Risk assessment

Risk assessment is essentially a process for identifying assessing and controlling risks in the work place. Mining and related activities are associated with several potential hazards to both employees and the public at large. A worker in a mine should be able to work under conditions which are pleasingly safe and healthy. At the same time the environmental conditions should not spoil his working efficiency. This is possible only when there are sufficient safety measurements taken in mine. Hence mine safety is one of the most crucial aspects of working mine. In the proposed project the mining activities are carried out under opencast operations, indeed safety of the mine and employees are taken care by the Metalliferous Mines Regulation 1961 and its subsequent amendments.

Hazards in Mines

The mining industry has witnessed innumerable number of accidents which are categorized simple & fatal. Even though high priority was given to safety in true spirit, all kinds of accidents occurs. Accident of hazardous situation may arise due to occurrence of any one of the following cases.

- Outbreak of fire
- Inundation
- Air blast
- Machineries, Heavy materials, Electrical installation etc.

Outbreak of fire

Outbreak of fires is generally caused due to electrical fault, mechanical friction, blasting, welding, explosions etc. Outbreak of such a fires in an open gallery of a mine generates huge quantity of toxic gases & smokes.

Inundation

An inundation is release of water from working of same mine or surface water bodies. The inundation causes due to surface water bodies, flood, hydro fracturing, fault reactivation, geo thermal process.

Air blast

Air blasts are defined as the ejection of rocks from main solid mass accompanied by violent explosion & thunderous noise followed by blasts of hot air. Air blast is common in long wall coal mines, especially those whose roof strata are competent and do not cave immediately behind the roof supports as the face advances. However no such danger is anticipated in proposed project working area.

Machineries, Heavy materials, Electrical installation etc

Machine failures are common in all mines / industries. The reasons for certain accidents were recognized for mechanical failures. A machine which has not been conducted periodical maintenance, service. Accidents were also due reckless handling of machineries, heavy materials.

Risk management in the proposed mine
Measures against the outbreak of fire

The following are some of the important measures proposed for control of outbreak of fire in the mine

- No inflammable material will be stored in the mine area, except at designated place.
- Surface workshop, diesel Storage area, compressor house, electrical sub-stations are provided with firefighting equipment's and regular maintenance will be done as per the schedule.
- Dry vegetation will be removed at regular intervals and will not be allowed to accumulate in the mine area.
- Regular inspection will be done to remove accumulation of greasy material, cotton waste, old conveyor pieces, waste hosepipes, wooden scrap etc are checked regularly.

Adequate number of persons will be trained in firefighting activities. Mock drills will be conducted on regular basis.

On the appearance of signs indicating that a fire has broken out, all persons other than those whose presence in the mine is deemed necessary for dealing with the fire shall be immediately withdrawn from the mine.

Firefighting operations will be carried out under the supervision of competent person along with trained firefighting personnel.

A sufficient supply of sand or incombustible dust or sufficient portable fire extinguishers shall be provided at entrance of the mine, crushing / screening plant, oil or other inflammable material storage areas. Provision for water under pressure will be provided at suitable locations. Suitable types of fire extinguishers are provided at different locations to deal with any kind of fire.

Precautions against Irruption of water

As there is no river or major nallah etc., except few small streams drain the rainwater to nearby natural streams, hence possibility of danger from surface water inundation in not envisaged. The applied area occupies a hillock range running N NW – S SE with a major mound continued with plain minor adulatory land towards east.

A water danger plan showing the following features will be maintained as required by the regulations.

- The position of workings below ground.
- The position of every dyke, faults and other geological disturbances, with the amount and direction of throw.
- Every source of water such as river, stream, water course and reservoir-water logged opencast workings on surface and also the outline of all water logged workings measured in any direction.
- Every reservoir, dam or other structure, either above or below ground, constructed to withstand a pressure of water or to control an inrush of water, along with reference to its design and other details of constructions.
- Surface contour lines drawn at vertical intervals not exceeding five meters.

Precautions against Air blast

No such danger is anticipated. However, the following precautionary measures will be observed.

- Any large scale collapse of wall rocks into voids may displace the air in violent manner and course accidents.
- Air blast shelters are established at suitable locations,

Precautions against Machineries, Heavy Materials, Electrical Installations etc.

Suitable overhead crane for lifting and transportation shall be provided where materials are handled. Proper tools and tackles are used with trained man power. Precautionary instruction shall be displayed on boards, near the potent moving machinery, hazards etc. Proper guards are provided on moving parts of machinery and equipment. Required electrical hazards prevention arrangement is followed and maintained on continuous basis that is zero open connections, suitable joint insulations and easy access to control panels etc., suitably precautionary instructions are displayed on board near the potent electrical hazard etc. suitable electrical protections shall be provided as required by statue.

Precautions against Dust, waste, oil etc.

Dust is suppressed at the place of formation for that purpose wet drilling will be done; water is sprayed on haul roads, at crushing and screening site. Proper dust extraction system is installed in the crushing and screening plant. Machineries are installed on impervious flooring, waste oil is collected in impervious pits with sand, spillage is kept bare minimum. The pits are cleaned periodically while charging oil for machines as per the schedule, waste oil is collected in cans and sent to the waste oil-refining unit separately.

Personnel safety & General

Necessary safety equipments like mask, helmet and boots are provided to all the employees working in the mine as per there work of activity. Suitable guards to prevent danger adequately fence every exposed part of any machinery used as or forming part of the equipment of a mine. Only authorized and trained persons are permitted to operate and maintain equipments. Danger signs are displayed at appropriate locations.

Safety Management

Safety management for mining operations is governed by a very well defined set of rules and regulations etc. framed by Government of India and modified time to time. All the operations in any metalliferous mines are carried out under the mines act 1952, rules and regulations framed under it. Metalliferous mines regulations is a comprehensive legislation framed under the mines act and it takes care of the technical and safety aspects of the mining operations.

Hazard Identification and Preliminary Hazard Analysis

The inventory of hazardous substances at the project site is given in the **Table 1**.

Table 1 Hazardous Material - Storage Capacity

S. No	Name of Hazardous Materials & Location	Nature of Hazard	No. of Storage Units	Capacity of storage / unit (Liters)	Total Storage Capacity / unit (Liters)
1	HSD (High Speed Diesel) Stored at Utilities Department	Fire & Explosion	1	1000	1000

Introduction to Hazard Identification

Identification of hazards in proposed site is of primary significance in the analysis, quantification and cost effective control of accidents involving chemicals and process. A classical definition of hazard states that hazard is in fact the characteristic of system /plant /process that presents potential for an accident. Hence, all the components of a system/ plant /process need to be thoroughly examined to assess their potential for initiating or propagating an unplanned event/sequence of events, which can be termed as an accident.

Identification of Major Hazardous Units

Hazardous substances may be Flammable substances, which are given in **Table 2.**

Table 2 Summary Table on the Inventories

Chemical	Codes/ Label	TLV	FBP	MP	FP	UEL	LEL
						%	
HSD (High Speed Diesel)	Combustable	100 mg/m3TWA	215 - 3760 C	NA	550 C	6.0	0.6
TLV : Threshold Limit Value			FBP : Final Boiling Point				
MP : Melting Point			FP : Flash Point				
UEL : Upper Explosive Limit			LEL : Lower Explosive Limit				

Classification Based On Inventory Rating

In order to ensure a steady supply of fuels, adequate inventory is maintained. The quantities stored and the degrees of hazard in terms of NFPA ratings are given below. The National Fire Protection Agency, USA (NFPA), on scale 0 to 4 (least to worst), hazard rating is used as a tool to assess the preliminary hazard potential of a material shown in the **Table 3**.

Table 3 Properties of Fuel employed

S. No	Raw Material	Nh	Nf	Nr
1	HSD (High Speed Diesel)	1	2	0
HSD falls under "moderate" category of flammability index with Nf being 2.				

Identification of Major Hazard Installations Based on Manufacture, Storage, and Import of Hazardous Chemicals (MSIHC) Rules 1989 and the Amended Rules in October 1994 and January 2000.

Following accidents in industry in India over the past few decades a specific legislation covering a major hazard activity has been enforced by Govt. of India in 1989 in conjunction with Environment Protection Act, 1986. This is referred here as MSIHC Rules 1989. For the purpose of identifying major hazard installations the rules employ certain criteria based on toxic, flammable and explosive properties of chemicals.

- Schedule 1 part II gives the list of hazardous substances with their threshold quantities
- Schedule II of the rules sets out the threshold quantities for isolated storage units.
- Schedule III gives a list of hazardous chemicals with their threshold quantities. In this schedule different chemicals are classified into distinct groups viz. Group 1 - Toxic substances, Group 2 -Toxic substances, Group 3 -Highly reactive substances, Group 4 -Explosive substances and Group 5-Flammable substances.
- Schedule IV of the rules indicate various operations which are hazardous during production, processing or treatment of organic and inorganic chemicals.

A systematic analysis of fuels and their quantities of storage has been carried out, to determine threshold quantities as notified by MSIHC Rules 1989 and amended rules in 1994 and 2000 and the applicable rules are identified. Indicative Criteria for Identification of Toxic, Flammable and Explosive Chemicals (MSIHC Rules 1989) is given in **Table 4**.

Table 4 Indicative Criteria for Identification of Toxic, Flammable and Explosive Chemicals (MSIHC Rules 1989)

a. Toxic Chemicals				
Chemicals having the following values of acute toxicity and which, owing to their physical and chemical properties, are capable of producing major accident hazards				
S. No.	Degree of Toxicity	Medium lethal dose by the oral route (oral toxicity) LD 50 (mg/Kg body weight of test animals)	Medium lethal dose by the dermal route (dermal toxicity) LD 50(mg/Kg body weight of test animals)	Medium lethal concentration by inhalation route (four hours) LC50 (mg/L inhalation in test animals)

1.	Extremely toxic	1-50	1-200	0.1-0.5
2.	Highly toxic	51-500	201-2000	0.5-2.0
b. Flammable Chemicals				
i. Flammable gases: Chemicals which in the gaseous state at normal pressure and when mixed with air become flammable and the boiling point of which at normal pressure is 20oC or below;				
ii. Highly flammable liquids: Chemicals, which have a flash point, lower than 23oC and the boiling point of which at normal pressure is above 20oC.				
iii. Flammable liquids :Chemicals which have a flash point lower than 650C and which remain liquids under pressure, where particular processing conditions, such as high pressure and high temperature, may create major accident hazards				
c. Explosives				
Chemicals which may explode under the effect of flame, heat or photo-chemical conditions or which are more sensitive to shocks or friction than dinitrobenzene.				

Based on the indicative criteria inventory (liquids/fuels) stored in proposed site has been analyzed for applicability of MSIHC Rules 1989and the results are summarized in **Table 5.**

Table 5 Applicability of MSIHC Rules to Storages

S. No.	Chemical/ Fuel	Listed in Schedule	*Actual Expected Quantity	Threshold Quantity	
				for Application of Rules 5,7 – 9 and 13 – 15	for Application of Rules 10 - 12
1	HSD	3 (2(e)(iii),5 and 6(1)(a) /)	1 Ton	2500 Ton	20,000 Ton
*Expected Quantity to be Stored for a week.					

From the above table it can be inferred that HSD storage tanks does not (with capacity 1 MT) attract rules 2(e)(iii), 5 and 6(1)(a) and 7-15, as the stored quantities are less than that of the stipulated threshold quantities

Short Listed Hazards

Based on the preliminary hazard analysis, the following scenarios are short-listed for consequence analysis to quantify the risks involved. The nature of Hazards that could occur in proposed site is presented in the **Table 6** along with the sources.

Table 6 Short listed Hazards

Nature Of Hazards	Sources & Location
Fire Hazards	HSD Storage area. Storage & handling of HSD in DG power house
Explosion Hazard	HSD

Nature Of Hazards	Sources & Location
Fire / explosions due to leakage	Spillage / transfer of HSD cause explosion due to leakage
Accidents due to material handling equipment	Connected with all material handling activities and equipment
Dust hazard	Storage and handling of product concentrate at production block as well in storage yard
High voltage electrical hazard	DG power house, switch yard, HT Motors/ lines
Fall from height	Civil construction works, welding and other hot jobs done at height.

Maximum Credible Accident Analysis

Hazardous substances may be released as a result of failures or catastrophes, causing possible damage to the surrounding area. This chapter deals with the question of how the consequences of the release of such substances and the damage to the surrounding area can be determined by means of models.

A disastrous situation is generally due to outcome of fire, explosion or toxic hazards in addition to other natural causes, which eventually lead to loss of life, property and ecological imbalance.

Various models for calculating the physical effects of the incidental release of hazardous substances are detailed subsequently. First, attention is paid to the factors, which are decisive for the selection of the models to be used in a particular situation, after which the various effect models are discussed.

Injuries Resulting from Flammable Liquids

In the case of flammable liquids such as HSD for immediate ignition of a pool fire will occur. The injuries in this case are mainly caused by heat radiation. Serious injuries as the result of the shock wave generally do not occur outside the fire ball zone. Fragmentation of the storage system can cause damage up to distance of over 50m depending on the capacity of the affected storage tank. If the gas is not ignited immediately, it will disperse into the atmosphere. If the gas cloud ignites it is assumed that everyone present within the gas cloud will die as a result of burns or asphyxiation. Outside the gas cloud the duration of the thermal load will be too brief to cause any injuries. In the event of very rapid combustion of the gas cloud the shock wave may cause damage outside the limits of the cloud. Explosive

combustion will only occur if the cloud is enclosed to some extent between buildings and obstacles. The Mathematical models and analytical models for Hazard Analysis of the flammable liquids in the proposed site considered are as shown in **Table 7,** damage criteria in **Table 8** and radiation exposure and lethality in **Table 9**.

Table 7 Mathematical models and analytical models for Hazard Analysis

S. No	Explosions	
1	Pool fire	Fire ball

Table 8 Damage criteria

Heat Radiation		Explosions		Toxic Gas Dispersion
Incident Flux KW/m2	**Damage**	**Peak overpressure (bar)**	**Damage**	
37.5	100% lethality, Heavy damage to equipment	0.3	Heavy - 90%	The extent of damage depends upon the concentration of the toxic compound in the atmosphere. The relation between percent of injuries and the toxic load is normally given in the form of probity function.
25.0	50% lethality, non-piloted ignition	0.03	Damage of glass	
12.5	1% lethality, piloted ignition	0.01	Crack of windows	
4.5	Not lethal, 1st degree burns			
1.6	No discomfort even after long exposure			

Table 9 Radiation Exposure and Lethality

Radiation Intensity (KW/m2)	Exposure Time (seconds)	Lethality (%)	Degree of Burns
1.6	--	0	No Discomfort even after long exposure
4.5	20	0	1 st
4.5	50	0	1 st
8.0	20	0	1 st
8.0	50	<1	3 rd
8.0	60	<1	3 rd
12.0	20	<1	2 nd
12.0	50	8	3 rd
12.5	--	1	--
25.0	--	50	--
37.5	--	100	--

Pool Fire Analysis of HSD Tanks

The detailed computations of FEI (Fire and Explosion Index) for HSD (High Speed Diesel) at proposed site are given in **Table 10.**

The Health (Nh), Flammability (Nf), Reactivity (Nr), and MF (Material Factor) for all the materials under consideration was derived from NFPA (National Fire Protection Association) codes. The GPH (General Process Hazard Factor) and SPH (Specific Process Hazard Factor) was calculated accordingly. Based on F&EI (Fire and Explosion Index), the HSD fall under light degree of hazard category an nil toxicity. Thus Risk Assessment and Hazard analysis has been carried out due to fire hazard for HSD storage tanks by carrying out MCA (Maximum Credible Accident) analysis.

Table 10 F&EI of fuels used for the Proposed Area

Chemical/Fuel	NFPA Classification				GPH	SPH	*F&EI	F&E Category
	Nh	Nf	Nr	MF				
HSD	1	2	0	10	1.1	1.4	50.4	Low
*FEI = MF *(1+GPH) * (1+SPH)								

The F&EI values are ranked into following categories

Table 11 F&EI Category

S.No	F&EI	F&E Category
1	1-60	Low
2	60-90	Medium
3	90 and above	Severe

Damage Distance Computations for MCA (Maximum Credible Accident) Analysis

The major hazard scenarios identified for the possibility of occurrence are mainly concerned with HSD Storage tanks.

Pool Fire of HSD Storage Tanks

A storage tank of HSD with a capacity of 1000 liters is considered for a DG sets of 250KVA for proposed mine. Tank fire would occur if the radiation intensity is high on the peripheral surface of tanks leading to increase in internal tank pressure. Pool fire would occur due to leakage gets ignited.

Table 12 Summary of Pool Fire for HSD

Site Data	
Location	Hosadurga, INDIA
Building Air Exchanges Per Hour	0.54 (unsheltered single storied)
Time	Time: February 16, 2017 1302 hours ST (using computer's clock)
Chemical Data:	
Chemical Name	High Speed Diesel
CAS Number	111-65-9
Molecular Weight	114.23 g/mol
PAC-1; PAC -2; PAC- 3	230 ppm; 385 ppm; 5000 ppm
IDLH	1000 ppm
Lower Emission Level	9600 ppm
Upper Emission Level	65000 ppm
Ambient Boiling Point	112.6 °C
Ambient Saturation Concentration	3.60%
Atmospheric Data: (Manual Input Of Data)	
Wind Speed	2.45 meters/second
Wind Direction	NE
Air Temperature	32° C
Stability Class	D
Relative Humidity	80%
Source Strength	
Source	Puddle
Type Of Puddle	Burning Puddle
Initial Puddle Temperature	32 °C
Tank Volume	1000 liters
Tank Diameter	0.8 meters
Tank Length	2 meters
Circular opening diameter	2 inches
Chemical Mass	662 kilograms
Max Flame Length	11 meters
Burn Duration	3 minutes
Max Burn Rate	62.6 kilograms/min
Total Amount Burned	102 kilograms
Threat Zone	
Threat Modeled	Thermal radiation from pool fire
Red	less than 10 meters(10.9 yards) --- (12.5 kW/(sq m))
Orange	16 meters --- (4.5 kW/(sq m))
Yellow	26 meters --- (1.6 kW/(sq m))

Figure 1 Risk Contours with Pool Fire Threat Zone for HSD

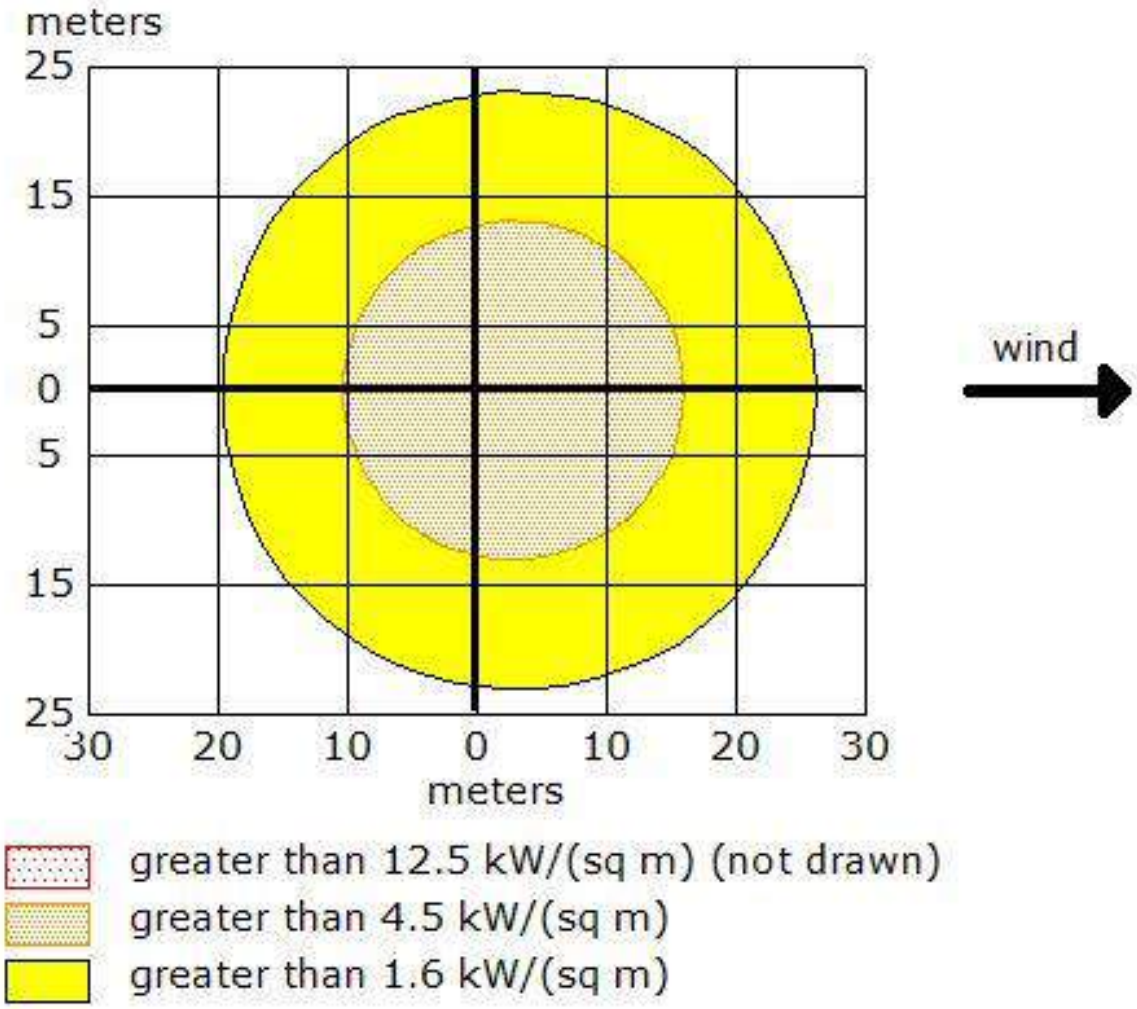

Figure 7.2 Risk Contours with Pool Fire Threat Zone in Google Earth Image

Orange Threat Zone 4.5 kW/(sq m)

Time: February 16, 2017 1302 hours ST
Chemical Name: N-OCTANE
Wind: 2.45 meters/second from NE at 10 meters

THREAT ZONE:
Red : less than 10 meters(10.9 yards) --- (12.5 kW/(sq m))
Orange: 16 meters --- (4.5 kW/(sq m))
Yellow: 26 meters --- (1.6 kW/(sq m))

Model: ALOHA Thermal radiation from pool fire

Yellow Threat Zone 1.6 kW/(sq m)

Time: February 16, 2017 1302 hours ST
Chemical Name: N-OCTANE
Wind: 2.45 meters/second from NE at 10 meters

THREAT ZONE:
Red : less than 10 meters(10.9 yards) --- (12.5 kW/(sq m))
Orange: 16 meters --- (4.5 kW/(sq m))
Yellow: 26 meters --- (1.6 kW/(sq m))

Model: ALOHA Thermal radiation from pool fire

Google Earth Pro

miles 2
km 3

Disaster Management Plan

Disaster management plan is prepared with respect to the following accidents-

Open Cast Bench Slope Failure

For determining factor of safety, the bench slopes are to be monitored regularly by sensitive instruments at precise level at regular intervals to check for any possible ground movement. A well-developed drainage system over the lease hold area is to be ensured to check the storm water flows out of the lease area.

- Failure to make and keep the quarry sides secure by proper benching, sloping and keeping benches of adequate height and width.
- Undercutting so as to cause dangerous covering.
- Inadequate nos. of competent persons for carrying out statutory inspections.
- Lack of supervision.

Accidents due to Transportation

- During reversal operation
- Unauthorized driving of vehicles (mostly by helpers)
- Riding of unauthorized vehicles
- Attempt to ride moving vehicles
- Overloading
- Driving vehicles in an intoxicated stage
- Vehicles moving in steep gradient or on benches of inadequate width

Other than Transportation Machinery

- Use of substandard equipment
- Attempt to clean moving parts of machinery
- Non provision or removal of guards for moving parts of machinery

Accidents due to use of Explosives

Since site mixed slurry will be used, there will be no requirement of large storage facilities. However a magazine is to be provided for the storage of primers, detonators, fuse etc.

The explosive magazine is designed in such a manner that normal chances of fire inside the magazine ruled out. Still following precaution are taken:

- Clearance of dried vegetation within 15m of Magazine House.
- Installation of lightening arresters on the Magazine to prevent damages in the event of an explosion.
- Provision of fire extinguishers, water and sand filled buckets.
- Arrangement of mounds around the magazine to mitigate damage in the event of an explosion.
- Keeping a safety zone margin around the Magazine as per the guidelines given in Schedule VIII of The Explosives Rules, 1983. The safety distance of 605m will be maintained from the public establishments.

Plans for Disaster Management:

On site plan: On Site plan shall be in place which includes the following:

- Regular safety audit/inspection;
- Incident Response team and role and responsibility of each member;
- Procedures for taking care of incidents/emergencies;
- Mock drills
- Assembly point;
- Communication system/arrangement with administrative and regulatory agencies, media and public etc.
- Siren for declaring/closing emergency;
- Regular training on first aid and evacuation etc.

Off site plan: Off site plan shall be in place which includes the following:

- Contact details of fire brigade, local police, hospitals, local district administration, factory inspector, state pollution control board, state electricity board etc.
- Demographic details and topography map of the surrounding area;
- Communication system/arrangement with above mentioned agencies, media and public etc.

Topography

Topographically project site area occupies a hillock range running NNW-SSE with a major mound continued with plain minor adulatory land towards east. These mounds are comprised of elevation of moderate to steep slopes. The highest elevation of site 800m AMSL observed at site center and lowest elevation of site 690 m AMSL is observed near seasonal nala. The drainage pattern of the buffer zone is dendritic to sub dendritic in nature. A seasonal nala is passing east to west at mid of the area.

Slope Analysis

Slope, aspect and altitude are important terrain parameters from land utilization point of view. Among the three, slope is very vital one for land irrigability and land capability assessment. Terrain captures the surface features and slope of the landscape, which are important determinants of drainage and soil characteristics. Slope is a fundamental determinant of land capability, run-off rates, soil erosion and groundwater recharge. Landforms have a structural and morphological origin, while slope represents the elevation or steepness of the landscape between any two adjoining points and the rate at which this changes.

Methodology

Survey of India Toposheet on 1:50,000 scales were used for deriving the formation on slopes, aspect and altitude. A land with five meters of vertical drop over a horizontal distance of 100 meters has 5% slopes. Accordingly, 10 m or 20m vertical drop for every 100 meters of horizontal distance is 10% or 20% slope respectively.

Topographical maps on 1:50,000 scale give contours with 20 metre interval. The vertical drop can be estimated/measured from the contour intervals and the horizontal distance in between the contours can be measured from maps by multiplying the map distance with the scale factor. Close spaced contours on the map have higher percentage slope as compared to sparse contours in the same space. Thus density of contours on the map can be used for preparing the slope map that gives various groups / categories of slopes. In case of drainage analysis, stream frequency represents the total number of channels required to drain a unit area of the watershed. Higher values imply greater 'slopes', lower permeability and greater structural control. This is particularly so for First and 2nd order stream frequency.It also forms a drainage divide, with the streams originating here taking a radial course. The area demarcated into slope categories are given in **Table 7.13** and shown in **Figure 7.3**.

Figure 3 Slope Map of the Study Area

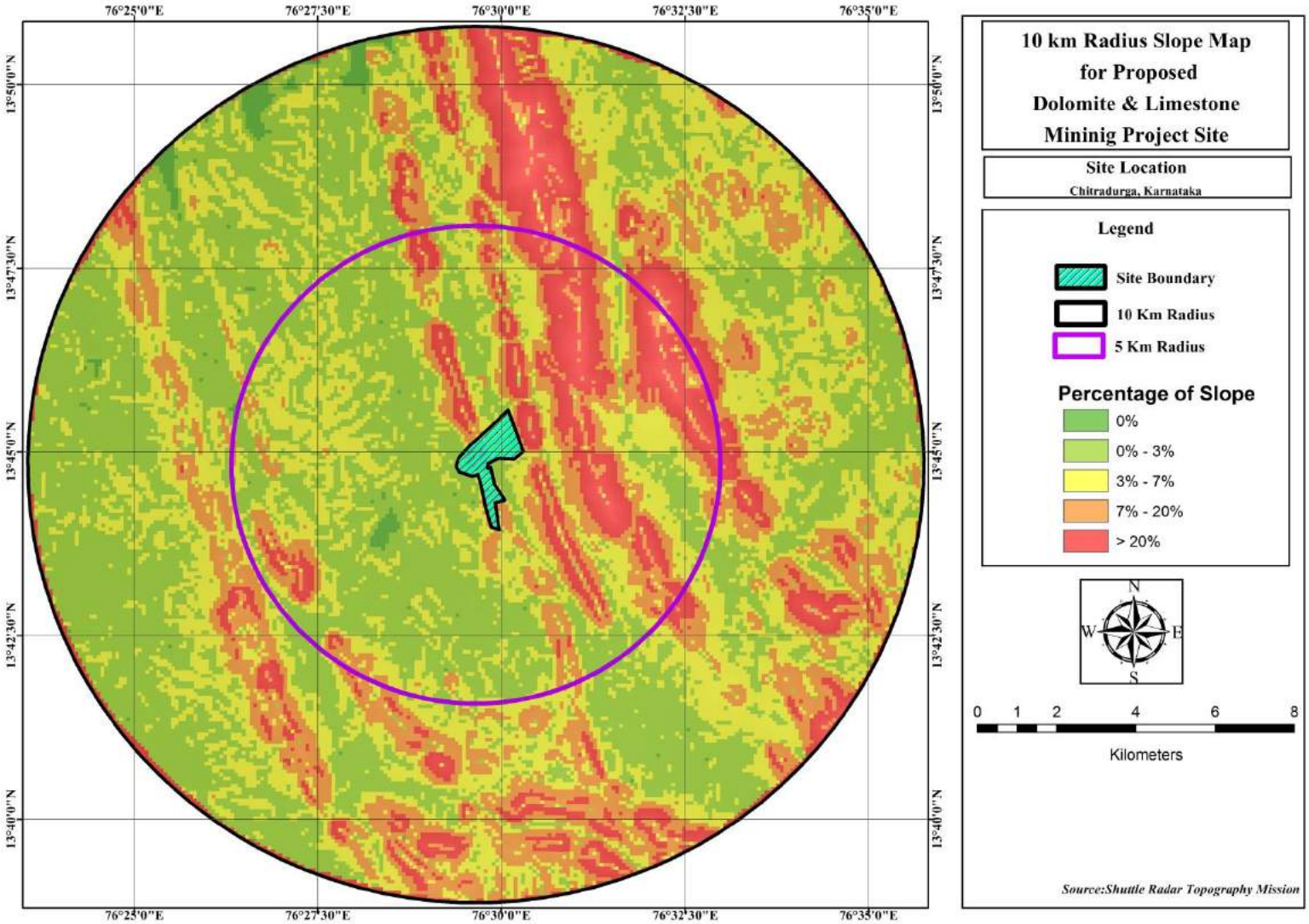

Table 13 Major Slope Categories in the Study Area

S. No.	Slope Category	Slope (%)
1	Nearly Level	0 – 5
2	Gently Sloping	5 – 10
3	Moderate Sloping	10 – 20
4	Steep Sloping	> 20