Hagler Bailly Pakistan

July 8, 2011

Final Report

HBP Ref: R1V08STR-A

Environmental and Social Impact Assessment

Star Power 133.5 MW Combined Cycle Power Plant

Star Power Generation Limited, Lahore

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Executive Summary

Star Power Generation Limited (SGPL), subsidiary of Pakistan Power Resources LLC. (PRR), intends to install a 133.5 MW gas-fired combined cycle power plant in District Ghotki of Sindh Province (see **Exhibit I**). The services of Hagler Bailly Pakistan (Pvt.) Ltd. were acquired for the preparation of this environmental assessment of the Project, required to meet the regulatory requirements of the country and the International Finance Corporation (IFC). Under the Pakistan Environmental Protection Act 1997 an initial examination (IEE) report of the proposed power plant project is to be submitted to the provincial environmental protection agency which will be the Sindh Environmental Protection Agency (SEPA). Under the requirements of IFC an Environmental and Social Impact Assessment (ESIA) report of the proposed project needs to be prepared and submitted to the IFC for funds approval. The environmental assessment report was prepared according to the environmental standards recognized by the international financing institutions as described in the performance standards and environmental guidelines of the IFC and the Equator Principles.

Project Description

The proposed plant site located about 5 km from the town of Daharki. The proposed plant site, owned by the project, is currently used for agricultural purposes by the local communities.

The plant will operate on low-calorific value natural gas from the Mari Deep gas field located about 15 km from the proposed site. The gas field is operated by the Mari Gas Company Limited (MGCL). The power plant will have two gas turbines, two associated heat recovery steam generators, and one steam turbine. The power produced from the plant will be exported by transmission line to be installed by the National Transmission and Dispatch Company (NTDC).

Effluents from the plant will be neutralized to the National Environmental Quality Standards (NEQS) and IFC guidelines for thermal power stations, while sanitary waste will be treated in a closed system. The treated effluent will be used for irrigation or arboriculture.

Recyclable solid waste will be segregated where possible and sold to local contractors. Hazardous material will be isolated and managed under compliance with international standards. Other solid waste will be landfilled in compliance with local standards.

Gaseous emissions from the plant will mainly be combustion gases from the plant's stacks and will be within the applicable environmental standards.

During the construction phase of the Project it is estimated that during the peak construction period 600 personnel will be working on the plant site. Once the plant is operational the staff requirement for plant operations will be 76. The Project will take about 30 months for construction.

Regulatory Requirements

The Pakistan Environmental Protection Act (PEPA), 1997 is the principal law enabling the government to enact regulations for the protection of the environment. The key features of the law that have a direct bearing on the proposed project include compliance requirements with respect to the National Environmental Quality Standards (NEQS) and the requirement to conduct an environmental impact assessment (EIA) or initial environmental examination (IEE) prior to the construction of any project.

Description of the Environment

The description of the natural and socio economic environment is briefly described as follows.

Natural Environment

The Project location is surrounded by cultivated land. Soil types range from dark brown sandy loam in most places to light-brown sand in others. Topography of the plant site and surroundings is generally flat.

The main canal in the area is the Ghotki Feeder Canal. Channels originating from the Gohtki Feeder Canal are Mahi Wah[1], Dahar Wah Upper, Sehar Wah, Naseer Minor, Reti Minor, Narli Minor and Rind Minor. Infiltrated seepage from Dahar Wah Lower and Dahar Wah Upper will serve as the main sources of water for the proposed project activities.

In general, the groundwater table in the Study Area is in the range 11-14 m (35-45 feet) below ground surface. However, in the area near the plant site, the water table was reportedly in the range of 14-17 m (45-55 ft) below ground level.

Groundwater in most of the Study Area contains high levels of dissolved salts.

The climate of the Study Area is broadly described as hot and arid. It receives approximately 88 mm of rain annually mostly in the monsoon months of July and August.

Major industrial setups—such as Engro Fertilizers Limited, Mari Gas Company, Fauji Fertilizers Limited, and TNB Liberty Power—are the significant stationery sources of gaseous emission in the Study Area. Trains of Pakistan railway and vehicular traffic are the other significant mobile sources of emissions.

No endemic or rare floral species exist in the Study Area. All species have wide ranges of distribution.

No threatened or vulnerable animals, birds and reptile species have been reported and only common and adaptable animal species are found from the Study Area.

Socioeconomic Environment

For the socioeconomic study, the Study Area includes area lying within 5 km radius of the proposed site and 500 m either side of the gas pipeline route. Administratively, the

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[1] *Wah* is Sindhi word for canal.

Study Area falls in Daharki and Mirpur Mathelo *talukas* in the Ghotki district of Sindh province.

Twenty one settlements were visited during the field survey in the Study Area. The total population of the surveyed villages is approximately 54,000. The average household size in the Study Area is 7. There is a potential workforce of about 9,000 people in the Study Area. Most of the houses in the Study Area are *kacha* (made of clay).

Most residents of the Study Area speak Sindhi. The major tribes of the area are *Bhutto, Samejo, Soomroo, Shaikh, Chacharh, Meghwawr, Machi, Malik, Syed, Sharr* and *Dahar*.

Majority of the people area engaged in agriculture. Only a few persons own big holdings. The rest are either landless *haris* or petty *khatedars* who live from hand to mouth. The principal crops of the Study Area are sugarcane, wheat, cotton, rice, maize, bajra, gram, barley etc. Canals are the main source of irrigation water in the Study Area; water from these canals is extracted using generator operated lift systems.

Groundwater is an important source of drinking water in the Study Area. Almost every house in the area has a hand pump.

Major health problems in the area are gastroenteritis, acute respiratory infection (ARI), Hepatitis B and C and malaria. There are no basic health facilities in the surveyed villages of the Study Area. People of these villages usually go to nearby Ubauro or Daharki for medical attention.

The literacy rate according to the census report of Ghotki is 44.21% of the men and 11.85% of the women are educated (Population Census Organization, 2000).

All the villages in the Study Area have electricity. Paved roads access is available in most of the Study Area. Vans, pickups, and buses provide regular transport service in the area. Gas supply is available only in the villages located near the national highway N-5.

Most decisions are made by the *Wadera* (tribal leader). People go to courts or consult the police usually only as a last resort.

No archaeological sites were observed in the Study Area during the field survey. However there is a shrine near Village Nur Hasan Shah which is frequently visited by people of the study area and adjoining areas.

Stakeholder Consultation

In the consultation process for this ESIA, following key stakeholders were consulted:

- Local communities: Men, women and village elders attended meetings.
- Sindh Irrigation and Drainage Authority (SIDA)
- Sindh Rural Support Organization (SRSO)
- Engro Fertilizers Limited (EFERT)
- National Commission for Human Development (NCHD)

An introductory leaflet was prepared for distribution amongst the participants of consultation meetings in which a brief overview of project activities and its likely social

and environmental impacts was provided. Majority of the participants of the consultation process supported the installation of the power plant project.

Potential Project Impacts and Mitigation

The potential environmental and social impacts of the proposed activities are assessed using the standard impact assessment methodology. It starts with scoping, through which potential environmental issues associated with the proposed project are identified. This is followed by definition of the criteria for determining significance of the impact, prediction of the magnitude of the impact, assessment of significance, identification of mitigation measures to reduce the adverse impacts to acceptable levels, evaluation of residual impacts, and identification of monitoring requirements.

The main impacts associated with the construction phase of the project are shown in **Exhibit II**. The exhibit also shows the criteria for determining significance and the key mitigation measures proposed to minimize the impacts.

Apart from this environmental impacts that have been discussed and for which mitigation measures have been proposed include: drainage and storm water run-off, camp effluent, and impact on wildlife and vegetation. Other social impacts such as impact on cultural resources and impact on archaeological resources are also evaluated.

The main impacts associated with the operation phase of the project are shown in **Exhibit III**. Other minor environmental impacts that have been discussed and for which mitigation measures have been proposed include disposal of operation related wastewater, and management of hazardous material.

The impact of the project on the ambient air quality of the study area has been assessed using air dispersion model. No significant impact on the ambient air quality is predicted.

Conclusion

After assessing the significance of the potential impacts, the environmental consultants, Hagler Bailly Pakistan, have concluded that, if the proposed project activities are conducted as proposed and described in this report and the recommended mitigation and environmental management measures are properly implemented, the project will not result in any long-term or significant impacts on the local community or the environment. The project will also comply with all relevant statutory requirements and standards.

Exhibit I: Project Location

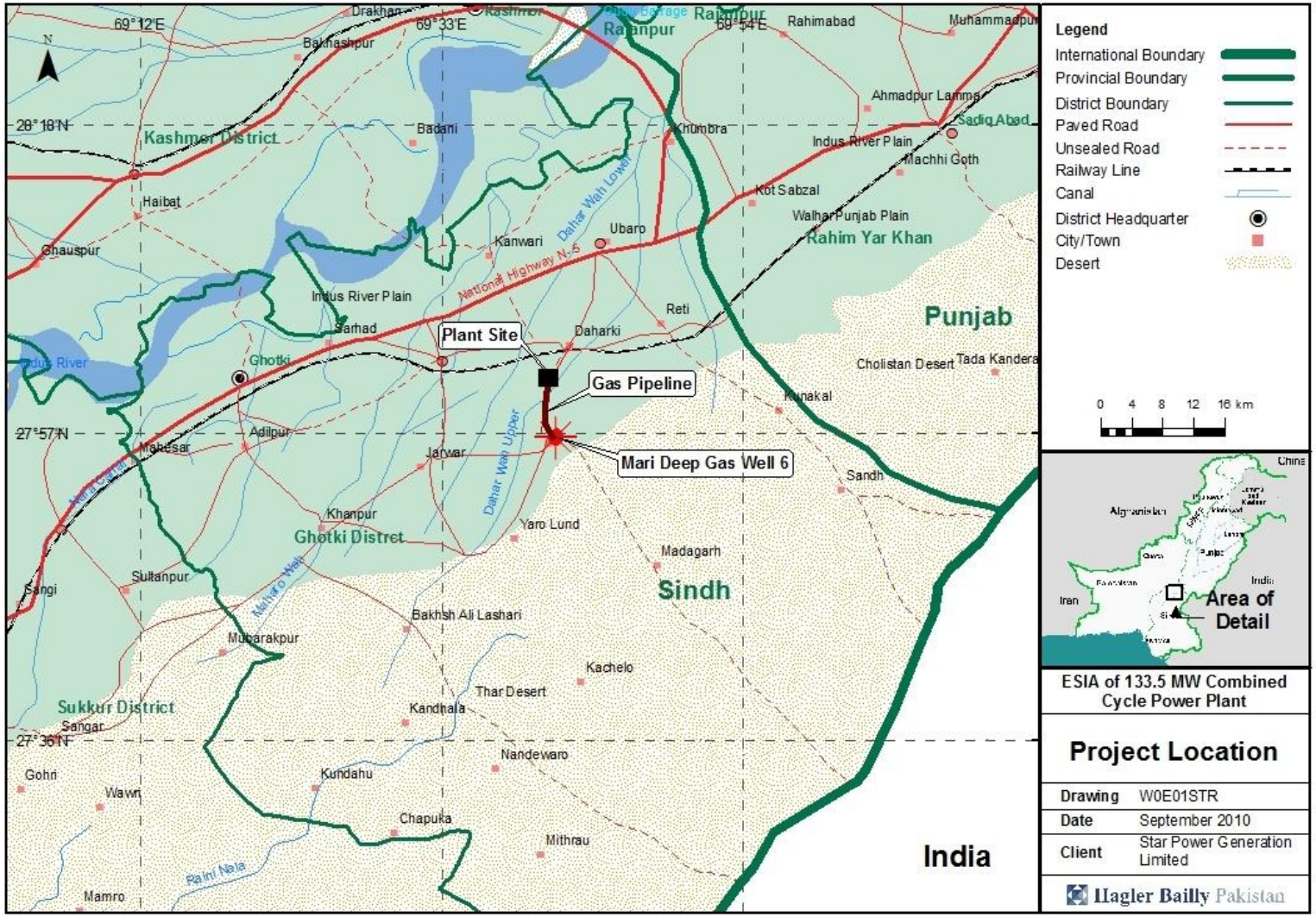

Exhibit II: Summary of Environmental and Social Impact of the Construction Phase

Potential Impact	*Description of Potential Impact*	*Criteria for Determining Significance*	*Mitigations*
Environmental Issues			
Construction Noise—Disturbance to surrounding communities of power plant due to operation of construction machinery at the plant site	Disturbance to communities in surrounding areas of the proposed plant site due to construction machinery operation	The NEQS for noise and IFC guidelines for noise require that the sound level in residential areas should not exceed 55 dB(A) during the day and 45 dB(A) during the night	▸ Reduction of equipment noise at source ▸ Conduct pre operation noise survey ▸ Prepare noise control plan ▸ Pre-construction noise survey of the construction equipment ▸ Select low noise equipment for the power plant ▸ Minimization of vehicular noise ▸ Training of all staff members for the use of PPE (Personal Protection Equipment)
Emissions—Particulate matter, NO_x and SO_x emitted during construction activities can result in deterioration of ambient air quality in the vicinity of the source, and be a nuisance to the community.	Dust—nuisance to surrounding communities of the proposed plant due to emission of dust during construction on the plant site Vehicle and equipment exhaust—Combustion exhaust from vehicles and construction can affect the ambient air quality of the Study Area	An increase in visible dust beyond the boundaries of the proposed power plant due to the activities undertaken at the plant site, or on the access road Adverse impact on community assets, or There are persistent complaints from the community or the vehicles are not in compliance with the NEQS for vehicles	▸ Sprinkling of water on unsealed surfaces for dust suppression ▸ Use of wind shield around aggregate and soil stockpiles ▸ Covering of material piles ▸ Restrictions on speed on unpaved roads ▸ Transportation of material in covered trucks and speed limits strictly observed ▸ Safe distance between the batching plant and the community ▸ Stockpiles will be placed at least 250 m from the community ▸ All vehicles and equipment will be properly tuned and maintained

Potential Impact	*Description of Potential Impact*	*Criteria for Determining Significance*	*Mitigations*
Soil and Water Contamination— Different types of effluents, solid waste and hazardous material may contaminate the water and soil resources of the Study Area	Untreated wastewater and other effluents from the construction activities may contaminate the water resources of the Study Area Hazardous materials and non hazardous waste if disposed of into the surroundings may contaminate the soil and water resources of the Study area	If the run off contains visible quantities of oil and grease and contains silt above NEQS levels or if it flows towards the community If any NEQS and IFC non compliant effluent is released to the environment If any person is exposed to hazardous waste generated from project related activities Disposal of waste outside designated areas	▸ Use of spill prevention trays and impermeable sheets to avoid soil contamination ▸ Storage of fuels, chemicals and lubricants in bounded areas with impervious flooring ▸ Emergency Response plan will be developed for hazardous substances ▸ Equipment and material containing asbestos, poly-chlorinated biphenyls (PCBs), and ozone depleting substances (ODSs) will not be used ▸ Material Safety Data Sheet (MSDS) will be maintained
Socioeconomic Issues			▸
Community Safety— Safety hazards associated with the construction activity, particularly the increase in traffic on the plant site access road	The proposed construction activity can potentially be a safety hazard for the community. In particular, the increase in construction related traffic on the proposed Project access road.	A significant community hazard will also be considered, if a condition is created during the construction activity that would be considered a safety hazard in a standard occupational and safety health assessment	▸ A public safety plan will be developed ▸ A speed limit of 20 km/h will be maintained on the proposed access road ▸ Nighttime driving of Project vehicles will be limited where possible ▸ Community complaint register and other means will be adopted for the community to complain about non-adherence of Project traffic to speed limits, safe driving and other safety-related concerns ▸ Work areas outside the proposed plant site, especially where machinery is involved will be roped off and will be constantly monitored to ensure that local people, especially children stay away

Potential Impact	*Description of Potential Impact*	*Criteria for Determining Significance*	*Mitigations*
Employment Conflicts— Conflicts may arise if the nearby communities feel that they are not given substantial share in project related job opportunities	The potential employment related issue includes dissatisfaction among local communities over the number of jobs offered to them, disagreement on definition of 'local' and also on distribution of jobs within the local community	A significant impact will be interpreted if the proportion of available unskilled jobs offered to the locals in the immediate area is less than around 50%	▸ Maximum number of unskilled and semi-skilled jobs will be provided to the local communities ▸ A local labor selection criterion will be developed in consultation with the community

Exhibit III: Summary of Environmental and Social Impact of the Operation Phase

Potential Impact	*Description of Potential Impact*	*Criteria for Determining Significance*	*Mitigations*
Environmental Issues			
Plant Noise	Unacceptable increase in noise levels in the communities	The NEQS for noise and IFC guidelines for noise require that the sound level in residential areas should not exceed 55 dB(A) during the day and 45 dB(A) during the night	▸ Low noise equipment will be preferred ▸ Fans for cooling tower will be of low noise type ▸ Silencers will be used on vents and ventilators ▸ Noise levels will be monitored regularly within the communities in order to take timely corrective measures, if needed
Plant Effluents	The power plant is expected to generate liquid effluents in the form of oily water, washing water, blow down water, treatment system effluent and sanitary wastewater	No discharge of untreated effluent to the environment or the canals	▸ The power plant water treatment system will be designed to ensure that the wastewater meets NEQS before it is drained into the drainage channels or used for arboriculture ▸
Emission	Emission from the plant can potentially affect air quality	NEQS and the IFC Thermal Power Plants Emission Limits	▸ No specific mitigation measures required
Water Resources	An adverse impact on the water resources will be interpreted if it is established that the water consumed by the Project has directly affected the ability of the community to meet their water needs	The extraction of water for the power plant construction activities can affect the groundwater availability for the Study Area communities	▸ SPGL will bore tube wells designated for its requirements along the outslope of perennial canal Dahar Wah Lower and Dahar Wah Upper ▸ Approval from Sindh Irrigation and Drainage Authority (SIDA) will be obtained for installation of water supply wells, approval is required in case the wells are within 300 m either side of major canal and 200 m either side in case of minor or distributory ▸ Initiation of a water conservation program

Potential Impact	*Description of Potential Impact*	*Criteria for Determining Significance*	*Mitigations*
Hazardous and Non-Hazardous Waste	Various types of wastes such as packing waste, metal scrap, and excess materials, uprooted vegetation, and excess soil will be generated during the construction phase. Besides being an eyesore, the waste can be a health hazard and pollute waterways, if disposed improperly	Material Safety Data Sheets (MSDS)	▸ Storage and handling of hazardous materials in accordance with international standards and appropriate to their hazard characteristics. ▸ Labeling of all storage vessels ▸ All hazardous waste will be separated from other wastes ▸ Availability of supporting information such as the MSDS ▸ A Hazardous Materials Register to be in place.
Waste Management	Waste generated during power plant operation can potentially damage the environment	Any person is exposed to potentially hazardous waste generated by the Project Project generates waste that can be avoided through practicable means (waste minimization) Reusable waste generated by the Project is discarded Recyclable waste instead of separation at the source is dumped at the trash bins Non-recyclable and non-reusable waste ends up at any place other than the designated landfill site.	▸ Separation of recyclable materials ▸ Regular audits of waste management system ▸ Maintenance of a Waste Tracking Register ▸ Separation of hazardous waste from non-hazardous waste. ▸ On-site segregation and initial storage of hazardous waste ▸ Off-site disposal of hazardous waste in approved hazardous waste disposal facility. ▸ Recyclable waste to be disposed via waste contractors ▸ Audits of the waste disposal contractors and waste disposal facilities ▸ Develop an emergency response plan for the hazardous substances ▸ Training of personnel in identification, segregation, and management of waste ▸ Appropriate labeling of all containers of hazardous waste

Abbreviations

ADB	Asian Development Bank
AFS-CV	Atomic Fluorescence Spectrophotometer (Cold Vapor Technique)
ASL	Air Sampling Location
BDL	Below Detection Limit
BHU	Basic Health Unit
BOD	Biological Oxygen Demand
CFC	Chlorofluorocarbon
CO	Carbon monoxide
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
CSSS	Canadian Society of the Soil Science
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ESIA	Environmental and Social Impact Assessment
GIS	Geographical Information System
GoP	Government of Pakistan
GPS	Global Positioning System
GT	Gas Turbine
HBP	Hagler Bailly Pakistan
HGAAS	Hydride Generation Atomic Absorption Spectroscopy
HRSG	Heat Recovery Steam Generator
HSD	High Speed Diesel
ICP-OES	Inductively Coupled Plasma (Optical Emission Spectrophotometry)
IEE	Initial Environmental Examination
IFC	International Finance Corporation
ISE	Ion Exchange Electrode
LoI	Letter of Intent
LoS	Letter of Support
MGCL	Mari Gas Company Ltd.
MSDS	Material Safety Data Sheets
NCHD	National Commission for Human Development
NCS	National Conservation Strategy
NE	North-East
NEPRA	National Electric Power Regulatory Authority
NEQS	National Environmental Quality Standards

NGO	Non-government Organization
NO_X	Oxides of Nitrogen
NTDC	National Transmission and Dispatch Company
ODSs	Ozone Depleting Substances
OGDCL	Oil and Gas Development Corporation Ltd
Pak EPA	Pakistan Environmental Protection Agency
PCBs	Poly-chlorinated biphenyls
PEPA 1997	Pakistan Environmental Protection Act, 1997
PEPC	Pakistan Environmental Protection Council
PM	Particulate Matter
PM_{10}	Particulate Matter Smaller than 10 micron
PPIB	Private Power Infrastructure Board
PS	Performance Standards
PTCL	Pakistan Telecommunication Limited
RHC	Rural Health Centre
SEPA	Sindh Environmental Protection Agency
SIDA	Sindh Irrigation and Drainage Authority
SO_X	Oxides of Sulfur
SO_2	Sulphur Dioxide
SRSO	Sindh Rural Support Organization
SW	South-West
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
WAPDA	Water and Power Development Authority
WB	World Bank
WHO	World Health Organization

Units

°C	Degree Celsius
µg/m^3	Microgram per Cubic Meter
µg/Nm^3	Microgram per Normal Cubic Meter
µS/cm	Micro Siemens per Centimeter
BTU	British Thermal Unit
BTU/scf	British Thermal Unit per Standard Cubic Foot
cusecs	Cubic Meter per Second
dB(A)	Decibel (A-rated)
ft	Foot
ha	Hectare
kg	Kilogram
kg/s	Kilogram per Second
Kg/Hour	Kilogram per Hour
Kg/MWh	Kilogram per Mega Watt-Hour
Leq	Equivalent Sound Level
Lmax	Maximum Sound Level
km	Kilometer
m	Meter
m^3	Cubic Meter
m^3/s	Cubic Meter per Second
mg/l	Milligrams per Liter
mg/kg	Milligram per Kilogram
mg/Nm^3	Milligrams per Normal Cubic Meter
mm	Millimeter
MMScfd	Million Standard Cubic Feet per Day
MW	Mega Watt
ng/J	Nanograms per Joule
Nm^3/h	Normal Cubic Meter per Hour
ppm	Parts per Million
s	Second
tcf	trillion cubic feet

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1. Introduction

Star Power Generation Limited (SGPL), a subsidiary of Pakistan Power Resources LLC. (PRR), intends to install a 133.5 MW gas-fired combined cycle power plant (the 'Project') at Daharki in District Ghotki of Sindh Province, Pakistan (see **Exhibit 1.1**). The services of Hagler Bailly Pakistan (Pvt.) Ltd. were acquired for the preparation of this environmental assessment of the Project, required to meet the regulatory requirements of the country and IFC. This document has been prepared to meet the following key requirements:

- The initial environmental examination (IEE) as required by the Pakistan Environmental Protection Act 1997 for submission and approval by Sindh Environmental Protection Agency (SEPA).
- The environmental and social impact assessment (ESIA) complying with the environmental guidelines of the International Finance Corporation (IFC) and meeting the performance standards of the IFC for submittal to financing agencies.

In this document, a generic term *Environmental Assessment* has been used for ESIA and IEE.

1.1 Project Overview

Until relatively recently, electrical power production, transmission, and distribution have been the domain of the public sector in Pakistan. Since 1994, however, due to insufficiency of state resources to meet rapidly rising demand, the Government of Pakistan (GoP) has opened the sector for private sector investments. The Star Power Project is being setup under the GoP's policy favoring independent power producers (IPPs) for thermal power generation. The Letter of Intent (LoI) for the Project was originally issued to the Project in February 2004.

The proposed plant will operate on low-calorific value natural gas from the Mari Deep gas field located about 12 km from the proposed site. The gas field is operated by the Mari Gas Company Limited (MGCL). The power plant will have two gas turbines, two associated heat recovery steam generators, and one steam turbine. The power produced from the plant will be exported by transmission line to be installed by the National Transmission and Dispatch Company (NTDC). The Project will take about 30 months for construction, and is expected to be commissioned in 2013.

1.2 Project Proponents

SPGL is owned and operated by PRR, which is a limited liability company organized under the laws of the United States of America. PPR is owned by the Associated Group (AG) and Walters Power International, LLC (WPI). AG is organized under the laws of Pakistan while WPI is organized under the laws of the United States of America. AG and WPI hold 65% and 35% shares of PPR, respectively.

AG, founded in 1965, is one of Pakistan's premier business houses in the energy sector. Within the energy sector, AG has three lines of business—liquefied petroleum gas (LPG), power generation, and liquefied natural gas (LNG). The flagship company of AG is Jamshoro Joint Venture Limited (JJVL) which is a state-of-the-art LPG extraction plant. In 2006, AG was awarded the leasehold rights to rehabilitate the 150-MW coal-fired Power Plant at Lakhra. The company is also developing what will be Pakistan's first LNG terminal at Port Qasim, Karachi.

WPI is a global provider of local power. WPI and its affiliated companies combine the expertise of independent power professionals with unparalleled international experience, extensive international networks and the financial resources to develop power projects and associated technologies around the world. WPI supplies, develops, services and manages electrical generation power plants around the world. Formed in 1995, WPI and its affiliated companies have combined the expertise of independent power professionals with the resources of individual and institutional investment funds to develop and supply more than $200 million in power projects in more than 20 countries. The Company is based in Oklahoma, USA.

PPR is now constructing the 51 MW Naudero I Power Plant using open-cycle gas turbines. PPR has also been awarded the 50 MW Naudero II, the 205 MW Jamshoro, the 192 MW Multan and the 110 MW Guddu projects.

1.3 Study Area

The 'Study Area' refers to the geographical area in which activities related to the construction and operation of the plant are proposed to take place or in which the environmental impact of these activities are likely to occur. Unless otherwise specified or implied by context, the term 'Study Area' will refer to the area within a radius of 5 km from the proposed plant site and 250 m of the buried gas pipeline (**Exhibit 1.2**).

1.4 Introduction to the EA

This EA is conducted to meet the regulatory requirements of Pakistan and the financing agencies, in particular the IFC and the US Overseas Private Investment Corporation (OPIC).

1.4.1 Objectives of the EA

The objectives of this environmental assessment are to:

- Assess the existing environmental conditions in the Study Area, including the identification of environmentally sensitive areas.
- Assess the proposed activities to identify their potential impacts, evaluate the impacts, and determine their significance.
- Propose appropriate mitigation and monitoring measures that can be incorporated into the design of the proposed activities to minimize any damaging effects or any lasting negative consequences identified by the assessment.
- Assess the proposed activities and determine whether they comply with the relevant environmental regulations of Pakistan.

The findings of the environmental assessment is to be documented in the form of report which is to be submitted to the international financing institutions as ESIA and to SEPA as IEE.

1.4.2 Scope of the EA

This environmental assessment report evaluates the physical, biological, and socioeconomic impact of the following:

- Construction activities at the proposed site
- Relevant off-site construction activities
- Operation of the plant.

The environmental assessment does not cover construction and operation of the associated power export transmission line.

1.4.3 Methodology

The environmental assessment was conducted in the manner outlined below.

Scoping

A scoping exercise was undertaken to identify the potential issues that are to be considered in the environmental assessment. The scoping exercise included the following tasks:

Project data compilation: A generic description of the proposed activities relevant to this environmental assessment was compiled with the help of the Project proponent.

Published literature review: Secondary data on weather, soil, water resources, wildlife and vegetation were reviewed.

Legislative review: Information on relevant legislation, regulations, guidelines, and standards was reviewed and compiled.

Identification of potential impacts: The information collected in the previous steps was reviewed and potential environmental issues identified.

Initial site visit: An initial site visit was conducted to get an overview of site conditions and the surrounding areas.

Stakeholder consultation: A stakeholder consultation was undertaken to document the concerns of the local community and other stakeholders, and to identify issues that may require additional assessment in order to address these concerns.

Baseline Data Collection

A considerable amount of baseline information on the Study Area was available from the environmental studies previously conducted in the region for other projects. A detailed environmental baseline survey was conducted to collect primary data on the proposed site and surrounding areas and to help identify sensitive receptors. The aspects that were covered during the survey included:

- Community and socioeconomic indicators

- Ground and surface water quality
- Hydrology
- Air quality
- Traffic
- Sensitive receptors
- Ecology
- Noise, and
- Soil.

Impact Assessment

Each of the potential impacts identified during the scoping phase was evaluated using the environmental, socioeconomic, and project information collected. Wherever relevant, quantitative models were used to predict the potential impact. In general, the impact assessment discussion covers the following aspects:

- The present baseline conditions
- The potential change in environmental parameters likely to be affected by Project-related activities
- The prediction of potential impacts
- The evaluation of the likelihood and significance of potential impacts
- The defining of mitigation measures to reduce impacts to as low as practicable
- The prediction of any residual impacts, including all long- and short-term, direct and indirect, and beneficial and adverse impacts
- The monitoring of residual impacts.

Documentation

The EA process and findings have been documented in this report for submission to the regulatory and financing institutions.

1.5 Organization of the EA Report

Section 2 (*Policy, Statutory, and Institutional Framework*) briefly discusses existing national policy and resulting legislation for sustainable development and environmental protection, and then presents the legislative requirements that need to be followed while conducting an ESIA.

Section 3 (*Project Description*) will describe the proposed Project.

Section 4 (*Project Alternatives*) will present the project alternatives that were considered, and the reasons for their selection or rejection.

Section 5 (*Description of the Environment*) will document in detail the Study Area's existing physical, biological, and socioeconomic conditions, including geomorphology and soils, water resources, and air quality, flora and fauna, and demography.

Section 6 (*Public Stakeholder Consultation*) will present the objectives and outcomes of the public stakeholder consultation that was conducted during the present ESIA.

Section 7 (*Project Impacts and Mitigation*) will present an assessment of the Project's impact to the physical, biological, and socioeconomic environment, as well as the required mitigation measures.

Section 8 (*Social and Environmental Management System*) will describes the framework and basic elements for the social and environmental management system for the Project.

Section 9 (*Conclusions*) will present the conclusions of this ESIA, and

Section 10 (*References*) will document the references of this report.

Exhibit 1.1: Project Location

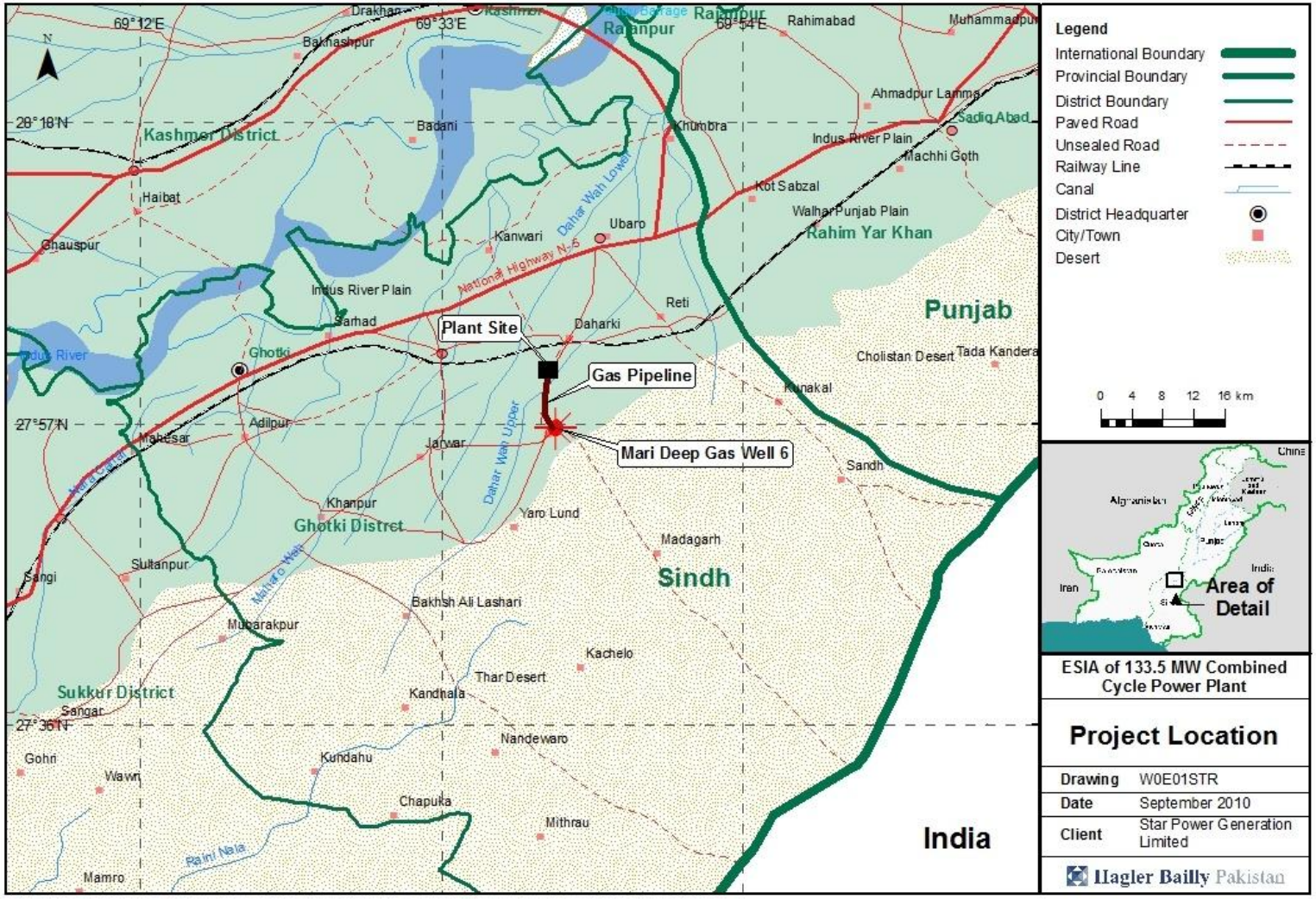
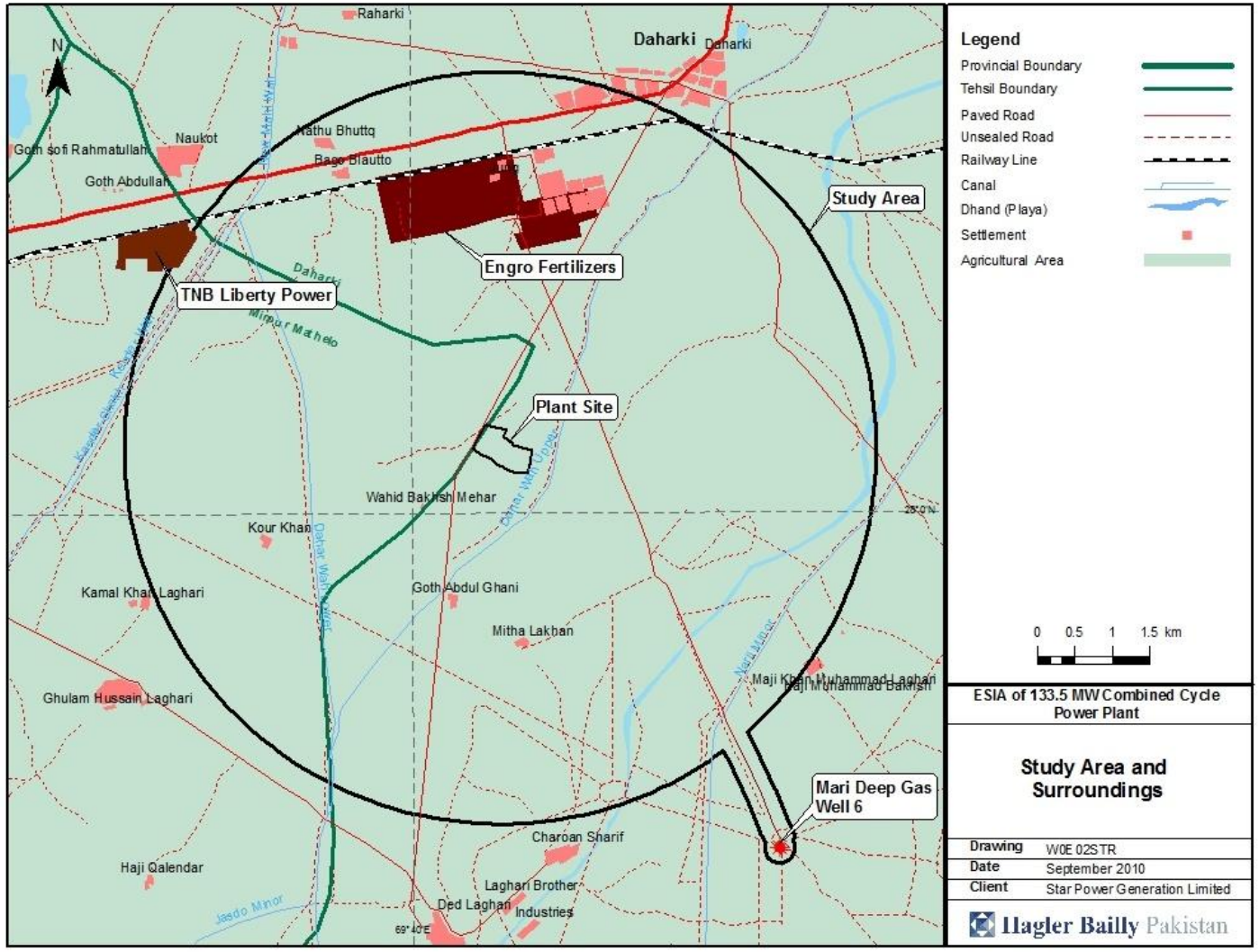


Exhibit 1.2: Study Area and Surroundings



2. Regulatory and Policy Framework

'Sustainable development' is a concept that has emerged over the past three decades to describe a new framework aimed at economic and social development while maintaining the long-term integrity of the ecological system. The principles of sustainable development are in the process of being incorporated into national policies and legislation in Pakistan through various statutory instruments. This chapter describes the current legal responsibilities of the Project proponent in the context of the environment and sustainable development, and the institutions that exist in the country that may influence the environmental management of the proposed Project.

2.1 Constitutional Provisions

The Constitution of Pakistan distributes legislative powers between the federal and provincial governments. Until recently, both the federal and the provincial governments were allowed to legislate on the subject of 'environmental pollution and ecology'. This is likely to change with the recent amendment (18th) to the Constitution that has redistributed legislative powers, henceforth only permitting the provincial governments to legislate on this subject. However, the federal government is likely to maintain an overall policy-making role.

Article 9 of the Constitution defines the right to life as a 'fundamental right' in these words "No person shall be deprived of life or liberty save in accordance with law". The Supreme Court of Pakistan in its judgment in the case *Shehla Zia and others vs WAPDA* (1994) declared that the right to a clean environment is part of the fundamental constitutional right to life.

2.2 Environmental Laws

The definition of environmental law can be derived from the legal definition of 'environment'. In Section 2(x) of the Pakistan Environmental Protection Act, 1997 (PEPA 1997), 'environment' is defined to include air, water, land and layers of the atmosphere; living organisms and inorganic matter; the ecosystem and ecological relationships; buildings, structures, roads, facilities and works; social and economic conditions affecting community life; and the interrelationship between these elements. From this definition, an environmental law can be considered to include all laws that are designed to, or that directly or indirectly affect, the management of natural resources, including the control of pollution of these natural resources.

By this definition, environmental laws include a) laws that have been specifically enacted to protect the environment, such as the PEPA 1997, and b) laws relating to subjects such as forests, water resources, wildlife, land, agriculture, health, and urban planning.

2.2.1 Pakistan Environmental Protection Act, 1997

The PEPA 1997 is the basic legislative tool empowering the government to frame regulations for the protection of the environment. The act is applicable to a broad range

of issues and extends to air, water, soil, marine, and noise pollution, as well as to the handling of hazardous wastes. A number of rules and regulations have been promulgated under the PEPA 1997. These are:

- Environmental Samples Rules, 2001
- Pollution Charge for Industry (Calculation and Collection) Rules, 2001
- Provincial Sustainable Development Fund Board (Procedure) Rules, 2001
- National Environmental Quality Standards (Certification of Environmental Laboratories) Regulations, 2000
- The National Environmental Quality Standard (Self-Monitoring and Reporting by Industry) Rule, 2001
- Pakistan Environmental Protection Agency Review of IEE and EIA Regulations, 2000
- National Environmental Quality Standards.

2.2.2 Other Environmental Laws

There is a long list of Pakistani legislation that falls in the category of or is relevant to environmental law. Some of the more important ones are:

- Sindh Wildlife Protection Ordinance, 1972
- The Antiquities Act, 1975
- Sindh Cultural Heritage (Preservation) Act, 1994
- Land Acquisition Act, 1894
- Factories Act, 1934
- Electricity Act, 1910
- Boilers Act, 1923
- Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997.

2.3 Specific Requirements

2.3.1 Environmental Assessment

Section 12(1) of the PEPA 1997 requires that "No proponent of a project shall commence construction or operation unless he has filed with the Federal Agency an initial environmental examination or, where the project is likely to cause an adverse environmental effect, an environmental impact assessment, and has obtained from the Federal Agency approval in respect thereof."

The *Pakistan Environmental Protection Agency Review of Initial Environmental Examination and Environmental Impact Assessment Regulations, 2000* (IEE-EIA Regulations, 2000) provide the necessary details on the preparation, submission, and review of the IEE and the EIA. The regulation categorizes projects on the basis of

anticipated degree of environmental impact. Project types that are likely to have significant adverse impact are listed in Schedule II of the regulations and require an EIA. Projects that are not likely to have significant adverse impact are listed in Schedule I and require an IEE to be conducted, rather than a full-fledged EIA, provided that the project is not located in an environmentally sensitive area. For thermal power generation, plants that are less than 200 MW in capacity require an IEE whereas larger plants require an EIA. Therefore, for this 133.5 MW Project, an IEE would be required under the law. The report will be submitted to the SEPA for approval and environmental clearance for the Project.

The IEE report submission and approval procedure is summarized below:

- Ten hardcopies of the IEE and two soft copies shall be submitted, together with a review fee and form included as Schedule IV of the IEE-EIA Regulations, 2000.
- The SEPA shall conduct a preliminary scrutiny and reply within 10 days of the submittal of the report a) confirming completeness, or b) asking for additional information, if needed, or c) returning the report requiring additional studies, if necessary.
- The SEPA is required to make every effort to complete the IEE review process within 45 days of the issue of confirmation of completeness.
- SEPA may constitute a Committee of Experts to assist the agency in review of the IEE
- The approval granted at the end of the review process is valid for three years for start of construction.
- Once project construction has been completed, the proponent is required to submit a request to the SEPA for confirmation of compliance. An environmental management plan for the operation phase is to accompany the request.
- The SEPA is required to communicate its decision within 15 days of receipt of the request. The project can commence operation only after it has received approval from the SEPA.

2.3.2 National Environmental Quality Standards

Section 11(1) of the PEPA 1997 states that "Subject to the provisions of this Act and the rules and regulations made thereunder, no person shall discharge or emit, or allow the discharge or emission of, any effluent or waste or air pollutant or noise in an amount, concentration, or level which is in excess of the National Environmental Quality Standards." The Pak EPA has published National Environmental Quality Standards (NEQS) that will be applicable to the proposed Project. The NEQS were first promulgated in 1993 and have been amended several times since then. The chronological list of NEQS is shown in **Exhibit 2.1**. The NEQS applicable to the Project is included as **Appendix A**.

2.3.3 Hazardous Waste

Section 14 of the PEPA 1997 requires that "Subject to the provisions of this Act, no person shall generate, collect, consign, transport, treat, dispose of, store, handle, or import any hazardous substance except (a) under a license issued by the Federal Agency and in such manner as may be prescribed; or (b) in accordance with the provisions of any other law for the time being in force, or of any international treaty, convention, protocol, code, standard, agreement, or other instrument to which Pakistan is a party."

Enforcement of this clause requires the Pak EPA to issue regulations regarding licensing procedures and to define 'hazardous substance.' Although, the Pak EPA has published draft regulations in this regard, these have not been enacted and therefore are not legally binding. International guidelines and best industry practices will be adopted for the management of hazardous waste. A pertinent reference is the International Finance Corporation (IFC) Environmental Guidelines on Hazardous Material Management.

2.3.4 Wildlife Management

The Sindh Wildlife Protection Ordinance, 1972 empowers the government to declare certain areas reserved for the protection of wildlife and to control activities within these areas. It also provides protection to endangered species of wildlife. Since the Study Area does not lie in or near any protected areas, therefore no provision of this law is applicable to the proposed Project.

2.3.5 Monitoring

Under the National Environmental Quality Standards (Self-Monitoring and Reporting by Industry) Rules, 2001, industrial units are responsible for monitoring their gaseous and liquid discharges and reporting them to the relevant environmental protection agency. The proponents will be required to monitor and report liquid effluent and gaseous emissions discharged from the plant to the SEPA on a predefined regular basis and format. The parameters to be monitored and monitoring frequency are defined under the rules.

2.3.6 Archaeological Relics

The Antiquities Act, 1975 ensures the protection of Pakistan's cultural resources. The Act defines 'antiquities' as ancient products of human activity, historical sites or sites of anthropological or cultural interest, national monuments, etc. The Act is designed to protect these antiquities from destruction, theft, negligence, unlawful excavation, trade, and export. The law prohibits new construction in the proximity of a protected antiquity and empowers the GoP to prohibit excavation in any area that may contain articles of archaeological significance. Under the Act, the Project proponents are obligated to ensure that no activity is undertaken within 61 m (200 ft) of a protected antiquity, and to report to the GoP's Department of Archaeology any archaeological discovery made during the course of the project.

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

No antiquity, as defined under and subject to these two laws, was identified in the vicinity of the proposed Project. The nearest protected entity is Mumalji Mari, a fortress dating back to 500 BC, located in the village Mathelo southeast of Ghotki and about 26 km west of the proposed site of the Project.

2.4 Guidelines

Various organizations have prepared guidelines for conducting environmental assessments of development projects. Key environmental guidelines are reviewed below.

2.4.1 The Pakistan EPA's Pakistan Environmental Assessment Procedures

The Federal EPA has published a set of environmental guidelines for conducting environmental assessments and the environmental management of different types of development projects. The guidelines that are relevant to the proposed Project are listed below, followed by comments on their relevance to the proposed Project:

- Policy and Procedures for Filing, Review and Approval of Environmental Assessments, Pakistan Environmental Protection Agency, September 1997

  These guidelines define the policy context and the administrative procedures that govern the environmental assessment process—from the project pre-feasibility stage to the approval of the environmental report. The section on administrative procedures has been superseded by the IEE-EIA Regulations, 2000.

- Guidelines for the Preparation and Review of Environmental Reports, Pakistan Environmental Protection Agency, 1997

  The guidelines on the preparation and review of environmental reports target project proponents and specify:

  - The nature of the information to be included in environmental reports
  - The minimum qualifications of the EIA conductors appointed
  - The need to incorporate suitable mitigation measures at every stage of project implementation
  - The need to specify monitoring procedures.

  The terms of reference for the reports are to be prepared by the project proponents themselves. The report must contain baseline data on the Study Area, detailed assessment thereof, and mitigation measures.

- *Guidelines for Public Consultation*, Pakistan Environmental Protection Agency, May, 1997

  These guidelines support the two guidelines mentioned above. They deal with possible approaches to public consultation and techniques for designing an effective program of consultation that reaches out to all major stakeholders and ensures the incorporation of their concerns in any impact assessment study.

- *Sectoral Guidelines: Major Thermal Power Stations,* Pakistan Environmental Protection Agency, October 1997

These guidelines are applicable to plants producing electrical energy from fossil fuels (coal, gas, or oil). The environmental issues discussed in these guidelines are the typical issues that should be addressed during the development of a thermal power plant. However, the degree and relevance of the issues vary from project to project and a specific power sector environmental assessment should focus on the environmental issues critical to that particular project.

2.4.2 International Finance Corporation Guidelines on Environment

The principal IFC publication that contains environmental guidelines is the *Environmental Health and Safety Guidelines, 2007* (IFC, 2007). The specific IFC guidelines applicable to the proposed project are the *Thermal Power: Guidelines for New Plants* (see **Appendix B**).

2.5 Requirement of the Equator Principles

Leading financial institutions around the world involved in project finance have adopted the 'Equator Principles' as a common framework to assess and manage the environmental and social risks in project financing. In essence, the financing institutions adhering to the Equator Principles have agreed to use the same environmental standards as that of the World Bank Group's International Finance Corporation (IFC).

IFC applies a set of *performance standards* to manage social and environmental impacts of the project that it finances. Together, the eight performance standards (PS) are:

PS 1: Social and Environmental Assessment and Management System

PS 2: Labor and Working Conditions

PS 3: Pollution Prevention and Abatement

PS 4: Community Health, Safety and Security

PS 5: Land Acquisition and Involuntary Resettlement

PS 6: Biodiversity Conservation and Sustainable Natural Resource Management

PS 7: Indigenous Peoples, and

PS 8: Cultural Heritage.

Performance Standard 1 establishes the importance of: (i) integrated assessment to identify the social and environmental impacts, risks, and opportunities of projects; (ii) effective community engagement through disclosure of project-related information and consultation with local communities on matters that directly affect them; and (iii) the client's management of social and environmental performance throughout the life of the project. Performance Standards 2 through 8 establish requirements to avoid, reduce, mitigate or compensate for impacts on people and the environment, and to improve conditions where appropriate. While all relevant social and environmental risks and potential impacts should be considered as part of the assessment, Performance Standards 2 through 8 describe potential social and environmental impacts that require particular attention in emerging markets. Where social or environmental impacts are anticipated, the client is required to manage them through its Social and Environmental Management System consistent with Performance Standard 1.

This environmental assessment has been conducted in compliance with the provisions of the Equator Principles. In **Appendix C**, the performance of the proposed project has been compared with each of the Equator Principles.

2.6 IFC's Environmental and Social Policy for Project Financing

The IFC's *Policy on Social and Environmental Sustainability* requires that all projects financed by the IFC should be socially and environmentally sustainable. The requirement is met by applying a set of rigorous performance standards (see **Section 2.5**).

These Performance Standards are essential documents to help IFC and its clients manage and improve their social and environment performance through an outcomes-based approach. The desired outcomes are described in the objectives of each Performance Standard, followed by specific requirements to help clients achieve these outcomes through means that are appropriate to the nature and scale of the project and commensurate with the level of social and environmental risks (i.e., likelihood of harm) and impacts. Central to these requirements is a consistent approach to avoid adverse impacts on workers, communities, and the environment or, if avoidance is not possible, to reduce, mitigate, or compensate for the impacts, as appropriate.

The key performance standards that are likely to have significance for the proposed Project are the following:

Social and Environmental Assessment and Management System

Performance Standard 1 underscores the importance of managing social and environmental performance throughout the life of a project (any business activity that is subject to assessment and management). It requires the development of an effective social and environmental management system that promotes a continuous process initiated by management and involving communication between the client, its workers, and the local communities directly affected by the project. It is expected that the system will entail the thorough assessment of potential social and environmental impacts and risks from the early stages of project development, and provide order and consistency for mitigating and managing these on an ongoing basis.

The standard also requires that project proponents will conduct a process of Social and Environmental Assessment that will consider, in an integrated manner, the potential social and environmental (including labor, health, and safety) risks and impacts of the project.

Lastly, specific management programs, action plans, monitoring plans, and training programs to enhance the capacity of the responsible persons to implement the environmental and social plans is required. Community involvement, public disclosure and setting up of a grievance redressal mechanism are the other key requirements of this standard.

Labor and Working Conditions

This performance standard recognizes that the pursuit of economic growth through employment creation and income generation should be balanced with protection of the basic rights of workers. It requires that businesses should recognize that the workforce is a valuable asset, and a sound worker-management relationship is key to the sustainability

of the enterprise. To achieve this, it is expected that a human resource labor policy shall be developed. Under the policy, the project proponent shall provide employees with information regarding their rights under national labor and employment law, including their rights related to wages and benefits. This policy will be clear and understandable to employees and will be explained or made accessible to each employee upon taking employment. The policy will cover working conditions, right to organize, non-discrimination, grievance mechanisms, child labor, and forced labor.

Pollution Prevention and Abatement

This performance standard recognizes that increased industrial activity and urbanization often generate increased levels of pollution to air, water, and land that may threaten people and the environment at the local, regional, and global level. It outlines a project approach to pollution prevention and abatement in line with these internationally disseminated technologies and practices. The performance standard promotes the private sector's ability to integrate such technologies and practices as far as their use is technically and financially feasible and cost-effective in the context of a project that relies on commercially available skills and resources.

Community Health, Safety and Security

This performance standard recognizes that although private sector projects often bring benefits to communities they can also increase the potential for community exposure to risks and impacts arising from equipment accidents, structural failures, and releases of hazardous materials. Communities may also be affected by impacts on their natural resources, exposure to diseases, and the use of security personnel. This performance standard addresses the responsibilities of project proponents in avoiding or minimizing the risks and impacts to community health, safety and security that may arise from project activities.

Land Acquisition and Involuntary Resettlement

This performance standard is designed to minimize the potentially adverse impacts arising out of land acquisition and involuntary resettlement. IFC desires that to the extent possible, involuntary resettlement should be avoided and, if that is not possible, than it should be minimized. It also requires that where involuntary resettlement is unavoidable, appropriate measures should be taken to mitigate adverse impacts on displaced persons and also on the communities in which the displaced persons are relocated. The direct involvement of the community and the client in resettlement activities is encouraged to make the process cost-effective and efficient, as well as to find innovative approaches to improving the livelihoods of those affected by resettlement. Lastly, project proponents are encouraged to acquire land rights through negotiated settlements wherever possible, even if they have the legal means to gain access to the land without the seller's consent. This approach is preferred since experience suggests that negotiated settlements help avoid expropriation and eliminate the need to use governmental authority to remove people forcibly.

Biodiversity Conservation and Sustainable Natural Resource Management

This performance standard is based on the recognition that protecting and conserving biodiversity and its ability to change and evolve, is fundamental to sustainable

development. It encourages conservation of biological diversity and the promotion of use of renewable natural resources in a sustainable manner. It addresses how project proponents can avoid or mitigate threats to biodiversity arising from their operations, as well as sustainably manage renewable natural resources.

Indigenous Peoples

This performance standard is based on the recognition that Indigenous Peoples, as social groups with identities that are distinct from dominant groups in national societies, are often among the most marginalized and vulnerable segments of the population. Because of their economic, social and legal status, often they have limited capacity to defend their interests and rights and are thus exposed to different types of risks and severity of impacts, including loss of identity, culture, and natural resource-based livelihoods, as well as exposure to impoverishment and disease. The IFC expects the project proponents to create opportunities for Indigenous Peoples to participate in, and benefit from project-related activities that may help them fulfill their aspiration for economic and social development. In addition, this performance standard recognizes that Indigenous Peoples may play a role in sustainable development by promoting and managing activities and enterprises as partners in development.

Cultural Heritage

This Performance Standard aims to protect irreplaceable cultural heritage and to guide project proponents in protecting cultural heritage in the course of their business operations.

Exhibit 2.1: National Environmental Quality Standards

Date	Number	Scope
1993	742(I)/1993	Liquid industrial effluent Industrial gaseous emission Vehicle exhaust and noise
1995	1023(I)/1995	Industrial gaseous emission from power plants operating on coal and oil (added)
2000	549(I)/2000	Liquid industrial effluent (amended) Industrial gaseous emission (amended)
2010	1062(I)/2010	Ambient Air
2010	1063(I)/2010	Drinking water quality
2010	1062(I)/2010	Noise

3. Project Description

The proposed combined-cycle power plant will have two gas turbo-generators with one heat recovery steam generator (HRSG) each and one steam turbine, with a total installed capacity of 133.5 MW. The other main components of the plant are two stacks, plant control systems, fuel storage tanks, water treatment and chlorination systems, fire protection system, and cooling towers. Plant components and operations are described in the following sections.

3.1 Project Site

The Project site measures 27.69 hectares (68.43 acres) located in northern Sindh (District Ghotki). The elevation of the land is approximately 70 m above mean sea level. The salient features of the land area as follows:

Administrative Location

Province:	Sindh
District:	Ghotki
Taluka:	Daharki

Geographical Coordinates

Northeast corner:	28° 00’26.92” N, 69°40’58.70” E
Northwest corner:	28° 00’38.05” N, 69°40’35.98” E
Southwest corner:	28° 00’27.74” N, 69°40’29.63” E
Southeast corner:	28° 00’26.92” N, 69°40’58.70” E

Land use within 500 m

North:	Unsealed road, agricultural land, about two houses
East:	Agricultural land
South:	Agricultural land, one house, non functional tube well
West:	Agricultural land

Access

Road:	About 4.5 km from National Highway N-5 on sealed road
Railway:	About 4 km from Daharki railway station
Air:	About 93 km from Sukkur Airport towards West and about 73 km from Rahim Yar Khan Airport to the East of the plant site

The plant site is shown in **Exhibit 3.1**.

3.2 Plant Components

Various components of the plant are shown in **Exhibit 3.2** and are discussed below.

3.2.1 Main Components

Gas Turbine

The power plant will have two gas turbo-generators, each having 42 MW capacity. These will be water-cooled.

Heat Recovery Steam Generator

One HRSG will be required for each gas turbine. During plant operation, degasified feedwater will be pumped from the feedwater tank to each boiler. Dual pressure, water-tube, pressurized waste heat boilers will be used.

Steam Turbine

The 45 MW capacity specially designed steam turbine will be directly coupled to the generator.

Stack

Each boiler will be equipped with a 30 m steel stack, with inner diameter of 2.5 m.

Cooling Water System

A closed-loop cooling water circuit has been proposed, comprising of induced draft cooling towers and circulating water pumps and connecting piping. The cooling towers shall be designed to produce 10 °C reductions in circulating water temperature.

To maintain water storage, a tank having a capacity of 6,500 m^3, sufficient to meet the requirements for 24 hours of plant operation, will be provided.

Auxiliary Cooling Water System

The auxiliary cooling water system will be designed to cope with the cooling requirements of following auxiliary equipment:

- Turbine oil coolers
- Generator air coolers
- Feedwater pumps
- Sample coolers
- Condenser pumps

Two water-to-water cooled heat exchangers will constitute part of the system. On the primary side of heat exchangers, circulating water will be supplied from the main cooling water system, and on the secondary side, clarified water will circulate in a closed circuit.

In order to maintain circulation of clarified water, three pumps will be provided to operate in a 2 + 1 configuration, i.e., two pumps will operate while the third is kept on standby.

3.2.2 Water Treatment Plant

Following are the essential components of the water treatment plant:

Water Clarification Plant

Water supplied from tubewells and stored in the main storage tank will be clarified by employing coagulation and filteration processes. The total capacity of this plant will be 2 × 180 tons per hour (T/h). This water will be used in the auxiliary cooling water circuit and evaporative coolers.

Demineralization Plant

In order to supply water to the heat recovery boiler for producing steam, tubewell water will be treated employing ion-exchangers, cation exchangers, and mixed bed filters. The plant will have two trains of 5 T/h capacity each.

Neutralization and Waste Water Treatment

All effluent from the power plant will be treated to meet the NEQS and the IFC guidelines. Effluent streams for Liquid waste will be routed through the neutralization tank before being discharged. The capacity of the neutralization basin will be such that all effluent will be taken up and neutralized. There will be two pumps, with each able to empty the basin in one hour on its own.

All effluent, after neutralization, will have a pH value of 6 to 9 before being disposed of.

3.2.3 Water System

Following is a brief description of the main components of the water system.

Fire Fighting System

Water for the fire fighting system will be provided from the main storage tank in order to have a regular and reliable water supply.

Two small pumps for maintaining permanent pressure in the fire mains will also be provided, with automatic startup in case of loss of pressure in the system. The firewater distribution circuit will be fitted with hydrants to connect hoses. The firewater pumps will be installed at ground level.

Oil tanks will be provided with a foam fire extinguishing system consisting of a mixing foaming agent, with water delivered by the fire mains.

To further enhance the reliability of the fire fighting system, a source of water supply from the overhead tank is also envisaged as a backup in the event of a power failure disabling the mains pumps.

Drinking Water System

Drinking water will be supplied from the main storage tank. The water will pass through anthracite filters, chlorinated and stored in an overhead tank of 200 m^3 storage capacity from which it will be distributed to the Project's residential area, offices and plant buildings through an underground piping system.

3.2.4 Compressed Air System

The compressed air system will be designed as a source of control air for pneumatic valves and other requirements. In order to meet with plant requirements, the compressor station will be equipped with two compressors, each having a capacity of 95m^3/hr, one of which will be in operation and the other on standby. Both the compressors will be connected to a common collector on the delivery side.

The compressors will be equipped with filters and a dryer in order to remove solid particles, condensed moisture, oil traces, etc.

3.3 Process Overview

The power plant will be based on two 42 MW gas turbines, two heat recovery steam generators (HRSGs), and one 45 MW steam generator. Exhaust gases from the gas turbines will be led by a duct system through the noise silencer and into the waste heat boilers. A bypass stack with damper will enable operation of the gas turbine (GT) independently of the HRSGs and steam turbine.

The waste heat boiler will be designed as a double-pressure, drum-type boiler with natural circulation through evaporators. Each steam boiler will generate 68 tons per hour of high-pressure (HP) steam with nominal parameters of 71 bar at 500 °C and 16 T/h of low-pressure (LP) steam at 5 bar/259 °C. It will be equipped with a condensate heating coil as well. Non-condensed gases will be exhausted by means of vacuum pumps or water ejectors.

The steam condensate will be pumped by condensate pumps into the feedwater tank through vent steam condensers and condensate heaters (in boilers). The feedwater tank, having a capacity of 80 m^3 and equipped with degasifiers, will be heated by LP steam from both boilers. Three 50% capacity feedwater pumps will be provided to pump feedwater from the feed tank to both boilers.

The main cooling circuit will be comprised of a closed cooling circuit with induced draft cooling towers and three pumps of 5,000 m^3/hr capacity each, two in operation and one on standby.

3.4 Fuel Supply

The plant will be operated on natural gas from the Mari Deep gas field. The Mari Deep gas field has estimated gas reserves of 1.143 trillion cubic feet (tcf). The plant will consume about 9.5 billion cubic feet per year. Average contracted heating value of the gas is 530-590 British Thermal Units per standard cubic foot (Btu/scf). The composition of Mari deep gas is not uniform across the field. The gas specification agreed with the supplier is shown in **Exhibit 3.3**.

The gas will be transported to the power plant through a buried pipeline from an existing gas manifold of the Mari Deep gas reservoir. The manifold is located near Well No. 6. The total length of the gas pipeline is about 11 km. Most of the pipeline will follow an existing gas pipeline right of way (RoW) that contains the pipeline supplying gas to the Engro Fertilizer from Mari Gas. New RoW will be acquired for the last 1,500 m of the pipeline route.

High-speed diesel (HSD) will be used as the backup fuel which will be mainly used during start-up and shutdown. HSD will be supplied to the plant by trucks. The possible sources of HSD are:

1. One of the refineries located at Karachi. Karachi is about 580 km south of the proposed plant site. Access to Karachi is the National Highway N-5, which is the main highway route that connects the upcountry cities to Karachi port. Most of the goods imported from abroad and exported overseas moves through this highway.
2. Refinery located in Mahmood Kot, 30 km west of Multan. Multan is located 330 km to the northeast of the proposed project site. Like Karachi, it is also connected to the site by the national highway N-5.

From N-5 the HSD will be brought in to the plant site via the access route that passes alongside the boundaries of the Engro Fertilizers plant and behind the Mari Gas Company facilities. The onsite storage capacity shall be of about 20 days and the reserves will be replenished as and when required.

3.5 Power Export

Power generated by the plant will be evacuated through a 132 kV double-circuit transmission line to be connected to the grid by the National Transmission and Despatch Company (NTDC). The construction and operation of the export transmission line shall be the responsibility of the NTDC.

3.6 Water Supply

The make-up water and other requirements for the plant running in closed cycle have been estimated as 264.3 cubic meters per hour (i.e., 2.6 cusecs). These requirements will be met by installing tube wells along the Dahar Wah Upper (design discharge 200 cusecs) and Dahar Wah Lower (design discharge 663 cusecs) canals.

All water requirements will be met using canal seep water. Five tubewells will be installed at 500 feet intervals along the outward slope of the Dahar Wah Lower. Water will be pipelined 3 km to the project site. Additional two tubewells will be located along the Dahar Wah Upper, which adjoins the project site on the east. All tubewells will have a design capacity of 76.5 m^3/h (0.75 cusecs), for a total installed capacity of 586 m^3/h (5.75 cusecs). Water from these tube wells will be conveyed to the underground water storage tank at project site by two independent water supply pipelines 4 to 8 km long. The pipelines will run along the Dahar Wah canal and Narli distributaries. There is no existing RoW near the plant site available that may be used, therefore a new RoW will have to be acquired to lay the proposed water supply pipeline.

The water quality of wells from the area is provided in **Exhibit 5.5** of **Section 5**.

3.7 Plant Wastes

Effluent from different streams Liquid waste (e.g., oily waters etc) and Thermal Discharge (cooling tower blowdown) will be collected and treated in an on-site neutralization tank in order to bring the temperature down to ensure that discharge water

temperature does not result in exceeding relevant ambient water temperature and pH range within limits (6-9), as specified in the NEQS and the IFC guidelines for thermal power plants. The treated effluents will be released to a drainage channel leading to nearby irrigation drains. Alternatively, cooling water blowdown may be used for arboriculture and plantation in and around the plant site.
Sanitary wastewaters from staff residential quarters will be treated in a closed system. The effluent will meet the NEQS and IFC effluent standards and be discharged to an irrigation drain. The total estimated quantity of effluent is 70 m^3/day.

Stormwater runoff from the plant site will also be discharged to an irrigation drain.

Solid wastes, estimated at about 200 kg/day, would be collected from the colony, transported, and disposed of in an approved municipal waste disposal facility in the vicinity of the plant site. The nearest municipal waste disposal facility is available in Ghotki. Although the facility in Ghotki may not meet acceptable standards for landfill site, the Government of Sindh is developing landfill facilities in different cities of Sindh.

Gaseous emissions from the plant will mainly be combustion gases from the plant's stacks. The total estimated quantity of the waste gases is given in **Exhibit 3.4**

3.8 Staff

It is estimated that during the peak construction period 600 personnel will be working on the plant site. Once the plant is operational the staff requirement for plant operations will be 76.

A staff residential colony covering an area of about 24 acres within the plant boundary shall be built to accommodate the staff that will be employed in the operation and maintenance of the proposed power plant.

3.9 Construction Activities

Various construction-phase activities expected to be carried out are described in the following sections.

3.9.1 Construction Camp

A temporary construction camp will be established to accommodate the staff of the construction contractor. Facilities at the camp will include residential areas, recreational and messing areas, kitchen, generator, water storage and treatment, and wastewater treatment facilities. The camp will be located within the plant site.

3.9.2 Preliminary Activities

Preliminary activities will include the following:

- Documentation to site licensing procedure
- Basic design
- Site construction license procedure
- Detailed design (to be continued in parallel with construction activities)

- Mobilization for civil works
- Mobilization for erection works.

3.9.3 Civil Works

Civil works will be started in the 7th month of the project schedule and are expected to be completed by the 25th month. These works will include the following activities:

- Landscaping and excavation works
- Civil structure works for HRSG 1 & 2
- Civil structure works for gas turbine GT1
- Civil structure works for gas turbine GT2
- Civil structure works on steam turbine hall
- Civil structure works for steam turbine
- Civil structure works for auxiliary systems
- Remaining civil structure works and finishing works.

3.9.4 Erection Works

Erection of electromechanical equipment will start immediately after the completion of civil works. The schedule of civil, mechanical, and electrical works is planned in such a way that one activity will not interfere with the other.

3.9.5 Commissioning of Equipment

The commissioning of Project-associated equipment will start in the 22nd month and continue till the 27th month of the Project schedule.

3.9.6 Complex Test

At the end of the 26th month, a pre-complex test of the entire combined-cycle plant will take place, and the testing will continue till the 27th month. Following a successful pre-complex test, a complex test (168 hrs, i.e., 7 days) will start in the 28th month.

3.9.7 Guarantee Test

The commercial operation of the combined-cycle power plant will start at the beginning of the 28th month. Therefore, the guarantee test of the power plant will also be conducted by that time and will end in the 29th month.

3.9.8 Project Duration

The Project's duration is estimated to be 29 months. After securing project financing, the project sponsor will enter into an agreement with an Engineering, Procurement and Construction (EPC) contractor. The commencement of Project works is reckoned from the effective date of the EPC contract and shall terminate at the completion of the guarantee test.

Exhibit 3.1: Plant Site

Exhibit 3.2: Plant Layout

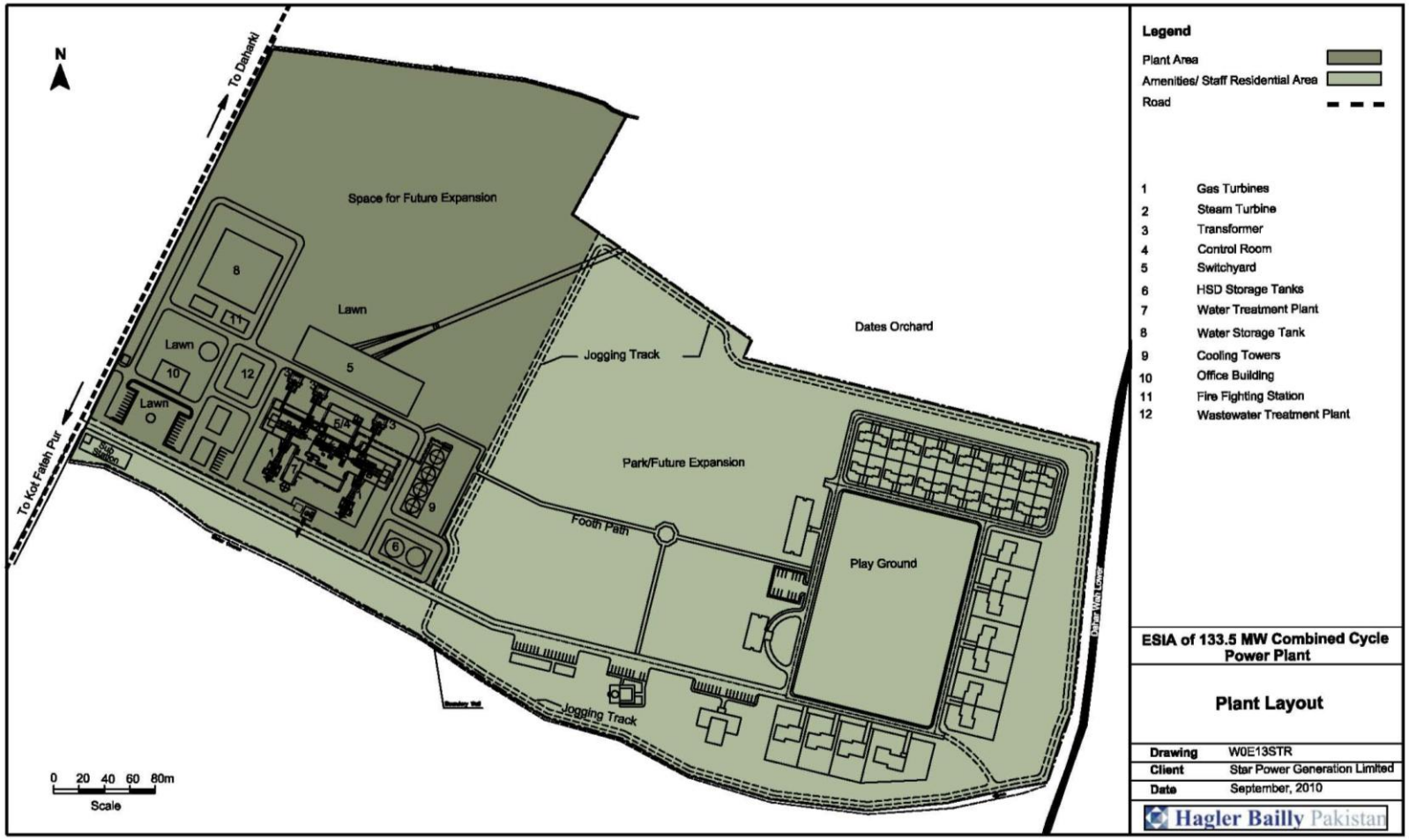


Exhibit 3.3: Contracted Gas Specification of Mari Deep Well

No.	*Component*	*Average Value of Gas Composition of 7 Wells*
1.	Methane	46 – 51%
2.	Ethane	2 – 3%
3.	CO_2	39 (± 2) Mole%
4.	Nitrogen Content	9 (± 2) Mole%
5.	Hydrogen sulfide	18 (± 2) ppm
6.	Higher heating value of the delivered gas	530 – 590 BTU/SCF
7.	Delivery Pressure at Mari Deep Gas Wells Central Manifold (up to 21 years)	500 (± 5%) psig
8.	Delivery Pressure at Mari Deep Gas Wells Central Manifold (after 21 years)	450 psig
9.	Water Contents	07 – 08 lbs/MMSCF

Exhibit 3.4: Estimated Emissions of Stack Gases

Emissions	*kg/Hour*
NO_x as NO_2	12.7
CO	6.7
Unburned hydrocarbon as CH_4	2.0
SO_x as SO_2	1.24
CO_2 (Net)	81,114

4. Project Alternatives

This section describes the various project management and location alternatives that were examined for the proposed power plant as part of the environmental assessment study.

4.1 Management Options

Management alternatives examine the 'no-action' option, i.e., not installing the power plant and bringing no change to the baseline scenario, and the 'alternative technology' option, i.e., using engines instead of turbines. These options are discussed in detail below.

4.1.1 No-Action

The 'no-action' option, if taken, would prevent the country from exploiting the potential to increase its electrical power production capacity, which is a sore need of its energy-deficient economy. The proposed activity offers a chance to improve Pakistan's energy balance and decrease the gap between its growing energy requirements and available energy supplies in the country. The proposed power plant would be using sub-pipeline quality gas from the Mari Deep gas field and, therefore, would be utilizing gas for generation of power without affecting the country's committed, commercial quality gas supplies.

Other impacts of the 'no-action' option would be loss of potential employment opportunities and infrastructural development in the Project Area, as the Project is bound to create jobs, result in infrastructure investments, and help integrate the area further into the national economy.

4.1.2 Alternative Technology Option

Using diesel engines instead of gas turbines to generate power, though apparently a much cheaper option as it requires less initial investment, would result in higher gaseous emissions, besides imposing a fuel import burden. The use of diesel engines would also require a larger plant workforce and a significant fuel storage facility.

4.2 Alternative Site

Three potential sites for the proposed power plant were considered. The three selected sites are shown in **Exhibit 4.1**. The criteria for selection of the plant site included:

1. Nearness to Mari Deep Well No. 6, the gas supply source
2. Nearness to water supply sources
3. Nearness to existing infrastructure, e.g., roads
4. Minimum effects of existing stack emissions from other industrial units
5. Ease and economy of acquisition of land.

6. Minimum interference with the existing underground Mari gas pipeline network.

A comparison of the three sites is presented in **Exhibit 4.2**. As all three sites scored the same on Criteria 5 (ease and economy in acquisition of land), this criteria was not included in the comparison matrix.

Based on this comparison, Sites 2 and 3 were discarded and Site 1 was selected as the preferred Project site. Site 2 was primarily rejected because of the long distance of National Highway (N-5) and other infrastructure facilities from the potential plant. Although Site 2 was close to the gas source, a power plant at this site was considered a hazard for the existing gas network and facilities by MGCL. The site was therefore rejected. Site 3 was primarily rejected because of the slightly longer distance from Mari Deep Well no. 6 and the long distance from Daharki over partially unsealed roads.

No such demerit was identified for Site 1. It is close to a reliable water source; it is at a lesser distance from N-5 making it easier for transportation of construction materials and equipments, it is at a manageable distance from relevant infrastructure. It is also near the existing gas pipeline network of other industrial units in the area and will be convenient to lay in and secure the proposed RoW for the gas pipeline of the project. Site 1 was therefore selected as the preferred site.

Exhibit 4.1: Potential Sites for the Proposed Project

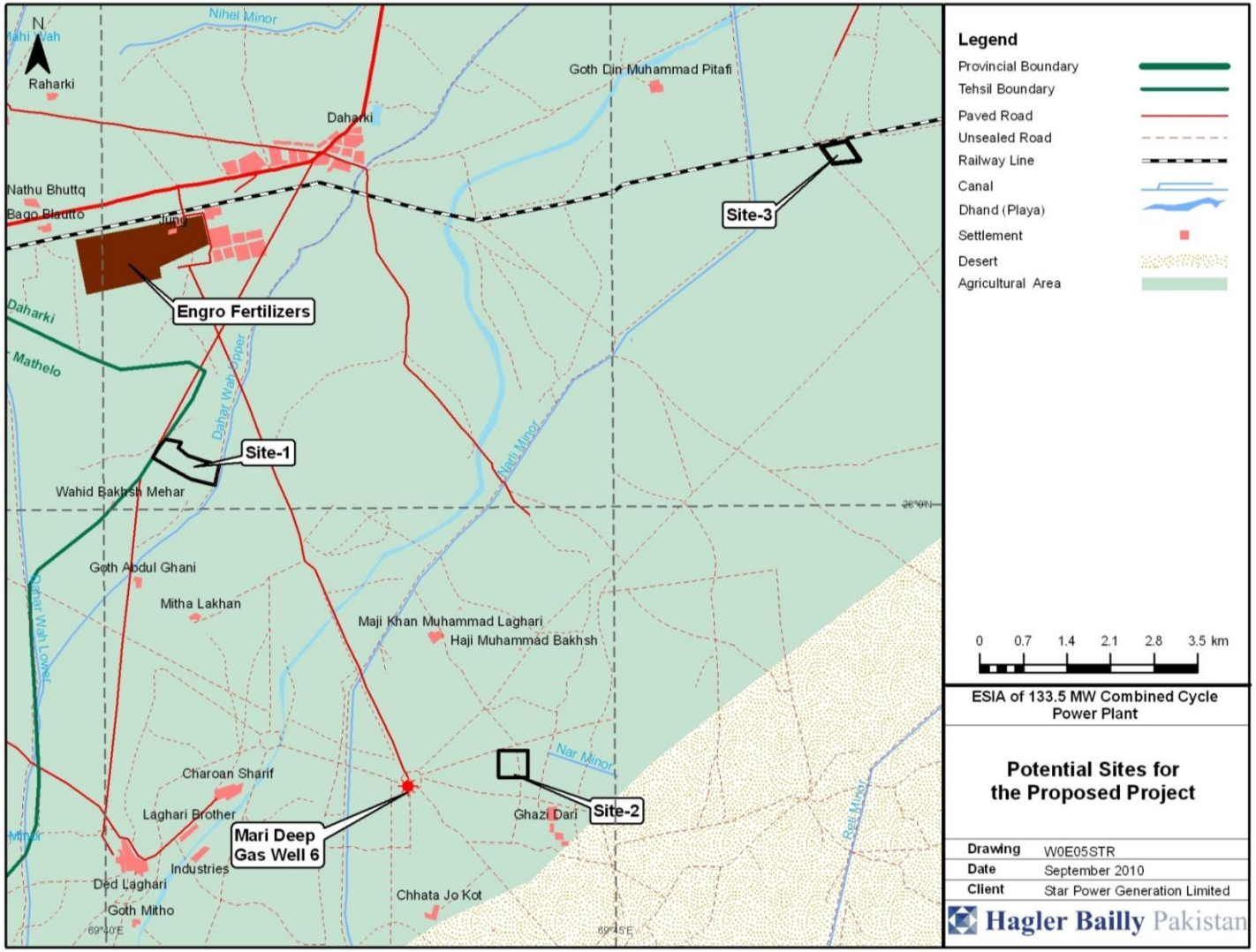


Exhibit 4.2: Comparison of Potential Sites

All distances in km

	Site 1	Site 2	Site 3
Distance from gas source [a]	6.5	1.5	12.8
Distance from other stacks [b]			
Engro	3.4	10.8	11.1
Liberty Power	5.1	12.6	15
Distance from highway [c]	6.0	13.3	13.9
Distance from water source [d]			
Dahar Wah Upper (200 cusecs)	0.0		
Narli Distribution (397 cusecs)	4.0	2.5	4.2
Dahar Wah Lower (663 cusecs)	2.4		
Reti Minor (186 cusecs)		3.4	4.2
Sehar Wah (652 cusecs)			10.4

a. (Length of pipeline along existing right-of ways, to the extent possible, from Well No 6 to fence line of the potential site

b. Crow flight distance from centre of the potential site to respective centers of the plants)

c. Road distance from the potential site to the nearest link to the highway N-5

d. Shortest distance between the canal and the fence line of the potential site

Key

High Score	
Medium Score	
Low Score	

5. Description of the Environment

The existing physical, biological, and socioeconomic environmental conditions of the Study Area are described in this section. Information for this section was collected from a variety of sources, including published literature, reports of other studies conducted in the area, and surveys conducted specifically for this Project.

The purpose of reviewing published literature was to gather information on the environmental setting and investigations already carried out in the area. Relevant literature was taken from previous studies conducted in the Study Area or in areas with a similar geographical and ecological setting. A complete list of references is provided at the end of this report.

The first survey was conducted from May 31 to June 03, 2010 which was followed by the second field visit from June 19 to June 24, 2010 and finally a third field visit was conducted from August 26 to August 30, 2010. Stakeholder consultations were also conducted during this period. Appropriate standard scientific methods have been used for each component of the study, and are described in the sections covering the respective components. For all spatial information, Global Positioning System (GPS) was used to mark the sampling sites. The GPS data were then used to produce Study Area maps, using geographical information system (GIS) software.

Results of water, soil and air samples collected from outside the Study Area, which are to be used as reference data if and when required, are presented in **Appendix D**.

Vegetation and wildlife data for the district were compiled using previously published literature and from assessments appearing in past studies conducted by HBP for Liberty Power (at Qadirpur), Engro Fertilizers Limited and Mari Gas Company Ltd. (at Daharki), and field visits specifically conducted for this Project.

The proposed plant site, owned by the project, is located on agriculture land (see **Exhibit 5.1**), approximately 5 km from the town of Daharki in Sindh province. It is bounded on the north by an unsealed road while rests of the three sides of the plant site are bordered by agriculture fields. The site is located in a predominantly agricultural area which is irrigated by a network of canals. Agriculture remains the main source of livelihood in the area; however, a large number of people are also employed by various industrial units in the area.

5.1 Description of the Physical Environment

A brief description of the physical environment of the Study Area is given below.

5.1.1 Geology

The Study Area is located in the sedimentary Southern Indus Basin, south of the Sukkur Rift–the divide between the Central and Southern Indus Basins. The Southern Indus Basin consists of the Thar Slope Platform, the Karachi Trough, the Kirthar Foredeep, the Kirthar Fold Belt, and the Offshore Indus. The platform and trough extend into the

Offshore Indus. The Thar Platform is a gently sloping monocline, whereas the sedimentary wedge thins towards the Indian Shield to the east. The platform, bordered on the east by the Indian Shield, merges into the Kirthar and Karachi Trough in the west and is bordered in the north by the Mari-Bugti Inner Folded Zone (Kadri, 1994). Reserves of natural gas are found in the Lower Kirthar ZN-'B' Limestone Formation.

5.1.2 Topography and Soil

The project location is surrounded by cultivated land. Soil types range from dark brown sandy loam in most places to light-brown sand in others.

As part of the baseline, soil samples were collected from various locations in the Study Area and analyzed. The sampling locations are shown in **Exhibit 5.2**. The results of the chemical analysis are provided in **Exhibit 5.3**. The soil was analyzed for common chemical ions (potassium, sodium, calcium, magnesium, sulfate, carbonate, bicarbonate, and chloride); organic matter and carbon, and some heavy metals (barium, lead, chromium, cadmium, arsenic, and mercury).

5.1.1 Water Resources

Water resources of the Study Area are briefly described under the following categories:

Surface Water Bodies

The main canal in the area is the Ghotki Feeder Canal (**Exhibit 5.4**). Ghotki Feeder Canal has the design flow of 865,476 cubic meters per hour (m^3/h) (8,490 cusecs). Various canals originating from the Ghotki Feeder Canal irrigate the Study Area. The main canals and their design capacities are as follows:

Mahi Wah[1]	Branch of Ghotki Feeder Canal	133,338 m^3/h (1,308 cusecs)
Kandar Distributory	Branch of Mahi Wah	25,689 m^3/h (252 cusecs)
Dahar Wah Lower	Branch of Mahi Wah	67,587 m^3/h (663 cusecs)
Dahar Wah Upper	Branch of Ghotki Feeder Canal	69,829 m^3/h (658 cusecs)
	Branch of Dahar Wah Upper near site	20,388 m^3/h (200 cusecs)
Narli Minor	Branch of Dahar Wah Upper	40,470 m^3/h (397 cusecs)
Sehar Wah	Branch of Ghotki Feeder Canal	66,465 m^3/h (652 cusecs)
Reti Minor	Branch of Sehar Wah	18,961 m^3/h (186 cusecs)

Groundwater wells sunk to capture seepage water from the Dahar Wah Upper and Dahar Wah Lower are proposed as the main source of water the proposed Project.

Groundwater

Information collected during the field visit from the community indicates that in general, the groundwater table in the Study Area is in the range 10-15 m (30-45 feet) below ground surface. Most of the houses are fitted with hand pumps for extracting water. In

[1] *Wah* is Sindhi word for canal.

some households, electric power driven pumps are also installed to draw water for domestic use. Few communal hand pumps are also installed along the road side. People living in and around plant site bring water for use from surrounding villages as the ground water in most places is saline.

A survey was conducted in the Study Area to assess the current water use and groundwater condition see **Exhibit 5.5** for results.

MGCL has provided drinking water tanks in major villages like in Goth Sher Muhammad Malik which are filled daily for the community.

Water Quality

To assess the quality of water in the Study Area, 20 water samples were collected from all available water sources. These samples were handled as per United States Environmental Protection Agency (USEPA) sampling procedures. The samples from the field survey were analyzed for 31 parameters. These included physiochemical parameters, such as pH, dissolved oxygen, bicarbonates, chlorides, and sulfates, and heavy metals (iron, aluminum, cadmium, chromium, cobalt, manganese, mercury, nickel, lead selenium, and zinc). Arsenic content in the drinking water was also monitored for the field samples. The results shows that the general water quality in the Study Area is good, although total hardness is slightly high, i.e., the water is hard (but hardness has proven not to pose any health concerns and there are no available guidelines for total hardness). Sodium concentration in groundwater is very high. Water sampling locations and the results of the general on-site chemical analysis of water from different sources are provided in **Exhibit 5.6** and **Exhibit 5.7** while results for lab analysis of water received are illustrated in **Exhibit 5.8**.

5.1.2 Climate

Overall climatic and weather conditions are described in the sections below.

Meteorology

The weather station closest to the Study Area is located at Sukkur (27° 42’ N, 68° 54’ E), approximately 90 km southwest of the project site. The climatic description of the Study Area presented in this section is based on weather data for Sukkur.

Rainfall

The Study Area receives approximately 88 mm of rain annually (Pakistan Meteorological Department (PMD), 1992). Most of the rain is concentrated in the monsoon months of July and August.

Climatic Classification

Climate is the average course or condition of the weather at a place usually over a period of years as exhibited by temperature, wind velocity, and precipitation. The climate of the Study Area is broadly described as hot and arid. Various meteorologists have developed classification schemes to describe the local climatic features of Pakistan. Classification based on two of the schemes is described below.

Shamshad (1956) has classified the climate of Pakistan on the basis of characteristic seasons found in the country. Taking into account topography, proximity to the sea,

rainfall, temperature, and winds, he has defined eleven climatic zones for Pakistan. Under his scheme, the climate of the Study Area is classified as 'subtropical double season hotland.' The characteristic features of this climatic zone are low rainfall (less than 250 millimeters per annum), hence the absence of a well-defined rainy season, and high temperatures that increase from east to west. The region west of the Indus River experiences the highest temperatures, as it is cut off from the westerly summer breeze by neighboring hills.

Kazi (1952) divides Pakistan into four major climatic regions, which are further subdivided into 18 micro-regions. Under this classification, the Study Area falls into the central irrigated plains of the sub-tropical Indus lowlands. The region is characterized by aridity and continentality, with high summer temperatures and late summer rains. Rainfall is less than 250 mm and concentrated in June to September. June and January are the hottest and coldest months, respectively. The presence of irrigated fields mitigates the summer heat to some extent.

Seasons

Broadly speaking, there are four seasons in Pakistan:

- Winter (December to March)
- Summer (April to June)
- Monsoon (July to August)
- Post-Monsoon summer (September to November).

These seasons are defined on the basis of temperature and the changes associated with the southwest monsoon. The southwest monsoon is a wind system that prevails from April to October in the Indian Ocean, and is characterized by a reversal in wind direction and heavy rainfall over most of the Indian Subcontinent. Within Pakistan, considerable variation is found in temperature and monsoonal changes. Thus, the specific characteristics and duration of seasons depend on geographic location. A complete characterization of the climate of the Study Area is illustrated in **Exhibit 5.9**. Monthly temperature, humidity, rainfall and wind data are provided in **Exhibit 5.10** to **Exhibit 5.13**.

5.1.3 Ambient Air Quality

Engro Fertilizers Limited, Engro Power Gen Limited, Mari Gas Company, Fauji Fertilizers Limited, and Liberty Power are the major significant stationary sources of gaseous emission in the Study Area. Another source that is likely to commission before the proposed Star Power Project is Foundation Power. Emissions from these sources mostly consist of ammonia, methane, nitrogen, and carbon dioxide. The main non-stationary sources of emissions are the road traffic on the National Highway N-5 and trains travelling on the main Karachi-Peshawar railway track of Pakistan Railway. Both of these corridors pass through the Study Area.

To assess the ambient air quality for the Study Area, ambient air quality was recorded at four separate locations around the plant site from August 27 to August 30, 2010 (see **Exhibit 5.14**). These locations were selected on their proximity to the plant site as well

as the location of sensitive receptors nearby, such as human settlements. Results of the ambient air quality monitoring are presented in **Exhibit 5.15**. Using this data and information from previous studies for other major emission sources in the area (see **Exhibit 5.16**), the ambient air quality of the Study Area was calculated as shown in **Exhibit 5.17**. The details of the calculation are included as **Appendix F**.

The average concentration calculated for the 24 hours in each season was assumed to represent the entire season. All values, with one exception, are well within guideline values set by NEQS and IFC. PM_{10} values exceeded IFC's annual ambient air quality guidelines but is within the 24-hour limits (150 $\mu g/m^3$). Due to dry conditions, the PM concentration in Pakistan is naturally high which explains why the national standard for PM is relatively high.

The average concentration calculated for the 24 hours in each season was assumed to represent the entire season. The averaged annual ambient air concentration for SO_2 and PM_{10} were well within guideline values set by NEQS. PM_{10} values exceeded IFC's annual ambient air quality guidelines but is within the 24-hour limits (150 $\mu g/m^3$). Due to dry conditions, the PM concentration in Pakistan is naturally high which explains why the national standard for PM is relatively high. The annual NO_2 concentration marginally exceeds IFC Guidelines values.

5.1.4 Noise

Noise data were collected:

- At the plant site at different times of the day.
- Along the access track from National Highway to the proposed plant site in the morning and evening.

Noise data collected at different points and time are shown in **Exhibit 5.18**. Three samples, each of one minute duration were undertaken at each location.

5.1.5 Vehicular Traffic

With the commencement of project activities, vehicular traffic volumes are likely to increase in the Study Area. To assess existing traffic volumes, hourly traffic data were recorded on the access track at Bhago Bhutto during field visits, using specifically-designed traffic survey forms.

Day time, Night time, and overall average counts for the access track is shown in **Exhibit 5.19** while complete graphical representation of the data collected is presented in **Exhibit 5.20** showing different types of vehicles going in and out of the study area for 16 hours.

5.2 Description of the Biological Environment

This section describes the flora and fauna of the study area.

5.2.1 Flora

Phytogeographically, the study area falls in the Saharo-Sindian region (Ali and Qaiser, 1986), which extends from the Atlantic coast of the Sahara Desert (North Africa) to Pakistan and Rajasthan in India. In Pakistan, this region comprises mainly the flat alluvial plains of the Indus and its adjoining tributaries that cover major parts of Sindh, the Punjab, and the foothills of Balochistan (Nasir and Robina 1995). However, the natural vegetation of this region has been replaced by cultivated species in areas where irrigation system has been developed.

The Project Study Area itself is located in irrigated agricultural fields, and does not support any rare or threatened plant species. The area is characterized by low rainfall, high summer temperatures and low floral diversity. The natural flora of the proposed project site has been completely replaced by agricultural fields. The natural vegetation that exists in the Study Area mostly includes herbaceous vegetation, found along the edges of the agricultural fields and water courses. Along the water canals and other moist places in the Study Area, there are some commercial species of *Desmostychya bipinnat*, *Saccharum spontaneum*, *Tamarix sp.* and *Typha angustata* planted which are used for making ropes, baskets and mats. Mostly, domestic livestock graze in this habitat of the Study Area. Fodder grasses found in the area are *Cynodon dactylon* and *Eleusine degyptica*. Most of the trees that are present along the margins of the agricultural fields were also planted by local communities.

Shisham *Dalbergia sissoo*, and Kikar *Acacia nilotica* are the main fuel wood trees and are much preferred for their hard wood. The trees are planted at the edges of agricultural fields. Other planted trees in the Study Area include some varieties of mulberry, such as shahtut *Morus alba* and tut *Morus idevigata*; ber Z*izyphus jujuba*, dhrek *Melia azadirachta*; and sharin *Albizzia lebbek*, a quick-growing tree. The mulberries and ber are the prefer fodder species for domestic livestock of the Project Area.

During the field visits for the ESIA, 15 species of plants belonging to nine families were identified in the Study Area. **Exhibit 5.21** provides a list of the observed floral species, whereas **Exhibit 5.22** provides the distribution of floral life forms. No endemic or rare floral species exist in the Study Area. All species have wide ranges of distribution.

5.2.2 Fauna

More than 90% of study area is under irrigated agriculture. The natural vegetation and desert habitats once occupying the area have been degraded and most of the area has been converted to agricultural fields. As a result of this ecological shift, most of the wildlife has been left. Most of the animals now found are common species that are highly adaptable and able to co-exist with people. No threatened or vulnerable animals, birds and reptile species have been reported from this area. Some literature on the wildlife of the project area, including mammals, birds, reptiles, and amphibians (Roberts, 1991, 1992, 1997; Minton, 1966; PMNH, 1997), is available.

During fieldwork for the ESIA, a survey was conducted to record the fauna of the study area. Observed footprints, droppings, and sightings indicate that Asiatic jackal, desert fox, and mongoose are the common mammals found in the Study Area. Palm squirrel was a commonly observed small mammal in the Study Area. Other small mammals

reported in the area include Indian desert jird, house rat, Indian jerbil and house mouse. All species are widely distributed throughout Pakistan (Roberts, 1997).

Asiatic jackal mostly hunt singly but are social in habits, while the desert fox lives singly and is not social in its hunting habits. They are not particularly afraid of man. It is well adapted to dry, open country and particularly frequents villages and the smaller rural towns attracted by refuse and garbage. The bulk of their food comprises of rodents (principally gerbils and jirds) and reptiles, supplemented by insects and refuse (Roberts, 1997).

The Study Area is inhabited by a number of resident and migratory birds. Common kingfisher, little brown dove, little egret, cattle egret, stilt, great shrike, marsh sand piper, spoonbill, house crow, common myna, common babbler, and house sparrow are all resident birds of the Study Area. Migratory birds reported from the area include rosy pastor and common starling.

The birds that prefer irrigated fields, such as the little egret, gray heron, pond heron, red-wattled lapwing, marsh sandpiper, and greenshank, were observed foraging in the agricultural fields. The common kingfisher, black-winged stilt, little green bee-eater, and common sandpiper were observed in the small water ponds along settlements and canals in the Study Area. Common myna, house sparrow and house crow were readily observed roosting in trees in the Study Area.

Reptile species observed from the Study Area include the sand swimmer, spotted Indian house gecko, *Hemidactylus brooki*, yellow-bellied house gecko *Hemidactylus flaviviridis*, and Indian garden lizard *Calotes versicolor*. Two poisonous snakes, the Indian krait *Bungarus caeruleus* and the oxus cobra *Naja naja oxiana*, have been reported in the Study Area (Minton 1966).

No amphibian species were recorded during the field visits. The reported species include the Indian toad, skittering frog, and burrowing frog.

Exhibit 5.23 to **Exhibit 5.24** provides lists of observed and reported mammals, birds, and reptiles in the Study Area.

5.3 Description of the Socioeconomic Environment

This section describes the key socioeconomic features of the Study Area, including information relating to the administrative setup, villages, population, education, health, infrastructure, occupations, and cultural resources. An overview of the socioeconomic features of the Study Area discussed in the following sections is presented as **Exhibit 5.25**, whereas photographs showing the socioeconomic features presented in **Exhibit 5.26**.

5.3.1 Study Area

Unless otherwise specified or implied by context, the term ‘Study Area’ will refer to the area which is in a radius of 5 km from the proposed plant site.

A village-level survey covering 21 villages in the Study Area was conducted. The following socioeconomic description is based on data collected during the field visit and

from secondary sources, mainly the 1998 population census report for the Ghotki District (Population Census Organization, 2000).

5.3.2 Administrative Setup

Administratively, the Study Area falls in Daharki and Mirpur Mathelo *talukas* of the Ghotki district in Sindh province. The district borders Kashmore district (Sindh) on the west and north, Rahim Yar Khan district (Punjab) on the northeast, Sukkur district on the south, and Jasalmir State of India on the east. The total area of the district is 6,083 km^2.

5.3.3 Population

The total population of the Ghotki district was 970,549 as enumerated in March 1998 with a male-female ratio of 111:100 (Population Census Organization, 2000). The current estimated population is 1.426 million.[2]

The population of Daharki Taluka was recorded as 204,495 in 1998 with a male-female ratio of 114:100 (Population Census Organization, 2000). The current population is estimated as more than 250,000. The population of Daharki town, the only urban area in the Taluka, was 34,615 which is presently estimated to be more than 50,000..

The total population of the surveyed villages is approximately 54,000. Demographic data for the villages are given in **Exhibit 5.27**. According to the 1998 census, male population between the age of 15 and 49 in rural areas of Daharki Taluka constituted 23.5% of the total rural population of the Taluka. On this basis, it is estimated that the current potential workforce in the Study Area is about 9,000.

The average household size in the Study Area is estimated to be about 7, compared to the average household size of 5.5 in the Ghotki district in 1998.

5.3.4 Housing

According to data collected during the field visit, there are 7,707 houses in the survey villages. These can be divided into *pakka* (made of baked brick and cement) and *kacha* (made of clay). The majority of houses in the Study Area are *kacha* houses. **Exhibit 5.28** gives housing data on the Study Area.

There are also single-room huts made of mud with the roofs are covered with dried leaves. This housing pattern is indicative of the poor economic conditions of the people living in the Study Area.

5.3.5 Tribes

Most residents of the Study Area speak *Sindhi*. The major tribes of the area are *Bhutto, Samejo, Lagahri, Soomroo, Shaikh, Chacharh, Meghwawr, Machi, Malik, Syed, Sharr* and *Dahar*.

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[2] Estimated on the basis of annual growth rate of 3.26% as reported in the district census report.

Conflicts Resolution

Conflicts mainly arise on issues of land and irrigation water. Most decisions are made by the tribal leaders (wadera) and wise men. People go to courts or consult the police usually only as a last resort.

5.3.6 Community Livelihood

In 1998, 58% of the total employed persons had skilled agricultural and fishery occupations followed by elementary occupations (sales and services, agriculture, fishery and related labors, mining, construction, manufacturing, and transport) representing 25.39%; services workers, shop and market sales workers at 8.12%; and crafts and related trades workers constituting 17.71%.

According respondents in the village survey, unemployment is prevalent in the Study Area. Unskilled jobs are available in farm labor. The number of people with technical training is reportedly less than 20 in the Study Area. Most of these people work in the Middle East.

Farming

Farming is the main source of livelihood. Few people have large land holdings; however, most of the landowners have small plots of land, which are not deemed sufficient to support their families. A large number of people are landless *haris* (who work on the fields in return for meager amounts of money). The principal crops of the Study Area are sugarcane, wheat, cotton, and rice. Cotton and sugarcane provide better cash returns as compared to other crops. All farms are irrigated by canals.

Livestock

The practice of livestock rearing is purely for household needs and not for commercial purposes. As such, this particular aspect of an agrarian economy is largely overlooked in this area. Livestock holdings of the villages surveyed during the field visits are presented in **Exhibit 5.29**.

5.3.7 Health

The major health problems in the area related to gastroenteritis, seasonal fevers, malaria and hepatitis B and C, which are caused by contamination of the groundwater by the open unlined drains and pools of stagnant wastewater.

There is a single Rural Health Centre in the Study Area which is not adequate for catering to the needs of the people living the Study Area. Usually, people travel to Daharki or Mirpur Mathelo to receive medical attention.

Snake bites are frequently reported in the Study Area and treatment is only available in Daharki; however, fatalities are not frequent, according to feedback obtained during the field visits.

There are no mother and child care facilities in the Study Area. It was revealed in the female consultations conducted during the field visit in the Study Area that there are no trained or untrained *daiees* (midwife); complications in childbirth are quite common and related deaths are also frequent, as the required medical help is not readily available.

5.3.8 Education

The overall literacy rate for Ghotki is 29.01%. The female literacy rate is 11.85%, as against male literacy of 44.21%. The literacy rate for both male and female is much higher in urban areas as compared to rural areas. The average urban literacy rate for both sexes is 49.38%, while the average rural literacy rate is 24.87%.

The education facilities in most of the villages are lacking. While in some of the villages the schools are lacking teachers. Where the schools are functional and have teachers teaching at those schools the number of school going children is very low in comparison to those who are forced to work in the field. Most of the children are forced to work in the fields, spend their time grazing cattle, or doing daily wage jobs in nearby towns. The main reasons for the lower literacy levels are lack of awareness, unavailability of educational facilities, and, most importantly, poverty

A school profile of the Study Area is shown in **Exhibit 5.30**.

5.3.9 Infrastructure

All the villages surveyed during the field visits to the Study Area were found to have electricity and are accessible by blacktop roads.

The proposed plant site is located at a distance 7 km from the National Highway (N-5). Along the way the access route which is a single lane road, passes through three settlements and a railway crossing of the Karachi-Lahore railway track. Throughout the project area there is a network of paved and unpaved roads (**see Exhibit 5.26**). It is connected to the rest of the country via the N-5 and railway Karachi –Lahore railway line. In general, most of the roads leading to and from the plant site and rst of the study area are having recurring broken and dusty patches.

Landline telephone facilities are available to about 6-8 settlements which are in proximity to Daharki. Vans, pickups, and buses provide regular transport services in the area. Natural gas facilities are also available in 3-5 villages that are again nearer to Daharki.

There are two police stations in Daharki and Dad Laghari while there is only a single sub post office in the study area.

There are no water supply schemes provided by the government in the Study Area. MGCL provides potable drinking water to about five villages in tanks built and replenished by MGCL on regular basis.

5.3.10 Gender Analysis

Gender analysis defines the evolving socioeconomic roles and functions of men and women as they relate to and complement each other within a specific socio-cultural and economic context. This section describes the roles and responsibilities of women in the Study Area after a detailed women's consultation was specifically conducted by the

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survey team with the help of a female sociologist. Women's access to and control over resources, access to health, education, and means of livelihood were also documented through consultation with the women of the area. The following discussion highlights other gender issues, different chores performed by women, domestic violence, etc.

The people in the Study Area raised serious concerns over the involvement of the females in the consultation process, and at several villages even the female consultant was not allowed to meet local women in their own homes.

Activities Performed by Women

Women have the major role of addressing their families' food security and nutritive well-being at the household level. From dawn to dusk, the typical day for a woman of the Study Area entails a tough and strenuous working schedule. She wakes up at dawn and retires after she has fed all the members of the family and with preparations for the following day. The activities performed by women include working in the fields, cooking daily meals for the entire family, washing clothes and utensils, feeding and milking the livestock, fetching drinking water, collecting fuelwood, rearing children, and taking care of the sick and elderly.

In some villages, women fetch water from a distance of 2 to 4 km, especially towards south of the proposed plant site where fresh drinking water is almost non-existent. After completing their morning chores, some of them also bring their livestock to the watercourses to allow them to drink.

Female Education and Awareness

The female population of the Study Area is largely illiterate, and there is very little awareness amongst them of the importance of formal education.

5.3.11 Archaeological and Cultural Sites

No archaeological sites were observed in the Study Area during the field surveys. There is no documented site of archaeological significance in the Study Area. However there is a shrine near Village Nur Hasan Shah which is frequently visited by people of the study area and adjoining areas.

Exhibit 5.1: Panoramic View of Proposed Plant Site

Exhibit 5.2: Soil Sampling Locations

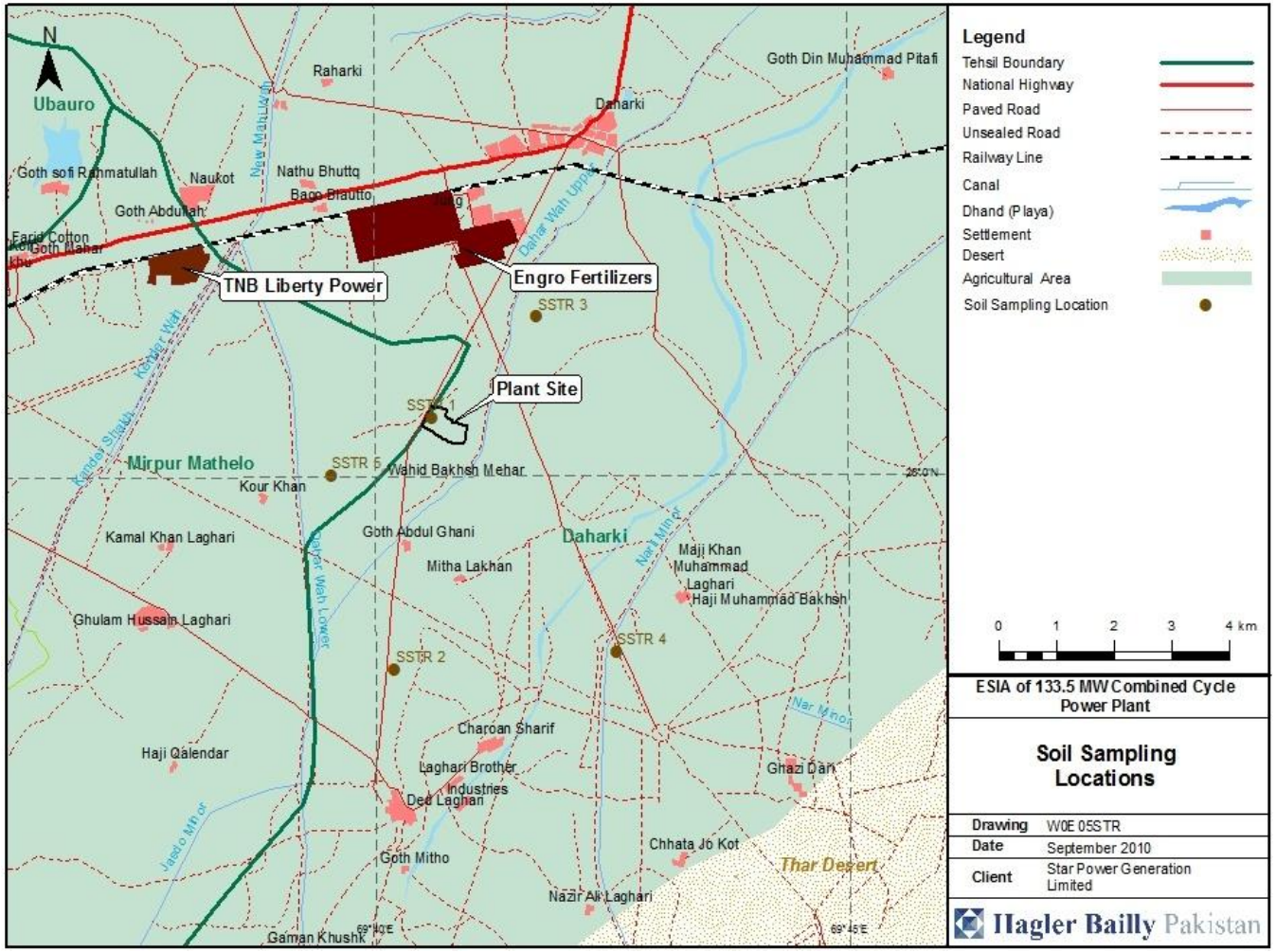

Exhibit 5.3: Soil Analysis Results from the Study Area

Parameter	*Analytical Method*	*Unit*	*Minimum Detection Limit*	Analysis Results *SSTR1*	Analysis Results *SSTR2*	Analysis Results *SSTR3*	Analysis Results *SSTR4*	Analysis Results *SSTR5*
pH	CSSS		0.0	6.90	7.50	7.20	7.20	7.50
Conductivity	CSSS	µS/cm	1.0	2,800	2,250	3,090	6,940	1,806
TDS	***	mg/kg	0.5	1,426	1,134	1,581	3,680	903
Salinity	***	%	0.001	0.14	0.11	0.16	0.38	0.09
Organic Matter	CSSS	%	0.1	0.51	2.07	0.74	0.65	0.81
Organic Carbon	CSSS	%	0.05	0.29	1.19	0.43	0.37	0.47
Sodium	ICP-OES	mg/kg	1.0	1,068.9	9,007.9	1,293.7	1,645.2	715.3
Potassium	ICP-OES	mg/kg	1.0	7,473.3	5,857.4	4,768.7	3,887.9	3,711.1
Calcium	ICP-OES	mg/kg	1.0	40,291.9	33,786.0	36,062.7	33,675.3	35,944.1
Magnesium	ICP-OES	mg/kg	1.0	14,754.1	18,793.9	11,721.3	11,721.3	10,599.5
Sulfate	ICP-OES	mg/kg	1.0	2,460.9	26,315.5	2,034.9	3,394.9	1,214.5
Carbonate	Volumetric Titration	mg/kg	1.0	107.5	BDL	BDL	BDL	BDL
Bicarbonate	Volumetric Titration	mg/kg	1.0	12.3	60	60	60	100
Chloride	ISE	mg/kg	1.0	53.9	4,184	613	1,241	388
Barium	ICP-OES	mg/kg	0.6	3.8	99.8	82.3	77.0	66.7
Lead	ICP-OES	mg/kg	0.15	1.01	7.9	8.6	7.2	4.2
Chromium	ICP-OES	mg/kg	0.06	6.90	52.6	45.2	48.8	45.2
Cadmium	ICP-OES	mg/kg	0.03	2,800	3.6	1.6	1.7	1.5
Arsenic	HGAAS	mg/kg	0.01	1,426	1.21	1.10	1.34	0.63

ICP-OES: Inductively Coupled Plasma (Optical Emission Spectrophotometry)
AFS-CV: Atomic Fluorescence Spectrophotometer (Cold Vapour Technique)
HGAAS: Hydride Generation Atomic Absorption Spectroscopy
CSSS: Canadian Society of the Soil Science
µS/cm: Microsiemens Per Centimeter
***= Analyzed with Conductivity Meter
mg/kg: Milligram Per Kilogram

Exhibit 5.4: Canal Network in the Study Area

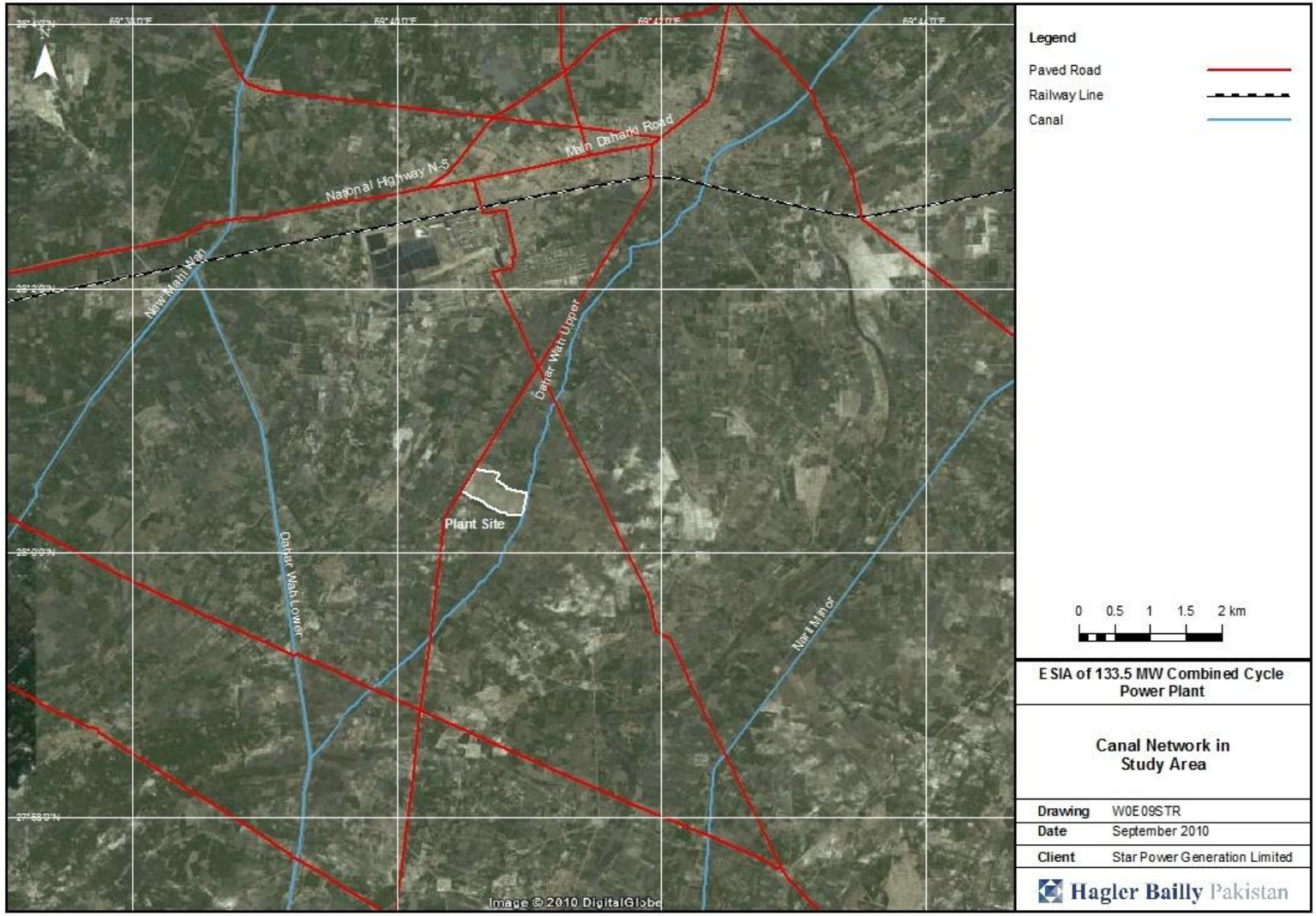

Exhibit 5.5: Survey of Wells in the Study Area

No.	*Name of Village*	*Northing*	*Easting*	*Type*	*Water Level (ft)*	*Water Discharge (l/hr)*	*Use*	*Summer Days/ Month*	*Hours /Day*	*Winter Days/Month*	*Hours/ Day*	*Annual Abstraction (m^3)*
1.	Fateh Pur	N28 00 37.7	E69 40 31.5	HP	40	1080	Domestic	30	3	30	2	986
2.	Shahbazi Khan Dahar	N28 00 39.3	E69 41 03.8	HP	40	1080	Domestic	30	4	30	3	1,380
3.	Rind Khan Sharr	N28 01 33.6	E69 41 33.7	BH	35	828	Domestic	30	2	30	2	604
4.	Bashir Ahmad Khu	N28 01 50.1	E69 40 55.2	HP	40	1440	Domestic	30	5	30	4	2,365
5.	Bahadur Laghari	N27 58 13.2	E69 40 13.3	HP	35	468	Domestic	30	5	30	3	683
6.	Kotlo Mirza	N28 02 11.0	E69 39 37.2	HP	35	756	Domestic	30	1	30	1	276
7.	Jumma Khan Mehar	N28 01 20.6	E69 39 45.0	HP	60	720	Domestic	30	8	30	8	2,102
8.	Allah Rakha Chowk	N28 01 26.9	E69 41 04.8	HP	40	720	Domestic	30	2	30	2	526
9.	Allah Rakha Chowk	N28 01 26.9	E69 41 04.8	BH	40	720	Domestic	30	6	30	6	1,577
10.	Jumma Khan	N27 58 23.7	E69 42 32.1	HP	20	828	Domestic	30	6	30	6	1,813
11.	Banho Malik	N27 59 23.1	E69 42 01.7	HP	25	900	Domestic	30	6	30	5	1,807
12.	Dad Laghari	N27 56 54.5	E69 40 15.2	HP	42	720	Domestic	30	9	30	7	2,102
13.	Gul Muhammad Patafi	N27 57 57.7	E69 38 49.7	HP	30	396	Domestic	30	1	30	1	145
14.	Wahid Baksh Mehar	N27 59 57.2	E69 39 13.8	HP	45	900	Domestic	30	3	30	2	821
15.	Allah Rakhio	N28 01 22.9	E69 40 56.9	BH	40	828	Domestic	30	3	30	2	756
16.	Dukhar Goth	N28 00 06.6	E69 42 02.1	HP	30	720	Domestic	30	1	30	1	263
17.	Gul Muhammad Laghari	N27 57 55.7	E69 42 52.9	HP	30	720	Domestic	30	3	30	3	788
18.	Sultan Lashari	N27 58 38.6	E69 39 39.2	HP	50	936	Domestic	30	3	30	3	1,025
19.	Jan Muhammad Bhugio	N28 01 28.0	E69 39 47.8	BH	20	756	Domestic	30	15	30	11	3587
20.	Bago Bhutto	N28 02 24.7	E69 39 21.4	HP	40	1188	Domestic	30	2	30	2	867
	Average			BH								1,631
				HP								1,122

HP: Handpump; **BH:** Borehole

Exhibit 5.6: Water Sampling Locations

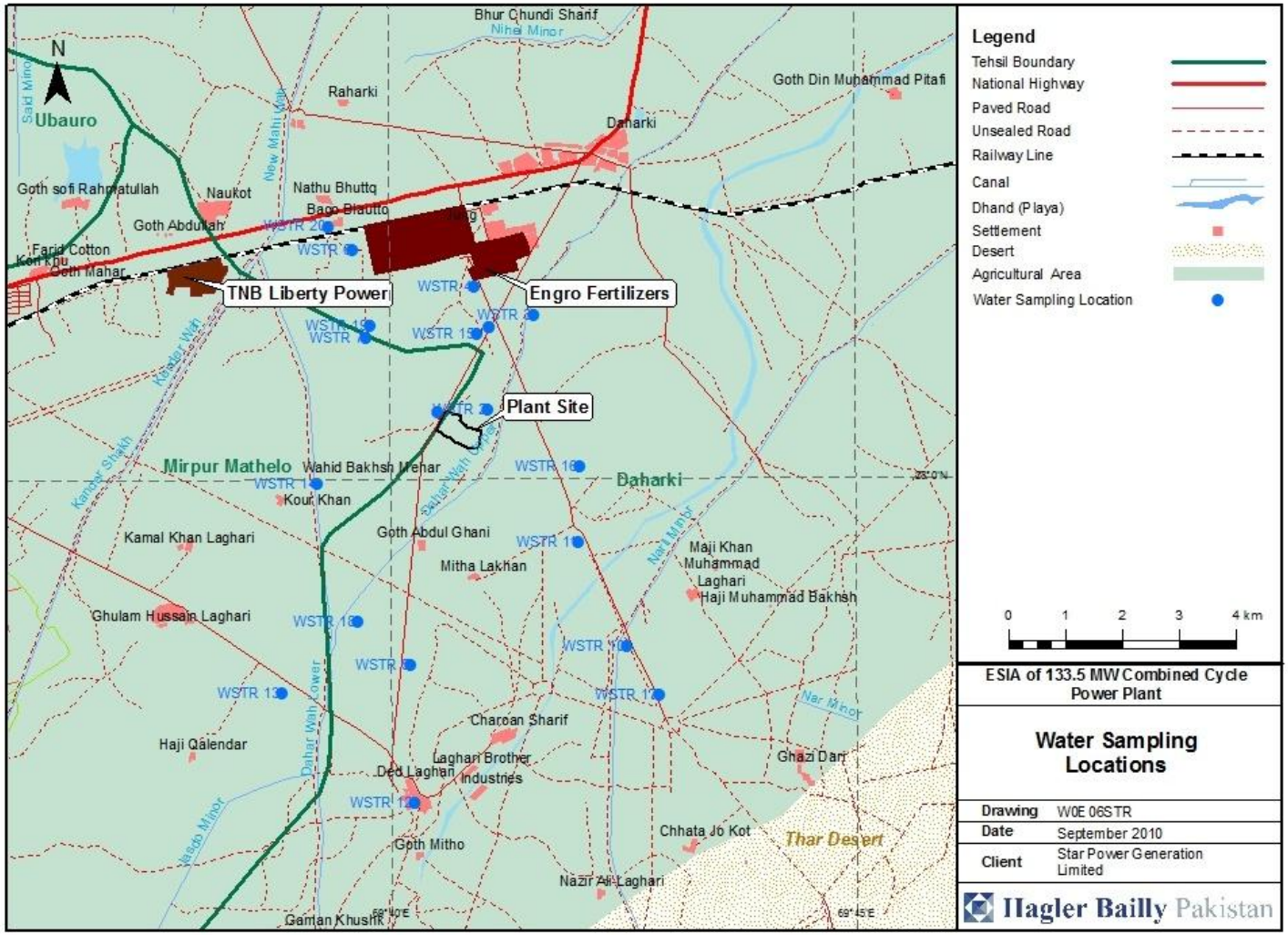

Exhibit 5.7: Water Quality Analysis On-Site Results of the Study Area

No.	*Village Name*	*Well ID*	*Northing*	*Easting*	*Temperature*	*EC us/cm*	*Salinity*	*TDS (mg/l)*	*DO (mg/l)*	*Color*
1.	Fateh Pur	WSTR 1	28 00 37.7	69 40 31.5	28.2	708	0.3	345	2.13	clear
2.	Shahbazi Khan Dahar	WSTR 2	28 00 39.3	69 41 03.8	30.1	803	0.4	432	2.3	clear
3.	Rind Khan Sharr	WSTR 3	28 01 33.6	69 41 33.7	33.5	856	0.4	419	1.8	clear
4.	Bashir Ahmad Khu	WSTR 4	28 01 50.1	69 40 55.2	30.4	2980	1.5	1527	1.9	clear
5.	Bahadur Laghari	WSTR 5	27 58 13.2	69 40 13.3	32.8	729	0.3	355	1.73	Turbid
6.	Kotlo Mirza	WSTR 6	28 02 11.0	69 39 37.2	31.2	1027	0.5	504	2.2	clear
7.	Jumma Khan Mehar	WSTR 7	28 01 20.6	69 39 45.0	30.6	2200	1.1	1100	2.7	clear
8.	Allah Rakha Chowk	WSTR 8	28 01 26.9	69 41 04.8	29.3	8500	4.7	4600	2.5	Turbid
9.	Allah Rakha Chowk	WSTR 9	28 01 26.9	69 41 04.8	30.6	2120	1.1	1068	2.9	clear
10.	Jumma Khan	WSTR 10	27 58 23.7	69 42 32.1	28.8	4710	2.5	2460	2.56	clear
11.	Banho Malik	WSTR 11	27 59 23.1	69 42 01.7	32.1	3380	1.8	1741	2.16	clear
12.	Dad Laghari	WSTR 12	27 56 54.5	69 40 15.2	28	1187	0.6	585	2.45	clear
13.	Gul Muhammad Patafi	WSTR 13	27 57 57.7	69 38 49.7	30.2	604	0.2	293	2.8	clear
14.	Wahid Baksh Mehar	WSTR 14	27 59 57.2	69 39 13.8	29.1	788	0.4	385	2.4	clear
15.	Allah Rakhio	WSTR 15	28 01 22.9	69 40 56.9	32.2	3220	1.7	1654	2.8	clear
16.	Dukhar Goth	WSTR 16	28 00 06.6	69 42 02.1	28.2	950	0.5	456	2.02	clear
17.	Gul Muhammad Laghari	WSTR 17	27 57 55.7	69 42 52.9	30.5	1258	0.6	621	2.2	clear
18.	Sultan Lashari	WSTR 18	27 58 38.6	69 39 39.2	31.4	1240	0.6	612	2.55	clear
19	Jan Muhammad Bhugio	WSTR 19	28 01 28.0	69 39 47.8	30.4	656	0.3	319	2.7	clear
20.	Bago Bhutto	WSTR 20	28 02 24.7	69 39 21.4	30.4	1220	0.6	602	2.7	clear

Exhibit 5.8: Water Quality Analysis Lab Results of the Study Area

Parameter	*Analytical Method*	*Unit*	*Minimum Detection Limit*	*WSTR10*	*WSTR13*	*WSTR14*	*WSTR16*	*WSTR19*	*WSTR3*
DO	US EPA 360.1	mg/l	1.0	2.56	2.80	2.40	2.02	2.70	1.80
Temperature	US EPA 170.1	°C	1.0	28.8	30.2	29.1	28.2	30.4	33.5
Nitrate	US EPA 352.1	mg/l	0.1	0.27	1.43	0.53	1.19	0.52	0.62
Ammonia	SMEW 4500-NH3	mg/l	0.5	BDL	BDL	BDL	BDL	BDL	BDL
pH	EPA 150.1		0.1	7.0	7.1	7.40	7.4	7.60	7.3
EC	EPA 120.1	µS/cm	1.0	3,230	773	850	950	656	10,720
Sodium	US EPA 6010 B	mg/l	0.1	417	70	28	146	219	2,228
Magnesium	US EPA 6010 B	mg/l	0.1	72	34	49	42	13	77
Calcium	US EPA 6010 B	mg/l	0.1	217	66	280	105	18	47
Potassium	US EPA 6010 B	mg/l	0.1	11	11	8	7	8	25
Sulfate	EPA 9056 A	mg/l	0.1	948.1	94.64	530	358	138.26	1,614.73
Chloride	EPA 9056 A	mg/l	0.1	460.85	33.68	33.98	141.8	56.72	2,033.06
Fluoride	EPA 9056 A	mg/l	0.1	0.7	0.75	0.84	0.52	0.9	0.64
Bicarbonate Alkalinity	EPA 310.1	mg/l	1.0	235	335	305	364	432	895
T. Hardness	EPA 130.2	mg/l	0.1	760	304	268	452	128	612
Silicate as SiO2	US EPA 6010 B	mg/l	0.1	17	20	19	15	17	22
TDS	***	mg/l	1.0	2,132	541	595	660	430	5,870
Sulfide S2-	EPA 376.1	mg/l	1.0	BDL	BDL	BDL	BDL	BDL	BDL
Iron	US EPA 6020 A	mg/l	0.01	0.38	0.32	0.09	0.2	0.06	BDL

Parameter	*Analytical Method*	*Unit*	*Minimum Detection Limit*	*WSTR10*	*WSTR13*	*WSTR14*	*WSTR16*	*WSTR19*	*WSTR3*
Aluminum	US EPA 6020 A	mg/l	0.01	BDL	BDL	BDL	BDL	BDL	BDL
Arsenic	US EPA 6020 A	mg/l	0.005	0.013	0.015	0.019	0.014	0.017	0.014
Cadmium	US EPA 6020 A	mg/l	0.001	BDL	BDL	BDL	BDL	BDL	BDL
Chromium	US EPA 6020 A	mg/l	0.001	BDL	BDL	BDL	BDL	BDL	BDL
Cobalt	US EPA 6020 A	mg/l	0.01	BDL	BDL	BDL	BDL	BDL	BDL
Copper	US EPA 6020 A	mg/l	0.001	BDL	BDL	BDL	BDL	BDL	BDL
Lead	US EPA 6020 A	mg/l	0.001	BDL	BDL	BDL	BDL	BDL	BDL
Manganese	US EPA 6020 A	mg/l	0.001	0.24	0.06	0.02	0.04	0.03	0.07
Nickel	US EPA 6020 A	mg/l	0.001	BDL	BDL	BDL	BDL	BDL	BDL
Selenium	US EPA 6020 A	mg/l	0.01	BDL	BDL	BDL	BDL	BDL	BDL
Zinc	US EPA 6020 A	mg/l	0.005	BDL	BDL	BDL	BDL	BDL	BDL

SMEW: Standard Methods for Examination of Water and Wastewater, 19th Edition
USEPA: United States Environmental Protection Agency
***= Analyzed with Conductivity Meter
BDL: Below Detection Limit
EC: Electrical Conductivity
mg/l: Milligram Per Liter
DO: Dissolved Oxygen

Exhibit 5.9: Seasonal Characteristics of the Study Area Climate

Season	*Temperature*	*Humidity*	*Rainfall*	*Wind*
Summer (Mid-March to mid-June)	March is the transition period from winter to summer. Daily maximum increases from about 27 °C at the start of the month to 34 °C at the end. It continues to increase and peaks at 44 °C just before the onset of the monsoon in late June.	Morning (evening) humidity decreases from 65% (28%) in March to about 52% (23%) by mid-April. It stays around this figure for about a month and starts increasing in late May and reaches 65% (25%) by June.	5-7 mm of rain falls in February. The rest of the season is dry—monthly rainfall is less than 5 mm.	Wind starts changing direction, from NE to S-SW, near the end of March. The average speed also increases from 3 knots to 4.5 knots by mid-June.
Monsoon (Mid-June to mid-September)	High winds and subsequent rainfall lowers the temperature by 4-5 °C in July. The maximum temperature remains around 38 °C in August and September.	Moisture associated with the monsoon increases humidity to more than 75% in the morning and 40% in the evening during July, August and most of September.	More than 55 mm of rain falls during this period; this accounts for more than 60% of the total rainfall received in the area.	Throughout this period, wind blows from the south at an average speed of 3.5 knots.
Post-Monsoon Summer (Mid-September to November)	The daily maximum temperature drops by more than 10 °C from early October to end of November.	Morning (evening) humidity decreases slightly; however, it remains above 70% (30%).	The season is dry. Monthly average rainfall is less than 5 mm.	Average wind speed drops below 2.5 knots. The direction starts changing back to NE by the end of September.
Winter (December to mid-March)	The daily maximum and minimum temperatures average around 24 °C and 9 °C, respectively.	Morning (evening) humidity increases to nearly 75% (35%) in December but drops to 65% (30%) by end of February.	The season is dry. Monthly average rainfall is less than 5 mm, except in February, when 5-7 mm of rain is received in the Study Area.	Mild winds (less than 2.5 knots) blow from the northeast throughout this season.

Exhibit 5.10: Monthly Temperatures for Sukkur

Month	*Mean Daily*		*Maximum Recorded*		*Minimum Recorded*	
	Max. (°C)	*Min. (°C)*	*Value (°C)*	*Date*	*Value (°C)*	*Date*
January	22.8	8.4	31	25/1932	–4	31/1929
February	25.3	10.9	38	27/1953	–1	01/1929
March	31.2	16.4	42.2	16/1969	4	02/1936
April	37.6	22.0	47	28/1979	10	03/1989
May	42.4	26.2	49	29/1981	16	08/1989
June	43.6	28.4	50	11/1979	19	13/1990
July	40.8	27.9	47	02/1976	17.5	26/1989
August	38.7	26.7	47	09/1987	17.5	28/1989
September	38.0	24.9	43.3	23/1968	16.5	27/1989
October	35.3	20.3	44	05/1951	9.5	28/1989
November	29.9	14.4	38	06/1990	5	30/1938
December	24.0	9.6	33	01/1953	–1.5	15/1986

Source: Pakistan Meteorological Department (1992).

Exhibit 5.11: Mean Monthly Relative Humidity at Sukkur

Month	*Relative Humidity at 5:00 am (%)*	*Relative Humidity at 5:00 pm (%)*
January	73	35
February	67	32
March	63	28
April	52	22
May	52	20
June	65	26
July	75	40
August	77	46
September	77	41
October	71	32
November	74	34
December	76	38

Source: Pakistan Meteorological Department (1992).

Exhibit 5.12: Rainfall Data for Sukkur

Month	*Mean of Monthly Total (mm)*	*Mean No. of Rainy Days*	*Wettest Month on Record*		*Heaviest Rainfall Recorded in 24 hours*	
			Amount (mm)	*Year*	*Amount (mm)*	*Date*
Jan.	3.5	0.4	39.9	1935	19.1	08/1957
Feb.	8	0.7	64.4	1979	34.8	19/1979
Mar.	5.7	0.7	51.9	1982	25	23/1982
Apr.	1.5	0.2	17.5	1937	11.4	07/1951
May.	4	0.2	43.2	1974	43.2	27/1974
Jun.	4.3	0.3	42.4	1964	21.6	10/1948
Jul.	25.7	1.5	336.1	1978	184.5	15/1978
Aug.	19.8	1.2	142.2	1933	139.7	09/1933
Sep.	10	0.5	155.2	1976	64.6	06/1975
Oct.	1.3	0.2	65.5	1930	62.2	02/1956
Nov.	0.6	0.2	19.3	1937	7.6	06/1959
Dec.	3.8	0.3	80.5	1967	7.6	22/1978

Source: Pakistan Meteorological Department (1992).

Exhibit 5.13: Wind Data for Sukkur

Month	*% of Time Calm*	*Mean Wind*			*Max. Wind Speed (knots)*
		Speed (knots)	*Direction*	*Steadiness*	
January	37	2.3	NE	69	13
February	27	3.1	NE	61	16
March	26	2.8	NE	50	21
April	25	2.9	Variable	16	19
May	20	3.3	SW	40	16
June	13	4.3	S	53	31
July	12	3.9	S	48	44
August	17	3.4	S	35	22
September	23	3.5	S	26	39
October	41	2	Variable	8	13
November	41	2.2	NE	53	13
December	40	1.9	NE	63	22

Source: Pakistan Meteorological Department (1992).

Exhibit 5.14: Ambient Air Quality Sampling Locations

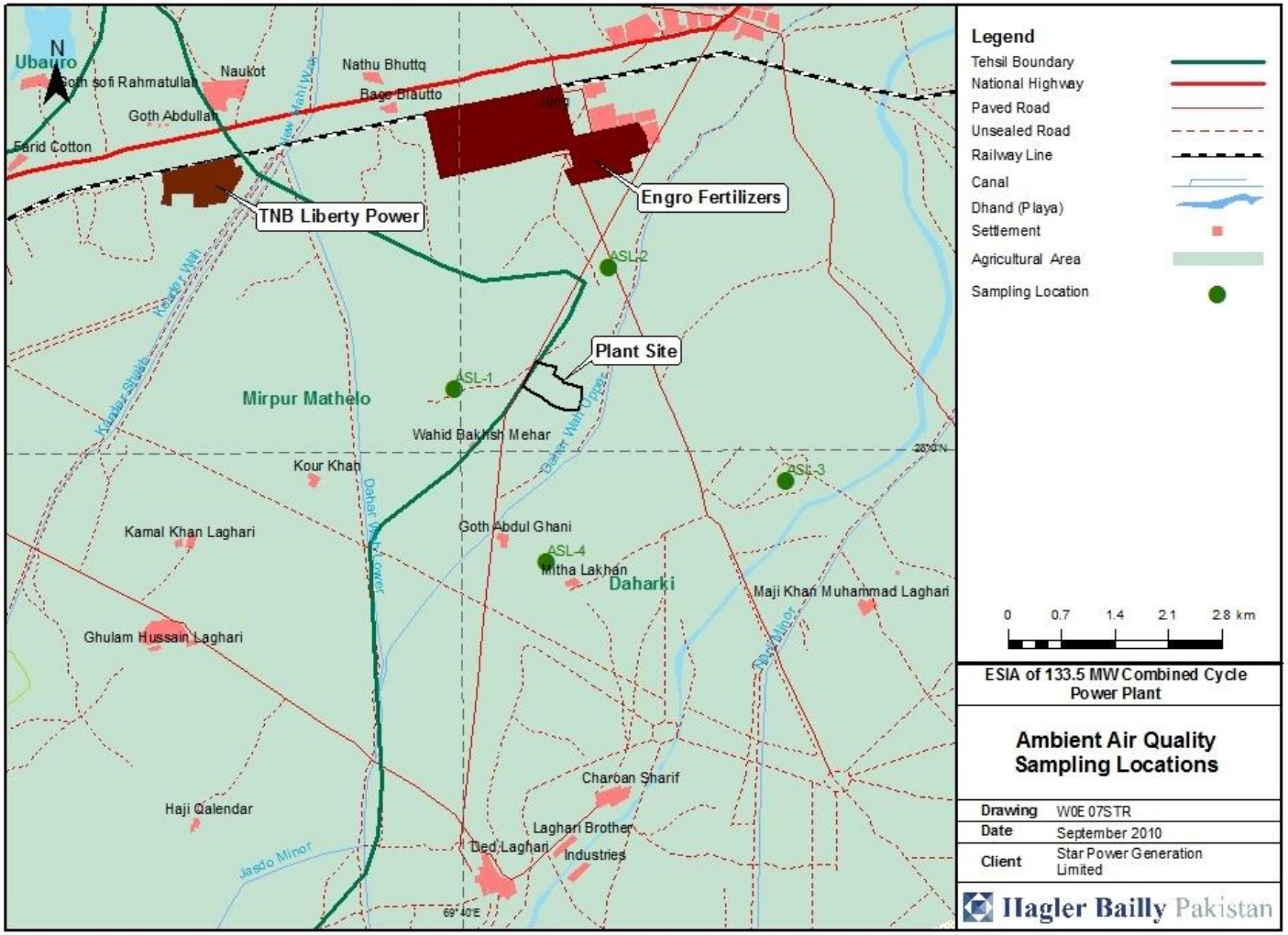

Exhibit 5.15: Ambient Air Quality Monitoring Results

Parameter	*Field ID*	*PM_{10} µg/Nm^3 (24 Hour Sampling)*	*CO mg/Nm^3*	*NOX µg/Nm^3*	*SOX µg/Nm^3*
Analytical Methods		US EPA 40 CFR App B Part 50	Electro Chemical	ISO 6768	US EPA App A Part 50 Pararosaniline
Coordinates N 28 00 26.9 E 069 39 57.4	ASL-1	171.4	0	52.0	13.5
N 28 01 18.3 E 069 41 11.6	ASL-2	132.0	0	57.5	9.5
N 27 59 46.7 E 069 42 36.2	ASL-3	166.4	0	43.0	10.0
N 27 59 12.6 E 069 40 41.1	ASL-4	150.4	0	44.4	12.0

mg/Nm^3: Milligram per normal cubic meter
µg/Nm^3: Microgram per normal cubic meter.

Exhibit 5.16: Major Emission Sources in the Vicinity of the Project Site

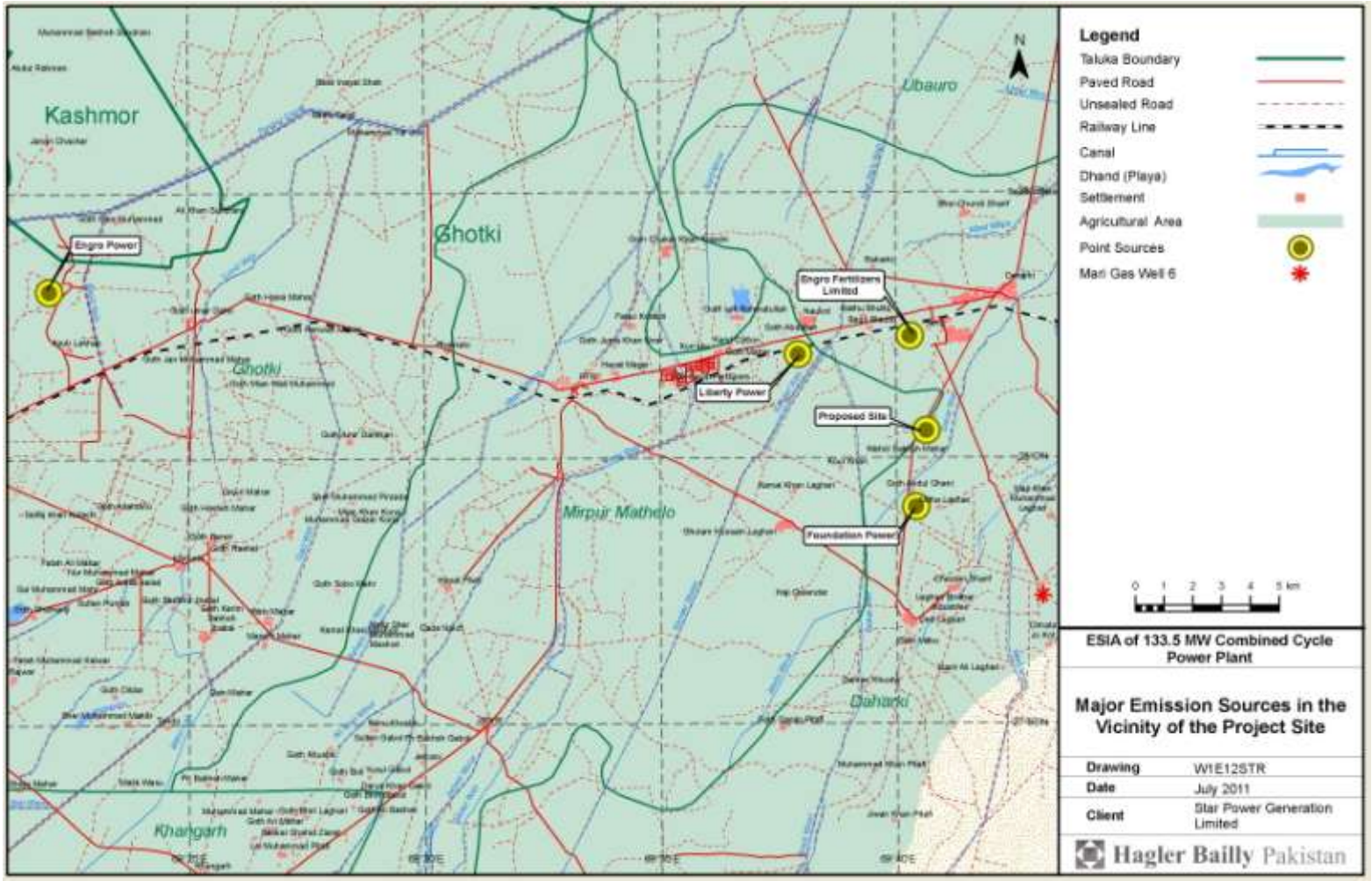

Exhibit 5.17: Ambient Air Quality in the Study Area

		SO_2 (ug/m^3)	NO_2 (ug/m^3)	CO (ug/m^3)	PM_{10} (ug/m^3)
Annual Average		34.1	34.7	991	138
Maximum		84.1	57.5	2,001	329
Criteria	Annual, IFC Guidelines	[a]	40.0		70[d]
	Annual, NEQS	80.0	40.0		200
	24-hour, IFC Guidelines	125.0[b]	200.0		150[d]
	24-hour, NEQS	120.0	80.0		250

[a] Blank cells indicate that no limit are set

[b] Interim target-1

Exhibit 5.18: Ambient Noise Level in Study Area

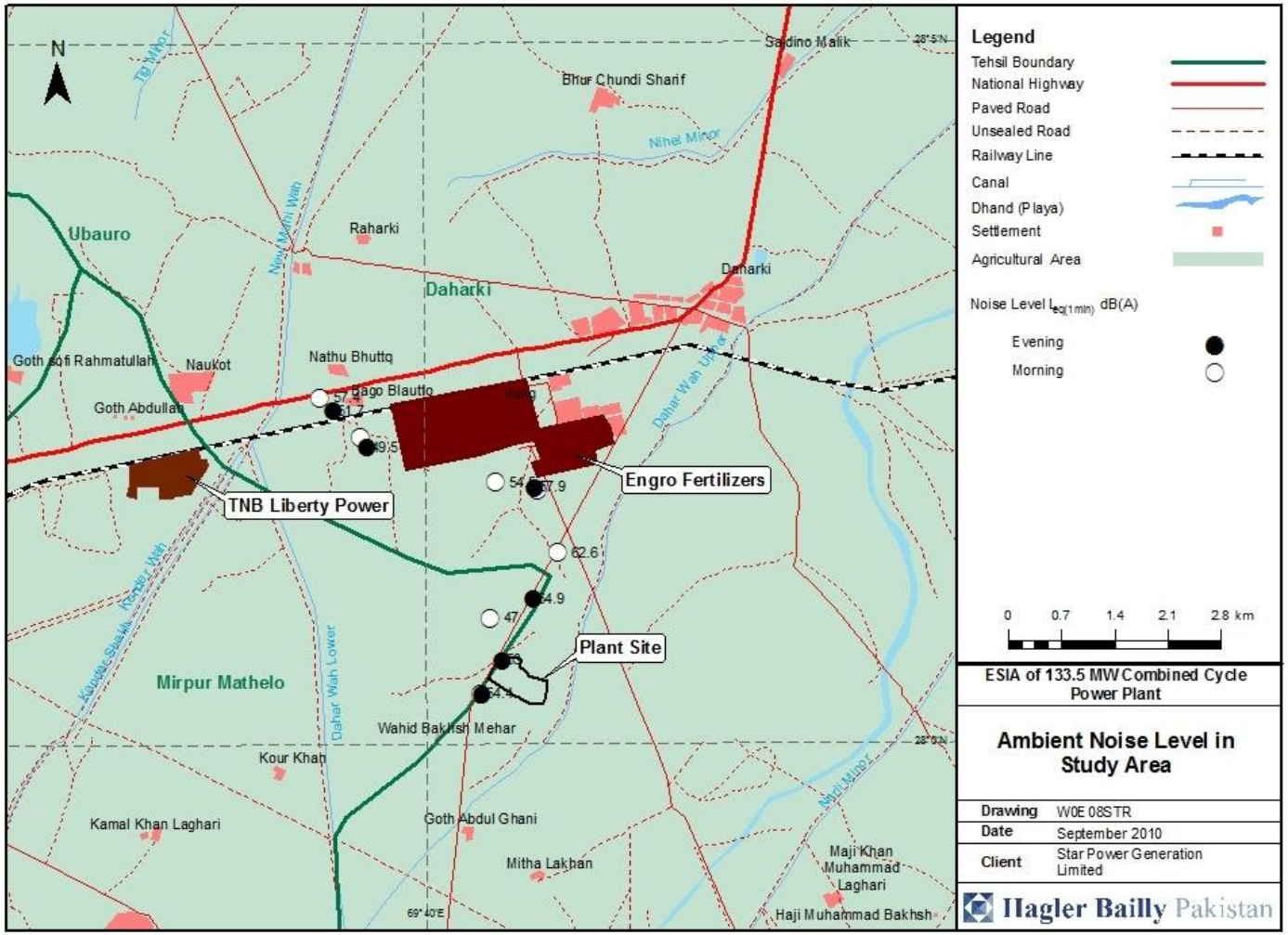

Exhibit 5.19: Traffic Flow on the Access Track

Location	*Sampling Hours*		*Day Time Average for 1 Hour*	*Night Time Average for 1 Hour*	*Overall Average for 1 Hour*
Traffic flow into the Project Area	Day time	12	27	15	24
	Night time	4			
Traffic flow out of the Project Area	Day time	12	28	12	24
	Night time	4			
	Night time				

Exhibit 5.20: Traffic on the Access Track

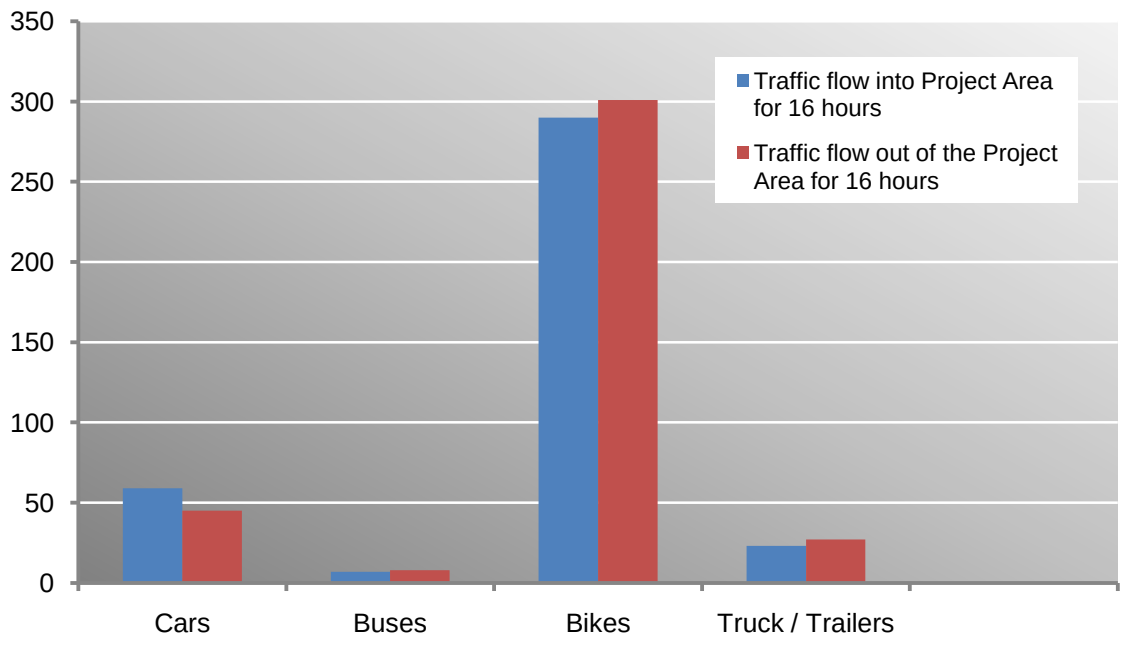

Exhibit 5.21: Floral Species of the Study Area

Species	*Family*	*Lifeform*	*Life Span*
Acacia nilotic	Mimosaceae	Tree	Perennial
Albizzia lebbek	Fabaceae	Tree	Perennial
Alhagi maurorum	Fabaceae	Weed	Perennial
Cynodon dactylon	Poaceae	Grass	Perennial
Dalbergia sissoo	Fabaceae	Tree	Perennial
Desmostychya bipinnata	Poaceae	Grass	Perennial
Eleusine degyptica	Poaceae	Grass	Annual
Melia azadirachta	Meliaceae	Tree	Perennial
Morus alba	Moraceae	Tree	Perennial
Morus idevigata	Moraceae	Tree	Perennial
Phragmites karka	Poaceae	Grass	Perennial
Saccharum spontaneum	Poaceae	Grass	Perennial
Tamarix aphylla.	Tamaricaceae	Tree	Perennial
Typha angustata	Typhaceae	Weed	Perennial
Zizyphus jujuba	Rhamnaceae	Tree	Perennial

Exhibit 5.22: Floral Life Forms and Their Occurrence

Life form	*Occurrence (%)*
Weed	13.3
Grass	33.3
Tree	53.4

Exhibit 5.23: Mammals of the Study Area

Scientific Name	*Common Name*	*Occurence*		
		Common	*Less Common*	*Rare*
Canis aureus	Asiatic Jackal	x		
Ratus Ratus	House Rat	x		
Mus musculus	House Mouse	x		
Herpestes javanicus	Mongoose	x		
Funambulus palmarum	Palm Squirrel	x		
Vulpes vulpes	Common Fox	x		
Meriones hurrianae	Indian Desert Jird	x		

Exhibit 5.24: Avian Species of the Study Area

Common Name	*Scientific Name*	*Status*			*Occurrence*		
		Migratory	*Resident*	*Common*	*Abundant*	*Less Common*	*Rare*
Black–winged Stilt	*Himantopus himantopus*	x		x			
Common Sandpiper	*Actitis hypoleucos*	x		x			
House Crow	*Corvus splendens*		x		x		
House Sparrow	*Passer domesticus*		x		x		
Common Myna	*Acridotheres tristis*		x		x		
Common Babbler	*Turdoides caudta*		x		x		
Little Brown Dove	*Streptopelia senegalensis*		x		x		
Little Egret	*Egretta garzetta*		x	x			
Shrike	*Lanius schach*		x	x			
White–breasted Kingfisher	*Halcyon smyrnensis*		x	x			
Common Starlig	*Sturnus vulgaris*		x	x			

Exhibit 5.25: Reported Reptilian Species in the Study Area

Common Name	*Scientific Name*	*Occurence*		
		Common	*Less Common*	*Rare*
Garden Lizard	*Calotes versicolor*	x		
Indian Krait	*Bungarus careulus*		x	
Indian Cobra	*Naja naja naja*		x	
Spotted Indian House Gecko	*Hemidactylus brookii brookii*	x		
Yellow bellied House Gecko	*Hemidactylus flaviviridis*	x		

Exhibit 5.26: Socioeconomic Features of Study Area

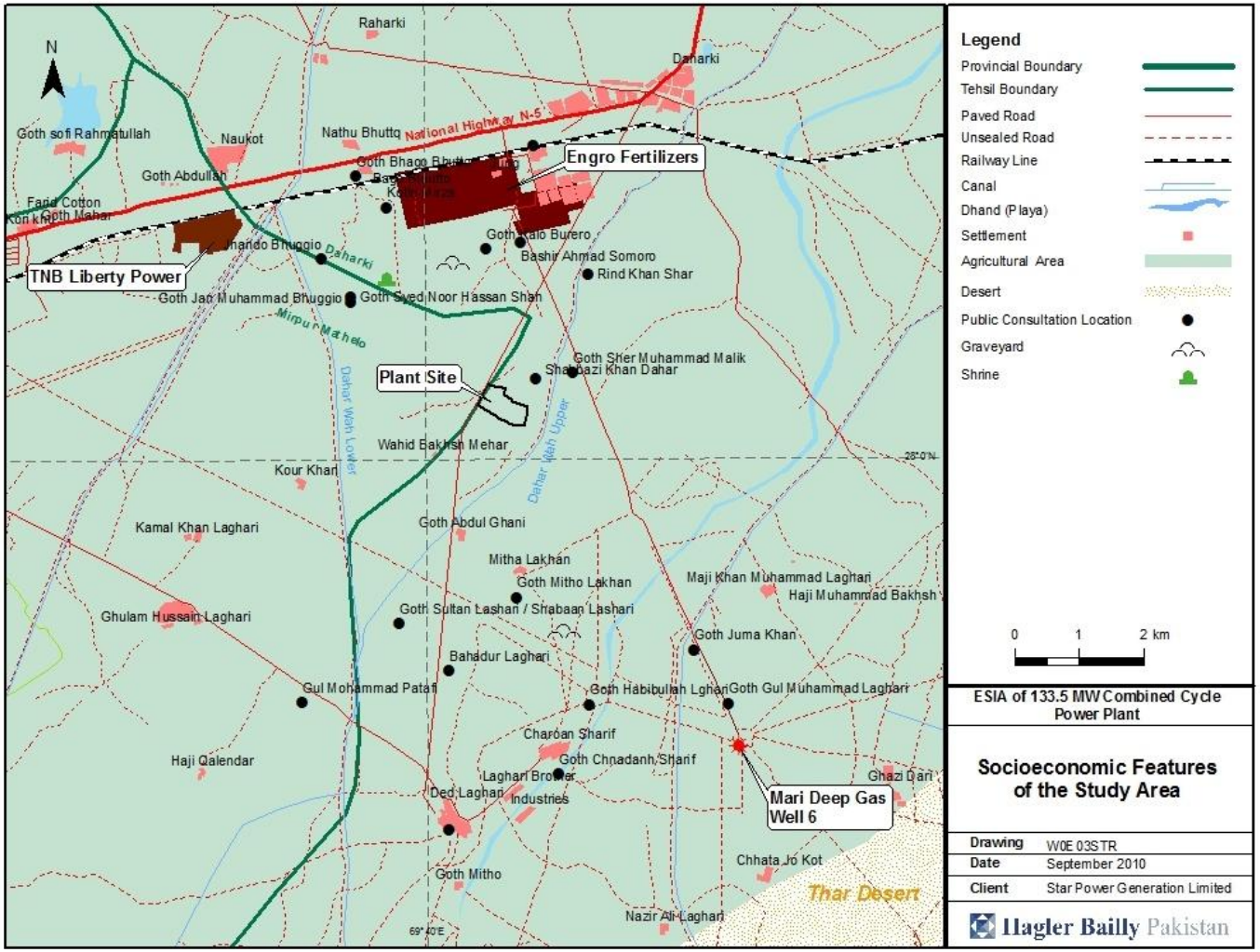

Exhibit 5.27: Photographs Showing Socioeconomic Conditions in the Study Area

Typical house in the Study Area

Common sitting place for men

Mosque in the Study Area

Graveyard near Goth Jan Muhammad Bhuggio

People working in rice fields in Study area

Brick kiln

Livestock in the Study Area

Dried cotton stems used as fuel in the Study Area

Exhibit 5.28: Demographic Data of Surveyed Villages in Study Area

Village	*Total Population*	*Total Households*	*Approximate No of Bricked House*
Bashir Ahmad Somoro	50	5	100%
Shahbazi Khan Dahar	270	30	50%
Rind Khan Shar	195	30	50%
Bahadur Laghari	70	10	50%
Goth Juma Khan	150	15	30%
Dad Laghari	20,000	2,000	50%
Gul Mohammad Patafi	100	10	20%
Goth Sher Muhammad Malik	500	45	30%
Goth Banho Malik	2,500	200	40%
Goth Mitho Lakhan	4,000	200	25%
Goth Gul Mohammad Laghari	2,000	150	10%
Bago Bhutto	3,000	320	60%
Goth Kalo Bulro	2,000	150	80%
Goth Sultan Lashari	1,500	90	15%
Goth Subhan Lashari	1,000	80	15%
Goth Chandarah Sharif	3,000	370	30%
Goth Habibullah Laghari	250	22	50%
Kotlo Mirza	800	100	40%
Goth Syed Noor Hassan Shah	2,500	1,200	30%
Jhando Bhuggio	450	200	40%
Jung	10,000	2,500	80%
Total	**54,335**	**7,727**	**55%**

Exhibit 5.29: Livestock Holdings in Surveyed Villages in Study Area

Village	*Goats*	*Buffalo*	*Cows*	*Donkeys*
Bashir Ahmad Somoro	10	8	4	
Shahbazi Khan Dahar		4		
Rind Khan Shar	20	120	800	
Bahadur Laghari	15	40	10	
Goth Juma Khan	5	15	5	2
Dad Laghari	1,000		5	50
Gul Mohammad Patafi	10	10	10	
Goth Sher Muhammad Malik	150	40	20	5
Goth Banho Malik	22	10	5	12
Goth Mitho Lakhan	100	120	30	11
Goth Gul Mohammad Laghari	400	300	80	22
Bago Bhutto	300	25	10	7
Goth Kalo Bulro	260	35	15	12
Goth Sultan Lashari	120	15	10	10
Goth Subhan Lashari		10	2	
Goth Chandarah Sharif	350	280	100	12
Goth Habibullah Laghari	50	60	20	2
Kotlo Mirza	100	40	10	2
Goth Syed Noor Hassan Shah	500	250	100	15
Jhando Bhuggio	300	100	60	5
Jung	800	120	50	20
Total	**4,512**	**1,602**	**1,346**	**187**

Exhibit 5.30: Schools in the Surveyed Villages/Settlements

Village/Settlement	*Boys Primary School*	*Girls Primary School*	*Boys Medium/High School*	*Girls Medium/High School*
Bashir Ahmad Somoro	N	N	N	N
Shahbazi Khan Dahar	N	N	N	N
Rind Khan Shar	Y	Y	N	N
Bahadur Laghari	N	N	N	N
Goth Juma Khan	Y	Y	N	N
Dad Laghari	Y	Y	Y	Y
Gul Mohammad Patafi	N	N	N	N
Goth Sher Muhammad Malik	N	N	N	N
Goth Banho Malik	Y	N	N	N
Goth Mitho Lakhan	Y	Y	N	N
Goth Gul Mohammad Laghari	N	N	N	N
Bago Bhutto	Y	Y	N	N
Goth Kalo Bulro	Y	Y	N	N
Goth Sultan Lashari	N	N	N	N
Goth Subhan Lashari	N	N	N	N
Goth Chandarah Sharif	Y	Y	Y	Y
Goth Habibullah Laghari	Y	Y	N	N
Kotlo Mirza	Y	Y	N	N
Goth Syed Noor Hassan Shah	Y	Y	N	N
Jhando Bhuggio	Y	Y	N	N
Jung	Y	Y	Y	Y

Y: Yes
N: No