

RISK ASSESSMENT REPORT

1.0 RISK ASSESSMENT AND HAZARD MANAGEMENT

Hazard analysis involves the identification and quantification of the various hazards (unsafe condition) that exist in the plant. On the other hand, risk analysis deals with the identification and quantification of the risk, the plant equipment and Personnel are exposed to, due to accidents resulting from the hazards present in the plant.

Risk analysis involves the identification and assessment of risks to the population exposed to hazards present. This requires an assessment of failure probability, credible accident scenario, vulnerability of population etc. Much of this information is difficult to get or generate consequently, the risk analysis in present case is confined to maximum credible accident studies and safety and risk aspect related to expansion of Grain based Distillery.

Activities requiring assessment of risk due to occurrence of most probable instances of hazard and accident are both onsite and off-site.

On-site

- Exposure to fugitive dust, noise, and other emissions
- Housekeeping practices requiring contact with solid and liquid wastes
- Alcohol leakage/ spillage through pipeline during pumping & subsequent fire

Off-site

- Exposure to pollutants released from offsite/ storage/related activities
- Contamination due to accidental releases or normal release in combination with natural hazard
- Deposition of toxic pollutants in vegetation / other sinks and possible sudden releases due to accidental occurrences.

In view of the hazards involved in handling and storage of hazardous chemicals and processes "On Site Emergency Plan" has been prepared. It gives a clear organization structure, including outside agencies and elaborates the duties to be performed by each individual when situation demands. The plan enumerates the actions required to be taken by various personal working at different work station in the plant. Particular emphasis is given to eight most vital areas of disaster planning like Organization responsibilities, procedure, training, mutual aid, communication, transportation and public relations.

2.0 Risk Analysis Methodologies

Risk assessment often requires the synthesis of risk profiles, which represent the probability distribution of total annual loss due to a certain set of events or activities. These assessments usually involve estimation of losses for several sub-classifications of the overall process and synthesis of the results into an aggregate risk profile.

Main risk assessment technologies are:

- Hazard And Operability Study (HAZOP), and
- Fault Tree Analysis (FTA)

2.1 Hazop Study

The HAZOP study is a systematic technique of identifying hazards of operability problems of a process and lists all possible deviations from normal operating condition and how they might occur. The consequences of the process are assessed and the means available to detect and correct the deviations are examined. Thus, within the entire process all “credible” deviations that could lead to hazardous events or operability problems are identified.

2.2 Fault Tree Analysis (FTA)

FTA is primarily a means of analyzing non-identifiable hazards. Hazards of top events (the ultimate happening that is to be avoided) are first identified by other techniques such as HAZOP. Then all combinations of individual failures that can lead to that hazardous event show the logical format of the fault tree. Estimating the individual probabilities and then using the appropriate arithmetical expressions can calculate the top event frequency.

2.3 Identification of Hazards

The following types of hazards are identified at the company.

TABLE: 1
Hazard Identification

S. No.	Hazard Area	Associated Hazard
1.	Biomass storage	Fire
	Enzymes, yeast, nutrients, etc	Exposure & inhalation
	Storage of Chemicals (Caustic, acids, etc)	Exposure to skin
2.	Distillation	Heat & Fire
3.	Boiler, D.G Sets	Noise, Heat, Fire & electrocution
4.	Alcohol	Fire
5.	Leakages from the vessels, rupture of pressure vessels and storage tanks	Exposure & Fire

2.4 Assessment of Risk along with mitigation measures

Qualitative risk assessment based on categorization of both probability and impact provides greater insight into the absolute risk severity. The risk impact assessment investigates the potential effect on a project objective such as schedule, cost, quality, or performance, including both negative effects for threats and positive effects for opportunities.

TABLE: 2
Risk Assessment along with mitigation measures

S. No.	Activity	Associated hazards	Associated risk/ health impact	Mitigation Measures
1.	Storage & handling of raw material & Chemicals	Bursting of storage tanks	Exposure, physical injuries	• Use of PPEs. • Inspection & regular monitoring • Training to workers for proper handling • Proper system for loading operation to prevent any spillage. • Spill kit for Acid and other chemicals
2.	Working near	Heat & Fire	Physical injuries	• Firefighting facility

Expansion of Existing Grain Based Distillery (110 to 170 KLPD) within Existing Plant Premises*At Village Durgapur, Block- Diamond Harbour-II, District South 24 Parganas, West Bengal***Risk Assessment Report**

S. No.	Activity	Associated hazards	Associated risk/ health impact	Mitigation Measures
	Distillation column		and burning	• Provision of pressure indicators in the vessels. • Use of PPEs. • Inspection & regular monitoring • Training to workers for proper handling
3.	Fuel yard	Heat & Fire	Physical injuries and burning	• Storage should be away from ignition source • Firefighting facility shall be provided • PPEs should be provided • First aid box
4.	APCD failure	Release of PM in ambient air	Air pollution	• Regular monitoring & inspection shall be done. • The plant shall immediately shut down on APCD failure
5.	Working at height	Slip, trips & falls of operators	Physical injuries	• Individual alertness of the workers. • First aid boxes shall be provided
6.	Storage of Alcohol	Exposure, inhalation, ingestion & Fire	Exposure to over 100 ppm may cause headache, drowsiness, etc. Ingestion may lead to depression of CNS, nausea, etc. Burn injuries	• Well ventilation • Keeping away from heat sparks & open flame. • PPEs. • Firefighting measures shall be readily available.
8.	Release of high pressure steam from boiler	Explosion	Risk of severe injury, damage to equipment	• Regular maintenance & inspection of parts. • Proper training to the individuals • PPEs • First aid kit
9.	Electrical maintenance work	Electric shock, short circuits in power room	Electrical shocks, Injury or burn	• Regular checking and maintenance of electrical units • PPEs • Provision of First aid box
10.	Working near Boiler, D.G. sets	High noise	Noise induced hearing losses	• Provision of PPEs to the workers.

3.0 Emergency Planning**3.1 Definition**

A major emergency in an activity/project is one which has the potential to cause serious injury or loss of life. It may cause extensive damage to property and serious disruption both inside and outside the activity/project. It would normally require the assistance of emergency services to handle it effectively.

3.2 Scope

An important element of mitigation is emergency planning, i.e. identifying accident possibility, assessing the consequences of such accidents and deciding on the emergency procedures, both on site and off site that would need to be implemented in the event of an emergency.

Emergency planning is just one aspect of safety and cannot be considered in isolation from the project and hence before starting to prepare the plan, works management will ensure that the necessary standards, appropriate to safety legislation, are in place.

3.3 Objectives

The overall objectives of the emergency plan will be:

- I. Define roles and responsibilities of site management
- II. Provide training and guidelines and requirements.
- III. Protect the human life and property.
- IV. Ensure the welfare of the public during emergency.
- V. Provide reference for those co-ordination emergency activities
- VI. Take account of shortcomings and update as appropriate from time to time.

3.4 Safety Measures for Storage & Handling of Alcohol

The alcohol is being/will be directly fed to the storage tanks (bottling unit) mechanically and no manual handling is being/will be involved which reduces/will reduce the risk of spillage. Following precautionary measures would be taken for safety:

- **HANDLING AND STORAGE:** Keeping away from heat, sparks and open flame, care is being/will be taken for avoidance of spillage, skin and eye contact, well ventilation, use of approved respirator if air contamination is above acceptable level is being/will be promoted. For Storage and handling following precautions are being/will be taken:
 - Keeping away from oxidizers, heat and flames.
 - Avoidance of plastics, rubber and coatings in the storage area.
 - Cool, dry, & ventilated storage and closed containers.
 - Grounding of the container and transferring of equipment to eliminate static electric sparks.
 - Storage of acid and alkalies should be done properly as they can cause severe burns on skin.

In case of any emergency following measures are being/will be taken:

- **FIRST AID MEASURES:** For skin contact, eye contact, & inhalation.
- **FIRE FIGHTING MEASURES:**
 - In plant precautions have been taken by declaring plant operating area as No Smoking Zone.
 - All the Electrical installations are flame proof type in the alcohol storage area.
 - Use of extinguishing media surrounding the fire as water, dry chemicals (BC or ABC powder), CO, Sand, etc
 - Foam System for firefighting is being/will be provided to control fire from the alcohol storage tank. The foam thus produced suppresses/will suppress fire by separating the fuel from the air (oxygen), and hence avoiding the fire & explosion to occur in the tank. Foam

would blanket the fuel surface smothering the fire. The fuel is being/will also be cooled by the water content of the foam.

- The foam blanket suppresses/will suppress the release of flammable vapors that can mix with the air.
 - Special Fire Fighting Procedures; Keeping the fire upwind. Shutting down of all possible sources of ignition, keeping of run-off water out of sewers and water sources. Avoidance of water in straight hose stream which will scatter and spread fire. Use of spray or fog nozzles will be promoted, cool containers will be exposed to flames with water from the side until well after the fire is out.
 - Hazardous Decomposition Products: gases of Carbon Monoxide (CO) & Carbon Dioxide (CO₂).
 - A team of security Guards is kept to maintain security round the clock in whole of the factory area. The Company has fully trained operating and security staff for fire fighting and fire drill is conducted by the fire experts on regular intervals.
- **ACCIDENTAL RELEASE MEASURES:** For Spill Cleanup well ventilation, shutting off or removal of all possible sources of ignition, absorbance of small quantities with paper towels and evaporate in safe place like fume hood and burning of these towels in a safe manner, Use of respiratory and/or liquid-contact protection by the clean-up personnel is being/will be promoted.
- **Action to be taken by the First Person noticing the Fire/Leakage /Failure:**
- a) If it is a small fire, try to extinguish with fire extinguishers.
 - b) After noticing the fire, immediately call for assistance by pressing alarm or by using telephone facilities inform shift in-charge on intercom.
 - c) Inform security on intercom

Whenever disaster occurs, the incident should be communicated to the concerned authority in minimum possible time, in case of failure of a means of communication due to electrical failure an officer should rush to the nearest public telephone booth/ police station to transmit message through line or police wireless.

During office hours on a working day

During office hours on working days senior most executive in the factory will take the charge of site main controller in case of any emergency. In case of incident controller is not present in the factory production chemist shall take over the function of incident controller as indicated in the organization chart.

4.0 Disaster Management Plan

4.1 General

Disaster Management Plan for an industrial unit is necessarily a combination of various actions which are to be taken in a very short time but in a present sequence to deal effectively and efficiently with

any disaster, emergency or major accident with an aim to keep the loss of men, material, plant/machinery etc. to the minimum.

The objectives of a detailed Disaster Management Plan, which includes:

- Identification of various types of expected disaster depending upon the type of the industrial unit.
- Identification of various groups, agencies, departments etc. necessary for dealing with a specific disaster effectively.
- Preparation – by intensive training of relevant teams/groups within the organization to deal with a specific disaster and keep them in readiness.
- Establishment of an early detection system for the disaster.
- Development of a reliable instant information/communication system.
- Organization and mobilization of all the concerned departments/ organizations / groups and agencies instantly when needed.
- A major disaster that can be expected due to fire in this distillery.

Key personnel in IFB Agro Industries Limited:

- Emergency can take place in any hour of the day. As such the key personal, who will handle the situation are those who are available in the factory for 24 hours.
 - Mr. S. K. Bayen : 90070-90803/ 94340-72228
 - Mr. Santanu Ghosh : 90070-90809/ 98307-02959
 - Mr. Alok Kr De : 94330-20383/ 90070-90801
 - Mr. Chinmay Mishra : 94335-40173/ 99033-79531
 - Mr. Santanu Sarkar : 9433304912
 - Shift Managers/ Utility Manager : 90070-90805/ 90070-90806
 - Mr. Dilip Kr. De : 94340-10007
 - Mr. Kaushik Goswami : 94340-14552
 - Mr. Debojoyti Bandopadhyaya : 98302-13819

4.2 Emergency Planning For Disaster Due To Fire

Any worker, who notices the emergency situation, shall run to the operator to inform him. To get the information, the operator shall immediately start acting as controller:

4.2.1 Classification of Fire

Class (A)

Fire involving combustible materials like wood, paper, cloth etc.

Class (B)

Fire due to liquid materials like oil, diesel, petroleum products and all inflammables.

Class (C)

Fires involving domestic and industrial gases like butane and propane etc.

Class (D)

Metal fires etc.

Class (E)

Electrical fires due to short circuiting etc.

4.2.2 Duties and Responsibility of Key Personnel of Environmental Management Cell

Site Main Controller:-

On getting information from any authentic source, he should proceed promptly to the factory and enter the Emergency Control Center and take overall charge of all the activities dealing with Emergency. He should remain at the emergency control center till the emergency is called off, so that all concerned are aware of the location of his availability during the emergency.

He is the final authority on all matters related to emergency; such as fire- fighting, emergency control, rescue operations, calling outside agencies for assistance, welfare, evacuation, transport rehabilitation, liaison, public relations etc.

- I. To co-ordinate with external and internal coordinator and give necessary instructions.
- II. To put the disaster control plan into action.
- III. To mobilize help from outside agencies and to ensure supply of firefighting equipment.
- IV. In case of disaster of high magnitude, the chief controller will inform district magistrate, local police station, and district health authorities for additional help and evacuation.
- V. Continuous review and assess possible developments to determine the most probable course of events.
- VI. Direct the shutting down of plants and their evacuation in consultation with the incident controller and key personnel.
- VII. Ensure that the casualties are receiving adequate attention.

Incident Controller:

- a) As soon as he is aware of an incident, the incident controller should assess its scale against emergency reference levels, and decide whether a major emergency exists or is likely. If so, he should immediately activate the on-site plan and if necessary the off- site emergency plan.
- b) He should assume the duties of the site main controller pending the later arrival in particular to:
 - I. Ensure the emergency services have been called.
 - II. Direct the shutting down and evacuation of the plant areas likely to be affected.
 - III. Ensure key personnel have been summoned.
- c) His main function, however, is to direct all operations at the scene of the incident e.g.
 - I. Rescue and fire- fighting operations, until the arrival of the fire brigade, when he should hand over control to a senior fire officer.
 - II. Search for casualties.
 - III. Evacuation of non-essential workers to assembly area.
- d) He should also
 - I. Set up a communication point with telephone or messenger contact with emergency control center.

- II. Give advice and information as requested to the emergency services.
- III. Brief the site main controller and keep him informed of developments.

Distillery Manager:

In case site controller and incident controller are not in the factory, he will take over the function of incident controller otherwise he will:

- I. Mobilize the fire-fighting operation and coordinate with external fire tenders/fire- fighting equipment.
- II. Liaison between the incident controller and the maintenance, fire, safety and production and medical services.
- III. The maintenance squad should isolate the hazardous area, and plug the leak.
- IV. Remove Hexane tank lorry or other vehicles to safe location.

Security Officer:

- I. To coordinate fire-fighting operation and replenish the fire-fighting equipment.
- II. To rescue the injured persons.
- III. To provide first aid/medical assistance.
- IV. To liaison with ambulance services.
- V. Remove tank lorry/other vehicles to safe location.

Maintenance Manager:

- I. Maintenance squad should plug the leak, isolate the hazardous area and ensure the safety of the remaining part of the factory.
- I. Remove the tank lorry and other vehicles form the factory premises.
- II. Liaison between the incident controller and fire and safety departments.
- III. The team will mobilize any repair work on an emergency basis.

Accounts Officer:

- I. To coordinate the evacuation of the visitors and office staff who have no role in controlling emergency.
- II. To rescue the injured persons.
- III. To provide first-aid/medical assistance to injured workers.
- IV. To liaison with ambulance services.

Personnel Manager:

- I. To communicate with the following authorities for the necessary help.
 - Police Station
 - Fire Brigade
 - Local Hospitals
 - Ambulance Services.
 - Head Office
- II. To request the police to control the traffic and maintain law and order.
- III. To liaison with neighboring organizations for assistance.

Shift In charge after office hours:

- I. Establish the emergency control center
- II. Mobilize all coordinators assembled at the Emergency Control center and put the disaster control plan into action.
- I. Mobilize the fire- fighting operations.
- II. Mobilize help from ambulance services and hospitals for medical assistance.
- III. Mobilize help from the outside agencies for firefighting (Indore Fire Brigade).
- IV. Inform the police and request to control traffic and maintain law and order.
- V. Inform site controller, incident controller and appraise the situation.
- VI. Direct the shutting down of plants and their evacuation.
- VII. Give adequate attention to the casualties and send them to hospital.

Cable rooms, transformer, unit, auxiliary transformers, oil tanks, etc. within the plant are the likely areas for which disaster management plan is to be made to deal with any eventuality of fire. Stores, workshop, canteen and administrative building are also included

4.2.3 Preparation of Plan**4.3.1 Alarm System**

A siren has been provided under the control of Security office in the plant premises to give warning. In case of emergencies this is used on the instructions to shift in charge that is positioned round the clock. The warning signal for emergency is as follows:

- Emergency Siren: Waxing and waning sound for 3 minutes.
- All clear signal: Continuous siren for one minute

4.3.2 Communication

Walkies & Talkies are located at strategic locations; internal telephone system EPBX with external P&T telephones are provided.

4.3.3 Fire Fighting System

The fire protection system for the unit is to provide for early detection, alarm, containment and suppression of fires. The fire detection and protection system has been planned to meet the above objective an all-statutory and insurance requirement of Tariff Advisory Committee (TAC) of India. The complete fire protection system comprises of the following.

(a) Fire brigade

Automatic / manual fire detection & alarm system

(b) Fire Hydrant

Fire hydrant will be provided at all around in the plant as per TAC Norms.

(c) Portable fire extinguishers

Various areas of the plant have one or more of the above system depending upon the particular nature of risk involved in that area.

(d) Portable chemical fire extinguishers

These are intended as a first line of defense, and hence will be stationed at strategic locations in different buildings and also for outdoor facilities. Portable fire extinguishers are foam type; carbon dioxide type and multipurpose dry chemical (MPDC) type.

(e) Fire detection and alarm system

Fire detection and alarm system an effective means of detection, visual indication of fire location and audible alarm of any fire at its incipient stage. This system will comprise fire alarm panels, automatic fire detectors, manual call points and fire siren (hooter).

The main fire alarm panel provides both visual and audible alarm of fire in any protected areas of the plant.

Manual break glass type fire alarms are provided at strategic locations where high hazards exists.

Automatic fire detectors are provided in plant areas such as control rooms, switchgear rooms, cable galleries etc.

4.3.4 Fire -fighting groups

The Fire Fighting groups are classified into three teams, Fire-in-chief who co-ordinates all the groups shall be safety officer:

a) Fire Fighting Team:-

- I. This team will be doing the first line fire- fighting.
- II. This team will be headed by shift in-charge/production chemist.
- III. This team will be assisted by all employees in the plant and those near the place of fire.

b) Assisting Team:-

- I. This team will assist the fire-fighting team.
- II. This team will be headed by Maintenance Head.
- III. This team shall be assisted Quality Control, production and Maintenance employees.

c) Rescue Team:-

- I. This team will communicate with outside agencies and arrange first aid.
- II. This team shall be headed by accounts in-charge.
- III. This team shall be assisted by all employees in administrative office and medical services.

Action to be taken by different types of teams (name and action is as below):

Action by Fire Fighting team:-

- Employees in the production department shall stop all their operations except emergency cooling.
- Fire pump operator will ensure that the hydrant and sprinkler lines have sufficient pressure.
- Employees working in production shall put off all the electrical supplies. If the accident occurs during the night hours, the lighting switches shall be kept on.

Action by Rescue Teams

- All office staff on hearing the alarm shall remove the important documents to a safe place.
- Cashier shall lock the cash and related documents in the locker.

- The group in-charge shall depute the employees for various jobs as mentioned below.
- One employee shall take charge of telephone and contact fire brigade, police, neighboring industries and hospitals for assistance.
- One employee shall regulate the traffic at main gate.
- One employee shall guide all outside of the plant.
- One employee shall go around the plant and ensure all plants and machineries are closed.
- Rest of the employees shall carry first aid box, various fire-fighting equipment from stores to the place of fire.

Action plan for fire/Explosion during night:

- Persons observing the fire/leakage should raise alarm by shouting and operate the nearest available hand siren.
- On hearing the hand siren, the watchman at the main gate shall operate electric siren intermittently to communicate emergency.
- Efforts should be made to put off the fire using fire extinguishers, sand buckets, hydrants and sprinklers in the area.
- All the electric supply (except lighting if it is night time) should be put off.
- Shift in-charge should contact chief technical manager, factory manager, and occupier and apprise them of the situation. If needed police, fire control, civil hospital and neighboring industries to be contacted for help.

4.3.5 Emergency Control Center

For the purpose of handling emergency, emergency control center has been identified and shown on the site plan. All communications to and from will originate at this control center. The emergency control center will have the following:-

- Updated copies of the On-site Disaster Management Plan.
- Emergency telephone numbers.
- The names, phone number, and address of external agencies, response organizations and neighboring facilities.
- The adequate number of telephone (more than two).
- Emergency lights, Clocks, Personal protective equipment.
- List of fire extinguishers with their type no. and location, capacity, etc.
- Safety helmets – List of quantity & location.
- Status boards/message board.
- Material safety data sheets for chemicals handled at the facility.
- Several maps of the facility including drainage system for surrounding area showing:
 - Areas where hazardous materials are stored.
 - Plot plans of storage tanks, routes of pipelines, all water permanent lines etc.
 - The locations where personal protective equipment are stored.
 - The position of pumping stations and other water sources.

- Roads and plant entrances.
- Assembly areas & layout of Hydrant lines.

4.3.6 Off-site emergency control plan:

The Off-Site emergency plan is based on those events which could affect the people and the environment outside the factory premises/installation. The nature of the accident is so serious that it becomes important not only in factory management but also for the general public outside the factory premises to deal with the situation. The basic objective is that damage to human life and property is minimized. Advance planning is the key. The on-site and off-site plans should detail so that the emergency services are summoned at the appropriate time and are provided with accurate information and the correct assessment of the situation. The responsibility for this should be with the site main controller. The various emergency services should be co-ordinated by fire and Safety coordinator who will liaise with site Main Controller.

Action Plan:-

The site Main Controller will assess the situation and if the emergency is likely to spread outside the installation or affect the neighbor industry and people outside the factory premises, will declare off-site emergency. He will coordinate with the incident controller and get in touch with all essential local authorities and mutual aid members for controlling the disaster. The local authorities will work under the direct supervision of the site Main Controller.

The help of the following agencies is summoned: -

- Local police,
- Fire Brigade,
- Hospitals
- Ambulance,
- Blood Banks,
- Home guards,
- Voluntary Agencies.

The responsibility of the Site main controller:-

- To provide emergency control center with necessary communication facilities.
- To coordinate with fire authorities for controlling the emergency and rescue operation.
- To arrange medical help to the casualties, ambulance services.
- To arrange rehabilitation of persons evacuated and arrange food, medicines, shelter etc.

After the incident has been controlled, the site Main Controller should assess the situation and call off the emergency.

TABLE:3
Emergency contact numbers

S.No.	Name	Telephone No.
1.	Diamond Harbour Fire Station	(03174) 258900
2.	Falta Fire Station	(03174) 222111
3.	Behala Fire Station	(033) 2467-2085

4.	West Bengal Fire service squad	(033) 2244-0101/ 8166/ 6170
5.	Falta (Ramnagar) Police Station	(03174) 222246
6.	SDPO Office	(03174) 255221
7.	Diamond Harbour Hospital	(03174) 255237
8.	Dr. Das' Nursing Home	(03174) 255260
9.	Baidhya Nursing Home	(03174) 256-373

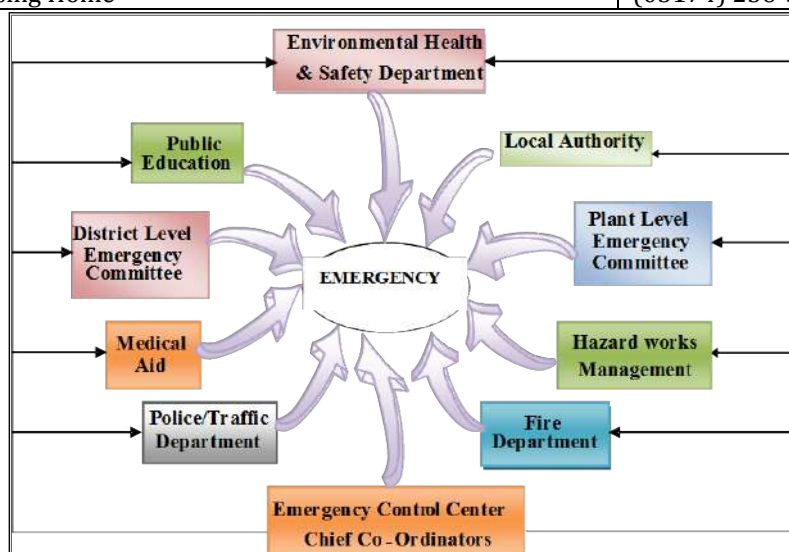


Figure 7.1: Various organizations involved during emergency

4.3.7

Sequence of operations required in case of emergency:

- 1) To take notice of the actual situation after hearing emergency siren.
- 2) To instruct the watchman for communication to all the agencies.
- 3) To see that person controlling the hazard wear appropriate personal protective appliances (Breathing Apparatus)
- 4) To move to the spot to assess what action is required.
- 5) To lose the valve which supply ammonia to the plant or to close down the valve as per demand of the emergency situation.
- 6) To ascertain that the message has been communicated to the desired persons properly.
- 7) To ensure that unwanted people goes far away from the incident spot.
- 8) The fire shall be controlled with the help of fire extinguishers here, water jets, Carbon dioxide Cylinders. The helper shall assist him in this job.
- 9) To remove the Gas- affected / fire effected workers, give first aid and to be sent for medical care.

5.0

GEOLOGICAL & GEO- HYDROLOGICAL STATUS

5.1

Geological features

The study area is located in the lower deltaic plain on the composite Gangetic Delta and is covered by the Quaternary sediments deposited by the Ganga and its tributaries. The top of the alluvium is clayey in nature. Fine sand and silty-clay capping also occurs in small patches in the alluvium.

Exploratory drilling down to a maximum depth of 614 m bgl in the area reveal a succession of coarse to fine grained sand, clay and kankar and their various admixtures with localized patches of gravel

and cemented sand grains. The sub-surface formations in and around study area found to be consisting of a thick succession of unconsolidated sediments comprising clay, silt of various colors, sand of various colors and gravels. The top surface in this tract is marked by an effective clay blanket with thickness varying from 15 to 76 m. towards the eastern part thickness is comparatively less up to only 6 m.

Underlying the clay blanket, occurs a huge thickness of unconsolidated sediments composed of gravel, fine to coarse grained sand, silt and clay with increasing thickness towards south-eastwards.

The gravel zone may be considered as a marker horizon which is underlain by another extensive clay zone at varying depths. Beneath this clay zone, occurs a second group of aquifers in the depth range of 160 to 360 meters with considerable aerial extent. Geological map of study area is shown in the figure below.

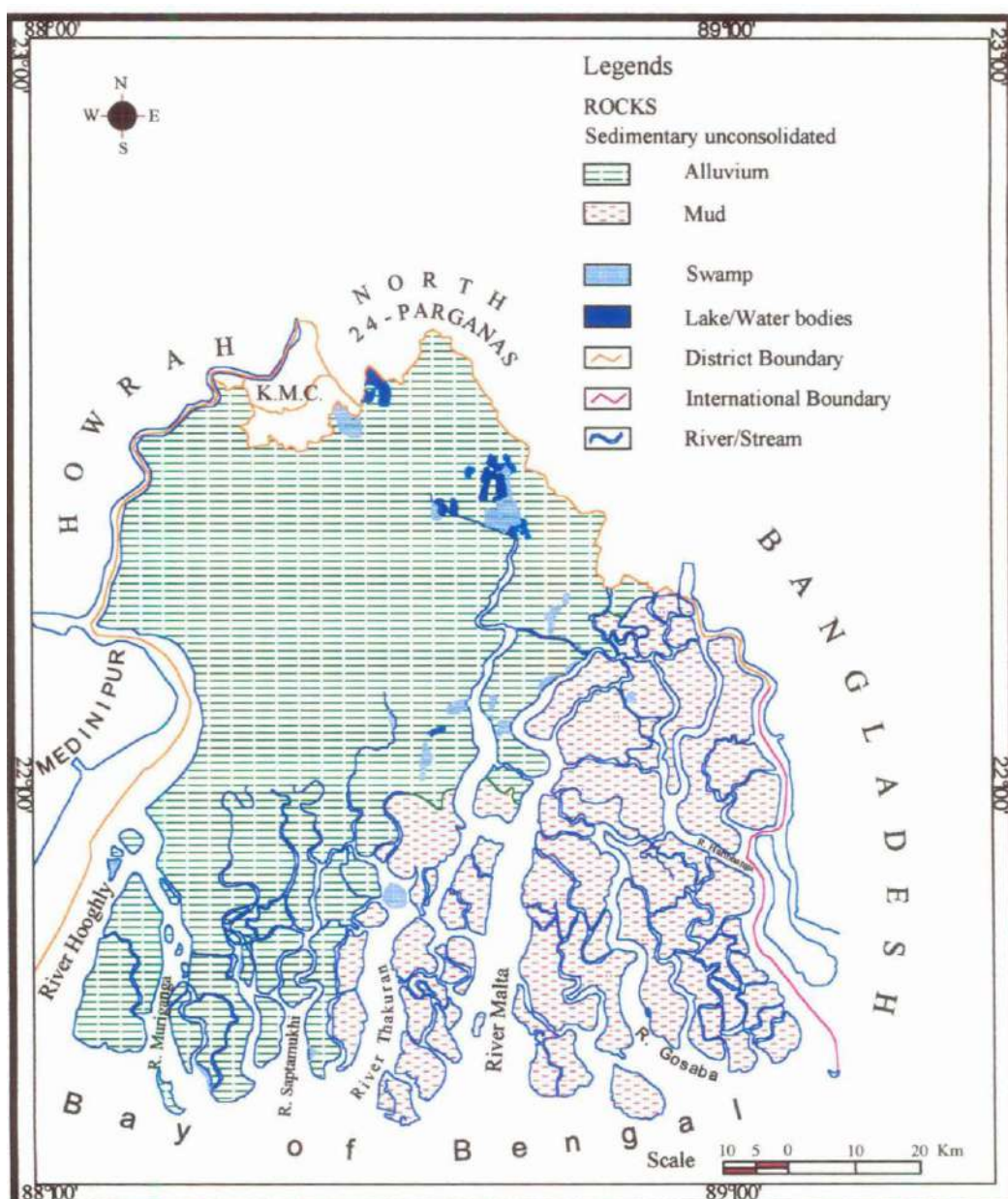


Figure 2: Geological Set-up of the Area

5.2 Hydro-geological features

The groundwater bearing aquifers are present in the district within Quaternary and Tertiary sediments and generally occur under confined condition in the depth range of 75 to 360 meters with numerous alternations of clayey and sandy layers of varying thickness. The confined aquifers can be divided into two groups in this district from north to extreme south. The upper one, usually in the depth span of 20 to 160 meters has a sandy gravel layer as a marker bed at its base which pinches out eastward. The groundwater in general except at a few places occurring in this upper group of aquifers, is brackish to saline (Chloride ranging from 1750 to 6300 ppm) and is not in use. The lower group of aquifer occurring in the depth range of 160 to 360 meter is separated from the upper group by a thick impermeable sticky clay bed which is laterally extensive with varying thickness. The ground water occurring in this lower group of aquifer is generally fresh and is used extensively. Map showing the hydro-geological features of the area is shown in the figure below.

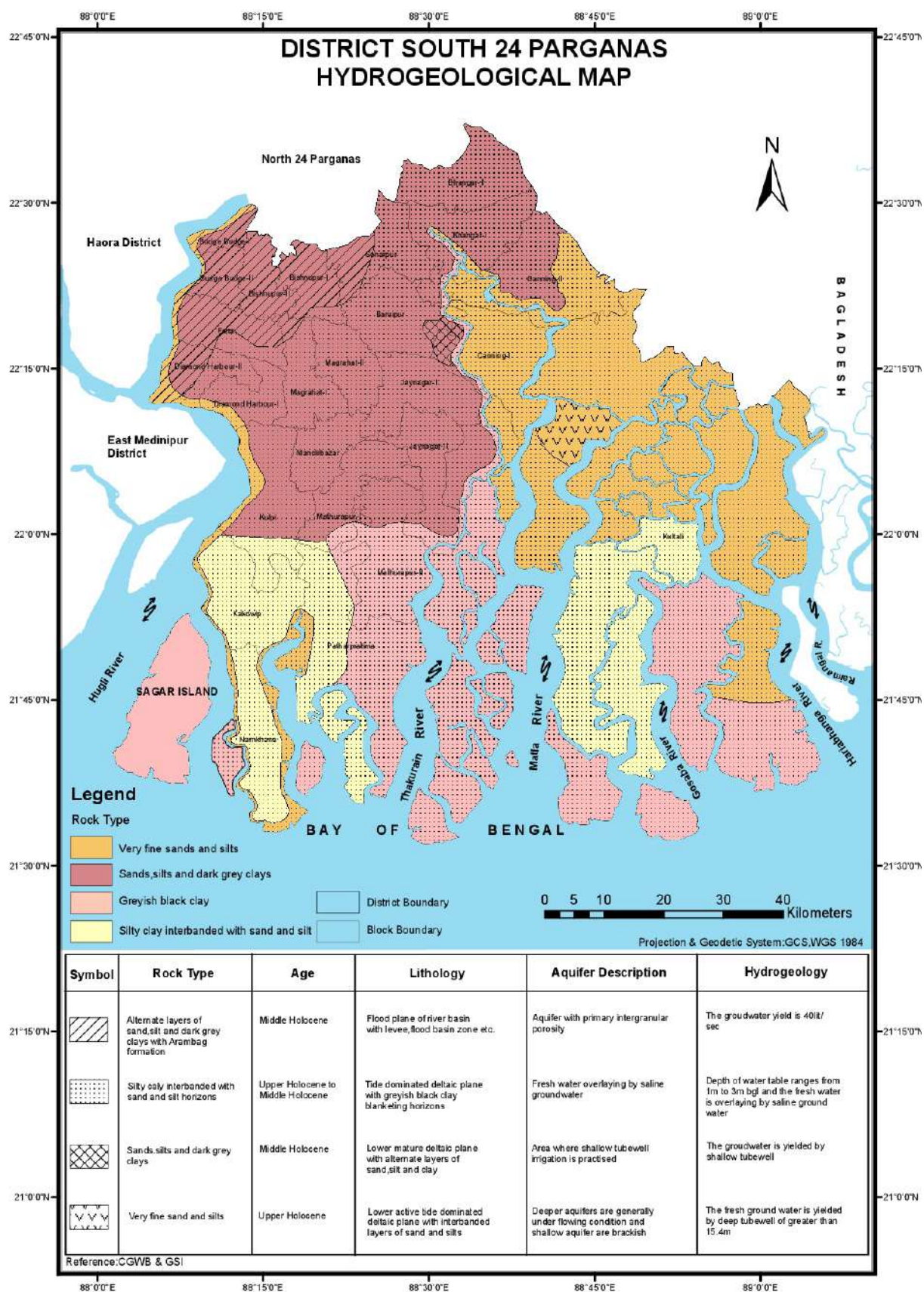


Figure 3: Hydro-geological map of South 24 Parganas