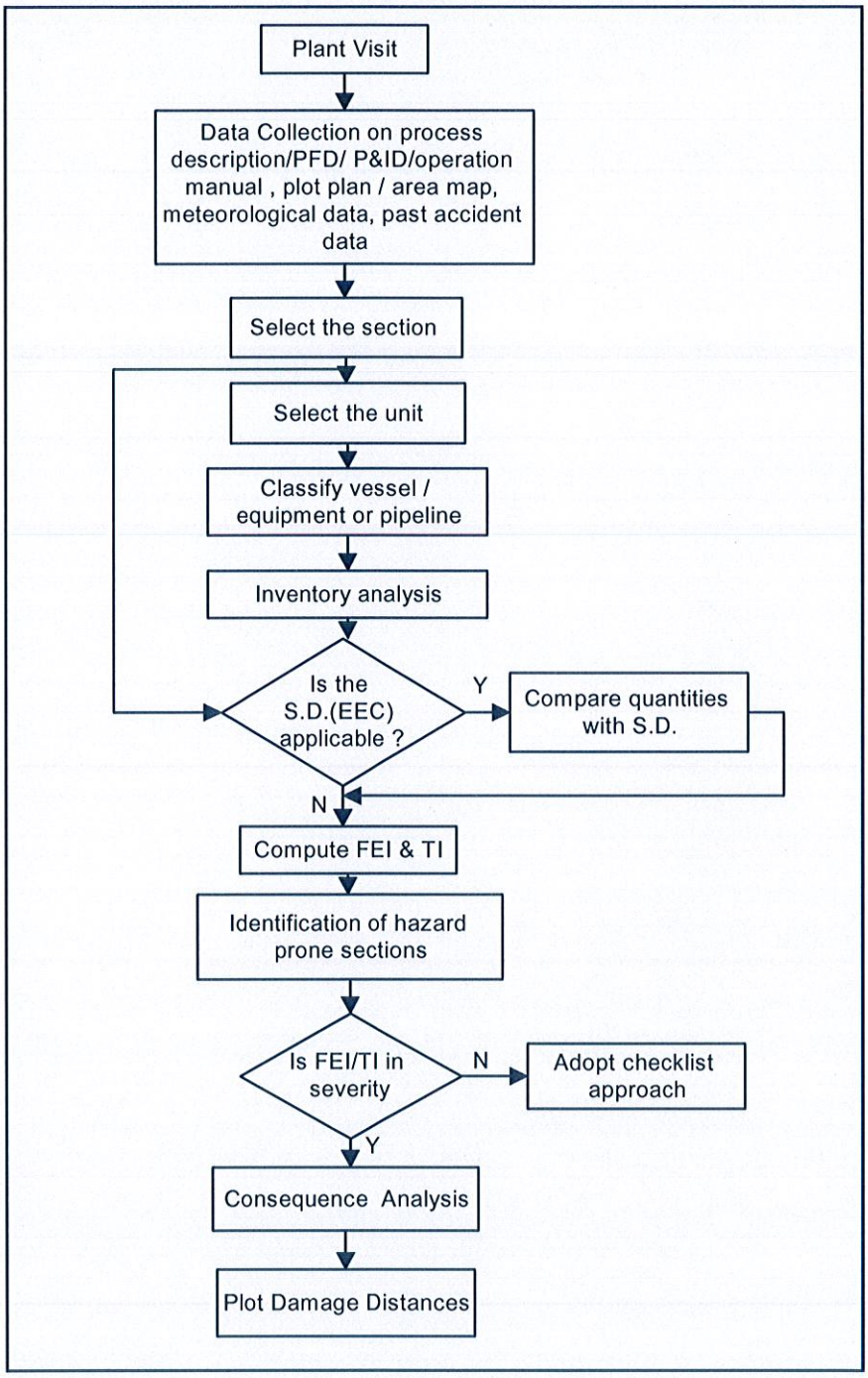


FIGURE-1.3
STEPS IN HAZARD IDENFICATION

1.2.3 Consequence Analysis

Hazardous substance, on release can cause damage on a large scale. The extent of the damage is dependent upon the nature of the release and the physical state of the material. In the present report the consequences for toxic hazards are considered and the damages caused due to such releases are assessed with recourse to MCA analysis. **Figure-1.3** shows a scenario for the accidental release of chemicals.

The accidental release of toxic substances would lead to dispersion of gas cloud in the prevailing wind direction. The extent of damage depends upon the nature of the release. It is important to visualize the consequence of the release of such substances and the damage caused to the surrounding areas.

An insight into physical effects resulting from the release of hazardous substances can be had by means of various models. Vulnerability models can also be used to translate the physical effects occurring in terms of injuries and damage to exposed population and buildings. **Table-1.6** depicts the input data required for consequence analysis.

TABLE 1.6
INPUT DATA FOR CONSEQUENCE ANALYSIS

Parameter	Case
Ambient Temperature	32°C
Atmospheric stability	D & F
Relative humidity	80%
Wind speed	2 m/s, 3 m/s & 5 m/s

Stability class D and F shows the stable and neutral conditions of the climate. Generally in the daytime, neutral condition i.e. Little Sun & High Wind causes high turbulence in the climate. And in the nighttime, stable condition i.e. with moderate cloud exists which is nothing but a calm environmental condition. As per risk point of view, out of these two conditions one is extreme calm and one is extreme worst. Dispersion point of view, both can highly affect the extent of vulnerability of probable incident. In India, the average speeds at these two conditions are assumed to be 2, 3 and 5 m/s.

Factors Influencing the Use of Physical Effect Models

In order to calculate the physical effects of the accidental release of hazardous substance, following steps must be carried out in succession:

- Determining the form in which the hazardous substance occurs e.g. gas, gas condensed to liquid or as a liquid in equilibrium with vapour
- Determination of the way in which the release takes place; for example intermittent or a continuous release
- Determination of the outflow volume (as a function of time) of the gas, vapour or liquid
- Dispersion of the released gas or vapour which has formed into the atmosphere.
- In evaluating the dispersion of releases, Pasquill-Giffard atmospheric stability classes (A to F) and relevant ranges of wind speeds are used (**Table 1.7**).

TABLE 1.7
PASQUILL – GIFFARD ATMOSPHERIC STABILITY

Sr. No.	Stability Class	Weather Conditions
1	A	Very unstable – sunny, light wind
2	A/B	Unstable - as with A only less sunny or more windy
3	B	Unstable - as with A/B only less sunny or more windy
4	B/C	Moderately unstable – moderate sunny and moderate wind
5	C	Moderately unstable – very windy / sunny or overcast / light wind
6	C/D	Moderate unstable – moderate sun and high wind
7	D	Neutral – little sun and high wind or overcast / windy night
8	E	Moderately stable – less overcast and less windy night than day
9	F	Stable – night with moderate clouds and light / moderate wind
10	G	Very stable – possibly fog

The model is based on a point source. In practice, however, a point source will never exist; for example, a surface sources in the case of pools. To enable the source dimensions to be included in the calculation in the dispersion models in spite of this, an imaginary (virtual) point source is assumed, which is put back in such a way that the cloud area calculated according to the model has the source dimensions at the site of the actual source. In calculations based on a continuous source, the duration of the source is also included in the calculation. Some conditions for this calculation model are as follows:

- There must be some wind at the site
- The model applies only to open terrain; allowance is made, however, for the roughness of the terrain. The influence of trees, houses, etc. on the dispersion can be determined by means of the roughness length.

(Ref: Risk Analysis and Reduction in the Chemical Process Industry", J.M. Santamaria Ramiro and P. A. Brana Aisa, Blackie Academic and Professional Publications)

Model for Gas Dispersion

The gas will disperse into the atmosphere following an accident and if the gas has a higher density than air, it will tend to spread in a radial direction because of gravity. This results in a gas cloud of particular diameter at a particular height. As a result of this, in contrast to a neutral gas, the gas released may spread against the wind direction.

Injuries Caused by Intoxication

In the event of people being exposed to toxic gases, the relationship between the damage and the toxic dose is established by a probit function, in the following form

$$Pr = a + b \ln (C^n t)$$

Where,

a = constant depending on the type of injury and toxic substance
b = constant depending on toxic substance
c = concentration of toxic substance in mg/m^3
t = exposure time in minutes
n = constant depending on toxic substance.

The Basic Preventive and Protective Features are given below. These are to be considered based on the damage distances computed through MCA analysis.

Basic preventive and protective features below should be provided regardless of the type of operation. When these protective features are not provided, the existing hazard exposure may be greater than the radius of exposure computed through consequence analysis.

- Adequate water supplies for fire protection. The amount/quantity of the water requirement is based on rate of firewater required for the worst possible fire and the time duration for which the fire will last
- Structural design of vessels, piping, structural steel, etc.
- Overpressure relief devices
- Corrosion resistance and/or allowances
- Segregation of reactive materials in pipelines and equipment
- Electrical equipment grounding
- Safe location of auxiliary electrical gear (transformers, breakers, etc.)
- Normal protection against utility loss (alternate electrical feeder, spare instrument, air compressor, etc.)
- Compliance with various applicable codes (ASME, ASTM, ANSI, Building Codes, Fire Codes, etc.).
- Fail-safe instrumentation
- Drainage to handle probable spills safely plus fire fighting water hose nozzle sprinkler and/or chemicals
- Insulation of hot surfaces that heat to within 80% of the auto-ignition temperature of any flammable material in the area
- Adherence to the National Electrical Code. The Code should be followed except where variances have been requested/approved
- Hazard area analysis followed by appropriate intrinsically safe electrical equipment wherever required
- Limitation of glass devices and expansion joints in flammable or hazardous service. Such devices are not permitted unless absolutely essential. Where used, they must be registered and approved by the production manager and installed in accordance with appropriate standards and specifications
- Provisions of accessible battery limit block valves.

1.2.4 Injuries to Human Population

Vulnerability Models

Vulnerability models are used in order to determine how people are injured by exposure to, for example toxic load. Such models are designed on the basis of animal experiments or on the basis of the analysis of injuries resulting from accidents, which have occurred. Vulnerability models often make use of a probit function. In a probit function a link is made between the load, the percentage of people exposed to a particular type of injury. The probit function is represented as follows:

$$Pr = k1 + k2 \, Ln \, (V)$$

In which

Pr = probit the measure of the percentage of people exposed to a particular injury
k1 = a constant depending on the type of injury and type of load
k2 = a constant depending on the type of load
V = load

The response percentage is plotted on the left and the probit linearly on the right; the S-shaped curve belongs to the left-hand axis and the straight line to the right-hand axis.

In the following sections vulnerability models are given for heat radiation and the inhalation of toxic substances making use of probit functions.

1.2.5 Results and Discussions-

Release of Chlorine due to Leakage in the Storage Tank- Toxic Release

The scenario was visualized for release of Cl_2 due to 10mm leak at a rate of 85 kg/min from the Cl_2 tank. The damage distances were computed for Immediate Danger to Life or Health (IDLH) at 10 ppm concentration as 1.3 km for weather conditions C/D. The damage distances computed for IDLH concentration due to catastrophic rupture of the Cl_2 tank are depicted in **Table-1.8**. Damage Contours for Toxic Release Scenario due to Catastrophic Rupture of Chlorine Tank are depicted in **Figure-1.4**.

TABLE 1.8
CONSEQUENCE ANALYSIS

Unit Name	Chemical	Scenario (mm)	Source rate (kg/min.)	Weather	Distance till IDLH	
					PPM	KM
Chlorine Tank	Chlorine	10	85	C/D	10	1.3
					5	1.9
					2.5	2.7

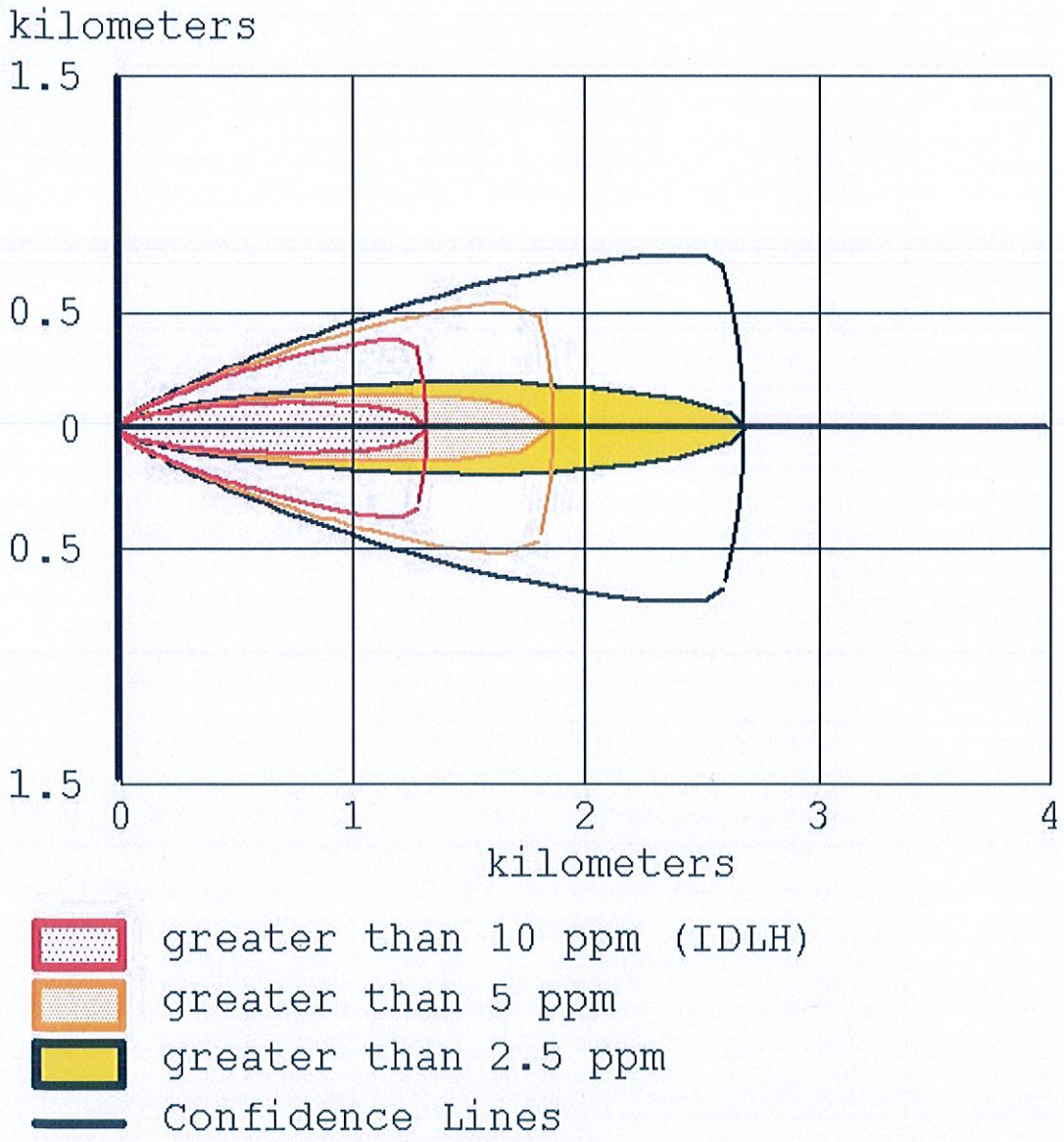


FIGURE-1.4
THREAT ZONE DUE TO 10 MM LEAK OF CHLORINE TANK

1.3 Risk Mitigation Measures

The scope of this Risk Assessment (RA) report covers risk mitigation measures based on Maximum Credible Accident (MCA) analysis. The Fire & Explosion and Toxicity Indices were computed for the identification and screening of vulnerable sections & consequences analysis was carried out for the accidental release

scenarios of hazardous chemicals. The overall objective is to compute the extent of damage distance in the event of accidental releases of hazardous chemicals. The following section presents the conclusion of RA Study of risk mitigation measures.

1.3.1 General Recommendations

Storage Vessels

- Fire is one of the major hazards, which can result from storage tanks. Fire prevention and code enforcement is one of the major areas of responsibility for the fire service. Hence the facility should be equipped with:
    - Water supply
    - Fire hydrant system
    - Foam system
    - Water fog and sprinkler system
    - Mobile Fire fighting equipment
    - First aid appliances (Fire Extinguishers)
- Proper dyke area should be provided for the storage of chemicals. In the event of a fire, the fire in the dyke area should be addressed first so as to minimize the heat input to the tank
- Surrounding population (includes all strata of society) should be made aware of the safety precautions to be taken in the event of any mishap within the plant. This can effectively be done by conducting the training programs
- Buildings possibly subjected to external blast waves should be made of reinforced concrete. The windows should be made of blast resistant glass with strong frame
- Structures possibly subjected to internal explosion should have a strong frame structure supporting roof and intermediate floors. If a solid wall is needed, use low weight wall panels to facilitate early explosion venting
- Safety escape routes should be provided at strategic locations and should be easily accessible
- Grating and vent panels should be provided to minimize Domino Effects
- Critical switches and alarm should be always kept in line
- Fire extinguishers should be tested periodically and should be always kept in operational mode
- Zebra marking to be made to identify the location of Fire Extinguishers easily.
- Smoke detectors should be installed near those units which handle large amount of explosive material and operate under high temperature and pressure
- Leakage sensor to be installed with alarm
- A wind direction pointer should also be installed at storage site, so that in an emergency the wind direction can be directly seen and downwind population cautioned
- Shut off and isolation valves should be easily approachable in emergencies.

Storage tanks should be designed, fabricated, inspected and maintained so that there is no possibility of a tank releasing its contents while it is kept within design conditions. Protective systems of quantified high reliability and availability should be designed to ensure that these physical conditions are maintained. Impurities should be controlled to obviate abnormal corrosion.

These measures should be backed up by relief systems such that the combination of vessel design, protection, quality control and relief eliminates the possibility of complete vessel failure. Storage tanks should be sited, or given protective barriers such that they are fully protected from external damage.

Control Rooms

- Control rooms shall be located at a safe distance from operating areas
- Minimum number of doors shall be provided in the control room while at the same time the number of doors shall be adequate for safe exit
- Halon / Its proven equivalent shall be used for control rooms and computer rooms
- Smoke detectors system shall be provided for control rooms at suitable locations
- To resist fire spread through ducts, dampers shall be installed in ducts
- One hydrant (minimum) for every 45m per wall of the building shall be positioned all around the building.

Fire Protection System, Inspection and Testing

The fire protection equipment shall be kept in good operating condition at all time and fire fighting system should be periodically tested for proper functioning and logged for record and corrective actions.

Training

On job training to the employees on various facets of risk analysis would go a long way in improving their horizon which in turn is expected to reflect in the operation of plant, especially from the safety stand point. In order to combat with emergency situations arising out of accident release of hazardous chemicals, it is necessary for industries to prepare an exhaustive offsite and onsite emergency preparedness plan. Mock-drills to be conducted periodically to train the employees at all levels to combat with emergency situation arising during accident release of hazardous chemicals. Standard Operation Procedure (SOP) should be developed for handling of hazardous chemicals. SOP to be displayed in local language at storage area.

1.3.2 Specific Recommendations

Ammonia Storage

- Cylinders should be stored in a well-ventilated, secure area, protected from the weather. It should be stored upright with valve outlet seals and valve protection caps in place.
- Storage temperature should not exceed 52 °C. Storage should be away from heavily traveled areas and emergency exits. It shouldn't be placed where salt or other corrosive materials are present.
- Full and empty cylinders should be segregated. Valve protection caps and valve outlet seals should remain on cylinders not connected for use.
- The usage should be first-in first-out inventory system to prevent full containers from being stored for long periods of time.

- Visually inspection of stored cylinders should be done on a routine basis, at least weekly, to ensure leakage or other problems.

Hydrochloric Acid Storage

- Hydrochloric acid spill should be flushed away by a large quantity of water. It is not recommended to store hydrochloric acid in any basement area.
- The hydrochloric acid containers must be mechanically strong and corrosion resistant
- The containers must be tightly sealed, and an appropriate head space generally 5% by volume or greater should be left
- Hydrochloric acid is a highly corrosive so the equipment used in handling should be inspected periodically
- Separate dyke area must be provided for the different products. Do not store the different products in the same dyke
- If hydrochloric acid is placed indoors, floor should be coated with asphalt, acid-resistant blocks, or sodium-silicate-treated concrete, because the buildings will be corroded by hydrochloric acid mist.

Sodium Hydroxide Storage

- It should be stored in a tightly closed container and away from incompatible substances. Storage under a nitrogen blanket has been recommended.
- It should be stored in a cool, dry, well-ventilated area away from ignition sources and oxidants, preferably outdoors.
- Shelter should be provided for storage drums in outside from direct sunlight. For indoor storage continuous ventilation should be done.
- Flammable materials should be stored in a separate safety storage cabinet or room. Keep away from heat. Keep away from sources of ignition.

Sulphuric acid Storage

- Storage area should be dry, cool, and well-ventilated away from incompatible substances.
- It should be kept in tightly closed containers which are appropriately labeled. Be ensuring that it should not contact with water.
- Always practice good personal hygiene. Refrain from eating, drinking, or smoking in work areas. Thoroughly wash hands before eating, drinking, or smoking.
- Storage temperature should not exceed 23 °C. It should not be stored near combustible materials, alkaline substances. Keep container closed when not in use.

Pump

The condition of centrifugal pump can be assessed by measurement of vibration and shock pulse levels of antifriction bearings. The frequency of measurement shall depend on the criticality of the equipment. Scheduled Non- Destructive Testing (NDT) should be made available to asses the condition of the equipment

(Non- Destructive Testing). All the following items shall be checked / recorded after the specified period:

After 1000 running hours or 3 months whichever earlier

- Bearing lubricant (for water contamination and sediments)
- Oil ring for performance
- Deflector for looseness
- Constant level oiler for leakage
- Mechanical seal for leakage
- Seal flushing/quenching system (of Mechanical Seal) for clogging and chocking
- Gland for leakage
- Cooling water flow in both the bearing housings
- Condition of bearing by sound and temperature (in running condition)
- Performance of all measuring instruments (Pressure/Temperature gauges and Flow Meters)
- Coupling Guard
- Electric Motor load current
- Axial position indicator (in case of multistage pump)
- Dowel pins (in position or not; wherever provided).

After 4000 running hours or 1 year whichever earlier

- Flushing of bearing with lube oil and refilling of oil to required level, whether carried out or not
- Flushing of cooling water lines and strainers, whether carried out or not (to ensure proper flow of cooling water)
- Foundation, foundation bolts and supports
- Replacement of old packing with new ones and condition of gland follower, lantern ring and sleeves (in case of gland packing)
- Condition of coupling, coupling bolts, nuts, spring washers and their confirmity to uniform size. Change grease in half coupling in case of gear type.

After 8000 hours or 2 years whichever earlier

- Condition of outboard bearing, lock nut and lock washer (in case lock washer found damaged and lock nut loose, shaft axial play shall be checked)
- Following items of Journal bearings:
    - Clearance of I/B and O/B bearings
    - High spot (High Spots shall be scrapped)
    - Condition of thrust bearing, lock nut and lock washer (in case lock washer found damaged and lock nut loose, shaft axial play shall be checked)
- Replace the bearings if necessary
- Pump float (adjust if necessary)
- Oil filter for cleanliness if journal bearings are hydrodynamic
- Condition of mechanical seals (OISD RP 125, "Inspection and Maintenance of Mechanical seals" shall be referred)
- Alignment (Misalignment shall not be more than 0.05 mm)
- Painting of equipment, whether carried out or not.

After 16000 hours or 4 years whichever earlier

- Complete overhauling of the pump shall be carried out
- This shall include part-wise inspection of the pump and all checks specified for 8000 hours.

Pipeline

Inspection during Shutdown

Shutdown inspection of pipelines relates to inspection of the lines when not carrying any product, and valves and other fittings in the network can be taken out. All piping, which cannot be checked on the run, shall be inspected during shutdown. During shutdown inspection, hammer-testing and hydro testing as applicable should be carried out in addition to visual, ultrasonic and radiographic inspections. Pipelines in some of the services like water and steam are prone to pitting corrosion. Neither ultrasonic nor radiographic testing will reveal the actual internal condition of the pipes in such service. In such cases samples shall be cut for thorough internal examination, at scheduled comprehensive inspections. The samples shall be spilt open in two halves and internal surfaces inspected for pitting, grooving, etc. The internally strip lined bends and pipes shall be visually examined for bulging, weld cracking, weld, defects, etc. Thickness of the strip should be measured to find out thinning of the strips.

Inspection for Corrosion, Erosion and Fouling

Piping shall be opened at various locations by removing valves at flanged locations to permit visual inspection. When erratic corrosion or erosion conditions are noted in areas accessible for visual examination, radiographic examination or ultrasonic testing shall be performed to determine thickness. This is applicable to piping, which cannot be inspected during operation. The nature and extent of internal deposits shall be noted. Samples should be collected for chemical analysis.

Inspection of Gasket Faces of Flanges

The gasket faces of flange joints, which have been opened, shall be inspected visually for corrosion and for defects such as scratches, cuts and grooving which might cause leakage. Ring gaskets and joints shall be checked for defects like dents, cuts, pitting and grooving.

Pressure Testing

All installed piping shall be pressure tested prior to commissioning. Piping systems open to atmosphere, such as drains vents and outlet piping for relief valves discharging to atmosphere. These lines shall be examined to determine that all joints are properly made up.

Test Pressure and Procedures

The test pressure and procedure for testing of piping shall be as per ANSI B 31.3 or equivalent. However, the following additional points shall be considered while carrying out testing.

i) All floats shall be removed before filling the system with water
ii) All air present in the system shall be vented while admitting the test fluid
iii) Piping designed for vapour and gas shall be provided with additional temporary supports, if necessary
iv) Valves shall not be subjected to a test pressure in excess of manufacturer's allowable test rating. When permitted, the installed valves shall be kept open
v) Control and relief valves shall be excluded from the test irrespective of their pressure rating
vi) Open ends of piping where blanks cannot be used e.g. pumps, compressors, etc. shall be blinded off by using standard blind flanges of same rating as the piping system being tested
vii) Indicating pressure gauges mounted locally may be tested with the line, provided the test pressure is not in excess of their scale ratings
viii) The test shall be carried out at ambient temperature
ix) All vent valves during filling up as during draining must be fully open.

Inspection Procedures

- Visual inspection shall be made to locate leaks. Particular attention should be given to pipe connections, the packing glands of valves and expansion joints.

Misalignment

The piping shall be inspected for misalignment. The following are some observations, which may indicate misalignment:

- Pipe dislodged from its support so that weight of the pipe is distributed unevenly on the hangers or the saddles
- Deformation of the wall of the vessel in the vicinity of the pipe attachment
- Pipe supports forced out of plumb by expansion or contraction of the piping
- Shifting of base plate or shearing of the foundation bolts of mechanical equipment to which the piping is attached
- Cracks in the connecting flanges or pump casings and turbines to which the piping is attached.

Supports

Pipe supports shall be visually inspected for the following:

- Condition of protective coating or fire proofing, if any. If fire proofing is found defective, sufficient fire proofing should be removed to determine extent of corrosion
- Evidence of corrosion
- Distortion
- General physical damage
- Movement or deterioration of concrete footings
- Condition of foundation bolts
- Free operation of pipe rollers
- Secure attachment of brackets and beams to the supports.

Secure attachment and proper adjustment of pipe hangers, if used. Spring hangers loading shall be checked both cold and hot and the readings obtained

shall be checked against the original cold and hot readings. The movement of spring supports shell be monitored.

- Broken or otherwise defective pipe anchors
- Free operation of pulleys or pivot points of counter balanced piping system.

Vibration

- If vibrations or swaying is observed, inspection shall be made for cracks in welds, particularly at points of restraint such as where piping is attached to equipment and in the vicinity of anchors. Additional supports should be considered for poorly braced small size piping and valves and for main vibrating line to which they are attached

- In case of severe vibration, detailed investigations shall be carried out to determine the source of problems

External Corrosion

- Inspection of piping for external corrosion shall be carried out with special attention

Bulging, Bowing and Sagging

- Line shall be checked for bulging, bowing and sagging in between the supports

Mechanical Damage from External Forces

- Pipes shall be inspected for dents, scratched etc. from external sources

Failure of Paint and Protective Coating

- Conditions of paint and protective coating shall be checked.

Cracks

- Pipelines shall be inspected for cracks. Particular attention should be given to areas near the weld joints.

Insulation

Damage of insulation shall be checked for hot as well as cold lines.

Concrete Lining

- Externally coverts lined piping shall be visually inspected for cracking and dislodging of concrete.

Fire Hydrant Pipe Line

The pipe distribution networks are the essential part of the fire water hydrant system. The optimal designing of the pipe network has a vital part in delivering water at required flow and pressure for fire fighting. A fire water network can be

defined as a set of links interconnected through nodes. In a water distribution network system, the pipes are connected to form a complex loop configuration which is created by using nodes and pipe links. Pipes are links that convey water from one point in the network to another. The node is a junction where two or more pipes combine or a point where water consumption is allocated and defined as demand. Function of these elements (links and nodes) is to lead water from the network source, which is a water reservoir, to the extremes points of the network called hydrant.

The NFPA, OISD and TAC standards requires that the hydraulic design of the pipe distribution network meet the required flow and pressure for a hydrant or a sprinkler system. The network analysis should be done during the design stages of the system and before envisaging any alteration/ modifications of the pipe network.

1.4 Disaster Management Plan

Chemicals occupy an important segment of our economy and are also the source of large benefits to the society. In recent years, there has been a rapid increase in the number, variety and complexity of the chemicals being used in the industry and in our daily life. However, many of these chemicals are toxic, highly reactive, explosive or inflammable or have a combination of these characteristics and all these are classed as hazardous chemicals. Such chemicals are potential hazardous not only to the human beings, flora and fauna but also to all forms of property and our environment as a whole. Thus, extreme care is essential in handling such chemicals in any form and at all stages of manufacture, processing, treatment, package, storage, transportation, use, collection, destruction, conversion or sale.

Several agencies of the Government, both at the Central and State levels, such as the Directorate of Explosives, the Inspectorate of Factories and Port and Transport Authorities are entrusted with the responsibility of ensuring safe handling and management of hazardous chemicals under Acts and Rules made for the purpose. In spite of these measures, the possibility of accidents can not be ruled out. Human errors and mechanical, electrical, instrumental or system failures have, on occasions, led to severe disasters. Apart from those which occurred at Bhopal. Mexico and other parts of the world in the last few decades have made people all over the world concerned with the dangers of chemical accidents. Occurrence of such accidents makes it essential that the Central and State Governments as well as the local authorities are fully prepared to mitigate the sufferings and meet the eventualities resulting from any unfortunate occurrence of chemical accidents in our country.

During the past decade there has been an increased public awareness of disaster situation in the vicinity of the plants particularly the chemical plants and locations where large quantities of inflammable materials are stored or handled. It is essential to evolve a Disaster Control Preparedness Plan to effectively make use of available resources. There are many agencies involved in the activities associated with effective handling of Disaster, e.g. Civic and Government authorities, Fire Services, Civil Defence, Medical, Police, Army, neighbouring industries, Voluntary organizations, etc. and this requires an organized multidisciplinary approach to the problem.

Disaster is a sudden occurrence of hazard with a magnitude which could affect the normal pattern of life in the facility and/or in vicinity causing extensive damage to life and/or property.

The Disaster Preparedness Plan gives a clear organizational structure and elaborates the duties to be performed (including outside agencies) by each when situation demands, so as to reduce the probability/severity of community suffering and property damage.

The activities among other things also include providing/help in arranging for food, shelter, clothing, medical attention and other life sustaining requirements.

1.4.1 Objectives

The purpose of DMP is to give an approach to detail organizational responsibilities, actions, reporting requirements and support resources available to ensure effective and timely management of emergencies associated to production and operations in the site. The overall objectives of DMP are to:

- Ensure safety of people, protect the environment and safeguard commercial considerations
- Immediate response to emergency scene with effective communication network and organized procedures.
- Obtain early warning of emergency conditions so as to prevent impact on personnel, assets and environment;
- Safeguard personnel to prevent injuries or loss of life by protecting personnel from the hazard and evacuating personnel from an installation when necessary
- Minimize the impact of the event on the installation and the environment, by:
  - -Minimizing the hazard as far as possible
  - -Minimizing the potential for escalation
  - -Containing any release.
  - ♦ To provide guidance to help stack holders take appropriate action to prevent accidents involving hazardous substances and to mitigate adverse effects of accidents that do nevertheless occur. **Figure-1.5** shows effect of loss of containment from the process

1.4.2 Disaster Scenarios

Various scenarios that are anticipated to cause major emergencies inside the industries are fire, explosion, toxic release and natural calamities like cyclone, flood, earthquake. All these scenarios are discussed in brief in the following text.

Fire

Fire is also a serious hazard and is normally regarded as having a disaster potential less than explosion or toxic release that can be controlled at the incipient stage. Certain examples are pool fire, jet flame fire, flash fire, tank fire, pump fire, flange fire, duct fire and cable tray fire. A fire involving a storage tank is serious and would require several days of fire fighting.

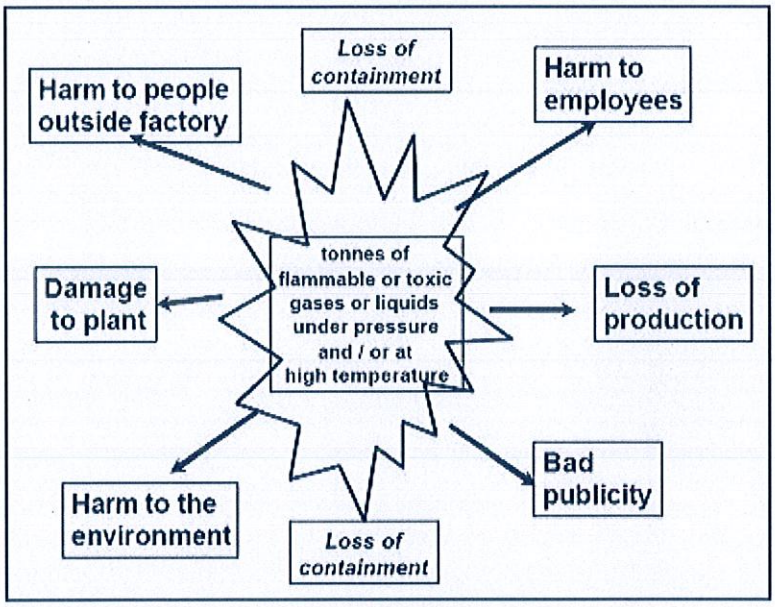


FIGURE. 1.5
FOCUS ON LOSS OF CONTAINMENT FROM THE PROCESS

Explosion

Explosion is a major hazard and the violence of explosion depends on the rate at which energy is released. Explosion can bring in certain effects like blast wave, thermal effects, missile effects, ground shock and injury to personnel. The explosion types considered in this plan for the purpose of Maximum Credible Accident (MCA) Analysis include Unconfined Vapor Cloud Explosion (UVCE) and Boiling Liquid Expanding Vapor Explosion (BLEVE) blast effect.

Toxic Release

Release of toxic chemicals in the form of gases and vapors can pose major hazards if proper care is not taken. Such hazards presented by a toxic release depend on the duration of exposure and on the chemical itself. It ranges from a sudden brief exposure at high concentration to a prolonged exposure at lower concentration over a working lifetime.

Cyclone

The possibility of cyclone striking the area cannot be ruled out. However, all the equipment and installations are designed to withstand a wind speed of 180 km/h. Receiving advance information from the local meteorological department can activate the strategic actions during a cyclone. While establishing the strategic actions during such scenarios, factors such as poor communication, loss of utilities, disrupted logistics and life-threatening rescue facilities are considered.

Earthquake

An earthquake can pose a major threat to the pipeline and associated facilities, property, life and environment. Some of the effects of an earthquake are ground shaking, ground lateral displacement, and ground uplift, ground settlement, soil liquefaction and fires. Though the earthquake is not a regular phenomenon in this region, the possibility of its occurrence cannot be ruled out.

Flood

With the advance information from the local meteorological department on flood warning, specific actions to be carried out on those occasions are considered in this plan. Some of the effects likely during flood are water entering the plants / processing units, danger to life of persons / property and outbreak of epidemics / other contagious diseases.

1.4.3 Different phases of disaster

Warning Phase

Many disasters are preceded by some sort of warning. For example, with the aid of satellites and network of weather stations, many meteorological disasters like cyclones and hurricanes can be predicted and actions can be taken to eliminate/reduce their effect to counteract them.

Period of Impact Phase

This is the period when the disaster actually strikes and very little can be done to lessen the effects of disaster. The period of impact may last for a few seconds (like fire, explosion, gas leak) or may prolong for days (fire, gas leak, etc.). This is the time to bring the action plan in force.

The coordinators in organization structure will perform the responsibilities assigned to them. Needless to emphasize that prompt and well Organised rescue operations can save valuable lives.

Rescue Phase

The rescue phase starts immediately after the impact and continues until necessary measures are taken to rush help and combat with the situation.

Relief Phase

In this phase, apart from organization and relief measures internally, depending on severity of the disaster, external help should also be summoned to provide relief measures (like evacuations to a safe place and providing medical help, food clothing etc.). This phase will continue till normalcy is restored.

Rehabilitation Phase

This is the final and longest phase. It includes rebuilding damaged property, estimating the damages, payment of compensation, etc. Help from

revenue/insurance authorities need to be obtained to assess the damage, quantum of compension to be paid etc.

1.4.4 Key Elements

Following are the key elements of Disaster Management Plan:

- Basis of the plan
- Accident/emergency response planning procedures
- On-site Disaster Management Plan
- Off-site Disaster Management Plan

1.4.4.1 Basis of the Plan

Identification and assessment of hazards is crucial for on-site emergency planning and it is therefore necessary to identify what emergencies could arise in production of various products and their storage. Hazard analysis or consequence analysis gives the following results.

- Hazards from spread of fire or release of flammable chemicals from storage, production units and transportation facilities
- Hazards due to formation of pressure waves due to vapor cloud explosion of flammable gases

1.4.4.2 Emergency Planning and Response Procedures

Emergency rarely occurs therefore activities during emergencies; require coordination of higher order than for planned activities carried out according to fixed time schedule or on a routine day-to-day basis. To effectively coordinate emergency response activities, an organizational approach to planning is required. The important areas of emergency planning are Organization and Responsibilities, Procedures, Communication, Transport, Resource requirements and Control Center. Offsite emergency requires additional planning over and above those considered under onsite plans, which should be properly integrated to ensure better coordination.

The emergency planning includes anticipatory action for emergency, maintenance and streamlining of emergency preparedness and ability for sudden mobilization of all forces to meet any calamity.

1.4.4.3 On-site Disaster Management Plan

Purpose

- To protect persons and property of storage terminals in case of all kinds of accidents, dangerous occurrences emergencies and disasters happening in or affecting plant at any time
- To informed people and surroundings about above happening if it is likely to adversely affect them
- To inform authorities including helping agencies (doctors, hospitals, fire, police transport etc.) in advance, and also at the time of actual happening

- To identify, assess, foresee and work out various kinds of possible hazards, their places, potential and damaging capacity and area in case of above happenings. Review, revise, redesign, replace or reconstruct the process, plant, vessels and control measures if so assessed.

During an emergency in order to handle disaster / emergency situations, an organizational chart entrusting responsibility to various plant personnel showing their specific roles during emergency should be available as shown in **Figure- 1.6**. The composition of the management team is given below:

Plant manager, Section In-charge, Site Controller, Incident Controller, Personnel, Administrative Manager, Communication Officer, Fire and Security Officer, Transport Coordinator, Medical Coordinator, Media Representatives, Communication Coordinator

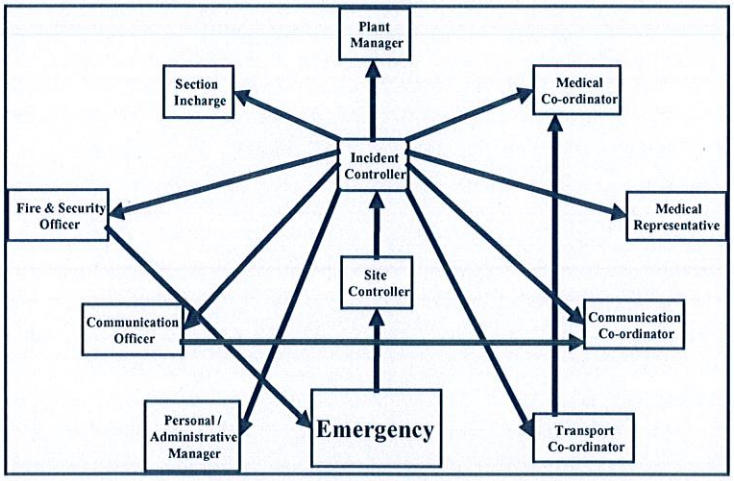


FIGURE-1.6
ONSITE DMP - DISASTER CONTROL/MANAGEMENT SYSTEM

Before Crisis

- Prepare a plan of the storage, handling and pumping stations premises and surrounding showing therein the areas of various hazards like fire, explosion toxic releases etc, and also location of assembly points ,fire station or equipments room, telephone room, first aid or ambulance room ,emergency control room, main gate ,emergency gates ,normal wind direction , north direction, outside fire station ,hospital and other services .Mention their distances from proposed activities.
- The fire protection equipment shall be kept in good operating condition at all time and fire fighting system should be periodically tested for people functioning logged for record and corrective action.
- The fire fighting training shall be provided to all officers, truck drivers and other employees who are likely to be present in installation
- There should be regular mock fire drills once a month record of such drills shall be maintained

- Every employee or authorized person working in the production shall be familiarized with the fire alarm signal and shall know the location of fire alarm point nearest to place of work
- Assign key personnel and alternate responsible for site safety
- Describe risk associated with each operation conducted.

During Crisis

- Monitor the behavior of entrant for any effects that suggests they should be evacuated
- Evacuate the space if any hazard that could danger the entrant is detected
- Perform no other duties that may interfere with their primary responsibilities
- Notify the attendant if they experience any warning signs or symptoms of exposures or detect a dangerous condition
- Exit the permit space when instructed by attendant
- Reporting Procedure
- In the event of fire from accidental release of flammable gas or liquid, a person seeing the incident will follow the laid down procedure in the plant and report as follows:
- Will dial the nearest telephone
- Will state his name and exact location of emergency
- Will contact affected officers on duty
- People reporting the accident will remain near the location to guide emergency crew arriving at the scene
- In case fire emergency person should activate the nearest available push button type instrument which will automatically sound an alarm in fire control room indicating the location of fire.

After Crisis

- Report injuries or blood or body fluid exposures to the appropriate supervisor immediately
- Assembly points:
    - Assembly points shall be set up farthest from the location of likely hazardous events, where pre-designed persons from the works, contractors and visitors would assemble in case of emergency. Up-to-Date list of pre-designed employees shift wise must be available at these points so that roll call could be taken. Pre-designated persons would take charge of these points and mark presence as the people come into it.
    - Wash wounds and skin sites that have been in contact with blood with soap and water.
    - Workers should be seen as soon as possible by a health professional.
    - Provide information to the relevant public authority and community including other closely located facilities regarding the nature of hazard and emergency procedure in event of major accident.
    - Record and discuss the lessons learned and the analysis of major accidents and misses with employees and employee representative.

1.4.4.4 Off-site Disaster Management Plan

Emergency is a sudden unexpected event, which can cause serious damage to personnel life, property and environment as a whole, which necessitate to evolve Off-site Emergency Plan to combat any such eventuality. In Offsite disaster management Plan many agencies are involved like Revenue, Public Health, Fire Services, Police, Civil Defense, Home Guards, Medical Services and other Voluntary organization. Thus handling of such emergencies requires an organized multidisciplinary approach.

If it becomes necessary to evacuate people, then this can be done in orderly way. The different agencies involved in evacuation of people are Civil Administration (both state and central), non Govt. organizations, factory Inspectorate and Police authorities.

Fire

Effects of fire on population will be mainly due to thermal radiation. In such cases, houses situated to the proximity of disaster need to be evacuated, although a severe smoke hazard due to fire is to be reviewed periodically.

Explosion

An explosion will give a very little time to warn population and areas affected may be much longer than that in case of fire. The effects of explosion on population will be mainly due to shock waves, flying splinters, collapse of structures and exposure to thermal radiation.

Off-site (Notifying External Agencies)

Depending on the type and severity of emergency, the communication controller must notify the appropriate external agencies. The major emergencies should be notified to:

- District Collector
- Law enforcement departments
- Local governments and other response teams
- Fire departments and other response teams
- Hospital and emergency medical services
- Ambulance services
- Local environmental agencies
- Utility companies, such as water, sewer, public works, telephone, and electricity
- Contractors for heavy and special machinery and supply of nitrogen/dry air for purging the pipeline
- Suppliers of emergency equipment
- Neighboring industries, which can provide additional emergency response personnel and material
- The broadcasting media
- The notice shall include the following information:
  - The name and address of the site where the release, has occurred
  - The name, position, and telephone number of the caller
  - The location of the point of the release; a description of the source, cause and type of release; the quantity and concentration of the material released; and whether the release is of a continuous nature

- Any know or anticipate acute or chronic health risks associated with the emergency and, where appropriate, advice regarding medical attention necessary for exposed individuals
- Proper precautions to be taken as a result of the release, including evacuation
- The name(s) and telephone number(s) of the person (s) to be contacted for further information
- Weather conditions, including wind direction and speed, and expected off-site effects, if any

Neighboring industries or activities can often provide additional resources, in terms of expertise, personnel, material and equipment. As for the case of other local external agencies, such possible co-operation can be more effective only if predetermined plans for intervention have been established.

Purpose

- To save lives and injuries and to prevent or reduce property losses
- To provide for quick resumption of normal situation or operation
- To make explicit the inter related be suggested if necessary
- To make explicit inter related set of actions to be undertaken in the event of an industrial accident posing hazards to the community
- To inform people and surrounding about emergency and disaster if it is likely to adversely affect machinery will be established for this purpose to guide the people in proper way
- To plan for rescue and recuperation of casualties and injuries. To plan for relief and rehabilitation
- To plan for prevention of harms, total loss and recurrence of disaster. It will be ensured that absolute safety and security is achieved within the shortest time

Before Crisis

This will include the safety procedure to be followed during an emergency through posters, talks and mass media in different languages including local language. Leaflets containing do's/ don'ts should be circulated to educate the people in vicinity

- People in vicinity of hazardous installation, and others who are potentially affected in the event of an accident, should be aware of the risks of accidents, know where to obtain information concerning the installation, and understand what to do in the event of an accident
- Non-governmental Organizations (NGO's) (Such as environmental, humanitarian and consumer group) should motivate their constituents and others, to be involved in risk reduction and accident prevention efforts. They should help to identify specific concerns and priorities regarding risk reduction and prevention, preparedness and response activities
- NGO's should facilitate efforts to inform the public and should provide technical assistance to help the public analyze and understand information that is made available
- Public authorities (at all levels) and management of hazardous installation should established emergency planning activities/ program's for accidents involving the hazardous substance

- All parties who will be involved in emergency planning process. In this respect public health authorities, including experts from information centers should be involved in relevant aspects of offsite emergency planning
- Emergency warning alert system alert system should be in place to warn the potentially affected public, or there is an imminent threat of an accident
- The system chosen should be effective and provide timely warning. Suitable warning system could include or a combination of for e.g.: sirens, automatic telephone massage, and mobile public address system

During Crisis

- Central Control Committee: As the off-site plan is to be prepared by the government a central control committee shall be formed under the chairmanship of area head. Other officers from police, fire, factory, medical, engineering, social welfare, publicity, railway, transport and requisite departments shall be incorporated as members. Some experts will also be included for guidance. The functions of committee should be:
  - To work as main co-coordinating body constituted of necessary district heads and other authorities with overall command, coordination, guidance, supervision, policy and doing all necessary things to control disaster in shortest times
  - To prepare, review, alter or cancel this plan and to keep it a complete document with all details
  - To take advice and assistance from experts in fields to make plan more successful
  - To set in motion all machineries to this plan in event of disaster causing or likely to cause severe damage to public, property or environment
  - The incident control committee, traffic control committee and press publicity committee will first be informed, as they are needed first

- Medical Help, Ambulance and Hospital Committee: This committee consisted of doctors for medical help to the injured persons because of disaster. Injuries may be of many types. As such doctors are rarely available we have to mobilize and utilize all available doctors in the area. Functions and duties of the committee include:
  - To give medical help to all injured as early as possible.
  - Civil surgeon is the secretary who will organize his team.
  - On receiving information to rush to spot he will immediately inform his team and will proceed with all necessary equipments.
  - First aid and possible treatment shall be provided at the spot or at some convenient place and patients may be requested to shift to hospitals for further treatment
  - All efforts shall be made on war basis to save maximum lives and to treat maximum injuries.
  - Continuity of the treatment shall be maintained till the disaster is controlled.

- Traffic Control, Law and Order: The committee is headed by District Superintendent of Police. Functions and duties of this committee should be:
  - To control traffic towards and near disaster , to maintain law and order
  - To evacuate the places badly affected or likely to be affected

- To shift the evacuated people to safe assembly points
- To rehabilitate them after disaster is over.
- Necessary vehicles, wireless sets and instruments for quick communications shall be maintained and used as per need

After Crisis:

- At the time of disaster, many people may badly be affected. Injured people shall be treated by medical help, ambulance and hospital committee but those not injured but displaced kept at assembly points, dead whose relative or property is lost, houses collapsed and in need of any kind of help shall be treated by this welfare and restoration committee. Functions and duties of this committee are:

  - To find out persons in need of human help owing to disastrous effect. They may give first aid if medical team is not available
  - They will serve the evacuated people kept at assembly points. They will arrange for their food, water, shelter, clothing, sanitation, and guidelines to reach any needful places
  - They will look for removal and disposal of dead bodies, for help of sick, weak, children and needy persons for their essential requirements
  - The team will also work for restoration of detached people, lost articles, essential commodities etc.
  - The team will also look after the restoration of government articles
  - The team will also ensure that the original activities, services and systems are resumed again as they were functioning before the disaster

- Police
  - The police should assist in controlling of the accident site, organizing evacuation and removing of any seriously injured people to hospitals
- Fire Brigade
  - The fire rigade shall organize to put out fires other than gas fires and provide assistance as required.

- Hospitals and Doctors
  - Hospitals and doctors must be ready to treat any injuries.
- Media

- The media should have ready and continuous access to designated officials with relevant information, as well as to other sources in order to provide essential and accurate information to public throughout the emergency and to help avoid confusion
- Efforts should be made to check the clarity and reliability of information as it becomes available, and before it is communicated to public
- Public health authorities should be consulted when issuing statements to the media concerning health aspects of chemical accidents
- Members of the media should facilitate response efforts by providing means for informing the public with credible information about accidents involving hazardous substances

- Non-governmental organizations (NGO)

- NGO's could provide a valuable source of expertise and information to support emergency response efforts. Members of NGOs could assist response personnel by performing specified tasks, as planned during the emergency planning process. Such tasks could include providing humanitarian, psychological and social assistance to members of community and response personnel. Various organizations involved during emergencies are shown in **Figure-1.7.**

1.4.5 Post Accident Activities

1.4.5.1 Accident Investigation

The GIL will proceed in analyzing accidents and failures, and at the minimum:

- Evaluate the situation
- Protect life and property
- Keep the area safe
- Conduct a leak survey
- Conduct pressure test of sphere
- Perform meter and regulator checks
- Question persons on the scene
- Examine burn and debris patterns
- Record weather conditions
- Select samples of the failed facility or equipment or equipment for laboratory examination for the purpose of determining the causes of the failure and minimising the possibility of recurrence
- Notify the appropriate Risk Management Office

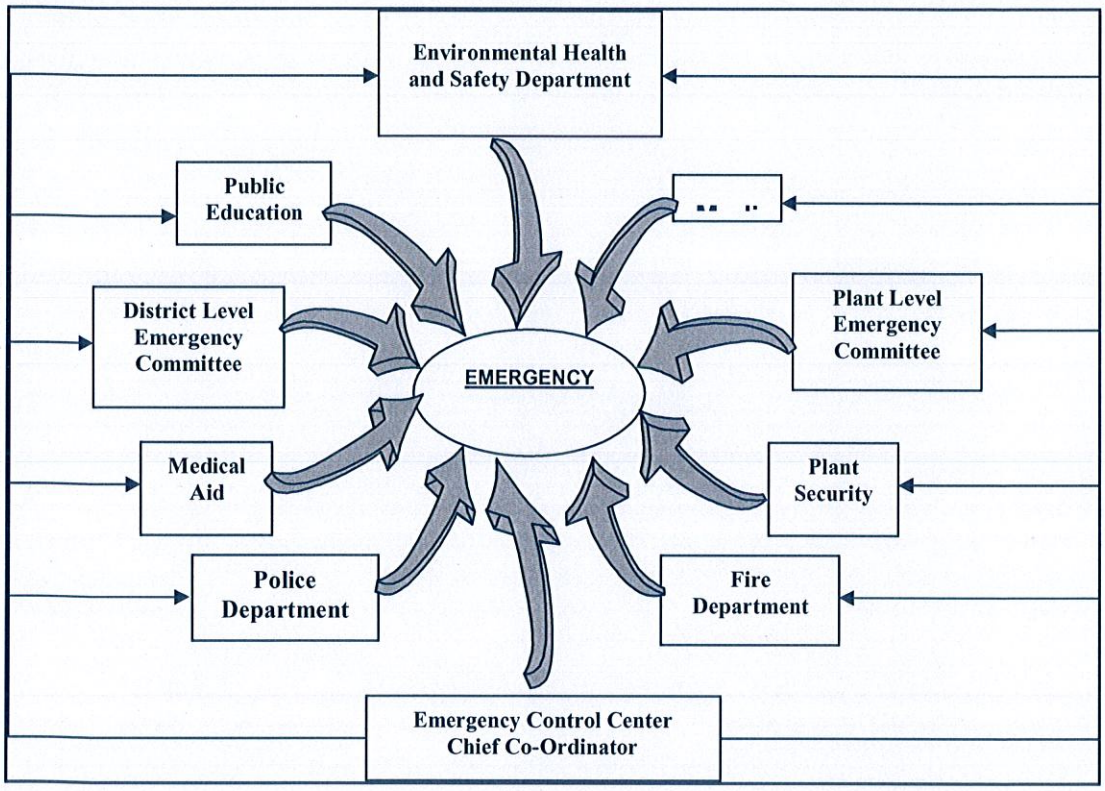


FIGURE-1.7
ORGANIZATIONS INVOLVED DURING EMERGENCIES

1.4.5.2 Post - Incident Reporting

- The officer of local Environmental Health & Safety shall within 72 hours of the Closure of the incident, schedule a debriefing with all agencies concerned. This debriefing shall include, but not be limited to :

  - Analysis of the incident including type of scenario, type of fire, impact distance, casualties and injuries etc.
  - Problem areas identified
  - Revisions to the emergency plan, if needed
  - Factors that caused the incident

- Upon completion of the debriefing, open discussion for questions and answers
- The officer of Environmental Health & Safety issues the final report

1.4.5.3 Relief to the Victims

Post-incident activities include the relief to the victims. The Public Liability Insurance Act provides for the owner who has control over handling hazardous substances, to pay specified amounts of money to the victims as interim relief. After proper assessment of the incident, he may invite applications for relief, conduct an enquiry into the claims and arrange payment of the relief amount to the victims.

1.4.6 Checklist for Capability Assessment

The checklist will help in assessing the preparedness, prevention and response resources capabilities. The points included in the checklist are only indicative and there is a need to closely examine the local requirements while preparing the checklist.

For good control and management of an incident, there are three important requisites.

- Defined Organisation
- Effective means
- Trained people

The organisation has to be properly structured for routine as well as emergency purposes with clear understanding of duties and responsibilities. The structure has to consider an execution and speedy implementation of the response plans; while at the same time, it should be flexible enough to tune itself to the fast changing situations. All plans and procedures for emergency handling should be established. Checklists in the form of Do's and Don'ts of preventive maintenance, strengthening of HSE, manufacturing utility staff are listed in the subsequent subsections. Checklists for customer visit and work permit are given in the **Table-1.9 & 1.10** respectively.

TABLE-1.9
CHECKLIST FOR CUSTOMER VISIT

Sr. No.	Check Points at Customer End	OK	Not OK
1.	Site Condition		
1.1	Shed with adequate ventilation No direct sun light or rains in nearby region Cemented platform with no accumulation of sludge/slit/water		
1.2	Unloading system		
	Chain pulley with proper tripod or crane arrangement Manual unloading with direct platform (Ramp system)		
1.3	Shifting Arrangement		
	Shifting of tonners, manual shifting through ramps & rollers Mech shifting by Hoist Shifting by fork lift (Not advisable because of falling hazards as well as friction which may arise & damage the container while inserting the fork inside the chlorine tonner)		
2.	Consuming system		
	Liquid phase or gas phase Manifold, single or multifold Tube connection Consumption rate Back pr/suction Pr Monitoring system Evacuation by water /steam /N2 gas /Dry air Possibility of process liquid back into tonner (More clarification require, what should be checked by a assigned person)		
3.	Empty tonner handling system		
	Methodology of checking complete emptiness Disconnection system Empty cylinder shifting from consumption point to storage (by mechanical / manual) Fixing of nuts / caps		
4	Loading of empty cylinder in truck		
	Putting valve protection cover Loading procedure (through ramp / mechanical) Nos. of layer of cylinder in stacking		
5	Emergency handling system		
	Facility to check leakage Frequency of checking Valve operating keys / other tools & tackles Emergency kit Suction hood PPE (SCBA, Air hood respirator, portable oxygen cylinder (Must not be used, Only Self contained air breathing apparatus is required. Direct inhalation of oxygen may cause of fatal accident), canister type gas musk, hand gloves) Wind shock indicator Communication procedure & system display at site Availability of emergency plan at control room Nearby emergency handling agencies Neutralization pit Population density near the usage of chlorine (Is it essential?)		
6	Legal compliance		
	Site approval from CCE License for storage of chlorine cylinder (updated)		

Name of supplier: Name of customer:

Signature: Signature:

TABLE-1.10
CHECKLIST FOR WORK PERMIT

Sr. No.	Precaution to be taken	Yes	No
1	Electrically isolated and fuse removed. Lock out-Tag out followed		
2	Flow isolated by closing valves		
3	De-pressurized – vacuum released		
4	Vessel cooled		
5	Drained fully and drain kept open		
6	Vent kept open		
7	Manhole kept open		
8	Vessel purged with steam		
9	Vessel purged with water		
10	Vessel purged with nitrogen/ air		
11	Vessel free from toxic gases/vapors/ flammable substances		
12	Gas test shows > 20% oxygen inside vessel		
13	Safety tags card placed wherever required		
14	Personal PPe's provided		
15	Exhaust / ventilation inside vessel is sufficient		
16	Caution boards placed		
17	Tools and tackles checked as per specifications		
18	Head count of the area known to relevant persons		
19	Trained Site supervisor nominated		
20	Safety measures such as hydrant, alarms, sensors checked		

Welding and cutting inspection checklist is described below:

- Are only authorized and trained personnel permitted to use welding, cutting, or brazing equipment?
- Does each operator have a copy of the appropriate operating instructions and are they directed to follow them.
- Are compressed gas cylinders regularly examined for obvious signs of defects, deep rusting, or leakage?
- Is care used in handling and storage of cylinders, safety valves, etc., to prevent damage?
- Are precautions taken to prevent the mixture of air or oxygen with flammable gases, except at a burner or in a standard touch?
- Are only approved apparatus (torches, regulators, pressure-reducing valves, acetylene generators, manifolds) used?
- Are cylinders kept away from elevators, stairs, or gangways?
- Is it prohibited to use cylinders as rollers or supports?
- Are empty cylinders appropriately marked and their valves closed?
- Are signs reading: DANGER-NO SMOKING, NO-MATCHES, OR NO-OPEN-LIGHTS, or the equivalent posted?
- Are cylinders, cylinder valves, couplings, regulators, hoses, and apparatus kept free of oily or greasy substances?
- Is care taken not to drop or strike cylinders?
- Unless secured on special trucks, are regulators removed and valve-protection caps put in place before moving cylinders?
- Do cylinders have keys, handles, or non-adjustable wrenches on stem valves in service?
- Are liquefied gases stored and shipped valve-end up with valve covers in place?
- Are provisions made to never crack a fuel-gas cylinder valve near sources of ignition?

- Before a regulator is removed, is the valve closed and gas released from the regulator?
- Is red used to identify the acetylene (and other fuel-gas) hose, green for Oxygen hose, and black for inert gas and air hose?
- Are pressure-reducing regulators used only for the gas and pressures for which they are intended?
- Is open circuit (no load) voltage of arc welding and cutting machines as low as possible and not in excess of the recommended limits?
- Under wet conditions, are automatic controls for reducing no load voltage use?
- Is grounding of the machine frame and safety ground connections of portable machines checked periodically?
- Are electrodes removed from the holders when not in use?
- Is it required that electric power to the welder be shut off when no one is in attendance?
- Is suitable fire extinguishing equipment available for immediate use?
- Is the welder forbidden to coil or loop welding electrode cable around his body?
- Are wet machines thoroughly dried and tested before being used?
- Are work and electrode lead cables frequently inspected for wear and damage and replaced when needed?
- Do means for connecting cable lengths have adequate insulation?
- When the object to be welded cannot be moved and fire hazards cannot be removed, are shields used to confine heat, sparks, and slag?
- Are fire watchers assigned when welding or cutting is performed in locations where a serious fire might develop?
- Are combustible floors kept wet, covered by damp sand, or protected by fire-resistant shields?
- When floors are wet down, are personnel protected from possible electrical shock?
- When welding is done on metal walls, are precautions taken to protect combustibles on the other side?
- Before hot work is begun, are used drums, barrels, tanks, and other containers so thoroughly cleaned that no substances remain that could explode, ignite, or produce toxic vapors? Have lines/pipes been disconnected or blanked?
- Is it required that eye protection helmets, hand shields, and goggles meet appropriate standards?

Laboratory premises & equipment checklist should be as per the below:

Laboratory Premises Checklist

- Have guidelines for commissioning and certification been considered for facility construction or post-construction evaluations?
- Do the premises meet national and local building requirements, including those relating to natural disaster precautions if necessary?
- Are the premises generally uncluttered and free from obstructions?
- Are the premises clean?
- Are there any structural defects in floors?
- Are floors and stairs uniform and slip-resistant?
- Is the working space adequate for safe operation?
- Are the circulation spaces and corridors adequate for the movement of people and large equipment?
- Are the benches, furniture and fittings in good condition?
- Are bench surfaces resistant to solvents and corrosive chemicals?

- Is there a hand-washing sink in each laboratory room?
- Are the premises constructed and maintained to prevent entry and harbourage of rodents and arthropods?
- Are all exposed steam and hot water pipes insulated or guarded to protect personnel?
- Is an independent power support unit provided in case of power breakdown?
- Can access to laboratory areas be restricted to authorized personnel?
- Has a risk assessment been performed to ensure that appropriate equipment and facilities are available to support the work being considered?

Laboratory equipment

- Is all equipment certified safe for use?
- Are procedures available for decontaminating equipment prior to maintenance?
- Are biological safety cabinets and fume cupboards regularly tested and serviced?
- Are autoclaves and other pressure vessels regularly inspected?
- Are centrifuge buckets and rotors regularly inspected?
- Are HEPA filters regularly changed?
- Are pipettes used instead of hypodermic needles?
- Is cracked and chipped glassware always discarded and not reused?
- Are there safe receptacles for broken glass?
- Are plastics used instead of glass where feasible?
- Are sharps disposal containers available and being used?

Flammable liquid storage facilities checklist is given below:

- Are storage facilities, shelves, etc. arranged so that stores are secure against sliding, collapse or falls?
- Are storage facilities kept free from accumulations of rubbish, unwanted materials and objects that present hazards from tripping, fire, explosion and harbourage of pests?
- Are freezers and storage areas lockable?
- Is the storage facility for bulk flammable liquids separated from the main building?
- Is it clearly labelled as a fire-risk area?
- Does it have a gravity or mechanical exhaust ventilation system that is separate from the main building system?
- Are the switches for lighting sealed or placed outside the building?
- Are the light fittings inside sealed to protect against ignition of vapours by sparking?
- Are flammable liquids stored in proper, ventilated containers that are made of Non-combustible materials?
- Are the contents of all containers correctly described on the labels?
- Are appropriate fire extinguishers and/or fire blankets placed outside but near to the flammable liquid store?
- Are "No smoking" signs clearly displayed inside and outside the flammable liquid store?
- Are only minimum amounts of flammable substances stored in laboratory rooms?
- Are they stored in properly constructed flammable storage cabinets?

- Are these cabinets adequately labelled with "Flammable liquid – Fire hazard" signs?
- Are personnel trained to properly use and transport flammable liquids?
- Sanitation, staff facilities, Heating, ventilation and Lighting checklist is given below:
- Are the premises maintained in a clean, orderly and sanitary condition?
- Is drinking-water available?
- Are clean and adequate toilet (WC) and washing facilities provided separately for male and female staff?
- Are hot and cold water, soap and towels provided?
- Are separate changing rooms provided for male and female staff?
- Is there accommodation (e.g. lockers) for street clothing for individual members of the staff?
- Is there a staff room for lunch, etc.?
- Are noise levels acceptable?
- Is there an adequate organization for the collection and disposal of general household rubbish?
- Is there a comfortable working temperature?
- Are blinds fitted to windows that are exposed to full sunlight?
- Is the ventilation adequate, e.g. at least six changes of air per hour, especially in rooms that have mechanical ventilation?
- Does mechanical ventilation compromise airflows in and around biological safety cabinets and fume cupboards?
- Is the general illumination adequate (e.g. 300–400 lx)?
- Is task (local) lighting provided at work benches?
- Are all areas well-lit, with no dark or ill-lit corners in rooms and corridors?

Services Checklist

- Is each laboratory room provided with enough sinks, water, electricity and gas outlets for safe working?
- Is there an adequate inspection and maintenance programme for fuses, lights, cables, pipes, etc.?
- Are faults corrected within a reasonable time?
- Are internal engineering and maintenance services available, with skilled engineers and craftsmen who also have some knowledge of the nature of the work of the laboratory?
- Is the access of engineering and maintenance personnel to various laboratory areas controlled and documented?
- If no internal engineering and maintenance services are available, have local engineers and builders been contacted and familiarized with the equipment and work of the laboratory?
- Are cleaning services available?
- Is the access of cleaning personnel to various laboratory areas controlled and documented?
- Are information technology services available and secured?

Fire prevention and fire protection checklist is delineated below:

- Is there a fire alarm system?
- Are the fire doors in good order?
- Is the fire detection system in good working order and regularly tested?

- Are fire alarm stations accessible?
- Are all exits marked by proper, illuminated signs?
- Is access to exits marked where the routes to them are not immediately visible?
- Are all exits unobstructed by decorations, furniture and equipment, and unlocked when the building is occupied?
- Is access to exits arranged so that it is not necessary to pass through a high-hazard area to escape?
- Do all exits lead to an open space?
- Are corridors, aisles and circulation areas clear and unobstructed for movement of staff and fire-fighting equipment?
- Is all fire-fighting equipment and apparatus easily identified by an appropriate color code?
- Are portable fire extinguishers maintained fully charged and in working order, and kept in designated places at all times?
- Are laboratory rooms with potential fire hazards equipped with appropriate extinguishers and/or fire blankets for emergency use?
- If flammable liquids and gases are used in any room, is the mechanical ventilation sufficient to remove vapours before they reach a hazardous concentration?
- Are personnel trained to respond to fire emergencies?

Checklist for Compressed and liquefied gases is mentioned below:

- Is each portable gas container legibly marked with its contents and correctly color coded?
- Are compressed-gas cylinders and their high-pressure and reduction valves regularly inspected?
- Are reduction valves regularly maintained?
- Is a pressure-relief device connected when a cylinder is in use?
- Are protection caps in place when cylinders are not in use or are being transported?
- Are all compressed gas cylinders secured so that they cannot fall, especially in the event of natural disaster?
- Are cylinders and liquid petroleum gas tanks kept away from sources of heat?
- Are personnel trained to properly use and transport compressed and liquefied gases?

Checklist for Electrical hazards is given below:

- Are all new electrical installations and all replacements, modifications or repairs made and maintained in accordance with a national electrical safety code?
- Does the interior wiring have an earthed/grounded conductor (i.e. a three-wire system)?
- Are circuit-breakers and earth-fault interrupters fitted to all laboratory circuits?
- Do all electrical appliances have testing laboratory approval?
- Are the flexible connecting cables of all equipment as short as practicable, in good condition, and not frayed, damaged or spliced?
- Is each electric socket outlet used for only one appliance (no adapters to be used)?

Checklist for personal protection is given below:

- Is protective clothing of approved design and fabric provided for all staff for normal work, e.g. gowns, coveralls, aprons, gloves?
- Is additional protective clothing provided for work with hazardous chemicals and radioactive and carcinogenic substances, e.g. rubber aprons and gloves for chemicals and for dealing with spillages; heat-resistant gloves for unloading autoclaves and ovens?
- Are safety glasses, goggles and shields (visors) provided?
- Are there eye-wash stations?
- Are there emergency showers (drench facilities)?
- Is radiation protection in accordance with national and international standards, including provision of dosimeters?
- Are respirators available, regularly cleaned, disinfected, inspected and stored in a clean and sanitary condition?

Checklist for handling chemical substances is given below

- Are incompatible chemicals effectively separated when stored or handled?
- Are all chemicals correctly labelled with names and warnings?
- Are chemical hazard warning charts prominently displayed?
- Are staffs trained to deal with spills?
- Are flammable substances correctly and safely stored in minimal amounts in approved cabinets?
- Are bottle carriers provided?