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Environmental Impact Assessment (EIA) and Prediction Method: Case Study

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ABSTRACT

Environmental Impact Assessments (EIAs) identify or predict any potential problems in the Environment at the planning stage of proposed development projects, and concerns are addressed as the Project progresses. It is in progress. The recommendations made by the EIA may lead to the redesign of specific project components, require additional studies, and suggest mitigation measures that will alter the socio-economic viability of the Project or cause delays in project implementation [1]. The EIA's main objective is to identify significant impacts early in the project cycle so that recommendations can be incorporated into the design and cost-benefit analysis without causing substantial delays. Increase or increase design costs [1]. The EIA will lead the appropriate environmental monitoring and management planning mechanism when implementation commences. In the case of this study, the EIA method is applied to evaluate different ecological components such as physical and chemical parameters and biological and socioeconomic parameters of the project “Construction of the office complex".

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1. Introduction

The Environmental Impact Assessment (EIA) study aims to consider the Environment its due place by clearly evaluating the environmental consequences of any developmental activity [2]. The study will seek to adequately investigate and address all potential impact issues to provide a clear and transparent understanding to the concerned authorities/Ministry and the public so that the proposed project work adheres to the required environmental standard per the engineering and technical requirements of the country. An EIA report is to be prepared only by a licensed third-party consultant by the associated EIA approval authority/Ministry competent. The findings of the EIA are presented in a document known as an environmental impact statement (EIS) which is considered by the competent authority in determining the development [3]. The emphasis of EIA is early prevention of ecological damage rather than its subsequent cure, and it should be seen both as an aid to decision making andkick a tool for sustainable environmental management [3].

1.1. Validity of eia study

In general, an environmental impact assessment for a project will cover the impacts for the following phases.

- Construction (including commissioning phase)
- Operation phase
- Abnormal /Emergency conditions

1.2. General Impact Assessment Process

The following figure illustrates the process of identifying and assessing impacts through scoping, screening, and detailed impact assessment [4] [5].

1) Scoping phase: project activities that interact with ecological and social receptors are identified for further evaluation. Areas, where no interaction is expected, are "excluded" from the evaluation.

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2) Initial Assessment: Potential interactions are further assessed based on site-specific conditions based on the information gathered through the baseline survey. Interactions are "sieved" if the potential for effects is nonexistent or negligible.

3) Detailed evaluation: The interaction with potential effects is evaluated in detail to determine the properties and characteristics. Mitigation measures will be applied, and the residual effect will be reassessed. Next, the importance of the remaining impact is reported.

Fig 1. *General steps in EIA*

2. EIA Study Plan: Methodology

The study will aim to adequately investigate and evaluate all potential impact issues to provide a clear and transparent understanding to approval authority highlighting the project facilities, its operations, safety measures and inform whether the Project is meeting the environmental requirements of the country. The EIA report to be structured based on the legislative Guideline on Environmental Impact Assessment as per Environmental protection Law and standards [6].

The following tasks will be conducted to fulfil the main objective of this EIA study:

- Project Mobilization, Review of available literature, Field visit and checking the prevailing conditions.
- Baseline Assessment (Characterize existing Environment and assess various Environmental Indicators air quality, soil, noise, and water)
- Assess, Identify, and quantify the impacts of various project activities on the identified environmental indicators
- EIA report preparation and submission.

Carryout meeting and presentation with Authority /Ministry and coordination between the project owner as per the applicable guidelines and requirements for necessary approvals.

The methodology used in this report has considered the “Construction of an office complex” as a case study.

2.1. Project Kick-off meeting

Introductory meeting between proponent and consultant. Discussing the details of the proposed Project with respect to layout, engineering details; quantity and type of materials used, Waste generation etc. must be made available to consultant by client.

2.2. Mobilization of the Project

This task will allow the project team members to become familiar with the scope of the work involved in each task, the scope of Project, objectives and duration of the Project and area of study.

2.3. Baseline assessment

Baseline assessment of the project area is one of the important elements in an EIA study which is time and cost-consuming activity. This includes a description of the existing environmental setting i.e., record of conditions before a project is introduced to the area selected. All environmental components with the potential to be affected by the Project will be assessed in this step [7].

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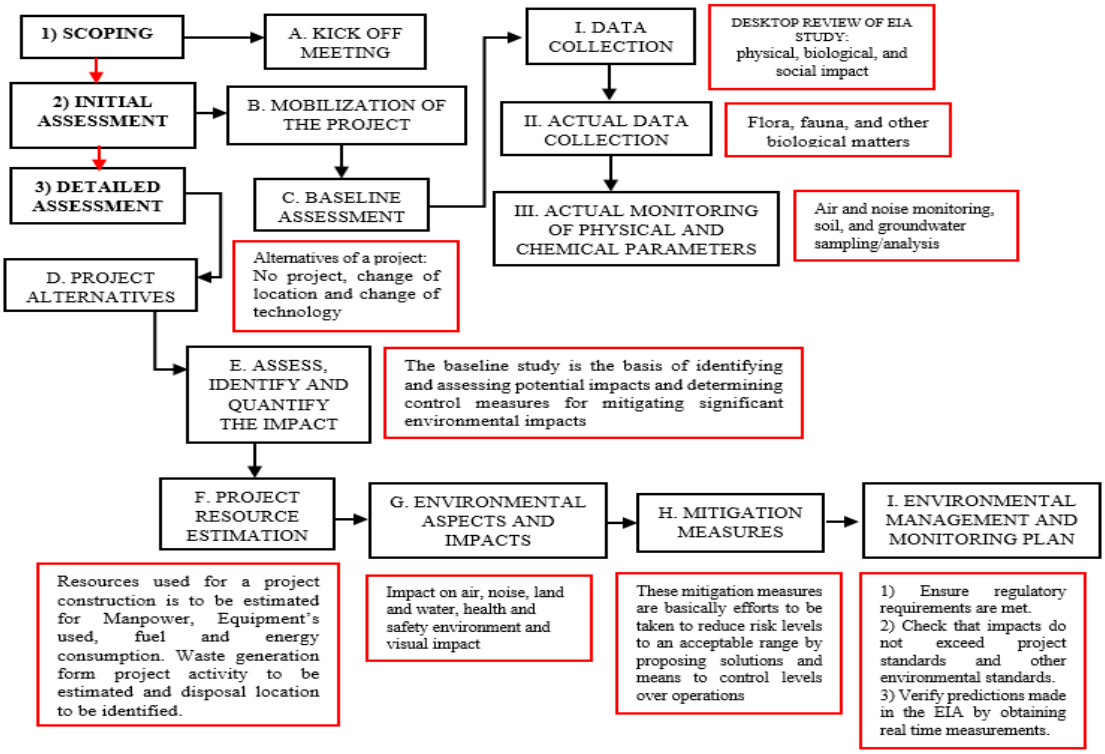

Fig 2. *Methodology*

2.3.1. Data collection: baseline data is collected by a desktop review of the Project's physical parameters like topography and geology, earthquakes, natural hazards, climate, and weather data. biological parameters like fish and marine living creatures, rare species, sensitive areas (forests, protected area, natural parks, etc) and socioeconomic parameters.

2.3.2. Actual baseline data collection: Information on the flora and fauna to be collected through visual observation and counting of vegetation and fauna observation based on different types and locations of occurrence and finally a summary table with name of species and location coordinates of observation. The presence of rare and endangered species or sensitive habitats are not observed within or near the project area (Actual site visit and latest published literature were referred).

2.3.3. Actual monitoring of physical and chemical parameters: Monitoring activities considered for baseline assessment are detailed below:

a) Air quality monitoring: 15 days of continuous air quality monitoring data were collected near the project location. Parameters to be monitored are SO_2, H_2S, NO_2, CO, O_3, HC (methane and non-methane), BTEX, PM_{10}, wind speed, and wind direction [2]. The meteorological parameters are recorded during air quality assessment. Plotting of wind rose is one of the essential requirements for the baseline assessment.

b) Nosie monitoring: short- and long-term noise monitoring to be carried out at project site using Sound meter at different locations to obtain a baseline noise data. This will be for an intermittent duration during peak and non-peak hours. Noise measurements were taken at minimum of 4 locations.

c) Soil sampling and analysis: During borehole drilling, soil samples were extracted from the surface and at 1m depth (to represent subsurface). which shall include two soil samples from the top of 50 cm near by the site, and three soil samples at the site boundaries. The samples will be tested for Oil and grease, Total Organic Carbon (TOC), TPH, Magnesium, Chloride, Sulphate, Nitrate, Fluoride, Sodium, Potassium and Heavy metals.

d) Groundwater sampling and analysis: At least two boreholes must be drilled at the site to understand the existence of groundwater in the vicinity of the Project. The number of drilling locations is determined based on the scope of the site and the nature of the proposed activity as the case study examined here is associated with a minor construction only. After collection of all data, necessary statistical interpretation, and comparison with applicable standards to be made to establish the baseline environmental conditions.

2.4. Project alternatives

Various alternatives assessed to minimize environmental impacts in a project need be included in an EIA report based on project planning and design team information [5] [9]. Alternatives of a project shall discuss the following:

1) No project: This option will be considered only when the result of impact assessment identifies significant negative impacts which cannot be recovered even after mitigation measures.

2) Change of location: Based on the impact assessment, if the change to an alternate location can reduce the impact and overall impact severity is high for the proposed location, then this option maybe taken under consideration.

3) Change of technology: The proposed office building to be constructed uses solar panels for self-powering the building and energy-saving option for all electrical items and fittings.

2.5. Assess, identify, and quantify the impacts:

The baseline study shall form the basis of identifying and assessing potential impacts to the Environment due to the Project development and determining control measures for mitigating significant environmental impacts [10].

2.6. Project resource estimation:

Resources used for a project construction is to be estimated for Manpower, Equipment's used, fuel and energy consumption. Waste generation form project activity to be estimated and disposal location to be identified in conformity with applicable guidelines existing with respect to selected project area [11].

2.7. Environmental aspects and impacts:

1) Impact on air environmental: The potential impacts on air quality will occur mostly during the excavation and from other equipment's used at project area [5].

2) Impact on noise environment: Project construction will cause some noise from pneumatic hammers, air compressors, and other earth movers during construction.

3) Impact on land and water environment Contamination of water from leakages of fuels and lubricants from the construction equipment's and vehicles may take place. Both solid and liquid wastes can be generated during construction phase of the Project. Different wastes including food scraps, packaging, building, rubbish, and latrine waste would be generated at the project site. Hazardous waste such as paints, solvents and chemicals can be generated.

4) Occupational health and safety environment: Working accidents might happen for different reasons in the work with excavators, trucks, and other related equipment.

5) Visual impact: Construction activities such as clearing, grading, and compacting using heavy machinery have potential to change the visual landscape.

2.8. Mitigation measures:

The mitigation measures are basically efforts to be taken to reduce risk levels to an acceptable range by proposing environmentally friendly solutions and means to control levels over operations [12]. This mainly include actions or control measures that are to be implemented to reduce the identified significant impacts [13].

2.9. Environmental management and monitoring plan:

Environmental management provides feedback about the actual environmental impacts of a project. It is also used to ensure compliance with environmental standards, and to facilitate any project design changes or operational changes [14]. This plan outlines the key monitoring requirements identified through the EIA process to monitor the environmental and social performance of the Project.

3. Impact Prediction Methods

Every Project has different type of methods to prepare EIA for the Project. Here is a list of methods (Table 1) and type of projects suitable against each of them [15].

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Table 1. *Prediction Methods*

S.No	*Methods*	*Projects*	*Remarks*
1	Aspect and Impact Risk Matrix Method	Oil and Gas pipelines	Generally used based on risk to asset and humans.
2	Rapid Impact Assessment Matrix (RIAM)	ALL SECTORS	Provides a quantitative assessment on all aspects selected. This requires multiple expert opinions.
3	Geographical Information System (GIS) method	Projects involving Land use.	Primarily used for marine dredging, city development, but still needs real-time data before and after a project. The time and cost of software is tremendous.
4	Ad hoc methods	broad areas of possible impacts by listing environmental parameters (Ex: flora and fauna)	Each parameter is considered separately, and the nature of impacts are considered. It gives a rough assessment of total impact while giving the broad areas and the general nature of possible impacts.
5	Checklist method	ALL SECTORS	Environmental factors are listed in a structured format by giving importance weightings for factors and application of scaling techniques for impacts of each alternative.
6	Network method	Small short-term projects	This method uses the matrix approach and extends it to include both the primary as well as the secondary impacts.
7	The Battelle method	Mainly used for water related projects also suitable for all other projects	It gives a comparative analysis between several situations; thus, it is particularly efficient when effecting choices between alternatives
8	Project Definition Rating Index (PDRI)	industrial projects, building projects, Railway, and Infrastructure Projects	The PDRI tool allows visibility of risk areas and focused attention.

4. Case Study: Construction of Office Complex

In order to cater the increased manpower growth expected by 2025, a plan to increase office spaces by constructing a New Office complex. The proposed Project is to create sufficient office spaces with well-designed Office Complex.

The scope of work for this Project is to construct Office Buildings with three-story reinforced concrete structures (ground, first & second floors), with approx. ground floor area of 15,000.00 M^2 and floor height approximately 5m. This office is planned to construct near an Oil & Gas production filed in middle east region. Total capacity is 2000 offices.

4.1. Baseline environmental condition

The existing site conditions were assessed via field observation, and literature review. Several site visits were performed for gathering information on the existing (baseline) environment. In the present context, the project activities are confined to the Oil & Gas production area. The proposed office complex construction site is devoid of any major vegetation. However, during the site visits, presence of Baileya multiradiata, Fagonia bruguieri, Salicornia europaea, Horwoodia dicksoniae were observed due to the prevailing warm climatic conditions.

4.1.1. Ambient air quality:

Ambient air quality monitoring data collected from the site in the recent period is utilized for basic understanding of air quality profile of the area. Monitoring was conducted in accordance with United States 40 CFR 53 for two weeks period. The analyzed parameters are, Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Carbon monoxide (CO), Ozone (O_3), Particulate Matter (PM_{10}), Ammonia (NH_3), Hydrogen Sulphide (H_2S), and Non-Methane Hydrocarbons (NMHC). Monitoring of meteorological parameters like Wind Direction, Wind Speed, Temperature, Humidity, Rainfall, and Solar Radiation were also done during the study period. The daily maximum and minimum ambient air quality parameters like PM_{10}, NO_2, NH_3, SO_2, H_2S, O_3, CO, and NMHC are observed to be within the set limit by the Local Environment Authority applicable to the project area. The wind rose diagram and summary data is presented below. Refer Figure 3 and Table II.

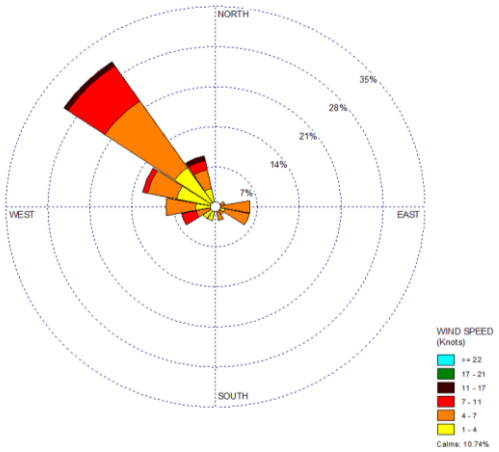

Fig 3. *Wind rose diagram of the construction location*

Table 2. *AAQ monitoring data*

	SO_2	NO_2	CO	O^3	PM_{10}	NH_3	H_2S	NMHC
	ppb	ppb	ppm	ppb	µg/m^3	ppb	ppb	ppm
EPA LIMIT	**75**	**100**	**35**			**800**	**100**	**0.24**
Max.	6.1	6.6	1.2	11.0	66.4	5.1	4.5	0.23
Min.	7.1	6.5	1.8	7.4	64.2	4.4	4.1	0.21
Average	6.6	6.55	1.5	9.2	65.3	4.75	4.3	0.22

4.1.2. Noise monitoring:

Based on the site visit, no significant noise emission source was identified in the project areas. This is attributed to the remoteness of the site to the noise sources. Noise monitoring was done for a period of seven days 24 hours. The hourly Leq values for the location are presented in Table III.

Table 3. *Noise Monitoring Data*

	Day 1	***Day 2***	***Day 3***	***Day 4***	***Day 5***	***Day 6***	***Day 7***
Min.	53.4	50.3	57.6	51.4	49.8	57.6	54.5
Max.	58.2	62	58.9	52.8	53.3	57.7	59.1
Avg	55.8	56.15	58.25	52.1	51.55	57.65	56.8

4.1.3. Flora and Fauna:

The quantitative evaluation of vegetation has not been conducted in detail in the initial stages of Project. However, during site visit, a scattered patch of desert vegetation is observed in the site vicinity which belongs to seasonal flora. Baileya multiradiata, Fagonia bruguieri, Salicornia europaea, Succulent plant and Horwoodia dicksoniae were observed at site. No animals are spotted at site during site visit. Minor arthropods were observed. No endangered habitats or rare species were reported within the proposed project site

4.1.4. Soil and Groundwater conditions:

Soil samples from surface (within 0.5m) and subsurface (within 1-2m) were collected and tested. The samples were analysed using EPA SW 846 method. (For analysis of moisture content ASTM D2216 method was used. Generally the physical nature of soil light brown, medium grained, silty sand, poorly-graded, non-plastic, moist condition, strong reaction with HCl (Hydrochloric acid) encountered within few meters (0 to 1.5m) below ground surface. The subsurface soil shows almost similar physical characteristics with weak reaction with HCl from a depth of 1.5m to 15m below ground surface. The soil is loose and dry with greater porosity. Total Petroleum Hydrocarbon, Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Copper, Lead, Mercury, Nickel, Zinc, Iron, Sulphates, pH (1:1), Chloride, Conductivity (1:1), Total Organic Carbon (TOC), Porosity and Moisture were analysed for each soil sample. The obtained results are within limits as per the Canadian Soil Quality standards for commercial land.

In the soil, the water-soluble chloride (Cl-) content ranges from 0.0142% to 0.0531% and the water soluble sulphate (SO4) content varies from 0.0287% to 0.3206 %. Organic matter contained in soil was found to vary from 0.018 % to 0.026 %, so it is a non-organic soil. The soil pH ranges from 7.84 to 8.24. Ground water was not encountered within the 15m depth of Borehole drilling.

4.2. Socio-economic Status

Since the discovery of oil, middle east region has witnessed unprecedented growth in economics and transformed the entire socioeconomic fabric of the country into modern Industrial state. It is reported that local GDP growth rate as 5.7%, and per capita income is approximately US$81,800 (2019). Average population growth varies from 2 to 5%. Community settlements are not observed within a radius of 10km.

4.3. Alternative analysis

This section describes various project alternatives that can be considered by the project proponents and the project implementer. By implementing any of the alternatives suggested, the project proponents can reduce the impact on the environment, reduce estimated cost, and enhance occupational health. The alternatives considered for this Project are the No Project Alternative and Change of Location.

4.3.1. No project alternative:

The new office complex construction is proposed in purview of the 2025 developmental strategy for accommodating further expansion in the workforce. In the context of no project alternative, the proposed construction activities will be ignored, and development strategies adopted so far must be halted. This will create a negative impact on the future growth aspects of the company itself. Hence a no project alternative must be ignored for a positive/progressive growth.

4.3.2. Change of Location:

Two locations were considered for this new office complex construction as option 1 and 2, which are *option 1*, distance from nearest road is 3km and 1km, proximity for emergency response team to reach the location will take them to travel 3.7km and the easiest access to the site is 1km from express road. The existing overhead cable must be replaced. For *option 2*, the access to the site from both nearby express road is within 500 meters, nearest hospital or emergency services is just 800 meters away and no demolition work is required.

Considering the above factors, it is evident that the Option 2 is the most viable option in terms of ease of emergency response, cost for access road construction, cost for demolition and relocation of overhead lines etc. Hence Option 2 is selected for construction of office complex.

4.4. Project resource estimation

Based on the project resource information collected from client, at the peak construction phase, the maximum number of employees would be around 500. During the planning phase, the maximum number of manpower is 50.

4.5. Project impacts

4.5.1. Positive aspects of the Project:

- The generation of employment and income to local community during construction phases of the Project is considered as short-term positive impact. The Project provides employment opportunities to around 500 individuals directly.
- The new office construction layout will be selected is a replica of newly developed buildings in the nearby office complex new with respect to size, design, and layout. Such uniformity will improve the aesthetics of the currently barren un-occupied location.
- By constructing the office complex, the barren un-occupied land will be utilized by transforming it into useful office space.

4.5.2. Impact on air environment:

Major site activities occur during the initial phases of construction. Drilling and trenching activities for laying cables involve major equipment usage and thus emissions like SO_x, NOx, and VOC etc. will be increased. Project area is being an arid desert, the topsoil is found to be loose and consists

of very fine, particulates and contributes for emission of dust (particularly PM_{10}) as suspended particulate matter.

4.5.3. Impact on noise environment:

In planning phase during the site survey and identification of physical site condition, the noise intensity from the facility will not pose any direct impact to people involved in planning phase. During borehole drilling activities at project site the noise level may exceed up to 87dBA. Since this is of short duration (10 to 15 days) the noise impact is slight negative for a short period. During the construction phase, an increase in noise levels are expected. The allowable limit during daytime for Industrial & commercial area is 70 dB(A) but standard equipment generated noise level would be 85 dB (A) approximately.

4.5.4. Impact on land:

During the construction period, solid wastes will be generated significantly as construction refuse. Liquid waste generation is also anticipated from temporary site office during construction. Sanitary liquid waste is expected during the operation phase of office complex.

4.5.5. Impact on Socioeconomic Environment:

The socioeconomic Environment includes various community-level impacts due to the project activity. Since the proposed Project is localized within an Oil and Gas operational area, the beneficiaries involve main contractors and sub-contractors. Based on project location, it can be stated that no involvement of local communities is expected. Hence the community level impact identification is not considered. The employment opportunities raised by the Project is the positive aspect to be considered in this Project. However, if the employment involves, immigration of technical/non-technical staff from overseas, a slight negative impact can be considered when the socio-cultural mixing and associated imbalance.

4.5.6. Impact on global climatic conditions:

The proposed Project will have negligible impact on the global climatic conditions due to the non-hazardous nature of the Project. However, emissions from vehicular movement and equipment usage can contribute marginal short-term increase in CO_2, NO_x, PM_{10} emissions which can contribute to global warming and associated global climatic changes. In the course of project development such situations are unavoidable.

4.5.7. Impact on biological Environment:

The biological resources of the area will not be affected much since the proposed project area does not support for any biologically important fauna and flora of the region. Since no endangered species are noticed during the site investigation, the biological communities will not be affected much due the construction activity. Site clearance and requirement of landfill space to dispose of generated wastes are the main aspects impacting fauna from the proposed Project which is anticipated to be marginal.

4.6. Mitigation measures

In the Environmental Impact Assessment context, mitigation refers to the set of measures taken to eliminate, reduce, or remedy potential undesirable effects resulting from the proposed Project. Mitigation measure typically considered in all the developmental stages of the facility, are, the site selection process, as well as the design, construction, and operation phases.

4.6.1. Air environment:

- Excavation/drilling can be delayed until all installation setup and necessary materials are ready. This would decrease total dust impacts from excavated piles.
- Excavation works need to halt during strong winds and sandstorms to minimize impacts from dust particulates
- Vehicles, heavy equipment, and machinery should be maintained regularly to keep air emissions under prescribed standards.

- Old and outdated heavy equipment and machinery should be replaced with new ones as they may cause high emissions and noise.
- Periodical audits need to be conducted so to check site air quality.
- Maximize use of existing asphalt roads for transport equipment and materials to minimize the impact from dust caused by movement of construction equipment.
- In general, to minimize impact from dust all excavations, stockpiles, embankments, access roads and other work areas will be properly maintained.
- Sand piles and temporary access roads to be sprinkled with water to minimize dust emissions.

4.6.2. Noise environment:

- Vehicles, heavy equipment, and machinery need be regularly maintained to keep noise levels at a minimum.
- Old and outdated equipment should be replaced with new ones as they may cause high noise.
- All machines in intermittent use need to be shut down when not in use.
- Harmful exposure to sound intensity in work areas that need to be eliminated or minimized by proper planning and careful design. Noise control considerations include replacement with quieter sources, insulation, containment, elastic mounting, and sound absorption techniques.
- Periodical audits need to take place to check site noise levels and workers usage of PPE.
- All vehicles and plants used during construction operations need to be fitted with appropriate effective mufflers and will be maintained in good working order.

4.6.3. Land environment:

- Increase green belts around and within site as possible so to decrease effects of winds (desertification) and improve surface soil stability.
- Use already existing routes if feasible so to decrease soil fragmentation.
- Minimize the site clearance area by staying within the defined boundaries.
- No direct disposal of untreated (contaminated) wastewater is to be made to unprotected site soils. Maintenance of site equipment need be monitored to make sure no oils are disposed of or leaked at site.
- When working hot, it is necessary to cover the sewers and drains and remove oil-contaminated soil.
- Drilling should be checked daily before starting work to ensure that the underlying soil is not settled. After the drainage ditches collapse due to heavy rain or falling objects, all excavations should be carefully inspected.

4.6.4. Waste management:

- Wastes from construction must be transported to the outside storage yard for construction refuse to a centralized disposal. Domestic refuse from site office to be collected and conveyed to landfill site for landfilling.
- Liquid waste from the proposed Project during the construction and operation period to be disposed through approved agents to authorized treatment facility to minimize adverse impact on neighboring Environment.

4.6.5. Biological Environment:

- Increase green belts around and within site to improve site ecology. This would also decrease air and noise pollution.
- Minimize as possible right of ways and use already existing routes so as to decrease habitat destruction.
- Develop ground greeneries and landscaping which can host plants and animals.
- A waste management program to be implemented to minimize the amount of generated solid waste so to minimize land requirement for landfilling that destroys flora and fauna habitat. It should establish the following hierarchy of preference, in choosing waste handling options: 1) source reduction, 2) recycling/reuse, 3) disposal

4.7. Monitoring plan

An environmental monitoring plan to be implemented to address the adverse environmental impacts of a project during its execution, to enhance project benefits, and to introduce standards of good practice

to be adopted for all Project works. A pre-construction as well as construction phase monitoring is suggested considering the nature of the present project scope.

5. Conclusions

A final Report incorporating comments from reviewing authority if any to be produced for acceptance for final approval and issue permit. Periodic monitoring plan to be submitted to approving authority and a construction completion report to be submitted indicating the environmental compliances and final site restoration conditions.

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