Draft Environmental Impact Assessment
Volume 1

Project Number: 48307-001
July 2014

PAK: Engro Fast Track LNG Regasification Project

Prepared by Environmental Management Consultants (EMC) for Engro Elengy Terminal Private Limited

ELENGY TERMINAL PAKISTAN LIMITED

JULY 2014

ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT REPORT

PROPOSED LNG IMPORT TERMINAL PROJECT, PORT QASIM-KARACHI

Environmental Management Consultants

بسم الله الرحمن الرحيم

In The Name of Allah, The Most Beneficent, The Most Merciful

ELENGY TERMINAL PAKISTAN LIMITED

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EXECUTIVE SUMMARY

INTRODUCTION AND OBJECTIVES

This Environmental & Social Impact Assessment (ESIA) evaluates the potential environmental, social, economic, cultural, and natural impacts of the proposed Liquefied Natural Gas (LNG) Import Floating Terminal Project. Environmental Management Consultants (EMC) Pakistan has been contracted as a third party consultant by Elengy Terminal Pakistan Limited (hereinafter referred as proponent) to conduct a detailed assessment (ESIA) of the proposed LNG project.

Elengy Terminal Pakistan Limited (ETPL) was registered under the SECP Act 1997, in January 2012, and is a 100% owned subsidiary of Engro Corporation Pakistan to position Engro as a partner of choice with Key Stake holders. ETPL boasts of experience in terminal business due to its affiliation with Engro Vopak Terminal Limited, a joint venture of Engro Corporation (Pakistan) Limited (50%) and Royal Vopak of the Netherlands (50%). ETPL intends to develop a 3.5 mtpa floating LNG terminal in the jurisdiction of Port Qasim. The project includes constructing and operating a Liquefied Natural Gas (LNG) terminal in Port Qasim, inclusive of ship berthing and import facilities, floating storage tanks and regasification equipment. The project intends to provide facilities for receiving supplies of LNG via a conventional LNG carrier, for offloading, transfer and loading into a Floating Storage and Regasification Arrangement (FSRA) which can be an FSRU, or FSU+ On Shore Regasification, or FSU + on barge Regasification. The FSRA will store and re-gasify the LNG and deliver the re-gasified liquefied natural gas (RLNG) via jetty and onshore associated facilities to the gas network operated by the in-country transmission pipeline providers.

Dredging will be required to create the berthing and the turning basin. Dredged material will be utilized for the reclamation and to construct shore protection structure. The balance will be dumped at sites advised by PQA. The construction of the LNG import terminal is expected to begin by 1Q 2014 and will be completed within 11 months. The estimated cost of the proposed project is USD 120 million.

The GOP had mandated SSGC to develop a project for the import of LNG. The first supply of LNG of 3.5 million tons per annum (equivalent to 500 MMCFD of gas) was targeted for the year 2011; followed by another for supply of 2.0mtpa by the year 2013. The projects stand delayed, while the shortage keeps multiplying. This has gone to the extent that the most populated province 'Punjab' is facing five to six days of gas shutdown while the electricity supply from power houses in Sindh and Punjab are resulting in shutdown from six to eight hours per day.

Each industry running boilers to generate steam is being forced to use coal, furnace oil and diesel with increased utilization of firewood and charcoal in homes, thus inducing rapid deforestation and warming of their microenvironment.

ETPL intends to follow a fast track approach towards developing the LNG import floating terminal in order to bridge the gap between supply and demand of energy. The Project is primarily based on developing the required infrastructure so that LNG can be brought into the Natural Gas (NG) market, which has witnessed phenomenal growth in the energy sector in Pakistan. In the first stage, the focus is on the fastest method to facilitate LNG flow into the NG pipeline network in Pakistan.

LEGISLATIVE REQUIREMENT

This ESIA has been prepared to fulfill the regulatory requirements of Pakistan Environmental Protection Act, 1997 and to satisfy the evaluation criteria of the International Finance Corporation (IFC). Applicable National & International Guidelines and regulations have been used as a reference in preparing this ESIA. The project falls in Schedule-II of Pakistan Environmental Protection Agency (Review of IEE/EIA) Regulations-2000 and Category-A of Equator Principles which means it could have significant environmental impacts if appropriate mitigating measures are not implemented. PEPA Review of IEE/EIA Regulations 2000 categorizes projects in two separate Schedules, which require either an IEE or an EIA. The LNG jetty comes under both Schedules which have port and harbor development projects listed. Schedule-I projects require an IEE and concerns ports and harbors having ship displacement of less than gross 500 tons. Schedule-II is applicable if the gross displacement exceeds 500 tons and requires an EIA. The proposed LNG terminal project falls under Schedule-II as it involves shipping activity having gross displacement above 500 tons and will thus require an EIA.

THE PROJECT

The Project is intended to provide facilities for receiving supplies of liquefied natural gas (LNG) via conventional LNG carrier (LNGC), for offloading and dockside transfer to an FSRA. The re-gasified liquefied natural gas (RLNG) will be delivered via a jetty and onshore facilities to the gas networks operated by SSGC. The facility would be designed as per the codes and standards mentioned in LNG Policy 2011, Guidelines provided by PQA and International Codes and standards that are recommended by the engineering consultant in line with the best practices of the industry. Given the nature of the business and the valuable asset placed in the proposed terminal, audits by LNGC and FSRU operator ensures that the terminal is designed and operated to international standards. Non conformance would mean non utilization of the terminal by LNGC

bringing product or the FSRU operator to process the gas to the SSGC.

From the ETPL, the re-gasified LNG will be transported via pipeline to SSGC Grid at KESC Bin Qasim Power Plant. The pipeline from ETPL boundary wall upto the Delivery point after KESC Bin Qasim shall be underground, buried with minimum depths of 1 m.

From this point, a 42 inch SSGC Branch Pipeline shall be constructed and buried underground all the way upto SMS Pakland. This route has the following salient features to its advantages;

- Total length ~23 km
- Majority of ROW within PQA
- No major population centers along the route
- Does not cross main navigational channel or any major road/rail crossings
- Existing SSGC pipelines follow similar route

The pipeline will be designed, installed and operated as per ASME B31.8, the American National Standards for Gas transmission and distribution piping systems. The pipeline design will be vetted by SSGC being experts in the field and their comments will be incorporated in the design.

The pipeline design will also be as per the geotechnical information of the area conducted by ETPL in consultation with PQA i.e. Allowable soil bearing capacities, modulus of sub-grade reaction, seismic coefficients, plasticity index and moisture and sulphate content of the soil.

HAZOP will be conducted regarding the FEED of the pipeline, preferably with participation of SSGC as well. A Detailed Quantitative / Qualitative Risk Assessment (QRA) has been carried out by ETPL.

Dredging will be required to create the berthing and the turning basin. Dredged material will be utilized for the reclamation and to construct shore protection structure and the dredged material would be dumped peer advice of PQA.

ETPL has sufficient backup area at the proposed brown field site that will be prepared to accommodate berthing of an LNG FSRU (floating storage and regasification unit), which will also act as a carrier vessel and will bring in LNG supplies to the jetty. The dredge spoils from the berthing and turning basin, as discussed below, will be utilized for land fill, if required. The elevation grade will be raised for flood protection purposes.

Approximate dredged quantity would be upto 1.6 Million cubic meters for brown field site (includes the dredged quantity for berthing basin, for berthing pocket and portion of the turning circle outside the channel).

In case alternate STS process is selected, the dredging volumes will decrease by approx. 40%. The existing turning circles at IOCB or QICT2 can be used and the dredging quantity can be brought down to upto 1.6 million cubic meters if the orientation of the jetty can be made parallel to the channel.

1) TECHNICAL REQUIREMENTS

Considering measured environmental conditions such as the wave climate, currents, and meteorological conditions (e.g. winds, temperatures, and precipitation) as described in the section 05 of ESIA, a 200-225 m wide channel based on the beam dimension of 40-45m, as recommended by SIGTTO (1997), was determined to be appropriate for the approach channel. The required width of the approach channel decreases with the decrease of the beam and will be appropriately designed after finalization of the logistics as part of the studies planned to be carried out.

The turning basin will be designed to allow the safe turning of a fully loaded design LNG carrier with tug assistance. The required turning basin diameter, minimum water depth and associated sedimentation issues are discussed below

A) DIAMETER

Applying SIGTTO (1997) guidelines a preliminary turning basin diameter of 400 to 700 m has been selected, the requirement is twice the LOA of the expected ship.

B) MINIMUM WATER DEPTH

As squat is not expected to be significant in the turning basin due to slow ship speeds, the turning basin will be dredged to a depth of 13.5 m CD or less depending on the FSRU design.

C) SEDIMENTATION ISSUES

According to studies referred and conducted by ESIA experts and the discussions with IUCN, the existing approach channel is experiencing significant sedimentation. However, (based upon available data showing the sediment transport patterns at the site) it is expected that sedimentation will not occur to an extent that would interfere with vessel traffic. Nevertheless, should there be a need; maintenance dredging operations may be carried out at the island in consultation with PQA.

2) HAZARD PROTECTION SYSTEMS

The hazard protection systems will include fire protection, spill containment structures and gas monitoring devices. A fire and hazard detection system will be provided to monitor for the presence of flammable gases, fire, and LNG spills in areas where a hazard to persons or equipment could exist. Audible and visible

alarms will be installed to warn an operator of a detected potential hazard. The operator will be required to analyze the potential hazard and determine if shutting down the equipment or activating the protection system is required. Protection systems and alarms will be provided for fire exposure, cryogenic spills, gas detection, flame detection, smoke detection, and high and low temperature detection. The protection systems will consist of fire hydrants and monitors, sprinklers and fixed water spray systems, dry chemical extinguishers, and passive thermal and cryogenic spill protection. The area around the loading arms will be sloped to drain any spill sumps locate at the ends of the platform.

a. Flame detectors will be located at various locations within the facility where the possibility of a fire is most likely to occur.

b. Smoke detectors will be located at various areas within the facility. These detectors will be programmed to alarm on all the operator terminals. These detectors will also activate audible alarms (e.g. hazard horns) and beacons.

c. High temperature detectors will be located on each of the tank relief valve discharge stacks. These detectors will be programmed to alarm on all the operator terminals. The detectors will also activate audible alarms (e.g. hazard horns) and beacons.

d. Low temperature detectors will be located in the LNG impoundment sumps and drip pan located at the tank platform. These detectors will be programmed to alarm on all the operator terminals. An audible alarm will sound in the area if a spill is detected.

e. The emergency shutdown system is designed to be fail-safe for increased system reliability. The emergency shutdown system will have the capability of being activated from various locations throughout the facility to initiate a plant wide shutdown. Redundant logic controllers and operator terminals will also be provided for increased plant safety.

f. Automatic emergency shutdown valves will be provided in the ship unloading lines, in pump discharge lines, at the inlet to each vaporizer and in the plant main outlet gas line.

3) UTILITY SYSTEMS

a. An instrument air system will be required which will consist of two air compressors (100% standby), an air dryer, and an air receiver. The instrument air system will be incorporated into the Jetty design while additional compressed air needs for maintenance will be provided by the Shore Side facility.

b. Nitrogen will be required to purge and inert the facility to prepare for maintenance or startup after a lengthy shutdown. It is envisaged that a nitrogen generator sufficient to sustain the normal operations of the Jetty facility will be provided.

c. Shore based LCR would be provided with minimum facilities such as rest room etc.

d. Minimal workshop and repair facilities provided on the plat form

e. Slop oil storage (storage method to be determined during detailed design)

f. No waste material would be discharge or disposed off into the sea.

g. Potable fresh water generating system or transfer of drinking water via boat

h. CCTV Facility

i. Wireless communication through Motorola

All standard utility systems which may be required for successful commissioning of the project will be provided.

ENVIRONMENTAL AND SOCIAL BASELINE

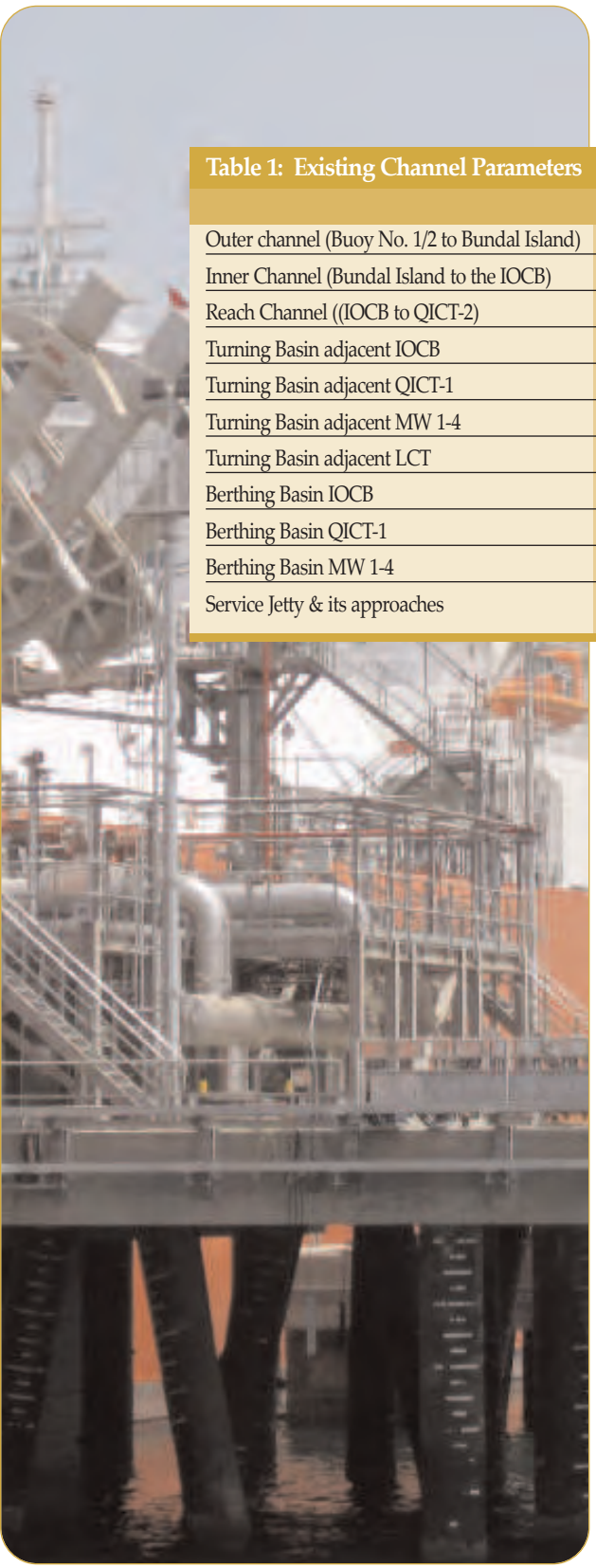
The microenvironment i.e. the project site is a sub component of the macroenvironment. The macroenvironment of the Project is the Port Qasim navigation channel while its hinterland extends from the Port area northward to the National Highway, and from Ghaggar Phatak on the east to Mehran Highway on the west. Gharo Creek forms the microenvironment of the site.

The main institutions that induced entrepreneurial potential in the macroenvironment of the LNG Import Floating Terminal Project are Port Qasim Authority (PQA) and Pakistan Steel Mills (PSM). Foundation stone of Port Qasim situated at a distance of about 45 km south-east of Karachi was laid on 25th August, 1973 by the then Prime Minister of Pakistan late Mr. Zulfiqar Ali Bhutto. Its inception was connected with the establishment of Pakistan Steel Mills situated in the same vicinity. Primarily, the purpose of this port was to facilitate and accelerate raw material imports of Pakistan Steel Mills. The planners also had in mind to expand the port to handle bulk imports so as to provide a sort of "load-shedding" at the Karachi Port.

This port is situated on the eastern coast of the country which has a mesh of numerous creeks interconnecting coastal area and high sea waters. One of these navigable creeks named "Phitti" was chosen to serve as approaching navigational channel to connect the open sea (Arabian Sea) with berthing site of Port Qasim. The channel runs along one of the many natural waterways that make up the historic Indus Delta. The channel was initially dredged in 1978 and is a total of 43.2 km long from Buoys Number 1 and Number 2 to the marginal wharf turning basin. The channel can be considered in three sections, namely:

a) The exposed Outer (Ahsan) Channel between the open sea and Bundal Island;

b) The more sheltered Inner Channel from Bundal Island to the IOCB;



c) The 'Reach' from the IOCB to the marginal wharfs.

*The depths currently maintained along the channel are shown in Table 1.

The Iron Ore and Coal Berth (IOCB), commonly known as "steel jetty" was the first berthing place which was completed by 1980 to receive the first ship in the last week of September, 1980 carrying iron ore for Pakistan Steel Mills. Simultaneously, four berths were also constructed on the marginal wharves. The number of berths on the marginal wharf was then increased from 4 to 7. In the early days of its operation the port was considered to be meant for handling bulk imports such as wheat, cement, fertilizers, coal, machinery/plants and raw material for Pakistan Steel besides export of rice etc. in bulk. The National Highway which is about 10 kilometers from the main port provides the mean of ready link between port and upcountry destinations.

Table 1: Existing Channel Parameters

	SDredged Depth (m)(below CD)	Width (m)	Length (km)
Outer channel (Buoy No. 1/2 to Bundal Island)	14.7*	Varies from 200 to 250	15.1
Inner Channel (Bundal Island to the IOCB)	13.0	200-250	25.1
Reach Channel ((IOCB to QICT-2)	13.0	Varies from 250 to 450	3.0
Turning Basin adjacent IOCB	13.0	600 diameter	-
Turning Basin adjacent QICT-1	12.5	450 diameter	-
Turning Basin adjacent MW 1-4	11.5	450 diameter	-
Turning Basin adjacent LCT	10.0	450 diameter	-
Berthing Basin IOCB	13.0	50 wide	-
Berthing Basin QICT-1	11.5	50 wide	-
Berthing Basin MW 1-4	10.5	50 wide	-
Service Jetty & its approaches	5.0	75 wide	-

Till 1980s the frequency of shipping activities remained low at Port Qasim. Port's future operational plan, however, had provision for the establishment of various storage and manufacturing sites in the area. Since early 1990s, the site caught the attention of private sector and investment started in the area this resulted in establishment of some sizeable storage sheds and manufacturing / processing units. This includes three car manufacturing units and a couple of edible oil refineries plus large scale chemical and fertilizer plants are operating in full swing in the Industrial Area of the Port. It was during this period that a number of bulk oil, chemical, LPG and edible oil terminals were also established inside the port area. Establishment of these industrial/storage units brought a revolutionary upward trend in the shipping activities at Port Qasim. The berthing and cargo handling facilities at Port Qasim were accordingly modernized.

PHYSICAL ENVIRONMENT

The Karachi coastline between Korangi creek inlet and Kadiro Creek encompasses coastline of three islands; Bundal Island, Buddo Island and Khiprianwala Island and two large and deep openings towards the sea viz. Phitti Creek Mouth (Approach channel of Port Qasim) and the Kadiro Creek Mouth. The eastern coast has tidal creeks with mangrove and mudflats which are linked with a network of creeks of Indus Delta. The sea bed at the eastern and south eastern coast is generally smooth and regular as depicted by the bed contours. The land slope is gentle, usually being in the order of 1/500 to 1/1000.

1) CLIMATE

The LNG Import Floating Terminal Project will be located in the coastal zone that has a relatively mild climate, characterized by dry, hot and humid conditions. There is minor seasonal intervention of a mild winter from mid-December to mid-February into a long hot and humid summer extending from April to mid-September.

2) GEOLOGY AND GEOMORPHOLOGY

The creek area is covered with mudflats supporting mangrove vegetation and does not exhibit much geological and pedagogical diversity. The information, as per geologic survey of Pakistan, reveals that in the project area and in its adjoining areas only the middle and upper tertiary formations are present. The formation found in the area is fresh and slightly weathered, recent and sub recent shore line deposits. These deposits are derived from Gaj/ Manchar formations of lower Miocene to middle Miocene/Upper Miocene to Pliocene age. Similar deposits are found all along the coastal belt of Karachi and adjoining areas. The seabed is predominantly sand and silt while the sediment of the delta is fine grained and resembles the soil from the continental shelf at the mouth of the Indus delta. The gravels or conglomerates are poorly transfixed with medium to coarse brown sand and are derived from Manchar formations of Pleistocene age. The Gaj formation consists of mostly limestone with sub ordinate shales and sand stones. The limestone is hard, sandy and extremely and fossilforus, this formation over lies nari formation which consists of harder lime stones beds and shales, conformably overlying Gaj formation is Manchar formation. Similar Manchar formation exists all along the coastal areas of Karachi and thus exposed in Clifton, Ibrahim Haidery, ghazi, orange and land areas. This formation is composed of sand stone, clay bed, cemented sand and grave (pseudo conglomerate). Sand stone is thick, porous and friable and also contains bands of conglomerate. The clay has various colors including grey, brown chocolate and orange, however the most widely occurring clay are of light brown and dark grey in color. Sandy layers are also found inter bedded with clay and gravel.

3) SEISMICITY

The Geological Survey of Pakistan has, however, defined the area of Port Qasim, where the site under study is located, to fall in a Seismic Zone 2B region. This suggests the possibility of moderate to major seismic hazard i.e. probability of earthquakes of intensity VI to VIII MM scale and 5.6 to 6.6 on Richter scale. From the charts published (such as figure, the peak ground level acceleration (PGA) for this zone is 28%. The seismic risk factor of 0.3 is advisable and will need to be incorporated in the design for constructions and installations in the coastal zone, for operational basis earthquakes (OBE) pertaining to damage due to moderate level earthquakes (MM-VI to VIII). The seismicity in the Karachi and at Project site is considered to be low. According to the published data the Project area lies in zone of low seismic activity, with acceleration ranging from 1.6 to 2.8 m/sec^2. A factor of 2.8 m/sec^2 will, on the other hand, have to be taken for a maximum credible earthquake (MCE). The design of the LNG terminal should take these values into consideration.

4) CYCLONES AND STORMS

High heat content of the Arabian Sea that is adjacent to the extensive heat zone of Pakistan usually upsets the heat balance and hence the water-balance of the region, particularly because it is the destination of windstorms. Tropical cyclones generally develop over Arabian Sea in low latitude i.e. 5-20 degrees north and dissipate after they move over land. The maximum frequency of tropical cyclone formation occurs in April, May and June and in the October-November period. The month of June receives least tropical cyclones in the region. About 76% of tropical cyclones in Karachi approach from the south through the east.

Tropical Cyclones contain heavy bands of clouds and cause heavy rains during landfall or sometimes cross along the coast far away. Heavy rainfall occurs as the end result. The Arabian Sea is known to be frequented by general cyclonic storms and some of these had been among the worst cyclonic storms of the world from their severity point of view, resulting in huge losses to life and property in the coastal areas. A significant number of the cyclonic storms produced in the Arabian Sea move towards north and northeast and some of them land in Pakistan. However most of these cyclones which tend to move towards southern part of the Pakistan coast very often reciprocate towards eastern coast of India.

BIOLOGICAL ENVIRONMENT

Coastal ecosystems provide a wide range of goods and services. They are the primary producers of marine fisheries including shellfish, besides seaweeds for both human and animal consumption. The marine ecosystem is also a source of chemicals, pharmaceuticals, cosmetics, house hold products and construction materials.

1) PHYTOPLANKTON

The average, net Primary Production rates are high at Isaro Creek (5-175 mg C/m^3/hour) and Gharo Creek (2 - 111 mg C/m^3/hour) while lower Primary Production rates were recorded at Gizri Creek (2 -13.5 mg C/m^3/hour) and Phitti-Korangi Creek (1-4 mg C/m^3/hour).

The Primary Production rates at Malir river estuary (5-15.5 mg C/m^3/hour) and at the open sea coastal waters (1.5-14.5 mg C/m^3/hour) adjacent to Phitti-Korangi-Kadiro Creeks were comparable to the rates at Gizri Creek.

The Primary Productivity values from literature for the months of February, March, and June show relatively higher productivity rates for these creeks. The overall Productivity in the mangrove areas has been reported to be high (365-780gC/m^2/year), compared to coastal waters (50-200gC/m^2/Year), which accounts for greater potential for fisheries yield in the former area. (Rizvi 1999)

2) MANGROVES

The Avicenna marina is the dominant species of the mangroves in the Indus Delta. In the PQA creek system the most dominant species are also Avicenna marina that grows on the northern and southern banks of the Phitti - Gharo Creek system. The density of mangrove trees is between 50-60 / 100 m^2. The height of the individual tree within the established Avicenna marina habitats were between 2-3 m.

3) MANGROVE POPULATION DENSITY

PQA is part of the Indus Delta. The Indus Delta supports one of the largest single mangrove ecosystems in the tropical coastal environments. In the Indus Delta mangrove ecosystem, eight species of mangroves have been reported out of 53 species known to occur in the tropical forests of the world. Other mangrove species in the deltaic region such as the Ceriops tagal occur in localized patches and there are a few plants of Rhizophora mucronata. All other species are rare and have disappeared from most part of the Delta due to adverse environmental conditions. Densities of high mangrove plantation were poor at the microenvironment. .

4) FAUNAL COMMUNITIES

The PQA area of interest and the associated Creeks had faunal communities that are characteristic of mud flats. The substrate had very fine sediments (mud and clay). The faunal communities present were dominated by faunal assemblages representing the soft sediments.

5) FISHERY

According to Government of Pakistan (2005) fish and fishery related sector

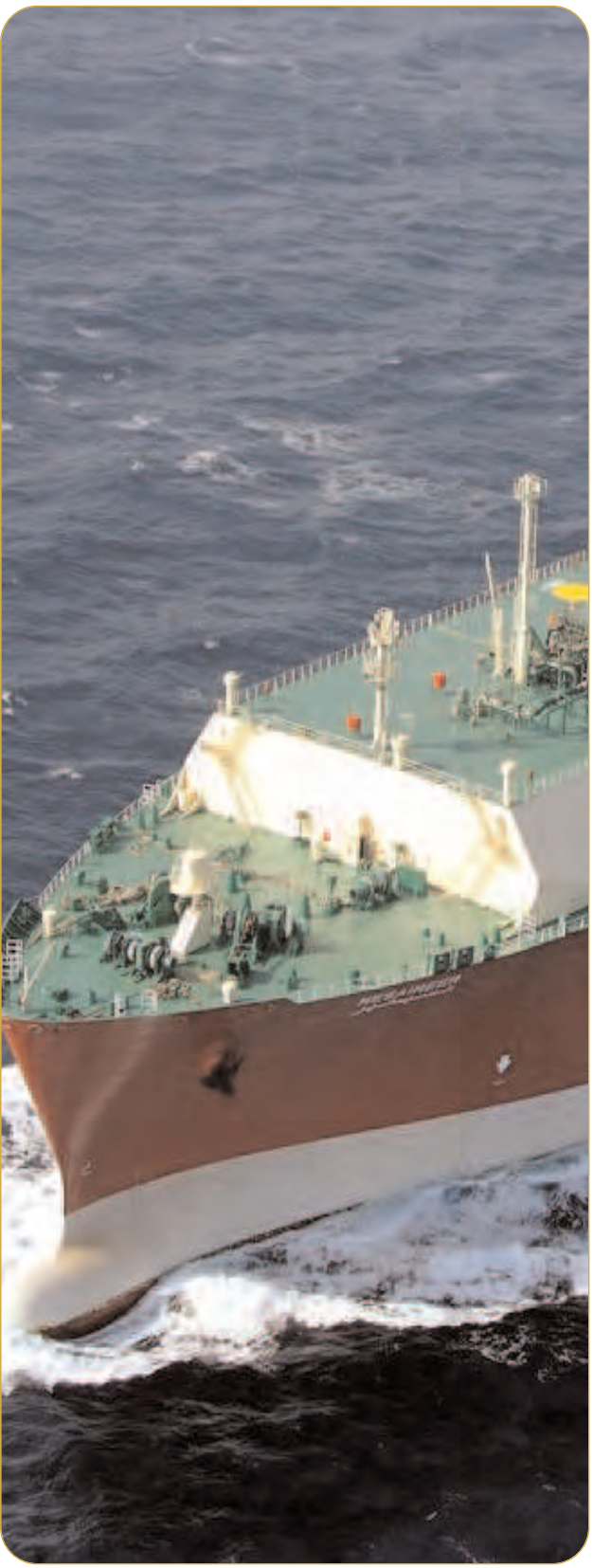
engages 1% of the Pakistan's population. The fishery sector generates 1% of Pakistan GDP earning through export of fishery products. Coastal and offshore areas of Pakistan support large fisheries. Fishing grounds for large pelagic species such as tuna, mackerel, sharks etc are located in the offshore waters. Whereas the species like mullet, silver wittings and other small sized demersal fishes specially juveniles of large commercially important estuarine fish are harvested from shallow water in the creek area of Indus as well as enclosed and semi-enclosed bays along the coast of Pakistan.

Benthic fish community includes the microbes: detritus feeders, small and large herbivores, and small and large carnivores. In the mangrove ecosystem, the benthic community of the adjacent shallow water is a subject of interest. Here, the microbes decompose the plant litter into organic detritus-a fundamental commodity of system energy. This detritus matter is picked up by the detritus feeders over the bottom, such as fishes, shrimps and shellfish, and then carried to the littoral zone by wave action, shared by the intertidal fauna such as crabs, shrimps, mudskippers, and other invertebrates. Grey mullets, gizzard shads, flat fishes, many skates and rays are some of the fish which prefer to live on soft bottom and feed on bottom detritus. At low tide, when a large part of muddy bottom is exposed, crabs, mudskippers and" waders are seen in large numbers picking up their food which includes worms and different animals left behind by the receding tide.

SOCIOECONOMIC ENVIRONMENT

The proposed brown field site is located in side bay next to existing EVTL terminal in Gharo creek. This site faces the Qasim International Container Terminal (QICT) in the west and Gharo Creek in the east and south. Pipri Badal Nala (stream) flows into the coast on the north of this site. This nala ultimately fall into the Gharo creek located to the south of the proposed site. There are no villages or residential colonies inside the microenvironment in a radius of 5 km. The nearest human settlement from the proposed site is village Lath Basti which is 7 km west to the site. The dargah (shrine) of Noor Hasan Shah is located approximately at 9 km east to the site. Other settlements which lie in the north and northwest of the project area at more than 9 km are Goth Lal Mohammad, Goth Mohammad Keserani and Pipri Colony. The Port Qasim residential colony is located approximately 8 km northwest from the proposed site.

At the Phitti Creek inlet (Approach Channel) there are four islands viz. Bundal Island, Buddo Island, Muchak Island and Khiprianwala Island. Buddo and Bundal Islands are the most prominent islands in Phitti Creek to the west of the Project site and at the entrance to Port Qasim. Buddo is about 6 km from Ibrahim Hyderi while Bundal Island is another 6 km from Buddo. Khiprianwala Island is located beyond 3.5 km of Ibrahim Hyderi. Buddo and Bundal islands are both fishermen's transit locations with a few clusters of



huts. Buddo is lush green with rich mangrove plantation and provides the area for camel grazing and breeding. The 8 km long and 4 km wide Bundal Island is the largest island in the creek. Approaching from the opening to the sea, it has sand dunes but inland it has large clusters of mangrove trees.

STAKEHOLDER CONSULTATION

Stakeholder consultation consisted of meetings held with relevant organizations and government departments, which are in some way linked to the project and therefore considered stakeholders. The purpose of these meetings was to apprise stakeholders of the project, assess how it may affect their activities, and document their concerns, whether real or perceived.

SCREENING OF IMPACTS AND MITIGATION MEASURES

The specific criteria used for determining the significance of impacts are identified for each resource, and the following assumptions are generally used when evaluating the potential project impacts:

- Project proponent will comply with all applicable laws and regulations;
- The construction phase of the project will proceed as described in Section 3 of ESIA; and
- Proponent will implement the mitigation measures and Environmental Management Plan in letter and Spirit.

Screening of potential impacts due to construction and operation stages of proposed LNG import terminal at Port Qasim are related to:

- Site Preparation
- LNG Terminal installation
- Waste Discharges
- Air Quality;
- Noise Level;
- Man Made Hazards;
- Natural Hazards;
- Sensitivity
- Operational Risks and management of Hazards
- Socioeconomic impacts

1) DREDGING

a. The dredging of berthing pocket at the project site will have a slightly negative impact on the marine habitat and the benthos of the creek; this would adversely affect fisheries reproduction. However, carefully regulated construction program and disposal of spoil at the designated areas plus reduced quantity of dredged area would minimize and localize these impacts. The extensive dredging and disposal of spoils carried out for Port Qasim over the last decade or so, has greatly reduced the benthic habitat. Proponent will ensure the adoption of careful methods to reduce the impact of construction on marine ecology of the site;

b. To prevent loss due to erosion, exposed soil materials will be protected by surface treatments such as armoring, pavement and vegetation. No mitigation measures other than those sites stated above are needed except that the entire operation will be keenly monitored by the proponent;

c. Any loss of mangrove habitat will be compensated by plantation/replantation of mangrove of as many mangrove trees as the canopy of the removed trees would require. The number of trees to be planted against the number removed will be determined in consultation with IUCN. It is to be noted that both sites have limited impact on mangroves;

d. Shore protection along the reclaimed site will consist primarily of concrete caissons or equivalent systems. These shore protection systems will be installed in areas that have already been impacted by prior dredging activities. Therefore, no additional impacts are expected due to the installation of the shore protection structures.

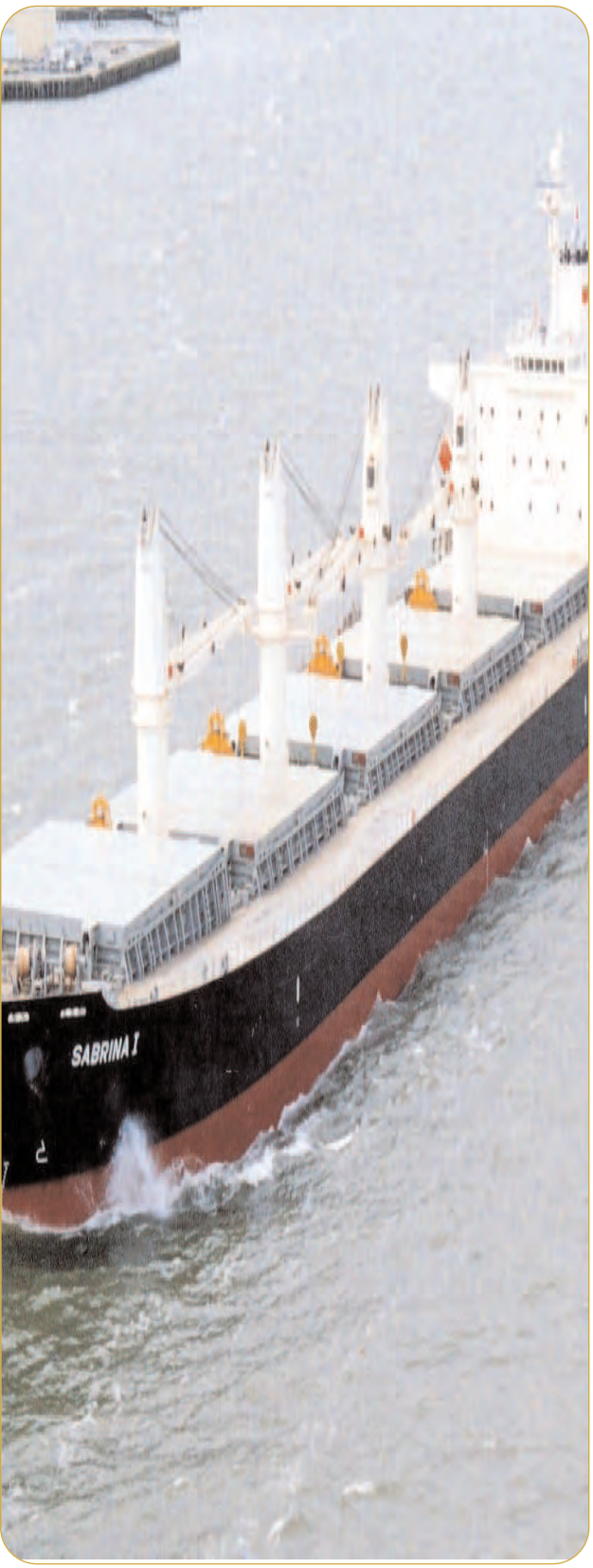
e. Monitoring of all activities related to removal of plantation and the replantation (other than mangroves).

2) LNG TERMINAL INSTALLATIONS

Impacts related to LNG Floating Terminal are those associated with the construction as well as operational activities at a LNG Floating import terminal.

a. Advance notices on upcoming construction activities impacting local fishermen will be provided to local fishermen, in order to mitigate possible obstruction of potential fishing areas during construction. Pakistan Fisherfolk Forum being the main stakeholder will be kept informed of all activities that could have negative impact on the fisheries operations. Most of the work is away from the channel and impact is expected to be minimum.

b. The construction contract should include provisions to limit the removal of bushes and mangrove to the bare minimum and restricted to the land area identified by PQA. The bushes and mangrove seedlings may, as far as possible be saved and transferred to the adjacent area. Other plants in the



vicinity will need to be protected against damage by construction operations. The areas beyond the limits of site shall not be disturbed or otherwise damaged. Trees and shrubs will be planted in consultation with PQA.

c. Once construction activities are completed, there are no anticipated long-term impacts that will occur as a direct result of installation of berthing facilities. Given appropriate substrate, sunlight, and temperature, benthic communities will be able to reestablish within the vicinity of the LNG terminal site. There is the potential for long-term impacts due to increased ship traffic, particularly as a result of accumulation of pollutants in the water column and sediment, which is known to adversely affect biological communities. In order to minimize and avoid impacts related to introduction of pollutants and invasive species all bilge discharge procedures will follow standard MARPOL regulations.

d. Mitigation of potential impacts to benthic habitats is anticipated to occur through natural reestablishment of bottom conditions and resettlement of associated faunas. Natural forces of currents and tides should restore the pre-construction distribution of soft bottom sediments that will be recolonized by infaunal organisms.

3) OPERATIONAL RISKS AND HAZARDS

The risks unique to LNG projects include operational risks arising from gas tanker and terminal operations involving transport, storage and the transfer of LNG. In particular, many gas terminals are located within the environs of established ports. So their operations and those of the tankers serving them share a common operational environment with other port users. The management of gas shipping operations within ports is therefore a matter of some importance, and needs to be taken into account by those who administer ports and provide essential services in port areas

ACCIDENTS: To a large extent, the overall positive safety record is rooted in the limited risks arising from LNG itself. Because LNG is stored at atmospheric pressure the major hazard is fire, rather than explosion. Hence the need for emergency fire detection and response is a way of combating this risk.

TERRORISM: LNG facilities and ships require a higher degree of planning, resources, knowledge, and risk to attack than softer targets. Terrorists want to be successful, so they look for ways to execute crimes that will have a desired impact with a high likelihood of success. Lastly, they work with the resources they can acquire to conduct their acts so they are less likely to attack assets requiring sophisticated and complex methods as is evidenced by the vast majority of events. Their strategic objectives are sometimes profound, but their weapons, tactics, and choice of targets tend to be common.

Existing EVTL terminal at PQA is ISPS certified and regular drills are carried out. Proponent will have their own contingency plan which will be supplemented

with the comprehensive contingency plan being proposed for all port terminals at PQA. All the relevant safety protocols would be followed by the Proponent and PQA; however, "no one can guarantee that a terrorist incident can't happen."

LIKELIHOOD OF TANKER COLLISION: The risk of a significant collision between the stationary ETPL-LNG facility and a LNG Carrier, sufficient to cause a breach of an LNG tank on either the LNG Facility or the LNG carrier is extremely low given that:

a. Safety zone requirement would be followed as per the results of the QRA. Detailed risk analysis has been conducted in the QRA study, recommendations of which will be followed in the design of the project.

b. LNG import facility is fitted with thrusters to maintain a fixed bearing and position during berthing operations;

c. LNG import facility is fitted with very robust fenders to protect both the facility and LNG carriers during berthing;

d. FSRA and LNG Carriers both have double hulls and, for a spill to occur, both hulls on either the FSRA or LNG Carrier as well as the LNG tank linings would need to be breached;

e. Proponent intends to place the LNG carrier inside a berthing pocket, dimensions of which will be confirmed in the FEED, so that the risk of collision between berthed LNG carrier and passing by Vessel is minimized and heavy displacement ships can also pass by in the main channel. Moreover; the Jetty arrangement would be designed to minimize/sustain the surge loads due to large ships passing by LNG ships.

4) SOCIOECONOMIC IMPACTS

There are undoubted positive impacts of an expanding gas sector on employment, competitiveness and sustainable development. However, the gas sector is a relatively modest creator of employment, and has contributed mostly as a substitute for coal in power generation. However NG is being used in the transport sector as CNG and also for cooking and heating. It is the main raw material for fertilizer production. These uses have modest impacts on competitiveness but have clear environmental benefits. In the drive to a low carbon economy, gas is a transitional fuel rather than the ideal fuel of the low-carbon economy. It nonetheless contributes to policies of sustainable development.

The majority of the raw materials to be used during construction are expected to be purchased from the local market since significant amount of cement, aggregate or ready mix concrete, and miscellaneous fabricated material may be sourced from different parts of country. Other required materials may also be purchased locally, and include such items as food, housing materials, ferries and other small marine vessels, household and office supplies, oils, chemicals and

cleaning supplies. These purchases are projected to infuse the local economy with additional revenues over the estimated 2-year construction period.

In short, the cumulative impact on the National economy will be a strongly positive one. Significant additional resources will be realized by the nation as a result of this project, which is consistent with the government's long-term development plan. The additional licensing income, among other sources of additional income, will add to the government revenues and economic growth resulting from expanded and diversified business development in Pakistan in future.

ENVIRONMENTAL MANAGEMENT PLAN (EMP)

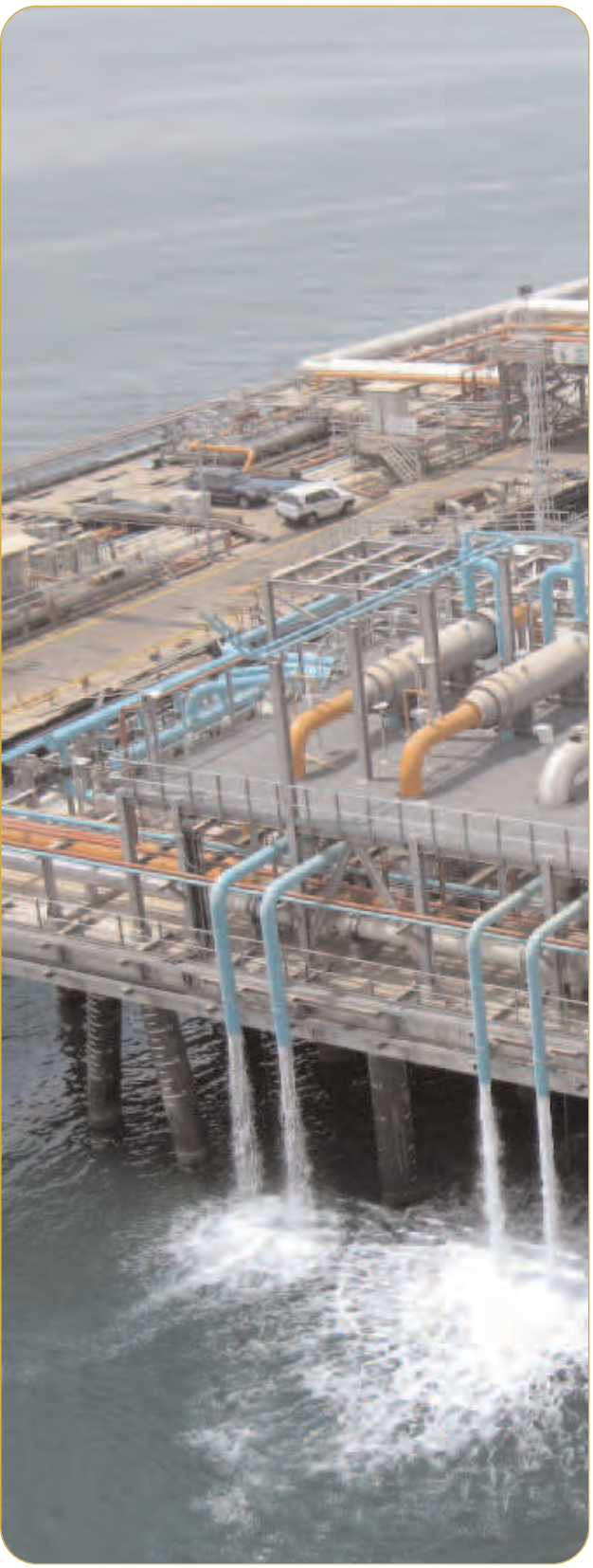
ETPL is committed to manage and operate its assets in a manner consistent with its core values to protect the health and safety of people and the environment and to comply with applicable Environment Health and Safety (SHE) laws, regulations and internal SHE standards. It already follows this regime at its existing facility and is envy of its peers in Vopak Asia.

Proponent will establish environment, health & safety (SHE) department which will handle all environment related concerns and issues. The SHE Manager will be the Head of SHE department and will be responsible for reporting to Chief Executive Officer. To support SHE management system, an SHE officer will be appointed to coordinate with the contractor during construction process and also monitor the activities at all the sensitive areas during the construction and operations stages of the terminal.

Compliance with EMP will be the responsibility of Proponent Management at each stage of project. ETPL Management will ensure that all executive activities during construction stage do not create adverse environmental effects. Contractor and sub-contractor will work in environment friendly manner under the supervision of SHE department of ETPL. All the regulatory agencies including EPA will be contacted as and when required to get advice for environmental management and they will be kept informed of the environmental conditions of the area periodically by ETPL management and their contractors/sub-contractors.

Some of the approaches to be followed during the environmental management practices are given below:

- Complying with the relevant legislation and regulations;
- Regularly reviewing of the impacts on the environment;
- Developing appropriate indicators to monitor core impacts;
- Setting appropriate annual objective, targets and publicly reporting on progress;



- Monitoring supplier's environmental management arrangements;
- Using sustainable materials (e.g. recycled paper and water based inks) for office supplies and environmentally safe raw materials with recycling options where appropriate;
- Communicating openly with internal and external stakeholder on environmental issues.

CONCLUSION

The impact assessment and proposed mitigation measures are based on the proposed Brown Field site located in the side bay adjacent to EVTL's exiting terminal. The selection of site by the proponent depends on the qualitative/quantitative risk analysis as part of the techno-economic feasibility. EMC has carried out analysis on the siting of the LNG terminal and Laying of HP Transmission Pipeline. Environmentally the proposed Brown Field site has been found feasible provided that the mitigations suggested are carried out. The pipeline route shall not interfere with any mangroves or population centers. It raises minimum social and environmental issues and avoids the laying of pipeline in the sub-sea environment; it additionally is economically more viable than the others.

The ESIA study finds that the ETPL's LNG import floating terminal project site location in PQA is compatible with the aims and objectives of (a) Sustainable Development in promoting improvement in quality of life, and (b) Energy Sector in making available a sustainable energy source and thus contributing to sustainable economic development in Pakistan.

This ESIA Study concludes that establishment of the LNG-Import Floating Terminal Project at Port Qasim would fulfill the requirements of sustainable development by being socially equitable, and economically viable in improving the quality of life for all citizens of Pakistan, without altering the balance in the resources of the ecosystem of the region.

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UNITS

°C	Degree Centigrade
Km	Kilometre
KW	Kilowatt
M	Meter
MGD	Million Gallons per Day
MMFCD	Million Cubic Feet Per Day
MMBTU	Million Metric British Thermal Unit
MTOE	Million Tonne Oil Equivalent
Mm	Millimetre
MT	Metric Ton
Psi	Pounds per square inch
Sq km (km^2)	Square Kilometre
$\mu g/m^3$	Microgram per meter cube

Glossary

ASME	American Standards for Mechanical Engineers
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
DGPC	Director General of Petroleum Concessions
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EMP	Environmental Management Plan
EPD	Environmental Protection Department
EVTL	Engro-Vopak Terminal Limited
ETPL	Elengy Terminal Pakistan Limited
FOTCO	Fauji Oil Terminal Corporation
FCL	Full Container Load
FFO	Furnace Fuel Oil
FLNG	Floating Liquefied Natural Gas
FSRA	Floating Storage and Re gasification Arrangement
FSRU	Floating Storage & Re-gasification Unit
FSU	Floating Storage Unit
GDP	Gross Domestic Product
HSE	Health Safety and Environment
IOCB	Iron Ore and Coal Berth
IEE	Initial Environmental Examination
IMC	Independent Monitoring Consultant
IUCN	International Union for Conservation of Nature
KPQ	Karachi Port Qasim
KDA	Karachi Development Authority
LCL	Loose Container Load
LFL	Lower Flammability Limit

LNG	Liquefied Natural Gas
LNGC	Liquefied Natural Gas Carrier
LPG	Liquefied Petroleum Gas
MCC	Motor Control Centre
MLLW	Mean Lower Low Water
MHHW	Mean Higher High Water
NCS	National Conservation Strategy
NEWCO	New Company
NEQS	National Environmental Quality Standards
NGO	Non Government Organization
PCRWR	Pakistan Council of Research in Water Resources
PEPO	Pakistan Environmental Ordinance
PEPA	Pakistan Environmental Protection Act
PQA	Port Qasim Authority
RLNG	Regasified Liquefied Natural Gas
QICT	Qasim International Container Terminal
QFS	Qasim Freight Station
SMART	Self Monitoring and Assessment Reporting Tool
SMRS	Self Monitoring and Reporting System
SPCC	Spill Prevention Control and Countermeasures
THA	Terminal Health Assessment
TOC	Total Organic Carbon
UNICEF	United Nations Children Education Fund
UNESCO	United Nations Educational Scientific & Cultural Organization
WB	World Bank
WHO	World Health Organization
WWF	World Wildlife Fund for Nature
WAPDA	Water and Power Development Authority

01 INTRODUCTION & OBJECTIVES

This Environmental & Social Impact Assessment (ESIA) evaluates the potential environmental, social, economic, cultural, and natural impacts of the proposed Liquefied Natural Gas (LNG) Import Terminal Project. Environmental Management Consultants (EMC) Pakistan has been contracted as a third party consultant by Elengy Terminal Pakistan Limited (hereinafter referred as proponent) to conduct a detailed assessment (ESIA) of the proposed LNG project.

The project includes constructing and operating a Liquefied Natural Gas (LNG) terminal in Port Qasim, inclusive of ship berthing and import facilities, floating storage tanks and regasification equipment. The project intends to provide facilities for receiving supplies of LNG via a conventional LNG carrier, for offloading, transfer and loading into a Floating Storage and Regasification Arrangement (FSRA) which can be an FSRU, or FSU+ On Shore Regasification, or FSU + on barge Regasification. The FSRA will store and re-gasify the LNG and deliver the re-gasified liquefied natural gas (RLNG) via jetty and onshore associated facilities to the gas network operated by the in-country transmission pipeline providers.

Dredging will be required to create the berthing and the turning basin. Dredged material will be utilized for the reclamation and to construct shore protection structure. The balance will be dumped at sites advised by PQA. The construction of the LNG import terminal is expected to begin by 1Q 2014 and will be completed within 11 months. The estimated cost of the proposed project is USD 120 million.

Project at a Glance

Project Type	**Floating LNG Import Terminal**
FSRU Size	**130,000 m^3 (upgradable)**
STS	**Double Banked Arrangement**
Length of Pipeline	**23 kms**
Dredging	**Between 1.3 Mn CUM and 1.6 Mn CUM**
Turning Circle	**Existing at IOCB/QICT2**
Channel	**260 m wide**

This ESIA has been prepared to fulfill the regulatory requirements of Pakistan Environmental Protection Act, 1997 and to satisfy the evaluation criteria of the ***Asian Development Bank (ADB) and International Finance Corporation (IFC)***. Applicable ***ADB Safeguard*** requirements and National & International Guidelines and regulations have been used as a reference in preparing this ESIA. The project falls in Schedule-II of Pakistan Environmental Protection Agency (Review of IEE/EIA) Regulations-2000 and Category-A of Equator Principles which means it could have significant environmental impacts if appropriate mitigating measures are not implemented.

1.1. THE PROJECT PROPONENT-ELENGY TERMINAL PAKISTAN LIMITED (ETPL)

Elengy Terminal Pakistan Limited (ETPL) was registered under the SECP Act 1997, in January 2012, and is a 100% owned subsidiary of Engro Corporation Pakistan to position Engro as a partner of choice with Key Stake holders. ETPL boasts of experience in terminal business due to its affiliation with Engro Vopak Terminal Limited, a joint venture of Engro Corporation (Pakistan) Limited (50%) and Royal Vopak of the Netherlands (50%).

EVTL, formerly Engro Paktank Terminal Ltd. (EPTL), was incorporated in 1995. EVTL provides the chemical and petrochemical industry and traders in Pakistan with the state of the art facilities to handle and store their bulk raw material and products at its terminal in Port Qasim in a safe, efficient and environmentally friendly manner. EVTL is actively engaged in handling about 74% of the bulk liquid chemicals and 70% of LPG imports into Pakistan. The company has ISO 9001, 14001, 18001 and was CDI-T

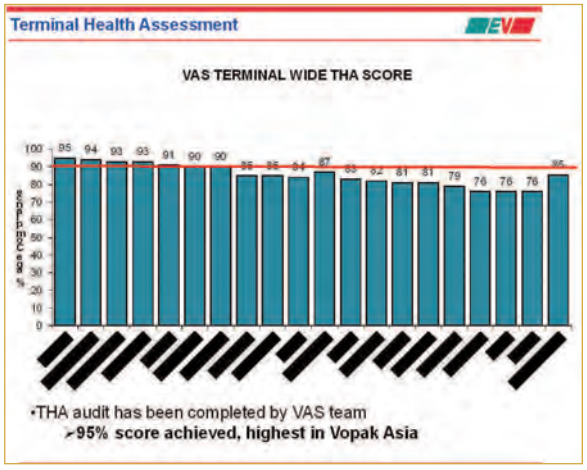

Figure 1.1: Terminal Health Assessment (THA) Score

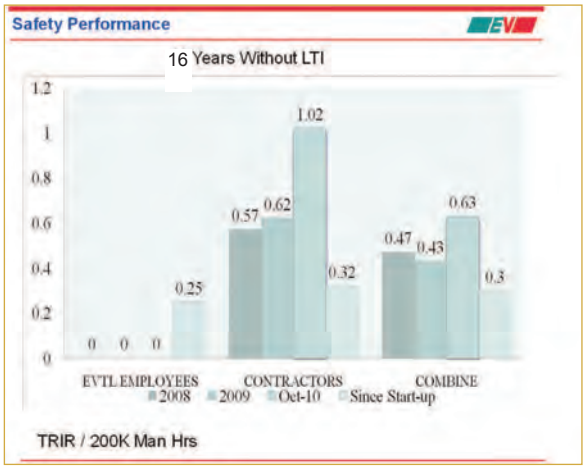

Figure 1.2: Safety Performance

certified which has now been replaced by internal assessment "THA" of Vopak Asia (Figure 1.1). Figure 1.2 presents the overall safety performance record of EVTL.

- ETPL wishes to develop the proposed LNG project in full compliance with applicable Pakistan's statutory requirements;
- EVTL's own policy statements on Health, Safety and Environment (HSE) to be modified for LNG handling
- LNG terminal international standards;
- Applicable international conventions, treaties and agreements;
- International guidelines including World Bank& IFC.

In line with these standards, ETPL aims to contribute to Sustainable Development. This means that a strategy will be followed that integrates economic, social, health and environmental considerations in all project decisions and actions. This also implies that ETPL is committed to carry out a full Environmental and Social Impact Assessment (ESIA), parallel to and as part of the development of this project. Engro Corp. has always conducted ESIA for its projects, with the most recent being for the investment in Pakistan.

This ESIA process for another cryogenic product LNG was started by ETPL as early as possible and in such a way that any implications resulting from the assessment could be included in the design and operation. The current report reflects the outcome of this ESIA process and takes into account the natural environmental, human health and social aspects, and any trans-boundary and global environmental aspects in an integrated way. The sustainability principle 'engage and work with stakeholders' entails that ETPL, during the ESIA, consults project-affected groups, local non-governmental organizations (NGOs) and any other group of stakeholders about the project's environmental and social aspects and takes their views into account.

ETPL aims at zero incidents by placing safety, health and environment above all other objectives. The company maintains the highest industry standards to ensure safety and reliability and meets all requirements of Pakistan Environmental Protection Agency. Its customers and financing institutions including SEPA have had audits conducted by local and international firms.

ETPL is committed to playing a leading role in the development of standards in the terminal services business in Pakistan and leads the industry by a distance.

1.2. PROJECT BACKGROUND

Natural gas accounts for the largest share of Pakistan's energy use, amounting to almost 45 percent of total energy consumption. Pakistan currently consumes all of its domestic natural gas production. Limited new gas discoveries and ever increasing demand has resulted in widening the gap between (demand and supply), and (supply and availability).

The projected demand/supply/availability analysis had indicated a shortfall of 3.0 MTOE in 2010 and the gap is expected to reach 19.9 MTOE in 2015 and 85.3 MTOE in 2030. Pakistan is exploring all possible avenues for cheap, abundant and environment-friendly sources of gas in order to continue with sustained economic growth in the coming years.

The gap between supply and demand of natural gas (NG) emerged in 2007- 08 and was projected to build up to 2,100 MMCFD by 2015, as the current gas fields gradually go off plateau. The demand and supply projections had indicated a widening gap of approximately 500 million cubic feet per day (MMCFD) by the year 2010. Winter of 2010-11has actually shown higher shortage then envisaged (Figure 1.3).

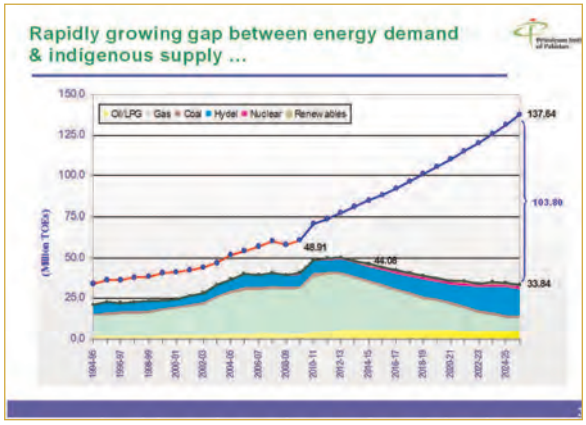

Figure 1.3: Energy Demand & Supply Gap

The existing demand of NG in the country is 5190.5 MMCFD, out of which 3895.5MMCFD is met by internal sources. As of June 30, 2010 the NG reserves were 28.90 trillion cubic feet. With no external source of NG available, Pakistan meets the demand from internal sources only. The increasing demand of NG has created a shortfall of 1,295 MMCFD and is expected to increase further. Gas load shedding has become a phenomenon with industry being forced to shut down for five days in a week in Punjab and fertilizer industry for 30-45 days. KESC and other IPPs had their gas allocations curtailed significantly resulting in gas load shedding of over 6-8 hours in the country. Industry running boilers to generate steam is being forced to use coal, furnace oil or diesel and diesel for power generation, with households utilizing charcoal and firewood, thus inducing rapid deforestation & warming of their microenvironment.

The present requirement of oil in the country is around 19 million tons per annum, out of which about three million tons (15%) is met from internal sources. The oil reserves being only 314.39 million barrels, the balance demand is met through imports of crude oil and other petroleum products.

Oil imports cost $ 32.26 billion for 58.64 million tons oil during last four years (2006-2009). In order to attract local and multi-national companies for investment in oil and gas sectors and in aggressive exploration, the government has given incentives in new Petroleum Policy 2009.

Since inception, exploration and production companies made 223 oil and gas discoveries in the country and that so far cumulative production from these discoveries is 543 million barrels oil and 24.433 trillion cubic feet of gas having worth of about Rs 27000 billion and Rs. 4930 billion respectively at an average international market price of oil and average wellhead value of gas for 2009.

In order to explore more oil and gas reserves the government granted 115 exploration licenses. Presently, 16 foreign companies are operating in 44 blocks in Pakistan for the purpose.

To fill the growing energy supply deficit, GOP is in earnest implementing a multi-pronged strategy which includes: (i) increasing domestic oil & gas exploration and production, (ii) fast track utilization of hydro power potential, (iii) expediting the development of vast local coal reserves, (iv) importing piped natural gas from neighboring countries, (v) importing LNG, (vi) setting-up new nuclear power plants, and (vii) exploiting affordable alternate energy resources.

Any commitment of additional gas supplies to industries, power and fertilizer production on a long term basis have not been possible, without confirmation of additional sources of gas supply. This may, however, have been possible through:

1) Gas pipeline import which at the earliest could come on-stream by 2017 as per the Gap Coverage Strategy from Iran or Turkmenistan,

2) A major on-shore/off-shore gas field discovery in the current year (the gas to market period being five years), or

3) LNG import which by current assessment could provide

gas by the year 2012-13. It was supposed to have started by 2010-11 under the Mashaal Project.

The GOP had mandated SSGC to develop a project for the import of LNG. The first supply of LNG of 3.5 million tons per annum (equivalent to 500MMCFD of gas) was targeted for the year 2011; followed by another for supply of 2.0mtpa by the year 2013. The projects stand delayed, while the shortage keeps multiplying.

ETPL intends to follow a fast track approach towards developing the LNG import terminal in order to bridge the gap between supply and demand of energy. The Project is primarily based on developing the required infrastructure so that LNG can be brought into the Natural Gas (NG) market, which has witnessed phenomenal growth in the energy sector in Pakistan. In the first stage, the focus is on the fastest method to facilitate LNG flow into the NG pipeline network in Pakistan.

The proponent is best placed in the energy sector, particularly in handling about 70% of LPG imports into Pakistan and the only cryogenic facility in Pakistan. EVTL operates a state of the art first LPG and chemical terminal in south western zone of Port Qasim. The terminal consists of a jetty, suitable for handling ships up to 75,000 DWT and houses storage tanks with a storage capacity of 10,100 cubic meters of LPG and balance for chemicals for a total storage capacity of EVTL 82,400 cbm.

The proposed site at Port Qasim is a dedicated area for Oil and Gas development and is promoting local energy supply system. FOTCO is utilized for oil imports and PRO-GAS for LPG in addition to EVTL. Proposed ETPL-LNG terminal for import of NG will also be located in the same zone. It will thus be integrated into the infrastructure of Oil & Gas sector being developed.

1.3. OBJECTIVES OF PROJECT

The main objectives of the Project are to:

- Bridge the gap between supply and demand of energy in Pakistan by facilitating import of LNG from countries that have liquefaction facilities;
- Create benefits for local economies through job creation and services;

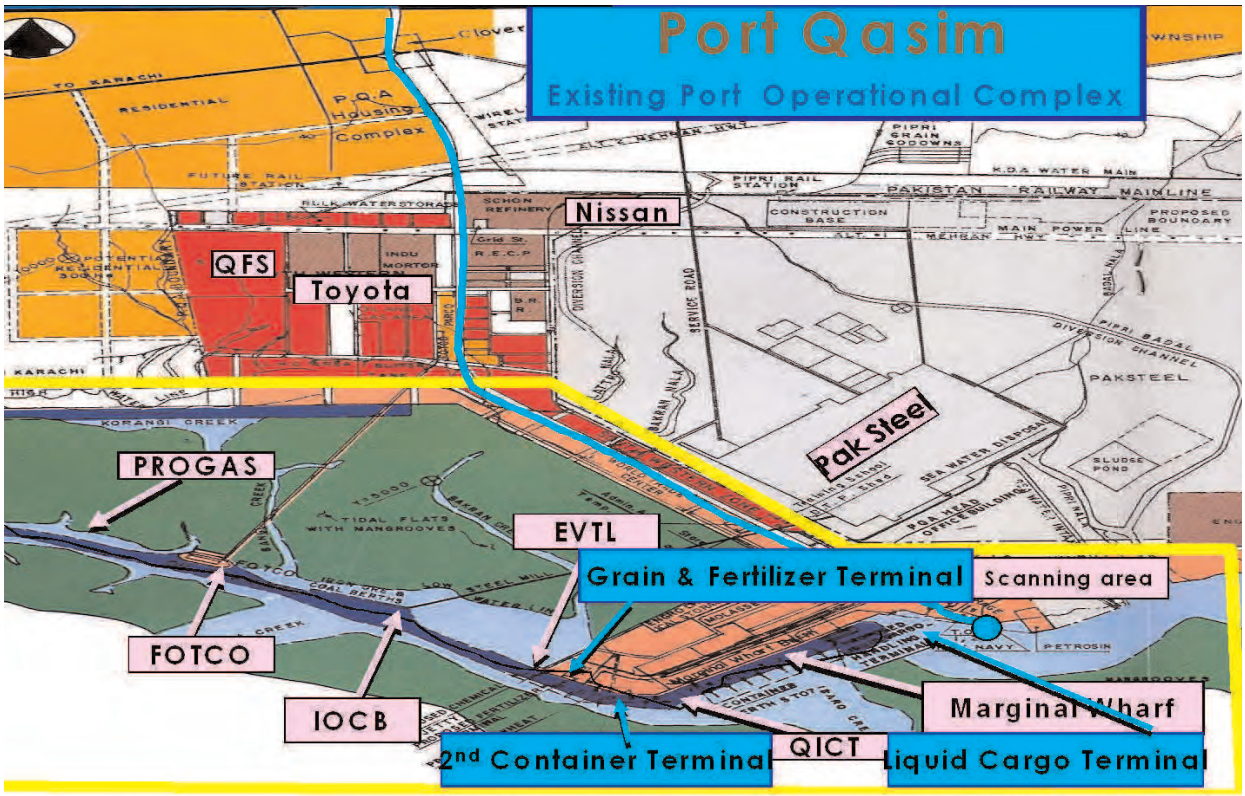

Figure 1.4: Location of EVTL in Port Qasim

- Ensure the availability of natural gas to industrial, commercial and residential customers throughout Pakistan;
- Observe the principles of sustainability by providing the benefits of economic gains while sustainably modifying the social and physical environment; and
- Promote sustainable development and ensure a better quality of life for everyone, now and for generations to come through the three strands of social equity which recognize the needs of all citizens of Pakistan, maintain stable levels of economic growth and employment, and use the natural resources including natural gas prudently, while protecting the environment and, enhancing its quality.

1.4. Overview of Siting Process

The proposed LNG Import Terminal project will be sited in Port Qasim area which comes under the jurisdiction of Port Qasim Authority, Government of Pakistan. ETPL requested PQA for designation of suitable site(s) in Port Qasim to establish an LNG terminal. PQA in response identified the following sites for ETPL to carry out necessary studies including an ESIA:

1) Two (Green Field) sites located on Khiprianwala Island.

i. OPTION 1: Lat: 24°46'60".53 N, Long: 067°12'54".12 E

ii. OPTION 2: Lat: 24°44'54".87 N, Long: 067°10'08".60 E

2) The Brown Field site referred as OPTION 3 where EVTL Chemical terminal and other terminals are located.

3) Existing EVTL Jetty as OPTION 4 that may be upgraded to accommodate berthing of an LNG FSRU (floating storage and regasification unit), which will also act as a carrier vessel and will bring in LNG supplies to the jetty.

This ESIA identifies the potential environmental and social aspects associated with the proposed ***Brown Field*** site (OPTION 3) keeping in view the relevant standards/guidelines/procedures on siting an LNG facility. A Quantitative/Qualitative Risk Assessment (QRA) has been carried out separately by ETPL. The study was undertaken by Lloyd's Register of UK and covers a wide scope which includes HAZARD IDENTIFICATION (HAZID) in participation of Vopak, PQA and its consultants ECIL, navigational simulations, Risk Assessment studies and Dispersion Modelling. The QRA likewise covers all the sites as stated herein and proposes certain mitigation measures which make all the sites technically viable after adopting of the relevant measures. The QRA can be found as Annexure 9.

1.5. Environmental & Social Impact Assessment (ESIA)

1.5.1 Justification for ESIA Study

Section 12 of Pakistan Environmental Protection Act 1997 and Pakistan Environmental Protection Agency (PEPA) Review of IEE/EIA Regulations 2000 require that every new development project in Pakistan has to be preceded by an Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA) depending upon the size and severity of impacts anticipated on commissioning of the project.

1.5.2 Categorization of the Project

PEPA Review of IEE/EIA Regulations 2000 categorizes projects in two separate Schedules, which require either an IEE or an EIA. The LNG jetty comes under both Schedules which have port and harbor development projects listed. Schedule-I projects require an IEE and concerns ports and harbors having ship displacement of less than gross 500 tons. Schedule-II is applicable if the gross displacement exceeds 500 tons and requires an EIA. The proposed LNG terminal project falls under Schedule-II as it involves shipping activity having gross displacement above 500 tons and will thus require an EIA.

1.5.3 Purpose of ESIA Study

The main purpose of this EIA Study is to respond to provision of Environmental Protection Act 1997, to provide

Figure 1.5: Location of Option 3: Brown Field Site near EVTL suitable for Fast Track LNG Project

information on the nature and extent of environmental impacts arising from the construction and operation of the project and related activities that would take place concurrently or subsequently. The ESIA study is conducted for the purpose of:

- Describing the existing environmental setting of the project area;
- Summarizing the project activities in relation to the environment;
- Ascertaining applicability of relevant rules and regulations to the project siting and operations;
- Undertaking the EIA from the perspective of environmental and social aspects in the project area, and suggesting mitigation measures for sustainable development;
- Identifying the environmental consequences of siting the project and inception of associated activities;
- Identifying conditions that may require detailed design, and specification on activities during construction and operations of the project, besides measures necessary to mitigate the adverse environmental consequences;
- Assessment of impact of major LNG escape and consequential hazards that is being covered under the QRA underway, including measures necessary to mitigate risks identified
- Determining the adequacy of proposed mitigation measures to deal with residual impacts after implementation of the Project.

1.5.4 Adopted Methodologies for ESIA

EMC adopted the following procedures for making assessment of impact of different activities during the construction, commissioning and operational phases on microenvironment and macroenvironment of the project activity areas:

1) Scoping Exercise

Holding meetings with ETPL Project Officials and other stakeholders to:

- Discuss and define the magnitude of study in the light of scope of work
- Plan a work schedule for collecting baseline data needed for Rapid Assessment of status of microenvironment of proposed project site, and its surrounding i.e. macro environment, and
- Obtain information on location and technology alternatives and on LNG import options.
- Incorporating views and comments of different stakeholders and their concerns on the project so as to prepare a generally consented document for approval of the decision makers.

2) Literature Reviews

Preparation of this study has input from field data collected by Environmental experts during their visits to the site, meeting with ETPL / EVTL Officials, EPA Sindh, Port Qasim Authority, stakeholders and the archives of the consultants. EMC contacted ETPL for the collection of project specific data such as design, site specification, soil survey, construction activities and operations besides HSE and Environmental Management and Emergency Response Plans which ETPL would adopt for the management of LNG Import Terminal. The information so obtained was reviewed for better understanding of project by experts prior to conducting detailed site visits of project area.

Additionally latest authenticated published data on the physical and social environment of the project area was reviewed to match up with the information obtained during the surveys.

3) Surveys

EMC organized surveys for collection of information on settlements around project specific location within 5 km

radius, considered here as forming the boundary of the microenvironment for ESIA study. Socio-economic surveys were conducted by socio-economic experts. Issues related to project were discussed with stakeholders including relevant departments. Surveys were conducted by ecologists/marine biologist to investigate the marine ecosystem of the microenvironment to generate baseline data for impact assessment.

4) Monitoring & Analysis

EMC acquired the services of SUPARCO to conduct air dispersion monitoring for 24 hours to examine and establish air quality profile of the site and to assess the possible impact of round the clock operations at the LNG terminal. The monitoring results were analyzed by SUPARCO experts to assess the risk in case of accidental release of LNG.

5) Identification of Aspects

The aspects identification and significance determination process is fundamentally important to investigate the incidence of impacts at different stages of the Project and their assessment. This step gives an inventory of the aspects. The aspects identified during this step cover all activities during construction/operations, production and services in order to determine those which have or can have significant impact on the environment.

6) Assessment of Anticipated Impacts

Environmental experts at EMC analyzed and assessed the anticipated impacts that are likely to arise due to the identified aspects. This step was followed by the use of collected data for identification of impacts on human health and the environment and risks involved in different activities during construction, commissioning and operation phases of the project.

7) Preventive Measures & EMP

Based on the impacts identified, mitigation and control measures were proposed by the experts in order to minimize the adverse impacts of construction of LNG jetty, pipeline and jetty operations on the environment. All mitigation measures were discussed in detail with the proponent representatives and an environmental management plan (EMP) has been developed to implement the mitigation measures in true spirit. A monitoring plan has also been incorporated in the EMP to monitor impact of all activities and performance of mitigation measures and to identify positive/negative changes in the environment.

8) Documentation & Review

This is the final step that completes the EIA study. The data generated during and for the study are compiled and examined by experts of the respective field. Sections of this report were prepared as the study progressed, by EMC office staff in consultation with experts. The report was finally reviewed by team leader, who analyzed the information, assessed the potential environmental impacts in the light of national and international guidelines and organized the Report to the present form.

1.6. Report Set-Up

This document has been prepared by compiling: i) ESIA for LNG Import Terminal, and ii) IEE for HP Transmission Pipeline and Nitrogen Blending facility. It contains the following sections:

Section#1 Introduction and Objectives: introduces the project, gives its objectives, need for ESIA, categorization and methodology adopted for conducting the ESIA. ***Section#2 Legislative and Administrative Framework***: gives an overview of policy and legislation along with International Guidelines relevant to LNG terminal and associated environmental and social aspects. **Section#3** ***Description of Project***: describes the LNG Import Terminal Project and associated facilities; ***Section#4 Screening of Alternatives &/or Subsequent Expansions***: presents the system alternatives to the proposed project, including the siting alternatives evaluated for the proposed Liquefied Natural Gas (LNG) terminal and the alternative technologies considered for the proposed LNG transfer facilities as well as dredging to create the berthing and turning basin, ***Section#5 Description of Physical & Biological Environment & Section#6 Description of Socioeconomic Environment***: provides a description of the

microenvironment and macro environment of the project area with regards to the environmental & social baseline conditions. ***Section#7 Public / Stakeholders Consultation & Information Disclosure***: presents the objectives and outcomes of the stakeholder consultation conducted during the ESIA process and the ongoing community engagement programme. ***Section#8 Potential Environmental Impacts of proposed development and recommended mitigation measures & Section#9 Potential Social Impacts of proposed development and recommended mitigation measures***: describes the potential environmental and social aspects and of the proposed LNG terminal on the different features of the micro and macro environment, and using the general guidelines present a screening of potential environmental impacts at the design, construction and operation stages. The screening process includes the residual impact as a result of adoption of mitigation measures that may be needed for minimizing the impact. **Section#10 presents Preliminary Cumulative Impact Assessment**. **Section#11 Environmental Management Plan**: presents the environmental management and monitoring plan. Finally **Section#12 Conclusion & Recommendations**: summarizes the report and presents its conclusions and recommendations.

1.7. ESIA TEAM

This EIA Report has been prepared by Environmental Management Consultants (EMC). EMC organized the following team for the purpose of conducting the environmental assessment and preparing the report:

Sr. No.	Name of Expert	Designation
1	Syed Nadeem Arif	Project Manager
2	Saquib Ejaz Hussain	Team Leader/Expert Pollution Chemistry
3	Dr. Mirza Arshad Ali Beg	Expert on Sustainable Development
4	Dr. Iqbal Ali	Expert on Water Resources
5	Dr. Shahid Amjad	Oceanographic & Marine Biology Expert
6	Dr. Badar Munir Ghauri	Expert on Air Quality
7	Dr. M. Masoom	Waste Management Expert
8	Mr. Sultan Mehmood Zaman	Expert on Soil Science
9	Ms. Zulekha Soorma	EHS Advisor
10	Dr. Kaneez Fatima Mamdani	Senior Sociologist

Contact Person

Proponent	Consultant
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02 Legislative & Administrative Framework

The principles of sustainable development are in the process of being incorporated into national policies and legislation in Pakistan through various statutory instruments. This section describes the policy framework, statutory framework, environmental and social guidelines, and also the legal responsibilities of the proponent in the context of the environment and sustainable development.

The proponent of this project (Elengy Terminal Pakistan Terminal) will comprehensively follow the requirements of the policy documents and legislative framework as well as recommendations of national and international guidelines.

As the possibility of financing for the project from international financing institutions is being explored, the assessment has been carried out to comply with both local and International Requirements of IFC & World Bank.

2.1 Policy Framework

The Pakistan National Conservation Strategy (NCS), which was approved by the Federal Cabinet in March 1992, is the principal policy document for environmental issues in the country. The NCS signifies the country's primary approach towards encouraging sustainable development, conserving natural resources, and improving efficiency in the use and management of resources. The NCS has 68 specific programs in 14 core areas in which policy intervention is considered crucial for the preservation of Pakistan's natural and physical environment. The core areas that are relevant to the proposed project are biodiversity conservation, restoration of rangelands, pollution prevention and abatement, and the preservation of cultural heritage.

Pakistan is a signatory to the Convention on Biological Diversity, and is thereby obligated to develop a national strategy for the conservation of biodiversity. The Government of Pakistan constituted a Biodiversity Working Group, under the auspices of the Ministry of Environment, to develop a Biodiversity Action Plan for the country, which was completed after an extensive consultative exercise. The plan, which has been designed to complement the NCS and the proposed provincial conservation strategies, identifies the causes of biodiversity loss in Pakistan and suggests a series of proposals for action to conserve biodiversity in the country. The Pakistan Environmental Protection Council (PEPC) has approved the action plan and steering committees at the federal and provincial levels have been formed to implement it.

Mid-term Review of NCS: Key Findings

An overview of the key environmental issues facing Pakistan is as follows:

- Per capita water availability in Pakistan has been decreasing at an alarming rate. In 1951, the per capita availability was 5300 cubic meter which has now decreased to 1105 cubic meter just touching water scarcity level of 1000 cubic meter.
- Almost all fresh water resources are severely polluted due to discharge of untreated industrial and municipal wastes. Pollution of coastal waters due to waste discharges and oil spills coupled with reduced freshwater flows is resulting in declining fish yields.
- About 55 percent of population has access to a relatively safe drinking water source. Potable water quality, assessed against WHO standards, fails to meet all the specified criteria, confirming evidence of extremely high pollutant loads.
- Approximately 35 percent of population has access to adequate sanitation facilities.
- Air pollution is on the rise, especially in urban areas.

Recent surveys conducted by Pakistan Environmental Protection Agency revealed presence of very high levels of suspended particulate matter (about 6 times higher than the World Health Organization's guidelines). 'Smog' also seriously affects almost entire Punjab during December and January every year.

- Noise pollution has become a serious issue in major urban centers.
- Of about 54,850 tons of solid waste generated daily in urban areas, less than 60 per cent is collected. No city in Pakistan has proper waste collection and disposal system for municipal, hazardous or healthcare wastes.
- The deforestation rate has been estimated at 0.2-0.5 percent per annum. Forest cover, which was 4.8 percent of total land area in 1992, could hardly be increased substantially despite all efforts.
- Degradation and encroachment of natural forests, rangelands and freshwater and marine ecosystems are resulting in loss of biodiversity. At least four mammal species, including tiger, swamp deer, lion and Indian one-horned rhinoceros, are known to have become extinct from Pakistan while at least 10 ecosystems of particular value for the species richness and uniqueness of their floral and faunal communities are considered to be critically threatened.
- Desertification affects over 43 million hectares of land annually.
- Pakistan is a highly energy in-efficient country. It uses approximately same amount of energy to generate 1 dollar of GNP as the USA.

The situation just mentioned is the result of a number of constraining factors including high population growth rate, prevailing poverty, unplanned urban and industrial expansion, insufficient emphasis on environmental protection in the government policies, lack of public awareness and education and above all the ailing economy which has caused deficiencies in institutional capacity and resources for effective environmental management.

The mid-term review of the NCS led the Government of Pakistan (GOP) and United Nations Development Program (UNDP) to jointly initiate an umbrella support program called the National Environmental Action Plan-Support Program (NEAP-SP) that was signed in October 2001 and implemented in 2002. The development objective supported by NEAP-SP is environmental sustainability and poverty reduction in the context of economic growth. The primary objective of NEAP is to initiate actions and programs for achieving a state of environment that safeguards public health, promotes sustainable livelihood, and enhances the quality of life of the people in Pakistan. The NEAP identifies four primary areas, (1) Clean air (2) Clean water (3) Management of solid waste (4) Ecosystem management. The plan also presents five additional areas of concern (i) Management of fresh water resources (ii) Marine pollution (iii) Toxic and hazardous substances handling and disposal (iv) Energy conservation and management (v) Compliance with international treaties and protocol.

Studies conducted by GOP and Donor Agencies in Pakistan have identified a number of environmental concerns with regard to energy, water and air pollution, waste management, irrigated agriculture, and biodiversity. These studies suggest an overall degradation in the quality and impoverishment of renewable natural resources such as water, forests and other flora as well as key biological habitats. The GOP, private sector and civil society have, with few exceptions, not responded positively to meet the challenges from these concerns.

2.2 Administrative Framework

Environmental issues are governed by three levels of the government viz. Federal, Provincial and Local Government. The Ministry of Environment and Local Government is the Ministry at the Federal level, which oversees the affairs of

the environment in the country. The Provincial Governments have designated the Ministries of Local Government to oversee matters related to the environment at the provincial level. The Provincial EPAs are directly under the respective Provincial Ministry of Local Government and Environment. Sindh EPA is placed under the Ministry of Environment and Alternative Energy, GoS.

2.2.1 Institutional Setup for Environmental Management

The apex environmental body in the country is the Pakistan Environmental Protection Council (PEPC), which is presided over by the Chief Executive of the Country. Other bodies include the Pakistan Environmental Protection Agency (Pak-EPA), provincial EPAs (for four provinces, AJK and Northern Areas), and environmental tribunals.

The EPAs were first established under the 1983 Environmental Protection Ordinance; the PEPA 1997 further strengthened their powers. The EPAs have been empowered to receive and review the environmental assessment reports (IEEs and EIAs) of the proposed projects, and provide their approval (or otherwise).

The proposed project would be located in Sindh Province. Hence this EIA Report will be sent to the Sindh EPA for review and issue of No Objection Certificate (NOC).

The GoS involvement in local government and municipal affairs has been devolved to the Environment Department of the CDGK. However, the devolution program has not been implemented since an environment officer, required to oversee the environmental issues has not been appointed. Coordination of the environmental monitoring activity continues as a provincial subject and is assigned to Provincial EPAs, in this case EPA Sindh, which has been duly authorized to enforce environmental compliance.

The main organizations responsible for providing services in the areas where the Project will be established include the Port Qasim Authority directly.

2.3 Statutory Framework

The Constitution of Pakistan distributes legislative powers between the federal and provincial governments through two 'lists' attached to the Constitution as Schedules. The Federal List covers the subjects over which the federal government has exclusive legislative power, while the Concurrent List contains subjects regarding which both the federal and provincial governments can enact laws.

The development of statutory and other instruments for environmental management has steadily gained priority in Pakistan since the late 1970s. The Pakistan Environmental Protection Ordinance, 1983 was the first piece of legislation designed specifically for the protection of the environment. The promulgation of this ordinance was followed, in 1984, by the establishment of the Pakistan Environmental Protection Agency, the primary government institution dealing with environmental issues. Significant work on developing environmental policy was carried out in the late 1980s, which culminated in the drafting of the Pakistan National Conservation Strategy. Provincial environmental protection agencies were also established at about the same time. The National Environmental Quality Standards were established in 1993. The enactment of the Pakistan Environmental Protection Act (PEPA), 1997 has conferred broad-based enforcement powers to the environmental protection agencies. The publication of the Pakistan Environmental Protection Agency Review of IEE and EIA Regulations (IEE-EIA Regulations), 2000 provided the necessary details on the preparation, submission, and review of initial environmental examinations (IEE) and environmental impact assessments (EIA).

In addition to the PEPA, 1997, Pakistan's statute books contain a number of other laws that have clauses concerning the regulation and protection of the environment.

2.3.1 Pakistan Environmental Protection Act, 1997

Pakistan Environmental Protection Act was introduced in December 1997 to provide for protection, conservation,

rehabilitation and improvement of the environment, for prevention and control of pollution and for sustainability of all development activities. The Act is the basic legislative tool that empowers the government to frame regulations to protect the environment. It broadly applies to air, water, soil, and noise pollution. There are 33 sections in the PEP Act, 1997. Following are very important clauses pertinent to establishment of proposed LNG Project:

- S.R.O. 339 (1)/2001 - In exercise of the powers referred in Section 33 of the PEPA 1997 (XXXIV of 1997), Pak - EPA has, with the approval of the Federal Government introduced "Pak-EPA (Review of IEE and EIA) Regulations, 2000.
- Clause 14 - "Handling of Hazardous Substances" requires anyone who generates, collects, consigns, transports, treats, disposes of stores, handles hazardous material or imports any hazardous waste has to have a permit to do so from EPA.
- Clause 16 - "Environmental Protection Order" permits EPA to enforce protection measures and remediation where contamination of the environment has taken place. Where an order is not carried out, FEPA has the authority to carry out the required works and to recover the costs from the person responsible for the source of environmental contamination.
- Clause 18 - "Offences by Bodies Corporate" identifies individual responsibility and liability to prosecution where contravention of an Ordinance is committed by a body corporate. Accordingly powers of the Federal and Provincial EPAs have been enhanced and they have the powers to conduct enquiries into possible breaches of environmental laws either of their own accord, or upon filing a complaint.
- Clause 30 - "Ordinance to over-ride other laws", takes precedence over other laws in effect at the time.

Under this Act no project including construction activities or any change in the existing physical environment can commence unless the fulfilment of pre-requisite to IEE or EIA has been conducted and its approval obtained from the Responsible Authority, in the present case from Sindh EPA.

A copy of PEPA Act, 1997 is attached as Annex-II.

2.3.2 PAK-EPA (REVIEW OF IEE/EIA) REGULATIONS 2000

Pakistan Environmental Protection Agency Review of IEE and EIA Regulations, 2000 promulgated under PEPA 1997 were enforced in June 2000. These Regulations define the applicability and procedures for preparation, submission and review of IEE and EIA. These Regulations also give legal status to the Pakistan Environmental Assessment Procedures prepared by the Federal EPA in 1997.

Accordingly the Environmental Protection Agencies, including Sindh EPA are bound to conduct a preliminary scrutiny and reply within 10 days of the submittal of the IEE/EIA report. These regulations require submission of a monitoring report to the concerned EPA after completion of the construction, followed by regular monitoring reports, in the case of EIAs, during subsequent operations. EPA is bound to approve or disapprove the report within a period of four months or else the ESIA would be deemed approved.

This regulation also provides procedures for classification of projects on the basis of expected severity of the adverse environmental impact and lists them into three separate schedules. Projects that may not have significant impacts on the environment are included in Schedule-A, and they therefore require an IEE. Schedule-II includes Projects having potentially significant environmental impacts and such projects require submission of an EIA. Schedule-C includes those projects which do not fall in Schedules I and II and do not require an EIA or IEE but require an environmental approval to be sought.

Placement of LNG Project in Schedule-II is based on its severity and due to the reason that it involves shipping activity having gross displacement above 500 tons.

A copy of PEPA IEE/EIA Regulations-2000 is attached as Annex-III.

2.3.3 NATIONAL ENVIRONMENTAL QUALITY STANDARDS (NEQS)

One of the functions of the Pak EPA under the provision of PEPO of 1983 was to issue NEQS for municipal and liquid industrial effluent, industrial gaseous emissions and motor vehicle exhaust and noise. The Pak EPA issued a statutory regulatory order (S.R.O) in 1994. It required all units coming into production after 1st July 1994 to comply immediately with the new standards. Those already in production at the time of S.R.O were required to comply starting 1st July 1996. The Pak EPA was not able to implement the NEQS effectively for many reasons, including lack of implementation capacity and resistance from industry.

With the PEPA, 1997 the Pak EPA revised the NEQS with full consultation of the private sector, industrialist, trade and business associations and NGOs. The municipal and liquid industrial effluent standards cover 32 parameters. The standards for industrial gaseous emissions specify limits for 16 parameters, and the standards for motor vehicles prescribe maximum permissible limits for smoke, carbon monoxide and noise. Revised standards cover discharges limits of effluents into inland water, sewage treatment plant and the sea. The NEQS are primarily concentration based. Unfortunately, the limits on industrial effluents are neither industry specific nor do they have any relationship with the quantum of production. The NEQS prohibit dilution, but this can be easily circumvented.

ETPL is committed to comply with the applicable NEQS in letter and spirit.

The complete set of NEQS is attached as Annex-IV & V.

2.3.4 SELF MONITORING AND REPORTING RULES 2001

The Self-Monitoring and Reporting System (SMART) aims to make the country's industry owners and operators responsible for systematic monitoring and reporting of their environmental performance.

By implementing this system, the government has in fact transferred the responsibility for examining and evaluating industry's environmental performance to individual industrial facilities. Apart from saving EPAs considerable expense, time and effort, this measure has enabled industry owners and operators to make long-term provisions for eco-friendly production. The reported data enables government agencies to assist industrial units in controlling their pollution levels.

All industry owners, majority being small or medium scale operators have not responded to the Self-Monitoring and Reporting System and efforts are underway to bring them in the SMART network.

LNG project should because of its severity fall under the Category A of industrial categorization and reporting procedure for SMART. Regular environmental reports on priority parameters will be sent to the relevant authorities as per the requirements of ESIA approval.

2.3.5 THE BIODIVERSITY ACTION PLAN

The key to protecting the biological heritage of Pakistan lies in the involvement of local people and in the support provided by competent institutions for conservation and sustainable use. The Government of Pakistan has recognized the importance of these measures in the preparation of the National Conservation Strategy and in becoming a signatory to, and in ratifying, the Convention on Biological Diversity (CBD) in 1994. Developing the Biodiversity Action Plan for Pakistan, 2000 has been the most significant direct steps towards addressing the biodiversity loss.

This EIA study has addressed all aspects of conservation, including Wildlife, and forest. It has specifically addressed the mangrove tree removal aspect and suggested mitigation measures.

2.3.6 THE SINDH FISHERIES ORDINANCE, 1980

The Sindh Fisheries Ordinance, 1980 regulates fishing in the public waters, including the coastal areas, of Sindh. It

empowers the government of Sindh to issue licenses for fishing in public waters, put restriction on the type of equipment that can be used for fishing, restrict fishing in certain areas or of certain species of fish, regulate the onshore trade of fish catch, and regulate the fish processing industry. Article 8 of the Ordinance prohibits the discharge of wastewater to public waters without the consent of the Director Fisheries. Sindh Fisheries Department has been informed of the establishment of the LNG Terminal at the sites under consideration. The department is in favor of proposed development and said that ETPL must take adequate measures to protect the biodiversity of the area.

2.3.7 ANTIQUITY ACT 1975

The Antiquities Act of 1975 ensures the protection of cultural resources in Pakistan. The act is designed to protect antiquities from destruction, theft, negligence, unlawful excavation, trade, and export. Antiquities have been defined in the Act as ancient products of human activity, historical sites, or sites of anthropological or cultural interest, national monuments, etc. The law prohibits new construction in the proximity of a protected antiquity and empowers the Government of Pakistan to prohibit excavation in any area that may contain such articles of archaeological significance. Under the Act, the project proponents are obligated to:

- Ensure that no activity is undertaken in the proximity of a protected antiquity
- If an archaeological discovery is made during the course of the project, it should be reported to the Department of Archaeology, Government of Pakistan.

The Act of 1975 is considered quite effective, provided it is administered appropriately. For its proper administration, the federal department of Archaeology needs adequate staff which has not been provided to it. Civic agencies authorized to grant permission for new constructions must keep in view the provisions of the Act. It has been suggested that the Act must be amended to make compulsory registration of the antiquities and the owner of the property be made responsible for preservation of the antiquity.

This ESIA Study has not found any antiquity artifact in the area concerned and does not find that the said Act would apply to siting of the LNG Terminal under consideration.

2.3.8 SINDH CULTURAL HERITAGE (PRESERVATION) ACT, 1994

The Sindh Cultural Heritage (Preservation) Act, 1994 is the provincial law for the protection of cultural heritage. Its objectives are similar to those of the Antiquity Act, 1975.

None of the sites protected under this law have been identified in the vicinity of Project site.

2.3.9 FOREST ACT 1927

This act empowers provincial forest authorities to declare any area as forest. The proposed project is not in forest declared area; however, mangroves (limited impact area) will have the prime importance and their conservation will be considered when the project is executed.

The Forestry Departments manage official forestry reserves and have expressed concern about the level of woodcutting, camel breeding which has taken place in the area. IUCN, Engro Polymer Chemical Pakistan Ltd as well as ETPL have undertaken plantation of mangrove trees in a systematic manner and their experience will ensure that the mangroves are conserved/replanted.

Conservation practices must be adopted at the proposed project site at the pre-construction and construction stages.

2.3.10 SINDH WILDLIFE PROTECTION (SECOND AMENDMENT) ORDINANCE, 2001

Sindh Wildlife Department is responsible for protection of wildlife in the Province. The Department's concerns are limited to areas designated as game reserves, national parks or wildlife sanctuaries and to protecting species afforded protection under the law. So long as the law is

not being contravened they have no official interest in activities carried on outside game reserves, national parks and wildlife sanctuaries. The Department nevertheless has the powers to halt illegal activities outside the protected areas.

Sindh Wildlife Protection Ordinance 1972 was enacted to protect wildlife resources of the province directly, and other natural resources indirectly. It classifies wildlife by degree of protection, i.e., animals that may be hunted on a permit or special license, and species that are protected and cannot be hunted under any circumstances. The Ordinance specifies restrictions on hunting, and trade in animals, trophies, or meat. The Ordinance also provides for the creation of three classes of special protected areas: National Parks (Section 15), Wildlife Sanctuaries (Section 14), and Game Reserves (Section 16).

The 2001-Amendment to Sindh Wildlife Protection Ordinance (1972) allows carrying out activities for exploration of oil and gas in wildlife sanctuaries of national park areas in the province. The Ordinance relates to oil and gas exploration activities in Kirthar National Park, which was declared protected area under Sindh Wildlife Protection Ordinance 1972.

The Wild Birds and Animals Protection Act, 1992, the West Pakistan Wildlife Protection Ordinance 1959, the Wildlife Protection Rules and the Forest Act, 1927 provide for the protection of flora and fauna in the territory, including vegetation and protected forests.

As no activities are planned in or in the vicinity of any protected areas and no provision of this law is applicable to the proposed project.

2.4 Environmental and Social Guidelines

Two sets of guidelines, the Pak-EPA's guidelines and the World Bank Environmental Guidelines are reviewed in this Report. These guidelines address the environmental as well as social aspects relevant to the proposed project.

2.4.1 Environmental Protection Agency's Environmental and Social Guidelines

The Federal EPA has prepared a set of guidelines for conducting environmental and social assessments. The guidelines derive from much of the existing work done by international donor agencies and NGOs. The package of regulations, of which the environmental and social guidelines form a part, includes the PEPA 1997 and the NEQS. These guidelines are listed below.

- Guidelines for the Preparation and Review of Environmental Reports,
- Guidelines for Public Consultation,
- Guidelines for Sensitive and Critical Areas,
- Sectoral Guidelines.

It is stated in the Pakistan Environmental Protection Agency (Review of IEE and EIA) Regulations, 2000 that the EIA or IEE must be prepared, to the extent practicable, in accordance with the Pakistan Environmental Protection Agency Environmental Guidelines.

a. Policy And Procedures For Filing, Review& Approval Of Environmental Assessments

These guidelines define the policy context and the administrative procedures that will govern the environmental assessment process, from the project pre-feasibility stage, to the approval of the environmental report.

This ESIA Study has followed the procedures laid out in the PEPA 1997 and Review guidelines 2000, and the ESIA will be submitted to the EPA Sindh in whose jurisdiction the project will be implemented. The PEPA has, however, been given the right to review any environmental report at any time and the power to revoke the decision of the provincial EPA, if it deems this to be necessary. Figure 2.1 shows EIA preparation and approval procedure.

b. Guidelines for Preparation &

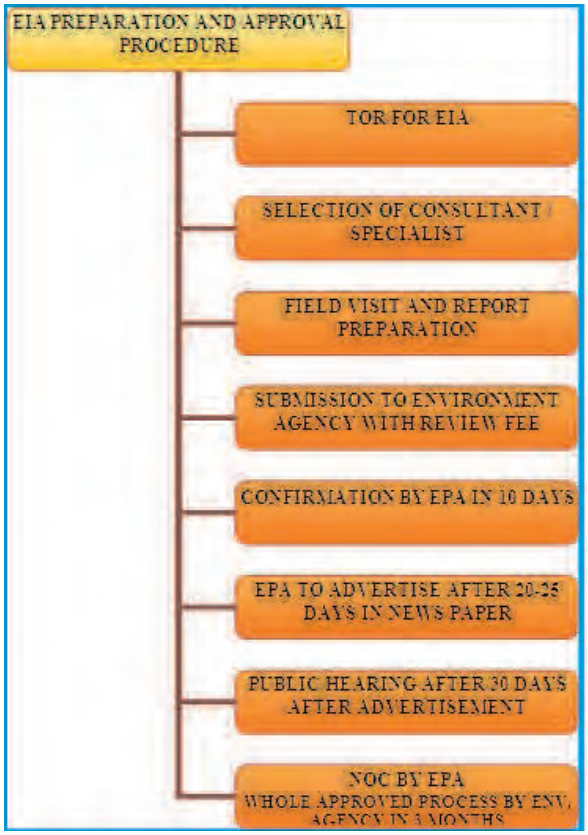


Figure 2.1: EIA Preparation and Approval Procedure

Review of Environmental Reports

It requires proponents to prepare terms of reference for the environmental assessment reports. It requires that all studies should contain baseline data on the area and must contain an assessment of the potential environmental impacts and the recommended mitigation measures.

The guidelines have been duly followed while preparing this ESIA.

c. Guidelines for Public Consultation

These guidelines are part of the package of regulations and guidelines. They provide assistance throughout the environmental assessment of project by involving the public which can lead to better and more acceptable decision-making. The guidelines envisage that public involvement, if undertaken in a positive manner and supported by real desire to use the information gained to improve the proposal, will lead to better outcomes, and lay the basis for ongoing positive relationships among the stakeholders.

2.4.2 World Bank Guidelines on Environment

The principal World Bank publications that contain environmental guidelines are listed below:

a. Environmental Assessment-Operational Policy 4.01. Washington, DC, USA. World Bank 1999;

b. Environmental Assessment Sourcebook, Volume I: Policies, Procedures, and Cross- Sectoral Issues. World Bank Technical Paper Number 139, Environment Department, the World Bank, 1991;

c. Environmental Assessment Sourcebook, Volume III: Guidelines for Environmental Assessment of Energy and Industry Projects. World Bank Technical Paper No. 154, Environment Department, the World Bank, 1991;

d. Pollution Prevention and Abatement Handbook: Towards Cleaner Production, Environment Department, the World Bank, United Nations Industrial Development Organization and the United Nations Environment Program, 1998.

The first two publications listed here provide general guidelines for the conduct of an IEE/EIA, and address the IEE/EIA practitioners themselves as well as project designers. While the Sourcebook in particular has been designed for the Bank projects, and is especially relevant for the impact assessment of large-scale infrastructure projects, it contains enormous information which is useful to environmentalists and project proponents.

2.4.3 Equator Principle

The Equator Principles (EP) comprises a series of standards for the management of environmental and social issues in financing development projects globally. Once adopted by banks and other financial institutions, the Equator Principles commit the adoptees to refrain from financing projects that fail to follow the processes

defined by the Principles. The private sector banks which developed the Equator Principles chose to model the Equator Principles on the environmental standards of the World Bank and the social policies of the International Finance Corporation (IFC). The Equator Principles have become the de facto standards for banks and investors on assessment of major development projects around the world.

Project financiers may encounter social and environmental issues that are both complex and challenging, particularly with respect to projects in the emerging markets. The Equator Principles Financial Institutions (EPFIs) have consequently adopted these Principles to ensure that the projects they finance are developed in a manner that is socially responsible and reflects sound environmental management practices. By doing so, negative impacts on project-affected ecosystems and communities are avoided where possible, and if these impacts are unavoidable, they are to be reduced, mitigated and/or compensated for appropriately. It is believed that adoption of and adherence to these principles offer significant benefits to institutions, their borrowers and local stakeholders through their borrowers' engagement with locally affected communities. It is therefore recognized that the role of the institutions as financiers affords them opportunities to promote responsible environmental stewardship and socially responsible development.

EPFIs therefore consider reviewing these principles from time-to-time based on implementation experience, and in order to reflect ongoing learning and emerging good practice. These principles are intended to serve as a common baseline and framework for the implementation by each EPFI of its own internal social and environmental policies, procedures and standards related to its project financing activities. The institutions will not provide loans to projects where the borrower will not or are unable to comply with their respective social and environmental policies and procedures that implement the Equator Principles.

The Equator Principles apply to projects over 10 million US dollars. The Principles state that adopting financial institutions will provide loans directly to projects only under the following circumstances:

A. Principle 1: Review and Categorization

The risk of the project is categorized in accordance with internal guidelines based upon the environmental and social screening criteria of the IFC. Projects are classified, relating to social or environmental impacts, in Category A (significant impacts), Category B (limited impacts) and Category C (minimal or no impacts).

B. Principle 2: Social and Environmental Assessment

For all medium or high risk projects (Category A and B projects), sponsors complete an Environmental Assessment, the preparation of which must meet the National and International requirements and satisfactorily address the key environmental and social issues.

C. Principle 3: Applicable Social and Environmental Standards

The Environmental Assessment report addresses baseline environmental and social conditions, requirements under host country laws and regulations, applicable international treaties and agreements, sustainable development and use of renewable natural resources, protection of human health, cultural properties, and biodiversity, including endangered species and sensitive ecosystems, use of dangerous substances, major hazards, occupational health, and safety, fire prevention and life safety, socio-economic impacts, land acquisition and land use, involuntary resettlement, impacts on indigenous peoples and communities, cumulative impacts of existing projects, the proposed project, and anticipated future projects, participation of affected parties in the design, review and implementation of the project, consideration of feasible environmentally and socially preferable alternatives, efficient production, delivery and use of energy, pollution prevention and waste minimization,

pollution control (liquid effluents and air emissions) and solid and chemical waste management.

D. Principle 4: Action Plan and Management System

Based on the Environmental Assessment, Equator banks then make agreements with their clients on how they mitigate, monitor and manage those risks through a 'Social Environmental Management Plan'.

E. Principle 5: Consultation and Disclosure

For risky projects, the borrower consults with stakeholders (NGOs and project affected groups) and provides them with information on the risks of the project. The borrower has to consult the project affected communities in a structured and culturally appropriate manner. The process will ensure free, prior and informed consultation for affected communities.

F. Principle 6: Grievance Mechanism

The borrower will establish a grievance mechanism as part of the management system.

G. Principle 7: Independent Review

Assessment, preparation of Assessment Plan and consultation process.

H. Principle 8: Covenants

Incorporation of Covenants linked to compliance. Compliance with the plan is required in the covenant. If the borrower does not comply with the agreed terms, the bank will take corrective action, which if unsuccessful, could ultimately result in the bank cancelling the loan and demanding immediate repayment.

I. Principle 9: Independent Monitoring and Reporting

An independent expert is consulted during the life of the loan for Category A and, if necessary in Category B.

J. Principle 10: EPFI Reporting

Each EPFI commits to report publicly at least annually about its implementation processes and experience on Equator Principles.

This ESIA study has adequately addressed the Equator Principles applicable to risky projects as stated hereunder:

a. Principle 1 Review and Categorization: The study has reviewed the National and International Laws and Guidelines on different environmental aspects and has categorized the LNG Project in Schedule-A (Major Hazard), requiring EIA.

b. Principle 2 Social and Environmental Assessment: The Study has been prepared to respond to the National and International requirements and to satisfactorily address the key environmental and social issues.

c. Principle 3 Applicable Social and Environmental Standards: For the purpose of this EIA Study, primary data on the baseline environmental and social conditions have been generated wherever necessary to address the requirements of National laws and regulations; applicable International Treaties and Agreements; sustainable development and use of renewable natural resources; protection of human health, cultural properties, and biodiversity and other physical, ecological and socioeconomic issues required to be addressed under this Principle.

d. Principle 4 Action Plan and Management System: Chapter 5 of this study screens the potential environmental impacts and proposes/provides Mitigation Measures to reduce the severity of impact. The study also includes the Environmental Monitoring and Management Plan, Contingency Plan and Disaster Management Plan.

e. Principle 5 Consultation and Disclosure: Being a risky project of Schedule -A, the public consultation is limited to the scoping sessions with stakeholders and an extensive socioeconomic survey of the villages/hamlets

that are all outside the boundary of the Project area. The surveys and consultation meetings have established that no resettlement or temporary relocation or acquisition of land is involved.

f. Principle 6 Grievance Mechanism: This Principle will not apply since no resettlement or temporary relocation or acquisition of land is involved.

g. Principle 7 Independent Review: Being placed in Schedule-A, an independent review may be needed.

h. Principle 8 Covenants: The EIA study has incorporated Covenants linked to compliance. Moreover, No Objection Certificates are issued to Proponents of Project under conditions of compliance with the Mitigation and Performance Monitoring Plan. Needless to say that if the proponent does not comply with the agreed terms, Sindh EPA is authorized to take corrective and even coercive action.

i. Principle 9 Independent Monitoring and Reporting: This Principle will be applicable to the LNG Project since it is a high risk project.

j. Principle 10 EPFI Reporting: The concerned EPFI may safely commit to report publicly at least annually about its Equator Principles implementation processes and experience.

2.4.4 IFC PERFORMANCE STANDARDS ON SOCIAL AND ENVIRONMENTAL SUSTAINABILITY

International Finance Corporation (IFC) applies the Performance Standards to manage social and environmental risks and impacts and to enhance development opportunities in its private sector financing in its member countries eligible for financing. The Performance Standards may also be applied by other financial institutions electing to apply them to projects in emerging markets. Together, the eight Performance Standards establish standards that the Proponent is to meet throughout the life of an investment by IFC/WB or other relevant financial institution.

The objectives of Performance standards are given below:

- To identify and assess social and environment impacts, both adverse and beneficial, in the project's area of influence
- To avoid, or where avoidance is not possible, minimize, mitigate, or compensate for adverse impacts on workers, affected communities , and the environment
- To ensure that affected communities are appropriately engaged on issues that could potentially affect them
- To promote improved social and environment performance of companies through the effective use of management systems.

A. PERFORMANCE STANDARD-1: ASSESSMENT AND MANAGEMENT OF ENVIRONMENTAL AND SOCIAL RISKS AND IMPACTS

This Performance Standard seeks to:

i) Identify and assess social and environment impacts in the project's area of influence;

ii) Avoid, minimize, mitigate, or compensate for adverse impacts on workers, affected communities, and the environment;

iii) Ensure that affected communities are appropriately engaged on issues that could potentially affect them; and

iv) Promote improved social and environment performance of the project through the effective use of management systems.

Under this Standard, the project is required to establish and maintain a social and environmental management system appropriate to the nature and scale of the project and in accordance with the level of social and environmental risks and impacts. The management system is required to incorporate the following elements:

- Social and Environmental Assessment;

- Management program;
- Organizational capacity;
- Training;
- Community engagement;
- Monitoring; and
- Reporting

This ESIA study has been conducted to respond to requirements of national legislation and international Guidelines and just as well fulfills the above requirements of the IFC Performance Standards PS1.

B. Performance Standard-2: Labor and Working Conditions

This PS seeks to establish, maintain and improve the worker-management relationship; promote fair treatment, non-discrimination and equal opportunity for workers, and compliance with national labor and employment laws; protect the workforce by addressing child labor and forced labor issues; and promote safe and healthy working conditions, and to protect and promote the health of workers.

The Sponsors of proposed project and their contractors will be required to adhere to this PS, in particular with regard to compliance with national labor and employment laws; employment of child labor, and promoting safe and healthy working conditions, besides protecting and promoting the health of workers. The proponent and its sponsors have actively pursued CSR activities and are responsible corporate citizens.

C. Performance Standard-3: Resource Efficiency and Pollution Prevention

The PS 3 seeks to avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities, and to promote the reduction of emissions that contribute to climate change. The Standard requires the project to consider during its entire lifecycle ambient conditions and apply pollution prevention and control technologies and practices that are best suited to avoid or, where avoidance is not feasible, minimize or reduce adverse impacts on human health and the environment while remaining technically and financially feasible and cost-effective.

PS 3 will be applicable to all stages of the LNG Project. Various aspects of pollution prevention and abatement of the proposed project are discussed separately in this report.

D. Performance Standard-4: Community Health, Safety, and Security

The PS 4 seeks to avoid or minimize risks to and impacts on the health and safety of local community during the project lifecycle from both routine and non-routine circumstances, and to ensure that the safeguarding of personnel and property is carried out in a legitimate manner that avoids or minimizes risks to the community's safety and security. The PS requires the project to evaluate the risks and impacts to the health and safety of the affected community during the design, construction, operation, and decommissioning of the project and establish preventive measures to address them in a manner commensurate with the identified risks and impacts.

The present assessment addresses the requirement of PS 4 for the proposed LNG Poject, and has evaluated the impacts of siting the LNG Terminal on health, safety and security of the community in the microenvironment as well as the macroenvironment. The Environmental Management Plan also addresses company community aspects.

E. Performance Standard-5: Land Acquisition and Involuntary Resettlement

This PS aims to address the adverse impacts associated with land acquisition and involuntary resettlement

caused by the project. The PS seeks to:

- avoid or at least minimize involuntary resettlement wherever feasible by exploring alternative project designs
- mitigate adverse social and economic impacts from land acquisition or restrictions on affected persons' use of land by: (i) providing compensation for loss of assets at replacement cost; and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected
- improve or at least restore the livelihoods and standards of living of displaced persons
- improve living conditions among displaced persons through provision of adequate housing with security of tenure at resettlement sites.

The LNG Project site is dedicated to establishment of facilities of similar nature. Moreover there is no settlement or hamlet within the designated area. Land acquisition by the Project will therefore not cause any involuntary resettlement as it is to be allocated by PQA.

f. Performance Standard-6: Biodiversity Conservation and Sustainable Management of Living Natural Resources

The PS 6 seeks to protect and conserve biodiversity, and promote sustainable management and use of natural resources through adoption of practices that integrate conservation needs and development priorities.

The present environmental assessment addresses the potential impacts of the LNG Project on the biodiversity. This ESIA has recommended measures for the conservation of flora, fauna and other natural resources including impact on marine life in case of leakage.

g. Performance Standard-7: Indigenous Peoples

The PS 7 seeks to address the impacts of the project on the indigenous people. Specifically, the objectives of the PS are to:

- ensure that the development process fosters full respect for the dignity, human rights, aspirations, cultures and natural resource-based livelihoods of Indigenous Peoples
- avoid adverse impacts of projects on communities of Indigenous Peoples, or when avoidance is not feasible, to minimize, mitigate, or compensate for such impacts , and to provide opportunities for development benefits, in a culturally appropriate manner
- establish and maintain an ongoing relationship with the Indigenous Peoples affected by a project throughout the life of the project
- foster good faith negotiation with and informed participation of Indigenous Peoples when projects are to be located on traditional or customary lands under use by the Indigenous Peoples
- respect and preserve the culture, knowledge and practices of Indigenous Peoples

No indigenous people - with a social and cultural identity distinct from the existing dominant society that makes them vulnerable to being disadvantaged in the development process of the LNG Project are known to exist in and around the proposed site. No such people were found in the area during the present study either. Therefore, this PS is not applicable for the proposed project.

h. Performance Standard-8: Cultural Heritage

The objectives of this PS are to protect cultural heritage from the adverse impacts of project activities and support its preservation, and to promote the equitable sharing of benefits from the use of cultural heritage in project activities.

No sites of cultural heritage are known to exist at or in the immediate vicinity of the LNG Project location. There are also no indications of any old settlement in the

area, nor is there any site covered under the listing of cultural heritage sites. This PS will therefore not be applicable to the Project.

2.4.5 National Strategy and Action Plan for Mangroves for the Future (MFF)

MFF National Strategy and Action Plan (NSAP) will support the development vision of the Government of Pakistan and associated policies as they relate to sustainable use and management of coastal ecosystems and adaptation to climate change in the context of integrated coastal management. The NSAP does not solely focus mangrove forests but entails mangrove ecosystem and associated biodiversity, thus the term 'mangrove' is used as a symbolic label. Pakistan's NSAP specifically addresses and treats issues related to the dominant coastal ecosystems viz mangroves, estuaries turtle nesting beaches and coral reef. NSAP Pakistan will contribute towards ecosystem-based integrated coastal management (ICM) and its goal would be to improve the quality of life of dependent communities. ICM by its inherent nature requires actions at local geographic sites - both entire ecosystems and parts thereof.

The NSAP conforms to Government of Pakistan's basic requirement of good governance and community participation in development programmes. It builds on the principles that a central body (NCB) should perform only those tasks which cannot be performed effectively at a more immediate or local level. However at local level Programme of Works (PoW) will be implemented by different organizations under the guidance of NCB. The NSAP follows a cross sectoral collaborative approach in harmony with other policies and programmes of development sectors including climate change mitigation and adaptation policy.

In the context of challenges to the coastal areas of Pakistan, the NSAP paves the way for development of ICM programme for Pakistan to ensure good governance, knowledge management, community empowerment, and public-private partnership (sustainable financing) by:

- Setting up ICM models in selected coastal ecosystems
- Scaling up the successful models at the entire coastal belt

2.4.6 National Climate Change Policy

The National Climate Change Policy provides a framework for addressing the issues that Pakistan faces or will face in future due to the changing climate.

The main objectives of Pakistan's climate change policy include:

- To pursue sustained economic growth by appropriately addressing the challenges of climate change;
- To integrate climate change policy with other interrelated national policies;
- To focus on pro-poor gender sensitive adaptation while also promoting mitigation to the extent possible in a cost effective manner;
- To ensure Water Security, Food Security and Energy Security of the country in the face of challenges posed by climate change;
- To minimize the risks arising from expected increase in frequency and intensity of extreme weather events: floods, droughts, tropical storms etc;
- To strengthen inter-ministerial decision making and coordination mechanism on climate change;
- To facilitate effective use of the opportunities, particularly financial, available both nationally and internationally;
- To foster the development of appropriate economic incentives to encourage public and private sector investment in adaptation measures;
- To enhance the awareness, skill and institutional

capacity of relevant stakeholders;

- To promote conservation of natural resources and long term sustainability.

2.4.7 IFC- Environment, Health & Safety Guidelines for LNG

A- EHS guidelines for LNG

These EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS guidelines are designed to be used together with the General EHS Guidelines document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors.

B- General EHS Guidelines

The General EHS Guidelines contain information on cross-cutting environmental, health, and safety issues potentially applicable to all industry sectors. These General EHS Guidelines are designed to be used together with the relevant Industry Sector EHS Guidelines which provide guidance to users on EHS issues in Specific industry sectors. EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. The General EHS Guidelines are organized as follows:

- Environmental
- Occupational health and safety
- Community health and safety
- Construction and decommissioning

This guideline applies to facilities or projects that generate emissions to air at any stage of the project life-cycle. The applicability of the EHS Guidelines need to be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment.

C- Environmental, Health, and Safety Guidelines for Liquefied Natural Gas (LNG) Facilities

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry. These EHS Guidelines are applied as required by their respective policies and standards. EHS guidelines for LNG facilities are designed to be used together with the General EHS Guidelines document, which Provides guidance to users on common EHS issues potentially applicable to all industrial sectors.

The applicability of EHS Guidelines for Crude Oil and Petroleum Product Terminals include information relevant to land and shore-based petroleum storage terminals receiving and dispatching bulk shipments of crude oil, gasoline, middle distillates, aviation gas, lube oil, residual fuel oil, compressed natural gas (CNG), liquid petroleum gas (LPG), and specialty products from pipelines, tankers, railcars, and trucks for subsequent commercial distribution. This guideline covers Industry-Specific Impacts and Management and Performance Indicators and Monitoring.

The EHS Guidelines for Liquefied Natural Gas (LNG) Facilities include information relevant to LNG base load liquefaction plants, transport by sea, and re-gasification and peak sharing terminals. For coastal LNG facilities including harbors, jetties and in general coastal facilities (e.g. coastal terminals marine supply bases, loading / offloading terminals), additional guidance is provided in the EHS Guidelines for Ports, Harbors, and Terminals. For EHS issues related to vessels, guidance is provided in the EHS Guidelines for Shipping. Issues related to LPG/Condensate production and storage in liquefaction plants are not covered in this Guideline.

Certain objectives have been set in IFC performance standards to achieve sustainable development. Those objectives are given below:

- To identify and assess social and environment impacts, both adverse and beneficial, in the area of influence of LNG project
- To avoid, or where avoidance is not possible, minimize, mitigate, or compensate for adverse impacts on workers, affected communities , and the

environment

- To ensure that affected communities are appropriately engaged on issues that could potentially affect them
- To promote improved social and environment performance of companies through the effective use of management systems.

Relevant International Standards for Noise and Effluent discharges have been tabulated & provided as Annex-VI.

2.4.8 ABB'S SAFEGUARD POLICY STATEMENT 2009

As per Asian Development Bank's SPS 2009, depending on the significance of project impacts and risks, the assessment may comprise a full-scale environmental impact assessment (EIA) for category A projects, an initial environmental examination or equivalent process for category B projects, or a desk review. ADB uses a classification system to reflect the significance of a project's potential environmental impacts. A project's category is determined by the category of its most environmentally sensitive component, including direct, indirect, cumulative, and induced impacts in the project's area of influence. Projects are assigned to one of the following four categories:

Category A: A proposed project is classified as category A if it is likely to have significant adverse environmental impacts that are irreversible, diverse, or unprecedented. These impacts may affect an areas larger than the sites or facilities subject to physical works. An environmental impact assessment is required.

Category B: A proposed project is classified as category B if its potential adverse environmental impacts are less adverse than those of category A projects. These impacts are site specific, few if any of them are irreversible, and in most cases mitigation measures can be designed more readily than for category A projects. An initial environmental examination is required.

Category C: A proposed project is classified as category C if it is likely to have minimal or no adverse environmental impacts. No environmental assessment is required although environmental implications need to be reviewed.

Category FI: A proposed project is classified as category Fl if it involves investment of ADB funds to or through a Fl

When the project involves existing activities or facilities, relevant external experts will perform environmental audits to determine the existence of any areas where the project may cause or is causing environmental risks or impacts. If the project does not foresee any new major expansion, the audit constitutes the environmental assessment for the project. The policy under the SPS 2009 for environmental assessment are:

- Apply pollution prevention and control technologies and practices consistent with international good practice, as reflected in internationally recognized standards such as the World Bank Group's Environmental, Health and Safety (EHS) Guidelines.
- Adopt cleaner production processes, and good practices of energy efficiency.
- Avoid or, when avoidance is not feasible, minimize or control the intensity or load of pollutants emissions and discharges, including direct and indirect greenhouse gases emissions, waste generation, and release of hazardous material from their production, transportation, handling and storage.
- Avoid the use of hazardous materials subject to international bans or phase-outs
- Use, purchase and manage pesticides based on integrated pest management approaches and reduce reliance on synthetic chemical pesticides

2.5 ACTS, REGULATIONS, GUIDELINES & POLICIES ON LNG

2.5.1 PORTS ACT 1908 & PAKISTAN

Territorial Waters & Maritime Zones Act 1976

The Ports Act 1908 ensures safe shipping in the sea and prevention of pollution in waters. Pakistan Territorial Waters and Maritime Act 1976 regulates the exploration, development, conservation, and management of living and nonliving resources in Pakistan's Exclusive Economic Zone (EEZ), which extends up to 200 miles from the country's coastal zone.

Ports Act 1908 and Pakistan Territorial Waters and Maritime Zones Act 1976 will both apply to the Project. The Project proponent will be mandated to ensure safe shipping of the LNG Carriers (LNGC)s and to adopt measures for prevention of pollution of the sea and the resources in Pakistan's Exclusive Economic Zone (EEZ), which extends up to 200 miles from the country's coastal zone.

2.5.2 Port Qasim Authority Act, 1973 (Modified in 2002)

This act empowers PQA to prepare master plan and a master-program for development of the port area. Environmental control and prevention of pollution in the port area are also responsibilities of this authority. This act encourages promising proponents to conduct EIA or IEE prior to any development in the port area. Clause 71B and 71C, explains the responsibilities of authorities and the penalties for non-compliance. Both the clauses are stated hereunder:

a. 71B (Port to be Pollution Free, etc)

- The authority shall be responsible for maintaining the marine environments of the port's limit in order to ensure that the sea, land and air are free from pollution.
- No owner or master of the vessel or any industry, manufacturing establishment, mill, factory or any kind, cargo handling company, terminal operator, etc. shall discharge any solid or liquid waste, oily, noxious radioactive and hazardous substances, bilge discharges, residues and mixtures containing noxious solid and liquid wastes, de blasting of unwashed cargo tanks and line washing, garbage, emission of any effluent or waste or air pollution or noise in any amount concentration or level in excess of NEQS, or standards, which may be specified, from time to time, by the Authority of Port limits.
- Any person contravening the provision of sub-section (2) shall be liable to penalty as determined and noticed by the authority from time to time for each contravention in addition to the charges for cleaning of port and removal of pollution therefrom.

b. Section 71C (Environmental Pollution)

No proponent of the project shall commence construction or operation unless he has filed with this authority an IEE or, where the project is likely to cause an adverse environmental effect, an EIA, and has obtained from authority approval thereof.

The authority shall:

- Review the IEE and accord its approval, or required submission of an EIA by the proponent; or
- Review the EIA and accord its approval subject to such condition as it may deem fit to impose, or require that the EIA be re-submitted after such modification as may be stipulated.

2.5.3 Coastal Zone Regulation 1991

Coastal Zone Regulation (CZR) 1991 concerns the coastal stretches of seas, bays, estuaries, creeks, rivers and backwaters. It extends on the beach up to 500 meters from the high tide line (HTL) and includes the land between the low tide land (LTL) and the HTL.

Setting up of new industries or expansion of existing industries, handling of hazardous wastes, discharge of untreated wastes and effluents, dumping of municipal wastes as landfill or otherwise, mining of sand, rocks and sub-strata materials and land reclamation within the CZR is forbidden, except for the purpose of construction of ports, harbors, jetties, wharves, quays, bridges and sea

links.

CZR specifically lays down that reclamation for commercial purposes such as shopping and housing complexes, hotels and entertainment activities shall not be permitted. However, separate guidelines for construction of beach tourist resorts/hotels in CZR-III are provided for a no development zone (NDZ) for 200 meters from the HTL and within the area between the HTL and LTL is defined. With the prior approval of the ministry of environment and forests, two-storey structures can be built in this NDZ

This EIA Study has taken cognizance of Coastal Zone Regulation 1991 in screening the potential environmental impact of siting the LNG Terminal.

2.5.4 LNG POLICY 2011

The LNG Policy 2011 aims to facilitate the potential investors in LNG sector, by bringing more clarity and predictability for investors, on the basis of their experience and the bottlenecks pointed out by the potential investors during various interactions with OGRA. The LNG Policy, 2011 covers Import Project Structure, LNG Procurement, Ownership & Operation of the LNG Terminal, RLNG Marketing & Transportation, and Regulatory Framework during construction period and operational period, Government Incentives, Pricing of RLNG, Government Guarantee, Freedom to Participate in the LNG Business, Technical Codes and Standards, Shipping of LNG, Other Permits and Licenses. Prior permission of GoP for Spot purchase of LNG will not be required. SSGCL/SNGPL will not sell gas priced under weighted average cost of gas mechanism, to industries, which are selected by GOP to use RLNG from time to time. Licensees will be required to furnish guarantee against their delivery commitment. In case of failure of the licensee to deliver LNG by stipulated date, its first right to 3rd Party Access will stand waived off. The involvement of Coast Guards or any other agency to control activities of entry and exit of shipping traffic and requirement of security escort through Coast Guards at the expense of LNG developer, LNG Terminal Owner/Operator and LNG Buyer will no longer be necessary.

Port authorities have been obligated to convey their decision on acceptance of site within one month of submittal of NOC from Sindh Environmental Protection Agency, Quantitative Risk Assessment Study and Navigational Simulation Study. OGRA's discretionary rights to grant exemptions from mandatory Regulated 3rd Party Access or Negotiated Third Party Access requirements are no longer valid. The project proponents have been allowed to establish gas storage facility subject to applicable rules and OGRA has been mandated to determine storage tariff. The committee will take up the tariff rationalization in the next meeting.

Pakistan's policy for the sustainable development of the energy sector, including the provision of reliable and competitively-priced energy is based on the following objectives:

a) Optimization of the primary energy mix, based on economic and strategic considerations;

b) Maximizing the utilization of indigenous energy resources;

c) Enhancing private sector participation in the energy sector by strengthening the regulatory framework and institutional capacity;

d) Developing energy infrastructure; and

e) Developing human resources with emphasis on energy sector-specific technical skills and expertise

Natural gas plays a key role in Pakistan's energy balance which is currently around 50% of the country's primary energy supplies. With accelerating economic growth, the demand for gas is projected to increase sharply and the country's recoverable indigenous gas reserves will be insufficient to meet this demand. Gas shortages have already emerged and shall increase substantially in the following years if indigenous supply is not supplemented through imports. In order to address the shortage, strong emphasis is being laid on importing gas

from neighboring gas-producing countries through cross-border gas pipelines and also in the form of liquefied natural gas ("LNG"). Necessary measures are being taken for installation of LNG receiving, storage, re-gasification facilities and expansion of gas transmission infrastructure, for the distribution and sale of Regasified LNG ("RLNG") in the domestic market.

The LNG Policy aims to facilitate expeditious implementation of the LNG Projects. It has laid out the following framework for the Ownership & Operation of LNG Terminals:

The LNG Developer or LNG TO/O, as the case may be, will obtain a license to design, construct, operate and own a LNG terminal from OGRA under the Oil and Gas Regulatory Authority Ordinance, 2002 subject to satisfying the following criteria:

(a) Technical: At least one member of the consortium of LNG Developer or LNG TO/O, as the case may be, should have experience in developing and operating a liquefaction plant or a regasification terminal. The LNG terminal will be constructed based on technical standards as prescribed by the OGRA from time to time, in consultation and approval of Department of Explosives, including internationally acceptable industry technical standards as stipulated in Appendix-1.

(b) Financial: The LNG Developer or LNG TO/O consortium (on a several or joint and several basis) should have liquidity, revenues, net income and net worth above prescribed minimum thresholds (to be set by OGRA taking into consideration the financial obligations associated with the development and operation of the LNG import terminal).

(c) Health, Safety & Environmental ("HSE") Standards:

1. The LNG Developer, LNG TO/O or LNG Buyer as the case may be, will ensure that the project complies with World Bank HSE Guidelines, Pakistan's Environmental Protection Act 1997 rules, regulations and guidelines made there under, National Environmental Quality Standards, Pakistan's health, environment and safety standards and is consistent with the best international LNG industry practices.

2. The LNG Developer or LNG TO/O will undertake a comprehensive environmental impact assessment of the design, construction and operational aspects of the project including impact assessment of shipping associated with the project, in accordance with international standards and practices. The studies and approvals required at the planning, construction, commissioning and operating phases are defined in the Pakistan Environmental Protection Act, 1997.

3. All LNG terminals shall be surrounded by safety zones which shall meet the industry standards set forth in safety codes of the National Fire Protection Association of USA and as per the risk assessment studies so as to ensure protection of neighboring communities and shipping traffic.

4. Site approval: The site (either land based terminal or offshore terminal of any type) for setting up an LNG terminal shall be selected by LNG Developer or LNG TO/O, as the case may be, taking into account the following factors:

- Existing and projected population and demographic characteristics of the location;
- Existing and proposed land use near the location;
- Physical aspects of the location;
- Medical, law enforcement and fire protection capabilities near the location that can cope with a risk caused by the facility;
- Exclusion zone distances from the terminal to property and population as per international standards are complied with;
- Proximity to existing gas infrastructure and market;
- Need to encourage remote sitting;
- Any other significant community concerns; and

- Environmental considerations.

In applying for the license, the LNG Developer or LNG TO/O will have the onus of demonstrating compliance with the above criteria through risk assessment and simulation studies.

Port Authorities will convey their decision on acceptance of site within one month of submission of NOC from SEPA, QRA study and navigational simulation study.

The licensee shall:

- Ensure delivery of LNG on fast track basis.
- Furnish guarantee against it commitment.

In case of licensee's failure to deliver LNG by stipulated date its right to Third Party Access will be subject to cancellation/review by OGRA.

2.5.5 Maritime Policy of Pakistan

The National Maritime Policy of Pakistan was approved and notified on October 16, 2002. The policy advocates "Management of Assets in a judicious manner with conscientious regard to the environment and international law". The objective of the policy is "protection and conservation of maritime environment/ecosystem" and section IV of the Policy holds the Port Authorities responsible to protect the maritime environment within their prescribed limits. This includes tasks of monitoring and combating spills of all kinds.

2.5.6 International Maritime Conventions

ETPL and its suppliers will comply with International Maritime Conventions in the import of LNG. These will include the conventions of the International Maritime Organization, International Labor Organization, United Nations, World Health Organization and others as appropriate.

The primary International Maritime Organization (IMO) safety standard governing the marine transport of LNG is the "International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk," (IGC Code - 1993 Edition).

A. MARPOL 1973 (modified in 1978

Ship-generated waste is regulated globally as part of the implementation of the International Convention for the prevention of pollution from Ships 1973 as modified by the Protocol of 1978 (MARPOL 73/78). The requirement of MARPOL 73/78 is established in 20 Articles, two Protocols and five annexes; these include contamination by oil, noxious liquid substances carried in bulk, harmful substances, sewage and garbage. Pakistan is signatory to all five annexes. Nevertheless, pollution prevention practices consistent with MARPOL requirements will be adhered to during all the phases of project. The Project proponent will be mandated to ensure safe shipping of the LNG Carriers (LNGC)s and besides adopting measures for prevention of pollution of the sea, will follow the International Convention for the prevention of pollution from Ships 1973 as modified by the Protocol of 1978 (MARPOL 73/78).

B. SIGTTO

The Society of International Gas Tankers and Terminal Operators (SIGTTO 1997) and The International Navigation Association (PIANC 1997) guidelines for LNG Docking facilities will be referred to during project design and construction.

C. London Convention 1972

In 1972, The London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter defines a Black List of toxic substances, and a Grey List of less hazardous substances that may only be dumped under a prior special permit, the dumping of any other wastes not specified in these lists requires a prior general permit. In 1990 this Convention was amended to require signatory countries to consider whether an adequate scientific basis exists for assessing the environmental impact of a substance (i.e. dredged material) before issuing a permit for dumping. Pakistan is signatory to the London Convention and a

Notification came into force on 8th April 1995.

The Project Proponent will follow the procedures adopted by the other units based in Port Qasim area for dumping the wastes including dredged material and on guidelines of PQA. PQA has notified locations of dumping dredged material.

D. LAWS OF SEAS:

The UN Convention on the Law of the Sea was adopted and opened for signature in 1982. On November 16th 1994, it entered into force for 68 countries. Pakistan is signatory to the convention. It establishes a basic structure of obligations, objectives and principles covering all sources of marine pollution that include:

- Pollution by vessels (operational and accidental discharges from ships), and
- Dumping (the deliberate disposal of wastes at sea by ships, aircrafts, platforms, or other manmade structures).

PQA will be mandated to ensure safe shipping of the LNG Carriers (LNGC)s and follow the Laws of Seas for prevention of pollution by vessels, besides taking measures to avoid dumping of ship wastes into the seas.

2.5.7 TECHNICAL GUIDELINES, STANDARDS AND REGULATIONS:

1) DESIGN CODES AND STANDARDS FOR FLOATING LNG TERMINALS

- Pressure Vessels - ASME Boiler and Pressure Vessel Code
- Hydrocarbon Piping - IMO IGC Code (International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk) where appropriate.
- Electrical Systems - NFPA 70, National Electrical Code
- Hydrocarbon Pumps - API Standard 610, Centrifugal Pumps for Refinery Service
- Fired Heaters - API Standard 560, Fired Heaters for General Refinery Services
- Shell and Tube Heat Exchangers - API Standard 660, Shell-and-Tube Heat Exchangers for General Refinery Service
- Fire Protection - NFPA, various.
- Structural - AISC, Manual of Steel Construction (including requirements for acceleration due to transportation and in-service motions)

2) TECHNICAL CODES AND STANDARDS FROM LNG POLICY 2011

(A) SHIPPING AND MARINE FACILITIES STANDARDS

- Standard for the Production, Storage and Handling of Liquefied Natural Gas (LNG) - 2006, NFPA 59A, NFPA.
- Installations and Equipment for Liquefied Natural Gas - Design of Onshore Installations - 1997, (BS EN 1473) CEN.
- Installations and Equipment for Liquefied Natural Gas - Design and Testing of Loading/Unloading Arms - 1996, (BS EN 1474) CEN.
- Installations and Equipment for Liquefied Natural Gas - Ship to Shore Interface for Liquefied Natural Gas - 1996, (BS EN 1532) CEN.
- Installations and Equipment for Liquefied Natural Gas - General Characteristics of Liquefied Natural Gas - 1997, (BS EN 1160) CEN.
- Maritime Structures - Part 1, General Criteria - 1984. (BS 6349), BSI.
- Maritime Structures - Part 4. Code of Practice for Design of Fendering and Mooring Systems - 1994, (BS 6349), BSI.
- IGC Code - IMO-104E - International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk - IGC Code, 1993 including

amendments.

- Guidance Notes, Classification and Certification of Floating Offshore Liquefied Gas Installations - Lloyd's Register, April 2004, Revision 2.
- Guidance Notes, Classification and Certification of Offshore Gravity Based Liquefied Gas Terminals - Lloyd's Register, April 2004, Revision 1.

(B) GUIDELINES

- Site Selection and Design for LNG Ports and Jetties - 1997. SIGTTO, ISBN 1 85609 129 5.
- Recommendations on the Safe Transport of Dangerous Cargoes and Related Activities in Port Areas - 1995, (IMO 290E) IMO, ISBN 92-801-1329-1.
- Dangerous Goods in Ports: Recommendations for Port Designers and Port Operators - 1985, PIANC.
- Mooring Equipment Guidelines - 1996, (OCIMF) Oil Companies International Marine Forum, ISBN 1 85609 088 4.13
- Prediction of Wind Loads on Large Liquefied Gas Carriers - 1985, SIGTTO, ISBN 0 90088697 8.
- Big Tankers and their Reception - 1974, PIANC.
- Guidelines on Port Safety and Environmental Protection - 1989, IAPH.

(C) OPERATING PRACTICES

- Accident Prevention - the Use of Hoses and Hard-Arms at Marine Terminals Handling Liquefied Gas - 1996 SIGTTO, ISBN 1 85609 1147.
- Manual on Chemical Pollution; Section 1: Problem Assessment and Response Arrangements - 1987, (IMO 630E) IMO, ISBN 92-801-1223-6.
- A Guide to Contingency Planning for Marine Terminals Handling Liquefied Gases in Bulk - 1989, SIGTTO, ISBN 0 948691 81 6.
- APELL: Awareness and Preparedness for Emergencies at Local Level - 1988, (UNEP) United Nations Environment Programme, ISBN 92807 1183 0 -00900P.
- Offshore Loading Safety Guidelines with Special Relevance to Harsh Weather Zones - 1999, OCIMF, ISBN 1 85609 1481.
- Tug Use in Port - H Hensen, Nautical Institute, 1997, ISBN 1 870077 39 3.
- Guidelines for Hazard Analysis as an Aid to Management of Safe Operations - 1992, SIGTTO, ISBN 1 85609 054 X.

(D) ONSHORE LNG TERMINAL STANDARDS

- Standard for the Production, Storage and Handling of Liquefied Natural Gas (LNG) - 2006, NFPA 59A, NFPA.
- Design and Construction of Large, Welded, Low - Pressure Storage Tanks, Appendix R - Low pressure Storage tanks for Refrigerated Products, (API 620 R).
- Installations and Equipment for Liquefied Natural Gas - Design of Onshore Installations - 1997, (BS EN 1473) CEN.
- Flat-Bottomed, Vertical, Cylindrical Storage Tanks for Low Temperature Service, (BS 7777).
- Installations and Equipment for Liquefied Natural Gas - General Characteristics of Liquefied Natural Gas - 1997, (BS EN 1160) CEN.
- Criteria for design and construction of refrigerated liquefied gas storage tanks - 'EEMUA 147'.
- Other internationally accepted European/American standards as may be required

The National Fire Protection Association (NFPA) develops fire safety codes and standards drawing upon the technical expertise of persons from diverse professional backgrounds that form technical committees. These committees address concerns about specific activities or conditions related to fire safety. The members of these committees use an open consensus process to develop standards for minimizing the possibility and

effects of fire. NFPA has adopted two comprehensive standards, NFPA 59A that relate to LNG.

NFPA 59A Standard for the Production, Storage and Handling of Liquefied Natural Gas (LNG) 2009 Edition describes the basic methods of equipment fabrication as well as LNG installation and operating practices that provide for protection of persons and property. It also "provides guidance to all persons concerned with the construction and operation of equipment for the production, storage, and handling of liquefied natural gas." This comprehensive standard contains detailed technical requirements to ensure safety of LNG facilities and operations, including general facility considerations, process systems, stationary LNG storage containers, vaporization facilities, piping systems and components, instrumentation and electrical services.

The standard also incorporates, by reference, technical standards developed by a number of other professional organizations, such as American Society of Mechanical Engineers (ASME), the American Society of Civil Engineers (ASCE), the American Petroleum Institute (API), the American Concrete Institute (ACI), and the American Society for Testing and Materials (ASTM).

The European codes and standards used would be explicitly mentioned in the detailed design. The technical design would be based on best industry practices and the technical standards and guidelines provided in LNG policy 2011 and guidelines provided along with the NOC issued by PQA, where applicable. Any international codes, guidelines and standards used will be justified based on international practices currently applicable at the time of design and it is the intention of the proponent to design the terminal using European standards.

e) Overseas Economic Cooperation Fund (OECF) Environmental Guidelines on Oil and Gas Pipelines

The OECF environmental guidelines specific to oil and gas pipelines are:

- The impact of changes in the water system because of project construction, on aquatic organisms, fisheries, and water utilization, should be monitored and appropriate mitigation measures adopted.
- In the case of oil pipelines, an emergency plan should be prepared to prevent oil spills in the event of an accident.
- The extent of noise and vibration from pumping stations should be monitored, and appropriate mitigation measures adopted.
- The effects on ecology should be monitored, and appropriate mitigation measures adopted. Safe paths should be provided for rare fauna.
- The effect of pipelines on landscape should be studied and appropriate mitigation measures adopted.
- The project site should not be located where it may damage historical or cultural sites. When carrying out a project near such a site, countermeasures to minimize the impact on historical or cultural monuments should be devised.
- The situation and circumstances of residents who will have to be relocated should be assessed and appropriate measures adopted.
- The effect on traffic should be studied and appropriate measures adopted.
- The location of installations and equipment, work methods, and the work period should be arranged so that project activities will cause as little inconvenience in the area as possible.
- An appropriate monitoring system is necessary: (1) when the devised environmental protection measures are implemented, but their effectiveness must be followed up; (2) when there are certain check items whose impact is not great enough to justify modifications in the project, but which are considered to require monitoring.

2.6 International Treaties and Conventions

Pakistan is signatory/member to various international treaties and conventions on conservation of environment and protection of wildlife. The country is obliged to adhere to the commitments specified in these treaties. The United Nations Conference on Environment and Development (UNCED), 1992 emphasized on Protection, rational use and development of resources; preventing further degradation and reducing the risk of long term irreversible effects; conservation of biodiversity, and sustainable use of genetic resources.

World Heritage Convention obligates the states to ensure identification, protection and transmission of natural heritage to future generations. A world heritage site is a site (natural or cultural) recognized by the international community (World Heritage Convention founded by the General Conference of UNESCO in 1972) as possessing universal value, and coming under a collective responsibility.

Other international conventions and programs to which Pakistan is a party relate to biodiversity conservation, for all of which there is a national legislation. Three conventions dealing with species are:

a. Convention on Conservation of Migratory Species of Wildlife Animals, adopted in Bonn, Germany in 1979 which Pakistan ratified in 1987;

b. Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES), signed in Washington in 1973 of which Pakistan became a party in 1976;

c. Convention on Biodiversity (CBD), singed in Rio de Janiero in 1992 which Pakistan ratified in 1994.

d. Convention on Wetlands of International Importance especially as Waterfowl Habitat, signed in Ramsar in Iran in 1971, to which Pakistan became a party in 1978; and

e. Convention Concerning the Protection of the World Culture and Natural Heritage, signed at United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris in 1972.

2.6.1 International Convention on Biodiversity

The International Convention on Biodiversity was adopted during the Earth Summit of 1992 at Rio de Janeiro. The Convention requires parties to develop national plans for the conservation and sustainable use of biodiversity, and to integrate these plans into national development programmes and policies. Parties are also required to identify components of biodiversity that are important for conservation, and to develop systems to monitor the use of such components with a view to promoting their sustainable use.

2.6.2 Convention on Wetlands of International Importance, (RAMSAR) 1971

Pakistan is a signatory to the RAMSAR Convention. The principal obligations of contracting parties to the Convention are:

- To designate wetlands for the List of Wetlands of International Importance
- To formulate and implement planning so as to promote wise use of wetlands
- To carry out Environmental Assessment before transformations of wetlands, and to make national wetland inventories
- To establish nature reserves on wetlands and provide adequately for their wardening and through management to increase waterfowl populations on appropriate wetlands
- To train personnel competent in wetland research, management and wardening
- To promote conservation of wetlands by combining far-sighted national policies with coordinated international action, to consult with other contracting parties about implementing obligations arising from the Convention, especially about shared wetlands and water system

- To promote wetland conservation concerns with development aid agencies
- To encourage research and exchange of data

So far 18 sites in Pakistan have been declared as wetlands of International Importance or RAMSAR Sites. Of these, there are about 45 game sanctuaries and reserves spread over an area of 0.90 million hectares in Sindh. None of these wetlands have been included within or close to the project area. Haleji Lake and Kinjhar (Kalri) Lake are the two lakes designated as Wildlife Sanctuary. These freshwater lakes are internationally important areas for breeding, staging and wintering water birds. They are however at 70 km and 150 km distance from LNG Project site in Port Qasim.

2.6.3 IUCN RED LIST

IUCN has published red list, it includes those species that are under potential threat of extinction. These species have been categorised as endangered, vulnerable in decline, lower risk species and data deficient species that may be at risk of extinction in the wild. Red list of mammals found in Pakistan is attached in the Annexure.

No faunal species that fall under the IUCN Red List category were observed during the surveys at the site for the ESIA study.

2.6.4 KYOTO PROTOCOL

The Kyoto Protocol to the United Nations (UN) Framework Convention on Climate Change (the Kyoto Protocol) addresses the emission of greenhouse gases. Greenhouse gases are naturally occurring and man-made gases that absorb infrared radiation and thus may enhance atmospheric warming. The Kyoto Protocol aims to reduce emissions of six greenhouse gases, including CO_2, methane (CH_4), and nitrous oxide (N_2O) by 2008-2012. Article 2 of the Kyoto Protocol calls on the participating governments to implement policies that enhance energy efficiency and encourage measures to limit or reduce emissions of greenhouse gases. The Kyoto Protocol was opened for signatures on March 16, 1999, at the UN Headquarters in New York. After signing the agreement, each government must ratify it before it becomes officially adopted. As of July 24, 2002, 84 parties have signed the agreement, and 22 nations have ratified the agreement. The Kyoto Protocol will become effective 90 days after it has been ratified by at least 55 Parties to the United Nations Framework Convention. This will represent at least 55 percent of the total 1990 CO_2 emissions from developed countries. The Pakistan has signed and acceded to the agreement.

The high efficiency of the Project's power generation and process equipment coupled with the primary use of natural gas complies with the Kyoto Protocol's goals of enhanced energy efficiency and reduction in greenhouse gases. Moreover, the FSRU complies with such requirements.

03 DESCRIPTION OF PROJECT

Elengy Terminal Pakistan Limited (ETPL) plans to develop a floating LNG terminal with a floating storage and regasification arrangement (FSRA) (either FSRU or FSU + on barge regasification or FSU + on shore regasification) and LNG transfer through a mooring arrangement (tandem, side by side or platform in between) and a minimum throughput of about 500 MMSCFD. The proposed model is to unload liquefied LNG from an LNGC to an FSRA and subsequently supplying it to the gas network system after gasification.

3.1 PROPOSED PROJECT FACILITIES AND REQUIRED INFRASTRUCTURE

3.1.1 PROPOSED FACILITIES

For the purposes of this ESIA, the project has been organized into the following components:

- Site Preparation;
- LNG Carrier/Cargo (LNGC)
- Floating LNG Terminal installations;

The facilities proposed for each of the project components are described below.

3.1.1.1 SITE PREPARATION

To accommodate the proposed facilities and to provide shore protection, the project includes land with water front, as well as an increase in site elevation grades. The site will thus be able to accommodate the proposed mooring arrangement and ancillary facilities.

ETPL has sufficient backup area at the proposed Brown Field site (figure 3.5) that will be prepared to accommodate berthing of an LNG FSRU (floating storage and regasification

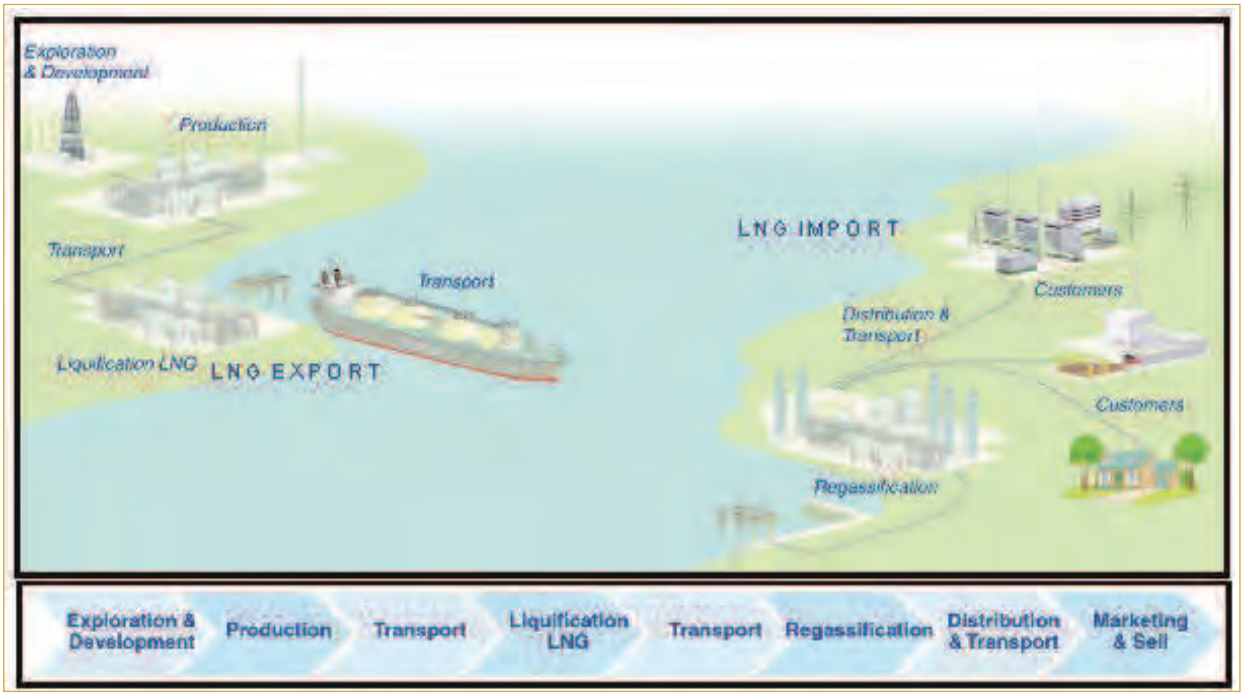


Figure 3.1: LNG Cycle - Exploration to Consumption

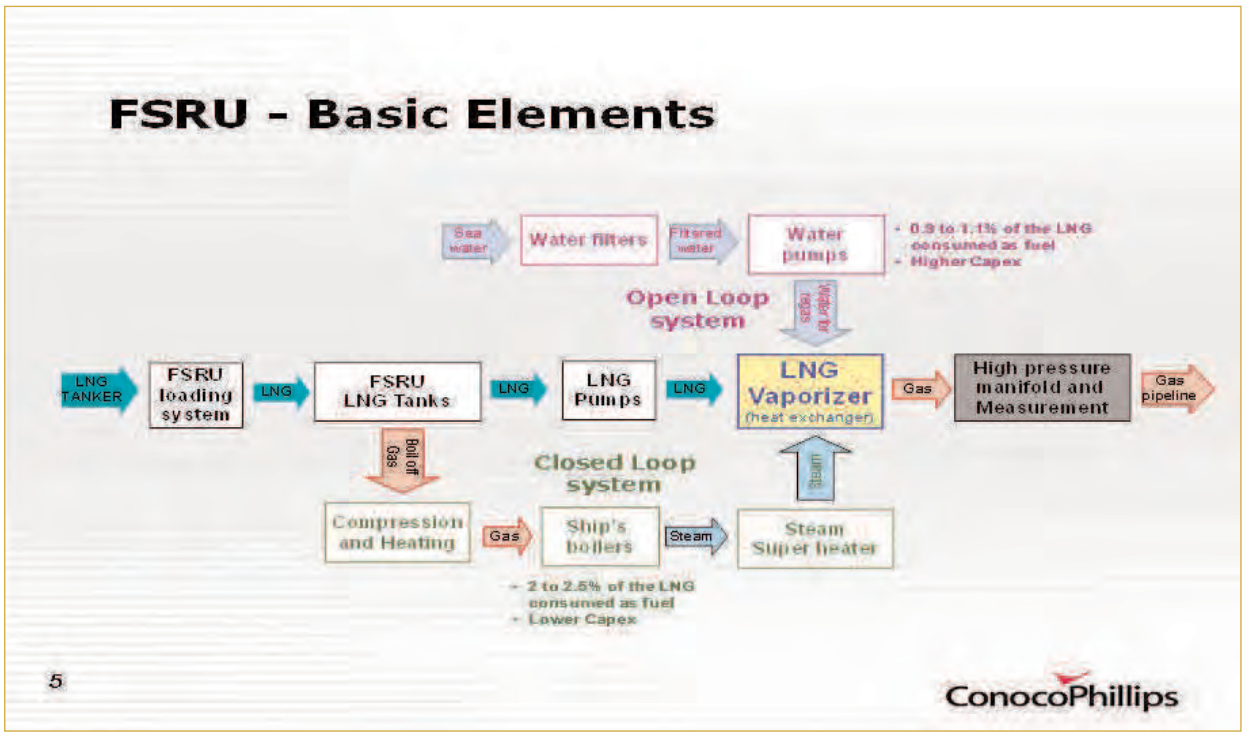


Figure 3.2: FSRU - Basic Elements

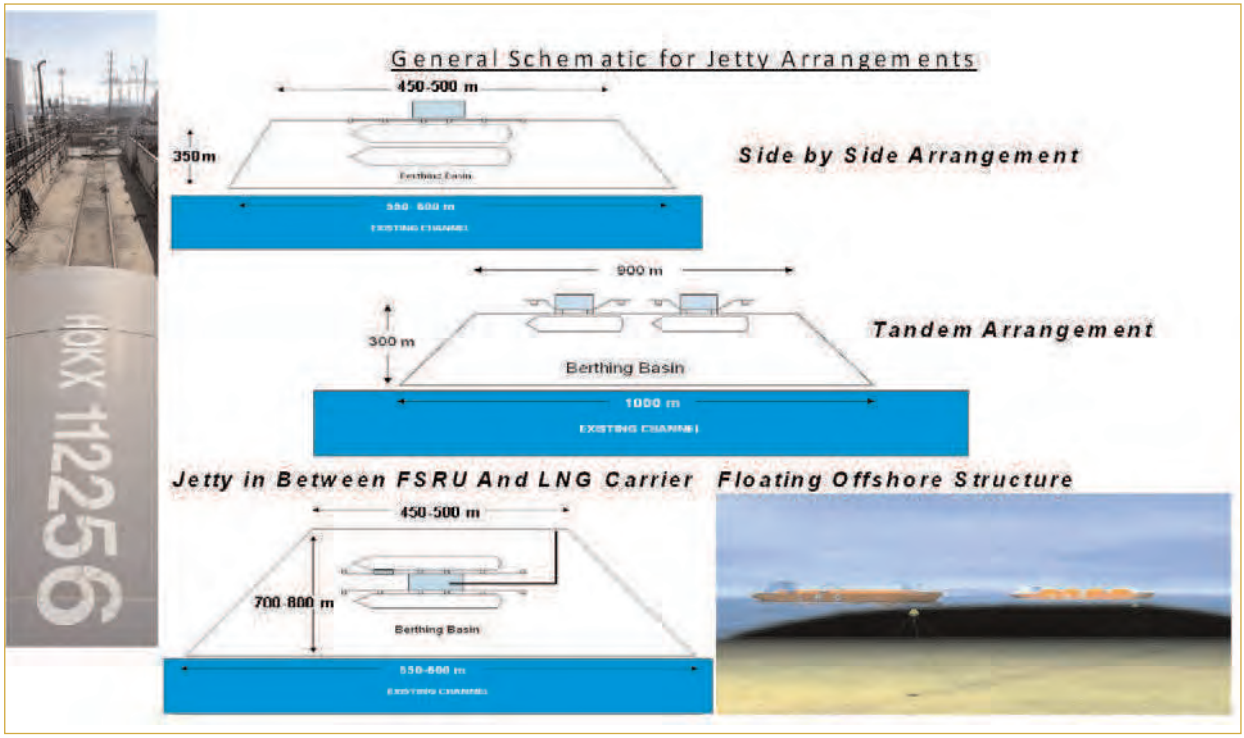


Figure 3.3: General Schematic for Jetty Arrangements

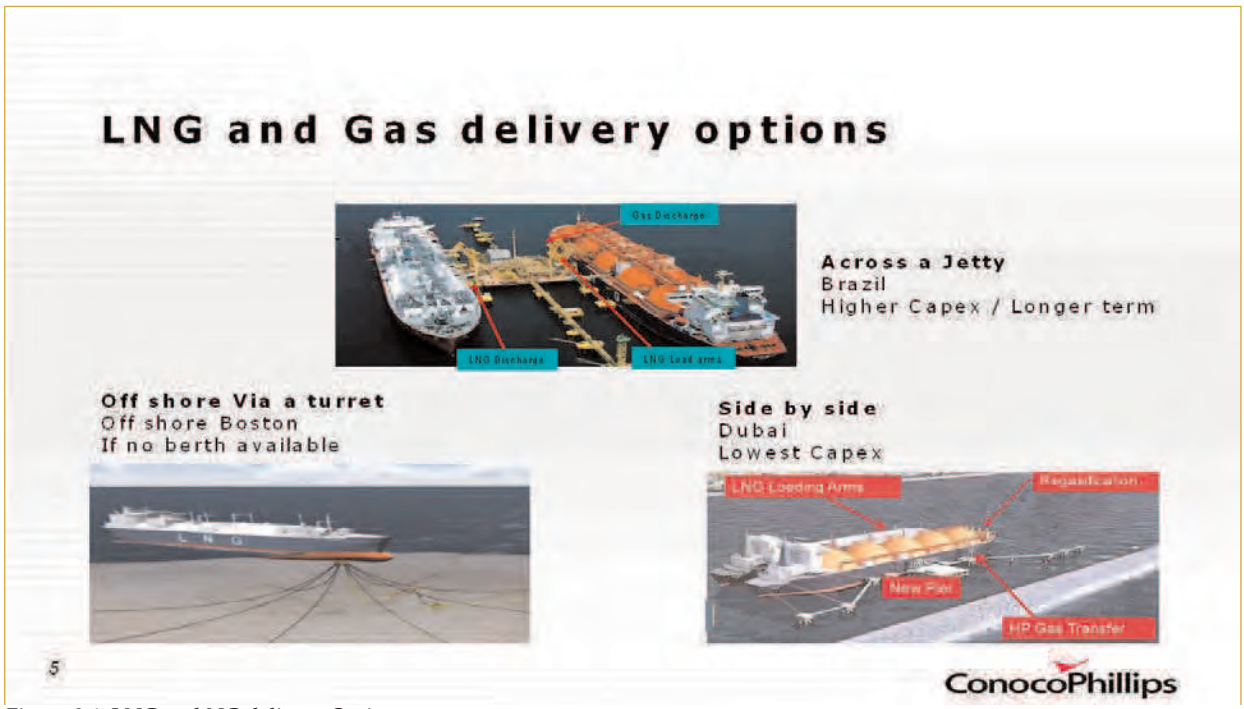


Figure 3.4: LNG and NG delivery Options

unit), which will also act as a carrier vessel and will bring in LNG supplies to the jetty. The dredge spoils from the berthing and turning basin, as discussed below, will be utilized for land fill. The elevation grade will be raised for flood protection purposes.

I DREDGING

The project requires a dredging of berthing basin to the depth of approximately 13.5 meters CD and berthing pocket to 15 m CD .The basin would be sufficient enough to accommodate the turning circle requirements of LNGC approximately twice the LOA of the envisaged vessel. The turning circle diameter envisaged at present is about 400 to 700m. Moreover, the basin would be at a sufficient distance inside the channel so that a safe distance is maintained from the ships moving in the main channel.

Approximate dredged quantity would be upto 1.6 Million cubic meters for the proposed Brown Field site (Includes the dredged quantity for berthing basin, for berthing pocket and portion of the turning circle outside the channel).

In case alternate STS process is selected, the dredging volumes is decreased by approx. 40%. The existing turning circles at IOCB or QICT-2 can be used and the dredging quantity can be brought down to upto 1.6 million cubic meters if the orientation of the jetty can be made parallel to the channel.

At the project site, geotubes, or equivalent, will be used to stabilize/contain the temporary stockpile of excess dredged material if any. Geotubes are large tubes fabricated using woven geotextile material, which are permeable fabrics able to hold back materials while allowing water to flow through. The standard geotube is made of woven geotextile sheets of widths of 4 to 6 m (13 to 20 ft) sewn along the edges with inlets and outlets sewn at regular intervals. Geotubes will be installed along the perimeter of the excess dredge material stock pile area. The perimeter dike will be constructed by stacking geotubes on top of one another. The geotubes will be removed once the excess dredge material has been harvested as part of the operations.

II WIDTH

At project site, the required width of the approach channel is determined by the beam of the largest vessel expected to call at the terminal. Two sets of guidelines-promulgated by

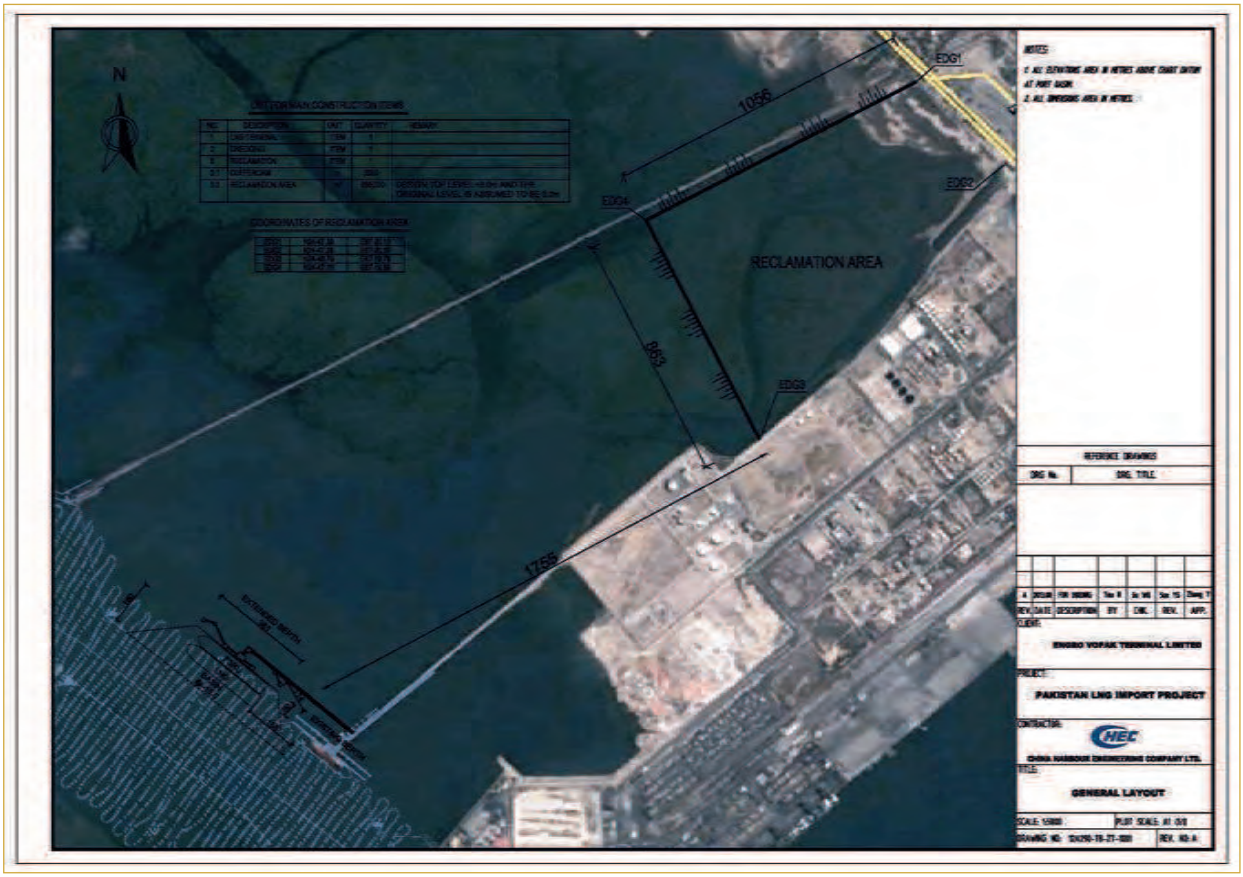


Figure 3.5: Location of proposed Brown Field site

Figure 3.6: 2200 m^3/h cutter suction dredger

the Society of International Gas Tanker and Terminal Operators (SIGTTO) (1997) and the Permanent International Association of Navigation Congress (PIANC) (1997) have been referred in the preparation of the preliminary layout for the approach channel. The SIGTTO guidelines suggest the minimum channel width requirement irrespective of site conditions. The guidelines suggest that the width of the approach channel should be a minimum of five times the beam of the design vessel. Considering measured environmental conditions such as the wave climate, currents, and meteorological conditions (e.g. winds, temperatures, and precipitation) as described in the section 05 of ESIA, a 200-225 m wide channel based on the beam dimension of 40-45 m, as recommended by SIGTTO (1997), may be appropriate for the approach channel. The required width of the approach channel decreases with the decreased of the beam and will be appropriately designed after finalization of the logistics as part of the studies planned to be carried out. There are precedents where different guidelines have been implemented safely e.g. Milford Haven, UK.

The detailed simulations in the QRA have review the safety aspects of channel and PQA with the proponent will devise measures to ensure safe handling of the LNGC. The simulation studies in the QRA prove that a vessel upto Q-Flex size can be maneuvered to the proposed site.

III Minimum Depth

The required channel depth is a function of the draft of the largest vessel expected to call at the terminal, vertical ship motion due to wave action, squat, keel clearance, dredging tolerances, and depth sounding accuracy. The guidelines of the Permanent International Association of Navigation Convention (PIANC) (1997) suggest using a depth to draft ratio of 1.10 to 1.15 for protected approach channels. For channels subject to wave action, a depth to draft ratio of 1.3 or more may be used. Wave induced motions of ships vary significantly for different ships depending on the wave and swell conditions to which they are exposed. Using British Standard Code of Practice for Maritime Structures (PART 1), the mean depth of ship motions due to wave action have been estimated at 0.5 m (1.6 ft). Squat is the tendency of a vessel to sink and trim when underway. The depth is highly dependent on the ship's speed and is accentuated in shallow water. A conservative squat estimate of 0.5 m (1.6 ft) will be used in the estimation of minimum channel depth during final design. The required under keel clearance is typically between 1.0 to 1.5 m (3.2 to 4.9 ft) for LNG ships. Typically, the dredging tolerance is set between 0.1 to 0.5 m (0.3 to 1.6 ft) and the sounding accuracy is normally approximately 0.25 m (0.82 ft) (Agerschou, et al., 1983). The existing channel is 13.7m -CD with outer anchorage of 14.7 m CD. PQA presently handles vessels within the channel much larger than the proposed size of the FSRU and conventional sized LNG Carriers. An LOA of upto 310m is being currently handled by PQA where as a QFlex is merely 315m LOA.

IV Turning Basin Expansion

The turning basin will be designed to allow the safe turning of a fully loaded design LNG carrier with tug assistance. The required turning basin diameter, minimum water depth and associated sedimentation issues are discussed below

A) Diameter

Applying SIGTTO (1997) guidelines a preliminary turning basin diameter of 400 to 700 m has been selected, the requirement is twice the LOA of the expected ship and will be adjusted based on the QRA studies and FEED studies by the proponent.

Presently, PQA has turning circles at IOCB and QICT-2, both have a radius of more than 570m and provide safe turning circle options with the assistance of tugs, as detailed in the QRA.

B) Minimum Water Depth

As squat is not expected to be significant in the turning basin due to slow ship speeds, the turning basin will be dredged to a depth of 13.5 m CDor less depending on the FSRU design.

C) Sedimentation Issues

According to studies referred and conducted by ESIA experts and the discussions with IUCN, the existing approach channel is experiencing significant sedimentation. However, (based upon available data showing the sediment

transport patterns at the site) it is expected that sedimentation will not occur to an extent that would interfere with vessel traffic. Nevertheless, should there be a need; maintenance dredging operations may be carried out at the island in consultation with PQA.

V Dredging Technique

According to the analysis on data of the previous works done in the same area, the main materials to be dredged are clay and sand, which are easily dredgeable. It is envisaged that the dredging operation will be performed by grab type dredger or with the help of a Cutter head Suction Dredger (CSD). The CSD is one of the most well-known, efficient and versatile types of dredging. A grab dredger picks up seabed material with a clam shell grab, which hangs from an onboard crane or a crane ship, or is carried by a hydraulic arm, or is mounted like on a dragline. A cutter-suction dredger's (CSD) suction tube has a cutter head at the suction inlet, to loosen the earth and transport it to the suction mouth. The cutter can also be used for hard surface materials like gravel or rock. The dredged soil is usually sucked up by a wear-resistant centrifugal pump and discharged through a pipe line or to a barge. In recent years, dredgers with more powerful cutters have been built in order to excavate harder rock without blasting. The type of dredging technique used would be confirmed in the detailed design.

Based on geotechnical information on offshore conditions gathered for the area, it is likely that the dredging will be accomplished with no blasting. Blasting is typically required when the compressive strength of rock is above 34,000 kPa (5000 psi). This assumption will be confirmed based on offshore borings and laboratory testing to be conducted by ETPL after a detailed QRA. If blasting is required, it will be accomplished by a spud barge using air track or hydraulic percussion or rotary drill rigs to drill vertical holes, which will be deeper than the desired rock cut depth. The holes will be loaded with explosives from a barge through a sand pipe, or "Kelly Bar," with detonator delays. Following loading of the holes, the barge will be pulled back. A preliminary low energy detonation will be made to deter mobile sea life away from the blast area, followed by detonation of the production blast needed to break up the rock. The blasted rock will then be dredged using the cutter head suction dredge and pipeline delivery method described above.

VI Site Fill & Soils Improvement

Reclamation of land will be achieved by placing dredge spoils (from the dredging conducted at site) in area earmarked for reclamation (Figure 3.5). This will involve placement of dredged material to spoils settlement / dewatering areas on project site. These areas will be sized to minimize the release of fine materials into the sea. Proper sizing of the settlement areas will allow the turbidity to be minimized in the effluent. The non-turbid effluent from the settling areas will be discharged into the waters surrounding project site. Site fill and soil improvement techniques proposed for the project include the use of appropriate Compaction method, drilled on-land piles, drilled offshore piles, interlocking pre-cast concrete retaining walls, steel sheet pile retaining walls, stone columns, and preloading.

The suitability of the dredged material for reclamation works would be checked by the soil investigation done during the preliminary study stage.

VII Shore Protection

A comprehensive shore protection system will be provided for the perimeter of project site in order to prevent erosion and provide adequate protection against coastal flooding. These facilities are being designed for wave and storm surge conditions associated with the nominal 100-year frequency hurricane event. The main purpose of this revetment system is to hold the fill material in place and protect the shoreline against wave induced erosion. On infrequent occasions during storms with a low probability of return, the revetment is expected to experience significant overtopping and some level of damage that will require repair.

VIII Tug Boats

Tug boats will be required to escort LNG ships while in transit in the approach channel and to assist the ships in the turning basin and during berthing maneuvers, the tug boats are to be provided by PQA. SIGTTO requires that sufficient tug assistance be provided to control the largest LNG carrier assuming that the engines are not available during maximum

permitted operating conditions. SIGTTO suggests that for 135,000 m^3 (849,047 bbl) capacity LNG carriers, three to four tugs with a combined bollard pull between 120 to 140 metric tons (MT) (132.3 to 154.3 Tons) be available to provide assistance as necessary. These tugs should be able to exert approximately half of this total power at each end of the ship. It is assumed that three tug boats will be required for this project to be confirmed through fast-time navigation simulations and limited real-time berthing simulations at detailed design stage of project. The length, width, and depth of the typical tugs utilized for planning purposes are outlined in Table 3.1.

3.1.1.2 General Arrangement of LNG Carrier (LNGC)

LNG carriers (LNGCs) would be supplying LNG to the Floating Storage and regasification arrangement. The LNG carrier would be equipped with following systems:

I Hull System

The International Maritime Organization's (IMO) code for the Construction and Equipment of Ships Carrying Liquefied Gas in Bulk (Gas Tanker Code) requires that LNG ships can withstand flooding of any two adjacent compartments without an adverse effect upon the stability of the ship. The cargo tanks must be a minimum of 30 inches from the outer hull and minimum distance above the bottom of the ship to equal the beam of the ship divided by 15, or 6.5ft, whichever is less. This distance is intended to prevent damage to the cargo tanks in case of low-energy-type accidents that might occur in harbors and during docking. Most large LNG ships have a distance of 10-15ft between the outer hull and the cargo tank.

Table 3.1: Dimensions of Typical Tugs

Main Parameters	Preliminary Values
LOA	30.0 (m) (98.4 ft)
LBP	24.0 (m) (78.7 ft)
Breadth Moulded	9.8 (m) (32.2 ft)
Depth Moulded	4.8 (m) (15.8 ft)
Draft	4.2 (m) (13.8 ft)
Gross Tonnage	298.4 (Gross Tonnage)
Main Engines	4,000 (HP)
Bollard Pull Ahead	50.0 (MT) (55 Tons)
Bollard Pull Stern	40.0 (MT) (44 Tons)

II Containment System

The LNG containment system on an LNG ship consists principally of the cargo tank (sometimes called 'primary barrier'), the secondary barrier and insulation. The containment system also includes cargo monitoring and control and safety systems.

Three basic tank designs have been developed for LNG cargo containment:

- Prismatic free-standing,
- Spherical, and
- Membrane

The earliest form of LNG containment is the prismatic free-standing tank. It consists of an aluminum alloy or 9 percent nickel-steel, self supporting tank that is supported and restrained by the hull structure. Insulation consists of reinforced polyurethane foam on the bottom and the sides, with fiberglass on the top.

The spherical tank design consists of an unstiffened, spherical, aluminum alloy tank that is supported at its equator by a vertical cylindrical skirt, with the bottom of the skirt integrally welded to the ship's structure. This free standing tank is insulated with multi-layer close-cell polyurethane panels.

In the membrane containment system, the ship's hull constitutes the outer tank wall, with an inner tank membrane separated by insulation. Two forms of membrane are commonly used: the Technigaz membrane using stainless steel and Gas-transport membrane using invar.

LNG tankers are of double-hull design regardless of the containment system used. A double bottom and double sides are provided for the full length of the cargo area and

arranged as ballast tanks, independent of the cargo containment in the event of grounding and collisions. Further, the segregated ballast tanks prevent ballast water from mixing with any residue in the cargo tanks.

III Pressure and Temperature control

The basic goal of all LNG containment systems is to maintain the LNG cargo at or near atmospheric pressure at a boiling temperature of the LNG. This is accomplished using "auto-refrigeration", a phenomenon that results from the constant heat flow into the tank and removal of the associated vapor.

The vapor generated during auto-refrigeration is known as boil-off gas. Typical boil-off gas rates of LNG ships range from up to 0.25 percent (by volume) per day. Currently, all LNG ships burn the boil-off gas as fuel with special arrangement fitted within an internalized combustion energy system that allows the ship boilers to consume all the boil-off gas to fuel the ship's steam propulsion system. Emissions from LNG ships are therefore much reduced compared with conventional oil-fired vessels.

IV Propulsion System

Almost all of the currently operational large LNG ships are steam turbine driven. Steam ships use boilers that are fired from the ship's boil-off gas. The boiler can be fired with heavy fuel oil.

V Ballast Tanks

Sufficient ballast water capacity is provided to permit the ship to return to the loading port safely under various sea conditions. LNG cargo tanks are not used as ballast tanks because these tanks must contain a minimal amount of LNG in them at all times, even when 'empty' in order to keep the tanks cold during normal operations. Consequently, LNG ships must be designed to provide adequate ballast capacity in other locations. Ballast water tanks of the LNG ships are arranged within the LNG ship's double hull. It is essential that ballast water does not leak into the containment system. To reduce the potential for leakage, the ballast tanks, cofferdams, and the walls of the void spaces are typically coated to reduce corrosion. LNG ships are also periodically inspected to examine the coating and to renew it as and when necessary.

A ballast control system, which permits the simultaneous ballasting during cargo transfer operations, is also incorporated into each LNG ship. This allows the LNG

Figure 3.7: Typical LNG Carrier

ship to maintain a constant draft during all phases of its operation to enhance performance.

VI Ship Safety Systems

LNG ships transporting cargo to a proposed terminal would be fitted with an array of cargo monitoring and control systems. These systems would automatically monitor key cargo parameters while the ship is at sea and during the remote control phase of cargo operations at the unloading terminal.

The system includes provision for pressure monitoring and control, temperature monitoring of the cargo tanks and surrounding ballast tanks, emergency shutdown of cargo pumps and closing of critical valves, monitoring of tank cargo levels, and gas and fire detection.

3.1.1.3 Floating LNG Terminal (General Schematic of FLNG)

The Project is intended to provide facilities for receiving supplies of liquefied natural gas (LNG) via conventional LNG carrier (LNGC), for offloading and dockside transfer to an FSRA. The re-gasified liquefied natural gas (RLNG) will be delivered via a jetty and onshore facilities to the gas networks operated by SSGC (underground /overhead connection to the pipeline proposed by SSGC for MASHAL Project, approximately 2 to 3 km in length). The facility would be designed as per the codes and standards mentioned in LNG Policy 2011, Guidelines provided by PQA and International Codes and standards recommended by the engineering consultant.

Following project details are envisaged, and final decision on the Mooring infrastructure and Floating storage and re gasification arrangement (FSRA) would be done at a later stage.

I FSRA and LNGC

A permanently parked Floating storage/regasification arrangement (FSRA) (FSU + On shore regasification, FSU + barge based regasification or FSRU) of capacity (125,000 m^3 to 171,000 m^3) supplying NG upto 500-575 MMSCFD would be placed as a tandem arrangement, side by side or platform in between design of jetty. LNGC carriers would be supplying LNG to the Floating Storage and re gasification arrangement. The FSRU would be able to accept LNG carriers of conventional size (90,000 cbm to 217,000 cbm (Q-flex)) and smaller vessels (10,000 cbm to 90,000 cbm) with a flow rate of approx 6,000 to 12,000 m^3/hr. Deepening and Widening of the PQA channel is planned and there after LNGC of larger size are expected to arrive at Jetty.

The maximum frequency of ship arrival with a FSRA of 171,000 m^3 storage and an LNG carrier of 217,000 m^3 considering per day consumption of NG at 500 MMSCFD would be after approximately 4 to 5 days. The frequency would change with respect to the FSRA capacity and the LNG Carrier deployed.

However; the size of FSRU and LNGC shall be finalized after QRA recommendations and FEED studies.

II Jetty Arrangement

The jetty mooring and breasting dolphin layout would be based on receiving LNG Carriers with a length overall up to 350 m keeping in view potential expansion. The jetty shall be equipped to initially allow the handling of large conventional size carriers and design would cater for smaller vessels as well. The type of Jetty arrangement tandem/side by side/platform in between would be concluded after the completion of the FEED study. Preliminary Parameters of Floating storage vessel are given in Table 3.2.

The Jetty design would include platforms, trestles, mooring and breasting dolphin arrangement, quick release coupling, gangways, crane and all other equipment necessary to build the Jetty as per the standards mentioned above.

III LNG Liquid, LNG Vapor and Re-Gasified LNG Loading Arms

Loading arms will be provided for LNG, LNG vapor and re gasified LNG. Following are some of the envisaged specifications of the Loading arms:

Figure 3.8: Floating LNG Unit (Bahia Blanca Gasport, Argentina)

A. NITROGEN PURGE

A nitrogen purge point will be provided at the apex swivel of each arm to provide product purging or inert gas blanketing during loading/un loading. In the parked position the loading arm quick connect/disconnect coupling will have a partial sealing blank. A low flow of nitrogen will be provided to maintain the inert blanket.

Table 3.2: Preliminary Parameters of Floating storage vessel

Main Parameters	Preliminary Values
Length Overall (LOA)	275.00 to 295.00m
Length Between Perpendiculars (LBP)	265.00 m to 280m
Breadth	40 to 45 m
Draft	11.5 to 12.0 m

B. LOADING ARM CONNECTION AND EMERGENCY RELEASE

Normal connection/disconnection of the arm to the LNGC or FSRA LNG manifolds will be typically via a 16" nominal size Class 150 raised face flange. For emergency isolation and release an emergency release coupling will be provided as a mean of isolating the LNG to the arm and ship sides prior to an emergency release in the event of the vessel/arm moving outside of the specified operating parameters, or manually initiated emergency disconnection.

C. HYDRAULIC OIL CONTAINMENT

Provision shall be made within the design of the hydraulic system and the design of the concrete work on Jetty for the containment of oil leaks such that oil cannot leak to the surrounding area or into the sea.

D. QC/DC-ERS

Connection to the FSRU will be made by a quick connect/quick disconnect and emergency release system (QC/DC-ERS). The (QC/DC-ERS) provides a means of connecting the arm, making a normal disconnection or in the event of the vessel/arm moving outside of the

Figure 3.9: Jetty Arrangment in Tandem

specified operating parameters, or manually initiated emergency disconnection.

E. COLD DRAINS TANK

Stainless steel cold drains tanks will be provided associated with the loading arms.

IV INTERCONNECTING PIPELINES

The liquid loading arms and vapor loading arms will supply to a class 150 stainless steel pipe work.

V LNG RE-GASIFICATION

In general terms, onboard the FSRA the LNG is pumped to the LNG Suction Drum, which serves as an accumulator and surge vessel for the HP LNG Pump. The HP LNG Pump raises the pressure of the LNG to match the Export Pipeline pressure (75 to 100 bar g) and sends the cold LNG to the LNG Vaporizer where the LNG is vaporized to natural gas and heated to approximately 1°C (35°F) in an open or closed loop arrangement. In leaving the LNG Vaporizer, the natural gas flows through a Pressure Regulating Station to maintain a minimum pressure of approximately 75 barg (1100 psig) in the Re gasification process, then through a metering station, and into the Export Pipeline.

At flow rates above the contractual flow rate, the pressure in the LNG vaporizer may rise above 75 barg to provide sufficient forcing pressure to meet the required entry point flow rate and pressure.

VI FSRU SHIP TO SHORE LINK

A Ship to Shore Link (SSL) will provide a facility to communicate between the FSRA and the shore side Safety Instrumentation System (SIS). The link will be a standard design used to interface with all LNG carriers and will be fully compatible with the FSRA. The link will consists of a fiber optic cable, stored on a mounted reel, connected back

to an approximate 19" rack panel in the Jetty Local Control Room (LCR). This panel will allow connection for:

a) Ship to Shore ESD signal

b) Shore to Ship ESD signal

c) Hot line telephones located at the Jetty and Local Control Room (LCR)

d) PSTN telephone line

e) PABX telephone line to the JCR

f) Marine Load monitor communication link.

VII PROCESS SUPPORT SYSTEMS

Pressure Control Station - during steady-state operation it is expected that the pipeline pressure will be high enough that the Jetty facility will operate satisfactorily while "riding" the pipeline. At pressures below approximately 1100 psig back pressure will be maintained in order to ensure that the LNG does not vaporize below critical pressure and affect the operation of the LNG Vaporizer.

IX EXPORT GAS HEATING

If required, export gas heating will be provided as a part of the Shore Facilities by shell and tube sea water heat exchangers.

X ODORIZATION

The injection of odorants will take place within the Shore Facilities downstream of the delivery point.

XI UTILITY SYSTEMS

- An instrument air system will be required which will consist of two air compressors (100% standby), an air dryer, and an air receiver. The instrument air system will be incorporated into the Jetty design while additional compressed air needs for maintenance will be provided by the Shore Side facility.
- Nitrogen will be required to purge and inert the facility to prepare for maintenance or startup after a lengthy shutdown. It is envisaged that a nitrogen generator sufficient to sustain the normal operations of the Jetty facility will be provided.
- Shore based LCR would be provided with minimum facilities such as rest room etc.
- Minimal workshop and repair facilities provided on the plat form
- Slop oil storage (storage method to be determined during detailed design)
- No waste material would be discharge or disposed off into the sea.
- Potable fresh water generating system or transfer of drinking water via boat
- CCTV Facility
- Wireless communication through Motorola

All other utility systems which may be required for successful commissioning of the project will be provided.

XII ELECTRICAL SYSTEMS

A. GENERATORS

Gas Generators will be installed for Jetty Operation. Switchgears, transformers, and motor control centers as needed to distribute power throughout the facility would be provided. FSRA would have in built power generation.

B. LIGHTING

The facility will include sufficient lighting to allow for night-time operation.

C. PROCESS CONTROL

Control valves and actuated block valves will be operated by instrument air, with electronic instrumentation providing the control signals. The PLC/DCS will be housed in a climate-controlled building

XIII FIRE FIGHTING EQUIPMENT

- The fire system will be completely self-contained in accordance with the requirements of NFPA/ SIGTTO/ OCIMF or other equivalent internationally accepted

standards/guidelines. This system would comprise of two diesel pumps running on sea water, with electrical jockey pumps to continuously charge the system. The fire water loop will be installed underground and fire monitors, hoses and fire extinguishers will be strategically located throughout the facility.

- LNG ships using terminal would also be fitted with active fire protection systems that meet or exceed design parameters in international codes, such as Gas tanker code etc.
- A water spray system that covers the accommodation house and control room and all main cargo control valves will be provided
- Wheeled dry chemical units with hoses;
- Hydrant hose lines providing firewater and stationary monitors for fire control and heat protection of equipment and structures adjacent to the fire; and,
- Hydrant hose lines providing firewater for fire control and heat protection of nearby equipment and structures.
- Water curtain will be provided if required
- Dry chemical fire extinguishers for system hydrocarbons fires will be provided
- A remote actuated dry chemical skid with preset monitor for fire extinguishing around the loading arm area.
- A carbon dioxide system for protecting the machinery such as generators etc. Will be provided
- All necessary fire fighting equipment necessary to fulfil the requirements of the standard as laid out in LNG Policy 2011

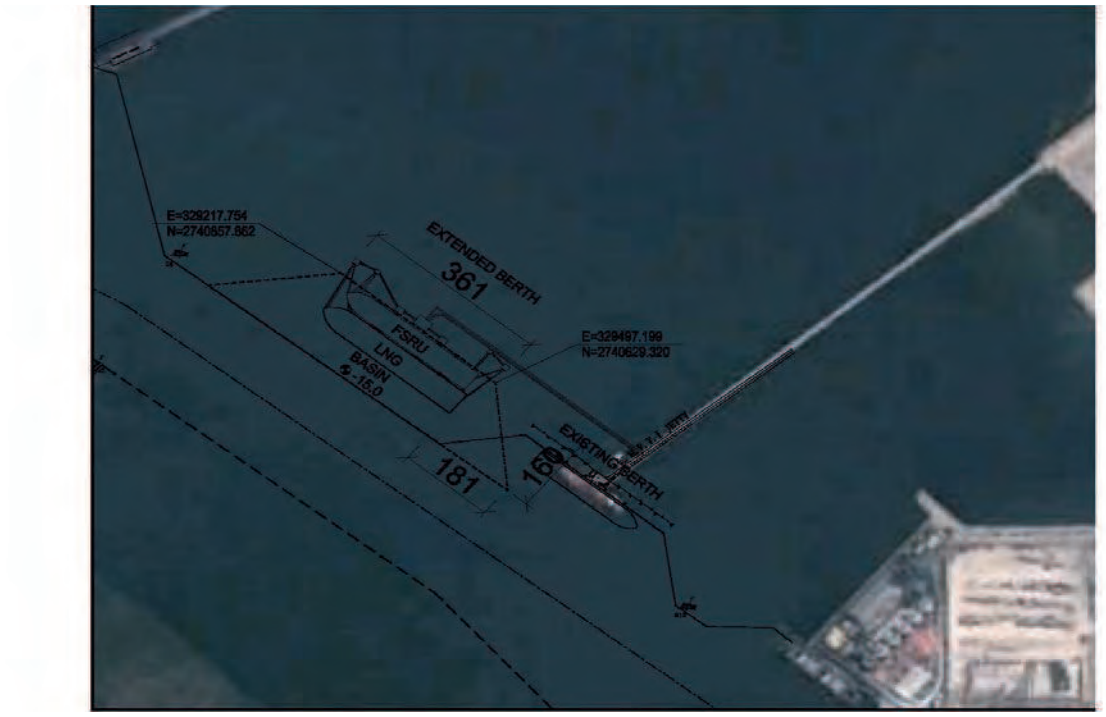
Any other items which are not identified in the list but are necessary for the proper installation, commissioning and operability of system shall be provided.

3.2 JETTY DESIGN

The existing EVTL Chemical jetty is approximately 230 meters away from Port Qasim's main navigational channel center line and is at a distance of approximately 40 kilometers from open sea. The main channel itself has a depth of at least 13.7m –CD .

The geo-coordinates of the proposed LNG Jetty is approximately: 24°46'18.62"N, 67°18'43.51"E as shown in figure 3.10.

Conceptual position of the LNG Jetty is shown in figure 3.11 subject to PQA and QRA Approval. The QRA states that a safety distance of approximately 200 m must be maintained from the channel traffic (Channel center line) therefore ETPL's LNG jetty shall be pushed 50m back from the existing berthing line of the EVTL existing Chemical Jetty. This will provide a sufficient distance from the channel center line to the berthed LNGC.



3.10: Coordinates of Proposed LNG Terminal in PQA

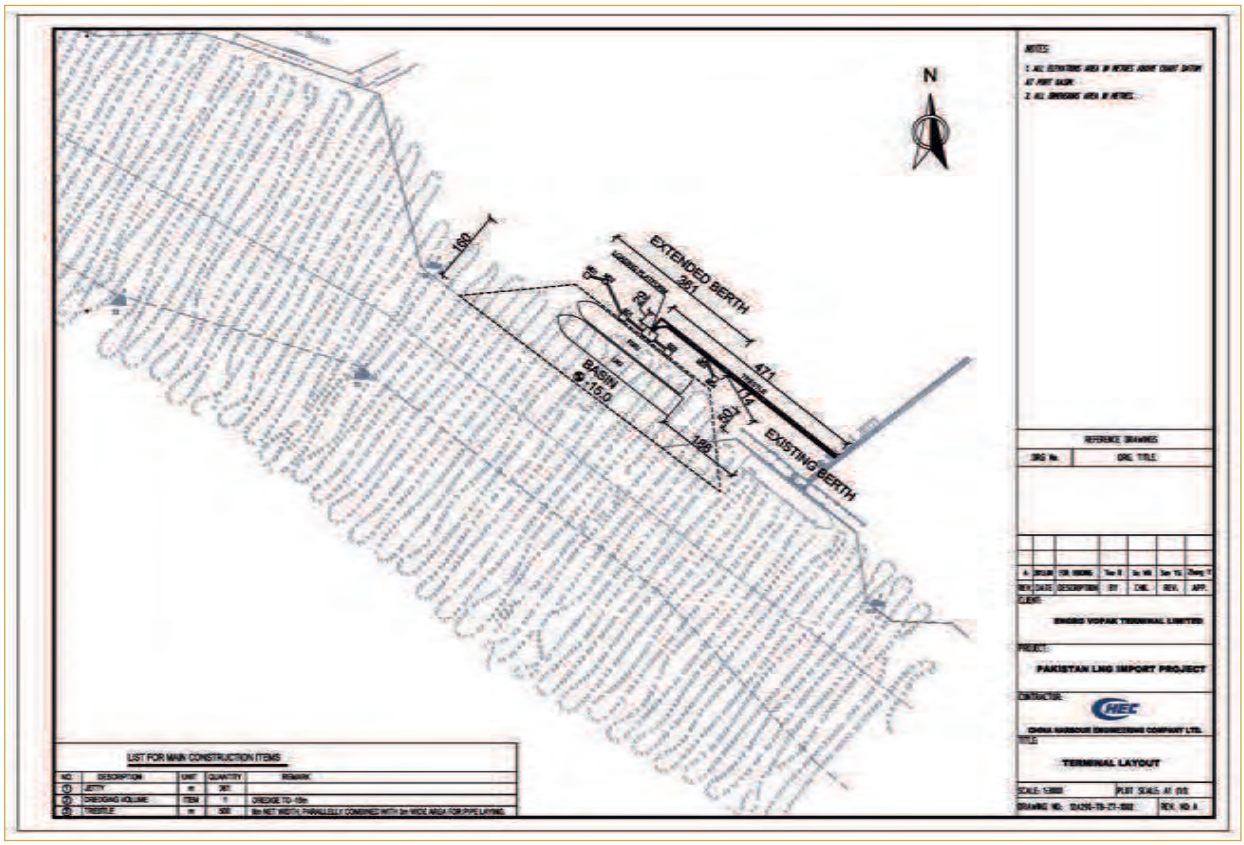


Figure 3.11 - Conceptual Layout of the LNG Jetty at brown field site

3.2.1 TURNING CIRCLE

As per the Implementation Agreement with PQA and standard Port practices, safe maneuvering of all vessels including pilotage and tug support, berthing and mooring of the vessels and turning of the vessels is the responsibility of the Port.

As per SIGTTO, 2 times LOA is required for the turning circle, and this requirement can be reduced upto 1.5 times LOA per PIANC if sufficient number of tugs are used for turning of the vessel.

For the FSRU of 291m LOA, a turning circle of approximately 580m diameter or lesser is required.

The Port has three options for the turning circle for the proposed LNG FSRUs and LNG Carriers. It should also be highlighted that as per the most recent notice to mariners, the PQA can handle vessels in their channel and turning circles upto 310m LOA and 13m draught, vs the proposed FSRU having LOA of 291m and draught of 12.2m.

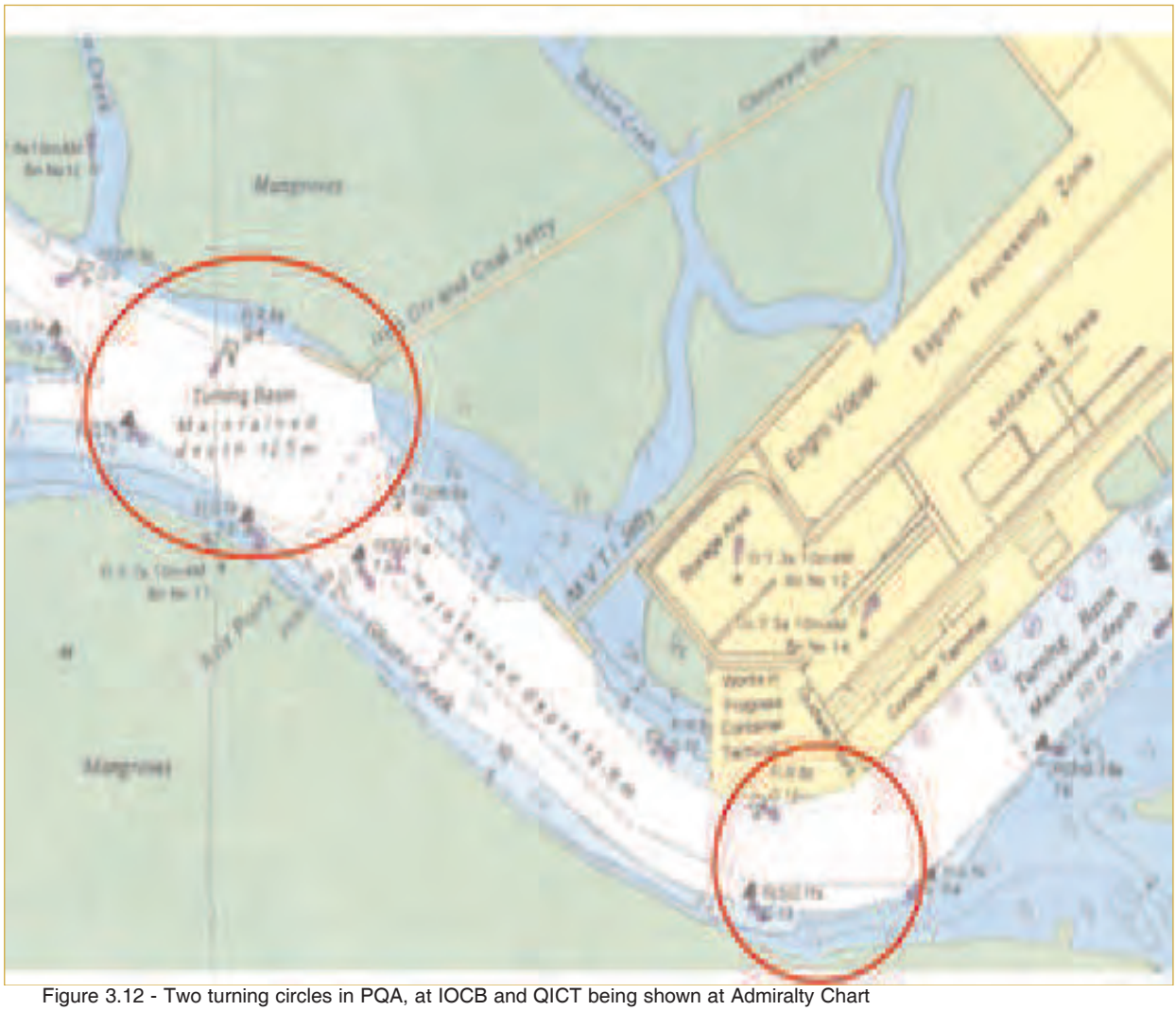


Figure 3.12 - Two turning circles in PQA, at IOCB and QICT being shown at Admiralty Chart

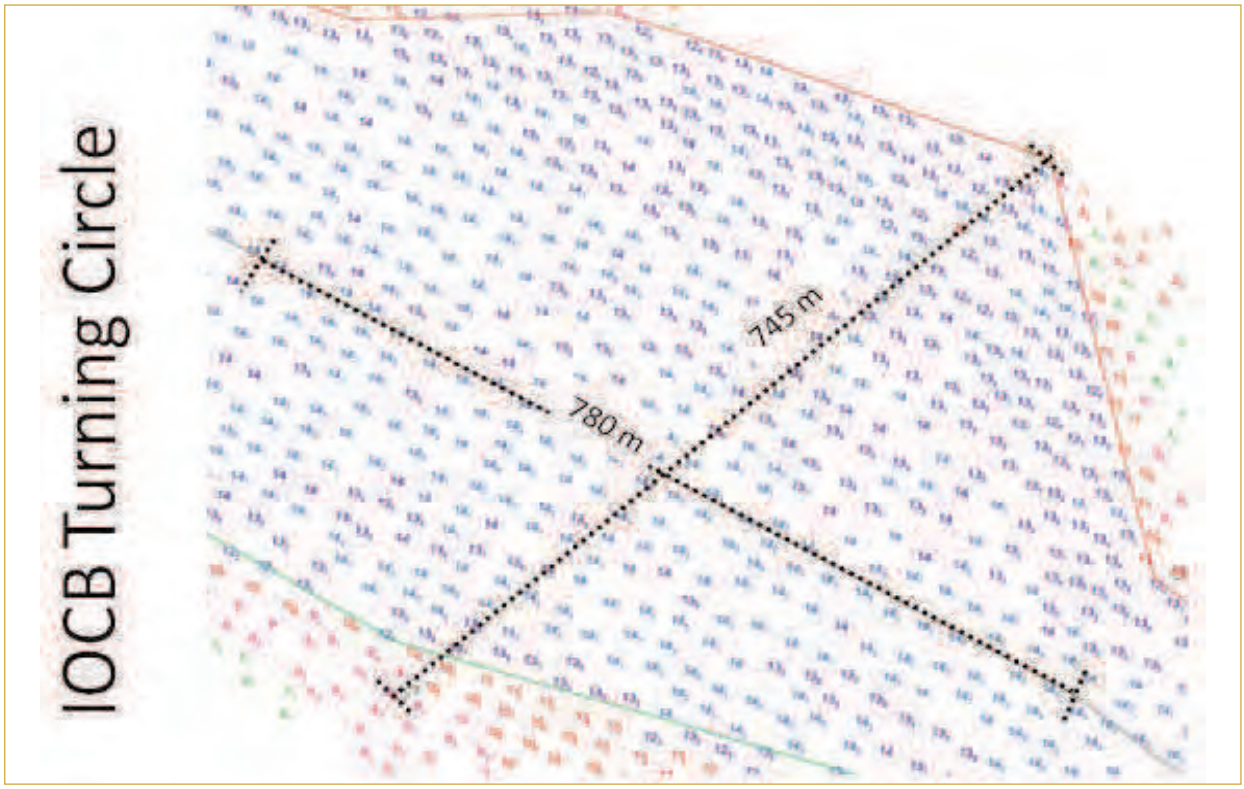


Figure 3.13 - Turning circle at IOCB with dredged depths upto 14 m - CD

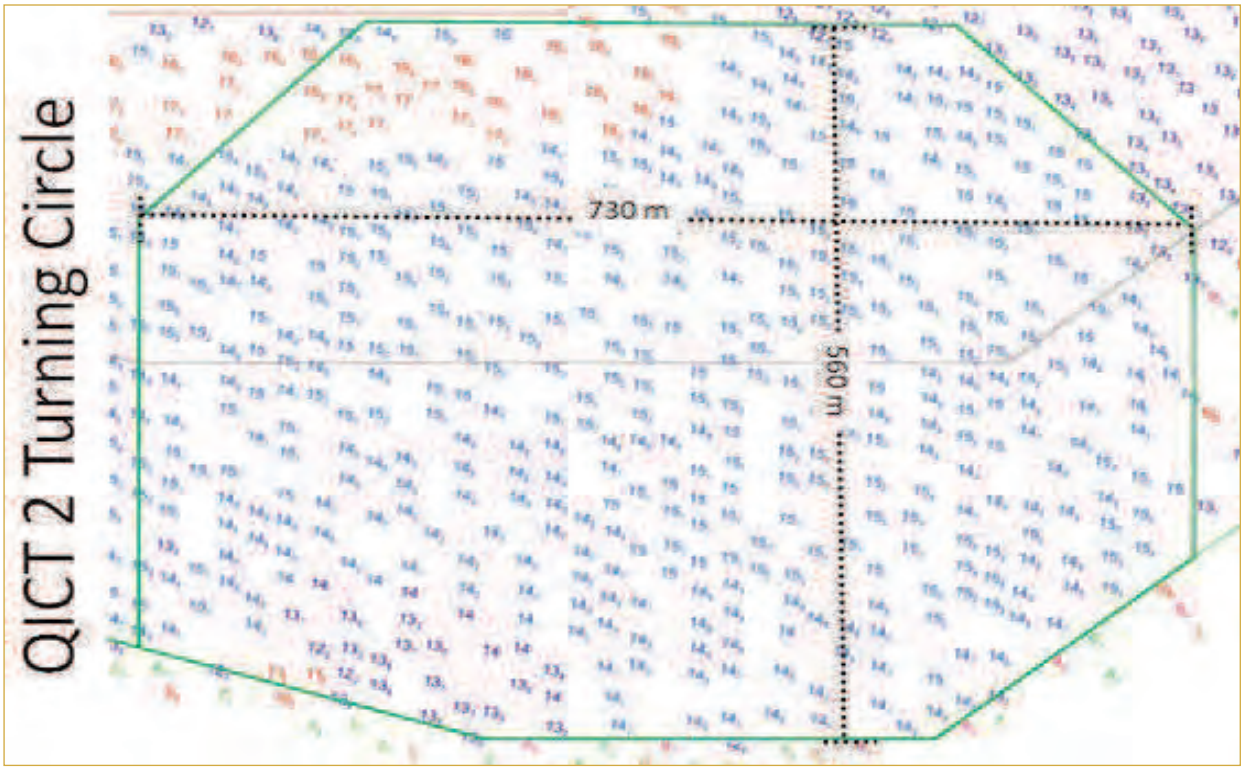


Figure 3.14 - Turning Circle at QICT 2 with dredged depths upto 14 m - CD

3.3 PIPELINE CONNECTION TO GAS NETWORK

From the ETPL, the re-gasified LNG will be transported via pipeline to SSGC Grid at KESC Bin Qasim Power Plant as shown in figure 3.15. The pipeline from ETPL boundary wall upto the Delivery point after KESC Bin Qasim shall be underground, buried with minimum depths of 1 m.

From this point, a 42 inch SSGC Branch Pipeline shall be constructed and buried underground all the way upto SMS Pakland as shown in the Routing Layout.

This route has the following salient features to its advantages;

- Total length ~23 km
- 19 km within PQA
- 4 km outside PQA
- No major population centers along the route
- Does not cross main navigational channel or any major road/rail crossings
- Existing SSGC pipelines follow similar route

1) PIPELINE DESIGN FEATURES

The pipeline will be designed, installed and operated as per ASME B31.8, the American National Standards for Gas transmission and distribution piping systems. The pipeline design will be vetted by SSGC being experts in the field and their comments will be incorporated in the design.

The pipeline design will also be as per the geotechnical information of the area conducted by ETPL in consultation with PQA i.e. Allowable soil bearing capacities, modulus of sub-grade reaction, seismic coefficients, plasticity index and moisture and sulphate content of the soil.

HAZOP will be conducted regarding the FEED of the pipeline, preferably with participation of SSGC as well.

Figure 3.15: Pipeline connection to SSGC Grid at KESC Plant

Figure 3.15: Pipeline connection to SMS Pakland

Figure 3.15: Pipeline connection (enlarge view - section 1)

Figure 3.15: Pipeline connection (enlarge view - section 2)

Figure 3.15: Pipeline connection (enlarge view - section 3)

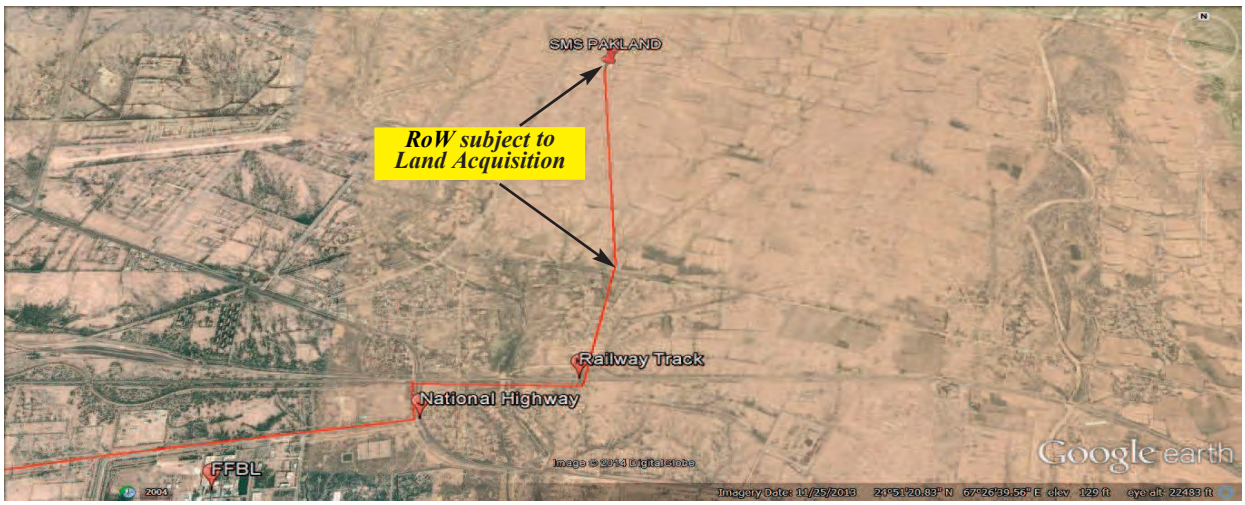


Figure 3.15: Pipeline connection (enlarge view - section 3)

2) DESIGN PARAMETERS

- Maximum RLNG supply capacity (/day): 500mmscfd (1400×104m^3/d)
- Maximum RLNG supply capacity (/hour): 59×104m^3/h
- LNG gasification pressure on FSRU: 9.5MPa
- LNG reception pressure: 8.3 MPa

3) PIPE DIAMETER AND DESIGN PRESSURE

- Design diameter of the single high pressure pipeline (Calculated): 600mm (DN600)
- Design pressure: 10.0 MPa;

4) PIPE MATERIAL & METHOD OF MANUFACTURE

- Spiral bilateral hidden arc welding steel pipe is recommended for the high pressure pipeline of diameter 600mm,
- UOE straight sew bilateral hidden arc welding steel pipe would be adopted for the hot-bending bends and such sections of water crossing area, road crossing area.
- Material of high pressure pipeline: X70, with outer diameter: 610 mm, and wall thickness: 12.7 mm.

In order to meet the pipeline horizontal and vertical stability requirements, the underwater pipeline laying would adopt concrete balance weight pipe, i.e. by covering concrete on the antisepticised pipe. Concrete balance weight pipes will be prefabricated at the manufacturer's facility.

5) PIPE ANTISEPTICISING

- The high pressure pipeline will adopt the normal 3-layer polyethylene antisepticised coating;
- For crossing area it will adopt the reinforced 3-layer polyethylene antisepticised coating.
- For hot-bending bends it will adopt double layers epoxy antisepticised coating.
- High pressure pipeline will be provided cathodic protection, except for the outer antisepticising.

6) ACCESSORY FACILITIES

The pipeline will be designed as per ASME B31.8.

7) PIPELINE LAYING

- Except for the trestle bridge-way at ETPL jetty (1.3 km) and the above ground portion on sleepers inside ETPL terminal (300 meters), the high pressure pipeline would be laid by the ground burying method,
- Conduit jacking method would be adopted with regard to the major crossing areas, and
- Ditch burying method would be adopted for the other areas,
- Smallest soil burying depth of pipeline is approximately 1.2 m.

8) INSTALLATION PROCEDURE FOR UNDERGROUND PIPELINE

The Standards Operating Procedures for laying the NG pipelines involve the following steps:

- Site preparation: The right of way (RoW) of the pipeline has been established after a reconnaissance with PQA and the site will be prepared in the terrestrial environment. The site will require about 12-15m for facilitating transportation of the pipes, ditching and necessary equipments for laying the pipeline. The surface or the topsoil will be stripped and separated from the excavated subsoil and will be returned after the backfill in order to re-vegetate the disturbed area.
- Pipe transportation: Sufficient space needs to be provided for movement of the trailers which will be used to move pipes from warehouse sites to RoW.
- Ditching: Position of trench to be excavated shall be confirmed and marked out. All the barriers along the

trench shall be cleared off to ensure the safety of the excavation prior to work start. Whether or not there are any foreign items buried under the ground shall be confirmed. The excavated soil shall not be placed near the trench. Excavated depth of trench shall be conformed as per the pipe burying depth in drawing. When excavated depth≥1.5m, shoring shall be done to avoid the slump of the soil for safety.

- Pipe bending: The pipe will be bent as per requirement of topography and elevation of the ditch.
- Pipe welding and X-ray: The 12 meter long sections of the pipes will be transported to the site where welding will join each section of pipe into a continuous line. The welded sections of the pipeline will be checked via Radiography and those failing the test will be re-welded.
- External coating: External coating of pipe will be done as per ASBM B 31.8 standard using some such coating materials as epoxy and high density polyethylene. After welding at the construction site, the pipes will be coated to prevent rust and rapture of the welding and checked before lowering into the ditch.
- Lowering in: Tractors/lifters/cranes will be used to lower the pipe into the ditch. In case a rock is encountered, the bottom will be bedded with soil or sand prior to lowering-in to protect the pipe and coating from damage due to bending.
- Backfilling & Land Restoration: Backfilling will be carried out in such manner as to ensure sufficient padding and bedding to prevent damages from the pipes already coated. The topsoil will be returned to allow re-vegetation. Planting of large trees in the proximity of the pipeline will be avoided to prevent roots from causing damages to the coating.

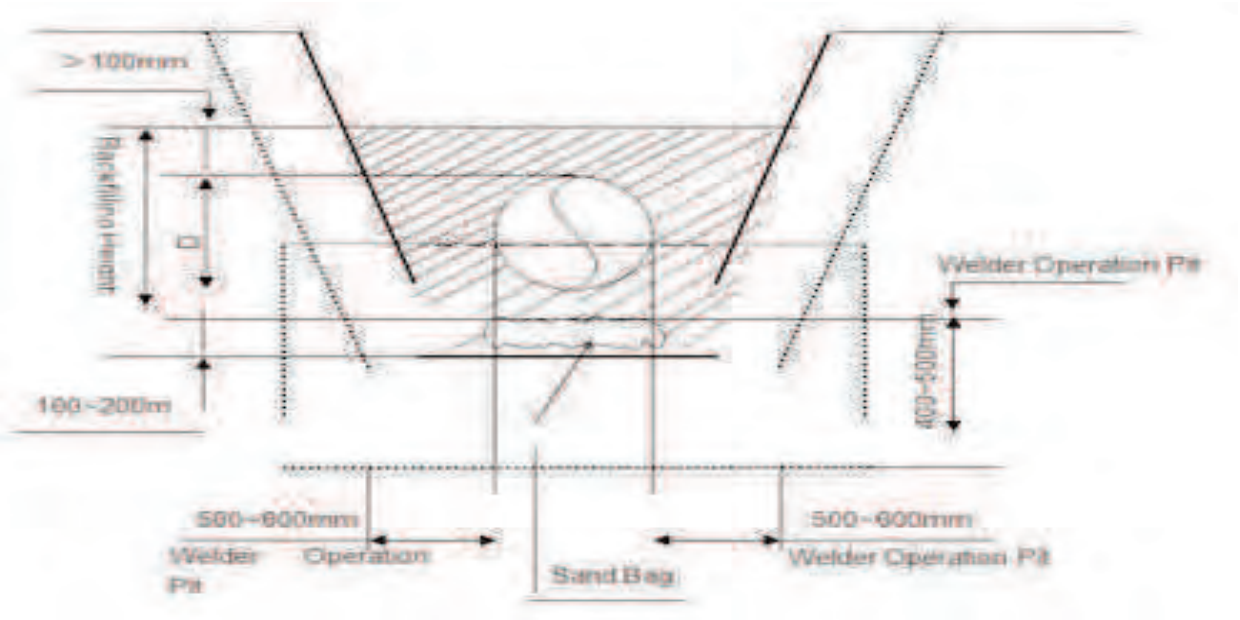


Figure 3.16: Installation procedure for pipeline

The connection point between the pipe and the equipment opening shall be supported well as per drawing to prevent the pipe displacement and the damage of the equipment connection opening. It will be ensured that no welding joints under the road while U/G pipe cross through the road. If it's inescapable, inspecting with effect method prior to backfilling shall take place. If subsection pressure test of U/G pipe must be processed, effect inspection must be processed substituting for the pressure test of the joint between sections. Opening of drainage cast iron pipes shall be installed against the water flowing direction. To avoid damaging anti-

corrosion layer on pipe surface, backfilling with fine soil or sand at the designated position as the following Sketch.

9) PRESSURE TEST

The work of pipeline installation (finish installation according to design and check it to PID drawing and installation of bracket to plan), welding, crack detection, heat treatment, etc for pressing testing system will be finished and checked and confirmed by pipeline engineer and welding engineer.

After all inspection/test record data of pressure test pipeline is completed, the pressure test procedure will be approved. Pressure gauge will be calibrated and within expiration data, the precision can't be less than 1.5 grade, full scale value of gauge shall be 1.5~2 times of gauged pressure value and pressure gauge of each test system can't be less than 2 pieces. Before testing, valves, equipments, instruments, blast board not included in the test should be temporarily removed, and nozzle stub can be used if needed; if expansion joint included in the test, temporary restraint device should be used.

The temporary blind board used in the test should be labeled with a plate and the corresponding mark should be made on system drawing. The blind boards must be removed completely by specially-assigned person after test. Valve that is closed during installation should be open in pressure test, and the valve needed to be closed during test should also be labeled with a plate.

It is especially emphasized that the equipments for which water in-taking is forbidden must be applied with some special measures to assure that no water enter into these equipment during test. If temporary bland flange can't be installed, valve can be used. During water pressure test, air discharge should be conducted at high point of system as possible, and water discharge at low point as possible. The security for outlet of air and water should be considered. Weld bond and other pipeline connection should not be painted before pressure test for convenience of check.

The test pressure should be no more than test-pressure of equipment which is included in the test. Especially for heat exchanger, owing to pressure discrepancy of pipeline and shell, its test-pressure should be confirmed by relevant engineer in writing form for preventing from damaging the heat exchanger.

The test medium and pressure should be according to requirements of design. Clean water is needed for

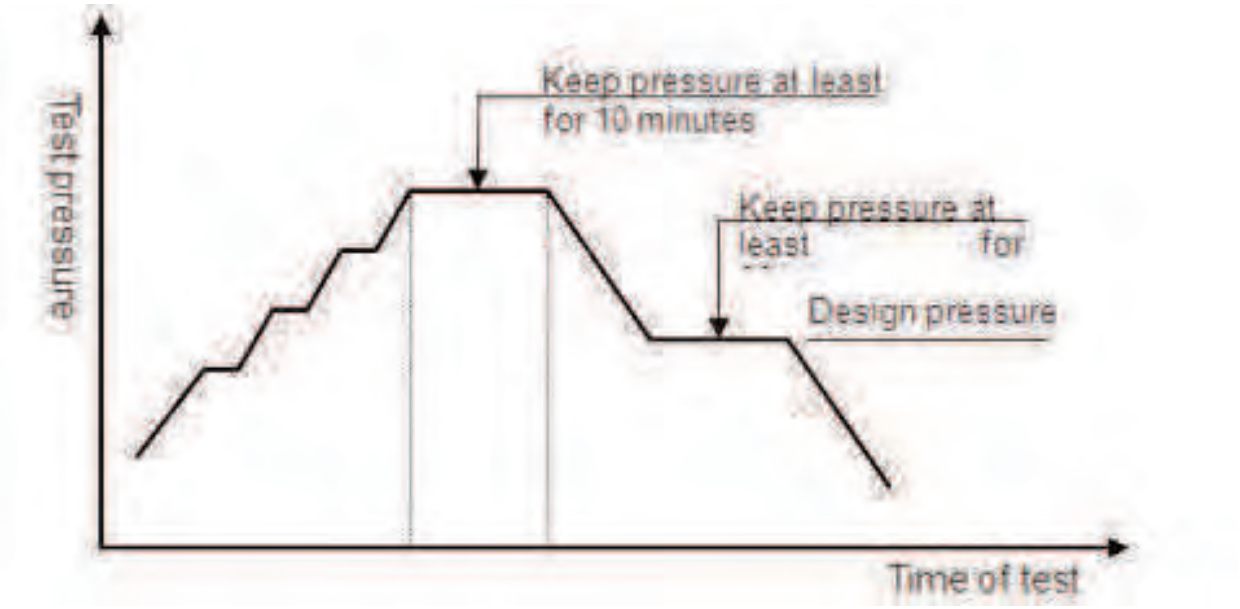


Figure 3.17: Pressure Lifting and Maintaining in Hydraulic Pressure

hydraulic pressure test. For stainless steel pipeline, the content of chlorine ion in water must not exceed 25ppm; otherwise desalted water should be used instead. The pressure for hydraulic pressure test shall be rose slowly, keeping the pressure for 10 minutes when it up to test pressure, and then reduce it to design pressure for 30 minutes; it can be acceptable if no leakage and no reduce of pressure.

For system using air medium, if pressure test is needed according to design, a trial test with pressure of 0.2Mpa should be carried out in advance. During air pressure test after that, air pressure should raised slowly until up to 50% of test pressure, then check if there be leakage or other abnormality, then raise the pressure gradually by 10% of test pressure until up to the test pressure. Keep the pressure for 10 minutes, and then reduce it to design pressure, check the craters and sealing surface of flanges by bushing soap water, the test can be considered to be up to standard if no pressure reduce and leakage is found.

The leakage test of pipeline system is carried out together with air tightness test (before laying-off test run) after blowing of pipeline is finished properly. The check should focus on the places from which some parts have been removed. During the test, leakage must not be disposed under pressure. The test should be repeated after the defects have been removed.

10) Blowing & Flushing

Prior to blowing and flushing, disassemble the orifices, adjusting valves of flange connection, main valves, throttles, safety valves and instruments etc. For welded valves and instruments, protection measures such as bypass or disassembling of the shell shall be taken. Blowing and flushing sequence shall be that the main pipe is first, branches and drainages follow. The dirt blowed out shall not be allowed to enter the clean pipes. Before blowing the anchors and hangers must be checked and fixed. While blowing and flushing, it is necessary to set forbidden zone, the blowing pressure shall not be over the design pressure of the vessels or pipes, and the blowing speed shall not be less than 20m/s. Set a white target near the outlet while blowing, watch the dirt of the venting gas, If within 5min there is no spot, dirt, sand or water on the target, it is qualified.

3.3.1 Onshore pipeline construction

1) Laying pipeline underneath the roads

To construct the pipeline underneath concrete or asphalt roads which are the main roads and heavily congested, a directional drilling method will be used to prevent traffic disturbance. As for small roads with less traffic, a ditch can be dug with a detour road being built or that the trench is covered by iron sheets to allow vehicles to pass over.

2) Laying pipeline under rail roads

The sections of pipeline need to be buried at a depth of at least 1.2 meters under the railways will be protected by casing with closing at both ends and supported by spacers which will be placed at 3-meter interval according to the specification together with ventilation tubes at both ends of the pipeline.

3.3.2 Safety Standards

1) Gas pipe: Material and specification

- The NG pipe will be made of high-tension steel. Its strength will vary in accordance with the pressure and site condition. API 5L-X65 requires the pipe to have a yield strength of 65,000 psi.
- The pipes will be produced by international standard factories and tested prior to shipment.
- The diameter of pipeline will be determined by the maximum gas flow.
- The thickness will depend upon several factors including maximum pressure of the gas, tension

during the pipe laying, external pressure which may damage the pipe.

- The thickness of the pipe as well as the bottom of the pipeline trench will conform to the international standard.
- Design of pipeline will conform to the ASME B31.8 Gas Transmission and Distribution Piping systems established by the American Society of Mechanical Engineers (ASME).

3.3.3 CORROSION PROTECTION

- Pipe coating: Pipes will be externally coated to prevent external corrosion. For submarine pipelines, there are two types of coating - corrosion coating and concrete coating to increase weight and enable them to lie on the seabed. The latter also prevents the pipeline from the impacts created by fishery and marine activities.
- Cathodic Protection will be designed for 30-year service. In case of steel, a corrosion cell is constructed by feeding a negative direct current to the pipe and a positive direct current to impressed current anodes designed to be erode instead of the pipe which are buried along the pipeline. The interval and size of anodes depend on the environment as well as gas qualification.
- Hydrostatic testing will be applied to identify if the pipeline can withstand a maximum designed pressure. For inland pipeline, the test pressure is set at 1.25 to 1.4 times over the designed pressure, and 1.25 times for offshore pipeline. The test will be conducted prior to the real gas transportation.

3.4 CONTROL AND COMMUNICATIONS

Sufficient communications system shall be provided that allow for communications between, the FSRU (via SSL), jetty approach facilities, and SSGC Control Centre. The communications design is based on a Dual Redundant Fiber Optic Link to connect Control Room (CCR).

- The Flow of the gas is controlled and assessed through Supervisory Control and Data Acquisition system or SCADA which will be centrally controlled.
- ETPL will ensure that real time live data being gathered is transmitted to SSGCL within polling time intervals of 4 to 12 seconds.
- Qualified engineers will be assigned to control the flow of the gas around the clock.
- The block valve stations will be located to inspect the pressure, velocity, temperature, density of the gas throughout the line.
- In compliance with international safety standard, the block valve stations will be constructed at a minimum of 7.5 meters away from the pipeline for safety practice. The wall will also be built for a block valve station having high traffic.
- Under abnormal circumstance, the valves will be directly commanded by the Operations Center. They will be turned on or shut down by automatic system.

3.4.1 INSPECTION

- In general area: Along the pipeline route, the inspection will be performed by car and walk through inspection. Some monitoring mechanism will be introduced to identify the changing environment such as the change of grass color above the pipeline.
- After the backfilling, the marker sign will be placed along the pipeline to indicate the location of the pipeline as well as entrepreneurs telephone numbers for reporting accident.
- Integrated Management System (IMS) will be applied in the project to minimize and prevent the pipeline from accidents.

3.5 CONSTRUCTION OF NITROGEN BLENDING FACILITY AT LINDE, PORT QASIM

Linde Pakistan Limited (formerly BOC), as a member of The Linde Group and the leading Gases supplier in Pakistan for more than 70 years, has supported the gases needs of a wide range of industries, contributing to the economic growth in the country and improving the quality of life of the people of Pakistan.

Linde manufactures and distributes industrial, medical and specialty gases as well as welding products and provide a range of related services including the installation of on-site plants, gas equipment, pipelines and associated engineering services.

Linde's facilities include air separation plants in Lahore, Port Qasim and Taxila and carbon dioxide plants at Port Qasim and Multan. They have also installed Hydrogen and Dissolved Acetylene plants in the South and West regions to meet customers demand nationwide.

For the adjustment of Wobbe Index of LNG to meet local (OGRA) grid gas specifications, RLNG dilution maybe required and thus onshore gas blending facilities will be provided at the Linde Above Ground Installation. The facilities will be designed to blend, meter and convey gas to the downstream pipe line and Gas Delivery Facility. Linde Pakistan will build, own and operate a dedicated nitrogen generator including a backup facility on their site at Port Qasim. Linde Pakistan will install two dedicated CRYOSS-N-Spectra Nitrogen generators, respectively a 10,000 and 30,000 with a combined capacity of 51,000 Nm^3/h on their Port Qasim site. The Nitrogen will be compressed to a pressure of 105 barg by 2 x 50% GAN compressors and injected through a mixing panel into RLNG pipeline to adjust the wobbe index.

The nitrogen generator will be equipped with two times 50% Main Air Compressors to accommodate the expected flow changes. Linde will also install a 400 tpd liquefier to produce liquid nitrogen in the periods the full capacity of nitrogen generators is not utilized, this allows to produce the necessary back-up.

A 10,000 m^3 (probably) LIN storage installation covers possible peak demands and will serve as a back-up for the nitrogen generator. The installation will provide around 7 days of back-up based on 50% of the plant capacity.

LIN will be withdrawn from the storage and compressed

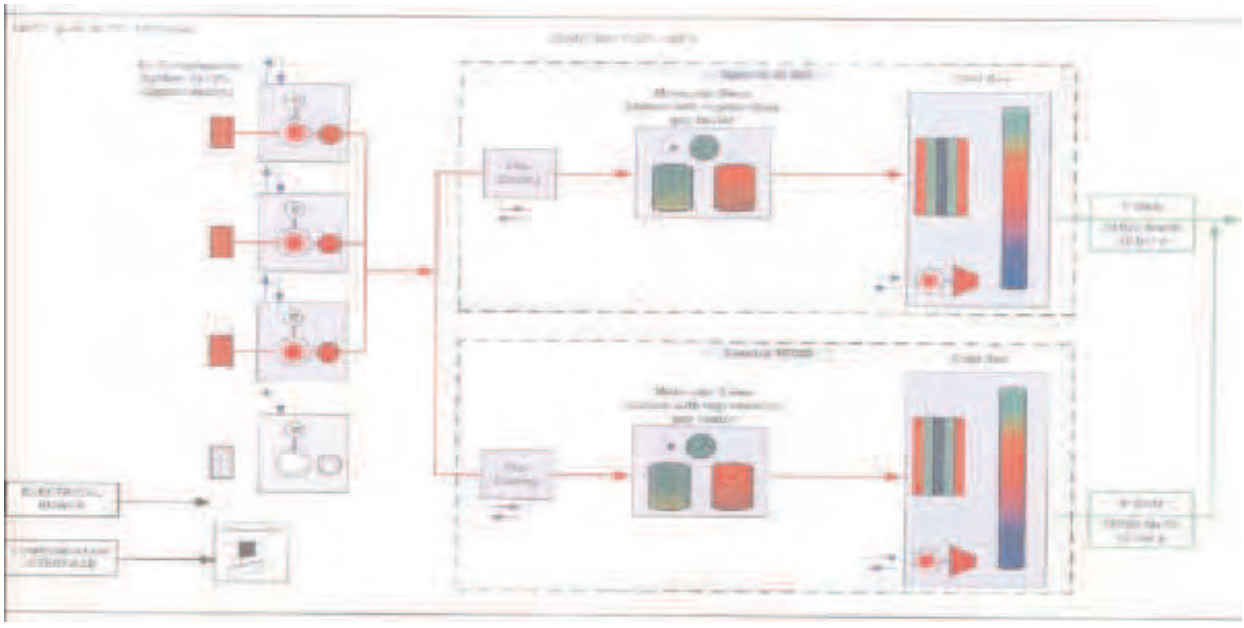


Figure 3.18a: Block Diagram of Nitrogen Blending Facility at Linde

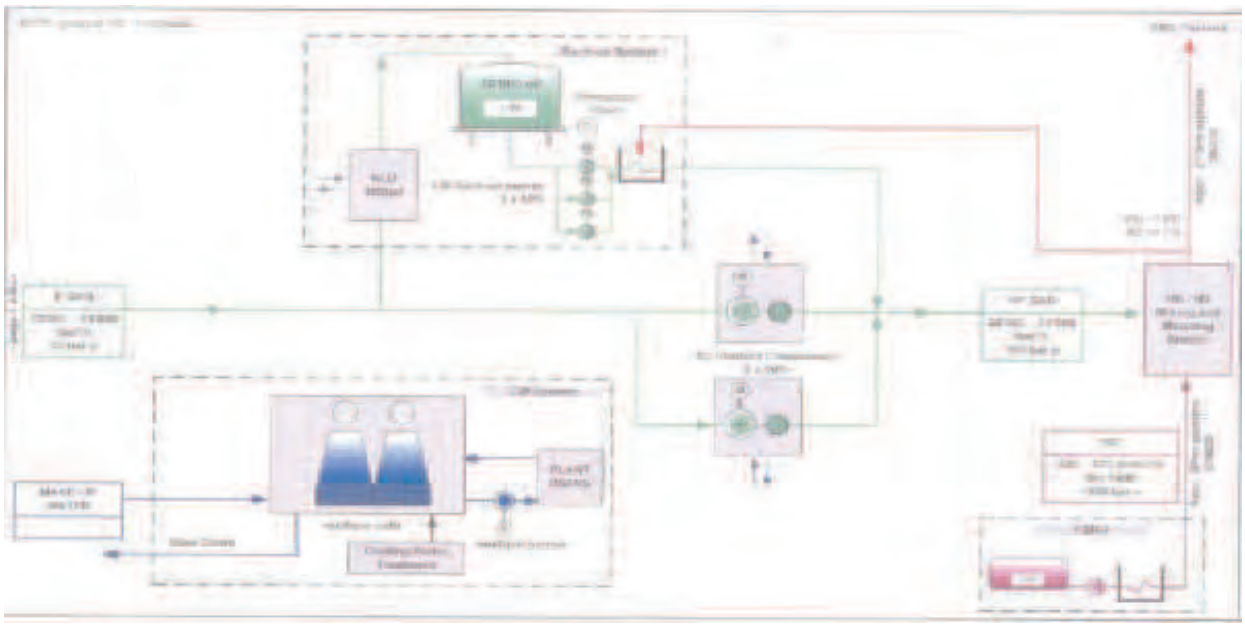


Figure 3.18b: Block Diagram of Nitrogen Blending Facility at Linde

Figure 3.19: Linde Pakistan Plan View of Existing Site

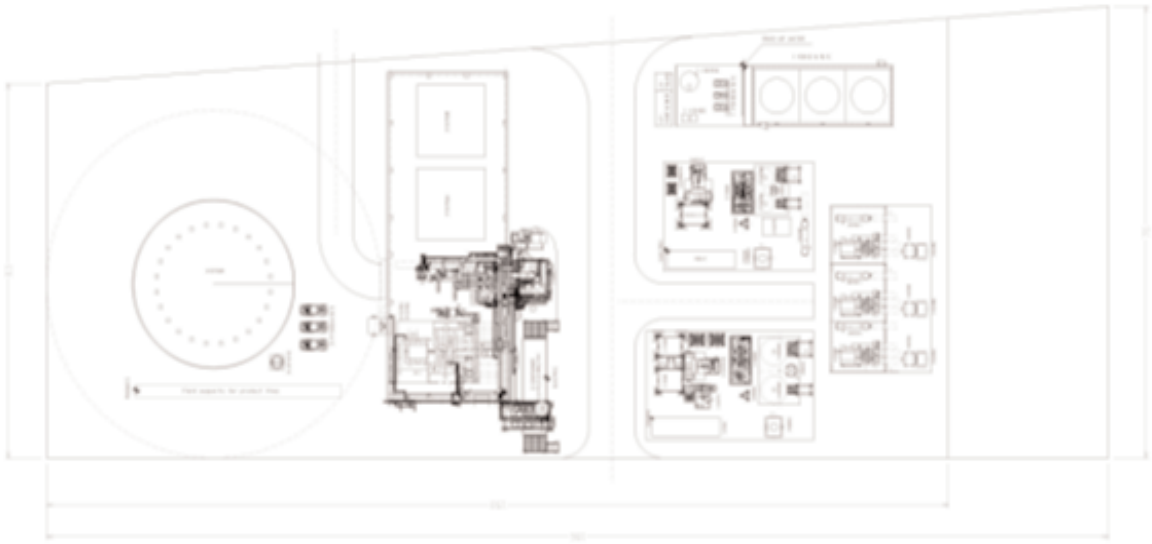


Figure 3.20: Linde Pakistan Plot Plan. Available Plot 186 m x 76 m. Needed area for ETPL N2 blending facility 156 m x 76m.

by 3 x 50% LIN pumps to 105 barg and vaporized in an NG fired vaporizer if there is a GAN demand that cannot be supplied from the GAN generators.

Linde will also install a NG fired (or diesel) power generator as a backup power supply for the LIN backup installation and the mixing panel.

Delivery time of the plant will be 12 to 15 months after placement of the order. The plant will be delivered highly pre-assembled (package unit cold boxes, factory accepted E-1 containers, pre-assembled molecular sieve skid, etc).

3.6 Design Considerations to Meet the Technical Requirements

Following preliminary design considerations have been made. Design Basis would be finalized after the completion of the FEED and an audit by the FSRA/LNGC supplier.

I LNG Liquid, Vapor and RLNG Loading Arm Operation

The arm will be securely parked when not in use. It is envisaged that the operator would have multiple means of operating the loading arm. The motive power to enable the operator to move, connect or disconnect the loading arm is provided by a hydraulic design, which takes into account:

- Wind load during operation and maneuvering of unit.
- Swivel friction torque.
- Rate of motion at outboard swivel and the resulting acceleration loads.
- When connected to the FSRA (or when securely parked) hydraulic system is in freewheel and will remain in "freewheel" in the event of electrical or hydraulic failure.

II Insulation Design

During the LNG Transfer process, heat is absorbed by the liquid through the pipe wall and insulation. The heat input into the liquid pipe work can be controlled by the thickness of the insulation. The type of insulation and any corrosion protection or anti abrasion coatings applied to the pipe work prior to insulation shall be determined at the detailed design stage.

III High Pressure Re-Gas System Design Parameters

The re-gas operation will be continuously manned and the re-gasification and gas delivery will be controlled. For each Regasification nomination the operator will utilize a configuration screen to input, three (3) "ordered" parameters.

a) Required discharge rate,

b) Maximum discharge pressure,

c) Minimum discharge temperature.

The ordered parameters will be set by the operator to meet the re-gas nomination specified. The discharge pressure will be determined by the re-gasification rate, the composition of the re-gas, the temperature of the re-gas and the prevailing pressure of the client's high pressure fuel gas network. The required minimum discharge temperature will be determined by the composition of the re-gas, mode of vaporization utilized, the utilization of supplementary re-gas heat exchangers located on the Jetty, the pressure difference between the vaporizer outlet and the high pressure fuel gas network entry point and the required gas temperature at the network entry point.

IV Load-Out and Transportation

Load-out and transportation shall be performed according relevant industry Standards.

V LNG Liquid/Vapor Pipe Work Design Parameters

The pipe work will be designed to ASME B31.3 Process Piping. The design parameters of the class 150 stainless steel pipe works are compatible with/exceed the design parameters of the LNGC and FSRU LNG liquid systems and the LNG loading arms.

VI Cold Drain Tanks Design

The Cold drains tanks will be designed to ASME VIII Boiler & Pressure Vessel Code. The design parameters of the stainless steel cold drains tanks are compatible with the design parameters of the LNGC and FSRA LNG liquid systems and the LNG loading arms.

3.7 LNG Terminal Hazard Protection System

The hazard protection systems will include fire protection, spill containment structures and gas monitoring devices. A fire and hazard detection system will be provided to monitor for the presence of flammable gases, fire, and LNG spills in areas where a hazard to persons or equipment could exist. Audible and visible alarms will be installed to warn an operator of a detected potential hazard. The operator will be required to analyze the potential hazard and determine if shutting down the equipment or activating the protection system is required.

Protection systems and alarms will be provided for fire exposure, cryogenic spills, gas detection, flame detection, smoke detection, and high and low temperature detection. The protection systems will consist of fire hydrants and monitors, sprinklers and fixed water spray systems, dry chemical extinguishers, and passive thermal and cryogenic spill protection. The area around the loading arms will be sloped to drain any spill sumps locate at the ends of the platform.

Flame detectors will be located at various locations within the facility where the possibility of a fire is most likely to occur.

Smoke detectors will be located at various areas within the facility. These detectors will be programmed to alarm on all the operator terminals. These detectors will also activate audible alarms (e.g. hazard horns) and beacons.

High temperature detectors will be located on each of the tank relief valve discharge stacks. These detectors will be programmed to alarm on all the operator terminals. The detectors will also activate audible alarms (e.g. hazard horns) and beacons.

Low temperature detectors will be located in the LNG impoundment sumps and drip pan located at the tank platform. These detectors will be programmed to alarm on all the operator terminals. An audible alarm will sound in the area if a spill is detected.

The emergency shutdown system is designed to be fail-safe for increased system reliability. The emergency shutdown system will have the capability of being activated from various locations throughout the facility to initiate a plant wide shutdown. Redundant logic controllers and operator terminals will also be provided for increased plant safety.

Automatic emergency shutdown valves will be provided in the ship unloading lines, in pump discharge lines, at the inlet to each vaporizer and in the plant main outlet gas line.

Following basic requirement would be fulfilled:

I Emergency Shutdown System (ESD)

The ESD system will be as electronic system with sufficient redundancy to ensure system reliability in the event of a safety-related upset. Field valves will be fail-safe. This system will also be hard wired to the FSRU ESD systems.

II Firewater

A firewater distribution system will be included in the base case design.

III Fire and Gas Detection

The facility will include a fire and gas detection system as an element of the ESD system. Details to be developed during detailed design.

IV Safety Measures in LNG Cargo Transfer

It will be ensured that the supply vessels will be able to moor and berth safely alongside while transferring LNG Cargo. The standard for ship's cargo manifolds and detail on surge pressure control will be defined in the design and operation plans.

V High Pressure Re-Gas System

The high pressure gas system will be protected by means of high pressure trips, low temperature trips, and relief valves. The FSRU ESD system will operate to shut down the re-gasification process in the event that a ship side ESD condition or shore side ESD condition is present. The FSRA integrated automation system (IAS) will be provided to assure the safe operation of the re-gasification plant within the system design parameters.

VI Spillage

The area around the loading arms will be sloped to drain any spills to the spill sumps located at the ends of the platform. Each sump will be sized for the contents of one loading arm plus piping up to the platform isolation valve.

04 Screening of Alternatives &/or Subsequent Expansions

This Section of the Environmental & Social Impact Assessment (ESIA), entitled "Screening of Alternatives and/or Subsequent Expansions," addresses the system alternatives to the proposed project, including the siting alternatives evaluated for the proposed Liquefied Natural Gas (LNG) terminal and the alternative technologies considered for the proposed LNG transfer facilities as well as dredging to create the berthing and turning basin.

The proposed project aims at development of a Floating Liquefied Natural Gas Import Terminal to facilitate the import of Natural Gas for the market within Pakistan and thus meet the shortfall in the current energy production system. The alternatives available are the following:

4.1 "No Action", continuation with the existing condition

The "No Action" alternative to the Project would mean that the proposed LNG terminal would not be constructed. The implications of this alternative to the national economy are significant. The "No Action" alternative would mean the loss of additional reliable and economical natural gas and certain economic and socioeconomic benefits associated with the Project.

This is not an acceptable proposition since the wide gap between supply and demand of energy from the conventional sources including fossil fuel must be bridged urgently. For that matter the availability of natural gas to industrial, commercial and residential customers throughout Pakistan needs to be ensured. This critical situation is not addressed by the 'no action' alternative.

The 'No Action Alternative' does not offer the advantages sought by the Energy Policy 2002 of the Government of Pakistan GoP nor to the LNG Policy 2011. It also does not respond to:

- The urgent and strategic needs to enhance the availability of NG for power production to meet the demand of industry, agriculture as well as commercial and domestic consumers of the country; nor does it propose better level of service for improvement of quality of life.
- The need to increase the current power production capacity despite the shortfall in energy availability resulting in load shedding of 3 to 8 hours every day.
- The requirement of slowing down on fossil fuel consumption that is adding to global warming on the one hand and on the other hand depleting the national potential of natural resources.

The proposed LNG Regasification Project therefore provides a more sustainable solution to meet the expected increase in energy demand than the 'No action/do-nothing' option. The "No Action Alternative" therefore does not merit further consideration.

4.2 LNG Terminal 'Siting' Alternatives

4.2.1 Siting Criteria and Guidelines of PQA

PQA has provided guidelines and recommended the sites accordingly. These indicative criteria with industry practices have been considered in the risk assessments during the design stage to ensure compliance with international standards. It is to be noted that LNGC and FLNG operators will also audit the facility prior to allowing their carrier to be stationed or delivered to the terminal. Same will also be undertaken by LNGC providers. The proponent is and has been in consultation with the LNGC and FLNG operators to ensure that their requirements are considered at all stages of the development and that international safety and environment standards are adhered to by all. Therefore

some indicative criteria are stated here for purpose of information.

- LNG Terminals be designated in sheltered locations, remote from other Port users and populated areas.
- The Location be so chosen as to reduce the risk of passing ships striking a berthed LNG carrier.
- LNG tankers could be vulnerable to penetration by collisions with heavy displacement ships. The Terminal be sited in a position that reduces the possibility of it being approached by heavy displacement ships thereby avoiding penetration of the hull of an LNGC.
- Large ships passing near to the berthed LNG carrier may cause surging along the jetty, with consequential risks to the moorings. This phenomenon be guarded against in the design.
- Narrow channels not be considered appropriate for jetties positions of LNG carriers without understanding the associated risks and their mitigants although Gasport in Kadiro Creek has been approved by SEPA and PQA
- The location should have adequate backup area.
- The location should be such that pipelines/ connection between LNG tank hold and re-gasification plant be minimum

4.2.2 NOC GUIDELINES

Following guidelines have been provided in the Provisional NOC granted by Port Qasim. The guidelines are however for reference only; safety aspects of the site are being addressed in detail under a QRA being conducted separately and risk mitigations proposed to be subsequently catered in the design and engineering of the facilities per current international standards selected by the proponent and its engineering consultant. Thus the risks identified in QRA will be considered in the detailed design and operation procedures of PQA. Milford Haven in UK has successfully operated at criteria much more stringent than those indicated here.

4.2.2.1 MILFORD HAVEN PORT, AUTLING UK - AN EXAMPLE OF THE RISK BASED REGIME

Milford Haven Port Authority notifies two zones for safe navigation of vessels within the port jurisdiction as follows:

- Controlled Zones

Controlled Zone is extending 1 mile ahead and astern of the specified vessel and within the main channel. No commercial vessel of 20 meters or more may navigate within the controlled zone except astern of the specified vessel where such navigation is away from it and provided that prior permission has been sought from and granted by Port control.

- Exclusion Zones

Exclusion zone is extending ahead to the limit of the line of sight from the bridge of the specified vessel within the confines of the channel; no vessel is permitted to navigate within this zone at any time. Such limit will be determined by a patrol vessel stationed ahead. The zone astern will extend to the stern of an escort tug, when provided, or 100 meters where it is not.

By specifying these controlled zones the ports is able to handle LNG ships without any issues. The idea is again based on a risk based regime.

4.2.2.2 STANDARD SAFETY PARAMETERS:

The recommended site for Jetty location should be sheltered area remote from other port users where other ships do not pose a collision risk and where any gas escape cannot effect a local population. More over Jetty location should be so chosen as to reduce the risk of passing ships striking a berthed LNG carrier.

Standard Safety Parameters are as follows:	
1. Approach Channel Width	5 times the beam design
2. Turning Circle Dia:	2 to 3 times the LOA
3. Tug Power:	Recommended 60 Ton Bollard Pull Tugs. 3/4 in number.
4. Traffic Control:	Vessel Tracking System (VTS) recommended for LNG carrier control.
5. Operating Limits:	To be established as per maximum wind
6. Speed Limits	Between 10-14 knot depending on hydraulic conditions prevailing.
7. Under-Keel Clearance:	1: 10 for sheltered channel. 1:15 for exposed channel. 1 Meter for berth.
8. Navigable Depth:	Not less than 10m CD but dependant on the vessel deployed for FSRU and LNGC.
9. Ignition Source:	Should be excluded from within the pre determined radius from the jetty manifold.
10. Mooring Layout:	Should hold the carrier safety alongside in all condition of wind and current (spacing about 150-290m and 40-50m inshore of berthing face).
11. Hooks:	Quick Release hooks must be provided.
12. Emergency Release System:	At each hard arm at the terminal. Emergency Release System (ERS) should be interlinked to the ship's Emergency Shutdown System (ESS).
13. Operating Limits:	Should be established for berthing, stopping, cargo transfer, hard arm, disconnection and departure from berth.
14. Standard Area Limits:	150-250- m around the vessels & jetty (Berthed/Discharging Cargo)

15. LNG terminal, berths preferably not be sited on the outside of channel bends

16. Pilots are mandatory on all vessels over 200 gross tons

17. A minimum of two fast patrol craft required to enforce the moving safety and security zones and to clear the channeland berth area in advance of the LNG vessel.

18. Two dedicated handling boats, with a minimum of 400 HP required for mooring services.

19. Buoys with range markers and radar reflectors on the tower are required for safe navigation

Note: More dangerous cargos are already being safely handled by PQA within the last 17 years

4.2.2.3 EXCLUSIVE ZONES FOR SAFETY AND SECURITY OF LNG SHIPS AND TERMINAL

The international practice imposes a safety and security zone around LNG vessels in transit and while berthed. The zone is applied and astern and on either side. The exclusion zones and safety distances are applicable to LNG v/s other ships/activity and not between two LNG carrier. Following LNG safety and security zones are applied by existing US, European and Far East NG terminals as advised by ECIL to PQA:

LNG Safety and Security Zones (US Vs EU)	
US (enforced by the US Coast Guard):	European & Far East Terminals:
■ Ahead: 1.5 - 3 km	■ Ahead: - 800 meters
■ Astern: 0.5 - 1.5 km	■ Astern: - 800 meters
■ Port and starboard: 500 meters	■ Port and starboard: typically the channel width

For an LNG vessel departing in ballast condition, no specific restrictions are required apart from clearing the channel ahead of a large vessel in transit. These are to be reviewed with PQA upon finalization of the operational procedures for LNGCs. As stated above it is the Port and the terminal authority that need to develop procedures to safeguard operations through reviews and studies as was done by Milford Haven in UK with SIGTTO consent.

Following are the flammability and radiation zones for all LNG spills:

Spill Source	Flammability	Radiation
Transfer Piping	250m radius	500m radius
Tanker holds	250m radius	2000m radius
Storage Tank	250m radius	3000m radius
The above radiation zone is categorized as follows		
Thermal Danger Zone	250m radius	500m radius
Danger Zone	250m radius	2000m radius
Semi Danger Zone	250m radius	3000m radius

Port Qasim will provide support in providing the vessels tracking systems, buoys with range markers and radar reflectors, tug boats and all necessary channel related facilities to assist proponent and as envisaged for other LNG terminals e.g. GASPORT.

4.2.3 OTHER CONSIDERATIONS

Siting the LNG Import Terminal has also taken the following aspects into consideration:

- The operations of LNG terminal include harboring, berthing, unloading of cargo, storage, re-gasification and transmission of Regasified LNG (RLNG) to onshore installations.
- Mitigation of risks while handling LNGC right from entry into the port to harboring, berthing, unloading, storage, re-gasification to bring the LNG from a low of -160°C to ambient temperatures and transmission to onshore installations/ pipeline.
- LNG is per se non-flammable i.e. it does not catch fire unless brought to vapor form. While vaporizing in open air it raises dense cloud in the vicinity. In case of

spill the liquefied gas at -160°C would not sink but float on the sea surface and raise the cloud of condensed water vapor and then vaporize in the air. This would require a contingency plan that would be different from the conventional. Specific hazard reduction and fire fighting facilities will have to be in place at the site or on the FSRU to deal with pool, jet and flash fires from LNGC ships and re-gasification facilities.

- Industry safety practices have ensured safe operations with no incidents on LNG facilities or vessels since many decades.

Table 4.1 compares hazards related to LNG and other fuels.

Table 4.1: Comparison of Hazards of Different Fuels

Hazard	LNG	LPG	Gasoline	Diesel
Toxic	No	No	Yes	Yes
Carcinogenic	No	No	Yes	Yes
Flammable	Yes	Yes	Yes	Yes
Asphyxiant	Yes, in confined spaces	Yes, same as LNG, but higher density encourages accumulation	No	No
Other Health Hazards	Low Temperature	No	Eye irritant, narcosis, nausea, others	Forms a flammable pool & flammable vapor cloud, environmental cleanup required
Flammable limit air %	5-15	2.1-9.5	1.3-6	N/A
Stored Pressure	Ambient, except in some small containers	Pressurized	Ambient	Ambient
Behavior, if spilled	Evaporates, forming visible, flammable vapor cloud that disperses quickly	Evaporates, forming flammable vapor cloud that tends to accumulate	Forms a flammable pool & flammable vapor cloud, environmental cleanup required	Forms a flammable pool & flammable vapor cloud, environmental cleanup required

The eventual selection of site by the proponent depends on the qualitative/quantitative risk analysis as part of the techno-economic feasibility. EMC has carried out analysis on the siting of the LNG terminal.

Environmentally Option 1 (Site at Khiprianwala Island), Option 3 (Brown Field site in the vicinity of EVTL) and Option 4 (EVTL existing chemical jetty) have been found feasible provided that the mitigations suggested are carried out; however, as mentioned above and after review of the site safety requirements to be considered in a detailed QRA and other associated studies being conducted and as agreed between ETPL and Port Qasim.

4.2.4 Option 1: Siting the LNG Terminal on Khiprianwala Island (Green Field Site) at the Junction of Kadiro and Phitti Creek: Preferred Alternative

(Option 1 : Lat: 24°46'60".53 N, Long: 067°12'54".12 E) was screened for siting the LNG import Terminal and was found feasible for further consideration on account for the following reasons and grounds:

- Option 1 (figure 4.1) is viable because the Jetty is near the terminating point for the proposed SSGC gas pipeline for MASHALL Project; moreover the site is less exposed to open sea.
- The jetties operational are about 8 to 10 km from Option 1. Hence locating the LNG terminal in close proximity to those terminals/jetties may have affected the traffic flow and operational activities. Therefore, optimal mitigation has been considered while selecting the site for the jetty.
- The configuration and arrangement of berthing FLNG and LNGC vessels is in concurrence with natural alignment of the creek.

- Minimum dredging should be required for option 1 for the preparation of the area required for jetty terminal as well as for the safe and effective movement and maneuverability of /LNG carriers.
- A major factor in selecting the green field option 1 location is to adequately address the safety environment of siting of LNG receiving terminal.
- Option 1 site considers minimal disturbance to ecosystem especially of the mangroves and other aquatic flora and fauna.
- The proposed green field location is remote from other port users and populated areas with regards to the recommended safety and security zones for siting the LNG terminal.
- ETPL intends to place the LNG carrier inside a berthing pocket at a safe distance from the navigational channel, dimensions of which will be confirmed in the FEED, so that the risk of collision between berthed LNG carrier and passing by Vessel is minimized and heavy displacement ships can also pass by in the main channel. Moreover; the Jetty arrangement would be designed to minimize/sustain the surge loads due to large ships passing by LNG ships.
- Since the site is before buoy K2 no issues have been highlighted by PQA regarding the channel width.
- A land area of about 75 to 100 acres as backup has been considered satisfactory by ECIL consultants of PQA.
- The site has been recommended by PQA and its consultant ECIL and is the zone earmarked for handling petroleum/LNG/LPG products
- Since, the approach is based on a floating terminal; the piping would be limited as, the only connection away from the jetty would be the tie in to the SSGC gas network.

4.2.5 Option 2: Siting the LNG Terminal in the Phitti Creek (Green Field Site) near but not exactly on Khiprianwala Island along the main navigation channel

(Option 2: Lat: 24°44'54".87 N, Long: 067°10'08".60 E) was screened for siting the LNG import Terminal. Following reservations were highlighted:

- The Option 2 site (figure 4.1) is critically exposed to open sea and therefore vulnerable to security risks.
- Tsunami wave hazard of magnitude higher than 5 meter would be a matter of concern to the dredged/reclaimed areas along the sea front in the main channel
- Extreme vulnerability to cyclone disasters; the wind (60 knots) and low pressure (980 mb) creates the storm surges which when combined with high tides, becomes a destructive force in the channel exposed to the sea. Coastal erosion and inundation are commonly associated with storm surges and these have been found to inundate the coastal area and thus showing the salt pans in the area.
- Stress on the mangrove and benthic communities; eroding sediments of high concentration (1000-2000 ppm) has been observed at the site. The factors responsible for the excessive erosion may be strong currents during ebb and flow of tides and also the waves generated as a result of moving vessels in the main channel just adjacent to the option 2.

The above concerns were also shown by the stakeholders particularly Sindh EPA, IUCN, National Institute of Oceanography (NIO). The site does not meet environment standards as well and is not recommended and is rejected.

4.2.6 Option 3: Siting the LNG Terminal adjacent to the existing Chemical Jetty of ETPL at Port Qasim (Brown Field Site- Acceptable Option)

The above site was screened for siting the LNG import Terminal and was found feasible for further consideration on account for the following reasons and grounds:

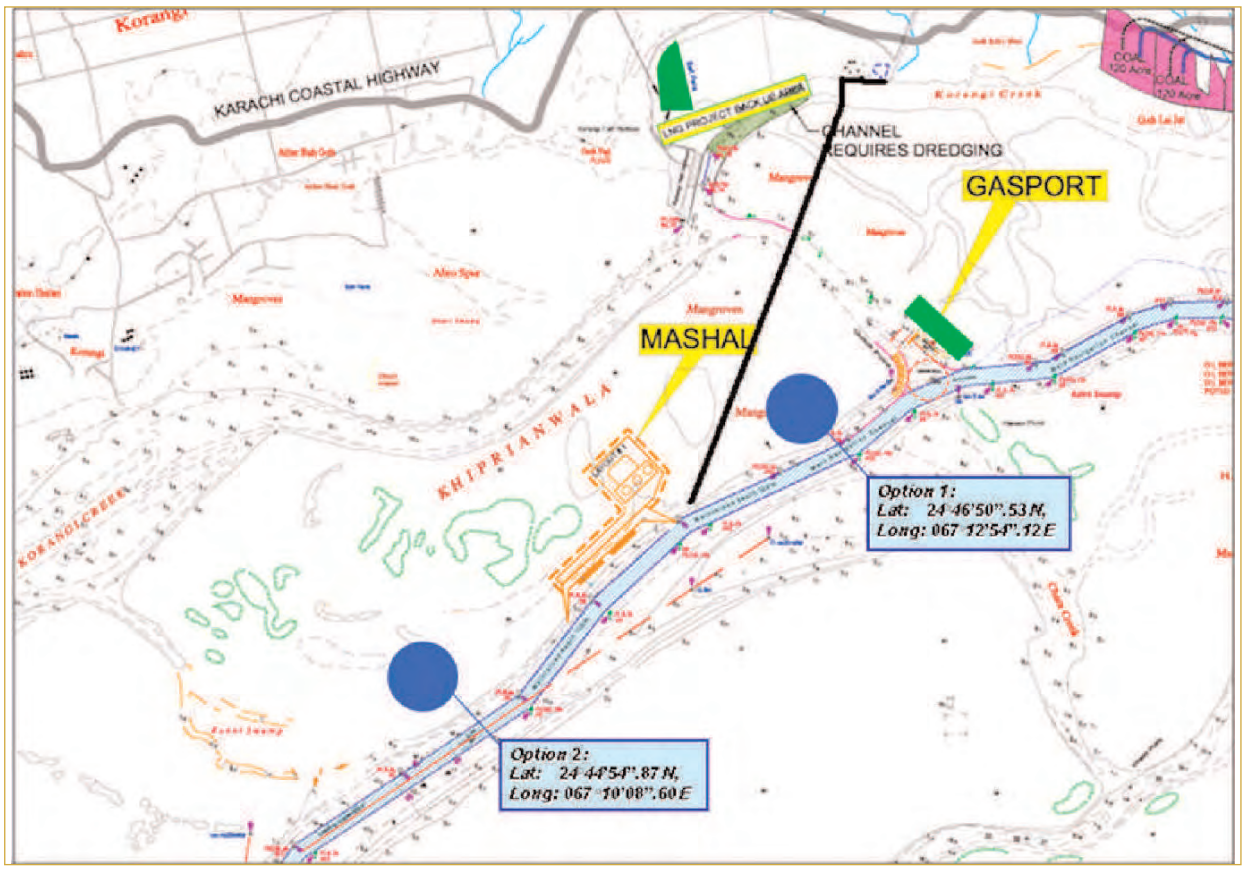


Figure 4.1: Green Field Sites (Option 1 and 2)

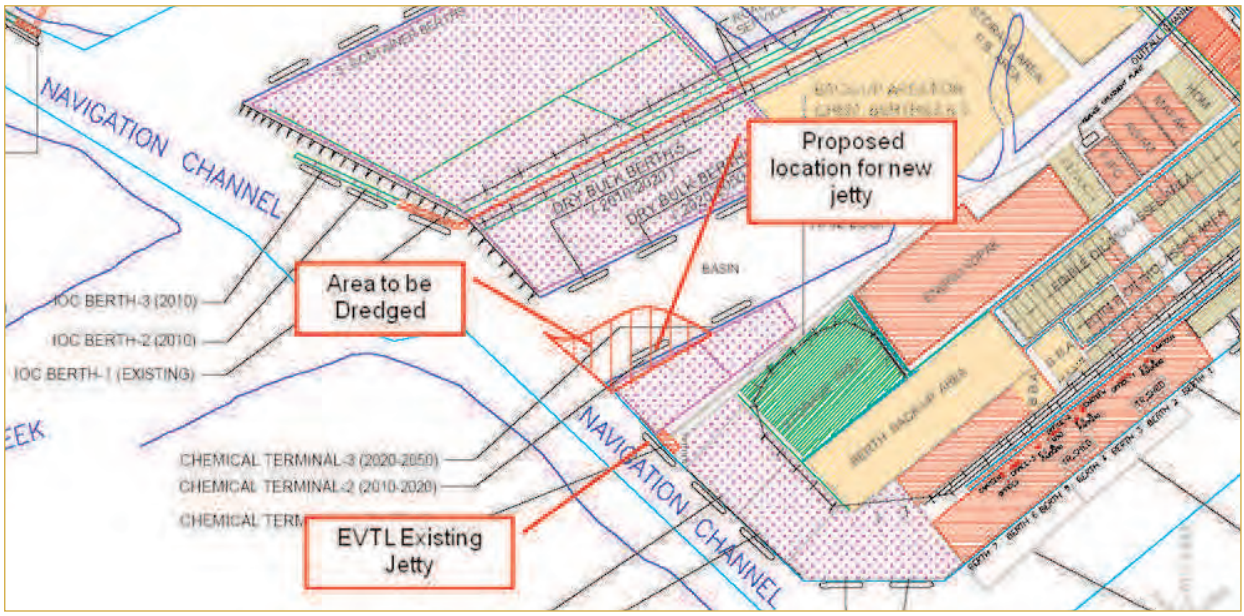


Figure 4.2: Brown Field Site (Option 3)

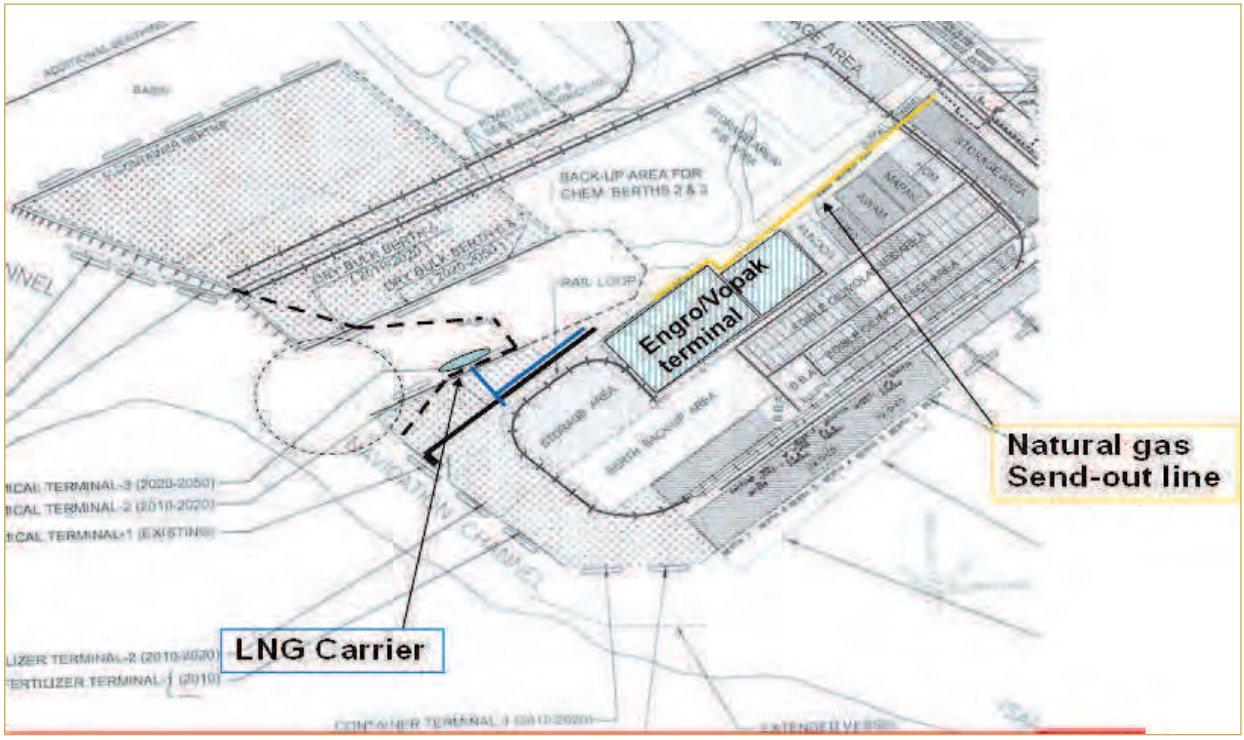


Figure 4.3: Another View of Brown Field Site (Option 3)

- Option 3 (figure 4.2) is considered because the Jetty is near the pipeline network of SSGC gas pipeline for Port Qasim; moreover the site is less exposed to open sea because of the location of the jetty in the adjoining basin.
- The jetties operational are near Option 3. Hence locating the LNG terminal in close proximity to those terminals/jetties may affect the traffic flow and operational activities. Therefore, optimal mitigation has been considered while selecting the site for the jetty.
- The configuration and arrangement of berthing FLNG and LNGC vessels is in concurrence with natural alignment of the creek.
- Minimum dredging should be required like option 1 STS approach for the preparation of the area required for jetty terminal as well as for the safe and effective movement and maneuverability of LNG carriers.
- Option 3 site considers minimal disturbance to ecosystem especially of the mangroves and other aquatic flora and fauna.
- ETPL intends to place the LNG carrier inside a berthing pocket at a safe distance from the navigational channel, dimensions of which will be confirmed in the FEED, so that the risk of collision between berthed LNG carrier and passing by Vessel is minimized and heavy displacement ships can also pass by in the main channel. Moreover; the Jetty arrangement would be designed to minimize/sustain the surge loads due to large ships passing by LNG ships.
- A land area of about 55 acres as backup is available.
- Since, the approach is based on a floating terminal; the piping would be limited as, the only connection away from the jetty would be the tie in to the SSGC gas network.

Following are the key reservations as communicated by PQA and replies from proponent (ETPL):

- PQA Navigational Channel from Buoy K-2 onward is narrow and safety zone distance of 200-300 meters in not available.

ETPL provided evidence to PQA of Milford Haven and stated that the Port Authority and Terminal Operator need to collaborate to mitigate the risks and develop acceptable procedures for safe operations.

- Turning Circle of 250 meters for berthing and safety zone is not available.

ETPL conveyed that 500-600m turning circle would be prepared in the basin adjoining its terminal and away from main channel. PQA has not studied the proposal in detail.

Existing turning circles at IOCB and QICT2 are available. QRA approves the Greenfield and brownfield sites

- One-way traffic is essential with priority rights for LNG carriers during transit in the channel. Average duration upto ETPL site will be 3-3.5 hours, which PQA cannot afford due to limited tidal window.

PQA procedures need to focus on efficiency and safe operations besides the projected traffic flow is not significant. As Port Authorities gain experience, the traffic management process will improve and become increasingly efficient due the skills of the pilotsIn addition, industry has operated at Milford Haven and on rivers with more difficult conditions. The traffic flow can be improved by night navigation facilities at the Port.

- Site being deep inside the Port where risk of increased traffic encounters and extended shallow water navigation exists.

Site is away from the main channel and in the adjoining basin.

- The location does not have sufficient backup area clear of habitation/port build ups related activities.

ETPL believes there is sufficient land available on its 103 acre facility for FSRU operation where regasification and storage is on the FSRU and minimal backup land is required.

ETPL considers that the above reservations can be taken care of by:

1. Concentrating on a floating storage solution in the side bay next to the existing ETPL terminal which itself is situated in front of Gharo Creek.

2. Bringing in smaller ships which have a beam such that five times of the beam is less than or equal to 200 m. This would result in compliance to the approach channel width criteria (small size ships are available in the market with capacity ranging from 10,000 cbm to 90,000 cbm, the beam size varies from 20 to 40m). This fact was also presented by a delegation from MISC to PQA. Moreover, larger vessels would need tug boat management specially in the monsoons.

3. Dredging of a turning circle as per the requirement of the guidelines.

4. Managing the traffic at Port Qasim more effectively; night navigation can be one solution; other would be creating lay bay areas as proposed in the widening and deepening project of PQA.

5. Locating the LNG Jetty in the pocket between IOCB and ETPL in a way that sufficient safety distance is maintained from the nearby infra structure and vessels.

6. Conducting a detailed QRA and acting upon the mitigation measures suggested in the study. An example is of Milford Haven where in spite of having a limited channel width LNGCs of Qmax/QFlex sizes are being accommodated; suitable safety measures are however being taken by optimum use of tugs etc. after detailed review of risks by the port authority and the operator.

Therefore, for the existing channel parameters (width and draught) ETPL's existing brown field site could be considered for smaller ships after necessary detailed QRA and partnership with PQA. From the perspective of this ESIA, the site is acceptable as is Site Option 1.

4.2.7 Option 4: Upgradation of Existing EVTL Chemical Handling Jetty to Handle LNG Supplies

This Project is based on utilizing the exiting EVTL Terminal so that LNG can be brought at the earliest into the Natural Gas (NG) network. The existing EVTL jetty is 320 m in length and is capable of handling vessel sizes up

to 290 m LOA. The jetty mooring and breasting dolphin layout would be based on receiving FSRU with a length overall up to 277 m.

The Jetty arrangements include platforms, trestles, mooring and breasting dolphin arrangement, quick release coupling, gangways, crane and all other equipment necessary to build the Jetty as per the standards mentioned above.

As per design study conducted by ETPL, a cryogenic marine loading arm will need to be installed at the existing jetty platform which will be linked with associated Emergency shutdown system. To absorb the berthing momentum, EVTL jetty fenders and front panels on its mooring dolphins will need to be replaced with larger size. Similarly, the Quick release hooks will need to be upgraded and a berthing speed monitor will need to be installed at the jetty. A new mooring dolphin may also be installed 60 meters away from the existing mooring dolphin (towards FAP terminal side). Additionaly laying of SS phosphoric pipeline from EVTL berth to Marginal Wharf will be undertaken to allow for higher berth vacancy rate at EVTL for the berth modification option.

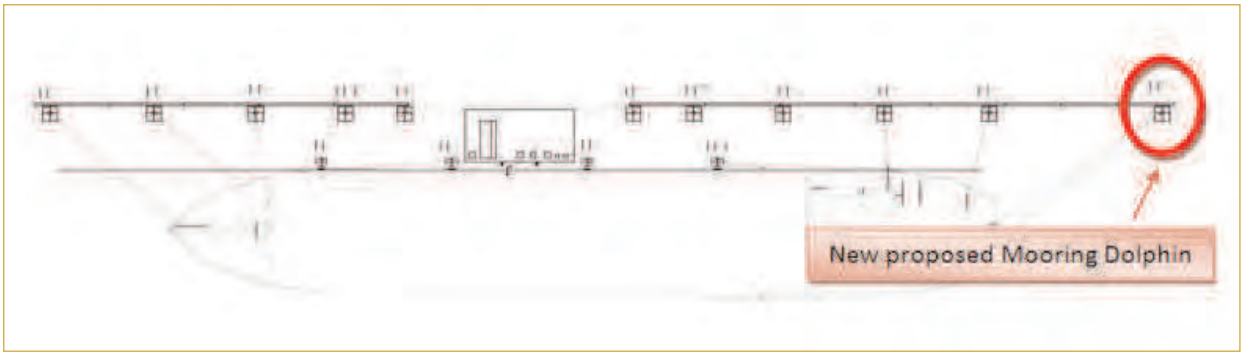


Figure 4.4: Proposed Mooring Dolphin (Option 4)

Almost all of these activities will have insignificant environmental impact and almost all of these activities are already a part of EVTL's maintenance plan.

4.3 SELECTION OF PREFERRED ALTERNATIVE TO PROCUREMENT OF NG

The energy procurement alternatives for Pakistan comprise of:

1) Continuation of import of crude oil for further refining;

2) Import of petroleum products including high sulphur furnace oil (HSFO), gasoline, high speed diesel (HSD) oil, and LPG.

3) Import of LNG or pipeline gas and

4) Local indigenous production of gas.

5) Import of LNG through LNGC and deliver as RLNG

Inadequate refining capacity in the country is a major constraint in alternative (1) while alternative (2) involves import of petroleum products whose ever-increasing cost demands provision of hydrocarbons alternative form or providing power from an alternative energy source. In addition, environment degradation is a serious concern as a result of increased carbon emissions. As regards alternative (3) and (4), the indigenous oil and gas resources have been depleted to the bare minimum, while the import of gas by pipeline despite being viable has become part of international politics and there is no viable solution to this effect in the offing. This leaves import of LNG as the only alternative that can deliver the gaseous hydrocarbon at the earliest and thus resolve the looming crisis that the Country is faced with.

(5) Import of LNG through LNGC and delivery as RLNG offers an economically viable alternative since:

- RLNG constitutes extractable hydrocarbon components other than methane depending upon the source and if rich,
- Natural gas is an eco-friendly fossil fuel, while the use of HSFO and HSD as fuel for power generation on large scale is least desirable due to high content of sulphur and consequent emissions of SOx and NOx.

Import of LNG is the preferred alternative for procurement of NG by which multiple objectives would be achieved. Additionally the project brings environmental benefit on a macro scale to the macroenvironment and global environment.

4.4 ALTERNATIVE TECHNOLOGIES FOR FLOATING LNG TERMINAL:

Alternatives available for the arrangement of a floating LNG terminal can be categorized as:

4.4.1 STORAGE AND REGASIFICATION ARRANGEMENTS

1. FSU with On Shore Regasification: This solution provides the advantage that the on shore regasification facility can be later used for a land based terminal. Such an arrangement would however require a higher investment since land will have be prepared for the installation of the equipment with necessary supporting infrastructure.

2. FSU and On Barge Regasification: Such an arrangement would provide the flexibility of increase in storage by merely replacing the FSU. However this would again be more capital intensive as more dredging would be required to place three ships (LNGC, FSU and the Barge) safely away from the channel. Moreover, separate utilities would be required which would add up to the cost.

3. FSRU: Such an arrangement would give a lesser flexibility as far as the expansion in the storage is concerned as larger vessels beyond 3.5mtpa have not been constructed so far; however it would definitely be the fastest available integrated solution. Additional capacity can be created by placing additional FSRU thereby creating the flexibility for expansion. The dredging requirements would also be less as compared to 1 & 2 discussed above in case of utilizing one FSRU.

4.4.2 MOORING INFRA STRUCTURE ARRANGEMENT

Mooring infra structures can be:

1) Tandem arrangement (Figure 4.5)

2) Ship to ship transfer (Figure 4.6)

3) Or a platform in the middle with LNGC and FLNG parked on either side. (Figure 4.7)

Figure 4.5: Tandem Arrangement

Figure 4.6: Dock side ship to ship LNG transfer

Figure 4.7: Platform in the middle

These alternate technology options would however cause no impact other than those mentioned in this ESIA report; hence this report is valid for any combination of options selected. The selection of the FSRA and the mooring infra structure arrangement would depend on the techno-economic viability as determined by the FEED study and safety consideration of LNG suppliers.

4.5 ALTERNATIVE DREDGING TECHNIQUES

The dredging may be accomplished by two ways:

1) Mechanical Dredging

2) Hydraulic Dredging

A detailed geotechnical investigation report shall reveal geological features of the area thus providing a basis for selection of dredging technique. Therefore, the selection of the technique will be decided at the detailed design stage. Table 4.2 presents a comparative analysis of the performance of mechanical and hydraulic dredging alternatives.

4.6 ALTERNATIVES FOR PIPELINE ROUTE

The pipeline will run through mangrove area, creeks, coastal area and along roadways of the Port Qasim and barren area in the Northeast corner of the intersection of the Pakistan Railway Line and National Highway N-5. The possible routes of proposed NG pipeline are shown in Figure 4.8-4.12.

The pipeline from the ETPL LNG Jetty to the existing pipeline trestle of EVTL shall be on pipe supports. The pipeline within EVTL boundary limits shall be on sleepers and shall be approximately 2 kms.

The pipeline from Option 3 (Greenfield), Option 4 (existing EVTL jetty) and Option 5 (ETPL jetty brownfield site) shall not interfere with any mangroves or population centers. It raises minimum social and environmental issues and avoids the laying of pipeline in the sub-sea environment; it additionally is economically more viable than the others.

Table 4.2: Analysis of Mechanical and Hydraulic Dredging Alternatives

Mechanical Dredges	Sedimentation Rate	Material capable of being Dredged	Production Rate	Comments
Grapple Dredge	High	Very Soft Deposits	Low	Not suitable for hard materials
Dragline Dredge	High	Very Soft Deposits	Low	Not suitable for hard materials
Dipper Dredge	High	Hard Compacted Rock	Low	Inefficient use of scows for disposal of materials
Bucket Dredge	High	Clays, gravel and coarse materials	Low	High noise, high fuel consumption due to barges for disposal of dredged material
Backhoe Dredge	Moderate	Clays, gravel and coarse materials	Low	Compact size, can be equipped with turbidity controls
Hydraulic Dredges				
Hopper Dredge	Low	Loose sediments and unconsolidated sand	High	Disposal of dredged material may require dredging operations to be suspended
Cutter head Suction Dredge	Low	All alluvial materials, compacted deposits and rock-like formations	High	Not designed for heavy sea conditions, floating pipeline can deposit dredge spoils in disposal area

Figure 4.8: NG Pipeline – Alternate Route # 1 for Green Field

Figure 4.9: NG Pipeline – Alternate Route # 2 for Green Field

Figure 4.10: NG Pipeline – Alternate Route # 3 for Green Field

Figure 4.11 - RLNG Pipeline routing - Alternate Route # 4 - Existing Jetty

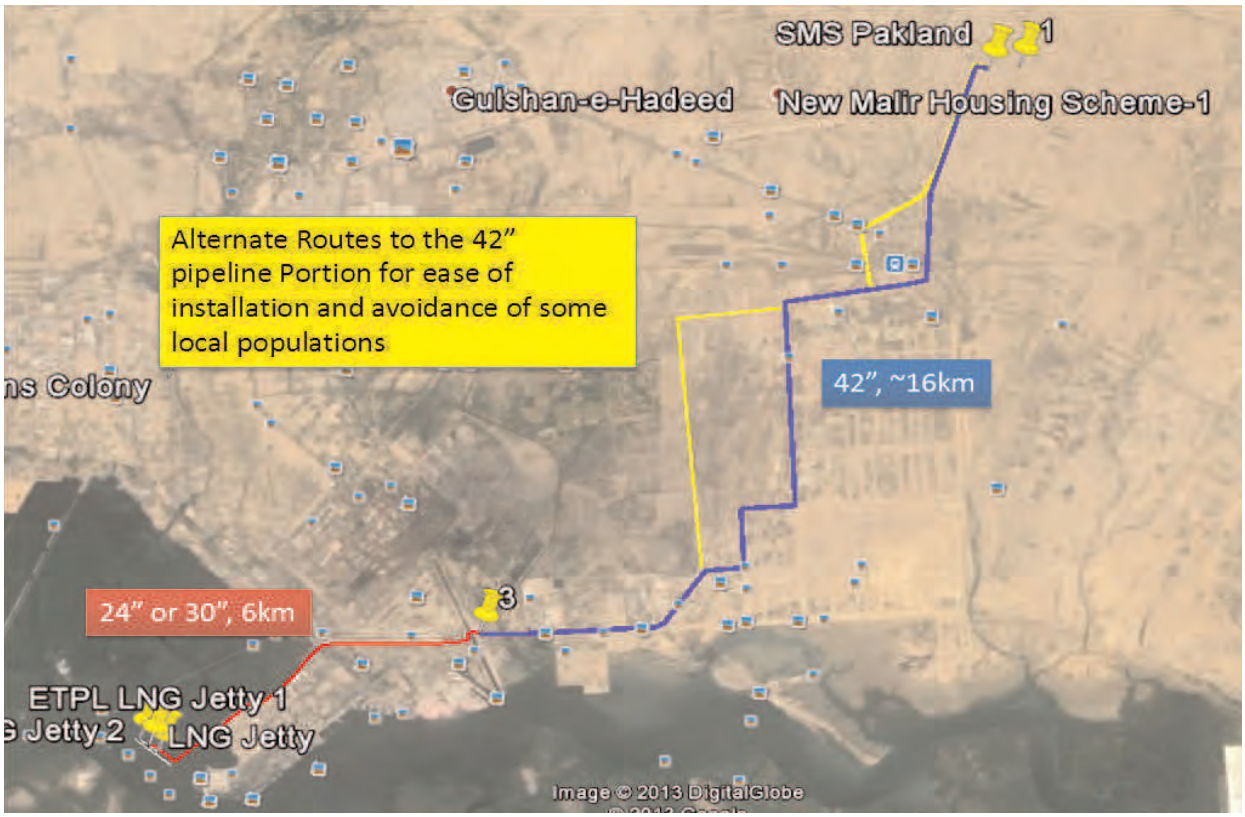


Figure 4.12 - RLNG Pipeline routing - Alternate Route # 5 - Brown Field

05 Description Of Physical & Biological Environment

This section describes the environmental setting of the project area. Baseline data reported here pertain to the physical, biological and socio-economic aspects of the macroenvironment as well as the microenvironment of proposed LNG Import Terminal site. The microenvironment i.e. the project site is a sub-component of the macroenvironment. The macroenvironment of the Project is the Port Qasim navigation channel while its hinterland extends from the Port area northward to the National Highway, and from Ghaggar Phatak on the east to Mehran Highway on the west. The Gharo Creek forms the microenvironment for the brown field site. Figure 5.1 shows macroenvironment of PQ.

Foundation stone of Port Qasim situated at a distance of about 45 km south-east of Karachi was laid on 25th August, 1973 by the then Prime Minister of Pakistan late Mr. Zulfiqar Ali Bhutto. Its inception was connected with the establishment of Pakistan Steel Mills situated in the same vicinity. Primarily, the purpose of this port was to facilitate and accelerate raw material imports of Pakistan Steel Mills. The planners also had in mind to expand the port to handle bulk imports so as to provide a sort of "load-shedding" at the Karachi Port.

This port is situated on the eastern coast of the country which has a mesh of numerous creeks interconnecting coastal area and high sea waters. One of these navigable

Figure 5.1: The Macroenvironment of Port Qasim

5.1 The Macroenvironment:

The main institutions that induced entrepreneurial potential in the macroenvironment of the LNG Import Terminal Project are Port Qasim Authority (PQA) and Pakistan Steel Mills (PSM).

creeks named "Phitti" was chosen to serve as approaching navigational channel to connect the open sea (Arabian Sea) with berthing site of Port Qasim. The channel runs along one of the many natural waterways that make up the historic Indus Delta. The channel was initially dredged in

1978 and is a total of 43.7 km long from Buoys Number 1 and Number 2 to the marginal wharf turning basin. The channel can be considered in three sections, namely:

i. The exposed Outer (Ahsan) Channel between the open sea and Bundal Island;

ii. The more sheltered Inner Channel from Bundal Island to the IOCB;

iii. The 'Reach' from the IOCB to the marginal wharfs.

*The depths currently maintained along the channel are shown in Table 5.1

Table - 5.1: Existing Channel Parameters *(Source: PQA)*

	Dredged Depth (m) (below CD)	Width(m)	Length(km)
Outer channel Buoy No. 1/2 to Bundal Island	14.7*	Varies from 200 to 250	15.1
Inner Channel Bundal Island to the IOCB	13.0	200-250	25.1
Reach Channel (IOCB to QICT-2)	13.0	Varies from 250 to 450	3.0
Turning Basin adjacent IOCB	13.0	600 diameter	-
Turning Basin adjacent QICT-1	12.5	450 diameter	-
Turning Basin adjacent MW 1-4	11.5	450 diameter	-
Turning Basin adjacent LCT	10.0	450 diameter	-
Berthing Basin IOCB	13.0	50 wide	-
Berthing Basin QICT-1	11.5	50 wide	-
Berthing Basin MW 1-4	10.5	50 wide	-
Service Jetty & its approaches	5.0	75 wide	-

The Iron Ore and Coal Berth (IOCB), commonly known as "steel jetty" was the first berthing place which was completed by 1980 to receive the first ship in the last week of September, 1980 carrying iron ore for Pakistan Steel Mills. Simultaneously, four berths were also constructed on the marginal wharves. The number of berths on the marginal wharf was then increased from 4 to 7. In the early days of its operation the port was considered to be meant for handling bulk imports such as wheat, cement, fertilizers, coal, machinery/plants and raw material for Pakistan Steel besides export of rice etc. in bulk. The National Highway which is about 10 kilometers from the main port provides the mean of ready link between port and upcountry destinations.

Till 1980s the frequency of shipping activities remained low at Port Qasim. Port's future operational plan, however, had provision for the establishment of various storage and manufacturing sites in the area. Since early 1990s, the site caught the attention of private sector and investment started in the area this resulted in establishment of some sizeable storage sheds and manufacturing/processing units. This includes three car manufacturing units and a couple of edible oil refineries plus large scale chemical and fertilizer plants are operating in full swing in the Industrial Area of the Port. It was during this period that a number of bulk oil terminals were also established inside the port area. Establishment of these industrial / storage units brought a revolutionary upward trend in the shipping activities at Port Qasim. The berthing and cargo handling facilities at Port Qasim were accordingly modernized.

The Karachi coastline between Korangi creek inlet and Kadiro Creek encompasses coastline of three islands; Bundal Island, Buddo Island and Khiprianwala Island and two large and deep openings towards the sea viz. Phitti Creek Mouth (Approach channel of Port Qasim) and the Kadiro Creek Mouth. The eastern coast has tidal creeks

with mangrove and mudflats which are linked with a network of creeks of Indus Delta. The sea bed at the eastern and south eastern coast is generally smooth and regular as depicted by the bed contours. The land slope is gentle, usually being in the order of 1/500 to 1/1000.

PQA has adopted its Environmental Management Plan in view of the environmental hazards inherent in the handling of liquid cargo including oil and molasses and other hazardous materials. It has been able to avoid what could have been certain eco-disasters. Such facilities and contingency plans are, according to information available, an integral part of the facilities at the oil terminal.

5.1.1 PORT DEVELOPMENT STATUS

All development projects at the port are being undertaken in private sector on BOT basis without costing a penny to PQA. Foreign Direct Investment (FDI) to the tune of US$ 1.22 billion is expected over a period of five years through development projects at the port.

1) LIQUID CARGO TERMINAL (LCT)

Liquid cargo Terminal, with handling capacity of 4 million tonnes per annum, has been developed through joint venture of by M/s Felda, Westbury and Qasim (FWQ). LCT has been formally inaugurated on 14th August 2009.

Figure 5.2: The Liquid Cargo Terminal in Port Qasim

2) 2ND CONTAINER TERMINAL

2nd Container Terminal is being developed by DP World at a cost of US$ 300 million with handling capacity of 1.175 million TEUs per annum. The Terminal is likely to be completed in 2011 recently.

Figure 5.3: The 2nd Container Terminal in Port Qasim

3) GASPORT LNG FLOATING TERMINAL

To meet the energy demands, an LNG Floating Terminal is being developed by M/s GasPort at a with handling capacity of 3 million tonnes per annum. The terminal has yet to commence construction

Figure 5.4: Location of proposed Gasport Terminal

4) GRAIN & FERTILIZER TERMINAL

A specialized Grain & Fertilizer Terminal developed by M/s Fauji Akbar Portia at a cost of US$ 135 million with handling capacity of over 4 million tonnes per annum has

Figure 5.5: Grain and Fertilizer Terminal in Port Qasim

been formally inaugurated by Prime Minister of Pakistan on 26th October 2010. This terminal was created by reclaiming 22 acres of water and has a 300 meter long jetty.

5) COAL, CLINKER & CEMENT TERMINAL

A dedicated Coal, Clinker & Cement Terminal is being undertaken at a cost of US$ 180 million with handling capacity of 8 million tonnes per annum with a storage capacity of 0.9 million tons. An Implementation Agreement has been signed on November 6, 2010 with PIBT (Pakistan International Bulk Terminal). The Terminal would be country's first dedicated dirty bulk cargo handling facility and is expected to become operational within next three years.

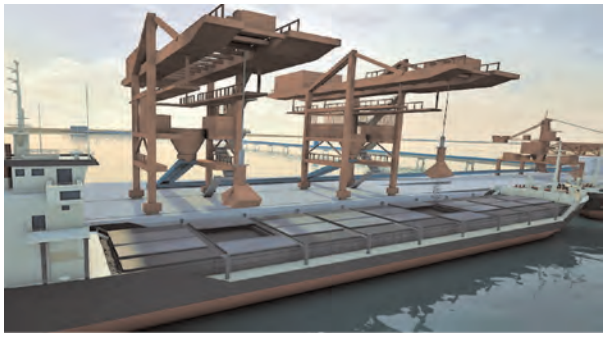


Figure 5.6: Proposed Coal, Clinker and Cement Terminal

6) LNG TERMINAL BY GRANADA

An LNG Terminal was planned to be developed by Granada group of Companies at a cost of US$ 274 million with handling capacity of 3.5 million tonnes per annum.

Figure 5.7: Proposed LNG Terminal by Granada

7) 2ND OIL TERMINAL

To handle increased volume of POL imports, a second Oil Terminal is planned to be developed at a cost of US$ 51.4 million with handling capacity of 9 million tonnes per annum.

Figure 5.8: 2nd Oil Terminal in Port Qasim

The Terminal is expected to be completed by 2012. Technical & Financial proposals are currently being evaluated.

8) 2ND STEEL JETTY

To handle increased volume of Pakistan Steel Mills and to accommodate Al-Tuwairqui Steel Mills imports, a second Iron Ore & Coal berth is planned to be developed at a cost of US$ 150 million with handling capacity of 8 million tonnes per annum. Outsourcing of the terminal is under active consideration. The development of the Terminal will be linked with Pak Steel Expansion program.

Figure 5.9: 2nd Steel Jetty in Port Qasim

9) DEEPENING OF NAVIGATION CHANNEL

The project of Deepening & Widening of navigation Channel is crucial for PQA. PQA plans deepening of navigation channel for all weather 14 meter draught vessels at a cost of US$ 200 million on Design, Construct and Finance basis. The project has Government approval and is in the bidding process.

10) INFRASTRUCTURE DEVELOPMENT PROJECTS

Besides capacity building projects, PQA is equally concerned

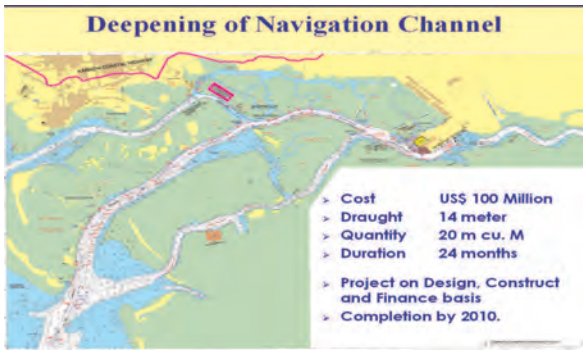


Figure5.10: Project for Deepening of Navigation Channel

for provision of infrastructure facilities in its industrial zones to gear up development of port based industrial and commercial activities, to facilitate the traffic flow PQA plans construction of 26 KM long Dual Carriageway from National Highway T-junction passing through PQA commercial areas (Western Industrial Zone and Eastern Industrial Zone), ending at Sassui Bridge Ghaghar Railway Crossing including up-gradation of Main Access Road and construction of two flyover on BOT basis at the estimated cost of Rs. 6.00 billion.

PQA has also awarded contract for development of Infrastructure facilities i.e. Roads, Water Supply, Sewerage and Drainage in Eastern Industrial Zone to FWO and NLC at the cost of Rs. 8.88 billion and work in progress.


Figure 5.11: Infrastructure Development Projects in PQ

11) ENGRO VOPAK TERMINAL LTD

The terminal has been developed to cater for liquid chemical imports by Engro Chemical Pakistan in collaboration with Vopak of Netherlands, on BOT basis, at a cost US$ 115 million. Operational since January 1998, the terminal can accommodate 75000 DWT class vessels with designed capacity of 4 million tonnes per annum. Engro Vopak Terminal Limited at present has total capacity of 82400 cbm it


Figure 5.12: Engro Vopak Terminal Limited

comprises of 10 mounded bullets, 2 spheres and 9 tanks.

12) TEXTILE CITY

To enhance production and export of value added textile products, GOP plans setting up a "Textile City" on 1250 acres in the Eastern Industrial Zone of PQA. PQA has handed over possession of 1250 acres of land. 5% leveling/Grading work completed - Combined Effluent Treatment Plant-Consultant appointed. Road/water Work to be commenced in June 09. LOI for establishment of 250WM power Plant in June 09. Environment Impact Assessment approved. This would not only facilitate vendors and suppliers of raw material and emergence of downstream and support industries but would also create immense employment opportunities as a result, during construction and operation phases besides earning valuable foreign exchange for the country.


Figure 5.13: Development of Pakistan Textile City Project in Port Qasim

5.1.2 MAJOR INDUSTRIAL AND COMMERCIAL PROJECTS

Some of the major Industrial and Commercial Projects

developed at PQA are:

1) KESC THERMAL POWER PLANT

The plant spread over an area 223 acres of land with 1260 MW power generation capacity has been developed at a cost of Rs.1.4 billion and is operational since 1984.

2) INDUS MOTORS AUTOMOBILE PLANT

Developed through joint venture between Toyota Company of Japan and House Habib is of Pakistan at a cost of US$100 million over an area of 105 acres of land, the plant is operational since 1993.

3) ENGRO POLYMER CHEMICAL LTD

The plant developed over an area of 30 acres of land at a cost of Rs.560 million to produce PVC and is operational since 2002. It has recently expanded its capacity and also produces caustic soda and chlorine

4) PPTA PLANT

Operational since 1998 with designed capacity of 0.43 million tonnes of annual productions, the plant is spread over an area of 150 acres and has been completed at a cost of US$ 500 million.

5) BIN QASIM FERTILIZER PLANT

Developed by Fauji Foundation of Pakistan over an area of 350 acres of land at a cost of US$ 370 million, the plant is operational since 1998.

6) IFFCO PAKISTAN

The refinery is developed over an area of 15 acres at a cost of US$ 34 million, integrated with its bulk oil terminal. It is operational since 1993 and has manufacturing capacity of 0.4 million tonnes per annum.

7) BOC GASES, UK

Established over an area of 10 acres of land, the plant has been developed at a cost of Rs.1.25 billion production hydrogen gas, nitrogen gas etc. The plant is operational since 1998.

8) ENGRO CHEMICALS (NPK PLANT)

The facility has been developed over an area of 30 acres of land at a cost of US$ 81 million to produce fertilizers of various types and has been operational since 1999.

9) MAPAK EDIBLE OIL REFINERY

The refinery has been developed at Port Qasim through joint venture of Malaysia and Pakistan with a refining capacity of around 0.4 million tonnes per annum at a cost of US$ 20 million. The plant was commissioned in 2006.

The Project macroenvironment extends over the administrative district viz. #17 Bin Qasim, Union Councils, UCs: Ibrahim Haidery, Rehri, Gulshan-i-Hadeed and Ghaggar. Geographical area of the macro-environment extends from the Korangi Creek on the west and along UC Ibrahim Haidery, Rehri, Chashma Goth, Korangi Fish Harbour, the deep sea fish harbour and salt works along the coast, Lath Basti, Juma Goth in the north; the FOTCO Jetty and Port Qasim Industrial Area in the northeast; the Steel Mills in the far east, and the large mudflat covered by mangroves forest in addition to the navigation channel of Port Qasim in the south.

5.2 NATURAL ENVIRONMENTAL BASELINE

5.2.1 TOPOGRAPHY

The project area is located in Karachi that is part of a major synclinorium stretching from Ranpathani River in the east to Cape Monze in the west; Mehar and Mol Jabals (mountains) in the north, and the Arabian Sea in the south. The rock units just mentioned have been folded to form anticlinal hills and synclinal valleys, with moderate to gentle dips. The fold axes run approximately north-south.

Structurally the area may be divided into two zones: 1) the zone that lies to the east and northeast and is characterized by relatively more intense folding and faulting, with rocks ranging in age from Paleocene to Oligocene also exposed in this section, 2) the zone that is located in the centre and to the west and southwest and comprises the large area, which opens southwards and largely consists of horizontal or near horizontal strata which form gentle structural undulations in the form of synclines and anticlines with low dips of 2 to 6 degrees (rarely up to 10 degrees). These folds have a general

southward plunge direction. These structural features clearly indicate that the structure of the Gaj basin (Khadeji basin) is more suitable for the accumulation and storage of ground water by virtue of more extensive recharge zones, locations of probable groundwater aquifers at shallower depths and several shallow synclinal structures.

A number of structures such as Pipri, Gulistane Jauhar, Pir Mangho and Cape Monze are exposed within the synclinorium. The presence of concealed structures under the Malir River Valley, Gadap and Mauripur plains can be deduced reasonably. The potentials of rock aggregates, sand, glass sand, lime stone and clay are being gainfully utilized. Gulistane Jauhar members of the Gaj Formation offer ground water potential but the same finds limited use.

Sub-Recent and Recent Deposits

Alluvial Deposits: Alluvial deposits are present mainly in flood basin and streams; they consist of poorly sorted, unconsolidated/loose gravels, sand and slit.

Stream bed Deposits: These deposits consist of material brought down by streams and laid down in their channels comprising loose fine to coarse sand, gravels, pebbles and boulders.

Piedmont and Sub-piedmont Deposits: The sub-recent deposits in the area have been mapped as un-differentiated piedmont and sub-piedmont deposits consisting of loosely packed boulders, cobbles, pebbles and coarse to fine stand.

5.2.2 Climate

The coastal meteorology and hydrography of Karachi is controlled by the seasonal change in the north Arabian Sea viz. monsoon system. The data collected for a number of studies along the Karachi coast show the influence of NE and SW monsoon winds. The meteorological conditions in the area around Port Qasim are characterized by generally hot and relatively humid conditions especially in the summers (April to October) when the prevailing wind is from the south west. The south west monsoon brings humid air in from the sea, but the rainfall is generally very low with nearly 80% of the 265mm of rain falling from July to September. Rainfall, when it does come is often torrential causing problems of drainage and erosion of the light and sparsely vegetated land.

The winters are short and mild from December to mid-February with the prevailing wind coming from the northeast with very little rainfall. The most important characteristics of the prevailing meteorological conditions are the generally high dusty conditions as a result of the aridity of the surrounding area; dust storms occur especially during the summer as well as winter monsoons. The higher winds during the south west monsoon tend to carry any air-borne contaminant inland during the summer months. In winter the winds tend to be light to moderate in intensity.

The LNG Import Terminal Project will be located in the coastal zone that has a relatively mild climate, characterized by dry, hot and humid conditions. There is minor seasonal intervention of a mild winter from mid-December to mid-February into a long hot and humid summer extending from April to mid-September.

Variation of climatic parameters during the past few years is described hereunder:

5.2.2.1 Temperature

The air temperature in the coastal area of Karachi City is generally temperate throughout the year. During winter the range of variation of temperature is large for Karachi coast especially with respect to maximum and minimum temperatures. The air temperature for Karachi has an average annual range of ~6°C to ~42°C. The highest temperatures (40°C or above) occur in May, June and October. During SW monsoon in July and August the temperature is relatively moderate due to cloud cover but humidity remains high (~70%). The mean monthly maximum and minimum temperatures recorded during the last nine years at Karachi Airport Meteorological Station of Pakistan Meteorological Department are given in the Tables 5.2 and 5.3.

The above Tables and Figure 5.14 indicate that the mean monthly maximum temperature in Karachi ranged between 32.0°C and 33.0°C during the 2001-2009 periods, while the mean monthly minimum temperature ranged between 21.0°C

Table 5.2: Mean Monthly Maximum Temperature °C

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2001	27.2	29.6	33.1	34.6	35.1	34.9	32.2	32.3	33.1	36.0	33.5	30.4	32.7
2002	27.0	28.2	33.3	35.4	35.6	35.1	32.2	31.6	31.4	36.5	32.7	28.1	32.3
2003	27.6	28.5	32.4	36.6	35.7	34.9	34.1	32.6	32.5	37.0	32.2	28.3	32.7
2004	26.6	29.9	36.2	35.4	36.8	35.6	33.8	32.7	32.8	33.7	33.1	29.4	33.0
2005	24.9	26.3	31.5	35.3	35.4	36.0	33.2	32.2	34.2	35.2	33.1	28.4	32.1
2006	26.0	31.3	31.8	34.0	34.6	35.3	33.8	31.0	34.2	35.0	33.4	26.3	32.2
2007	26.9	29.4	31.4	37.7	36.0	36.4	N/A	N/A	N/A	N/A	N/A	N/A	33.0
2008	24.4	26.9	34.3	34.4	33.9	35.1	33.5	31.9	34.7	35.5	32.5	27.2	32.0
2009	26.2	29.8	33.0	36.0	36.8	35.7	34.5	33.0	32.8	35.9	33.0	28.6	32.9

Source: Pakistan Meteorological Department

Table 5.3: Mean Monthly Minimum Temperature °C

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2001	11.5	14.9	19.6	23.8	28.1	29.0	27.1	26.5	25.9	24.4	18.6	15.8	22.1
2002	12.8	13.8	19.5	23.9	27.0	28.2	29.6	25.6	24.8	22.5	17.7	14.9	21.7
2003	12.7	16.9	19.8	24.2	26.5	28.2	23.6	27.0	25.3	20.9	15.2	12.0	21.0
2004	12.9	14.5	19.1	24.8	27.3	28.8	27.5	26.3	25.3	22.4	18.0	15.4	21.9
2005	12.3	11.3	20.3	23.0	26.4	28.3	27.2	26.6	26.6	22.9	18.9	13.0	21.4
2006	11.7	18.1	19.6	24.5	27.5	28.5	28.3	26.3	26.8	25.7	19.4	14.0	22.5
2007	13.0	17.3	19.7	24.7	27.6	28.6	N/A	N/A	N/A	N/A	N/A	N/A	21.8
2008	10.1	11.1	19.6	24.0	27.3	29.1	27.9	26.8	26.6	23.8	17.6	14.9	21.6
2009	14.7	16.5	20.8	23.8	27.6	28.7	28.1	27.5	26.5	22.6	17.0	13.9	22.3

Source: Pakistan Meteorological Department

and 22.5°C. The mean maximum and mean minimum temperature during 1991-99 period were 32.2 °C and 20.9°C, which indicates that there has been a slight but significant rise in the mean minimum temperature during the last 20 years.

5.2.2.2 PRECIPITATION

The mean relative humidity in summer is 60-70% while the mean relative humidity during winter is 25-30%. The rain fall in the Karachi coastal zone is extremely low and erratic; accordingly this region falls in the semi arid climatic zone. Table 5.4 shows the last nine years precipitation data recorded at Karachi Airport station.

The 9-years record for rainfall of PMD at Karachi Airport (2001-2009) suggests that July and August are the wettest months and that the maximum rainfall recorded in Karachi during 2001-2009 period was 270.4 mm during the month of July 2003, while the maximum annual rainfall was 324.9 mm

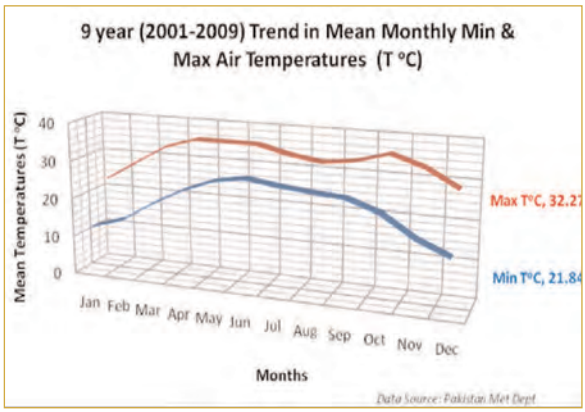


Figure5.14: 9 year trend in Mean Monthly Min & Max Temp

during the year 2003, followed by 301 mm in 2006 and 279.9 mm in 2009. The wet years followed a 3-year cycle during the first 9 years of the New Millennium. The year 2010 seems to be among the wettest years since Karachi City had witnessed more than 5 spells of 50 mm each during the month of July, three major spells of 60 to 100 mm in August and two spells of

Table 5.4: Monthly Amount of Precipitation (mm) at Karachi Air Port

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2001	0.0	0.0	0.0	0.0	0.0	10.6	73.6	16.2	N/A	0.0	0.0	0.0	100.4
2002	0.0	2.4	0.0	0.0	0.0	N/A	N/A	52.2	N/A	0.0	0.5	0.4	55.5
2003	6.4	21.8	0.0	0.0	0.0	16.3	270.4	9.8	N/A	0.0	0.2	0.0	324.9
2004	13.7	0.0	0.0	0.0	0.0	N/A	3.0	5.6	N/A	39.3	0.0	4.3	65.9
2005	6.6	12.8	N/A	0.0	0.0	N/A	N/A	0.3	54.9	0.0	0.0	17.1	91.7
2006	N/A	0.0	N/A	0.0	0.0	0.0	66.2	148.6	21.9	0.0	3.1	61.3	301.1
2007	0.0	13.2	33.4	0.0	0.0	110.2	N/A	N/A	N/A	N/A	N/A	N/A	156.8
2008	8.0	Trace	1.1	0.0	0.0	0.0	54.0	37.5	Trace	0.0	0.0	21.0	121.6
2009	3.0	Trace	0.0	Trace	0.0	2.6	159.9	44.0	68.9	0.0	0.0	1.5	279.9

Source: Pakistan Meteorological Department

25 and 10 mm each in the month of September.

Karachi was facing drought conditions in the past and rainfall was erratic at around 50 mm for three years followed by wet spells every third year. The average of two decades (70s and 80s) shows that rainfall varies between 150 and 250 mm during the years. For Karachi the average number of rainy days / year is less than ten. However, most of the precipitation usually takes place within a short spell of 2 to 7 days. About 50 to 65 percent of the total annual rainfall occurs during July and August while the southwest monsoon is on, another 15 to 25 percent of the annual rainfall occurs during NE monsoon in winter months (December - February). The rest of the rainfall occurs in the form of occasional cloud burst.

5.2.2.3 WIND SPEED AND DIRECTION

The meteorology of Karachi is controlled by the seasonal changes in the north Arabian Sea. In summer, Southwest monsoon prevails with wind force ranging between 3.8 m/s and 14.1 m/s on account of low pressure prevailing over most of Balochistan - Sindh - Punjab region that forms the heat zone. Heavy storms of severe intensity are rare but strong gusts of winds take place abruptly due to changes in atmospheric pressure. The wind blows throughout the year with highest velocities during the summer months (from June to August), when the direction is southwest to west with wind speed exceeding 40 km/hr (22 knots) for about 71% of the time. Inter-monsoon transitions occur from October to November and March to May. The wind direction and speed between the summer and winter monsoon seasons are rather unsettled and large variations are noted both with respect to speed and direction. During winter or the northeast monsoon (from December to March), winds blow from northeast and north, shifting southwest to west in the evening hours, with wind speed exceeding 20 km/hr (11 knots) only for 12% of the time. The strongest winds with

Table 5.5: Wind Speed (m/s) at 12:00 UTS

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2001	2.6	3.4	4.3	5.6	7.5	8.1	6.8	7.3	5.5	3.7	2.0	2.4	4.9
2002	3.6	3.9	4.0	6.5	8.5	8.2	9.8	7.3	7.7	3.3	2.9	3.2	5.7
2003	4.0	5.0	5.4	5.2	7.7	8.8	6.7	7.1	6.0	3.2	3.1	3.0	5.4
2004	3.4	3.7	4.0	6.0	8.0	9.0	10.0	9.5	7.3	3.8	1.0	2.5	5.7
2005	3.6	4.2	4.8	5.1	7.1	7.5	9.0	6.9	6.4	3.9	2.0	1.5	5.2
2006	2.0	3.0	3.0	6.2	8.0	7.7	8.3	6.2	4.7	4.2	2.2	3.0	4.9
2007	2.0	3.7	4.0	4.0	6.0	6.3	N/A	N/A	N/A	N/A	N/A	N/A	4.3
2008	4.3	7.6	8.2	10.5	12.6	7.6	11.0	9.3	8.7	6.6	5.1	3.9	7.9
2009	7.0	7.2	7.9	9.3	9.8	9.7	9.5	9.3	9.1	6.1	5.0	3.9	7.8

Source: Pakistan Meteorological Department

Table 5.6: Wind Direction at 12:00 UTS

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	S54W	S43W	S42W	S45W	S46W	S45W	N52W	S59W	S44W	N56W	S45W	S06W
2002	S67W	S52W	S51W	S55W	S51W	S42W	S54W	S45W	S48W	S56W	N54W	S41W
2003	S60W	N50W	S45W	S48W	S45W	S68W	S60W	S47W	S43W	S54W	S50W	S27W
2004	N27E	S46W	S53W	S49W	S52W	S54W	S54W	S62W	S56W	S47W	S45W	N86E
2005	N63E	S51W	S50W	S52W	S63W	S48W	S54W	S49W	S87W	S54W	S52W	N23W
2006	S48W	S62W	S50W	S57W	S64W	S60W	S67W	S78W	S51W	S53W	S49W	N79E
2007	S30W	S62W	S47W	S55W	S58W	S47W	S41W	S55W	S60W	S48W	S48W	N45E
2008	N45E	S47W	S54W	S51W	S52W	S39W	S50W	S52W	S46W	S39W	S38W	N
2009	N45E	S45W	S41W	S58W	S46W	S46W	S56W	S49W	S56W	S42W	S39W	S45E

Source: Pakistan Meteorological Department

velocities greater than 40 km/hr (22 knots) blow only for 1% of the time. The wind usually carries sand and salt resulting in severe erosion and corrosion.

The nine years wind velocity record (2001-2009) indicates that the velocity varies and ranges between 2.6 m/s to 12.6 m/s. The Tables 5.5 and 5.6 show the wind speed and direction respectively.

5.2.2.4 HUMIDITY

Being on the coastline, the humidity level in Karachi generally remains high throughout the year. Annual range is from 50% (December, driest month) to 85 % (August, most moist month). The Table 5.7 describes typical variation of humidity during the year 2006.

5.2.2.5 VISIBILITY

Visibility depends on weather conditions such as fog, haze, rainfall and dust storms also to a certain extent on the amount of particulate matter present in the ambient urban atmosphere. Visibility in Karachi generally ranges up to 10 nautical miles. Haze generally prevails in the morning, which clears by noon. In SW monsoon period however, the visibility is reduced to about 2 to 5 nautical miles with sky mostly overcast while in NE monsoon sky is clear but the visibility is occasionally less than 1 nautical mile due to dust storms that frequent a large area of Balochistan. The hanging dust takes time but the fog dissipates by afternoon. This occurs less than 3 to 4 days a month in winter.

5.2.3 REGIONAL GEOLOGY & GEOMORPHOLOGY

5.2.3.1 MORPHOLOGY OF THE INDUS RIVER SHELF

In natural conditions, the Indus River had one of the largest sediment loads in the world, building an extensive delta on the high energy coast of the Arabian Sea. However, water and sediment discharge have been drastically altered in the Indus since the early 1960s, when several barrages were built along the river to feed the world's largest irrigations system. A digital terrain model based on detailed 19th century surveys has been constructed to assess the morphology of the Indus shelf.

Table 5.7: Relative Humidity data of Karachi

Month	Relative Humidity (%)	
	AM	PM
January	63	3.6
February	72	6.4
March	79	8.3
April	87	4.9
May	88	0.0
June	86	3.9
July	28	64.4
August	90	44.8
September	89	22.8
October	83	0.3
November	68	1.7
December	64	4.5

Source: Pakistan Meteorological Department

Comparison of the digital terrain to a 1950s Pakistani Bathymetric Survey allowed an estimation of the natural sedimentation regime before extensive human induced changes. Digital analysis of the Indus delta coast line based on satellite imagery was used to explore the effects of the drastic decrease in sediment delivery following extensive dam building.

The Indus canyon is a dominant feature of the region dissecting the shelf to with in 20m water depth and 3.5km of the coast. Theoretical considerations based on estimated of the relative important energy vs fluid sediment delivery suggests that the Indus delta should develop a mid shelf subaqueous clinoform, the Indus shelf exhibits a compound clinoform morphology. A shallow delta front clinoform extends along the entire delta coast from the shoreline to the 10 - 25m water depth. A mid shelf slinoform developed probably as a prodella clinoform between 30 and 90 m water depth. The advanced position of the mid shelf clinoform east of the Indus canyon might reflect either reflect either a prolonged sediment delivery from the Indus River in that area compared to the shelf west of the canyon or the presence of a relict pre Holocene and mid shelf delta. A distinct lobe of the mid shelf clinoform developed along the kutuch (kachchh) coast probably as sediment advected alongshore was redeposited on the mid shelf by strong as sediment advected offshore directed tidal currents in the gulf of Kutch Mouth.

Accumulation and erosion between 1895/96 and 1952/54 occurred primarily on the delta front clinoform, but also on the prodelta clinoform sector covered by both the surveys. During the time period, at the active Indus mouths, the delta front clinoforms has built directly into the Indus Canyon, where sedimentation rates exceeded 50 cm/year. A sediment budget for the shelf for the 1895/96-1952/54 period suggests that the previous estimate of an Indus sediment discharge rate of 250 million tons per year in natural conditions is probably a minimum estimate. For the same interval, the shore line advanced along most of the delta coast. The progradation rate at the active mouths along the central delta coast surpassed 100m/year. Following the 80% reduction in sediment discharge after the 1950s, the deltaic shore line along the central delta coast started to recede at average rates of ~ 50 m/year. The abandoned delta shore (south eastern and north eastern sectors of the delta coast) remained largely progradational over the same period, with the south western sector prograding over the same period, with the south eastern sector prograding at an even greater rate than before. The differential behavior of the delta shoreline suggests a significant role for delta front sediment transfer processes in the evolution of abandoned deltaic coast.

5.2.3.2 GENERAL SITE CONDITIONS

Phitti - Gharo creek system is the largest amongst the group of creeks developed on the western parts of the Indus delta formerly the delta of the Indus river. Phitti Creek is connected to a system of creeks including Jhari, Kadiro, Korangi and Gharo Creeks. Some smaller creeks branch of these major creeks forming a big network of the Indus delta. This network of creeks is a very sensitive ecological area of the delta and has all the characteristics of the deltaic behavior. A chain of small Islands such as Bundal, Buddo, and Khiprianwala are off shoots of Indus Delta formation system and are either sand banks or swamps partially submerged at high tide. Extensive vegetation of mangrove also exists. The islands are mostly flat and swampy.

The main creek is a tidal channel with mangroves and mud flats. The coastal land forms of beaches, sand bars, tidal flats and mangrove swamps are the result of erosion/deposition activities of tidal currents and sea waves. Sand dunes of varying heights along the shoreline are major topographical features displaying typical characteristics of semi desert. Surface soil is dry and loose, which remains subjected to wind erosion and transportation. There is a wide sand bar with shallow depth at the mouth of the creek.

Configuration of the coast line of Phitti - Gharo Creek system and its environs are erratic due to the deltaic formation where sea boundary cannot be defined. Sand formation is brown in color and the grain size ranges from fine to medium. Normally sand thrown by sea waves on the coast are carried inwards, work-up into dunes by wind action. Beach and sea bottom material in the vicinity of Phitti mouth is predominantly composed of Micaceous, very well sorted fine

sand. Acoustic images suggest fine to medium grained homogenous seafloor material, most probably clay/silt and fine sand etc.

Compaction is moderate with shrub growth. Beach deposits vary from very fine soft grey clay sediments to round pebbles. Coastal morphology and the historical data of Indus delta indicate that Buddo, the arch shape island evolved about 50 to 160 years back, has now eroded again. This island acted as a protective sand barrier for Bundal and Khiprianwala Islands but now they are exposed to the high-energy waves and tidal currents especially during SW monsoon. Sediments in suspension in the channel were observed to be variable with respect to NE and SW monsoon intensity.

A general geotechnical survey record indicates that the Port Qasim area is mainly composed of grey sand or friable sand stone, grey to brownish clay inter-bedded with brown, medium to coarse sand and assorted gravels of various sizes poorly cemented to form a mass like conglomerate.

Tectonically, the Indus zone is moderately active. Tidal wave generated due to an earthquake in Karachi (1945) gave a surge of about 4m in the shape of Tsunami. Low rise in tide was due to the coincidence of Tsunami rise with ebb tide. The effects of 2005 Tsunami in the Indian Ocean, which ravaged Indonesia and Sri Lanka, was very low in Port Qasim Area. However, geologically and seismically the area remains prone to these activities.

Within Karachi area, only the middle and upper Tertiary are represented. Nari beds of Oligocene system for the lower most our crops. These are over lain by Miocene Rocks, the Gaj formation of Late Miocene and Lower Mancher of Early Miocene age. The Upper Mancher are included in Pliocene System, which is better developed in Makran.

Quaternary deposits are represented by conglomerates, which uncomfortably overlie the Mancher rocks and slightly over lap on the Gaj formation of comparatively recent origin that is made up of alluvial sand and gravels, windblown material and other shore line deposits.

General sub soil conditions of the Approach Channel are described as homogenous formation of dark grey very fine micaceous sand (75 to 125 microns) exists below the seabed. Relative density is the range of 40% to 65% which may be termined as medium dense state of compactness. Channel along Bundal Island shows a uniform stratum of dark clay silt. Overlaying sand-layers have generally medium dense compactness. The underlying clay stratum appears to be very stiff to hard.

Geological investigations for the Bin Qasim area suggest the presence of only middle and upper tertiary rock formations comprising fresh, and slightly weathered recent and sub-recent shoreline deposits. Principal constituents of the deposits are the inter-bedded sandstone and shale together with subordinate amounts of large sized gravels or conglomerate

The creek area is covered with mudflats supporting mangrove vegetation and does not exhibit much geological and pedagogical diversity. The information, as per geologic survey of Pakistan, reveals that in the project area and in its adjoining areas only the middle and upper tertiary formations are present. The formation found in the area is fresh and slightly weathered, recent and sub recent shore line deposits. These deposits are derived from Gaj/ Manchar formations of lower Miocene to middle Miocene/Upper Miocene to Pliocene age. Similar deposits are found all along the coastal belt of Karachi and adjoining areas. The seabed is predominantly sand and silt while the sediment of the delta is fine grained and resembles the soil from the continental shelf at the mouth of the Indus delta. The gravels or conglomerates are poorly transfixed with medium to coarse brown sand and are derived from Manchar formations of Pleistocene age. The Gaj formation consists of mostly limestone with sub ordinate shales and sand stones. The limestone is hard, sandy and extremely and fossilforus, this formation over lies nari formation which consists of harder lime stones beds and shales, conformably overlying Gaj formation is Manchar formation. Similar Manchar formation exists all along the coastal areas of Karachi and thus exposed in Clifton, Ibrahim Haidery, ghazi, orange and land areas. This formation is composed of sand stone, clay bed, cemented sand and grave (pseudo conglomerate). Sand stone is thick, porous and friable and also contains bands of conglomerate. The clay has various colors including grey, brown chocolate and orange, however the most widely occurring clay are of light brown and

dark grey in color. Sandy layers are also found inter bedded with clay and gravel

The mud flats are recent deposits of delta are while soil cover is the drift type that has been slightly withered with time and marine activity, it seems to have been transferred with the flood flow from malir rivers from the west and Indus from the east.

5.2.4 SEISMICITY

Karachi is situated close to the junction of three tectonic plates (Indo-Pakistan, Arabian and Eurasian Plates). The earth hazard in the Indus Delta and the estuaries of the passive continental margin is mainly from the intra-plate active faults, principally the Rann-of-Kutch Karachi Fault (also known as Karachi-Jati-Allah Bund fault), the Pab-Null Fault and their respective strands. The Rann-of-Kutch Fault passes close to the Eastern industrial Zone of Port Qasim.

Karachi coast has three other segments namely the Jhimpir fault, the Pab fault, and the Surjani fault. These are the intra-plate active faults that pose major earthquake hazard in the Indus delta and the estuaries of the passive continental margin. The orientation of the Rann of Kutch fault is roughly east-west; it is 225 km in length and is responsible for the production of earthquakes of considerably high magnitude of up to 7.6 M on Richter scale and of IX to X intensity on the Modified Mercali (MM) scale. The Pab fault on the other hand is 135 Km in length and is oriented north-south. On the basis of the study of the seismic potential of the active faults viz. Rann of Kutch and Pab faults over their entire length, along with analysis of historical and instrumental records of the Pakistan coastal zone the risk factor for this region is estimated to be 7.7 to 8.2 M for the former and 7.2 to 7.8 M for the later.

The Geological Survey of Pakistan has, however, defined the area of Port Qasim, where the site under study is located, to fall in a Seismic Zone 2B region. This suggests the possibility of moderate to major seismic hazard i.e. probability of earthquakes of intensity VI to VIII MM scale and 5.6 to 6.6 on Richter scale. From the charts published (such as figure 5.15), the peak ground level acceleration (PGA) for this zone is 28%. The seismic risk factor of 0.3 is advisable and will need to be incorporated in the design for constructions and installations in the coastal zone, for operational basis earthquakes (OBE) pertaining to damage due to moderate level earthquakes (MM-VI to VIII). The seismicity in the Karachi and at Project site is considered to be low. According to the published data the Project area lies in zone of low seismic activity, with acceleration ranging from 1.6 to 2.8 m/sec^2. A factor of 2.8 m/sec^2 will, on the other hand, have to be taken for a maximum credible earthquake (MCE). The design of the LNG terminal should take these values into consideration.

The coastal areas of Karachi also cover the Indus Deltaic region and the seismic activity in the Indus Deltaic region is mainly due to active faults. The northern flank of Indus Delta is delimited by an E-W-fault. This tectonic lineament shows signatures of reactivation during Pleistocene and is also well evidenced by frequent seismicity, although of low magnitude.

The most spectacular effect of the active fault of Rann of Kutch which lies close to the Steel Mills was due to the severe earthquake of June, 1891. It resulted in the 6m uplift of 16km vide and 81km long tract of alluvial land which blocked an eastern branch of the Indus River and therefore the locals called it Allah Band (Oldham, 1926). Figure-5.16 represents onshore and offshore historical Earthquakes recorded in Pakistan and its vicinity.

A list of earthquakes with inland epicentres, since 1977 to date which affected the Indus Deltaic Creeks are given in Table-5.8.

5.2.5 TSUNAMIS

Major damages done by Tsunamis, the impulsively generated seawater waves that are a result of underwater earthquakes, have not been recorded for the coastal area south of Karachi. There are, however, evidences of a 1.2 m tsunami generated by an offshore earthquake of intensity 8 M in 1945, which caused only minor damages in Port Qasim area. This event was followed by another Tidal wave that was recorded in 1953. The Tsunami of December 26, 2004 had no impact on the macroenvironment of the Port Qasim area.

Tsunami hazards exist on the contiguous coastline. The > 1-hour delay between the main shock and the arrival of the

damaging tsunami associated with the 1945 earthquake was very probably caused by submarine slumping offshore rather than direct uplift of the coast. If this were indeed the case, even a modest earthquake in the Rann of Cutch region would be sufficient to trigger a submarine slide that would endanger the shoreline of District Thatta, which however is more than 80 km from the Project site. There is therefore no likelihood of Tsunami threat to the site.

Tsunamis in Indo-Pak region are relatively rare. Destructive tsunamis that may have occurred in the Arabian Sea have not been documented. The oldest known tsunamis in North Indian Ocean are:

a. 326 BC

b. 1st April and 9th May 1008

c. 1884

d. 26th June 1941

e. 27th /28th November 1945(origin Makran)

The 1945 Tsunami having a magnitude of 8.3 on Richter Scale was the deadliest. It originated off the Makran coast in Pakistan and was centered at 97.6 kilometers SSW of Pasni, 98.5 kilometers SE of Gwadar, and 408 kilometers W of Karachi. It reached a height of 40 feet in some Makran ports and caused great damage to the entire coastal region. The fishing village of Khudi, some 30 miles west of Karachi, was wiped out completely. All the inhabitants and their huts were washed away. The towns of Pasni and Ormara were badly affected. Both were reportedly under water after the tsunami.

At Karachi, the tsunami arrived from the direction of Clifton and Gizri. It ran along the oil installations at Keamari and flooded a few compounds. The waves were 6.5 feet or 2.0 meter high when they reached Karachi. There was a delay of more than one hour between the main shock and arrival of the damaging tsunami at Karachi.

The sea is 3.36 meter (11ft) below the road level at FOTCO and 2.7 meters (8.8 ft) below the average ground level at Native Jetty in the Manora Channel. This would suggest that a tsunami of magnitude similar to the 1945 Tsunami would affect the 2.5 meter contour on the beach front at Clifton but not the 5 to 9 meter contour from Korangi Creek to Ghaggar nala. A tsunami wave of magnitude higher than 5 meter would nevertheless be a matter of concern to the reclaimed areas along the sea front in the DHA, Korangi- Ibrahim Hyderi-Rehri- Lath Busti and Port Qasim area. Such events are less likely to occur in the north of the Arabian Sea.

Table 5.8: List of Earthquakes in Indus Deltaic region and surroundings within latitude 23.0 - 25.0 °N and longitude 67.5 - 71.0 °E

DATE	LAT. (°N)	LONG. (°E)	DEPTH (km)	MAGNITUDE (RITCHER SCALE)
26-09-1977	25.4	68.2	33	4.5
25-11-1982	25.6	67.9	33	4.9
17-12-1985	24.9	67.4	33	4.9
24-12-1985	24.8	67.6	33	4.7
10-09-1991	24.4	68.7	33	4.8
19-09-1991	24.3	68.7	33	4.7
23-04-1992	24.3	68.8	33	3.7
24-12-1992	25.2	67.7	33	3.6
05-02-1993	24.6	68.9	4.3	4.3
26-01-2001	23.4	70.32	7.6	7.6

Source: Pakistan Meteorological Department

5.2.6 OCEANOGRAPHIC CONDITIONS

5.2.6.1 RECENT TREND IN MONSOON PATTERN

The regular monsoon system was rendered inoperative

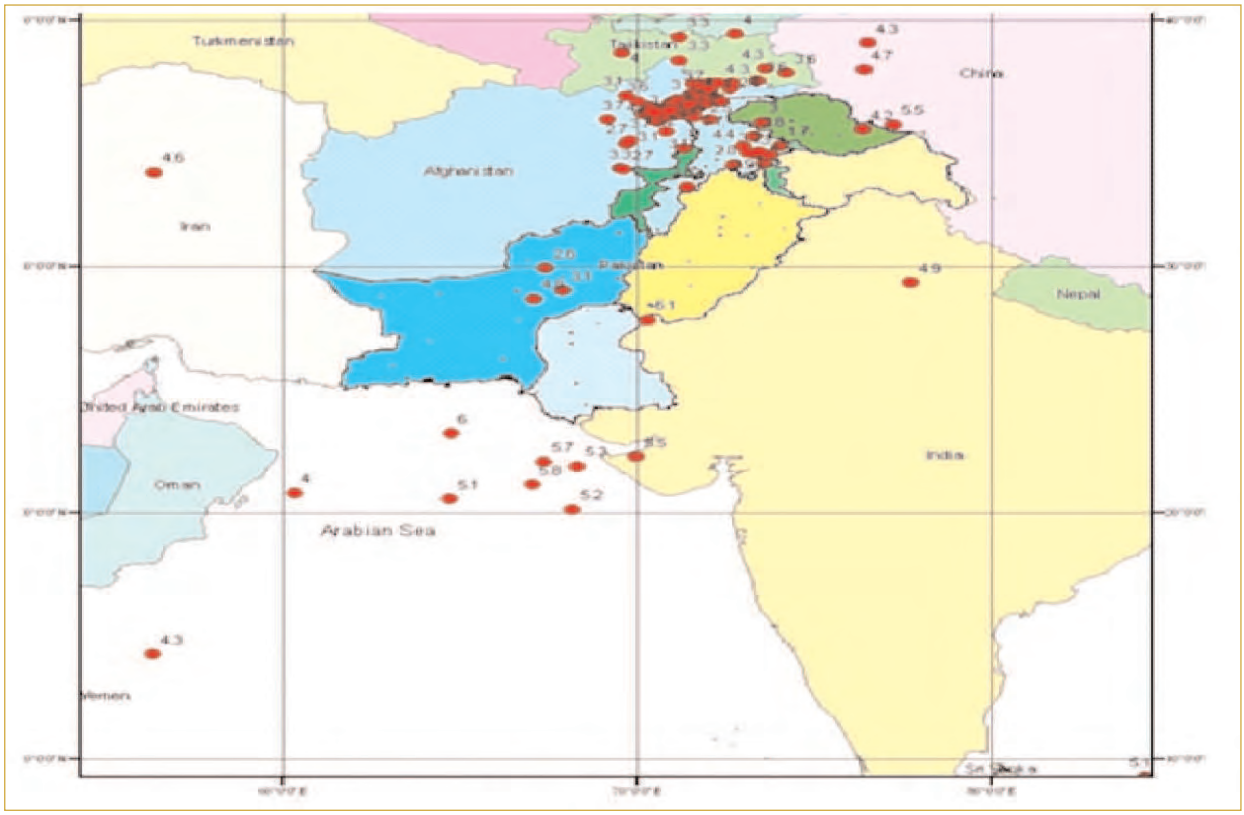


Figure 5.16: Onshore and offshore historical Earthquakes reordered in Pakistan and its vicinity (values are in Richter scale).

by the persistence of the El-Nino and La-Nina effects in the earlier part of the first decade of the New Millennium. The monsoon system in the north of Indian Ocean and in particular between the west and east Arabian Sea has not been active for quite some time but seems to have been activated after the year 2004. It may be recalled that the monsoon system on the western coast of India had become dormant for some seven to eight years and was revived in the year 2005, as suggested in an article in August 18, 2006 and subsequently presented at a Conference on Climate Change. (Climate Change Variations & Vulnerability Coastal Areas of Pakistan to Hazards of Climate Change, Paper presented at Euro-Asian Research and Training Workshop on Climate Change Management, Karachi University, June 30, 2007) For the earlier four to seven years this system was unable to operate because of the persistence of the El-Nino effect.

It may be recalled that the monsoon system on the western coast of India had become dormant for some seven to eight years. For the earlier four to seven years this system was unable to operate because of the persistence of the El-Nino effect. That system seems to have been broken by the powerful Tsunami of December 2004 which was caused by the 1000 km long and 4 km wide rupture under the Indonesian Seas that initiated the propagation of sea waves. The powerful Tsunami waves were traveling at a speed of 700 km/hour and were cause for the disruption of the ocean current system of the Indian Ocean that had been operating under the El-Nino system.

It has been hypothesized (Climate Change Variations & Vulnerability Coastal Areas of Pakistan to Hazards of Climate Change, Paper presented at Euro-Asian Research and Training Workshop on Climate Change Management, Karachi University, June 30, 2007) that the dormancy of the system was broken by the powerful December 26, 2004 Tsunami which was caused by the 1000 km long and 4 km wide rupture under the Indonesian Seas that initiated the propagation of tsunami waves. The powerful Tsunami was traveling at a speed of 700 km/hour and was cause for disruption of the Indian Ocean current system that had been operating under the El-Nino system for almost seven years. The Tsunami seems to have affected the Ekman

effect whereby the slow moving deep layers of the western edge of the Indian Ocean current were forced to move rapidly. This disturbed the salinity of the deep layers of the Indian Ocean and flushed the Arabian Sea besides changing the equilibrium at the boundary layer between the surface layer and deep waters in the eastern boundary current of the Arabian Sea that contributes to the Indian Ocean Current. The disturbance caused by the Tsunami to the underwater movement of the deep layers identified the Arabian Sea as a separate ecosystem that has developed into a highly saline system resulting from high evaporation leading to increase in salinity and higher heat content of the Sea. The increase in salinity was also caused by substantially reduced input of freshwater into the Arabian Sea. Freshwater flow into the Arabian Sea has been reduced from all sides by each country bordering this Sea. None of the rivers in East Africa, Arabian Peninsula, Gulf of Oman, Iran, Balochistan, Sindh, the Tapti at Cutch Peninsula, the Narmada and all the rivers along the Western Ghat of India allows a reasonable flow of freshwater into the Arabian Sea.

All the rivers have been dammed and have thus damned the Arabian Sea by making it hyper-saline. The hyper-salinity and high rate of evaporation are cause for retention of thermal energy and thus for raising the temperature of the Arabian Sea by at least 1°C to 1.5°C and higher near the shoreline. This small but significant rise is not a recent phenomenon but spans over at least half a century during which the Arabian Sea has been under serious stress while all the rivers failed to deliver freshwater into their delta and the sea.

The Tsunami aggravated the stress with its shearing action to restrain the outflow of the Arabian Sea current and containing the stress into the ecosystem just north of the tip of the Indian Peninsula. Time has shown that the Tsunami has had long range impact on the Indian Ocean by identifying the Arabian Sea as a separate ecosystem under high stress of salinity.

It seems that the disturbance caused by the Tsunami of December 2004 system was instrumental in bringing rains though still below average in Sindh in the year 2005. The disruption of the oceanic current system firmed up in the year 2006, suggesting revival of the past system when there would be heavy rains after periods of drought.

The revival of the system seems to be persistent during subsequent years. This is authenticated by the Long Range Forecast for 2007 South-west Monsoon Season Rainfall, by which the Indian Meteorological Department reported that moderate El Nino conditions developed over the equatorial Pacific Ocean during the end of August 2006, but the event was very short lived. The warm sea surface temperature (SST) anomalies over the east equatorial Pacific disappeared during February 2007. By the end of February, SSTs were near average in the vicinity of the date line, and below average over the eastern equatorial Pacific. The equatorial upper-ocean heat content (average temperature departures in the upper 300 m of the ocean) also decreased rapidly. These trends in surface and subsurface ocean temperatures indicate that the warm (El Niño) episode had ended and that conditions were becoming favorable for La Niña to develop.

It seems that the disturbance caused by the December 2004 Tsunami system was instrumental in setting off the 3-year temperature cycle on Karachi coast mentioned above and also initiated rainfall events though still below average in Sindh. This caused serious disturbances in the current pattern in the Arabian Sea leading to major cyclonic events thereafter. The disruption of the oceanic current system firmed up hereafter and thus there was revival of the past system when there would be heavy rains after periods of drought.

Monsoon history of recent and distant past suggests that excessive sunshine results in high input of solar energy over the heat zone on Pakistan that extends from Nokundi-Sibi-Mianwali to Gilgit. Accordingly the temperatures from the third week of April to second week of May all along the heat belt and the plains eastward into India are 45 degrees and above. Historically, these are indications of above normal rainfall in the monsoon season.

May is usually one of the hottest months of the year. Starting from the 1st to 15th May weather would be hot and dry over most parts of Pakistan. Isolated dust storm and thunderstorm occur during the third week, while light rain accompanies the storms over northeast Balochistan, Upper Sindh, Punjab, Upper KP, Northern Areas and Kashmir. Scattered dust storm or thunderstorm with rain occurs in the last week of May over most of the agriculture plains of the country.

The monsoon system that has been bringing rains to Pakistan comprises two system, one that travels over the tip of the Indian Peninsula into the Bay of Bengal in the east and the other that operates from the Gulf of Oman in the west Arabian Sea and travels into Balochistan, the Khyber Pakhtunkhwa (KP) and Kashmir. It is initiated every year by input of solar radiation over the heat zone which covers a vast area from Nokundi-Sibi-Jacobabad-Multan-Mianwali and over to Gilgit. The year 2007 was however witness to 10% above normal total duration of bright sunshine in Pakistan. It ranged for 6 to 9 hrs/day with increasing intensity of radiation ranging from 19 MJ/M² to 23 MJ/M²/day and had an increasing trend from North to South.

The west Arabian Sea system was expected in the year 2007 to cross into Maharashtra by June 09. Gonu had held up the monsoon system and when it faded away, other weather conditions turned favorable, and the powerful South West Monsoon took its annual course from the tip of the Indian Peninsula and over the Western Ghat to the Bay of Bengal and along the slopes of the Himalayas to Kashmir and finally to the plains in Pakistan.

High temperatures, intense rainfall followed in these areas over the few days before the landing of Gonu. A punishing heat wave started sweeping across the country and pushed the mercury to 51 degrees centigrade in at least three cities, making June 09 one of the hottest days of the year.

Lahore sizzled at 48 degrees centigrade, a feat accomplished after 78 years. Islamabad was exceptionally warm at 43.5 degrees centigrade. Karachi fared a little better at 36.5 degrees centigrade, but high humidity (65 per cent), gusty winds and long-drawn spells of load-shedding caused outbreaks of power riots across the city.

Sibi, Mianwali and Larkana bore the brunt of the heat wave where the mercury rose to 51 degrees centigrade, according to the data input by the Pakistan Meteorology Department.

The onset of high heat zone came to an end after India's annual monsoon rains gathered strength on the west coast of India or East Arabian Sea and reached Mumbai in two days after their movement to the western region from the south.

Western System: On the western side of the monsoon belt, the west Arabian Sea had also witnessed major incidents during the 2007 monsoon season. Low pressure had developed high up in the air of the surface in the Gulf of Oman. This was suggested to be part of the South West Monsoon, which was brewing in the second week of May. North and west of this low, the air was hot and dry owing to high pressure up in the air. Such conditions are indicators of formation of a cyclone.

Stray thunderstorms started blowing from the 14th May over the mountains of northwest Pakistan; along the Hindu Kush and the western Himalayas further north. Stray thunderstorms were incident over SW Asia between Iran, Syria and Turkey in the north and the highlands of Yemen and SW Saudi Arabia in the south. Low pressure over the easternmost Mediterranean Sea triggered more stray thunderstorms on the following day. They were accompanied by low rainfall. Faizabad in Afghanistan was inundated on May 16, 2007 by flash floods and heavy rainfall killed more than 24 people and damaged over 530 houses in several districts of the northeastern Afghan province of Badakhshan. Flooding of course inflicted serious agricultural damage and killed dozens of farm animals in the isolated and impoverished province.

5.2.6.2 Cyclones & Storms

High heat content of the Arabian Sea that is adjacent to the extensive heat zone of Pakistan usually upsets the heat

balance and hence the water-balance of the region, particularly because it is the destination of windstorms. Tropical cyclones generally develop over Arabian Sea in low latitude i.e. 5-20 degrees north and dissipate after they move over land. The maximum frequency of tropical cyclone formation occurs in April, May and June and in the October-November period. The month of June receives least tropical cyclones in the region. About 76% of tropical cyclones in Karachi approach from the south through the east.

Tropical cyclones that come near the proximity of Karachi are generally weakened. The one that came near the coastal area on May 12, 1999 changed its direction and hit the coastal area of Badin, however Karachi was safe from this cyclone as it is located in the peripheral area and only rain showers of moderate intensity were recorded.

The cyclone in September 2006 proceeded towards coastal belt of Badin; but it did not hit the area and changed its direction. Although some cyclones have passed near the coastal belt of Badin but still it is classified outside the zone of cyclone activity for the Arabian Sea.

In late May 2007 the heat zone in Pakistan attracted the Tropical Cyclone Gonu, and by Tropical Cyclone 03A from the south of Mumbai, and thereafter by Tropical Cyclone 04B nicknamed Yemyin, and then a series of depressions travelling almost directly to the heat zone in Pakistan.

Soon after the beginning of June 07 the tropical cyclone Gonu visited the Coastal area of Oman for the first time in history and set the beginning of destruction over the coastal area of western Baluchistan. At this time it seemed that cyclone Yemyin was trekking westward south of Sindh and Baluchistan while also weakening, but numerical forecasts were indicating that a huge, strong system was developing high up in the sky diagonally on the path i.e. Arabia and Iran and thereby cutting off the impact and almost restraining the cyclonic system to proceed further from the Indus Delta and proceeding towards Karachi. On the night of July 3, 2007 Sindh especially lower Sindh received widespread rains, but luckily Karachi escaped from a high impact of this system. Scattered rains in Sindh with isolated heavy falls in eastern Sindh occurred.

The June 6, 2010 cyclone 03A, nicknamed Phet had landed on the coast of Oman and had lost its intensity. Moving in clockwise direction it poured heavy rains on Gwadar and Pasni. The rain bearing winds moved along the coastline towards Karachi. It touched Karachi only tangentially and brought 100 mm rainfall two days before it landed south of Thatta District.

The low cloud covers and increased sunshine results in rise in temperature of landmass in the hinterland. Moenjo Daro recorded the world record of 55°C on May 25. Such high temperatures on vast territory has (i) turned large territory of Pakistan into an extensive heat zone, and (ii) raised the temperature of the North Arabian Sea by 1°C to 1.5°C. The heat zone serves as the main heat engine and the significant rise in temperature of the Arabian Sea leading to higher salinity can trigger cyclones in the Arabian Sea just south of Project area besides heavy monsoon rains all over the Indo-Pakistan region.

Such rise in temperature indicates onset of low-pressure zone on land and salinity steep gradient on the sea. The former parameter can attract rain bearing winds in case they are around, while the latter can nucleate cyclones/storms.

Such attraction of moisture laden winds did cause severe storms, the latest on June 6, 2010; June 5, 2007; on August 21, 2007; and on August 17, 2006 and brought sudden heavy rains of as much as 50 to 100 mm in two to three hours. Earlier on 150 mm rain fell in 3 hours in 1967 and caused accumulation of 8 ft water in Shershah. In the 1977 monsoon season the incessant pouring brought 200 mm rains in five hours. The cyclonic event that was incident on June 6, 2010 brought 100 mm rainfall in two hours; on August 10 and 11 of 2007 it brought unusually high rainfall of 107mm in 24 hours as compared with the normal of about 60mm for August.

The wettest August ever experienced by the city of Karachi was in 1979, when over 262mm rainfall was

recorded. The record for maximum rainfall within 24 hours was 166mm of rain on August 7, 1979. The heavy rainfall was thus not unusual particularly because it was caused by the system that travelled from across Rajasthan and lay over Sindh. The monsoon weather system did not move towards Baluchistan but the penetration of moist currents from Sindh brought scattered to heavy rain in southern Baluchistan, particularly along its coastal regions.

The rainfall system that started on July 30, 2006 was a repetition of the 50 year cycle since in 1956 also the recorded rainfall was 400 mm. The regular monsoon system was rendered inoperative by the persistence of the El-Nino and La-Nina effects. That system seems to have been broken by the powerful Tsunami which was caused by the 1000 km long and 4 km wide rupture under the Indonesian Seas that initiated the propagation of sea waves. The powerful Tsunami waves were traveling at a speed of 700 km/hour and were cause for the disruption of the ocean current system of the Indian Ocean that had been operating under the El-Nino system.

It seems that the disturbance caused by the Tsunami of December 2004 system was instrumental in bringing rains though still below average in Sindh. The disruption of the oceanic current system firmed up in the year 2006 and thus there was revival of the past system when there would be heavy rains after periods of drought.

The monsoon activity does not subside until mid September but in 2007 it was more than usual. One of the indicators of its activity is the up welling that comes along. Up welling had intensified during the year 2007 because of the increased input of sunshine over the land area of Pakistan. This has caused serious disturbances in the current pattern in the Arabian Sea leading to major cyclonic events during the year 2007.

The Table 5.9 shows the movement of cyclones and storms in the Arabian Sea. The movement is generally in the west-north-westerly direction. The one that moved into the coastal area on May 12, 1999 changed direction and hit the coastal area of Badin while the coastal area southeast of Karachi was in the periphery and only rain showers of moderate intensity were recorded. This coast is otherwise classified outside the zone of cyclone activity for the Arabian Sea. Thunderstorm frequency is also low and is reported to occur at an average rate of 10 thunderstorms/year.

The pattern seems heading towards a change during the last two years. Coastal area of Pakistan has experienced an increase in the frequency of storms in the southern part of Pakistan especially along Balochistan coast. In the month of June 2007 two tropical cyclonic storms namely Gonu and Yemyin hit the Balochistan coast. Under their influence, rain /thunder showers associated with gusty winds and thunderstorms occurred at isolated places of Makran Coast, while the sea conditions were very rough along the coast of Sindh. The high heat content of the Arabian Sea that is adjacent to the heat zone of Pakistan had disturbed the heat balance and water balance of the region. This induced the windstorm in late May, followed by the Tropical Cyclone Gonu in the first week of June, then by Tropical Cyclone 03A from the south of Mumbai, and thereafter by Tropical Cyclone 04B nicknamed Yemyin.

The June 6, 2010 cyclone 03A, nicknamed Phet had landed on the coast of Oman and had lost its intensity. Moving in clockwise direction it poured heavy rains on Gwadar and Pasni. The rain bearing winds moved along the coastline towards Karachi. It touched Karachi only tangentially and brought 100 mm rainfall in Karachi and 50 mm rainfall in Hyderabad two days before it landed south of Thatta District.

Tropical Cyclones contain heavy bands of clouds and cause heavy rains during landfall or sometimes cross along the coast far away. Heavy rainfall occurs as the end result. The Arabian Sea is known to be frequented by general cyclonic storms and some of these had been among the worst cyclonic storms of the world from their severity point of view, resulting in huge losses to life and property in the coastal areas. A significant number of the cyclonic storms produced in the Arabian Sea move towards north and northeast and some of them land in

Table 5.9: CYCLONES & STORMS DURING LAST 15 YEARS

Sr. No.	Year	Type/ Location of Cyclone	Wind Speed Range (km/h)
1	November 1993	Tropical Cyclone/ Northeast Arabian Sea	62 - 88
2.	June 1996	Cyclonic Storm /East Central Arabian Sea	62 - 88
3.	October 1996	Tropical Storm /Southeast Arabian Sea	62 - 88
4.	June 1998	Cyclonic Storm /Southeast Arabian Sea	62 - 88
5.	October 1998	Cyclonic Storm /East Central Arabian Sea	62 - 88
6.	May 1999	Very Severe Cyclonic Storm /East Central Arabian Sea	> 118
7.	May 2001	Very Severe Cyclonic Storm /East Central Arabian Sea	> 118
8.	September 2001	Cyclonic Storm /East Central Arabian Sea	62 - 88
9.	May 2002	Tropical Cyclone /West Central Arabian Sea	62 - 88
10.	May 2004	Very Severe Cyclonic Storm /Southeast Arabian Sea	> 118
11.	October 2004	Severe Cyclonic Storm /Northeast Arabian Sea	89 - 117
12.	September 2006	Tropical Cyclone /East Central Adjoining Northeast Arabian Sea	62 - 88
13.	02 June 2007	Tropical Cyclone /East Central Arabian Sea	62 - 88
14.	07 June 2007	Very Severe Cyclonic Storm /Northwesterly of East Central Arabian Sea	> 118
15.	21 June 2007	Tropical Cyclone (Deep Depression) /Northeast Arabian Sea	> 50
16	07 June 2010	Tropical Cyclone /Northeast Arabian Sea	> 50

Source: AEDB

Pakistan. However most of these cyclones which tend to move towards southern part of the Pakistan coast very often reciprocate towards eastern coast of India.

Coastal Sindh is more vulnerable than the west coast of Pakistan to storm surges, associated with the severe cyclonic storm generated in the adjoining Arabian Sea. The available data on cyclones and storm reveals that Pakistan is vulnerable mostly during the period from April through June while no storm has ever been observed during January to March (news report).

The main cyclonic activity in the Project Area takes place in the month of June. All the cyclonic storms that emerge in the Arabian Sea either curve sharply into the Gulf of Kutch or cross the Arabian Sea from East to West and end up at the coast of the Arabian Peninsula creating some storm surges at the coast (UNESCAP, 1996). When the cyclones cross the coast they are accompanied by storm surges, generally known as storm tides. The cyclones that cross the coast in the month of June generate winds of approximately 15- 18 m/s.

Tropical cyclones squander between Gulf of Cambay and Karachi. The size of the tropical cyclones is generally 270 -720 Km with an average speed of 7 to 18 Km/hr. Majority of the cyclones land in the vicinity of Indus deltaic creek system creating storm surges of few feet height. In the creek system the tidal range is quite high which is favorable for the amplification of surges. If the peak surge does not occur close to the time of high tide, no major water level oscillations occur in this region.

Beside these, the SW monsoon wind also blows in June and adds about 0.3 m of surge to the current tides. Thus very high tidal level over 4.0 m prevailing in the Port Qasim region inundate the creek banks and erode the coastal areas. Such high tides were experienced in 1986, 1990, 1993 and 1999 when heavy damage was recorded in the coastal areas of Badin and Thatta districts.

Sometime the cyclones cross the deltaic coast itself. Cyclones generally constitute the strong winds having the speed of over 60 Knots and the central pressure as low as 980 mb. The wind and low pressure creates the storm surges which when combined with high tides, becomes a destructive force in the coastal area. Coastal erosion and inundation are commonly associated with storm surges. Beside the cyclones, several depression with less severe intensity frequently occur in the northern Arabian sea, which are also related with surges. These surges which

are about 0.5 m in height, when combined with HHW becomes the potential source of the erosion thus creating high waves in the open sandy coast thereby increasing tide water level favoring tidal inundation.

water level oscillation occurs in this region. In between Dwarka (India) and Karachi there is sparsely populated extensive marshy area known as Rann of Kutch. The frequency of storm in the region is generally low and the tracks are not usually favorable for major surge development.

Table -5.10 Month-Wise Intensity And Location Of Storms In Arabian Sea

Months	Intensity of Storms on an arbitrary scale 0-4	Primary Area of activity
Jan	0-no storm	
Feb	0-no storm	
Mar	0-no storm	
Apr	2	S. Arabian Sea
May	3	S. Arabian Sea
Jun	3	N Arabian Sea
Jul	1	N Arabian Sea
Aug	1	N Arabian Sea
Sep	2	North and Central Arabian Sea
Oct	4-severe	South eastern Arabian Sea
Nov	4-severe	South eastern Arabian Sea
Dec	1	South eastern Arabian Sea

Information source Marine Investigators 1998

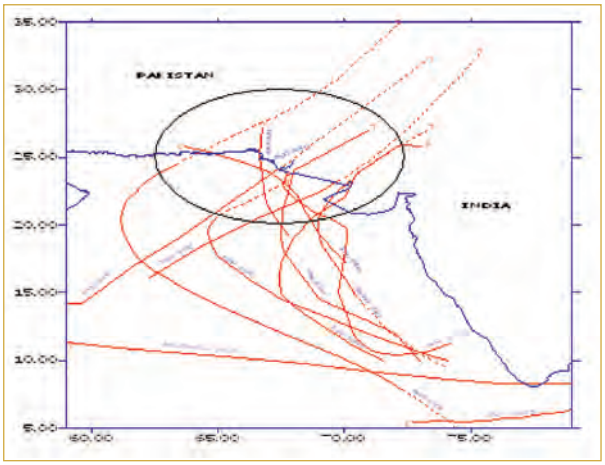


Figure 5.17: Historical Record of Tropical Cyclones within 300nm radius (encircled) of Karachi (Data Obtained from the Archives of National Institute of Oceanography)

According to the studies hitherto carried out, the Sindh coast falls in a dangerous zone. In this belt the frequency of the storm striking the coast is low (for over a 75 year period only four storms struck the coast between 18 and 19o N and only three of these struck between 19 and 20° N). Since the tidal range in this belt is quite high unless peak surge occurs close to the time of high tide no major

Tidal data recorded at Port Qasim as well Karachi Port was obtained and analyzed for the separation of surges on the basis of the recorded values. 1982 was selected for analysis due to the fact that the data for both the parts was available for that particular year. It was observed that maximum surge was never more than 2.0 feet. Analysis of the tidal data on surges for Karachi for the period of fourteen years has been extracted and is recorded in Table 5.11.

The highest surge of 2.6 feet so far recorded at Karachi was due to a storm that crossed the coast 80 Km east of Karachi on May 1920. Although most of the storms resulted in the rise of sea level but the surge height was never critical. Nevertheless, the coastal topography being gentle and flat, even a surge of 2.0 feet during spring tide can create flooding.

Relationship between predicted astronomical tide and the time of occurrence of surge was developed by Quraishee in the year 1974 which is considered as fairly applicable to prediction of surge level. When surge occurs at the rising tide, it builds up whereas during falling tide the

interactive effect reduces its intensity.

5.2.6.3 WAVES

The waves and their height at Karachi Coast vary with the season. During NE winter monsoon the wind speed is around 10 knots and the coastal waters are almost calm and the wave height is less than 1 meter. During SW summer monsoon the winds pick up speed of about 25 knots; the wave height on the Karachi Coast is then in the range of 3 to 4 meters. In the interim months i.e. inter-monsoon period the wave height is around 1.5 to 2.5 meters.

5.2.6.4 TIDES

Tides along Karachi Coast are semidiurnal but diurnal inequality is also present. The effect of this inequality shows up in daily tidal cycle as there are two High Waters and two Low Waters which also vary considerably from each other in tidal heights. These are classified as HHW, LHW, LLW and HLW. The tides move from west to east i.e. the tide at the Hub River estuary arrives about 20 minutes earlier than at Karachi. Similarly the tides at Karachi Harbour arrive at about 10 minutes earlier than at entrance of Port Qasim. When tides progress up the Phitti Creek its magnitude increases and there is a time lag. At Port Bin Qasim which is about 32 km from Karachi and is located about 25 km up the creek from the sea the tides reach after 22 minutes. At Gharo Creek tides fall rapidly due to frictional effects and the gradual weakening of the tidal forces. At Gharo 60 km from the Phitti Creek entrance the tides are almost half of the mean sea tides at the entrance.

Table 5.11 High tides and surges in past

Month	Height of tide (ft)	Height of surges (ft)
Jun58	9.7	1.3
Jul58	8.2	1.3
Oct58	9.6	1.4
Nov58	8.1	0.8
May59	9.9	1.8
Jun59	6.9	1.6
Jun59	9.2	1.5
Jun64	8.6	1.7
Jun70	8.4	2.0

Source: Quraishee G.S et al (1984)

The tides at Port Qasim are predominantly semi-diurnal with a substantial diurnal component. The Mean Higher High Water (MHHW) to Mean Lower Low Water (MLLW) range is about 2.4 m at the port complex while the peak tide over diurnal range is about 3.5m. The tide levels at Port Qasim are presented in Table 5.12. The flow pattern within this large, relatively deep and generally stable creek system around Port Qasim is strongly influenced by tides and the presence of extensive inter-tidal flats.

5.2.6.5 SEAWATER CURRENTS

The speed of sea currents is generally low:~0.5 knots. The speed increases up to 1 knot during SW monsoon. The direction of the sea current is directly related with the prevailing wind system. The set is generally easterly in the SW monsoon and westerly in the NE monsoon. The slight difference in direction in the Western and Eastern part of Karachi Coast is due to circulatory pattern of the current around gyrals which are usually formed at the center of the sea. There is a clockwise gyre during SW monsoon and anti-clockwise gyre during NE monsoon (Quraishee, 1988). Quraishee (1984, 1988) has also observed the existence of warm core eddies in the offshore areas of Pakistan.

5.2.6.6 SEAWATER TEMPERATURE

According to UNESCAP Report (1996) the average annual sea-surface temperature in near shore waters along Karachi Coast Ranges between 20.7°C and 29.3°C as shown in table 5.13. During winter months the temperature range is 20.7°C to 23.8°C whereas during summer months the range is between 27.9°C to 29.3°C. In the creeks along Indus Delta the sea-surface temperature generally ranges between 23.4°C to 29.5°C as shown in table 5.13. Water temperature in tidal channels in the Indus Delta creeks have been reported form 19°C in

January to 30°C in June (Harrison et al. 1994, Zaqoot, 2000). The temperatures at a depth of 100 m are lower and generally have an annual range between 19.5°C to 24.5°C.

5.2.6.7 SEAWATER SALINITY

According to UNEP (1986) the salinity ranges from 3.55 to 3.69 percent in the inshore waters of Karachi and may rise to as high as 4.1 to 4.2 percent in the back water and tidal creeks. The average annual salinity in coastal waters along Karachi and Indus Delta ranges from 3.6 to 3.67 percent (UNEP, 1996). The monthly distributions of salinity along Sindh coast are presented in Table 5.14.

The tidal channels in Indus Deltaic area are generally hyper-saline with salinity range of 3.8 to 4.5 percent over the year except during August and September when due to rainy season the runoff from Indus River reduces the sea water Salinity to 2.6 to 3.0 percent (Harrison et al., 1994). Low salinity values of 2.8 to 3.0 percent were reported by Rabbani and Khan (1988) for Khobar Creek of Indus Delta. Inside Karachi Harbour from Lyari River mouth to the mouth of Manora Channel the Salinity values in the range of 2.5 to 3.4 percent have also been reported (Zaqoot, 2000).

5.2.7 HYDROLOGY AND HYDROGEOLOGY

The Indus Delta represents a major example of negative effects of the progressive reduction in fresh water discharge over a period of many years. Historical records indicate that the distribution of mangroves in the Indus Delta has significantly changed during the past several hundred years with the shifting pattern of the river (Snedaker, 1984).

Table 5.12: Tidal Levels at Port Qasim

Location	MLLW	MHLW	MLHW	MHHW	HAT	LAT
Bundal Island	+0.6	+1.2	+2.3	+2.9	NA	NA
Hasan Point	+0.6	+1.3	+2.8	+2.9	+3.4	+0.6
Port Qasim	01.0	+1.4	+2.1	+3.4	+4.00	-0.6

Until recently the Indus River had a largely river dominated estuary but increased utilization of the river for agriculture etc. has resulted in discharge to the Arabian Sea only during the summer southwest monsoon. During remaining nine to ten months the Indus River has no estuary due to elimination of the river discharge (Geology of the Indus Delta, AH Kazmi, in Marine Geology & Oceanography of Arabian Sea and Coastal Pakistan, ed. BU Haq, JD Milliman, Van Nostrand Reinhold Company, New York 1984, Sediment Discharge from River Indus to The Ocean, Past, Present & Future, JD Milliman,GS Quraishi and Mirza Arshad Ali Beg). As a result, the mangrove ecosystem has been adversely affected. Some decades ago the area of mangrove cover in the active Indus Delta was estimated at about 250,000ha (Khan, 1966, Mirza et al, 1973, SC Snedaker, Mangroves: A Summary of Knowledge with emphasis on Pakistan, in Marine Geology & Oceanography of Arabian Sea and Coastal Pakistan, ed. BU Haq, JD Milliman, Van Nostrand Reinhold Company, New York 1984).

The mangroves are degrading rapidly caused by a number of factors such as cutting, browsing and by

Table 5.13 Monthly distribution of temperature in °Calong the Pakistan Coast (UNESCAP, 1996)

	Jan	Temp.	Feb	Temp.	Mar	Temp.	Apr	Temp.	May	Temp.	Jun	Temp.
Indus delta	19.2	23.6	20.2	23.8	24.3	24.9	29.0	27.0	29.5	27.9	30.0	29.5
Karachi	19.2	23.5	20.5	23.8	24.0	24.8	27.0	26.5	29.0	27.9	30.0	29.3
Gawadar	18.3	20.2	19.5	20.2	22.3	22.0	27.5	24.2	30.1	26.5	31.2	28.3
	Jul	Temp.	Aug	Temp.	Sep	Temp.	Oct	Temp.	Nov	Temp.	Dec	Temp.
	Air	Sea	Air	Sea	Air	Sea	Air	Sea	Air	Sea	Air	Sea
Indus delta	29.5	28.7	28.0	28.5	26.5	27.0	27.0	27.8	23.5	26.5	19.5	23.4
Karachi	29.3	28.0	28.0	28.0	28.5	27.3	27.2	27.0	27.5	24.4	27.0	20.7
Gawadar	29.2	27.3	28.5	28.0	29.4	28.3	27.0	28.0	23.1	25.3	20.1	23.2

Table 5.14: Monthly distribution of salinity along the Pakistan Coast (UNESCAP, 1996)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Indus delta	36.1	36.15	36.5	36.4	36.6	36.6	36.7	36.61	36.48	36.47	36.5	36.2
Karachi	36.0	36.2	36.5	36.5	36.5	36.6	36.7	36.6	36.5	36.5	36.5	36.2
Gawadar	36.05	36.26	36.53	36.55	36.58	36.65	36.74	36.68	36.55	36.55	26.54	26.3

Table 5.15: Sea Temp, Salinity and Density of Creeks

Locations	Sea water Temp	SalinityPpt	Density kg/m3
Gizri Ck (top end)	21	33.95	1.025
Gizri Ck (DHA club)	20	33.4	1.025
Korangi Ck (Rehri)	22	37.8	1.028
Korangi Ck (Lath Basti)	23	36	1.027
PSO Oil Jetty	25	37	1.028
Phitti Creek	22.7	38.78	1.029
Jhari Creek	23	39.2	1.03
Chara Creek	23	38.41	1.03
Gharo Creek	24	38.44	1.029

reduced silt laden river water. (Mirza Arshad Ali Beg, Environmental Impact Assessment of Reduced Flow Downstream Kotri and (2) Environmental Impact Assessment of Groundwater Extraction in Riverine Areas in Sindh), part of studies carried out for the Govt. of Sindh (1993), and Mirza Arshad Ali Beg, Ecological Imbalances in the coastal areas of Pakistan and Karachi harbour, Pakistan Journal of Marine Sciences, 4(2), 159-74, 1995) These forests which covered 263,000ha in 1977 have recessed to about 160,000ha in 1990 (Kela, 1999, IUCN, 2005).This is probably the most serious problem focusing mangroves of Indus Delta, therefore the salinity value of 40 ppt or more is common in mangrove areas. Although there exist no previous records of salinity values in the area for past some decades, but it was appreciably lower since rice was once cultivated in Keti Bunder in the vicinity of mangrove stands (Saifullah, 1982). Due to hyper salinity and nutrient impoverishment decline in mangrove is now visible everywhere.

Early dense and extensive forest has changed to stunted growth of trees and reduction in forest area. Dams and diversionary barrages also affect bed-load and suspended transport of sediments by capturing this material and preventing its uniform dispersal over mangrove areas during flood season. Thus the mangroves are deprived of an annual silting (and input of inorganic nutrients) and the depositional character of the mangrove environment is severely altered.

Further, in the absence of flushing, distributary rivers in delta regions become silted and cease to function. The filling and death of distributary rivers has occurred and is taking place in such major river deltas as the Ganges and Indus. When dams and barrages are constructed the

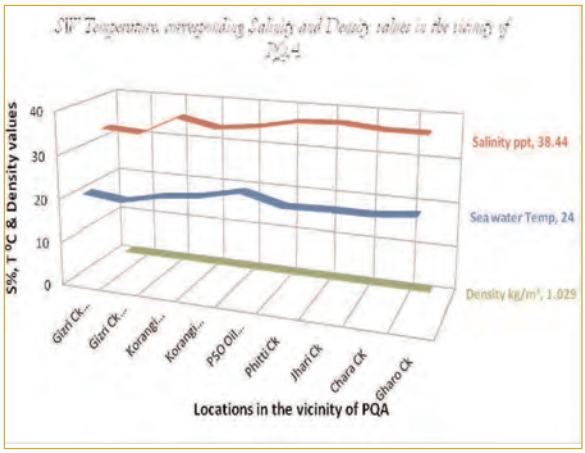


Figure 5.18: Mean concentration seawater surface temperature, salinity and density values in PQA.

mangroves below the dam are subject to a variety of stress conditions which leads to shifts in species dominance, reduced structural complexity and lowered productivity which is quite evident in mangroves of Indus Delta including Port Qasim area in the vicinity of Karachi [Mirza Arshad Ali Beg, Ecological Imbalances in the coastal areas of Pakistan and Karachi harbour, Pakistan Journal of

Marine Sciences, 4(2), 159-74, 1995].

5.2.7.1 SURFACE AND GROUND WATER QUALITY IN COASTAL AREA OF KARACHI

There is no inland surface water body in project area except the mudflat lying between the 9 meter contour and the coastline of Arabian Sea. There are quite a few springs including the Chashma at Chashma goth and some along the coastal road that runs along the base of the 5-9 meter contour that is conspicuous in the region.

The major industrial complexes including Korangi Industrial area (KIA), Landhi Industrial Trading Estate (LITE), Port Qasim Industrial Area and Pakistan Steel Mill are located in the proximity of the creeks adjoining Port Qasim. The KIA is located adjacent to Korangi- Kadiro creeks, LITE is situated close to the Kadiro-Gharo creeks and Steel Mill is located on the Gharo creek. The creeks adjacent to the mudflats are recipient of at least 25% of the total pollution load of Karachi through Malir River and about 15% that is directly discharged into the adjacent open sea coast or to the Gizri, Korangi and Gharo creeks.

Coastal villages such as Ibrahim Haidery, Rehri, Lath Basti are part of the macroenvironment that includes Korangi creek, Phitti creek, Kadiro creek and Gharo creek system which form an inter-related system of creeks receiving bulk of the domestic and industrial wastes generated in the southeast of Karachi.

The complex creek system southeast of Karachi is part of the Indus Delta. The Delta presents a major case study of adverse impact of the progressive reduction in fresh water discharge over a period of time. Whereas construction of dams and barrages has reduced the flow of freshwater into the Arabian Sea, the Indus Basin irrigation system per se has outlived its age. This is the conclusion of an extensive survey for the Ecosystem Research on Water Resource Management in Sindh West (Mirza Arshad Ali Beg, Yasmin Nergis, and Mughal Shareef, HEC Project 1196, 2008-2010) that supports the following hypotheses in quantitative terms:

- Industries, industrial estates, irrigation and municipalities as well as tourism activities have over-exploited the groundwater sources to the extent that critical limits of the hydrological potential of the region have been reached. Consequently the Indus delta as well as areas inland from the sea is at risk to seawater intrusion and of seismic events in the coastal areas.
- Diversion of Indus River water into irrigation canals and channels has depleted the Indus Delta of freshwater and induced seawater intrusion into extensive areas inland, besides waterlogging and salinizing the land in the terminal zones of the irrigation system in the coastal areas of District Thatta in Sindh West.
- The creek channels are no longer hyper-saline as is being maintained by several reports by concerned agencies. Contrarily the creek channels are hypo-saline for as long as the irrigation system is supplying the water to adjacent land.

The findings of the Surveys suggest that while the Indus delta has been deprived of the 8.2 MAF water flow thus virtually drying it up of the freshwater, the ecosystems adjacent to the canal command area have been salinized and water logged. This has resulted in dilution of the creek water with the seepage from waterlogged land areas and discharge from drainage canals to the extent that their salinity is no longer 40-43ppt, as is being reported, but has come down to 27ppt during the kharif season and after the rains.

The creeks are hyposaline with salinity in the 27 to 29 ppt range, the dilution having been effected by the seepage which has, according to the estimates exceeded the normal 10% and is rated at 15 to 25% as a result of cultivation of the water intensive rice crop that by the traditional system also requires puddling the fields, which is in line with the hypotheses proposed earlier [Mirza Arshad Ali Beg, Ecological Imbalances in the coastal areas of Pakistan and Karachi harbour, Pakistan Journal of Marine Sciences, 4(2), 159-74, 1995]. The observation with respect to water logging and salinization supports the hypothesis that the Barrage system of making water available at farm gates has outlived its age and is doing more harm than good to sustainable development

through its distribution system.

Reduced water flow downstream Kotri has also resulted in land erosion and land submergence; the seawater current pattern has apparently assumed adequate potential energy to erode the surfaces of the land over the creeks and this is the reason that many of the islands between Mirpur Sakro and Keti Bunder have lost their identity, Lakha Island in Boharo being an example.

Chemical and bacteriological analyses of surface water, groundwater, seawater, and wastewater support the conclusions that:

1) Aater still flowing during the period when there is no discharge downstream Kotri Barrage, is contaminated with seawater that intrudes inland up to Kotri during the high tides in particular during the middle of the Lunar months and around the time of solar and Lunar eclipse.

2) Fresh water being supplied to Karachi marginally meets the drinking water quality standards, while treatment of wastewater remains unattended.

3) Extensive mining of groundwater has dried up the aquifer and it is barely recharged once in three years.

4) Extensive excavation of sand and gravel from the riverine

Table 5.16: Summary of Water Analysis

Sr. #	Parameters/Analytes Descriptions	Results						
		Unit	1	2	3	4	5	6
1	Collection Time	Hr: mn	0550	0600	0649	0700	0910	0920
2	Sample Collection date	d.m.y	03.03.10	03.03.10	03.03.10	03.03.10	06.03.10	06.03.10
3	Temperature	°C	25.9	27.1	23.5	26.2	29.0	26.5
4	pH Value	SU	7.68	8.38	7.47	8.32	7.11	7.24
5	Color	App.	Susp	Susp	Muddy	Susp	Susp	Clear
6	Total Dissolve Solids (TDS)	mg/L	30010	42900	40000	43280	1932	1549
7	Conductivity	µs/cm	61200	68400	60000	67700	4040	3110
8	Dissolve Oxygen (DO)	mg/L	4.04	2.01	3.39	4.02	5.13	5.69
9	Chloride (Cl-1)	mg/L	14400	2281	21701	23230	770	630
10	Bicarbonate (HCO_3)	mg/L	2401	22470	2108	2230	330	260
11	Sulfate (SO_4)	mg/L	1901	970	940	1020	210	120
12	Nitrate (NO_3)	mg/L	31.8	18.8	13.2	9.8	8.7	4.8
13	Carbonate (CO_3)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL
14	Calcium (Ca)	mg/L	830	1203	1170	1302	225	135
15	Magnesium (Mg)	mg/L	520	876	850	990	170	105
16	Sodium (Na)	mg/L	9900	14421	13190	14330	487	220
17	Potassium (K)	mg/L	231	259	312	270	113	27
18	5-Days BOD	mg/L	BDL	237	468	BDL	BDL	218
19	Chemical Oxygen Demand (COD)	mg/L	BDL	304	559	BDL	BDL	426
20	Mercury (Hg)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL
21	Lead (Pb)	mg/L	BDL	1.398	BDL	BDL	BDL	BDL
22	Cadmium (Cd)	mg/L	BDL	0.876	BDL	BDL	BDL	BDL
23	Arsenic (As)	mg/L	BDL	BDL	BDL	BDL	0.0418	BDL
24	Nickel (Ni)	mg/L	BDL	1.174	BDL	BDL	0.0621	0.2617
25	Zinc (Zn)	mg/L	BDL	8.984	3.289	BDL	0.5118	1.9146
26	Total Plate Count @37°C	Cfu	110	TNTC	TNTC	TNTC	TNTC	TNTC
27	Total Coliforms @42°C	Cfu	70	TNTC	TNTC	TNTC	TNTC	TNTC
28	Escherichia Coli @37°C	cfu	+ ve	+ ve	+ ve	+ ve	+ ve	+ ve
29	Sodium Absorption Ratio (SAR)	:	66.09	76.84	71.31	72.53	5.94	3.44

1 -Sea Water (Pakistan Steel Mill-Channel). 2-Pakistan Steel Mill Sewage Effluent. 3-Sea Water Creek Ziarat Hasan Shah. 4-Sea Water/Stagnant way to Ziarat Hasan Shah. 5- Spring Water Baba Juman Shah. 6-Spring Water Drain to Dhabji.

Table 5.17: Summary of Water Analysis

Sr. #	Parameters/Analytes Descriptions	Results						
		Unit	7	8	9	10	11	12
1	Collection Time	Hr: mn	1240	0104	0110	0150	0230	0240
2	Sample Collection date	d.m.y	03.03.10	03.03.10	03.03.10	03.03.10	03.03.10	3.03.10
3	Temperature	°C	26.5	26.6	26.6	28.6	29	28.9
4	pH Value	SU	7.44	8.45	8.17	7.58	7.28	7.06
5	Color	App.	susp	clear	clear	susp	clear	clear
6	Total Dissolve Solids (TDS)	mg/L	38700	228	232	38700	2410	1418
7	Conductivity	µs/cm	61500	496	496	64000	4990	2990
8	Dissolve Oxygen (DO)	mg/L	4.02	5.08	5.10	3.97	4.07	4.96
9	Chloride (Cl-1)	mg/L	20810	58	59	20808	970	528
10	Bicarbonate (HCO_3)	mg/L	1940	70	72	1920	415	270
11	Sulfate (SO_4)	mg/L	920	34	34	930	212	92
12	Nitrate (NO_3)	mg/L	17.6	3.28	1.19	4.26	3.28	7.8
13	Carbonate (CO_3)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL
14	Calcium (Ca)	mg/L	1210	19	20	1220	312	120
15	Magnesium (Mg)	mg/L	965	11	12.0	970	230	115
16	Sodium (Na)	mg/L	12790	34	34	12770	330	195
17	Potassium (K)	mg/L	191	2.9	2.9	189	29.0	43.0
18	5-Days BOD	mg/L	37	BDL	BDL	BDL	BDL	BDL
19	Chemical Oxygen Demand (COD)	mg/L	57	BDL	BDL	BDL	BDL	BDL
20	Mercury (Hg)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL
21	Lead (Pb)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL
22	Cadmium (Cd)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL
23	Arsenic (As)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL
24	Nickel (Ni)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL
25	Zinc (Zn)	mg/L	BDL	BDL	BDL	BDL	BDL	0.0268
26	Total Plate Count @37°C	Cfu	TNTC	210	140	TNTC	TNTC	TNTC
27	Total Coliforms @42°C	Cfu	TNTC	- ve	TNTC	TNTC	TNTC	TNTC
28	Escherichia Coli @37°C	cfu	+ ve	+ ve	+ ve	+ ve	+ ve	+ ve
29	Sodium Absorption Ratio (SAR)	:	66.25	1.53	1.48	65.93	3.44	3.04

7-Sea water Lath Basti. 8-KDA Water Lath Basti #1. 9-KDA Line Water Lath Basti. 10-Sea Water Lath Basti. 11-Boring Water Cattle Farm. 12-Boring Water Cattle Farm 200ft.

areas has dried up the aquifer and flash floods are taking their toll, while excavation of sand from the coastal area has destabilized the coastline at several places.

The Malir River drains into the Korangi Creek/Ghizri Creek. Korangi Creek forms part of the Indus Delta that harbors the fifth largest single arid region mangrove forest in the world. Physico-chemical characteristics of water from different sources including seawater, groundwater, industrial wastewater, spring overflow in the macroenvironment of PQA are summarized in Table 5.16 & 5.17.

Sea water samples collected from Steel Mills intake and outfall channels, and from Ziarat Hasan Shah had lower SAR ~66 76 but TDS varying from 30,000 to 43,280 at 26 and 27°C, pH 7.44 and 8.4, and DO ~4.0 showing dilution with wastewater discharges and concentration due to evaporation on the outside of the creek. Seawater at the Ziarat Hasan Shah beach had SAR 71.3, TDS 40,000, DO 3.39 and pH 7.47 at 23.5°C. The samples from spring and the nala receiving the overflow from the spring show characteristics of groundwater having higher proportions of sodium and chloride ions.

Sea water samples collected from Lath Basti had lower SAR ~65 but TDS ~38700 at 26 and 28°C, pH 7.44 and 7.58, and

DO ~4.0 showing dilution with wastewater discharges from the surrounding. The samples from boreholes show characteristics of groundwater having higher proportions of sodium and chloride ions. The water supply samples with SAR above 1.2 show characteristics of fresh water contamination with groundwater.

Wastewater samples collected from Korangi Industrial Area which is the outfall region of Malir River, had SAR values ranging from 2.79 to 5.56; TDS ranging from 1228 to 4310; low DO 0.39 to 0.62 and the high BOD and COD values in the samples; they are characterized as industrial wastewater mixed with sewage. The sewage is in higher proportion upstream while industrial effluent is dominant as the river enters its delta area. Seawater intrusion was noted at Malir River/Korangi Industrial Area during high tide. It was noted that the sample collected from here had SAR 57.68, TDS 22300, DO 0.82 and quite high BOD and COD, and is characterized as seawater contaminated with sewage and industrial effluent.

The water quality results of the samples collected from the Gharo Creek in the vicinity of proposed site during the current ESIA study are presented in Table 5.18.

5.2.7.2 NUTRIENT CONCENTRATION

Table 5.18: Water Quality in the Project Area

S. #	Parameters	Sea Water Sample # 1	Sea Water Sample # 2
1	Temperature	28.5	29.2
2	pH	7.41	7.19
3	Biological Oxygen Demand (BOD5) (mg/L)	19	15
4	Chemical Oxygen Demand (COD) (mg/L)	1080	1070
5	Total Suspended Solids (TSS) (mg/L)	50	47
6	Total Dissolved Solids (TDS) (mg/L)	25700	24600
7	Oil & Grease (mg/L)	< 1	< 1
8	Phenolic Compounds (as Phenols) (mg/L)	ND	ND
9	Chloride (mg/L)	21000	21400
10	Fluoride (mg/L)	1.7	2.7
11	Cyanide (mg/L)	ND	ND
12	An-ionic detergents (as MBAS) (mg/L)	0.045	0.051
13	Sulphate (mg/L)	4500	4250
14	Sulphide (mg/L)	ND	ND
15	Ammonia (mg/L)	0.15	0.15
16	Salinity (mg/L)	27500	27200
17	Cadmium (mg/L)	ND	ND
18	Chromium (mg/L)	0.0470	0.0228
19	Copper	0.1491	0.1154
20	Lead	0.2361	ND
21	Mercury	ND	ND
22	Selenium	0.1064	0.0482
23	Nickel	0.0476	0.0360
24	Silver	0.0132	0.0073
25	Zinc	0.1493	0.6961
26	Arsenic	0.0983	0.0801
27	Barium	0.3851	0.1797
28	Iron	16.2857	7.3580
29	Manganese	0.3180	0.1527
30	Boron	3.2194	2.9542
31	Chlorine	0.03	0.04

The nutrients including Phosphate, Nitrate, Nitrite and Ammonia play vital role in the food chain of marine ecosystem in primary production of coastal and oceanic waters. They support the growth of phytoplankton which serve as the food for zooplankton as well as larval stages and juveniles of fish and crustaceans and also serve as food for filter feeders.

As may be seen from Table 5.19 the average nutrient concentration (NIO archives) generally increases from Keamari coast towards Gizri creek, suggesting that the coastal waters opposite DHA beaches are very productive which is also influenced by Gizri creek and Korangi creek waters harboring mangrove forest which itself is one of the highly productive marine ecosystems. Nutrients in the Gharo creek do not appear to be limiting to primary productivity in the channels. If there is any limitation, it is due to turbidity and thus to a highly restricted protic zone.

The Karachi Harbour, Gizri creek, Gharo creek and Korangi creek receive large quantities of nutrients as part of the sewage effluent and garbage that is disposed of in these creeks. Higher concentrations of nutrients result in overproduction and exhaustion of dissolved oxygen in the seawater. This leads to anoxic conditions and eutrophication. Anoxic conditions prevail in about 40percent of the bottom areas of Karachi Harbour and about 60 percent of the Gizri creek areas (Rizvi et al. 1999). Eutrophication is conspicuous in the middle and lower parts of Gizri creek.

The nutrient distribution in Karachi Harbour area is presented in Table 5.20. These data show that nutrient enrichment particularly of inorganic phosphate is dominant over the entire harbour area which receives a mix of sewage and industrial discharges. The nutrients enrich the surface and near bottom layers of sea water and their excess is cause for eutrophication in coastal areas.

5.2.7.3 PHYSICO-CHEMICAL CONDITIONS OF CREEKS IN MACROENVIRONMENT

General physico-chemical characteristics of various localities in the macroenvironment of PQA are summarized in Table 5.21 and Figure 5.19.

Temperature of sea water was found in the 22-25°C range during winter and 28 to 29°C during summer (SW monsoon). The pH values ranged from 7.43 to 7.83 in the area opposite Lat Basti and Ibrahim Haideri. The density of sea water was found generally in the range of 1.027 to 1.03 and the salinity ranged from 36 to 39% however the tidal channels are hyper saline and the salinity value is much higher in the creek system.

Almost similar conditions were also observed in Gizri Creek and Korangi Creek during northeast and Southwest monsoon surveys conducted during 2007 (Kidwai, Personal Communication). They also found the temperature at sub-surface depths in these creeks in the range of 19.38 to 29.08°C, Salinity in the range of 3.6 to 3.89% and dissolved oxygen in the range of 0.15 to 5.76ml/l.

5.2.7.4 SUSPENDED MATTER

The suspended matter in the creek areas has an annual range of 25-170 ppm. The higher values were observed during the southwest monsoon period (usually May-August). The average suspended load during June-July was between 80-115 ppm. However, higher values (115-170 ppm) were also recorded at some places in the Phitti/Korangi/Kadiro Creek system. Lower suspended matter (25-50 ppm) was recorded from September to March each year when the river flow is considerably reduced. The suspended load in the creeks also exhibits variations with the degree of turbulence during the tidal cycle. During the flood season in the Indus River (June-September) the suspended load rises to about 4000 ppm in Khobar Creek and to about 1500 to 2000ppm in the adjacent creeks.

The transparency of water (Secchi disc disappearance depth) depends on the magnitude of turbidity in the sea water. In Khobar creek the light penetration was up to a depth of <1.0 m. The maximum water transparency in the major creeks of the Indus Delta are 2.5-4.5m in the Gharo creek, 3.0-5.0m in the Phitti creek and 7.0m in the offshore water during the Jan-Feb. period. The minimum values

Table 5.19: Average concentrations (Ranges) of Selected Water Quality Parameters along Clifton and DHA Beach

		SELECTED PARAMETER					
S.No	LOCALITY /BEACH	pH	Dissolved Oxygen (mg/l)	Nutrients (ugI-1)			
				PO4-P	NH4-N	NO2-N	NO3-N
1	Keamari (opposite Oil terminal)	8.3-8.4	4.9-6.6	11-48	17-33	0.56-1.1	7.8-27.0
2	Clifton (Opposite Shirin Jinnah Colony)	8.3-8.4	5.4-9.0	12-68	31-41	1.4-4.9	25-26
3	Clifton Beach (Near Casino)	8.3-8.4	4.7-6.6	11-70	59-60	3.9-5.0	8.4-28.0
4	Opposite Sea View	8.3-8.4	4.8-6.5	16-140	57-110	3.6-11.0	16-59.0
5	Gizri Creek	8.3-8.4	4.6-6.4	36-77	36-160	9.8-14	30-81.0

Table 5.20: Nutrient Distribution in Karachi Harbour

General				Nutrients (ugI-1)		
Station	Location	Water Level	Average Depth (m)	PO4-P	NO3-N	NO2-N
1	West Wharf	Surface Bottom	10	10.35 4.28	3.81 –	2.44 –
2	Fish Harbour	Surface Bottom	3	23.25 31.25	0.18 1.83	0.10 1.11
3	Opp.Lyari Mouth	Surface Bottom	3	4.60 4.70	1.35 2.01	0.83 1.28
4	Chari Kund	Surface Bottom	6	6.70 14.0	8.74 6.27	5.16 3.93
5	Manora channel	Surface Bottom	11	14.05 6.05	2.05 6.61	1.02 4.13
6	Mausa Channel near entrance	Surface Bottom	13	4.40 3.05	1.19 16.31	1.29 1.80

Table 5.21: Average concentrations of some physical and chemical characteristics (Nov-Dec, 1999) in the vicinity of Port Qasim

		Parameters						
S.No.	Locations	S.W. Temp °C	Density kg/m3	Salinity %	pH	D.Omg/l	T.D.S ppm	Organic matter mg/l
01	Gizri Creek (Top End)	21.0	1.025	33.950	8.10	2.298	41231	5.75
02	Gizri Creek (DHA Cluub)	20.0	1.025	33.400	8.30	3.957	41385	5.93
03	Korangi Creek (Rehri)	22.0	1.028	37.801	7.83	4.330	33908	2.35
04	Korangi Creek (Lat Basti)	23.0	1.027	36.00	7.43	0.430	50036	3.91
05	PSO Oil Jetty	25.0	1.028	37.00	7.70	3.170	42209	4.96
06	Phitti Creek	22.7	1.029	38.784	7.48	4.250	38972	5.77
07	Jhari Creek	23.0	1.030	39.207	8.10	3.860	34132	6.72
08	Chase Creek	23.0	1.030	38.418	8.20	3.060	42508	4.22
09	Gharo Creek	24.0	1.029	38.443	8.20	3.570	31276	5.48

(0.5-1.0m) of sea water transparency in the Gharo/Kadiro creek, <0.2m in the Phitti creek and 0.2 to >2.0m in offshore area adjacent to the creeks, during the May to August period.

The turbidity values in the offshore waters adjacent to the delta are higher during southwest monsoon period than during the rest of the year. Turbidity values are also influenced by the strong tidal flux which reverses its direction during ebbing and flooding. Generally the turbidity is higher during ebb tides, particularly in the shallow creeks. The turbidity is also high within the delta area and in the adjacent coastal waters during river runoff

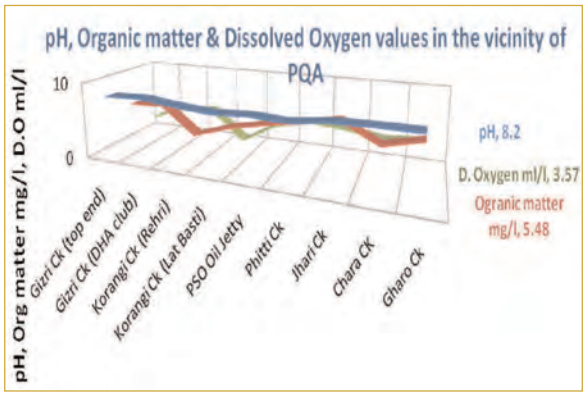


Figure 5.19: Concentration of pH, Organic matter and dissolved values in the Vicinity of PQA.

after the rainy season of southwest monsoon.

5.2.7.5 Heavy Metals in Sea Water and Marine Sediments

Some studies conducted during 1990-2000 on Heavy metals have shown higher concentrations of selected heavy metals in water and sediment samples collected from various localities along Karachi coast. (Mirza Arshad Ali Beg, S.N. Mahmood and A.H.K. Yousufzai (1985) Assessment of the Impact of Heavy Metal Pollution on Aquatic Food Animals, Report Prepared for the Pakistan Agricultural Council, pp 32, Saleem et al. 1999, Zaqoot, 2000, Saifullah et al. 2002, 2004). Mangrove habitat has been shown to serve as sink for heavy metals[Mirza Arshad Ali Beg, Ecological Imbalances in the coastal areas of Pakistan and Karachi harbour, Pakistan Journal of Marine Sciences, 4(2), 159-74, 1995].

The sediments are major trap for metals followed by mangrove plants. According to Williams et al. (1996) detrital silicates and sulphides are the principal carriers of iron and other heavy metals and, therefore, make sediments a long term contaminant sink.

The order of accumulation in different sections of habitat is from sediment to pneumatophores to bark to leaves to twigs to flowers. The concentration of copper, iron and nickel in different components of mangrove ecosystem are presented in Tables 5.22-5.26.

5.2.7.6 Sources of Water Pollution

The coastline of Karachi is highly polluted with a variety of hazardous substances of industrial, municipal and agriculture origin, yet there is no proper monitoring or treatment facilities to mitigate their harmful effects. The levels of pollutants particularly heavy metals have already crossed the limits of natural oceanic concentrations (Bruland, 1983) in the vicinity of Karachi such as Karachi Harbour, Sandspit, Korangi creek and creeks adjoining Port Qasim [Mirza Arshad Ali Beg, Ecological Imbalances in the coastal areas of Pakistan and Karachi harbour, Pakistan Journal of Marine Sciences, 4(2), 159-74, 1995].

The Indus Delta creeks in the vicinity of Karachi and Karachi city have progressively become the Centre of major socioeconomic activities in the country Karachi is not only the major industrial centre but it also has two ports (Karachi and Port Qasim) which play vital role in the development of the economy of the country. It is estimated that about 262 MGD of sewage is generated in Karachi from industrial and domestic sources. Of this 111MGD is contributed through municipal and the remaining from industrial sources (approximately 6000 units). Out of this waste only 20% is treated and the rest is discharged into coastal waters untreated.

It is estimated that Lyari and Malir Rivers contribute 60% and 25% of the total pollution load of Karachi where as 15% of the pollution load is directly discharged into the adjacent open sea coast or to the Gizri, Korangi and Gharo creeks. In the proximity of the creeks adjoining Port Qasim area major industrial complexes include Korangi Industrial area (KIA), Landhi Industrial Trading Estate (LITE), Port Qasim Industrial Area and Pakistan Steel Mill. The KIA is located adjacent to Korangi- Kadiro creeks, LITE is situated close to the Kadiro-Gharo creeks and Steel Mill is located on the Gharo creek.

Coastal villages such as Ibrahim Haidery, Rehri, Lath Basti are part of this ecosystem. Thus the entire Korangi creek, Phitti creek, Kadiro creek and Gharo creek form an inter-related system of creeks receiving bulk of the domestic and industrial wastes in the south-east of Karachi.

Table 5.22: Concentration (ppb) of Cu in water of mangrove habitat of Karachi

Locality	Average conc. +/- SE*	N**	Range
Sandspit	1.5 +/- 0.49	7	1.06 - 3.26
Karachi Harbour	0.61 +/- 0.18	10	0.02 - 1.86
Korangi Creek	1.17 +/- 0.87	3	0.06 - 1.94
Port Qasim	3.06 +/- 0.63	5	1.89 - 5.17
Lat Basti	1.50 +/- 0.35	7	0.047 - 1.728
Chara Creek	0.78 +/- 0.49	3	0.31 - 1.79
Miani Hor	0.041 +/- 0.00	1	-

*South East ** North

Table 5.23: Concentration of Cu (ppb) in sediments of mangrove habitat of Karachi

LOCATION	Average conc. +/- SE	N	Range
Sandspit	48.09 +/- 2.43	19	28.90 - 65.70
Pir Shams	57.60 +/- 0.0	1	-
Port Qasim	44.02 +/- 0.07	4	36.70 - 51.20
Lat Basti	69.02 +/- 8.09	3	56.90 - 85.60
Chara Creek	46.55 +/- 1.35	2	-
Korangi Creek	48.10 +/- 0.00	2	42.20 - 54.00
Miani Hor	9.80 + 0.0	1	-

*South East ** North

Table 5.24: Average Concentration (ppb) of Fe in water in different mangrove habitats of Karachi

LOCATION	Average conc. +/- SE	N	Range
Sandspit	0.09 +/- 0.025	7	0.020 - 0.176
Port Qasim	0.099 +/- 0.039	5	0.016 - 0.211
Rehri	0.06 +/- 0.03	3	0.021 - 0.118
Chara Creek	0.094 + /-0.042	3	0.010 - 0.152
Karachi Harbour	0.042 +/- 0.114	10	0.019 - 0.059
Lat Basti	0.115 +/- 0.031	1	0.012 - 0.247

*South East ** North

5.2.7.7 OIL POLLUTION

The studies on oil pollution prior to Tasman Spirit incident had shown that sediments of Karachi Harbour were generally heavily polluted with oil. The concentration of oil and grease in sediments collected from the creek areas was not as high as found in Karachi Harbour. The concentration of oil in creeks adjoining Port Qasim ranges from 16.25mg/kg to 81.25 mg/kg.

The highest concentration was found in the sediments collected from Gizri creek. Korangi creek sediments are also contaminated by oil and grease which could be attributed to fishing activities at Ibrahim Haideri. The sediments of other creeks adjacent to Port Qasim area have not been found polluted with oil to the same level as Karachi Harbour. The level of oil and grease is very low there and the environment is also not threatened by oil pollution so far (Zaqoot, 2000). The level of total oil and grease in sediments in the vicinity of Port Qasim are presented in Table 5.27.

Table 5.25: Average Concentration (ppm) of Fe in sediments of mangrove habitats of Karachi

LOCATION	Average conc. +/- SE	N	Range
Sandspit	25624 + 1778	19	6369 23440
B/Shams Islands	28120 + -	1	-
Port Qasim	27489 + 2481	3	22678 - 31148
Lat Basti	23310 + 4105	3	17657 - 31545
Miani Hor	1248 + -	1	-
Chara reek	30067 + 2515	4	22640 - 33120
Rehri	34436 + 2249	2	29982 - 344336
Phitti Creek	16480 + 9333	2	7240 - 25720
Bkran Creek	23900 + 866	2	23040 - 24760
Shamspir	17060 + 381	2	13280 20840

*South East ** North

Table 5.26: Average Concentration of Ni (ppm) in surface sediments along Karachi Coast

Locality	Average Concentration (ppm)
Sandspit	77.1
B/Shams Islands	58.2
Rehri	52.4
Lat Basti	48.3
Port Qasim	55.1

The seawater samples collected from Gizri creek showed considerable effect of oily wastes mostly released from industrial wastes and Pakistan Refinery effluents discharged through Malir River. Lower degree of oil pollution was observed in the creeks adjoining Port Qasim area such as PSO Jetty, Phitti-Korangi creek, Jhari creek, Chara creek and Gharo creek (Zaqoot, 2000).

In 2003, on 27th July an oil tanker MT Tasman Sprit grounded off Karachi Port Trust near the entrance channel. During August, 2003, approximately 31,000 tons of Crude Oil spilled from this grounded oil tanker and spread along Clifton beach. Scientific investigations to assess the damage to the natural resources as a consequence of the oil spill were undertaken by Pak-EPA under the Ministry of Environment, Government of Pakistan.

The results as summarized were presented at a "National Symposium on Natural Resource Damage Assessment of Tasman Sprit Oil Spill" at Karachi on 30-31 May, 2005. Some of the information presented regarding pollution due to Tasman Spirit Oil Spill along Karachi Coast from August - December, 2003 is presented in Table 5.28.

The oil concentration in surface and deeper water column ranged between 1 to 9 ppm as seen from the Table 5.29. The intertidal area as expected shows higher concentrations which gradually decreasing towards deeper waters. Similar trend was also observed in sediments of intertidal area to deeper waters along the coast of Karachi.

5.2.8 BIOLOGICAL ENVIRONMENT

5.2.8.1 COASTAL & MARINE ECOSYSTEM

Coastal ecosystems provide a wide range of goods and services. They are the primary producers of marine fisheries including shellfish, besides seaweeds for both human and animal consumption. The marine ecosystem is also a source of chemicals, pharmaceuticals, cosmetics, house hold products and construction materials.

Table 5.27: Concentration of Oil & grease in marine sediments in the vicinity of Port Qasim (Dec, 1999)

Locality	Average conc + SE
Lath Basti (Korangi Creek)	78.75
Gizri Creek (Opposite Marina Club)	17.50
Phitti Korangi Creek	16.25
Jhari Creek	33.75
Chara Creek	31.25
Opposite Korangi Fish Harbour	20.00

5.2.8.2 MARINE FLORA

I) PHYTOPLANKTON

The average, net Primary Production rates are high at Isaro Creek (5-175 mg C/m^3/hour) and Gharo Creek (2 - 111 mg C/m^3/hour) while lower Primary Production rates were recorded at Gizri Creek (2 -13.5 mg C/m^3/hour) and Phitti-Korangi Creek (1-4 mg C/m^3/hour).

The Primary Production rates at Malir river estuary (5-15.5 mg C/m^3/hour) and at the open sea coastal waters (1.5-14.5 mg C/m^3/hour) adjacent to Phitti-Korangi-Kadiro Creeks were comparable to the rates at Gizri Creek.

The Primary Productivity values from literature for the months of February, March, and June show relatively higher productivity rates for these creeks. The overall Productivity in the mangrove areas has been reported to be high (365-780gC/m^2/year), compared to coastal waters (50-200gC/m^2/Year), which accounts for greater potential for fisheries yield in the former area. (Rizvi 1999.)

II) MANGROVES

The Avicenna marina is the dominant species of the mangroves in the Indus Delta. In the PQA creek system the most dominant species are also Avicenna marina that grows on the northern and southern banks of the Phitti - Gharo Creek system. The density of mangrove trees is between 50-60 / 100 m^2. The height of the individual tree within the established Avicenna marina habitats were between 2-3 m near Korangi Creek.

III) MANGROVE POPULATION DENSITY

PQA is part of the Indus Delta. The Indus Delta supports one of the largest single mangrove ecosystems in the tropical coastal environments. In the Indus Delta mangrove ecosystem, eight species of mangroves have been reported out of 53 species known to occur in the tropical forests of the world. Other mangrove species in the deltaic region such as the Ceriops tagal occur in localized patches and there are a

Table-5.28: Concentration of oil in the sediments from coastal waters of Karachi during August to December 2003 after Tasman spirit oil spill

Sampling Zones	Oil concentrations (ppm) (19th August to early September 2003 during the Oil-Spill) Surface Sediments (0-10 cm layer)	Oil Concentration (ppm) (25th October - 10th December 2003) (55 - 65 days after the spill)	
Zone-1	195 ppm	(0-10 cm layer) 300 - 2700 ppm	10 - 30 cm layer 200 - 1800 ppm
Zone-2 (5-10 meter depths)	195 - 968 ppm	(0 - 10 cm layer) 300 - 800 ppm	(10 - 30 cm layer) 200 - 500 ppm
Zone-3 (10-20 meter depths)	51 - 382 ppm	(0 - 10 cm layer) 300 ppm	(10 - 30 cm layer) 100 - 250 ppm
Zone-4 (20-30 meter depths)	---	---	---
Average Range	51- 968 ppm	300 - 2700 ppm	100 - 1800 ppm

Table-5.29: concentration of total oil in the water column along Karachi coast after Tasman Spirit oil spill

S.No	Coastal Sampling Zones	Oil Concentrations (ppm) Surface Waters (0.5 m Column)	Oil Concentration (ppm) Bottom waters (0.5 m h)	Oil quantity (tons) (0.5m Column) in 150 Sq km area
1	Zone-I (Inter-tidal areas)	01-09 ppm	15-33 ppm	196.964
2	Zone-2(5-10 meter depths)	02-19 ppm	13-30 ppm	523.361
3	Zone-3(10-20 meter depths)	02-04 ppm	08-25 ppm	225.102
4	Zone-4(20-30 meter depths)	02-03 ppm	08-15 ppm	67.530
	Average Range	02-04 ppm	08-33 ppm	Total = 1012.957

few plants of Rhizophora mucronata. All other species are rare and have disappeared from most part of the Delta due to adverse environmental conditions.

The mangrove trees growing 200-300 m away from the creek (seawater) in the land ward direction showed an overall decline in the height of the mangrove plantations. The density of mangrove vegetation was randomly evaluated a100 m^2 area within the PQA. The trees were characterized by visual observations according to their arbitrary height (Table 5.30).

- The height of mangrove seedling were characterized as <0.25 m
- Mangrove sapling height 0.5 -1.0 m
- Short mangroves trees were characterized as having 1-2 m height.
- Medium height mangroves trees had were characterized as having 2-3 m height.
- High mangroves trees had were characterized as having 2-3 m height.

Densities of high mangrove plantation were poor at station at the coastline/high water mark of Brown Field site. Mangrove saplings / seedlings / propagules of A. marina were observed to be in greater numbers (100-150 m^2) at the entire area except the one fronting the open channel. Mangroves at high water mark shown in Figure 5.20 (a) and 5.20 (b)

IV) Creek Erosion and Mangroves

Considerable sediment erosion was observed in the project area. Well established mangrove plantations (high tress) were observed to be under stress due to eroding sediments in the Phitti - Gharo Creek system as shown in Figures 5.21 and 5.22. The factors responsible for the excessive erosion may be strong currents during ebb and flow of tides and also the waves generated as a result of moving vessels in the creek. However, low sediment load in the Indus River discharges and human activities including camel grazing is largely responsible for uprooting the trees whose pencil-like roots were holding the sediment/mud. Their removal by the root destabilized the soil of the mud flat. The proposed terminal is before Phitti creek.

Rizvi (1999) observed annual values of the suspended matter in the Indus creek system in the range of 25-170 ppm. The higher values were observed during the southwest monsoon period (usually May-August). The average suspended load during June-July was between 80-115 ppm. However, higher values (115-170 ppm) were also recorded at some places in the Gharo/Korangi Creek system. Lower suspended matter (25-50 ppm) was recorded during March and the September-November period. The suspended load in these creeks also exhibits variations with the degree of turbulence during a tidal cycle. During the flood season in the Indus River (July - September) the suspended load rises to about 4000 ppm in Khobar Creek and to about 1500 to 2000ppm in the adjacent creeks.

5.2.8.3 Marine and Benthic Fauna

I) Marine Benthic Invertebrates. (MBI)

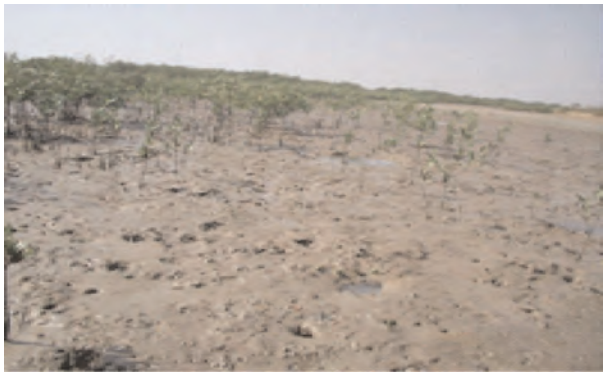
The MBI plays an important role in mixing the organically enriched bottom sediments. The MBI are a key linkage in transferring the energy from lower trophic level to the next higher trophic level in the food chain. The species distribution pattern of benthic invertebrates in the PQA area of interest is randomly distributed, while a few species aggregate as shown in table 5.28. The distribution of invertebrates is dependent on the surface current that redistributes the planktonic larval form to locations away from where they were spawned they are hence random in their population densities. Aggregation is also a function of reproduction, where the benthic organisms tend to colonies together. Nematodes, Annelid Polychaete worms, bivalve mollusk, Pinnotherid crabs, and species of Tanaidacean were by far the most dominant benthic species in the benthic samples collected from the project area.

Methodology for Habitat Surveys

In order to evaluate the baseline population of coastal faunal communities, four sampling stations were identified approximately 2-3 km in the East/West and North/ South direction from the EVTL Jetty. The surveyed was

undertaken at low tide (0.2 m MSL). A shallow draft, fiber boat 4 m in length with an outboard motor (10 HP) was used to access the locations along the coast and to observe changes in coastal habitats. A hand held GPS (GarmineTrek) was used to mark changes in the coastal configuration, and mark any significant marine faunal sightings. The boat was navigated at slow speed between 2-3 Kts, along the coast at shallow depths of less than 1-2 m. The coastal area and the mangroves observation were made from were within 20-25 meters distance from boat. The main objective of a faunal survey was to identify the faunal habitats and the assemblage of species present. Estimates of relative species abundance at each station was accomplished by using a quadrat to represent 0.5 x 0.5 m^2 surface area. The small quadrat size are considered most suitable for a study of the dispersion of substrate faunal assemblages.

The Habitat surveys were undertaken during low tides at daylight hours. Low tides facilitated in exposing submerged mud flat community. The species were identified upto genus level in the field, using standard field guides. Sediment substrate and sea surface water samples were collected. The substrate samples were collected using a plastic spatula that was penetrated approximately 15-20 cm depth into the soft sediments at each station. The replicated substrate samples were preserved in the field in large mouth plastic containers containing 10% formalin. The preserved samples were sent to the National Institute



a

b

Figure 5.20 (a) and 5.20 (b). Natural vegetation of Mangroves, young saplings & seedling of Avicenna marina in patches (100-150 m^2) at high water mark, substrate mud to clayey

Figure 5.21: Established mangrove trees Avicenna marina collapse due to Coastal erosion in the southern bank of the Phitti Creek. Bow wave created by large vessels also contributes towards coastal erosion.

Figure 5.22: Eroded mud banks and destruction of mangrove community

Table 5.30 Density and tree heights of mangrove Avicenna marina in 100 m² area at each of the stations surveyed

Positions Lat/Long.	Mangrove Heights	(%) Mangrove Density/100m²
N 24, 47, 367 E 067, 15, 67	High	60
	Medium	30
	Short	5
	Sapling	5
N 24, 46, 271 E 067,3, 547	High	40
	Medium	40
	Short	10
	Sapling	10
N 24, 46, 850 E 067,19, 955	High	30
	Medium	60
	Short	5
	Sapling	5
N 24, 43, 576 E 067,18, 607	High	0
	Medium	20
	Short	30
	Sapling	50
N 24, 47, 210 E 067,15, 982	High	70
	Medium	20
	Short	5
	Sapling	5
N 24, 46, 302 E 067,18, 032	High	50
	Medium	30
	Short	10
	Sapling	10
N 24, 45, 728 E 067,18, 934	High	50
	Medium	30
	Short	15
	Sapling	5

of Oceanography (NIO) Karachi for analysis of interstitial benthic fauna (macro/meiofauna) and identification of collected specimens. Standard identification and analysis techniques were followed. The specimens were also photographed under state of the art binocular microscope for record.

Appropriate statistical analyses were performed using dedicated statistical software packages for data crunching and interpretation of results.

Four Random stations for Benthic Invertebrates were identified by using a hand held Global Position System (Garmin GPS) along a transect at different locations to correspond to near zero tidal heights during the day light hours that would facilitate in survey of exposed mud flats, coastal habitats and the Mangrove community within a radius of 2 Km from the proposed planned site near EVTL.

The components that were considered necessary for undertaking the survey in order to establish an environmental baseline survey in the proposed area included Marine fauna and the associated ecosystems. Documenting all the plants and animals living in the port area was not a viable option. Instead, the habitat components with the highest likelihood of being affected by the project were examined.

Table 5.31 Specie wise distribution of Marine Benthic Invertebrates and their distribution pattern in PQA benthic samples collected in close vicinity of the proposed jetty

Species	Variance	Mean	Chi-sq	d.f.	Probability	Aggregation
Brittle star (Amphiurid)	0.2292	0.3125	11	15	0.7534056	Random
Annelida (Polychaeta)	3.2292	2.1875	22.1429	15	0.1037196	Random
Mollusca (Gastropods)	2.5958	1.0625	36.6471	15	0.0014828	Aggregated
Ostracods	0.1167	0.125	14	15	0.525942	Random
Crabs (pinnotherid)	2.4667	0.75	49.3333	15	0.0000186	Aggregated
False Crabs	0.0625	0.0625	15	15	0.4515619	Random
Hydrozoan	0.3833	0.375	15.3333	15	0.4277409	Random
Sea anemone	0.0625	0.0625	15	15	0.4515619	Random
Amphipods	6.65	1.125	88.6667	15	0	Aggregated
Nematoda	1.8292	0.6875	39.9091	15	0.0005004	Aggregated
Tanaidacean	26.5333	3	132.6667	15	0	Aggregated

The Marine Benthic Invertebrates (MBI) plays an important role in mixing the organically enriched bottom sediments. The MBI are a key linkage in transferring the energy from lower trophic level to the next higher trophic level in the food chain.

Statistical Analysis of Benthic Invertebrate Fauna

The statistical analysis was performed on benthic invertebrates species observed at different location using statistical software package. The faunal samples were sorted, enumerated and identified using standard identification keys. The overall faunal statistic is shown in Table 5.33.

The species distribution pattern of benthic invertebrates in the PQA area of interest is randomly distributed, while a few species aggregate (Table 5.34). The distribution of benthic invertebrates and interstitial fauna (macro and meiofauna) is dependent on the surface current that redistributes the planktonic larval form to locations away from where they were spawned they are hence random in their population densities. Aggregation is also a function of reproduction, where the benthic organisms tend to colonies together. The substrate sediment samples taken from the creeks, Littorina sp. Nemetodes, Annelid Polychaete worms, Capitellids, bivalve mollusk, were by far the most dominant interstitial species observed in the benthic sediment samples collected from Kadiro Creek, PQA.

Benthic Species Biodiversity Index

The Shannon Weiner species biodiversity index is a useful tool for measuring the health of the ecosystem. The biodiversity values observed for benthic species to range from a minimum of 0.441 at station D at station location C to a maximum of 0.976 at station location A and 0.677 at Station B respectively. The species diversity values in PQA are generally low, since the whole areas is disturbed due to navigational, dredging and shipping activity. Further, sediment grain size and compactness (Silt/clay) provides less interstitial space and less oxygenated water for the benthic animals to survive, which leads to higher Redox Potential Discontinuity Layer. (RPD).

Marine Benthic Invertebrates Cluster Analysis

Bray and Curtis cluster analysis was performed to evaluate the relationship between the similarities of species in the samples. This is given in the form of a dendrogram figure 5.26. That shows stepwise similarity were groups at locations observed (stations) are not clearly dissimilar from each other. (Sample. A, B and D show similarity), while Species in sample C are placed under a different dendroline although not too dissimilar with AB&D shown in benthic invertebrate groupings.

Refraction Plot

Rarefaction is a technique to assess species richness from the results of sampling. Rarefaction allows the calculation of species richness for a given number of individual samples, based on the construction of so called rarefaction curves. This curve is a plot of the number of species as a function of the number of samples. The steep slope indicates that a large fraction of the species diversity remains to be discovered. If the curve becomes flatter to the right, a reasonable number of individual samples have been taken: more intensive sampling is likely to yield only few additional species. Rarefaction curves generally grow rapidly at first, as the most common species are found, but the curves plateau as only the rarest species remain to be sampled. (Figure 5.27)

5.2.8.4 Coastal Habitats

Coastal areas and the intertidal region is a complex system where the division between land and sea is unclear. Coastal intertidal areas have a diverse range of communities including sandy shores, mudflats, and mangrove forests.

In the PQA, the Phitti Creek has faunal community characteristic of very fine sediments from muddy to clayey. The communities included mud flats which were dominated by faunal assemblages representing the soft sediments with high percentage of silt and clay. The sediment substrate was generally found to be high in organic content and with black mud just below the substrate.

Results of Coastal Habitat Survey are presented below:

I) Faunal Communities

The PQA area of interest and the associated Creeks had faunal communities that are characteristic of mud flats. The substrate had very fine sediments (mud and clay). The faunal communities present were dominated by faunal assemblages representing the soft sediments. Table 5.34, provides information on the statistics of species at PQA and its vicinity; the mean individuals in along with variance, standard deviation and standard error of mean.

The result of spatial dispersion of a population describes the spatial distribution of the individuals in the population. Temporal changes in dispersion will usually occur, and different stages of the same species will often show different patterns of dispersion.

Crustacean Caridean Shrimp, were abundantly distributed and showed an aggregate distribution pattern at station H6. The Carid shrimps were easily caught with the hand held scoop net. The scoop net measuring 10 X 10 cm caught 15-20 shrimp. The bivales Gafrarium spp, Marcinaria, and Gastropod Cerithium spp, Turritella spp were also found to aggregate in the mud flat habitat collected at the stations surveyed in the PQA area.

Statistically, the dispersion of a Population determines the relations between the variance and the arithmetic mean. If the variance more or less equals the mean then the Population is said to be randomly distributed. If the variance is less than the mean the Population is termed as regularly distributed. And if the variance is greater than the mean then the Population is considered as being an aggregate population that is known as being found in clumps. The highly aggregate populations of Caridean Shrimp Species: Cerithium spp, Turritella spp have been found as clumped together.

Cerithium species are a large group characterized by an upturned canal in their shell that protects the siphon and allows them to live just beneath the substrate. Cerithium spp are algae and detritus feeders and are common prey for predatory mollusks.

Turritella are by far the largest family group and also one of the oldest, being represented in the fossil record as long as 135 million years, during the Cretaceous Period. During this presence on Earth, they have occupied every geographical locality and are ubiquitous.

II) Animal Communities

The beaches of the creeks adjoining Port Qasim area are mostly muddy - sandy or muddy. Hard bottom beaches are generally absent in this area but occasionally one may be found. Animal communities of different substrate (muddy cum sandy and hard substrate) in PQA and its

Table 5.32: Sampling station and locations in proximity to EVTL Jetty.

Station No	Date	Sampling Location/Station	Lat N. Long E Substrate Type	Tidal height m	Type Survey
A	25th. Nov	24 46 49.53 N, 67 19 18.93 E	Mud to fine sand	0.9 m Ebb	Habitat Survey, benthic invertibrates
B	25th. Nov	24 46 43.23 N, 67 19 28.02 E	Mud to Clay	0.8 m Ebb	Habitat Survey, benthic invertibrates
C	25th. Nov	24 46 42.21 N, 67 19 13.57 E	Mud to Clay	1.0 m Flow	Habitat Survey, benthic invertibrates
D	25th. Nov	24 46 36.08 N, 67 19 21.66 E	Mud to Clay	1.0 mFlow	Habitat Survey, benthic invertibrates

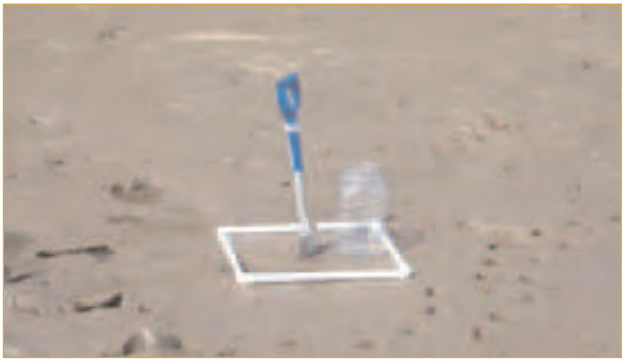


Figure 5.23: Sampling substrate using a 0.5 x0.5 m quadrate at the sampling stations.

Table 5.33:Faunal statistic of marine benthic invertebrates collected from the sampling stations in Kadiro Creek PQA.

Sample	Mean Individuals	Variance	Standard Deviation	Standard Error	Total Individuals	Total Species	Minimum	Maximum	Mean Confidence Interval
Sample A	9.273	224.97	14.999	3.198	204	18	0	64	94.009
Sample B	5.818	149.68	12.234	2.608	128	6	0	44	62.547
Sample C	2.091	37.134	6.094	1.299	46	6	0	28	15.517
Sample D	12.364	1335.861	36.549	7.792	272	5	0	156	558.221

Dosinia sp.

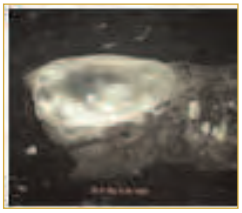
Soletellina sp.

Trapezium sp.

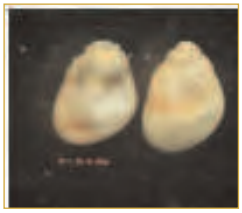
Mactra sp.

Bivalves sp

Gafrarium sp.



Oyster sp.



Littorina sp.

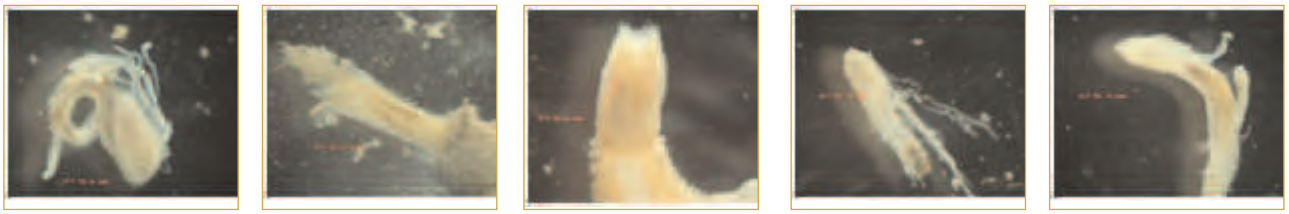
Natica sp.

Gastropod sp

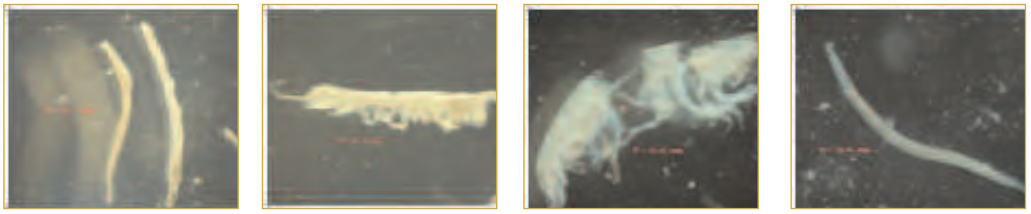
Figure 5.24: Diversity of Molluscs invertebrate in benthic sediments observed at the sampling stations

Table 5.34. Species distribution and aggregation behavior in sampled stations

Species	Variance	Mean	Chi-sq	d.f.	Probability	Aggregation
Dosinia sp.	1	0.5	6	3	0.1098782	Random
Soletellina sp.	9	1.5	18	3	0.0005294	Aggregated
Trapezium sp.	1	0.5	6	3	0.1098782	Random
Mactra sp.	9	1.5	18	3	0.0005294	Aggregated
Un identified	36	3	36	3	3.00E-07	Aggregated
Gafrarium sp.	1	0.5	6	3	0.1098782	Random
Littorina sp.	5732	43	399.907	3	0	Aggregated
Natica sp.	1.3333	1	4	3	0.260453	Random
Fam: Spionidae a	9	1.5	18	3	0.0005294	Aggregated
Scolelepis sp.	1	0.5	6	3	0.1098782	Random
Fam: Ampharetidae	169	6.5	78	3	0	Aggregated
Nephthes sp.	1	0.5	6	3	0.1098782	Random
Cossura sp.	289	8.5	102	3	0	Aggregated
Fam: Capitellidae	950.3333	24.5	116.3673	3	0	Aggregated
Spionidae b	4	1	12	3	0.0075408	Aggregated
Tanaidacean	22.6667	3	22.6667	3	7.02E-05	Aggregated
Nematode	1190.333	24.5	145.7551	3	0	Aggregated
Bivalves	187.6667	7.5	75.0667	3	0	Aggregated
Nereid worm	76	5	45.6	3	0	Aggregated
Polycheate	453.3333	22	61.8182	3	0	Aggregated
Ocypod Crabs	76	5	45.6	3	0	Aggregated
Amphipod	1.3333	1	4	3	0.260453	Random



Spionid worm sp.A | Ampharetidae | Naphthydidae | Spionid worm sp.B | Spionid worm sp.3



Capitellidae | Tanaidacean | Amphipod | Nematode worm

Figure 5.25. Marine Benthic fauna observed in the samples from Kadiro Creek.

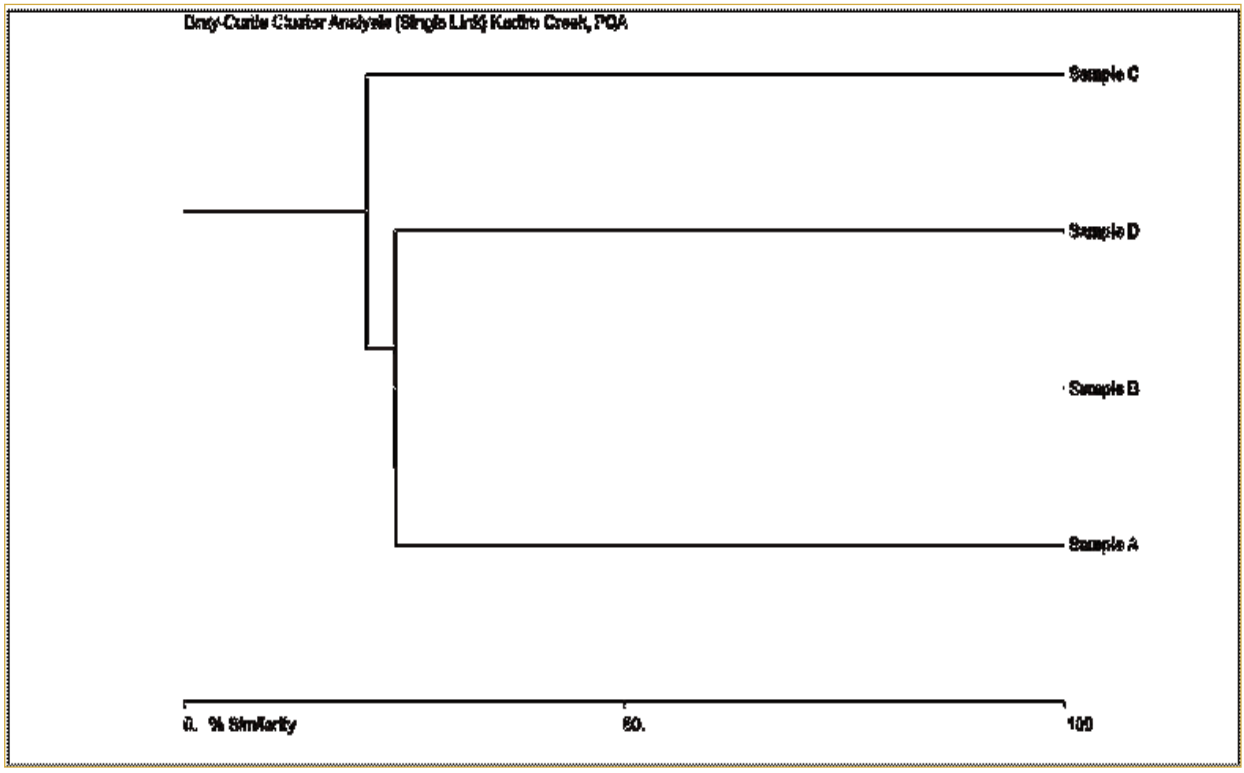


Figure 5.26: Similarity index Bray –Curtis Cluster analysis

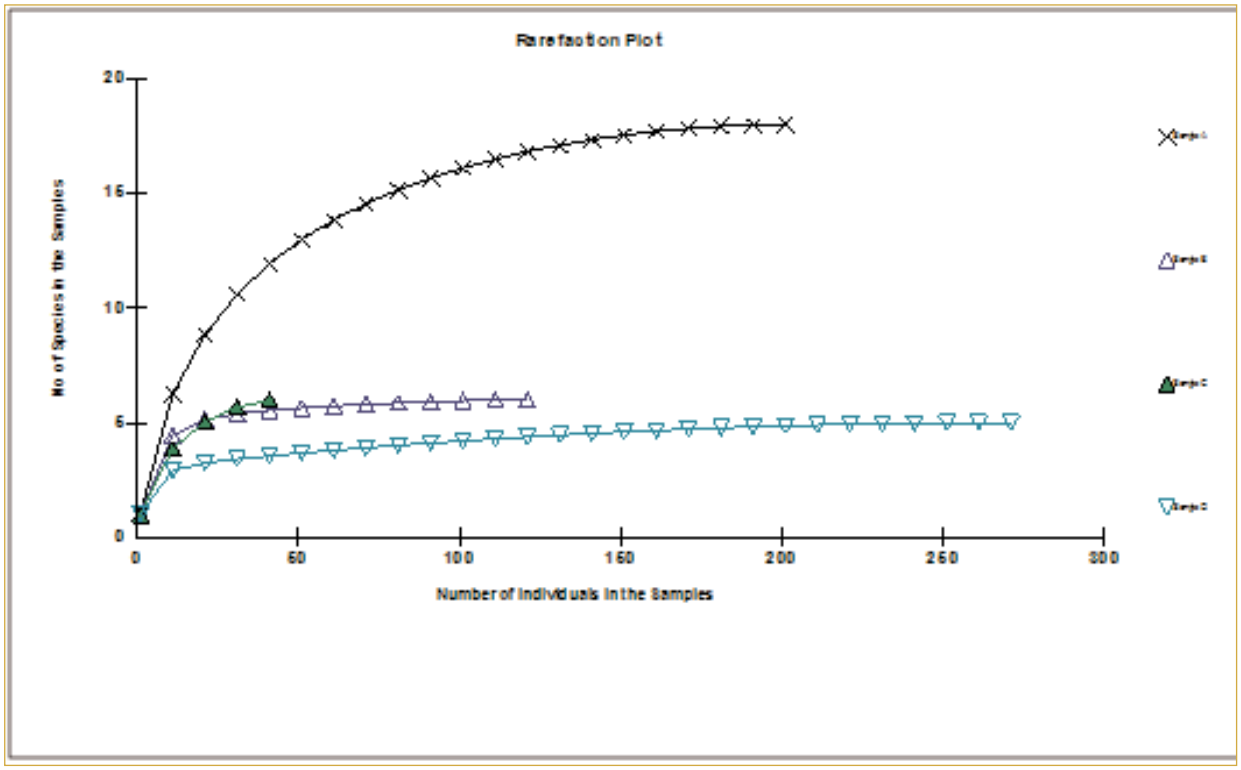
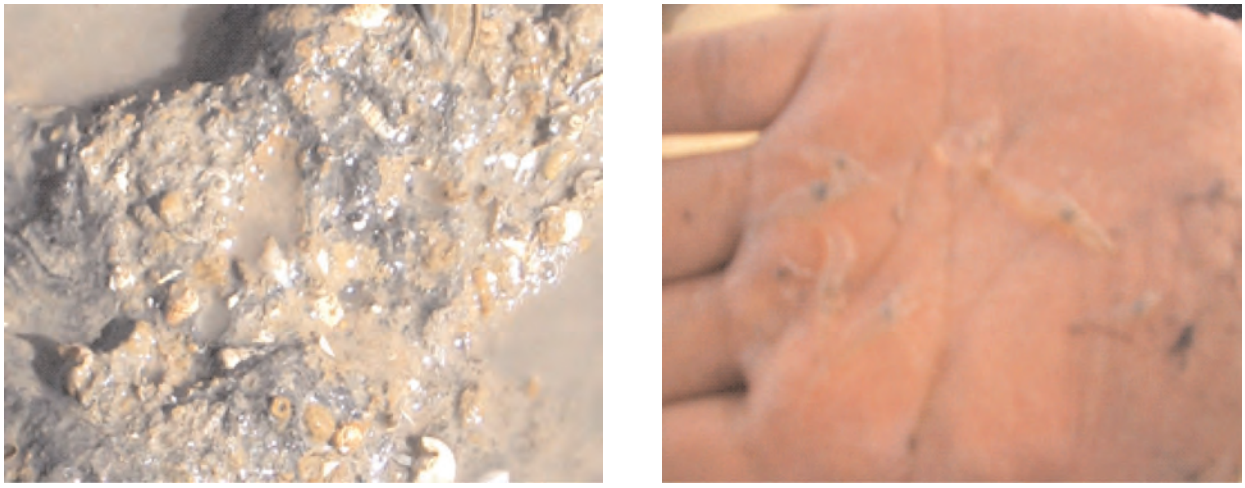


Figure 5.27: Rarefraction plot showing No. of Species and No of individuals in the samples

Table. 5.35. Statistical parameters and dispersion pattern of species observed in the mudflats in the Coastal Habitat Survey conducted at each of the sampled at PQA and its vicinity

Invertebrate sp	Variance	Mean	Chi-sq	d.f.	Probability	Aggregation
Metaplex disctincta	0.2857	0.4286	4	6	0.6788355	Random
Volutidae	0.2381	0.2857	5	6	0.5453557	Random
Caridean Shrimp	19.2381	2.2857	50.5	6	0	Aggregated
Eurycarcinus orientalis	0.2857	0.4286	4	6	0.6788355	Random
Marcinaria	0.619	0.4286	8.66	6	0.192137	Random
Cerithidae	0.2381	0.2857	5	6	0.5453557	Random
Bullia	0.2381	0.2857	5	6	0.5453557	Random
Barbatia	0.2857	0.4286	4	6	0.6788355	Random
Gafrarium	1.2857	0.4286	18	6	0.0063792	Aggregated
Telescopium	1.4762	0.8571	10.33	6	0.1103398	Random
Marcinaria	3.5714	0.7143	30	6	5.19E-05	Aggregated
Tellina (Tellinidae)	0.2381	0.2857	5	6	0.5453557	Random
Codakia(Lucinidae)	0.2381	0.2857	5	6	0.5453557	Random
Cerithium (Cerithidae)	17.2857	1.5714	66	6	0	Aggregated
Turritella(Turritellidae)	20.5714	1.7143	72	6	0	Aggregated
Nerita spp	0.1429	0.1429	6	6	0.4236949	Random
Polycheate (worms)	0.8095	0.8571	5.66	6	0.5375987	Random



a b

Figure 5.28 (a) and (b): Carid shrimps and Cerithium spp, Turritella spp are clumped together in the mudflat at Phitti Creek near Khiprianwala Island site.

vicinity are shown in Table 5.36.The animal communities inhabiting different creeks are described below:

A) Korangi Creek (Ibrahim Haidery Beach)

This is muddy - sandy beach with very gradual slope. The beach is greatly affected by anthropogenic eutrophication as it receives domestic effluents, fisheries wastes from a

fishing village and heated effluents from a KESC power plant. Suspension feeding/filter feeding bivalves are mostly absent from the beach. Sometimes ago Placuna placenta, the window-paneoyster, and the brachiopod Lingula sp which used to abound on this beach have disappeared. The cause of their disappearance may be either too much siltation or anoxic condition of the habitat. The beach is inhabited by fiddler crabs and mud skippers. In winter the mud flats are covered with Enteromorpha and Ulva mats.

b) Bakran Creek of Gharo-Phitti Creek System

This is a long mud-sand flat in the Port Qasim area. It receives effluents from the Port area and from Pakistan Steel Mill as well as anthropogenic contributions from local villages along the delta. It has a gradual slope with mangrove stands towards low tide. Isolated small stunted mangroves occur further up shore. The barnacle Balanus amphitrite is abundant on the leaves of the mangroves Avicennia marina. In this area Enteromorpha and Ulva cover the beach in winter. The animal communities are not very abundant except mudskipper fish, fiddler crabs and the snail Cerithidea cingulata a pollution indicator species.

c) Broekhoven Jetty Beach (Gharo-Phitti Creek System)

This is an unusual beach in the Gharo-Phitti creek system being a hard rocky beach. It has a slight slope and is covered with mud, sand and on some places, oil sheen. This beach shows the greatest diversity of animal species in the area. It is characterized by the presence of a large bed of dead, edible oysters although live oysters are also found occasionally. The beach has a number of invertebrates, such as sea urchins, ascidians, sponges, colonial coelenterates and ophistho branch mollusks which are indicative of oceanic conditions. The beach is located about 18 km inland from the open sea in the Port Qasim area. The oceanic influence seems to have reached here because of the greater inflow of water from the sea following the deepening of the Port Qasim navigational channel to accommodate large vessels.

d) Marine Algal Epiphytes in Mangroves of Korangi Creek

In the mangrove ecosystem the producers are the mangroves and marine algae both micro and macroscopic. While the algae are not as large and dominant as the mangroves they nevertheless contribute significantly to the energy budget of the system. The macroscopic algae grow on the lower parts of the mangrove plants mostly on the Pneumatophores with the exception of Enteromorpha intestinalis and Ulva reticulatewhich form a green mat on the dark mud of the mangrove habitat (Saifullal and Nizamuddin, 1977). Marine algae inhabiting the mangrove area of Korangi Creek and its vicinity have been reported by Saifullah and Taj (1995). They collected the algae from the Pneumatophores of Avicenia marina growing luxuriantly in the Korangi Creek and adjacent areas. They have reported twelve species of marine macro algae growing as epiphytes. That species belonging to the four major groups of algae i.e. Chlorophyta, Phaeophyta, Rhodophyta and Cyanophyta found in mangroves of Korangi Creek are listed below:

- Chlorophyta
- Boodleopsis Pusilla
- Chaetomorpha gracilis
- Cladophora sp
- Enteromorpha torta
- Rhizoslonium kerneri
- Phaeophyta
- Hincksia terminalis
- Rhodophyta
- Caloglossa leprieurii
- Herposiphonia secunda
- Polysiphnia abcissa

Table 5.36: Animal communities of different substrate (muddy cum sandy, hard substrate, in PQA and its vicinity.

Species	Variance	Mean	Chi-sq	d.f.	Probability	Aggregation
Uca lactea (fiddler crab)	5.3333	2.6667	4	2	0.132834	Random
U. annulipes (fiddler crab)	1.3333	1.3333	2	2	0.369441	Random
Eurycarcinus orientalis (crab)	0.3333	0.6667	1	2	0.612402	Random
Macrophthalmus pectinipes (crab)	0.3333	0.3333	2	2	0.369441	Random
Grapsus sp (crab)	1.3333	1.3333	2	2	0.369441	Random
Scylla serrata (crab)	1.3333	1.3333	2	2	0.369441	Random
Cerianthus sp (sea anemone)	1.3333	0.6667	4	2	0.132834	Random
Loimia medusa (polycheate)	0.3333	0.6667	1	2	0.612402	Random
Hesione pantharina (polycheate)	0.3333	0.6667	1	2	0.612402	Random
Lycastis indica (polycheate)	1.3333	0.6667	4	2	0.132834	Random
Nemertean worms (nemertean)	1	1	2	2	0.369441	Random
Crassostrea rivularis (oyster)	0.3333	0.6667	1	2	0.612402	Random
C. gryphoides (oyster)	0.3333	0.3333	2	2	0.369441	Random
C. madrasenis (oyster)	0.3333	0.6667	1	2	0.612402	Random
C. globmerata (oyster)	5.3333	2.6667	4	2	0.132834	Random
Placuna placenta (oyster)	0.3333	0.3333	2	2	0.369441	Random
Dosinia sp (clam)	0.3333	0.3333	2	2	0.369441	Random
pitar nobilis (clam)	0.3333	0.3333	2	2	0.369441	Random
Pandora flexuosa (clam)	1.3333	0.6667	4	2	0.132834	Random
Dentalium sp (tusk shell)	0.3333	0.3333	2	2	0.369441	Random
Tellina sp (clam)	0.3333	0.3333	2	2	0.369441	Random
Telescopium telescopium (snail)	0.3333	0.3333	2	2	0.369441	Random
Cerithidea cingulata (snail)	5.3333	1.3333	8	2	0.018062	Aggregated
Thais sp (snail)	2.3333	1.6667	2.8	2	0.245286	Random
Natca sp (snail)	0.3333	0.6667	1	2	0.612402	Random
Mudskipper (fish)	5.3333	2.6667	4	2	0.132834	Random
Balanus amphitrite (barnicle)	5.3333	2.6667	4	2	0.132834	Random
Diodora sp (limpet)	1.3333	0.6667	4	2	0.132834	Random
Glycymeris sp (pectin)	0.3333	0.3333	2	2	0.369441	Random
Anomis sp (oyster)	1.3333	0.6667	4	2	0.132834	Random
Pinna bicolor (mussel)	0.3333	0.3333	2	2	0.369441	Random
Perna sp (mussel)	0.3333	0.3333	2	2	0.369441	Random
Cypraea sp (snail)	0.3333	0.3333	2	2	0.369441	Random
Euchelus sp (snail)	0.3333	0.3333	2	2	0.369441	Random
Ozius rugulosus (crab)	0.3333	0.3333	2	2	0.369441	Random
Ascidians (sea-squirt)	1.3333	0.6667	4	2	0.132834	Random

Table - 5.37: Break-up of Mangrove Habitat Fish Fauna

Species Name	Number of species
Clupeiformls	15 Species
Scopeliformes	04 Species
Cyprinitbormes	06 Species
Anguillifomes	02 Species
Perciformes	46 Species
Betoniformes	03 Species
Syngnathi formes	05 Species
Mugiliformes	06 Species
Polynemiformes	04 Species
Pleuronectifomes	06 Species
Batrachodiformes	61 Species

- Cyanophyta (Cyanobacteria)
- Hydrocoleum lyngbaceum
- Lyngbya majuscula
- Phormidium ambiguum

III) FISHERY

According to Government of Pakistan (2005) fish and fishery related sector engages 1% of the Pakistan's population. The fishery sector generates 1% of Pakistan GDP earning through export of fishery products. Coastal and offshore areas of Pakistan support large fisheries. Fishing grounds for large pelagic species such as tuna, mackerel, sharks etc are located in the offshore waters. Whereas the species like mullet, silver wittings and other small sized demersal fishes specially juveniles of large commercially important estuarine fish are harvested from shallow water in the creek area of Indus as well as enclosed and semi-enclosed bays along the coast of Pakistan.

Ahmed (1983) reported 98 species of fish from mangrove swamps of Korangi-Phitti creek system and backwaters of sandspit. Out of these 98 species 46 species were fingerling or young stages while 52 species were either sub-adult or adult. Mudskippers have adopted themselves to live in this particular environment. Pleuronectiformes which represent bottom living fish move towards this area for their food. Many detritus feeders like clupeids, grey mullets etc. and small carnivorous fish like silver biddies and pony fish find this environment suitable for their living. The order and species wise break-up of the mangrove habitat fish fauna are given in Table-5.37.

In Korangi Creek and the adjoining creeks areas Ahmed (1988) has described in detail four types of fish groups; the permanent dwellers which are few; partial residents; tidal; and seasonal visitors in the mangrove habitat where over 180 species of fish have been reported. As many as 148 species of fingerlings or young stages and juveniles have been reported from the mangrove of Indus Delta (UNESCAP, 1996). More common larvae of fishes described for Korangi Creek and adjoining creeks in Indus Delta belong to the families Mugilidae, Gerreidae, Clupeidae, Nemipteridae, Gobiidae, Sciaenidae, Engraulidae, Sillaginidae and Lutjanidae. Their abundance from season to season varies. There are a number of settlements of fishermen along the creeks of Indus Delta which depend on the fisheries resources of these creeks.

A) BENTHIC FISH COMMUNITY

Benthic fish community includes the microbes: detritus feeders, small and large herbivores, and small and large carnivores. In the mangrove ecosystem, the benthic community of the adjacent shallow water is a subject of interest. Here, the microbes decompose the plant litter into organic detritus-a fundamental commodity of system energy. This detritus matter is picked up by the detritus feeders over the bottom, such as fishes, shrimps and shellfish, and then carried to the littoral zone by wave action, shared by the intertidal fauna such as crabs, shrimps, mudskippers, and other invertebrates. Grey mullets, gizzard shads, flat fishes, many skates and rays are some of the fish which prefer to live on soft bottom and feed on bottom detritus. At low tide, when a large part of muddy bottom is exposed, crabs, mudskippers and" waders are seen in large numbers picking up their food which includes worms and different animals left behind by the receding tide.

B) PELAGIC COMMUNITY

Pelagic community includes powerful swimmers, which are exclusively carnivore in nature like predaceous fishes, croakers, snappers, barracudas, sharks, sea basses, carangids breams, perches, mackerels and sea snakes. Dolphin and seagulls are some important forms, which readily pick up fishes, shrimps, and cephalopods for food. In the mangrove ecosystem the predaceous forms are often small in size and easily wander among the mangroves at high tide.

C) ARTISANAL CRAB FISHERY

Local fishing community members from nearby village fish for mud crabs Scylla serrata during low tide. The mud crab burrows in mudflats in close proximity to the mangrove plantation. The locals excavate the soft mud with bare hands during low tide. The crabs are caught from their habitats and kept alive in moist gunny bags

a

b

Figure 5.29 (a) & (b:) Scylla serrata Mud crab found in the mangrove mud flat in PQA area.

c

d

Figure 5.29 (c) & (d): Local crab fisherman; excavating exposed mud flat at low tide to locate mud crabs and transporting them in live in wet gunny bags in PQA

(Figure 5.24 c & d). The gunny bag containing crabs are towed by a small wooden boat to be sold in the village for further processing and possibly for exports to foreign countries by the crab processing factory. The local earn their livelihood through the capture and sale of mud crabs.

D) CETACEANS

Dolphins have been sighted in the Korangi-Phitti-Gharo Creeks system and. The survey team did not see any dolphins in the area during the boat survey. There is no published information available with regards to the number of Cetaceans that visit the area.

Similarly, the team did not find any feeding turtles in the area nor any turtle tracks were found on the muddy shores. No turtle nest was observed. It is unlikely that the turtles would nest in muddy substrate, they prefer sandy substrates instead.

5.2.8.5 BIRDS POPULATION IN PQA

Korangi-Phitti-Gharo Creek system is reported to harbour 52 species belonging to 30 genera and 12 families as shown in table 5.38. The Populations of Pluvialis squatarola (Grey Plovers), Pluvialis apricaria apricaria (Golden Plover), Charadrius mongolus atrifrons (Lesser Sand Plover), Numenius arquata arquata (Curlew), Limosa limosa limosa (Bartailed Godwit) and Xenus cinereus (Terek Sandpiper) are fewer in numbers in Korangi/Phitti creek system than the birds observed in Shah Bundar area of the Indus delta.

I) ENDEMIC BIRDS OF INDUS DELTA

The mangroves of the Indus Delta provide abundant food and shelter to a number of endemic species of birds. The common birds are Oystercatcher, Lesser Sand Plover, Greater Sand Plover, Grey Plover, Golden Plover, Little Ringed Plover, Kentish Plover, Sanderling, Dunlin, Curlew, Whimbrel, Marsh Sandpiper and Common Sandpiper.

Breeding activities of a number of endemic birds have been reported in the coastal wetlands the Delta particularly Little Tern, Common Tern, Gullbilled Tern, Yellow legged Herring, Lesser Black backed Gull and Great Black headed Gull.

II) MIGRATORY BIRDS

The common migratory waterfowl of the lakes in the

Table 5.38: Biodiversity of bird fauna at Korangi/Phitti creek system

S.No.	Family	Genera	Species	Population Status		
				A	C	LC
1.	Phalacrocoracidae	1	2			2
2.	Pelecanidae	1	1			1
3.	Ardeidae	4	7		4	3
4.	Phoenicopteridae	1	1			1
5.	Accipitridae	3	4		3	1
6.	Charadriidae	7	18	1	9	8
7.	Recurvistridae	2	2		-	2
8.	Laridae	5	11		5	6
9.	Alecedinidae	3	3		3	
10.	Meriopidae	1	1		1	
11.	Motacillidae	1	1		1	
12.	Corvidae	1	1	1		
	30	52	2	26	24	

A = Abundant, C = Common, LC = Less Common *Source: Hasan (1996)*

Indus Delta include a variety of ducks including Dunlin, Redshank, Coot, White Pelicans, Flamingoes, and Spoonbills. The Indus Delta also provides refuge for the rare species of birds such as Painted Stork, White Stork, Greater Knot, Crane, Ruddy Shelduck (SURKHAB), Greyleg Geese, Common Shelduck and Marbled teal.

5.2.8.6 Marine Mammals

Marine mammals belong to the order Cetacea and include dolphins, porpoises and whales. In Pakistani waters 12 species of cetaceans have been recorded / observed, out of which 10 species have been recorded from Sindh (IUCN, 2005). The blue whale is an endangered species while humpbacked whale is vulnerable. The marine mammals recorded from Sindh are found in coastal and open ocean waters and do not inhabit in the vicinity of proposed site.

5.2.8.7 Endangered Species

The Phitti-Korangi-Gharo Creek systems had in the past a large population of Lingula, the representative of brachiopod occurring on muddy/sandy beaches of Sindh but now it is rarely seen. Similarly windowpane oysters

Figure 5.30: Greater flamingos between 70-80 birds in flight

were also commonly found in Korangi creek and adjoining areas. Presently none of these are easily found in this area and the extinction may be attributed to increase in pollution level in the vicinity of Korangi creek due to industrial and sewage pollution brought through Malir River, Gizri Creek and discharges from industrial areas and coastal villages of Landhi and Korangi etc. There is no designated park for conservation in this region and no endangered and rare species is reported from the proposed site.

5.2.8.8 Supra-tidal Community

Part of the coastal belt beyond tidal influence is dry and deserted and includes characteristic xerophytic plantation as shown in figures 5.31, 5.32 & 5.33. Through this part, land fauna enters the system for food and sometimes for shelter also. Land vertebrates constitute the major part of the community. Rodents, hares, squirrels and wild boars are herbivores, whereas snakes, lizards, cats, jackals and foxes are omnivores. Water and land birds are also found here which are to some extent omnivores, as also is the case with jackals and foxes.

5.3 Ambient Air, Noise Quality & Environmental Contamination

5.3.1 Ambient Air Quality & Noise Level

Records with respect to air quality and noise emission level are not available for the project location. Field data were generated to establish the baseline of ambient air quality at Korangi Fish Harbour, which represents the macroenvironment of PQA. There is not much development activity in the area. The only source of air contamination is the few fishing boats and trawlers emitting a limited amount of air pollutants which get dispersed immediately by the wind on the coastal area. Five samples for air quality at FAP terminal and one sample at EVTL Terminal were taken which represent the microenvironment of proposed Brown Field site.

5.3.2 Methodology and Equipment

Air and noise monitoring was conducted by SUPARCO mobile laboratory and personnel. The Mobile laboratory is equipped with online US EPA designated ambient air

Figure 5.31: Patches of terrestrial vegetation family Gramineae observed growing at high water mark level.

Figure 5.32: Patches of terrestrial vegetation family Gramineae observed growing at high water mark level

Figure 5.33: Patches of terrestrial vegetation family Chillopodaceae observed growing at high water mark level

analyzers for specific criteria pollutants. The international protocols were followed during the acquisition of ambient air pollutants data such as, monitoring site selection, distance of analyser/sampler above the ground and type of monitoring technique etc. Concentration of TSP/PM10, SO_2, CO, CO_2, and NOx was recorded along with meteorological parameters at each study site. The sampling interval of measurement was 15 minutes and monitoring was carried out continuously for 24 hrs at the site. One-hour means were calculated from 15 minutes data. The peak value in hourly mean has been recorded graphically.

5.3.3 Discussion on Ambient Air and Noise Quality Results

The average observed levels of Total Suspended Particulate (TSP) and PM10 were 173.6 $\mu g/m^3$ and 93.3 $\mu g/m^3$, respectively. These concentrations were well within the prescribed limits for TSP (260 $\mu g/m^3$ for 24 hrs) & PM10 (150 $\mu g/m^3$ for 24 hrs) of USEPA. The measured mean concentrations of gaseous pollutants were, 0.9 ppm for CO, 8.1 ppb for SO_2, 11.9 ppb for NOx and 300.8 ppm CO_2. All these levels of gaseous pollutants were well within limits of USEPA, WHO and World Bank. The major source contributing to the observed level of pollution were long distance transport of urban air pollution and from population centers as the monitoring site was downwind of these sites. The mean noise level at the site was 54 dB(A), which also shows the absence of any source of emission close to the proposed site. Furthermore the substantially strong winds have diluting and dispersive effect on the pervading pollution levels. The levels of air pollutants and noise at FAP terminal & EVTL sites are also within limits.

5.3.4 Environmental Contamination

On the eastern side of Karachi-- between Karachi and Keti Bunder- the area extending from Korangi/ Rehri Creek at the north-eastern side is known as the Korangi Creek which further extends to Phitti, Gizri, Khuddi, Khai, Pitiani, Dobbo, Sisa, Hajamro, Turshian and Khobar creeks. The Korangi-Phitti area is spread over about 64,000 hectares; it

comprises dense mangroves and tidal creeks, mud flats and sand. The distance between Bundal Island and Gharo at the farthest end is about 50 km.

Korangi creek is the worst affected area by pollution by the large-scale discharge of effluent from Korangi, Landhi, and Karachi Export Processing Zone and the residential areas. In the Korangi industrial areas, 2500 industrial units including 170 tanneries dispose of untreated waste into the sea.

Highly contaminated water flows from Cattle Colony in Quaidabad into the sea near Chashma goth and is a source of annoyance to people in Rehri. Oil discharge in the Port Qasim area as a result of shipping activities also affects marine communities. Additionally, large oil spills have been observed in the region that disrupt fishing activity, paralyse economic activity and eventually impact the local fishing community.

Port Qasim, located some 45km up the Phitti-Gharo Creek, is surrounded by mangrove forests, It is estimated from satellite imagery that in the PQA area (64,000 ha) there are 10,500 ha of dense mangroves, 4,645 ha of medium mangroves and 3960 ha of sparse mangroves. Mangroves are recognized as a critical ecosystem for coastal protection; as a breeding ground for many commercial fish species, especially shrimps; providing the coastal village economy with fuel wood, fodder and camel grazing grounds, and being an important destination for migratory bird species. There are plans to make the area fronting Rehri town an important eco-tourism location.

There are clear signs of stress in the mangrove ecosystem due to clear-cutting of mangroves, dumping of dredge spoils, ever-browsing by camels, frequent fodder collection, pollution and Eutrophication of the landward creeks. PQA has no management policy or activities related to the mangrove or coastal environment, although they have allowed Sindh Forest Department to carry out experimental plantations in the area.

Some parts of the PQ area are highly polluted from land based activities which include port operations, thermal effluents from Pakistan Steel and KESC power stations, the Landhi Cattle Colony, Sindh Alkalies plant (defunct), industrial and domestic wastes and the wastes discharged into Gizri Creek by the tannery and refinery effluents. The Korangi and Bakran Creeks are grossly polluted and suffering Eutrophication. The Landhi Industrial Estate and Korangi Industrial Area discharge more than 23 million gallon per day (mgd) effluent into the mangrove mudflats of the Korangi Creek whereas thermal pollution is increasing due to the discharge from the Steel Mills directly into the Gharo Creek.

The Phitti-Kadiro-Gharo creeks are less polluted, and the influence of pollution decreases as one moves away from the land. Overall, the creeks are relatively less polluted at present.

FOTCO is sited in a very sensitive ecological zone, right amongst the mangrove clusters. Whilst this may be the best site functionally, oil spills are the worst kind of pollution for mangroves. Over the course of time oil spills have not endangered the mangrove population as much as the development activities largely including the siting of jetties. Small segments of the mangroves have been removed by the scores of development activities related to establishment of jetties but the entrepreneurs including EVTL have responded by systematically planting the plantlets thus partly compensating for the loss of tree cover.

Table 5.39: Air Emission Standards and Guidelines

S.No.	Family		Genera		Species		Population Status	
	Averaging Time	Standard	Averaging Time	Standard	Averaging Time	Standard	Averaging Time	Standard
SO2	SO2	365ug/m3 (140 ppb)	24 HRS 1 HR	90 ug/m3 (34 ppb) 350 ug/m3	ANNUAL MEAN 24 HRS	100 ug/m3 (38 ppb) 500 ug/m3	ANNUAL MEAN 24 HRS	0 ug/m3 (38 ppb) 400 ug/m3
CO	CO	10 mg/m3 (9 ppm) 40 mg/m3	8 - HRS	10 mg/m3 (8.7 ppm)	-	-	-	-
NOx	NOx	100 ug/m3	1 HR	190-320 ug/m3 120 ug/m3	ANNUAL MEAN	100 ug/m3 (50 ppb)	ANNUAL MEAN	100 ug/m3 (53 ppb)
O3	O3	(53 ppb)	8 HRS1 1 HR	200 ug/m3	-	-	-	-
TSP	TSP	235ug/m3 260 ug/m3	24 HRS	150-230 ug/m3 -	ANNUAL MEAN 24 HRS	100 ug/m3 500 ug/m3	-	-
PM10	PM10	150 ug/m3	-		-	-	-	-

Table 5.40: Ambient Levels of Gaseous Pollutants and Noise Levels (for 24 hours) at Korangi Fish Harbour

	SO_2(ppb)	NOX(ppb)	CO_2 (ppm)	CO (ppm)	Noise(dB)	Wind Speed (m/s)	Humidity(%)
Min.	5	9	282	0.71	51	4.3	50
Max.	11	17	317	1.8	61	6.8	95
Avg.	8.1	11.9	300.8	0.9	54	5.8	74

Table 5.41: Ambient Levels of Particulate Matter (Total Suspended Particulate) TSP, & PM10

Date	Filter Paper No.	Time Duration	Time		Air Volume (m3)	Weight(g)			Conc. (µg/m³)
			Start	Stop		Before	After	Net	
12-09-07	S-003	24 hrs	11:00	11:00	1008	3.941	4.116	0.175	TSP 173.6
12-09-07	S-002	24 hrs	11:00	11:00	1008	4.018	4.112	0.094	PM10 93.3

Table 5.42: Ambient Levels of Gaseous Pollutants and Noise Levels (for 24 hours) at FAP Terminal Site

	Location 1	Location 2	Location 3	Location 4	Location 5
SO2(ppb)	32	30	36	34	36
NOX(ppb)	24	22	26	28	22
CO (ppm)	Nil	Nil	Nil	Nil	Nil
Noise	54	55	63	61	53

Table 5.43: Ambient Air Quality in the microenvironment of EVTL Existing Chemical Handling Terminal

NOx (ppb)				SO_2 (ppb)				CO (ppm)				PM10 (µg/m³)			
Max	Min	Avg.	NEQS	Max	Min	Avg.	NEQS	Max	Min	Avg.	NEQS	Max	Min	Avg.	NEQS
23	13	16.2	43 ppb	16	09	11.8	45	2.6	1.0	1.5	9	152	112	122.4	250

Table 5.44: Noise Levels in Project Area

S. No.	Location	Noise Level (dBA)	NEQS
1.	FOTCO Jetty	55	75
2.	FOTCO Trestle	43	75
3.	Tank Farm Area	49	75
4.	Kadiro Creek	59	75
5.	Port Qasim Road	51	75
6.	Korangi Fish Harbour	63	65
7.	Rehri Goth	58	55
8.	National Highway	87	65
9.	EVTL Jetty	42	75
10.	EVTL Trestle	47	75

06 Description Of Socioeconomic Environment

6.1 Socio-economic Profile of the Macroenvironment

The macroenvironment of concern for the consideration of socioeconomic and environmental of the LNG projects is outside of the safety and security zone recommended by PQA and international guidelines such as SIGTTO for siting the LNG terminals. The proposed site in side bay next to existing EVTL terminal in Gharo creek was evaluated for siting the terminal in sheltered locations, remote from populated areas and built environment. Within the limits of Port Qasim, and above the high water line, there is no residential area. However, adjacent to these limits there large urban settlements, including the PQA employees residential colony, Pakistan Steel Mills employees township Gulshane Hadeed across the National Highway, Union Council Ibrahim Haidery located at the mouth of Korangi creek, Chashma Goth, Rehri town, Lath Basti and Juma Goth. The coastal towns of Ibrahim Haidery, Rehri and Chashma Goth, as well as the deep sea fish harbour and salt works along the coast are spread over an area of over 18,000 hectares. They form an outlet for the industrial activities as well as industrial emissions and waste discharges due to which the physical, biological as well as human environment has been seriously degraded.

The proposed brown field site is located in side bay next to existing EVTL terminal in Gharo creek. This site faces the Qasim International Container Terminal (QICT) in the east and Gharo Creek in the east and south. Pipri Badal Nala (stream) flows into the coast on the north of this site. This nala ultimately fall into the Gharo creek located to the south of the proposed site. There are no villages or residential colonies inside the microenvironment in a radius of 5 km. The nearest human settlement from the proposed site is village Lath Basti which is 7 km west to the site. The dargah (shrine) of Noor Hasan Shah is located approximately at 9 km east to the site. Other settlements which lie in the north and northwest of the project area at more than 9 km are Goth Lal Mohammad, Goth Mohammad Keserani and Pipri Colony. The Port Qasim residential colony is located approximately 8 km northwest from the proposed site.

The macroenvironment have the built environment outside of the safety and security zone recommended by PQA and international guidelines such as SIGTTO for siting the LNG terminals. It is scattered over the coastal area of Bin Qasim District, which includes the Union Councils of Rehri and Ibrahim Haidery besides the two settlements of Chashma Goth and Lath Basti. It extends from the Korangi Creek on the North and along UC Ibrahim Haidery, Rehri, Chashma Goth, Korangi Fish Harbour, the deep sea fish harbour and salt works along the coast, Lath Basti and Juma Goth in the north; the FOTCO Jetty and Port Qasim Industrial Area in the northeast; the Steel Mills in the far east, and the large mudflat covered by mangroves forest in addition to the navigation channel of Port Qasim in the south.

At the Phitti Creek inlet (Approach Channel) there are four islands viz. Bundal Island, Buddo Island, Muchak Island and Khiprianwala Island. Buddo and Bundal Islands are the most prominent islands in Phitti Creek to the west of the Project site and at the entrance to Port Qasim. Buddo is about 6 km from Ibrahim Hyderi while Bundal Island is another 6 km from Buddo. Khiprianwala Island is located beyond 3.5 km of Ibrahim Hyderi. Buddo and Bundal islands are both fishermen's transit locations with a few clusters of huts. Buddo is lush green with rich mangrove plantation and provides the area for camel grazing and breeding. The 8 km long and 4 km wide Bundal Island is the largest island in the creek. Approaching from the opening to the sea, it has sand dunes but inland it has large clusters of mangrove trees. On proceeding further inland there are colorful flags hoisted indicating the presence of a shrine. An annual gathering is held here after Eid. The

Fisher Folk Forum claims that about 4,000 trips are made by fishing boats every day near the Bundal coast. The fisher folk forum claims that the deep water channel has narrowed down due to changes that have been effected in the navigation channel.

PQA has claimed jurisdiction over the two islands and had at one time considered the Bundal island as one of the potential sites for setting up LNG Terminal. This could not proceed further due to challenges on ownership from Sindh government. According to a letter sent on Sept 6, 2001 by EDO (Revenue) of Karachi "the ownership of these islands vests in the provincial government. In the past the government of Sindh has made allotments to DHA and PQA but these islands have not been allotted."

Ecology of the two UCs viz. Ibrahim Haidery and Rehri, which are the main constituencies of the macroenvironment of the proposed project site at Khiprianwala, has completely changed by having grown from villages dominated mainly by fishermen until the late 1950s with hardly 250 huts each scattered along the coast to attain the category of towns with population estimated by the local residents to exceed 50,000. Both of them are now the headquarters for Union Council Administration. Lath Basti and Chashma Goth have also grown from villages to small towns; they are both part of Rehri Union Council.

Residents of Ibrahim Haidery and Rehri were traditional fishermen involved in fishing business since the last few centuries. They have been joined by scores of migrants from coastal villages and towns like Shah Bunder and Keti Bunder on the east and west of Indus Delta respectively and also the Bangladeshis and Burmese who appeared here as cheap labor. Lath Basti on the other hand is home for the Jat tribe, who were traditionally engaged in cattle and camel farming. The Jat tribe had migrated from the interior of Sindh and has been residing at the present site of Lath Basti for the last seven or eight decades. Juma Goth with its Railway Station and a large plot of land, designated to house the KCR displaced population, lies between Cattle Colony and Port Qasim Employees Residential area.

Major human settlements in the macro-environment of the LNG terminal alternate sites are the several large and small rural villages and urban townships. Table 6.1 gives the estimated population of these villages.

6.1.1 DEMOGRAPHY

Population in the built environment of the alternate sites belongs to different clans and tribes. Traditionally, these clans/tribes had hereditary productive activities. For example, the Khaskhelis were agriculturists; the Jats were pastoral people, breeders of camels and suppliers of timber/fuel. The Memons and Shidis were merchants and traders, the Dablas were fishermen. These people served the clan communities and in exchange were maintained by them. All economic relations between the clans were those of barter. Cash transactions only took place between the Sardars (tribal chiefs) and Waderas (tribal elders) and through them with the outside world. This system guaranteed not only the economic independence of the village but also the supremacy of the feudal class.

Survey of the villages in macroenvironment reveals that "Old Jokhio" used to live there before the industrial developments.

Table 6.1: Population Data

S.#	Name Union Council	Areas/Description	Population as per Census of 1998
1	Ibrahim Haidery	Deh Ibrahim Haidery	43,583
2	Rehri	Deh Rehri & Ganhiaro	31,506

The population mix in UC Ibrahim Haidery is overwhelmingly Sindhi and Balochi speaking, followed by the Bengali-speaking people. Gulshan-i-Hadeed has a combination of all ethnicities with Sindhis forming the slightly larger group. Union Council Rehri is overwhelmingly Sindhi and Balochi and while the

number of other clans is almost negligible.

The cattle colony is the center of cattle and meat trade in Karachi. The Cattle Colony is the dairy products shopping and supply center of Karachi. Its population is overwhelmingly Punjabi.

scarcity of water. In Juma Goth and areas close to Cattle Colony extensive areas are under cultivation of vegetables using the effluent from the cattle yards. Livestock herding is not a healthy and reliable income generating option, and the few livestock holdings in the settlements are primarily

Table 6.2: Significant Population Centres in the Macroenvironment

S.No.	Location	Rural /Urban	Population (Approx.)
1	Port Qasim Colony	Urban	1,260
2	Wireless Colony	Urban	238
3	Gulshan-e-Hadeed	Urban	20,000
4	Steel Town	Urban	12,000
5	Nasirabad	Urban	12,500
6	Railway Marshaling Yard	Urban	2,500
7	Nishtrabad	Urban	1,400
8	Edu Goth	Rural	2,400
9	Pir Nau Goth	Rural	1,000
10	Razzakabad	Rural	3,500
11	Abdullah Goth	Rural	1,050
12	Ranju Goth	Rural	750
13	Kamran Khan Goth	Rural	325
14	Allah Dino Goth	Rural	230
15	Muhammad Raheem Goth	Rural	250
16	Mai Hur Goth	Rural	230
17	Abdul Latif Goth	Rural	200
18	Muhammad Saleem Goth	Rural	180
19	Morund Khan Goth	Rural	200
20	Mayo Khan Goth	Rural	150
21	Ali Khan Goth	Rural	270
22	Asmaj Goth	Rural	85
23	Ahmed Goth	Rural	78
24	Khan Muhammad Goth	Rural	120
25	Allah Bakh Goth	Rural	80
26	Abdul Rehman Goth	Rural	70
27	Abdul Raza Goth	Rural	80
28	Muhammad Ahsan Goth	Rural	80

6.1.2 EMPLOYMENT AND LIVING CONDITIONS

The macroenvironment does not offer opportunities for employment and the population is primarily employed as cheap unskilled labor force in the industrial areas of PQA. Agriculture is limited to subsistence farming due to

for household and domestic use, a source of dairy consumables. Skilled labor is rare and the categories of skilled laborers are mostly drivers, welders, plumbers and electricians. Government service is rarely available.

The population in the UCs can be broadly placed in three categories - fishing communities residing in small clusters of households down south along the coastline, labor class

and workers employed in the industries in the area, and very few white-collar workers. Majority being illiterate or lacking education, the people find employment either in subsistence farming or at best as casual and unskilled labor engaged in the surrounding industrial installations, with the Pakistan Steel, KESC Thermal power plant, Dewan/Pakland Cement factory and the Pakistan Railway Marshalling Yard being major employers. Numerous small villages in the UC have not been supplied with electricity despite the fact that high tension lines bring in power for numerous industries that have been established here.

Port Qasim colony, which is at a distance of about 8 kilometers from the brown field site, has a total estimated population of 2200 consisting of families of PQA's employees having average household comprising 8 persons. Port Qasim Colony has all the basic facilities of life including; electricity, telecommunication, gas, and drinking water. Transportation and access to main highway through the link road is available. Amenities and mosques are present. People working in PQA belong to low to high-income groups having average earning up to Rs 15,000 per month.

The population resident in UC Ibrahim Haidery and Rehri is totally dependent on low level engagements including fishing. The UCs surrounding the microenvironment of the proposed site at Khiprianwala, consist of scattered villages inhabited by old Jokhio tribe. Being farther away from the main highway they have not been provided with all the basic civic facilities and are among the underdeveloped areas of Karachi City District. The area is marked with poverty with average household income not exceeding Rs 7000.

The Settlements in the Korangi Creek area are fisherman's villages but the dwellers are engaged in other low level occupations as well. The employment and therefore earnings for a large section of population in the area is variable, heavily dependent on fisheries. Prawn, shrimp and crab fishing from inshore waters is the main source of income of the majority. However, quite a substantial segment of population is employed on deep-sea fishing boats. The relatively low level of income in this rural setting is reflected in the poor condition of housing, with water supply and sanitation being too inadequate. Some of these villages are now provided with electricity, connected by paved road and served by Public Transport.

6.1.3 Dependence on Mangroves

Mangroves are a valuable resource for many of the coastal villages. They are primarily used as a source of fuel and fodder and provide the feeding grounds for prawn and shrimp, besides protecting the land from erosion. The people have been overexploiting this resource over the years. IUCN has, in association with Sindh Forestry Department, initiated a program of mangrove conservation, replanting and sustainable management along the coastline of Rehri village. Engro Asahi Polymers has undertaken an extensive program of plantation of mangroves. They have a nursery where they cultivate the mangroves from the millions of propogules shed by the mature trees in the surrounding.

6.1.4 Education

Educational facilities in the surrounding area of the UCs Ibrahim Haideri and Rehri are limited to primary and secondary schools. Each village in the area has access to a primary school within a distance of three to four kilometers. There is also a high school in Ibrahim Haideri and Rehri that covers and meets the demands of nearby Deh. Availability and access to education may be regarded inadequate because of lack of efficient and effective schooling system to facilitate and promote literacy and education. Literacy rate among females is low, especially in adult females who are rarely literate.

Training in technical skills is inadequate. Skilled labor consists of drivers, mechanics, water pump attendants which are estimated to be less than 10 % of the total labor force. Thus the resident population in the immediate neighborhood is not capable of being employed in skilled category as might be perceived by the LNG Project in near future.

6.1..5 Health

Clean and safe water is one of the major problems being faced by the residents of UCs Ibrahim Haideri and Rehri.

Though the Karachi Water and Sewerage Board's pipelines bring in approximately 580 million gallons of water daily from the Indus river and Hub Dam to Karachi and route it through Bin Qasim Town, yet a majority of the villages have not been given water connections and have to depend on ground water and other sources including the unhealthy springs, for drinking as well as domestic purposes.

Health problems of the UCs Ibrahim Haideri and Rehri are generally associated with water availability and quality aggravating sanitary conditions due to lack of facilities and reliable water supply. Health facilities are inadequate and sub-standard. Both UCs have one Basic Health Unit (BHU) and a primary health care unit (PHCU) but both units are understaffed and not well-equipped. For advanced medical aid treatment cases are referred to health centres at Quaidabad or city centres of Karachi.

6.1.6 LANDSCAPING

The terrestrial environment around the UCs consists of sparse scrub and a few trees of Acacia nilotica, with some grazing from domesticated animals including camels, goats and cattle. The land adjacent to the coastline has deposits of poorly sorted, unconsolidated loose gravel, sand and silt. It has sand bar deposits comprising medium to coarse sand, which is being exploited for cut-and-fill in the construction industry, and for land preparation for the industrial zone and for reclamation of land area on extensive areas in the south. This has disturbed the landform during and has irreversibly changed the landscape of the near-shore area.

6.1.7 TRANSPORTATION NETWORK

The built environment of the Project is served by the developed infrastructure of Port Qasim industrial area, Port Qasim International seaport, National highway and also the rail network which connect the macroenvironment with the city centre of Karachi and other cities of the country.

The composition of traffic is similar to other sections of National Highway passing through rural areas. Heavy traffic includes trailer, trucks and tankers that dominate the overall traffic stream. Road network within Port Qasim Industrial Zone is superior to other industrial estates in Karachi and roads are wide enough to support all types of vehicular traffic movement.

6.1.8 INDUSTRIES

Presently 176 industrial units are operational at PQA industrial area and about 278 industries are in different stages of development.

6.2 ARCHAEOLOGICAL AND HISTORICAL SITES

A review of investigations in the Port Qasim area and a visit to the macroenvironment of the alternate sites, did not indicate existence of any feature or structure of cultural significance or of archaeological interest within the area of the proposed activity. There is a grave of a certain saint Baba Kamal Shah about 8 km on the northwest of project area, said to be attracting some devotees. Shallow sweet water well near the shrine is an attraction for the devotees. These features, however, do not suggest that the place has any historical or cultural significance. The nearest archaeological sites of ancient Port of Debal and the town of Bhambore are about 18 kms NW of the site. The graveyard of Chowkhandi is 15 km from the project site.

6.3 LNG RELATED HAZARD ZONES AND POPULATION DISTANCES

Sandia National Labs has defined the outer limits of the three hazard zones discussed in their report: Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water. These criteria are listed in Table 6.3. The criterion used to define the outer limits of Zone 1 and Zone 2 is incident heat flux, i.e., thermal radiation that would be expected from an intense LNG vapor fire. Within Zone 1, the thermal radiation can cause serious injuries or significant damage to structures. Within Zone 2, thermal radiation can cause injuries or some damage to structures. The outer limit of Zone 3 is defined

based on the lower flammability limit of LNG vapor, i.e., when the concentrations of natural gas and oxygen does not have enough fuel to burn. Within all three zones, the level of risk is reduced as the distance from the source increases.

Table 6.3: Definition of Hazard Zone Boundaries

Zone	Criteria (10 minute exposure time)	Distance	Basis
Zone 1	37.5 kW/m²*	500 m	High potential for major injuries or significant damage to structures
Zone 2	5 kW/m²	1600 m	Potential for injuries and some property damage
Zone 3	Lower flammability limit (5%)	3500 m	Outer limit where LNG vapor can be ignited

Source: Sandia Report
*Note: *Kilowatts per square meter*

The severity of impacts within Hazard Zones 1 through 3 would depend on the location of the incident relative to a specific area, the scope of the incident, and whether or not the released LNG ignited or dispersed. This could be a significant impact, being most severe in Hazard Zone 1 and decreasing outward through Hazard Zones 2 and 3. However, because of the implementation of safety and security measures during marine transit, the likelihood of marine LNG spill is extremely remote.

None of the population centre listed above (Table 6.2) is located within or near the hazard zones identified by Sandia. Similarly, the pipeline route would be preferred which raises minimum social and environmental issues.