3.6MW Gugera Hydro Power Project, Distt. Nankana

# Application to NEPRA for Generation License

GHC

Facilitated by PPDB, Government of Punjab

Gugera Hydro Power Co.

Pg: 1

# Gugera Hydro Power Co.

64-Ahmad Block, New Garden Town, Lahore, Pakistan
**Tel:** +92 42 35851559-60 **Fax:** +92 42 35832796
**E-mail:** gugerahydro@gmail.com


Dated: 05 October 2016

The Registrar
National Electric Power Regulatory Authority (NEPRA)
NEPRA Tower, Ataturk Avenue (East)
G-5/1, Islamabad

**Subject: 3.6 MW Gugera Hydro Power Project, District Nankana - Application for Generation License – Proposed Financing Arrangements (Clause 3(5)(d)(ii))**

Dear Sir,

We refer to our application for the issuance of Generation License for 3.6 MW Gugera Hydropower Project (the "Project"). One of the requirement of Section 3(5)(d)(ii) of NEPRA (Application and Modification Procedure) Regulation 1999 is that the Applicant shall provide expression of interest to provide credit or financing for the Project.

In this regard we would like to humbly submit that we intend to finance this Project under "limited recourse financing scheme" whereby project lenders issue such expression of interests following the issuance of Letter of Support (the "LOS") by the Government. You would appreciate that very purpose of issuance of LOS is to give certain time to the sponsors to arrange financing to achieve the financial closing of the Project. Additionally, it may be noted that Project lenders prefer to show their interest once the financial viability of the project is established through approval of tariff for which we intend to apply to NEPRA after the issuance of Generation License.

Generally, we would like to inform that our management team include the specific experience to arrange financing of USD 600 million for New Bong Escape Hydropower Project and 102 MW Gulpur Hydropower Project. In this respect we will approach local banks including Habib Bank Limited, National Bank of Pakistan and Allied Bank Limited for financing immediately after issuance of LOS. We will also explore the possibility of foreign financing through International Finance Corporation and Asian Development Bank.

We sincerely hope that aforesaid explanation shall suffice to satisfy the requirements of Section 3(5)(d)(ii) of NEPRA (Application and Modification Procedure) Regulation 1999.

With best regards,

Nasir Ali

Gugera Hydro Power Co.

Nasir A Malik
CEO

SAMBU

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# Gugera Hydro Power Co.

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# Check List

## For Examination of License Application of New Generation Facility (Hydel)

| | |
|---|---|
| **Name of Company** | Gugera Hydropower Company (Pvt). Ltd. |
| **Power Generation Capacity** | 3.6 MW |
| **Prepared / Updated on** | 05-10-2016 |
| **Application Submission** | The Application is being filed pursuant to NEPRA (Application and Modification Procedure)Regulations 1999 |

| Regulation No | Required Information / Part II 3 | Compliance / Remarks |
|---|---|---|
| 3 (1) | An Application for Generation License shall be made in the form specified in Schedule 1 to these rules. Authorization from Board of Directors Resolution/Power of Attorney | The Application is as per Format of Schedule1.<br><br>Authorization of Board of Directors (BOD) is attached with the Application at **Annexure 2.1.**<br><br>Affidavit by the CEO is also attached at Annexure 2.1(a). |
| 3(3) | The Registrars shall not receive the application unless it is accompanied with the correct amount of application fee. (including indexation) | A Cheque amounting to Rs.145,712/- in favour of NEPRA is attached with the Application in a separate sealed cover. |
| 3(4) | The Application foΔr Generation Lice nse shall be submitted in triplicate | Three Copies of the Application for the Generation License with supporting documents are hereby submitted please. |
| 3(5)(a)(i) | Certified copy of *Certificate of <u>incorporation</u>* shall be filed as documents-in-support along with Application for Generation License. | Certificate of Incorporation with SECP is attached with this Application as **Annexure 2.2**. |
| 3(5)(a)(ii) | Certified copy of *Memorandum and Articles of Association* shall be filed as documents-in-support along with application for license. | Copy of Memorandum and Articles of Association attached as **Annexure 2.3.** |
| 3(5)(a)(iii) | Certified copy of Annual Return in case of applicant required to be submitted to the Registrar of companies pursuant to Section 156 of the Ordinance, shall be filed as documents-in-support along with application for license | Form A is not applicable as company has obtained its registration with SECP on July 2016.<br><br>All other relevant documents are attached herewith as **Annexure 2.4.** |

| Regulation No | Required Information / Part II 3 | Compliance / Remarks |
|---|---|---|
| **3(5)(a)(iv)** | In case of an applicant to whom sub-clause (a)(iii) of Sub-clause (5) is not applicable, a return comprising all such information, in as close a form and content as possible, laid down in the third schedule to the Ordinance | Not Applicable |
| **3(5)(b)** | A reasonably detailed profile of the experience of the Applicant, its management staff and its members in the electricity industry | Experience Profile of the Applicant and its management staff is attached at **Annexure 2.5.** |
| **3(5)(c)** | The Curriculum Vitae of the Applicant's senior management, technical and professional staff | The requisite CVs are attached at **Annexure 2.6.** |
| **3(5)(d)(i)** | **Evidence**, satisfactory to the Authority, of the availability of adequate financial and technical, resources to the Applicant for the purpose of Generation, transmission or distribution business, as the case may be, and such evidence may consist of: **Cash Balances held in reserve along with the bank certificates.** | The Project has been awarded to the Applicant under Government of Punjab Power Policy 2006 according to which Applicant has demonstrated the financial and technical strength to PPDB.<br><br>For the purpose of this requirement, a copy of LOI is attached as **Annexure 2.7**.<br><br>The financial strength of Sponsors Sambu Construction of Korea and Multiline Enterprises are attached as Please **Aannex-2.8.** |
| **3(5)(d)(ii)** | **Evidence**, satisfactory to the Authority, of the availability of **adequate financial** and **technical resources** to the Applicant for the purpose of the **Generation**, transmission or distribution business, as the case may be, and such **evidence may consist of expression of interest to provide credit or financing sources and details there at.** | Please refer to **Annexure 2.8** for the financial strength of the Sponsors.<br><br>Generally, the financing of renewable project especially Hydropower Projects is top priority of international and local banks for Pakistan. Therefore, the applicant does not see any issue in arranging the financing of this project.<br><br>Additionally, management of this company was directly involved in financing New Bong Escape Hydropower Project and Gulpur Hydropower Project. and has successfully arranged financing of USD 600 million. |

| Regulation No | Required Information / Part II 3 | Compliance / Remarks |
|---|---|---|
| 3(5)(d)(iii) | Latest financial statements of the applicant. | As mentioned above, the clause is not applicable since we are at a stage where only Feasibility Report stands approved by PPDB, Government of Punjab.<br><br>However, Financial Statements of our Sponsors are attached at **Annexure 2.8**. |
| 3(5)(d)(iv) | **Evidence**, satisfactory to the Authority, of the availability of adequate financial and technical resources to the applicant for the purpose of the generation, transmission or distribution business, as the case may be, and such **evidence may consist of: employment records of engineering and technical staff of the applicant or proposed to be employed** | Requisite employment records of the existing Engineering and Technical staff of the Applicant are attached with the Application at **Annexure 2.9.** |
| 3(5)(d)(v) | Evidence, satisfactory to the Authority, of the availability of adequate financial and technical resources to the applicant for the purpose of the generation, transmission or distribution business, as the case may be, and such evidence may consist of: ***profile of sub-contractors, if any, along with expressions** of interest of sub-contractors.* | Not Applicable at this stage of development.<br><br>The Project will be financed through Non-Recourse Project Financing wherein one of the key requirements of the project Lenders is that project should be constructed based on "Engineering, Procurement and Construction" mode.<br><br>The Company will proceed for EPC bidding process following the issuance of Letter Of Support (LOS) by PPDB. |
| 3(5)(d)(vi) | **Evidence**, satisfactory to the Authority, of the availability of adequate financial and technical resources to the applicant for the purpose of the generation, transmission or distribution business, as the case may be, and such evidence may **consist of: verifiable references in respect of experience of the Applicant and its proposed sub-contractor.** | The Project will be financed through Non-Recourse Project Financing wherein one of the key requirements of the project Lender is implementation of project should be on "Engineering, Procurement and Construction" mode.<br><br>The Company will proceed for EPC bidding process following the issuance of Letter Of Support (LOS) by Punjab PPDB. EPC Bidding at this |

| Regulation No | Required Information / Part II 3 | Compliance / Remarks |
|---|---|---|
| | | stage will not be practical as it would be difficult for EPC contractor to hold the EPC Price intact for a long period of more than 1 year.<br><br>Such information shall be provided at the time of approval tariff petition. |
| **3(5)(e)** | In respect of a going concern, details of any charges or encumbrances attached to the company's assets | Not applicable. There are no charges or encumbrances |
| **3(5)(f)** | In case of a first Application for a License by a going concern, technical and financial proposals in reasonable detail for the operation, maintenance, planning and development of the **Generation**, transmission, or distribution facility or system in respect of which the License is sought | A comprehensive Planning and Development Proposal for the implementation of the Project is attached at **Section No. 8** of this Application. The Project shall be constructed through Engineering, Procurement, Construction (EPC) mode. O&M after COD shall also be implemented through and experienced plant operator to be selected through competitive bidding from private sector.<br><br>Company revenue shall be earned by the sale of electricity generated from the Plant through Power Purchase Agreement (PPA) to be entered with CPPAg. For more details, please refer to Section No.3, 4, 5, 7,8 of the Application. |
| **3(5)(g)(a)** | In case of **Generation License Application**, the type, technology, model, technical details and design of the facilities proposed to be acquired, constructed, developed or installed. | The required information is provided at **Section No. 4 & 5** of the Application. |
| **3(5)(g)(b)(i)** | Distribution and transmission license applications: the type, technology, model, technical details and design of the facilities proposed to be acquired, constructed, developed or installed. | Not applicable |
| **3(5)(g)(b)(ii)** | Distribution and transmission license applications: a territorial map of the service area proposed to be covered. | Not Applicable |
| **3(5)(g)(b)(iii)** | Distribution and transmission license applications: particulars in respect of | Not Applicable |

| Regulation No | Required Information / Part II 3 | Compliance / Remarks |
|---|---|---|
| | the availability, sources, rates and evidence of commitments from the sources of electric power. | |
| 3(5)(h)(i) | In case of a **License for a new facility** or system, a **Feasibility Report** in respect **of the Project**, specifying in details: the type, technology, model, technical details and design of the facilities proposed to be constructed, developed or installed | Three sets of the **Feasibility Report** duly approved by PPDB are attached with this Application.<br><br>Three sets of **Initial Environmental Examination** (IEE) and the approval letter of IEE from Environmental Protection Department (EPD) Punjab is attached with this Application as part of Feasibility Report.<br><br>Three sets of **Interconnection Study** and approval letter Lahore Electric Supply Corporation (LESCO) is attached with this Application as part of Feasibility Report. |
| 3(5)(h)(ii) | In case of a **License for a new facility** or system, a feasibility report in respect of the project, specifying in details: ***<u>the expected life of the facility or the system;</u>*** | The Company shall enter into a Power Purchase Agreement with CPPAg with a term of 30 years after COD (total 33 years including construction period) 3 years for Construction phase and 30 years for operational phase of PPA (Power Purchase Agreement).<br><br>Following expiry of PPA the the project shall be transferred to Govt. of Punjab. |
| 3(5)(h)(iii) | In case of a license for a new facility or system, a feasibility report in respect of the project, specifying in details: the location of the facility or the system, or the territory with outer boundaries within which the facilities or the system is proposed to be installed and operated by the licensee, along with maps and plans | The Project has been proposed on Upper Gugera Canal (UGC) in Nankana District of the Punjab Province. The Project site is approximately 70 km from Lahore.<br><br>The Plant is of Very Low Head type to be placed in the permanent Diversion Channel on right side of the UGC. |

| Regulation No | Required Information / Part II 3 | Compliance / Remarks |
|---|---|---|
| | | The Gugera HPP will be constructed at RD214+500; more details are given in the Project Description at Section No.4 and in the Feasibility Study. |
| **3(5)(h)(iv)** | The type and details of the services to be provided. | Please refer to Section No. 4&5. |
| **3(5)(i)** | A Prospectus of the Company. | Refer to Section No.3 of the Application. |

## SCHEDULE III
## Regulation 3(6) C, New Generation Facilities (HYDEL)

| Sr. No | Required Information | Compliance/ Remarks |
|---|---|---|
| 1 | Location (location maps, site map) | Project site and area is located in Nankana District. The project area is located about 70 km from Lahore, 35 km from Sheikhupura city and 67 km from Faisalabad.<br><br>The area is accessible by Motorways and GT roads. The area is also accessible via railway network & airports at Lahore and Islamabad.<br><br>The location & site maps are shown in **Section 4**. |
| 2 | Plant: Run of the River, Storage, and weir. | Gugera HPP is of Run of the River type as there is no water storage facility on the Canal.<br><br>The Project will be built on the Bypass of Upper Gugera Canal (UGC). |
| 3 | Head: Minimum, Maximum | Min: Net Head 2.8 m<br>Max: Net Head 3.0 m |
| 4 | Technology: Francis, Pelton, etc size, number of unit | Kaplan Turbine, Horizontal Type, 3 Units each of 1.2 MW Capacity |
| 5 | Tunnel (if proposed): length, diameter | Tunnel is not required for Gugera HPP |
| 6 | ESSA (Environmental & Social Soundness Assessment) | Three Sets of the IEE Report duly approved by Punjab EPA submitted and attached herewith.<br><br>ESSA is not applicable for this Project. |
| 7 | Detailed Feasibility Report | Three Sets of the Feasibility Report duly approved by PPDB are attached herewith. |

## SCHEDULE III
## Regulation 3(6) C, New Generation Facilities (HYDEL)

| Sr. No | Required Information | Compliance/ Remarks |
|---|---|---|
| 8 | Resettlement Issues | No such issues have been confronted as there is no population or house-structure on Project site. |
| 9 | Consents | • Feasibility Study Report got approved from PPDB, Government of Punjab. Attached with this Application<br>• Initial Environmental Examination (IEE) got approved from EPA Punjab. Attached with this Application.<br>• Interconnection Study Report got approved from LESCO, Lahore. Attached with this Application.<br>• Remaining Consents shall also be obtained as per Project Development Schedule. |
| 10 | Infrastructure Development | Provision for residential colony, community center, mosque, shops and roads etc has been included in the Project Feasibility Report. |
| 11 | Interconnection with National Grid Company. Distance and name of the nearest grid, voltage level (single line diagram) | Requisite Interconnection studies already conducted and got approved from LESCO, Lahore (copy attached).<br><br>Walgan Suhail 132/11 KV is the nearest LESCO Grid Station located at a distance of 07 km from the Power Plant. SLD also attached in Section No.4 of the Application. |
| 12 | Project Cost , information regarding sources and amounts of equity and debt | EPC Cost: US$ 11.38 Million<br>Project Base Cost: US$ 14.26 Million<br>Total Project Cost: US$ 17.62 Million<br>Debt Portion: 80%<br>Equity Portion: 20% |
| | Project Schedule, expected life | Major activities in Project Schedule include Feasibility Study and approval, IEE and approval. Interconnection Study and approval, Generation License, approval of Upfront Tariff, Issuance of LOS, EPC Design, EPC Tendering, financing arrangements, insurance arrangements, O&M arrangements, financial closing, construction, testing, commissioning and COD.<br><br>LOS shall be issued following Upfront Tariff approval expected by 31 December 2016.<br><br>Financial Closing shall be achieved by December 31, 2017 |

## SCHEDULE III
## Regulation 3(6) C, New Generation Facilities (HYDEL)

| Sr. No | Required Information | Compliance/ Remarks |
|---|---|---|
| | | Total Construction Period will be 3 years and expected COD shall be December 31, 2020. |
| **14** | Peaking / Base load operation | The Plant is of Base-Load Operation type as there is no Water Storage Facility on the UGC at Project site. |
| **15** | Plant characteristics: generation voltage, power factor, frequency, automatic generation control, ramping rate, control, metering and instrumentation | Generation Voltage: 0.69KV<br>Transmission Voltage: 11KV<br>Power Factor: 0.85<br>Frequency: 50 Hz<br><br>For more details, refer to **Section No. 4 & 5**. |
| **16** | System studies load flow, short circuit & stability studies | System Studies such as Load Flow, Short Circuit & Dynamic Stability Analysis already conducted and approved by LESCO Lahore (Three Sets of the full Report attached herewith). |
| **17** | Training and Development | Training of E&M Staff will be arranged before COD of the Plant by the EPC Contractor and Turbine manufacturer. |

Hydro Power Co.

# 3-Company Prospectus

## 3.6 GUGERA HYDROPOWER

GHC

# 3.1 Project Development and Ownership

### 3.1.1 INTRODUCTION

Gugera Hydro Power Company Pvt. Ltd (herein referred to as "GHC" or "Company") is a special purpose company, setup to design, construct, own, operate and maintain 3.6MW Gugera hydro power plant (the "Project") under Government of Punjab Policy for Power Generation Projects 2006. Sambu Construction Company of Korea ("Sambu") and Mutiltiline Enterprise ("Multiline") are the sponsors of this project.

The Project will have 3.6 MW installed power capacity with annual generation capability of 20.8 GWh. The Project site falls administratively in District Nankana in Punjab and located about 70 km from Lahore City and 67Km from Faisalabad City.

### 3.1.2 MISSION

GHC is a private hydropower company with the aim to promote small hydropower plants in Punjab. We are a team of professionals and talented ambitious youth for bringing excellence and innovations in the upcoming projects.

### 3.1.3 VISION

**Become innovative and key Hydropower developer in Pakistan**

### 3.1.4 DEVELOPMENT HISTORY

a. The Company is an unlisted Private Limited Company, incorporated in 2016 with SECP under the Companies Ordinance, 1984 to develop, construct, own, operate and transfer the Project.

b. The Letter of Interest ("LOI") for the Project was issued to the Company on June 20, 2013 vide Letter No. PPDB/542/2013 by the Punjab Power Development Board (Annexure 2.7).

c. Pursuant to the terms of the LOI and the 2006 Power Policy, the Sponsors conducted the detailed Feasibility Study of the Project through TEAM consultants (Technical, Engineering and Management Consultants Pakistan).

d. Feasibility study for the Project after subsequent comments of the PPDB Panel of Experts, was approved vide letter number PPDB/863/2016 dated 23-06-2016.

e. Initial Environment Examination (IEE) report was prepared by the Sustainable Solutions Consultants, approval of which was accorded by DG Environment, Punjab, vide its letter No DD(EIA)/EPA/F-634(IEE)/2903/2015/144 dated 04/04/2016.

f. Interconnection study of the project was prepared by the consultant (Power Planers International Limited). The report was finally approved by LESCO vide its letter No 25649-52-MMT-240 dated 7/06/2016.

g. After approval of Feasibility Report, in pursuance of the advice of PPDB Government of Punjab, Application for Generation License has been prepared with all the required documents and being submitted for obtaining approval of NEPRA.

h. Tariff petition shall be prepared and submitted to NEPRA for approval of Upfront Tariff related to the small hydropower generation projects notified on March 28, 2016.

i. Power Purchase Agreement (EPA) shall be negotiated & subsequently signed with CPPAg.

j. Design and bid documents including detailed performance specifications and testing guidelines shall be prepared for hiring the EPC Contractor. At the same time, we shall conduct any additional studies and investigations as may be necessary to minimize design and construction risks.

k. Following the financing and insurance arrangements the Company shall achieve Financial Closing by December 2017 after meeting certain conditions precedents.

Hydro Power Co.

## 3.1.5 PROJECT OWNERSHIP

The Project is owned by Sambu and Multiline Enterprises.

# I. SAMBU

Holder of Republic of Korea's Construction Business License No 1, SAMBU has been involved in numerous works as frontrunner in civil works. It has demonstrated outstanding technologies in construction of major dams of KOREA. SAMBU has vast civil work experience of constructing Dams and Hydropower Projects, Ports and Harbors, Highways, Bridges, Tunnels, Subways and Railroads.

SAMBU engages in continuous self-assessment, research and setting new challenges to create better space in future where man and environment can co-exist in harmony. Through innovative and motivating management SAMBU has set firm goal of becoming world class Construction Company in 21st century.

More than six decades have passed since the inception of SAMBU and 46 years since it obtained the construction contractor license – the first to be granted in Korea. Sambu is actively working on Pakistan for past 17 years and has completed number of road projects. Sambu is currently finishing the Lowari tunnel of some 8.5km connecting to Chitral and completed in extremely challenging and difficult conditions. SAMBU has the pride to construct the first hydropower project ( 81MW HUBCO New Bong Escape Hydro Electric Power Project )in private sector in Pakistan . At present, in addition to the other projects, SAMBU is also constructing 106MW Golan Gol Hydropower Project in Chitral area of KPK province. Detail Profile of SAMBU is attached with this chapter.

# II. MULTILINE ENTERPRISES

Multiline Enterprises is basically an Engineering Company formed during 1994 with its head office in Lahore and regional offices in Rawalpindi/Islamabad, Karachi and Hyderabad.

MULTILINE ENTERPRISES has been engaged in supply of Heavy Construction Machines, Welding solutions, their consumables and spares along with after sales services. Multiline Enterprises has an integrated workshop facility being handled by experienced and qualified persons for maintenance and repair of the equipment supplied to our clients which include major Government organizations, private and public sector companies and contractors. The Company had supplied E&M equipment and allied parts at the following projects:

- Allai Khwar Hydropower Project (121 MW)
- Duber Khwar Hydro Power Project (130 MW)
- Satpara Dam Project ( 17.3 MW)
- HUBCO new Bong Escape Hydro Electric Power Project(81MW)

# 3.2 PROJECT MANAGEMENT & IMPLEMENTATION

## 3.2.1 INTRODUCTION

The Company's Board of Directors will manage the business of the Gugera Hydropower Company (Pvt) Ltd and delegate overall management authority to the Chief Executive Officer. The Directors may pay all expenses incurred in promoting and registering the Company, and may exercise all such powers of the Company as are not by the Companies Ordinance 1984 or any statutory modification thereof for the time being in force, or by these regulations, required to be exercised by the Company in General Meeting.

## 3.2.2 THE BOARD OF DIRECTORS

Under Companies Articles of Association, the Board of Directors (the "Board") consists of not less than three elected by a vote of shareholders, together with the Chief Executive. At present it is expected that Board will meet at least once every quarter. In addition, the Board will hold such other meetings as are considered appropriate.
The Board has ultimate responsibility for managing the Company and is the source of all executive authority. All Directors will share collective responsibility for decisions of the Board. At present the Board comprises the following members (Directors).

| Name | Position | Other Positions |
|---|---|---|
| Nasir Ahmed Malik | Chairman Board (CEO of the Company) | CEO Multiline Enterprises |
| Sultan Ahmad | Director | COO Mira Power |
| Sheikh Aslam | Director | Finance Head Multiline Enterprises |

## 3.2.3 MANAGEMENT STRUCTURE

The Chief Executive under delegated authority from the Board will be required to manage the day to day affairs of the Company. The Chief Executive has established a Management

Gugera Hydro Power Co.

Committee to assist him in the management of corporate affairs. The Management Committee, which will meet at least weekly, includes:

| S. No | Name | Designation |
|---|---|---|
| 01 | Mr. Nasir Ahmad Malik | Chief Executive Officer |
| 02 | Mr. Sultan Ahmad | Director |
| 03 | Mr. Sheikh Aslam | Director |
| 04 | Mr Tariq Mehmood | Company Sectary |
| 05 | Mr. Yousaf Joiya | Technical Director |
| **06** | Mr Ansarullah Shahbaz | Project Engineer |

The Company has hired a team possessing first-hand experience of development of first hydro IPP in Pakistan to ensure timely implementation of the Project and performance of Company's obligations.

# 3.3 FINANCING, PROJECT COST & TARIFF

## 3.3.1 PROJECT COST

Hydropower is a capital-intensive technology with long lead-times for development and construction due to the significant feasibility, planning, design and civil engineering works. Costs of hydropower projects are driven by site-specific elements that impact on the civil engineering design and scope of work. Proper site selection and hydro scheme design are therefore, key challenges and detailed work at the design stage can avoid expensive mistakes. Conclusively, it is expressed that whenever power-project options are considered, not only capital specific cost Per KW or MW but also Energy Cost Per KWh over the entire life span, should also be taken into account for the sake of true comparison and prudent decision making for the benefits of electricity consumers, in general and the Nation, in particular.

Keeping in view the above mentioned facts, total cost of Gugera Hydropower Project the price level of December 2014, has been calculated after thorough analysis and understanding of the factors that affect the development, construction and operation of a hydro power project. Break-up of the Total Project Cost is provided below:

| Cost Head | Project Cost PKR Million |
|---|---|
| EPC Cost | 1223 |
| Project Base Cost including Non EPC components | 1398 |
| Total Financial Cost of Project including IDC and ROEDC. | 1797 |

Initial estimates of the Project Cost are mentioned above. However, we would like to inform that at present the basic design of the Project is being finalized, following which the Company may need to increase or decrease the EPC cost provided there is significant material change in the design.

# 3.4 PROJECT SITE

## 3.4.1 PROJECT LOCATION

The Project is located at RD214+500 along upper Gugera Canal which is off-taking from Lower Chenab Canal at RD 140+050. The Lower Chenab Canal is off-taking from left bank of Khanki H eadworks on river Chenab. The project site is located near the center of Lahore-Faisalabad dual Carriageway on Manawala-Nankana road in District Nankana. The site is located in Upper Punj ab which is the heart of agriculture crops, especially producing rice of excellent quality.

## 3.4.2 Environmental & Social Aspects of the Project:

The potential social and environmental impacts are likely to occur due to development of Guge ra Hydro Electric Power Project. The company is conscious with its environmental obligations under Pakistan laws as well as environment and safeguard policies of loan-giving banks. The In itial Environmental Examination (IEE) was done to ascertain the environmental potential hazar ds and its mitigation for construction of Gugera Hydropower Project.

The Gugera Electric Power Plant falls under Category B as per schedules of Pakistan Environme ntal Assessment Regulations in terms of its anticipated potential impacts. The proponents of th e projects that have more adverse environmental impacts are required to submit a complete En vironmental Impact Assessment (EIA). Therefore, detailed Environmental Impact Assessment ( EIA) is not required for this project and only Initial Environmental Examination (IEE) has been performed. So IEE of Gugera Hydro Electric Power Project District Nankana, Punjab, Pakistan h as been carried out to fulfill the requirements of the Government of Punjab, Pakistan. Summary of Environmental Mitigation measurements included in the EMP, are mentioned as below:

| Potential Impact | Mitigation Measurement |
|---|---|
| Construction Impacts | Implementation through detailed EMP given in the IEE Report including provision of drinking water & compensation of trees etc |
| Permanent loss of small amount of agricultural land and some trees. | Compensation package for permanent loss of land and trees.<br>Implement tree planting program. |

## 3.4.3 Social Benefits:

The project will save substantial amount of precious foreign exchange annually that would othe rwise be required for import of oil needed for an equivalent thermal plant. The revenues of the government would increase due to direct and indirect taxation, duties and levies on the produc tion

of goods and services that will result from the power generation benefits within the project are a as well as from the electricity duty collected by the Federal Government, Government of Punj ab or any other agency. Water Use Charges will be paid to Irrigation Department, Government o f the Punjab. .

Indirect or the secondary benefits would include creation of employment opportunities and improved standard of living of the people Nankana District and vicinity. There will be multiple effects on socio-economic development of the region as well. Communication, infrastructures, livestock, forestry, cottage industry, livestock development and other opportunities would open up with construction of the proposed project. Most of the indirect benefits are difficult to quantify in monetary terms but should not be ignored while making the decision for the implementation of the Project.

### 3.4.4 Hydrology

Chenab River is part of Indus Basin River system and the third river of the Western river on which water Pakistan has the right under Indus Basin Treaty Signed between India and Pakistan under the office of World Bank. It contributes a good part of water supply to the irrigated agriculture system in Pakistan. The river Chenab originates in the Kulu and Kangra Districts of the Himachal Pardesh Province of India. Its two Chief streams are Chandra and Bhaba. These Streams join at Tandi in the state of Jammu and Kashmir at an elevation of 2770 m (9,090 ft) above mean sea level. Khanki Head-Works, on river Chenab, situated about 14.5 km downstream from Town of Wazirabad, was built and made operational in the year 1892. This was the first weir in Punjab which had been founded on alluvial bed of the river. The Gugera Branch Canal originates from the Lower Chenab Canal (LCC) from its RD140+050.The LCC itself off-takes from Khanki Head-Works. The main areas to which it supplies water are Toba Take-Singh and Faisalabad. Upper Gugera Branch after travelling a distance of about 85.95 km, it further bifurcates at RD280+000 into two canals namely Lower Gugera Branch (LGB) and Burala Branch. The tail of LGB is at RD387+566 and Burala Branch is at RD485+755.

### 3.4.5 Availability of Water Flows

Flow duration analysis is made on daily basis for each year.separately and Presented in Figure 5.16 of Feasibility Report VOL 1. The flow duration curve for full period starting from 2008 till 2013 on daily basis is also prepared and presented in Figure 2.17. It shows the following:

- Discharge of 05 m3/s is available for 91.81% of Time
- Discharge of 22 m3/s is available for 91.18% of Time
- Discharge of 45 m3/s is available for 90.08% of Time

Gugera Hydro Power Co.

- Discharge of 75 m3/s is available for 82.76% of Time
- Discharge of 100 m3/s is available for 56.76% of Time
- Discharge of 120 m3/s is available for 8.11% of Time
- On the basis of above, the following is concluded:

The average canal closure period is 26 days. Therefore to get more benefits of energy it is proposed that closure period be kept up to 20 to 26 days in future.

The upstream level will be kept constant at designed full supply level.

The Energy Potential has been worked out on daily basis for a period between year 2008 and 2013 for which record was available.

### 3.4.6 Technical Details of Project

The proposed hydroelectric power project will have installed capacity of 3.6 MW and would generate 20.80 GWh annually. The project would be equipped with three (3) horizontal kaplan turbines, each having capacity of 1.2MW. The project would be connected with LESCO 132/11 kV Grid at Walgan Suhai which is about 07 km from the Project site. The plant would be connected through two 11kV TLs having Osprey Conductor. The location and layout of the preferred layout has been selected on the basis of unit cost analysis. The preferred layout is such which offers minimum

cost per kWh. Therefore, the project physical arrangement and overall characteristics have been configured for optimum hydropower development of the Gugera Hydro Electric Power Project. The project features have been selected considering foundation conditions, cost and schedule, constructability and environmental issues. The preferred layout is the powerhouse and spillway placed in the bypass arrangement just upstream of the existing fall at RD 216+100 along its right bank. The Spillway is placed along the left bank of powerhouse structures. The powerhouse and spillway are placed at RD 214+500 due to constraint of space on right side of the canal near RD 216+100 because of existence of Manawala-Nankana Sahib Road Bridge. There is no need of canal diversion for construction of powerhouse and spillway. Powerhouse/spillway would be constructed under dry-condition along right bank. After construction of the Powerhouse and Spillway, the canal flows will be diverted towards Powerhouse by connecting the Headrace with Tailrace from Upstream to Downstream.

### 3.4.7 Major Components

The Gugera Hydro Electric Power Project comprises the following main components:

- -Headrace
- -Powerhouse and spillway Intake Bay
- -Powerhouse (Machine hall and Service bay)
- -Turbine and Generators
- -Main/Unit Transformers and Switchgear

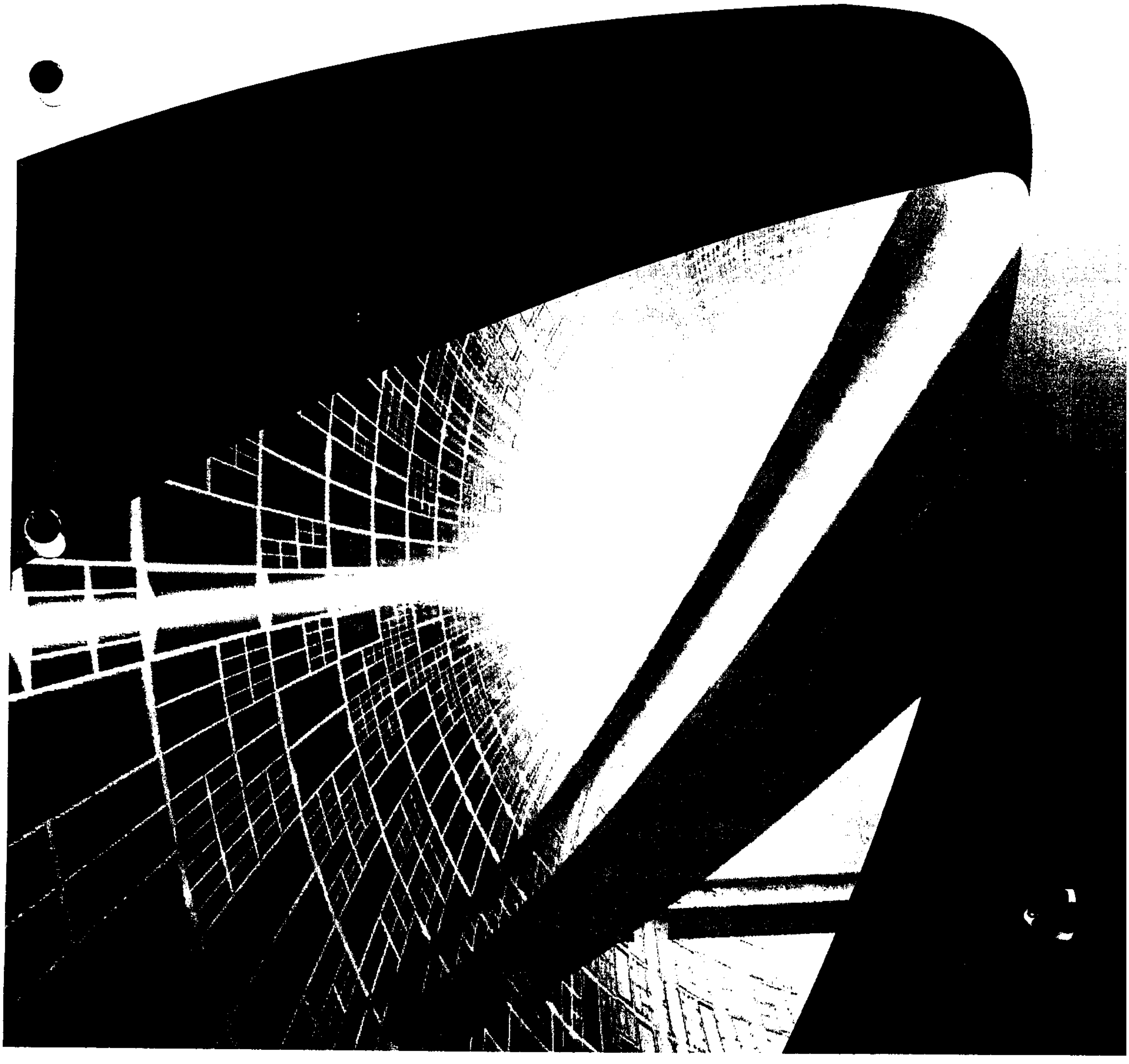
Gugera Hydro Power Co.

- -Transmission line and interconnection facilities
- -Erection bay on right side of the Powerhouse
- -Gated Spillway along left bank of Powerhouse structure
- -Powerhouse Outlet bay
- -Tailrace
- -Access Road on left and right banks of Lower Gugera Branch Canal
- -Colony for O&M staff and Rest House and other Civic Facilities

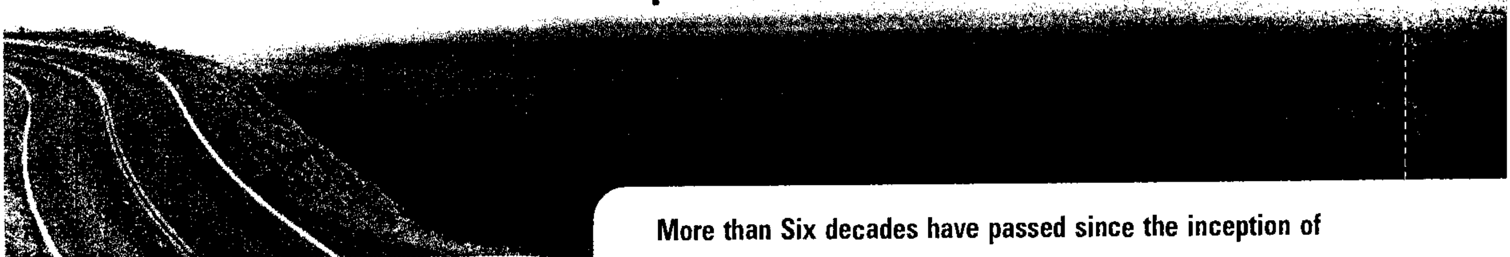
Hydro Power Co.

Creative Challenge Toward a Better Future!

SINCE



Amid the whirlpool of changes in the 21st century, there is one thing that remains constant, and that is the **artisanship of SAMBU**



**More than Six decades have passed since the inception of SAMBU Construction Co., Ltd.** and half-century have passed since it obtained the construction contractor license - the first to be granted in Korea. The history of SAMBU is synonymous with the growth and development of Korea's construction industry. There have been numerous setbacks and hardships that often sidetracked SAMBU's progress. However, SAMBU has been able to overcome each obstacle through its unyielding spirit of "artisanship" that elevated the company above mundane tribulations.

# SAMBU CONSTRUCTION CO.,LTD.

CONTENTS

## Drawing on its technological know-how accumulated through more than Six decades, SAMBU is strongly committed to development of new technology

**CHO, NAM-WOOK**
Chairman & CEO

I would, first of all, like to extend my heartfelt gratitude to all our clients for their unflagging support and encouragement. Since its inception in 1948, SAMBU Construction Co., Ltd. has always been committed to executing projects faithfully and responsibly with artisanship, and has played a pivotal role in advancing the structure of Korea's construction industry with its abundant experience and know-how accumulated in diverse fields of works.

In particular, SAMBU demonstrated Korea's construction technological prowess by capturing the Gold Medal for Civil Engineering Construction for its successful completion of the Under-Riverbed Subway Tunnel Project at the 28th IFAWPCA Convention in Seoul. The technological scheme applied to the Under-Riverbed Subway Tunnel, shortening the construction period and lowering the cost, was the first of its kind in Korea. SAMBU's technological repute is not confined to the domestic market. The company has been involved in civil engineering, architecture, plant and various other works around the globe, including Saudi Arabia, Malaysia, Nepal and Pakistan, with a sense of accountability as Korea's representative contractor.

SAMBU never rests on its laurels and continuously strives to enhance its reputation for accumulated technologies, abundant experience, quality customer service and responsible works. We are confident that

SAMBU can fully meet the particular needs of clients in a full range of work from simple construction to development investments, which involve the entire process of construction from project survey, planning, feasibility study, design, and construction; as well as maintenance & repair, development & sale in lots, and turnkey projects,

Always focused on the future, SAMBU has adopted an efficient management system to realize scientific and sophisticated management, and is pushing ahead with total project management, digital management and other measures of corporate restructuring on a phased basis so that it can achieve a quantum leap to emerge as a world-class construction giant in the information & high-tech era of the 21st century.

We consistently strive to provide maximum value to our customers under the best possible conditions, recruit and nurture human resources to instill in them a sense of bold creativity, and develop advanced technologies, drawing on the technological prowess developed during the past half century. SAMBU, committed to satisfying customers, cultivating human resources, and developing cutting-edge technology, stands at the forefront of creating a new construction culture in the 21st century.

Thank you.

**CHO, NAM-WON**
Vice Chairman

**JUNG, HAE-KIL**
President

Gugera Hydro Power Co.

# SAMBU Blossomed during Times of Distress and Hardship of Korea's Modern History. Today, SAMBU is a Representative Construction Company that Elevates the International Stature of Korea.

SAMBU, a representative contractor of Korea, has successfully undertaken numerous civil engineering and construction projects both at home and abroad. Through its brilliant performances, SAMBU has laid a solid foundation to become a world's leading engineering and construction company.

## Chronicle

April 4, 1948 : NATO inaugurated
July 20, 1948 : Lee Seung-man inaugurated as Korea's first president
June 25, 1950 : The Korean War breaks out

April 19, 1960 : The April 19th Student Uprising
May 16, 1961 : The May 16th Military Coup
January 5, 1962 : The first Five-Year Economic Development Plan launched.
December 17, 1963 : Park Chung hee elected as the fifth President of Korea
July 21, 1969 : The Seoul-Incheon Expressway opens
July 7, 1970 : The Seoul-Busan Expressway opens
June 17, 1972 : The Watergate Scandal erupts

The First Oil Crisis of 1973

October 16, 1973 : The 4th Middle East war breaks out
November 14, 1973 : Honam and Namhae expressways open
August 15, 1974 : Seoul Subway Line #1 opens
October 14, 1975 : Yeongdong and Donghae expressways open
November 3, 1976 : The Overseas Contractors' Association founded

The Second Oil Crisis of 1979

October 26, 1979 : President Park Chung hee assassinated
December 21, 1979 : Choi Kyu-ha inaugurated as the 10th President of Korea

May 18, 1980 : The democracy uprising in Gwangju
September 1, 1980 : Chun Doo Hwan inaugurated as the 11th President of Korea

## History of SAMBU

Spreading Its Wings & Taking Flight

April 1, 1948 : SAMBU Construction Co., Ltd. established
May 22, 1962 : Civil Engineering and Architectural Construction License No. 1 obtained
January 15, 1963 : Honored by the President for contribution to the construction industry

July 7, 1970 : Awarded with the industrial service merit, "Iron Tower" (for construction of the Seoul-Busan Expressway)
July 31, 1972 : SAMBU Concrete Co., Ltd. established
June 23, 1975 : The first monthly morning gathering (cultural lecture) held
October 29, 1975 : Yeoi Trading Co., Ltd. established
August 25, 1976 : Overseas construction license obtained (General Construction No. 12 and Special Construction No. 4)
March 25, 1977 : The Nepal branch office established

Flying Ever Higher

July 11, 1978 : Offices established in Kuala Lumpur Malaysia and Riyadh, Saudi Arabia
March 7, 1979 : Chairman Cho Jeong-gu honored with the industrial service merit, "Gold Tower" (in recognition of overseas inroads)
February 26, 1980 : Korea Landscape Architecture Corporation taken over and renamed as Korea Landscape Co., Ltd.
April 1, 1980 : The Gyeongju Bomun Hotel Co., Ltd. restructured as the Bomun Tourism Co., Ltd.
December 16, 1982 : Chairman Cho Jeong-gu and President Cho Chang-gu honored by the King of the Kingdom of Nepal(in recognition of the Kulekhani Hydroelectric Dam construction in Nepal)
January 5, 1983 : New York branch established

March 2, 1983 : Chairman Cho Jeong-gu, President Cho Chang-gu, and Vice President Cho Nam-wook inaugurated as the group chairman, chairman and president, respectively.

July 19, 1985 : Part of Busan Subway Line #1 opens

February 25, 1988 : Roh Tae-woo inaugurated as the 13th President of Korea

September 17, 1988 : The 24th Seoul Summer Olympics held

June 4, 1989 : The pro-democracy demonstrations at Tiananmen Square

November 9, 1989 : The Berlin Wall torn down

October 3, 1990 : East and West Germany reunited

January 17, 1991 : The Gulf War breaks out

Korea's Foreign Exchange Crisis and Subsequent Economic Management under the IMF Regime

February 25, 1993 : Kim Young-sam inaugurated as the 14th President of Korea

January 1, 1994 : The United States, Canada and Mexico establish the NAFTA

July 8, 1994 : North Korean leader Kim Il-sung dies

January 1, 1995 : The WTO inaugurated

December 12, 1996 : South Korea becomes a member of the OECD

February 25, 1998 : Kim Dae-jung inaugurated as the 15th President of Korea

September 11, 2001 : Terrorist attacks in New York

May 31, 2002 : The FIFA World Cup Korea/Japan held

February 25, 2003 : Roh Moo-hyun inaugurated as the 16th President of Korea

March 20, 2003 : US launched a war against Iraq

February 20, 2005 : 2nd term of George W. Bush, US President, inaugurated

December 15, 2006 : Ban Ki-moon inaugurated as the 8th secretary general of United Nation

February 24, 2008 : Lee Myung-bak inaugurated as the 17th President of Korea

January 20, 2009 Barack Hussain Obama inaugurated as the 44th President of United States

November 5, 1986 : Namwoo Tourism Co., Ltd. established

September 14, 1987 : President Cho Nam-wook honored with the Service Merit (in recognition of the construction of the Grand Hwangsan Bridge)

July 6, 1988 : The Ramada Renaissance Hotel wholly opened

A Second Leap

March 23, 1990 : Incorporated in Malaysia

April 1, 1991 : The Japan branch established

April 12, 1993 : SAMBU Development Co., Ltd. established

October 8, 1993 : The second Grand Korea Architectural Culture Award received (the main award for the National Museum in Buyeo and the award for Samyang Group's research institute)

March 28, 1996 : Chairman Cho Nam-wook named honorary chairman of the Korea Construction Association

September 19, 1996 : The IFAWPCA Gold Medal for Civil Engineering received for the Under-Riverbed Subway Tunnel construction

February 19, 1997 : ISO 9001 Certification acquired

May 14, 1998 : The 50th anniversary of the founding of the company observed in a ceremony

June 18, 1998 : Chairman Cho Nam-wook honored with the Industrial Service Merit, "Gold Tower" (in recognition of his contribution to the development of Korea's construction industry)

March 22, 2000 : Vice President Cheong Jin-woo inaugurated as the president

October 31, 2000 : SAMBU Concrete Co., Ltd. and Korea Landscape Co., Ltd. merged to become SAMBU Construction Industrial Co., Ltd.

December 27, 2001 : The KEPIC Certificate acquired (MN, SN, EN)

March 18, 2003 : ISO 14001 Certification acquired
ISO 9001/ISO 14001 Integrated Certification acquired

July 7, 2004 : Presidential Citation awarded (in recognition of Sambu's contribution to the national development)

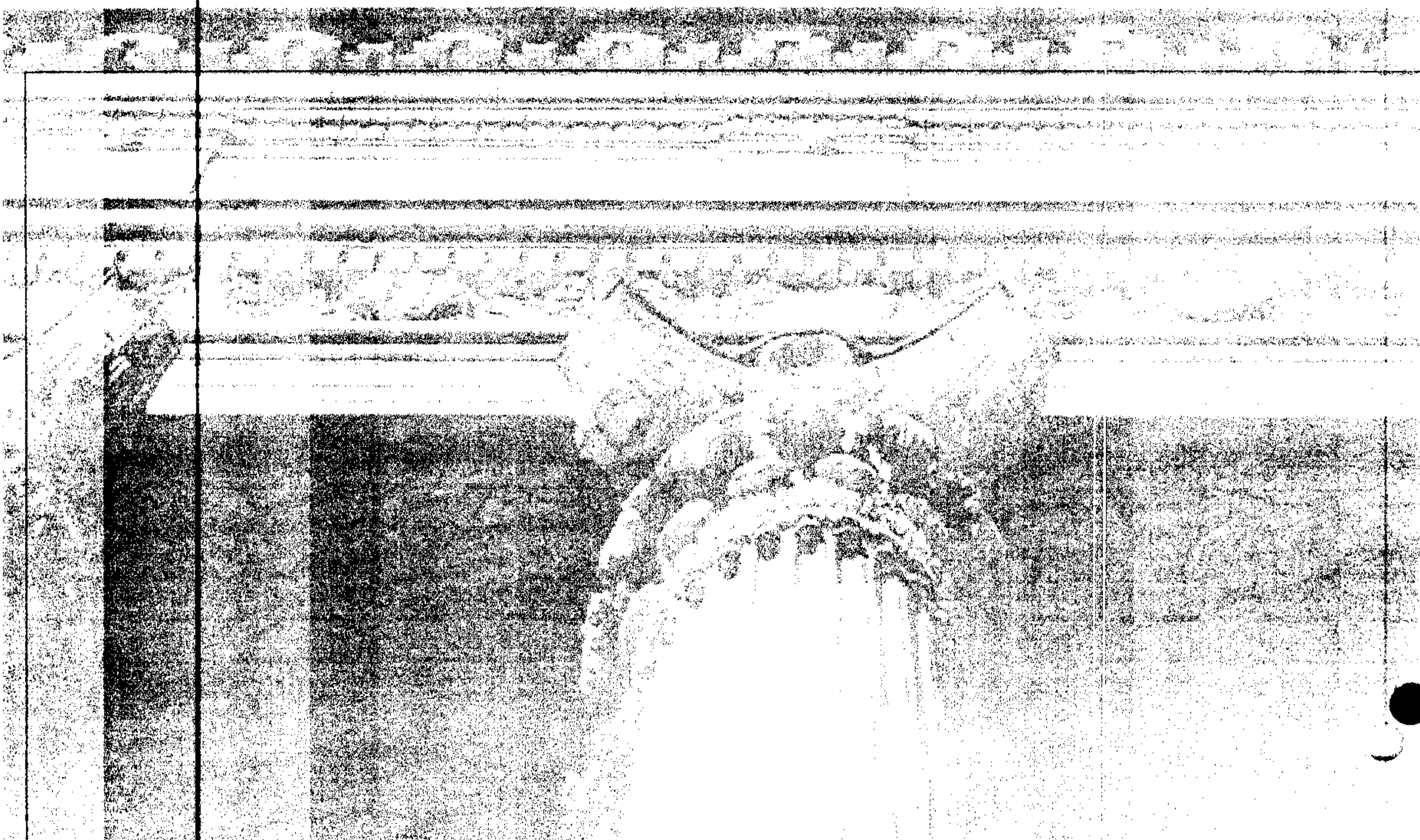
June 17, 2005 : Vice Chairman Cho Nam-won honored with the Industrial Service Merit, "Gold Tower" (in recognition of his contribution to the development of Korea's construction industry)

July 13, 2006 : Shilla Millennium Co., Ltd. established

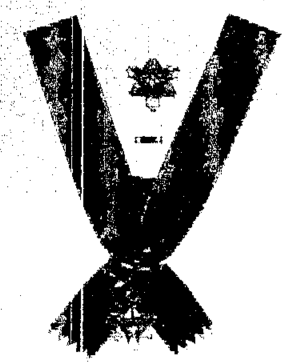
March 30, 2007 : Gyeongju Shilla Millennium Park Opened

May 14, 2008 The 60th anniversary of the founding of the company

October 5, 2009 The 18th Korean Architecture Award received for building Seoul Namsan Gugakdang



# Pride and Honour



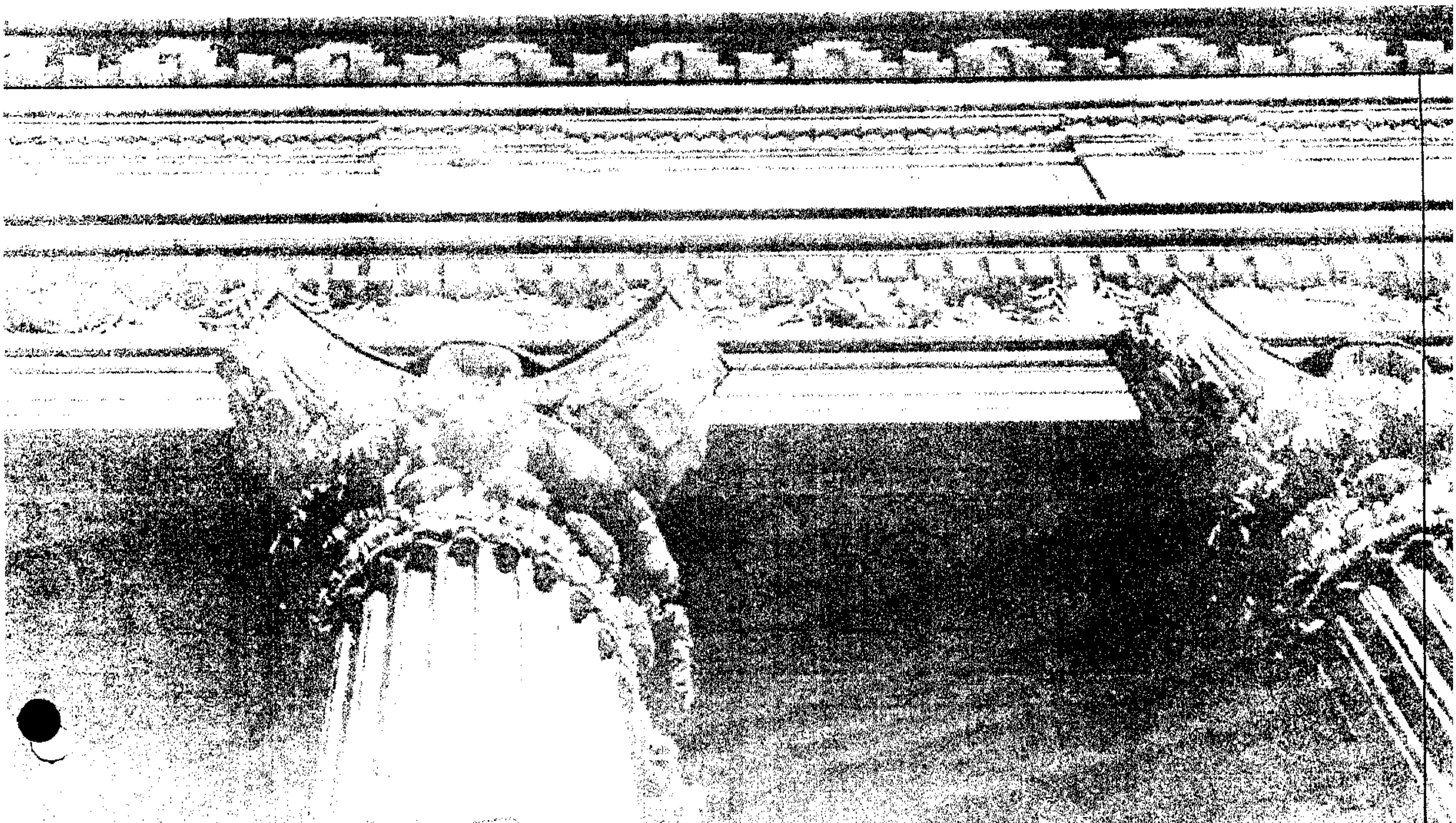
March 7, 1979 : Chairman **Cho Jeong-gu** honored with the
"Gold Tower Order of Industrial Service Merit"

June 18, 1998 : Chairman **Cho Nam-wook** honored with the
"Gold Tower Order of Industrial Service Merit"

June 17, 2005 : Vice Chairman **Cho Nam-won** honored with the
"Gold Tower Order of Industrial Service Merit"

The "Gold Tower Order of Industrial Service Merit" is the nation's most prestigious award presented to a company that realizes remarkable industrial achievement and noteworthy contribution to industrial development. It is a hallmark of the nation's industrial leader.

Although the rigorous competition makes it difficult to receive the top honor even once, SAMBU Construction has been honored with this most coveted award on three occasions through two generations of corporate leadership. This is an unprecedented confirmation that SAMBU Construction is the unparalleled leader of the nation's construction industry.



**CHO, JEONG-GU**
Group Chairman

Group Chairman Cho Jeong-gu honored with the industrial service merit, "Gold Tower" on March 7, 1979(in recognition of overseas inroads)

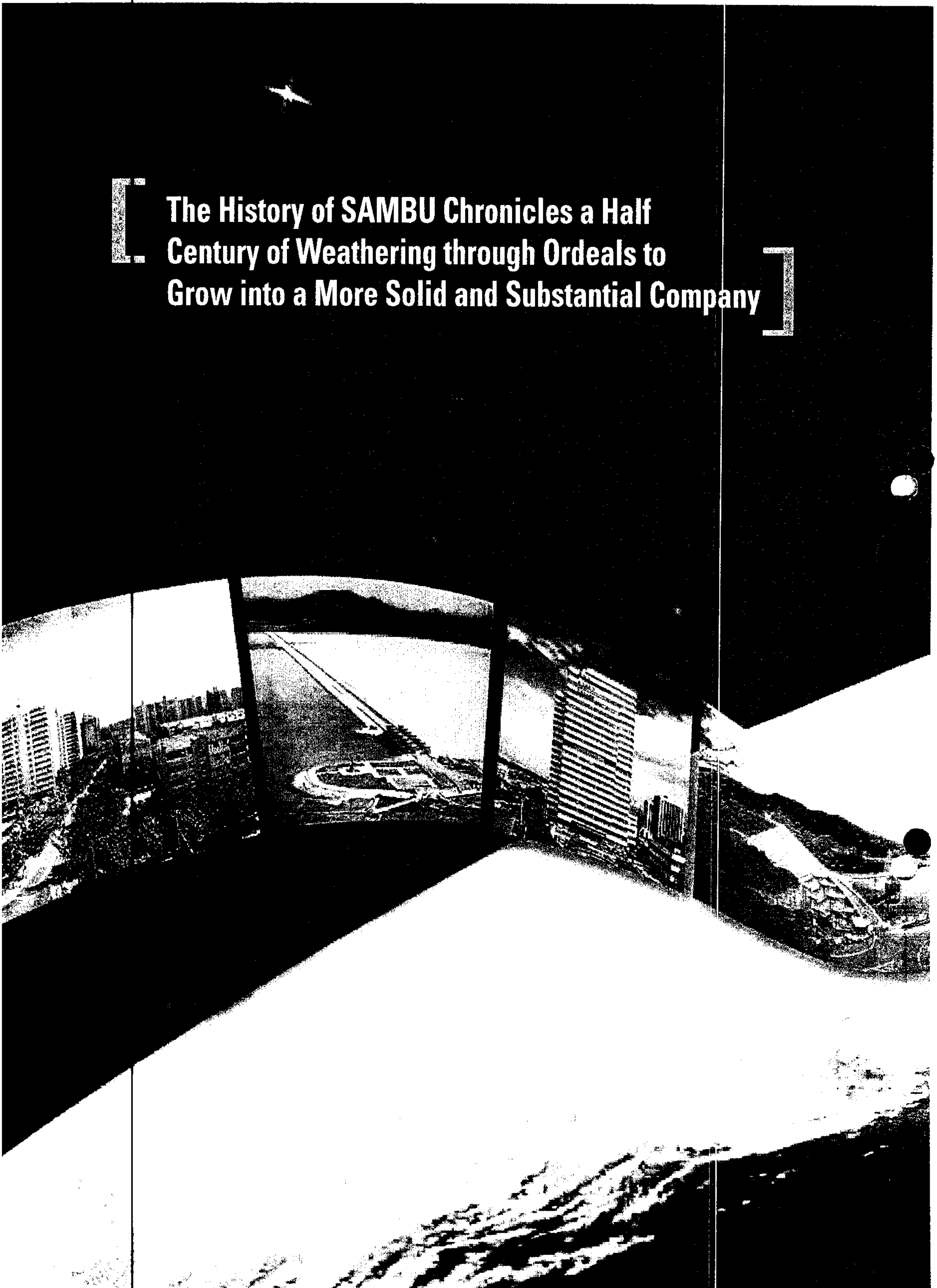
**CHO, NAM-WOOK**
Chairman & CEO

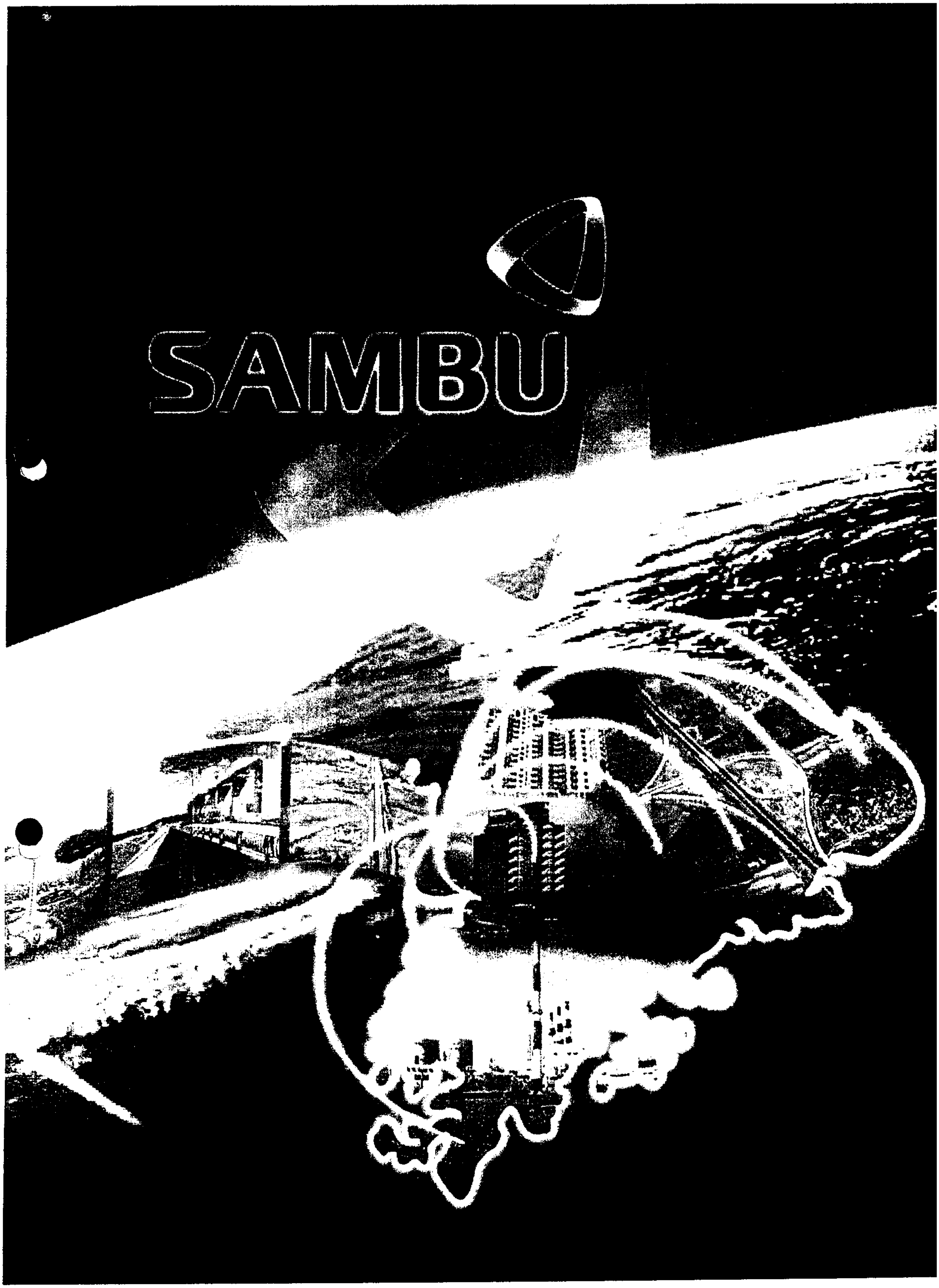
Chairman Cho Nam-wook honored with the industrial service merit, "Gold Tower" on June 18, 1998(in recognition of his contribution to the development of Korea's construction industry)

**CHO, NAM-WON**
Vice Chairman

Vice Chairman Cho Nam-won honored with the industrial service merit, "Gold Tower" on June 17, 2005(in recognition of his contribution to the development of Korea's construction industry)

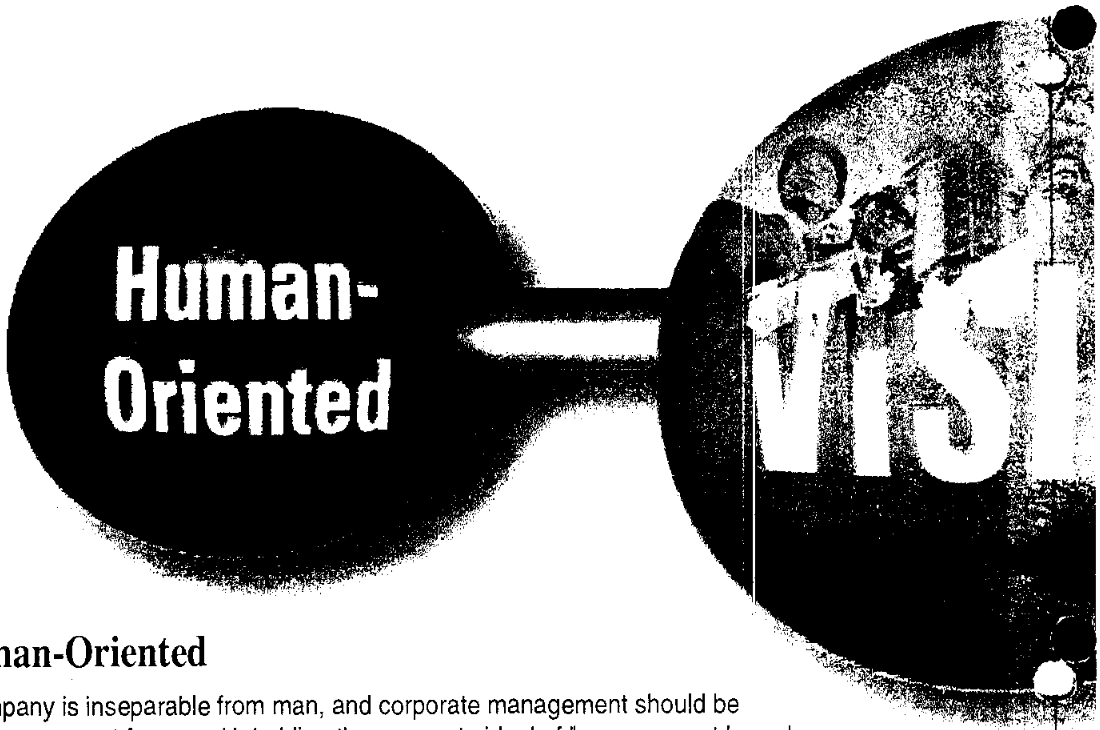
# The History of SAMBU Chronicles a Half Century of Weathering through Ordeals to Grow into a More Solid and Substantial Company




SAMBU

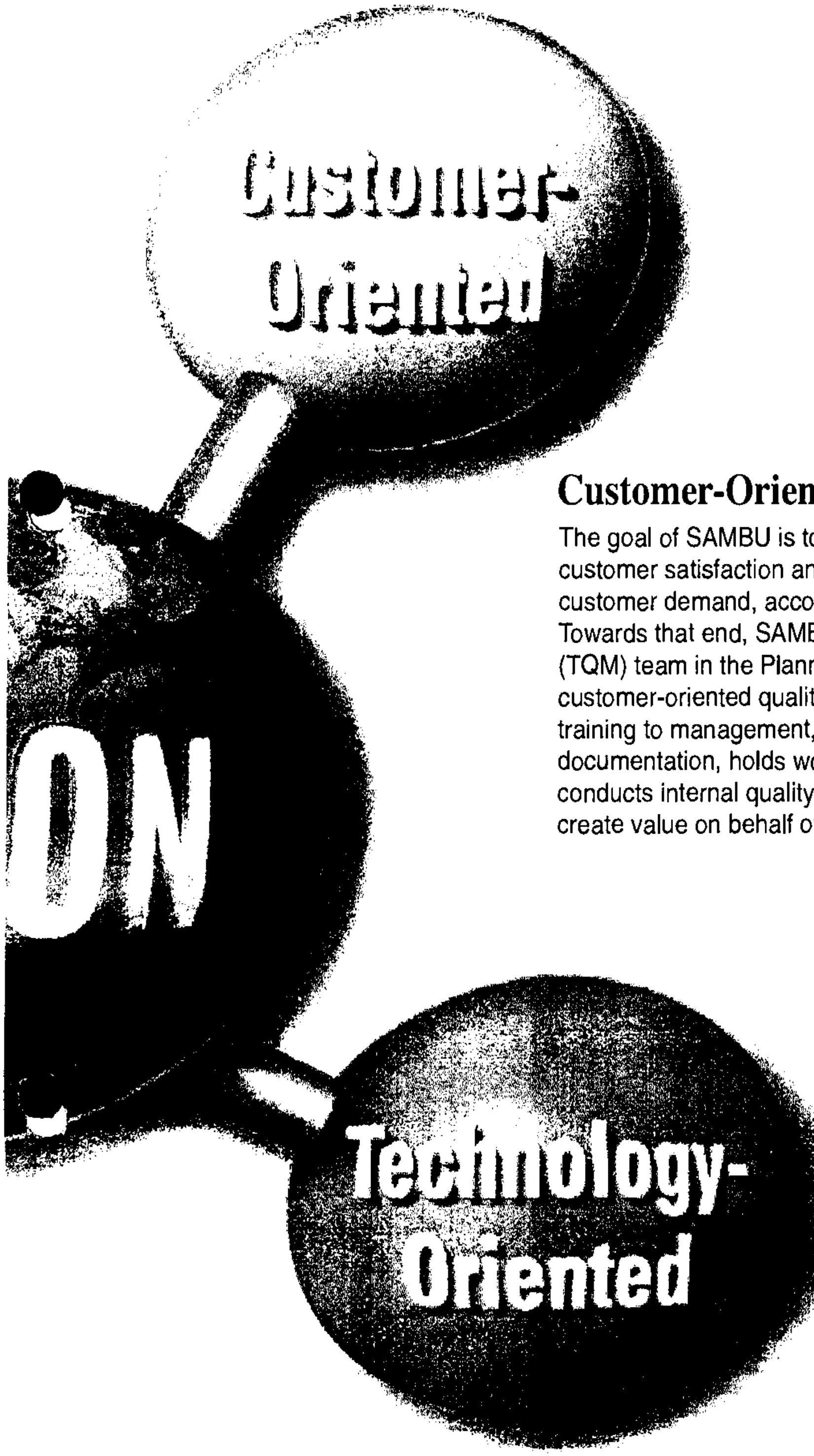
SAMBU engages in continuous self-assessment, research and setting new challenges to create a better space in the future, where man and the environment can coexist in perfect harmony. Through innovative and motivating management, SAMBU has set a firm goal of becoming a world-class construction company in the 21st century.

Creative Challenge Toward a Better Future!




## Human-Oriented

A company is inseparable from man, and corporate management should be based on respect for man. Upholding the corporate ideal of "management based on respect for man," SAMBU respects each individual as the holder of noble character and certain inalienable rights, while at the same time rendering efforts to create an environment where each individual can respect himself or herself. Towards that end, SAMBU has nurtured experts in each field through language, OA and other long-term education & training. Emphasis is also placed on discovering and nurturing human resources with creative and challenging spirit through a rejuvenating system of being open to suggestions. In addition, rewards and promotions are based on performance and competency, rather than duration of service and connections. Innovative intelligence and active posture, rather than authority and self-satisfaction are valued so that each individual can exert his or her capabilities to the full. Through efficient management of human resources, SAMBU has made great strides to create an environment where workers are content and highly motivated.



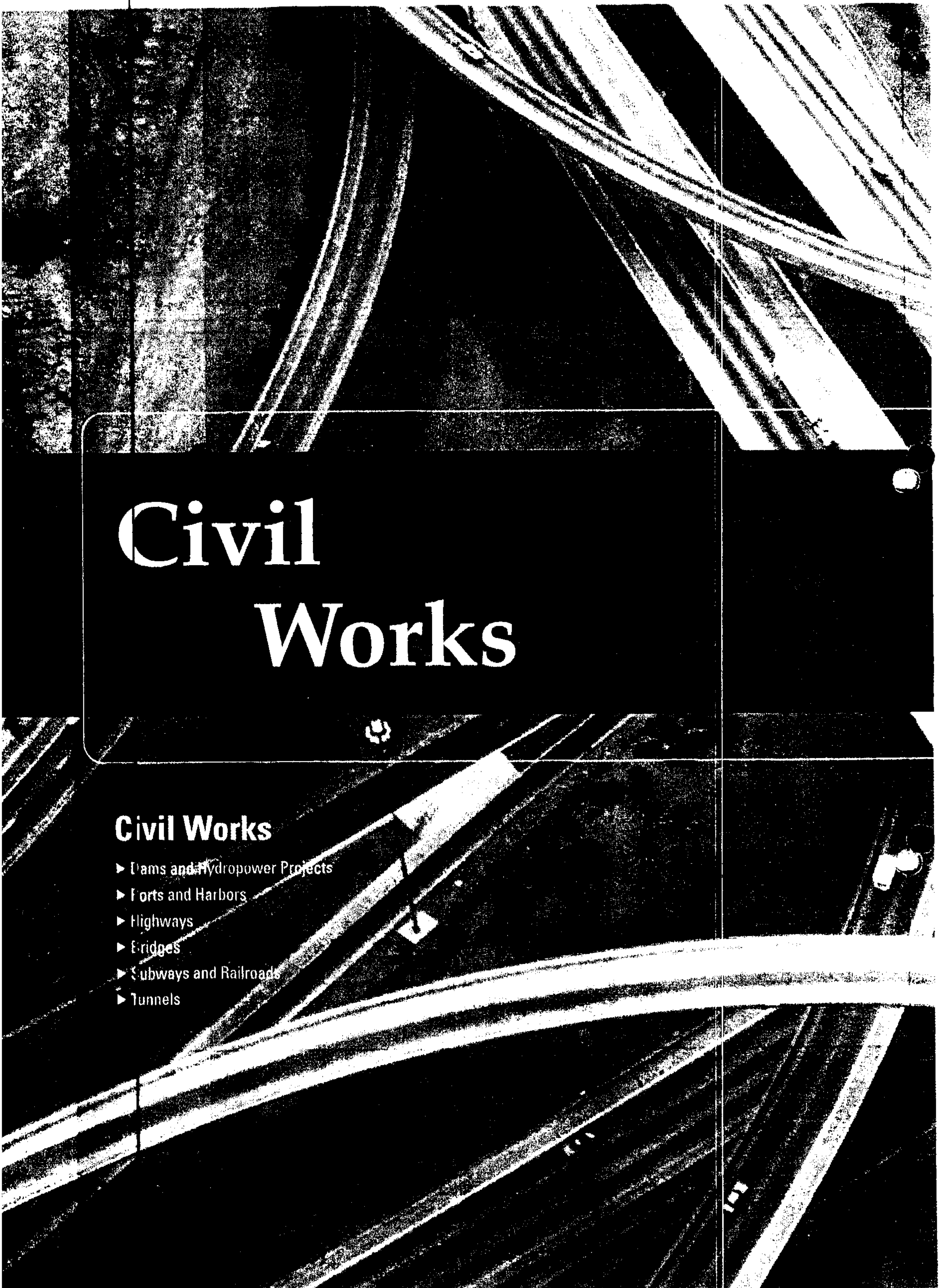

## Customer-Oriented

The goal of SAMBU is to provide service "for customers" and "for customer satisfaction and happiness." It has always been ready to meet customer demand, accommodating their unique needs and views. Towards that end, SAMBU has established a Total Quality Management (TQM) team in the Planning Office as part of the efforts to operate a customer-oriented quality assurance system. TQM provides education and training to management, office and field personnel, conducts documentation, holds workshops, establishes quality documents, conducts internal quality inspection and renders various other services to create value on behalf of the customers.

## Technology-Oriented

To create a more prosperous future, SAMBU endeavors relentlessly to provide pleasant spaces where man and environment coexist in perfect harmony in appropriate living environment, industrial space and facilities. Recognizing that systematic development of cutting-edge technology is the foundation of strengthening competitiveness, SAMBU has established a Technology Development Committee to research & develop new technologies and schemes as well as to introduce, disseminate and apply such advanced technology. The Committee oversees the collection and adaptation of technological plans and documents, presents seminars, improves & preserves existing schemes, offers technical training, conducts research & development of building materials, and evaluates construction & quality control, and strives to develop and secure the technologies required for productivity improvement and sharpening the competitive edge.

Gugera Hydro Power Co. SAMBU

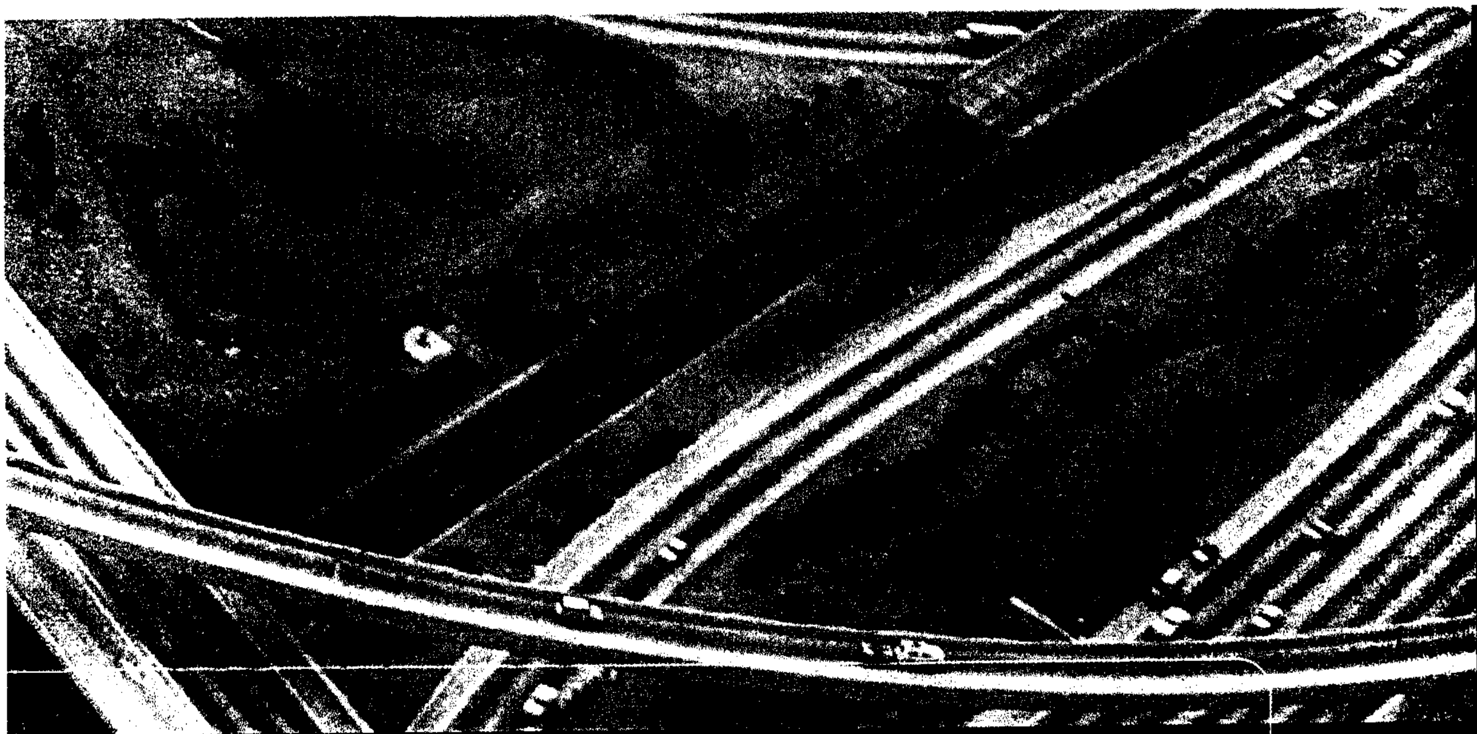


# Civil Works

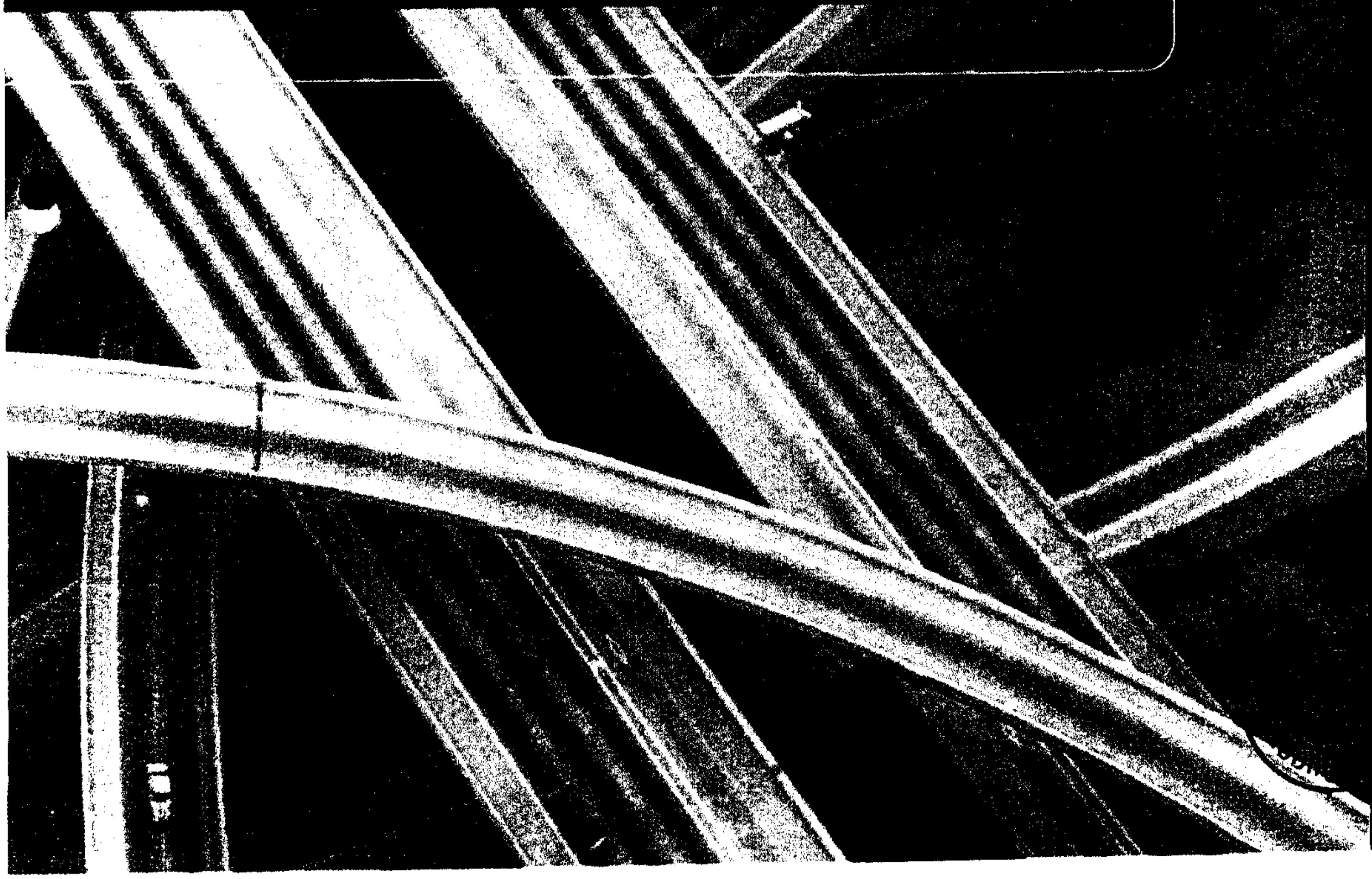
## Civil Works

- Dams and Hydropower Projects
- Ports and Harbors
- Highways
- Bridges
- Subways and Railroads
- Tunnels

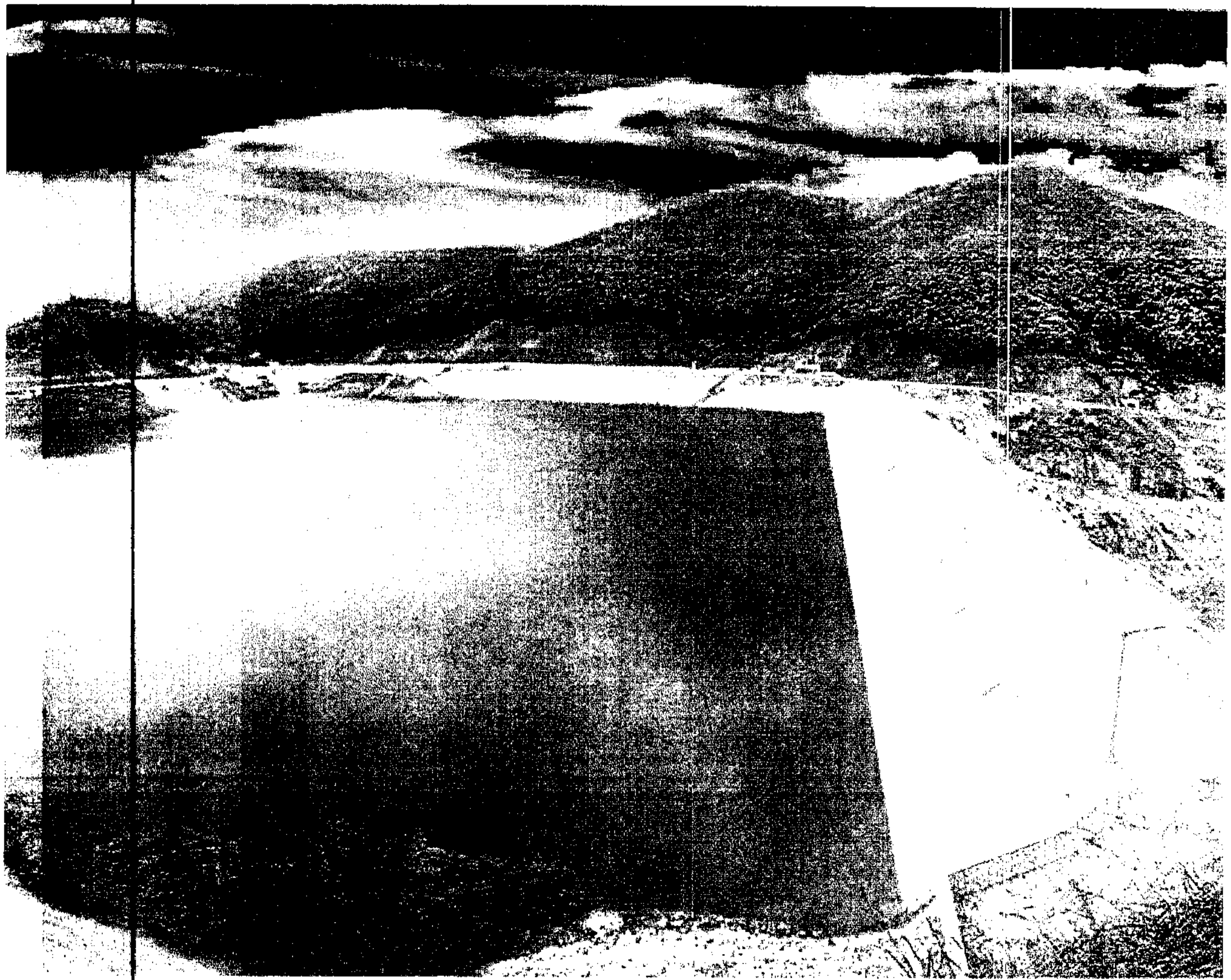
# Civil Works



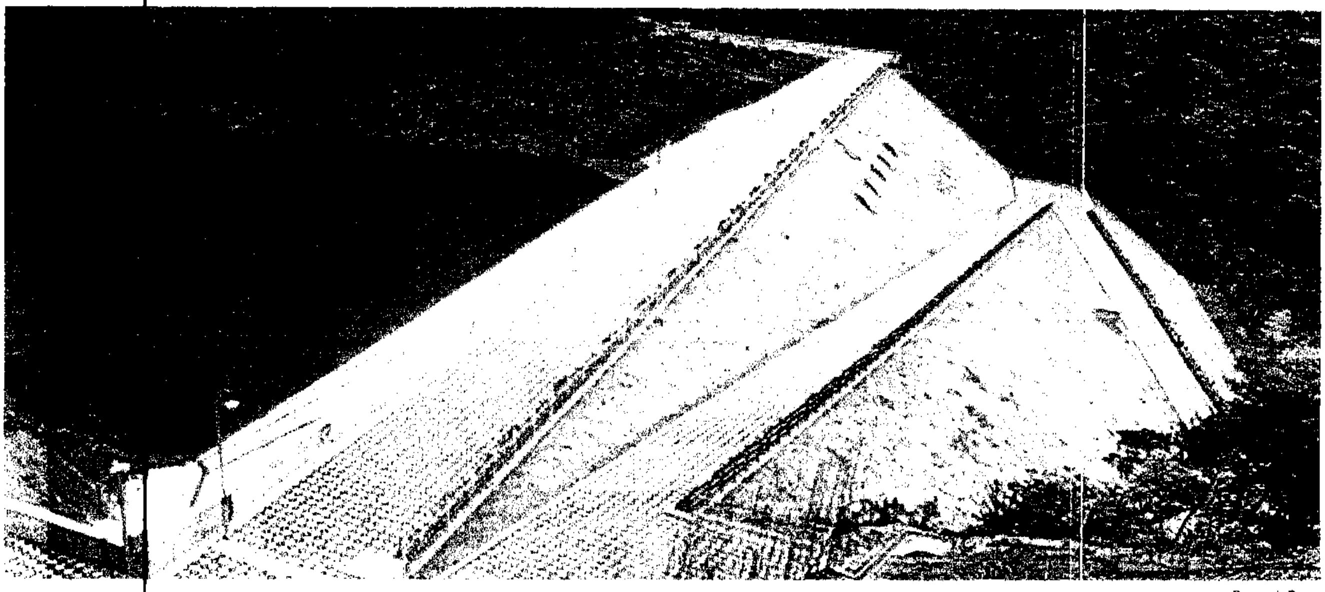
Holder of the Republic of Korea's Construction Business License No. 1, SAMBU has been involved in numerous works as the frontrunner in civil works. It has demonstrated outstanding technologies in construction of major dams for harnessing the nation's water resources, roads, harbors, railroads, subways, bridges, etc. In particular, the flawless construction of the nation's first-ever under-riverbed subway tunnel linking Mapo and Yeoido is one of the shining examples of SAMBU's technological achievements.



# Dams · Hydropower Projects



Sancheong Dam

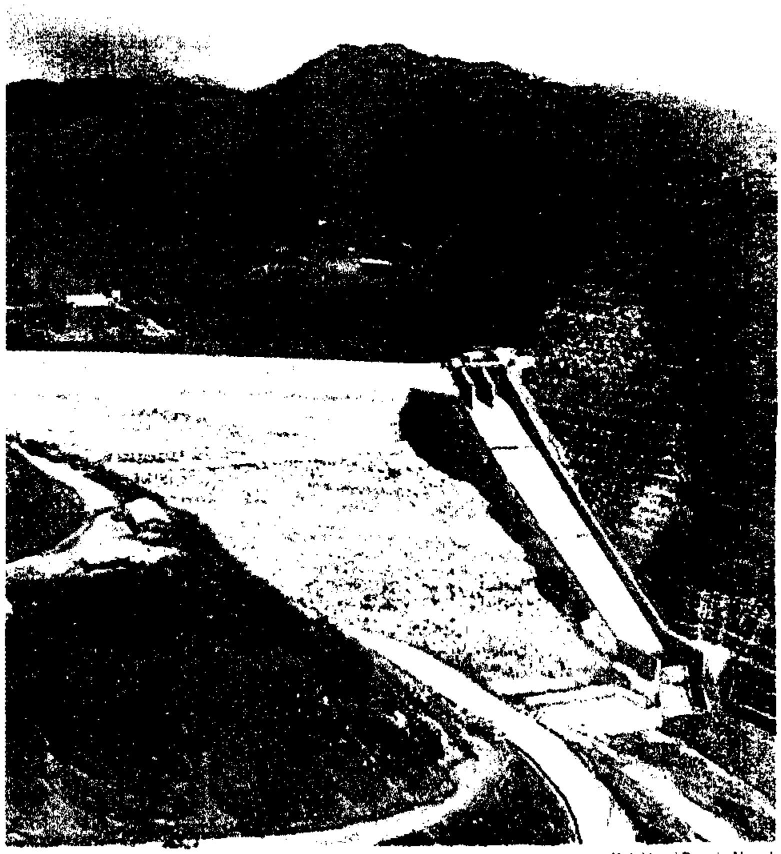


Daegok Dam

# DAMS · HYDROPOWER PROJECTS

SAMBU, a leading civil works contractor, built the Ulsan Sayeonje Dam, the first ever rockfill dam in Korea. Drawing on its sophisticated dam construction technologies accumulated over the years, SAMBU built the Sueocheon Rockfill Dam, the source of water supply for the Yeocheon Industrial Complex, Andong Multipurpose Dam, Nam River Multipurpose Dam, Geumho River Unmun Rockfill Dam, Kulekhani Dam in Nepal, along with many others. With unparalleled dam construction achievements, SAMBU is recognized as Korea's leading contractor specializing in dam construction.

Buhang Dam



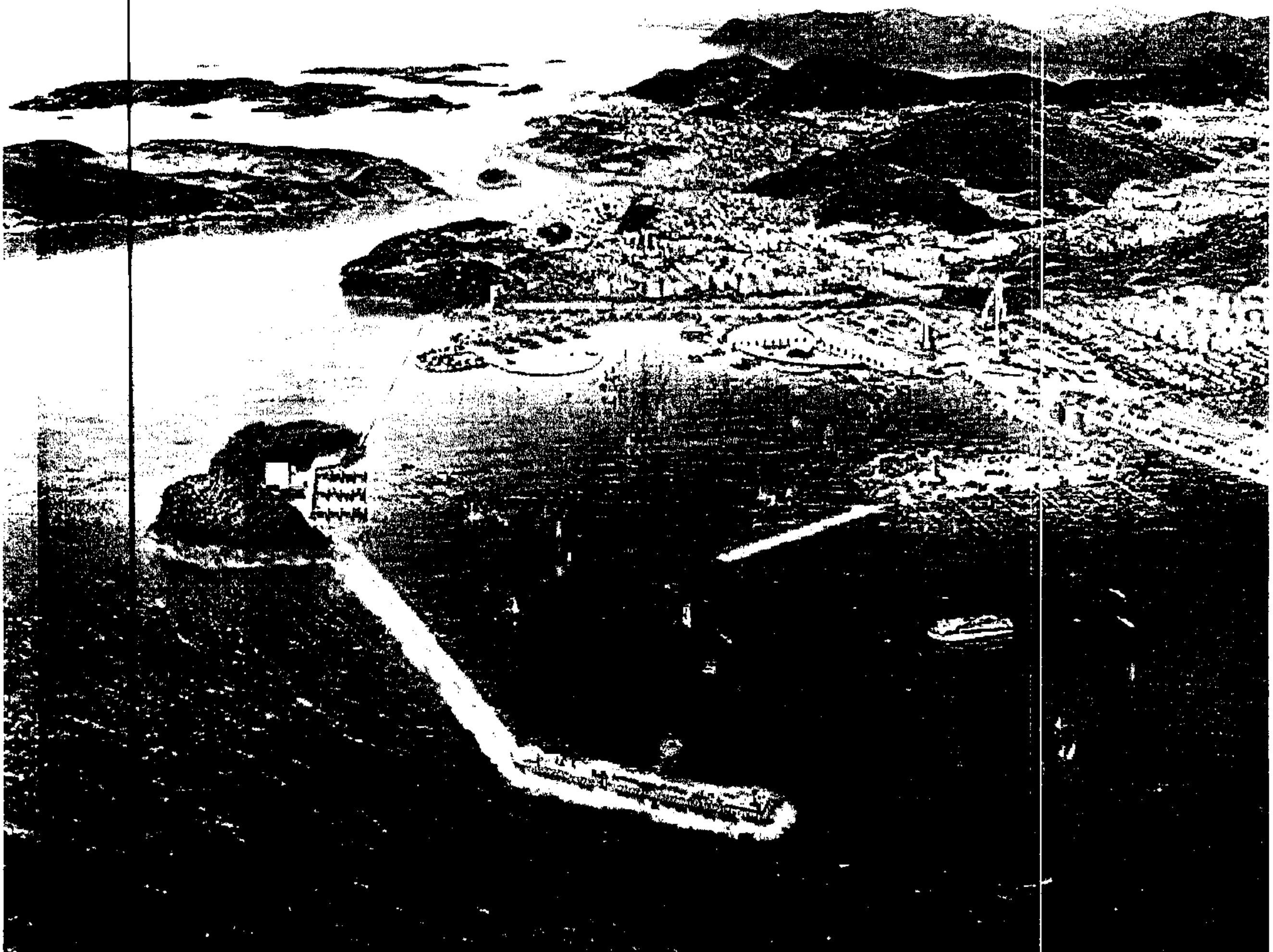
Kulekhani Dam in Nepal

Andong Multipurpose Dam

* MAJOR PROJECTS

- Andong Multipurpose Dam
- Sayeonje Rockfill Dam
- Geumho River Unmun Rockfill Dam
- Daegok Dam
- Nam River Multipurpose Dam
- Sueocheon Dam
- Sancheong Dam
- Kulekhani Dam in Nepal
- Buhang Dam
- Hwabuk Dam
- Cheongpyeong Hydro Power Plant Extension(Unit 4)
- New Bong Escape Hydro-electric Power Complex in Pakistan

# Ports and Harbors


Yeosu Port, East Breakwater


Yeongil Bay New Harbor

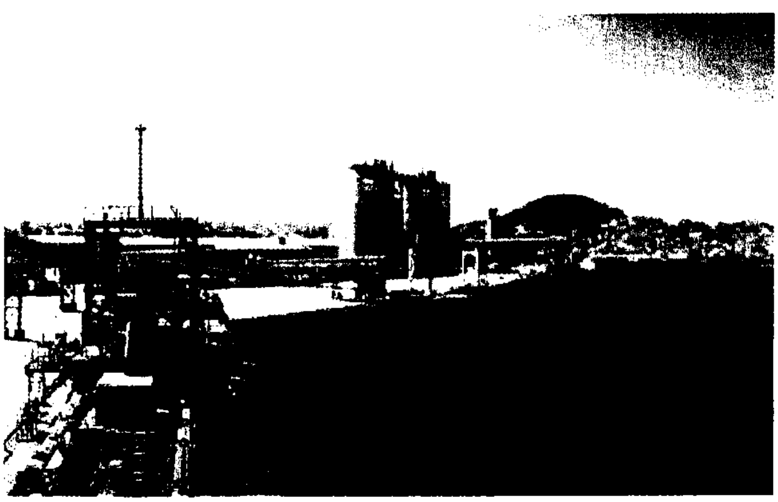
# PORTS AND HARBORS

SAMBU constructed the Incheon Port and Pohang New Port, the driving force of the nation's export drive, Soheuksan Island Port, and Donghae Bukpyeong Port, the largest industrial port on the East Coast. It also built the Jeodong Port on Ulleung Island and Mukho Port, the outpost for development of the Taebaek area, for which it had to overcome untold hardships with a challenging spirit and tenacity. SAMBU has engaged in the national effort to expand ports and harbors to contribute to the nation's economic development.

Soheuksan Island Port

Donghae Port North-Breakwater Rehabilitation & Reinforcement

Pohang New Port

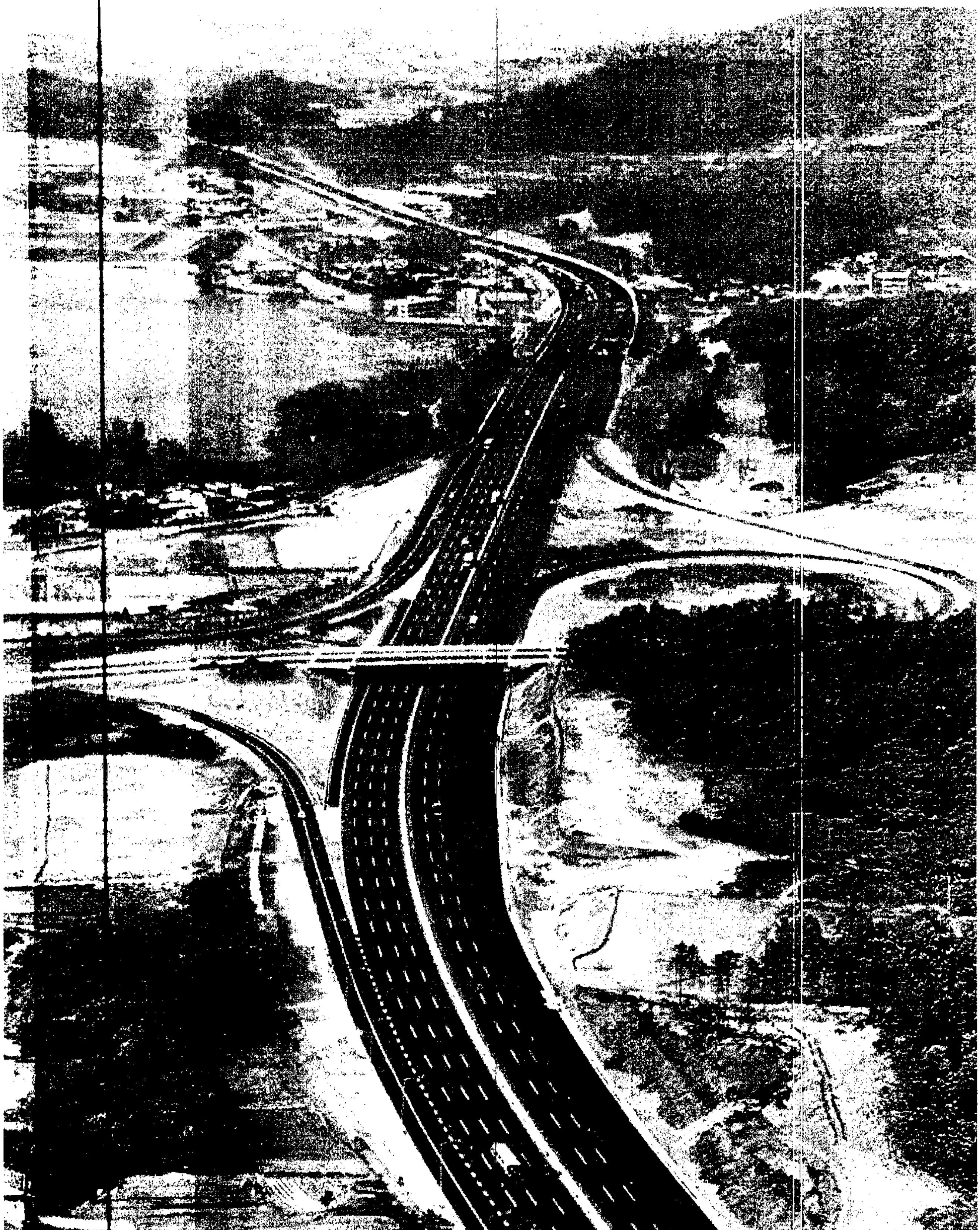


Mukho Port

Ulrung Island Sadong Port Breakwater Project

* MAJOR PROJECTS

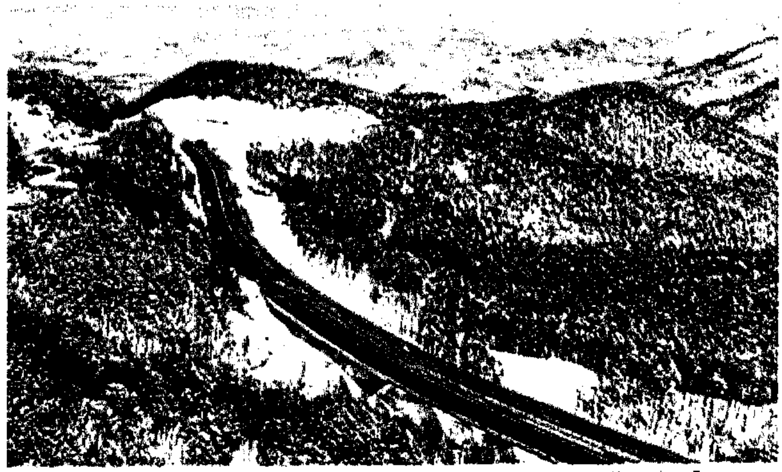
- Incheon Port
- Berthing Facilities at Jinhae Naval Base
- Breakwater for Hwasun Port in Jeju Island
- Fishing Port at Yeongil Bay New Harbor
- Asan Naval Port
- Jeodong Port in Ulleung Island
- Donghae Port North-Breakwater Rehabilitation & Reinforcement
- Breakwater for Jo Island in Busan
- Pohang New Port
- Yeongil Bay New Harbor
- Soheuksan Island Port
- Ulrung Island Sadong Port Breakwater Project
- Mukho Port
- Breakwater of Donghae Port
- Yeosu Port, East Breakwater
- Pyeongtaek-Dangjin Port

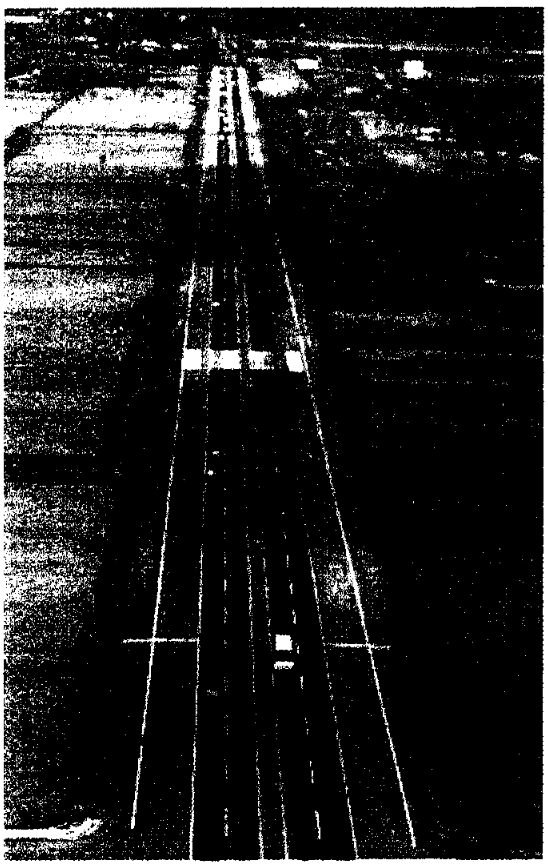


Seoul-Busan Expressway

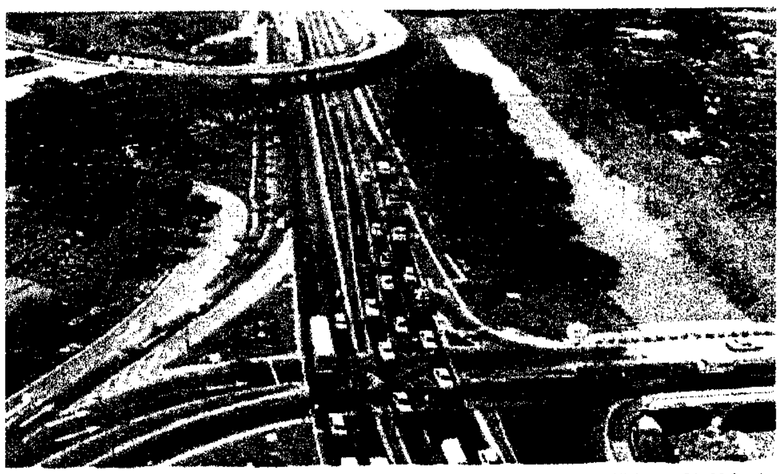
# HIGHWAYS

SAMBU has devoted its efforts to the construction of the national infrastructure, the artery of the national economy, to facilitate more rapid and advanced transport. It started with the construction of the nation's first-ever highway between Seoul and Incheon, and SAMBU was involved in the construction of the Seoul-Busan Expressway, a landmark project that will be long remembered in the history of Korean construction, the Honam and Namhae expressways, symbols of harmony between the Honam and Yeongnam regions, Yeongdong and Donghae expressways through the rugged Taebaek mountain range, and the nation's first-ever expansion and concrete pavement of the Busan-Masan expressway. Taking advantage of its accumulated technologies, SAMBU has performed brilliantly in overseas markets by building the Malaysian trunk line, Federal Highway No. 2, and the Kuala Lumpur-Petaling Jaya Traffic Diversion Scheme Stages I and II. Through these and other projects, SAMBU has been recognized for its top-notch road-building technologies both at home and abroad.


Yeongdong Expressway

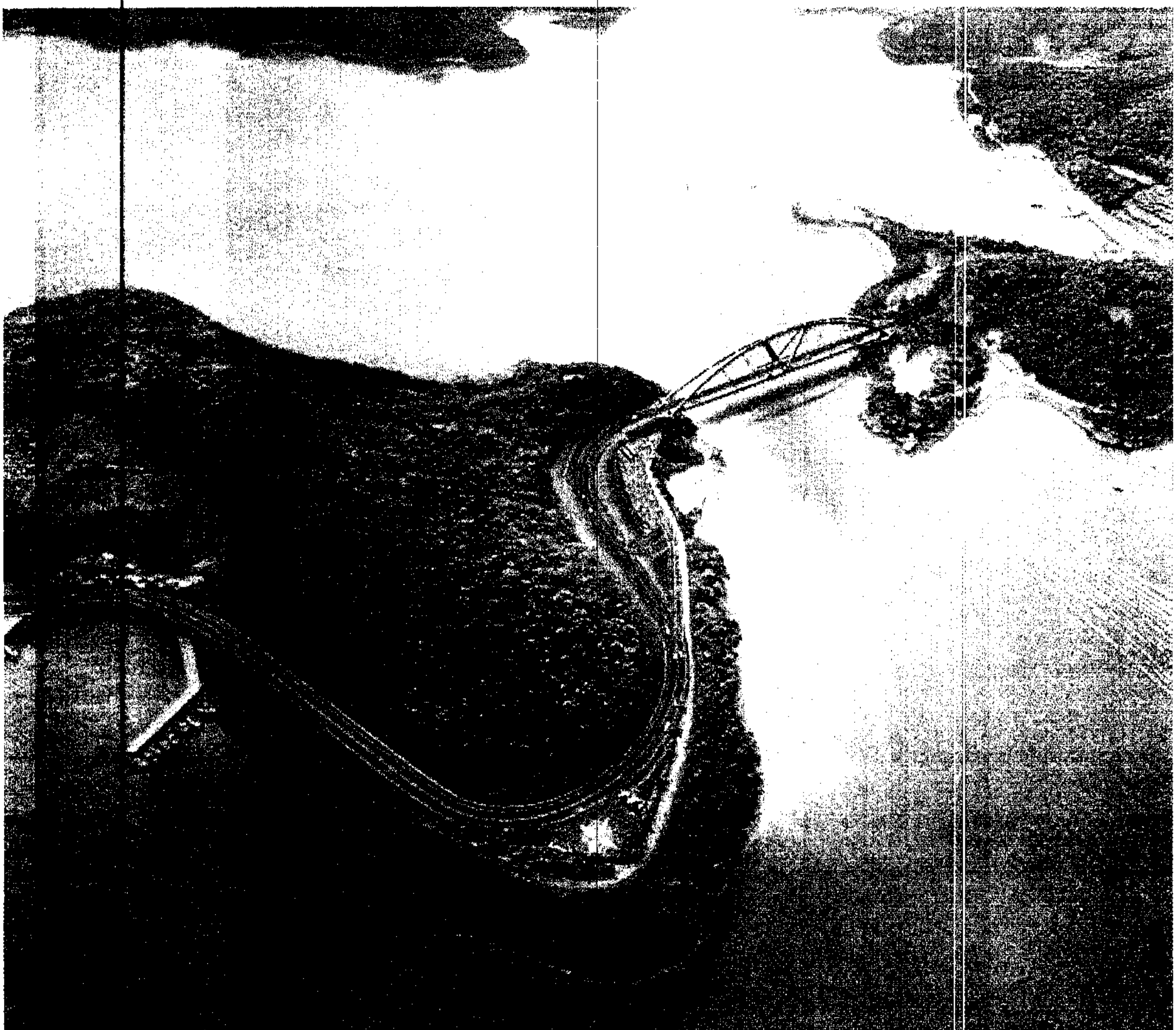

Seoul-Busan Expressway


Seocheon-Gongju Expressway Lot.3


Federal Highway #2 in Malaysia

*** MAJOR PROJECTS**

- Seoul-Busan Expressway
- Seoul-Incheon Expressway
- YeongdongExpressway
- Namhae Expressway
- Jungbu Expressway
- Jeju Island Highway & Ring Road
- Angang-Pohang Highway
- Yeongdong and Donghae Expressways
- Daejeon-Tongyeong Expressway
- Cheongha-Ganggu Highway
- Nonsan-Sangwol Highway
- Baekje Keungil Highway
- Sangnim-Haepyeong Highway
- Federal Highway #2 in Malaysia
- Kuala Lumpur-Petaling Jaya Traffic Diversion Scheme (Sections #3 and #4 under Stages I and II)
- Multan-Mianchannu Additional Carriageway in Pakistan
- Bhatkanda-Silgadhi Highway in Nepal
- Hwacheon Industrial Road
- Kwangmyung Highway
- Removal Road for Daegok Dam
- Mogok-Balsan Highway
- Iksan-Pohang Expressway Expansion Iksan-Changsu (Lot. 8)
- Cheongwon-Sangju Expressway Lot. 1, 8
- Gochang-Damyang Expressway Expansion, Jangsung-Damyang (Lot. 3)
- Seocheon-Gongju Expressway Lot. 3
- Changsung Combined Freight Terminal Access Road
- Nammyeon-Yangmok Highway
- Doam-Kangjin Highway
- Incheon Int'l Airport Highway Phase II, Southern & Northern Roads and Main Drainage Facilities
- Dogye-Chojeong Highway
- Pohang Circuitous Highway
- Pungdeokcheon-Geumgok I/C Highway
- Cheonan Circuitous Highway
- Jangheung-Songchu Highway
- Angang-Cheongnyeong Highway
- Donghongcheon-Yangyang Expressway Lot.5
- Socheon-Seomyeon Highway
- Jangheung-Gwangyang Expressway Lot.4,7
- Jumunjin-Sokcho Expressway Lot.7

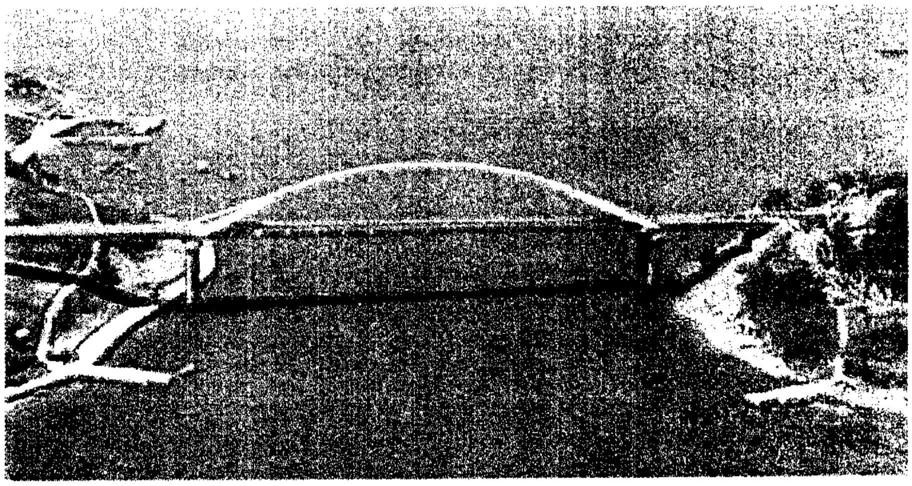


Connection Bridge for Jeo Island (T/K Project)

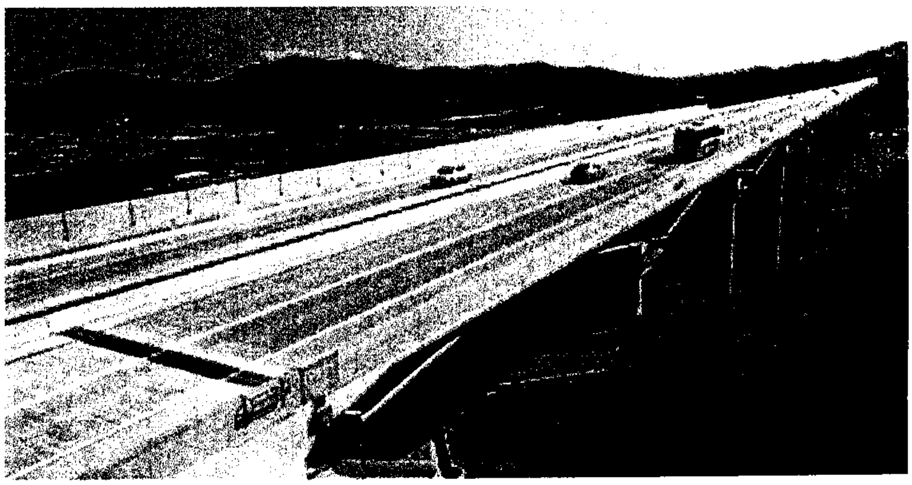
Suyeong No.4 Bridge

# BRIDGES

SAMBU has always followed only one path as a contractor. Careful planning and responsible workmanship have earned SAMBU a reputation for reliability and experience. It successfully built the Hwangsan Bridge, Asia's longest ILM (Incremental Launching Method) bridge (1,050 m), Geumnam Bridge, the nation's first-ever concrete box bridge, Baekje Bridge, based on the Well scheme, and Yeonyuk Bridge of Anheung Port, which is expected to help realize the vision of developing the nation's western coastal area into a business hub. The safe, solid and aesthetically pleasing bridges, built with SAMBU's technologies, have been highly acclaimed at home and abroad.

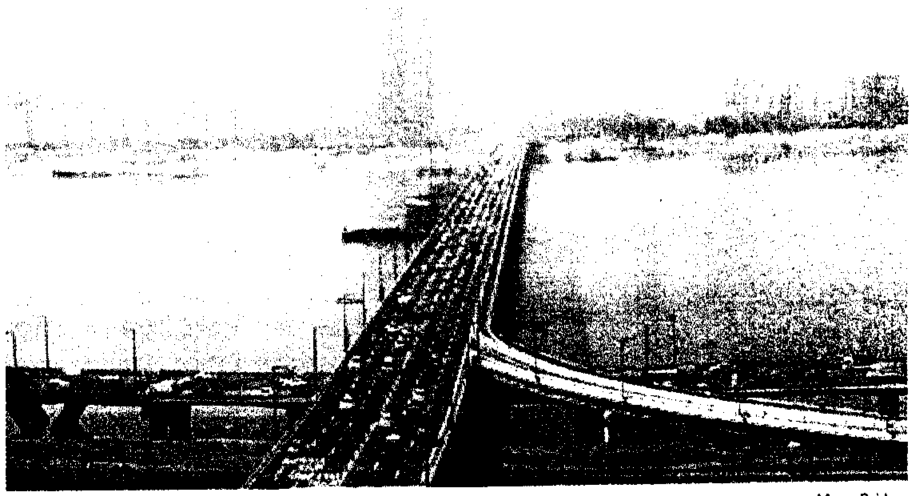


Connection Bridge for Yeocheon-Hwayang

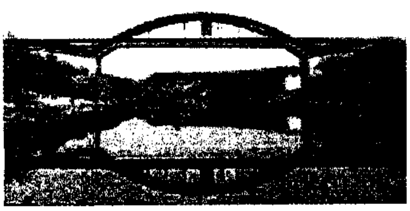


Cheongnam Bridge

Buyeo Bridge



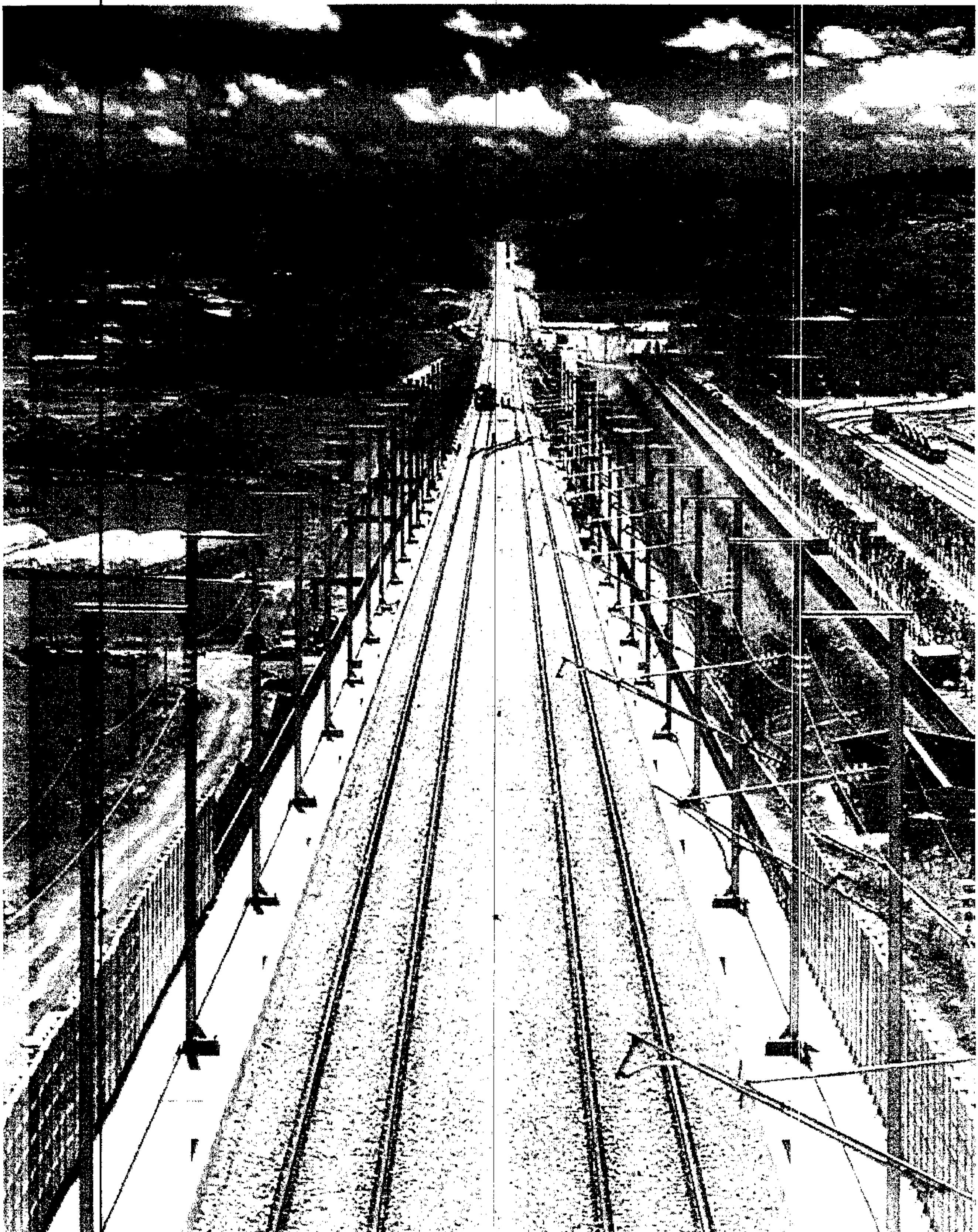
Mapo Bridge



Jiktang Bridge

* MAJOR PROJECTS

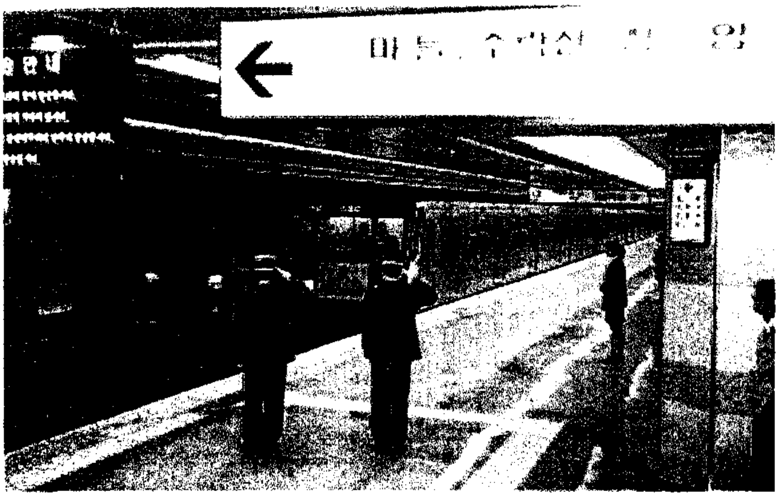
- Yanghwa Bridge
- Hyeongsan River New Steel Bridge
- Geumnam Bridge
- Baekma River Bridge
- Yulji Bridge
- Connection Bridge for Upper and Lower Jo islands
- New Yanghwa Bridge
- Goryeong Bridge
- Seomjin River Bridge
- Hwangsan Bridge
- Jiktang Bridge
- Yukang Oepal Bridge
- Mapo Bridge
- Baekje Bridge
- Connection Bridge for Yeocheon-Hwayang
- Nakdong Bridge
- Bakjin Bridge
- Connection Bridge for Jeo Island (T/K Project)
- Babai Weir-cum-Bridge in Nepal
- Beopheung Bridge
- Baekya Bridge
- Suyeong No.4 Bridge
- Cheongnam Bridge
- Pailas Bridge in Santa Cruz, Bolivia
- Buyeo Bridge



Seoul-Busan High-Speed Railroad Section #7-1

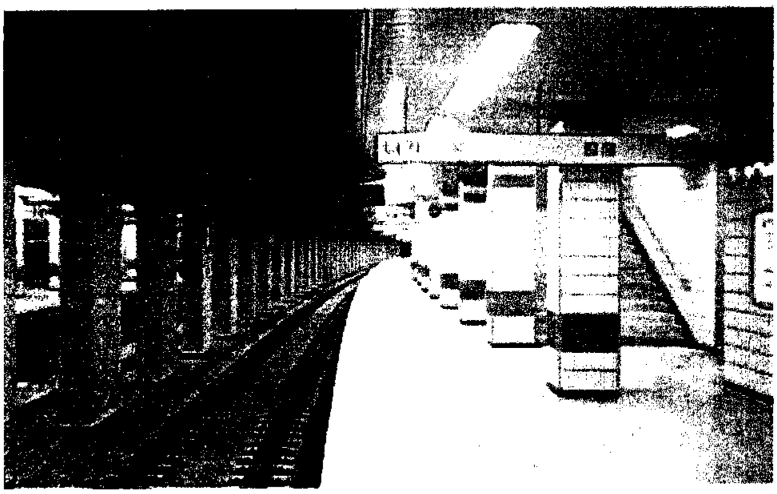
# SUBWAYS · RAILROADS

SAMBU has extensive experience in the construction of more rapid and solid transport infrastructure and subways to cope with traffic congestion due to the population increase in and around the capital area. It built the Yangyang-Samcheok railway line linking mines along the East Coast and nearby cities, the Yemi-Jeongseon line for mining in the Taebaek Mountain Range, Seoul Subway Line 2 (section #2) to create a new transportation culture necessary for the capital to become a global city, Seoul Subway Line 5 (section #5-18 between Yeoido and Mapo), the nation's first-ever under-riverbed subway tunnel, the double-track Geumjeong-Sadang Line (section #10), and the Seoul-Busan high-speed railroad (section #7-1) requiring the attainment of sophisticated technology. SAMBU has been recognized for its technological prowess by successfully participating in these and many other railroad and subway construction projects in Korea.

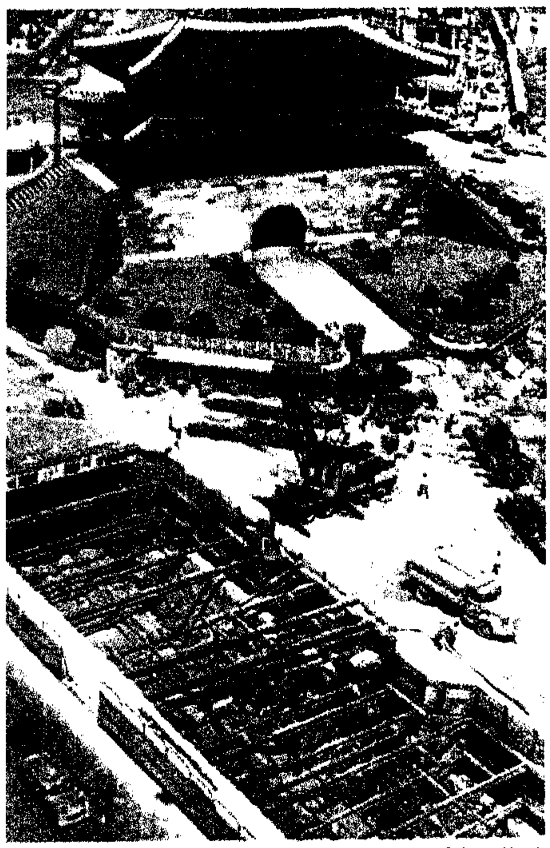


Nowon Subway Station

Yeoui Naru Station



Seoul Subway Line 4 (Isu-Sadang section)

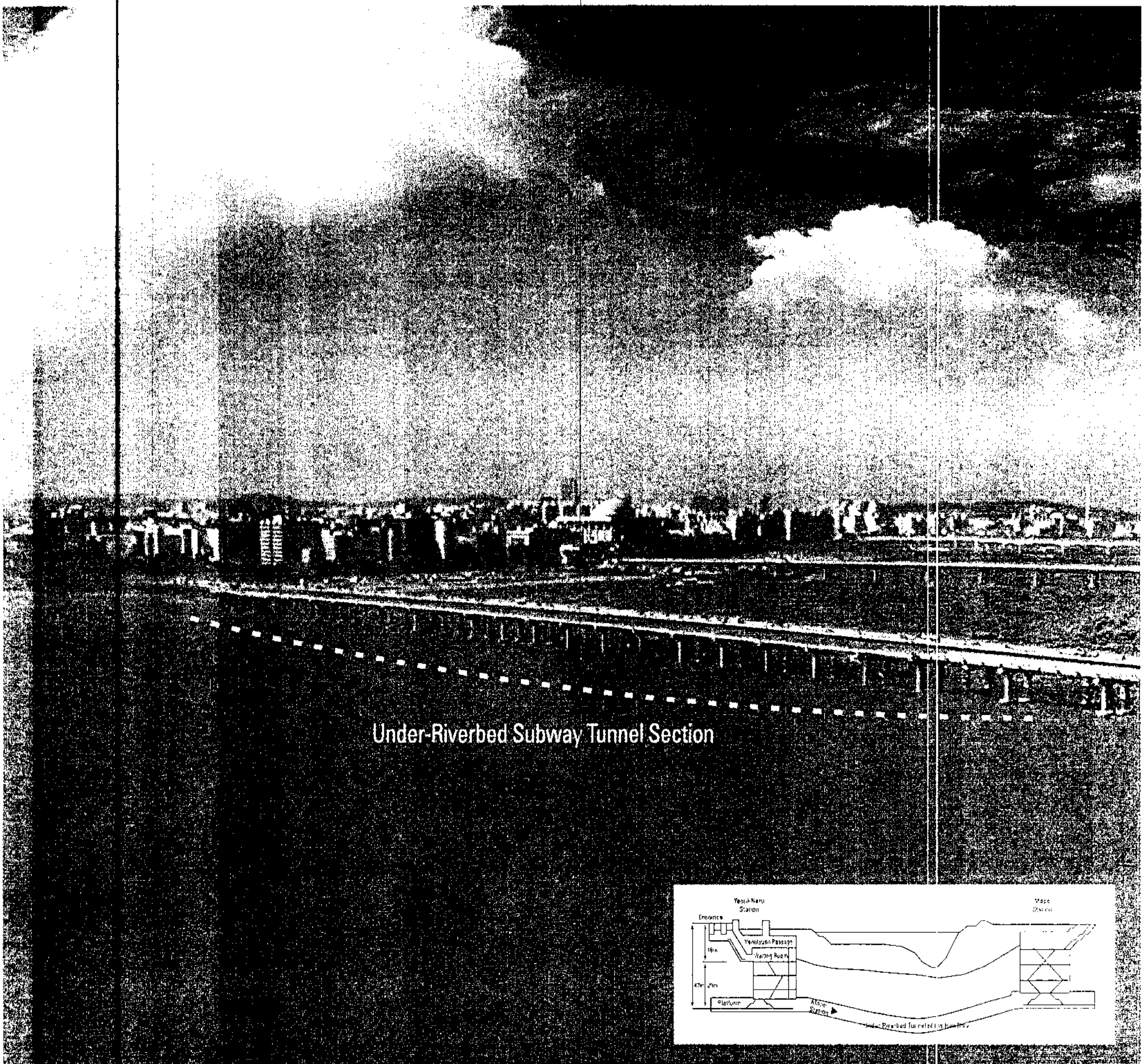


Seoul Subway Line 1

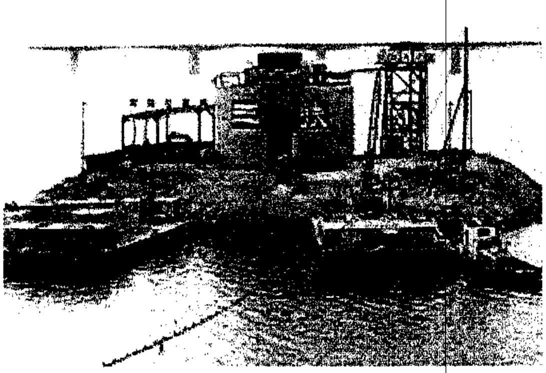
* MAJOR PROJECTS

- Yemi-Jeongseon Line
- Double-track Geumjeong-Sadang electric railroad
- Metropolitan Railroad Line 1 (section #1-8)
- Seoul-Busan high-speed railroad (section #7-1)
- Nowon Subway Station
- Yeoui Naru Station
- Nonsan-Ganggyeong Line
- Yusu-Dasolsa line
- Gwangju Metropolitan Line No. 1 (Section #1-5)
- Seoul Subway (Lines #1~8)
- Bukpyeong-Imhang line
- East Daegu-Cheongcheon line
- Daejeon Metropolitan Railroad Line 1 (section #1-11)
- Sinpung-Yeocheon Line
- Incheon Int.1 Airport Railroad
- Double-track Seongnam-Yeoju electric railroad(Section #4)

# Tunnels




Yeoido Under-Riverbed Subway Tunnel (section #5-18)

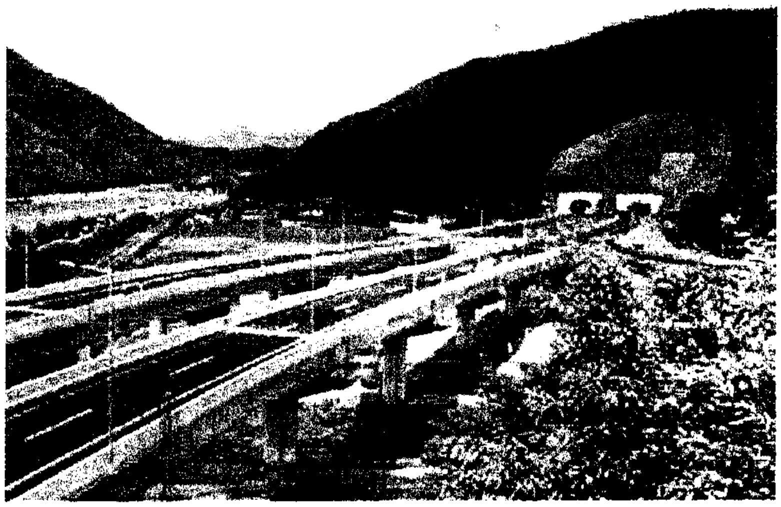


Yeoido Under-Riverbed Subway Tunnel Work (artificial island)

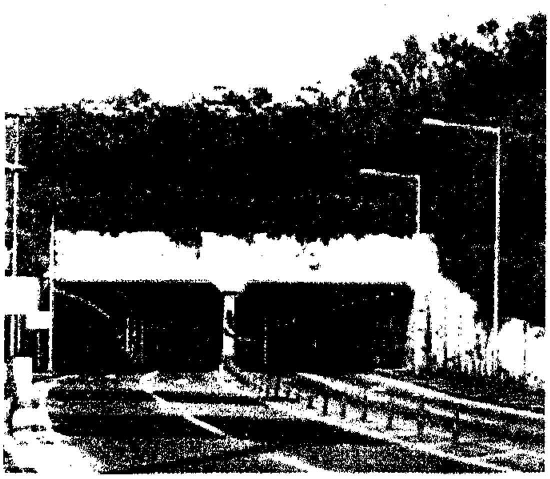
Yeoido Under-Riverbed Subway Tunnel (section #5-18)

# TUNNELS

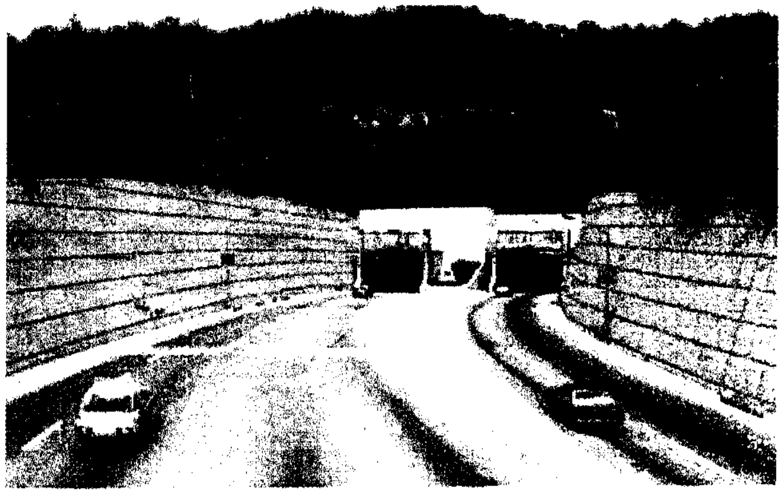
The technological know-how that SAMBU has accumulated in civil works is well evidenced in its expertise in building tunnels. In particular, the Han River Tunnel, the nation's first-ever under-riverbed tunnel (Yeoido Section #5-18), was awarded the Gold Medal for Civil Engineering Construction at the 28th IFAWPCA Convention in Seoul, as its new construction paradigm significantly reduced the construction period as well as the cost. The recognition by such a prestigious international forum was a confirmation of Korea's advanced level of engineering and construction technology. SAMBU's tradition of flawless construction has continued with the Yu River Oepal Bridge Tunnel, Sillim-Anyang Tunnel, Hamyang Tunnel, etc.



Yu River Oepal Bridge Tunnel

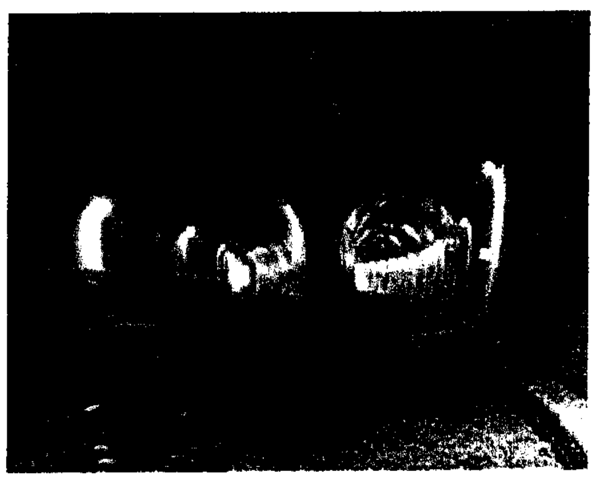


Hoam Tunnel (Sillim-Anyang)



Geumhwa Tunnel

Sanwoi-Sangbuk Highway, Neungdong Tunnel



Twin Tunnel (Seoul Subway Line 3)

* MAJOR PROJECTS

- Hamyang Tunnel (Sasang-Hamyang)
- Daejeon Tunnel (Cheongwon-Jungyak, Seoul-Busan Expressway)
- Munsan Tunnel (Sangmun-Jungchon, Namhae Expressway)
- Cheongam Tunnel (Cheongam-Sicheon)
- Naengjeong Tunnel (Naeseo-Naengjeong, Namhae Expressway)
- Hoam Tunnel (Sillim -Anyang)
- Yeoido Under-Riverbed Subway Tunnel ( Section #5-18)
- Jinju Tunnel (Sangmun-Jungchon, Namhae Expressway)
- Geumhwa Tunnel
- Yu River Oepal Bridge Tunnel
- Twin Tunnel (Seoul Subway Line 3)
- Sanwoi-Sangbuk Highway, Neungdong Tunnel
- Maebara No.1 Tunnel in Maebara, Japan
- Jangheung-Songchu Highway, Jangheung Tunnel
- Jinju No.1,2 Tunnel(Jinju-Masan Highway)
- Lowari Tunnel in Chitral, Pakistan

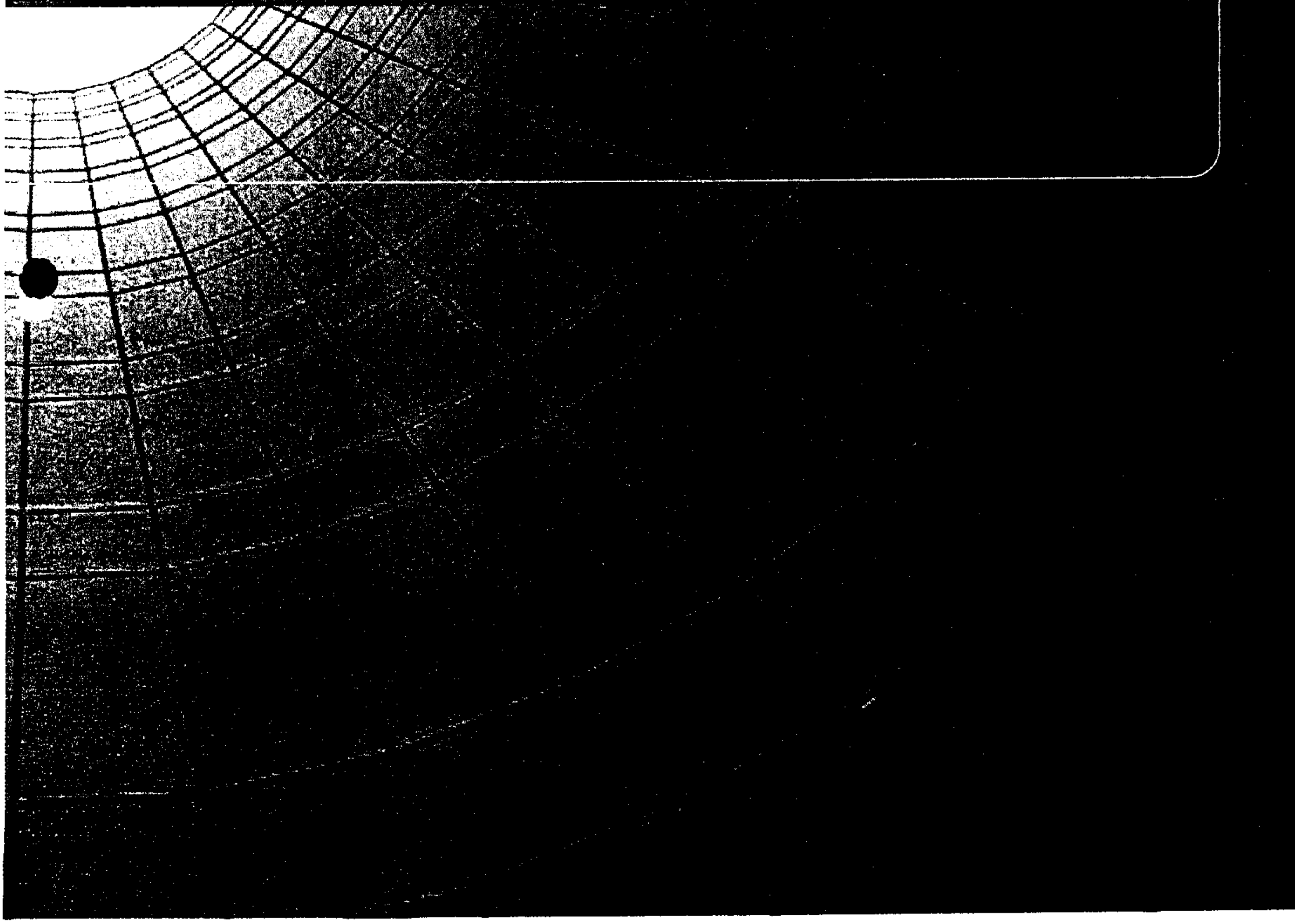
# Architectural Works

## Architectural Works

- Office and Commercial Buildings
- Hotels
- Museums and Cultural Properties
- Educational and Research Facilities
- Religious Facilities
- Sports and Leisure Facilities
- Renovations

Architectural Works

As is well demonstrated by the super high-rise buildings in foreign countries as well as museums and hotels that require delicate and careful workmanship, SAMBU's sophisticated architectural technology has been recognized both at home and abroad. Construction of the highest quality for posh hotels, mixture of traditional and advanced technologies to restore and preserve museums and cultural assets, and an impressive housing culture are what SAMBU delivers. SAMBU stands for superb architecture, where technology and customer needs coincide to create a space of dreams.

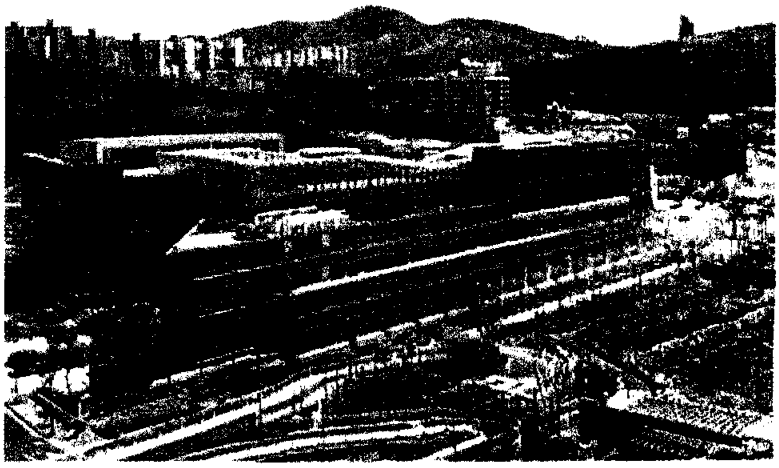


MBF Finance Headquarters, Malaysia

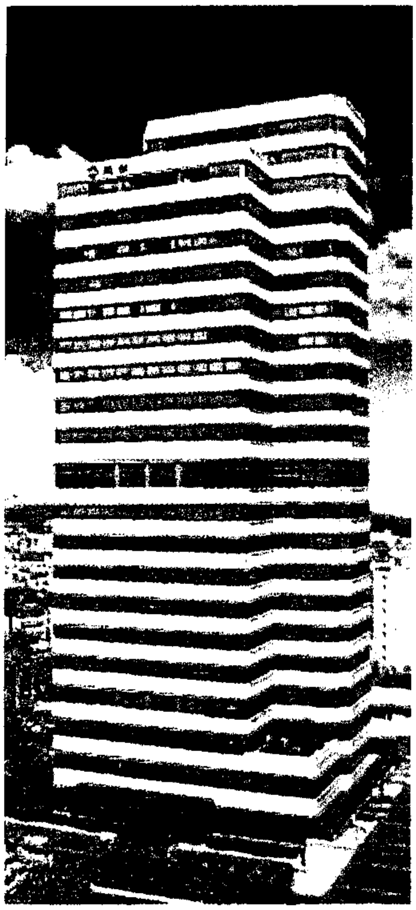
# OFFICE · COMMERCIAL BUILDINGS

SAMBU, totally committed to stability and reliability, has followed a single path of an expert contractor for more than five decades. Its works ranging from towering high-rise office buildings to public facilities have impressed customers both at home and abroad.

The MBF Finance Headquarters building, which changed the skyline of Malaysia, has been acclaimed as a masterpiece wrought by SAMBU's artisanship. The high-tech intelligent building with optimized IT business efficiency showcases the future-oriented, corporate ideals of SAMBU.

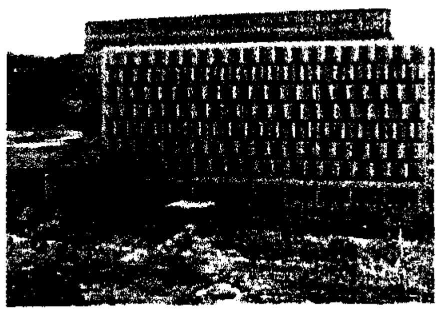


Yongin Donbaek Shopping Center(Junwave)

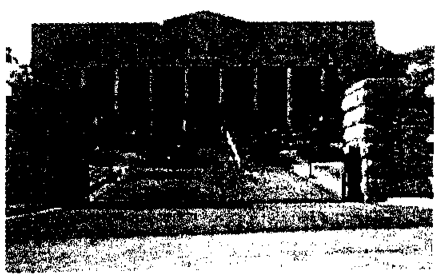


The SAMBU Building at Yeoksam-dong


Daehan Theater



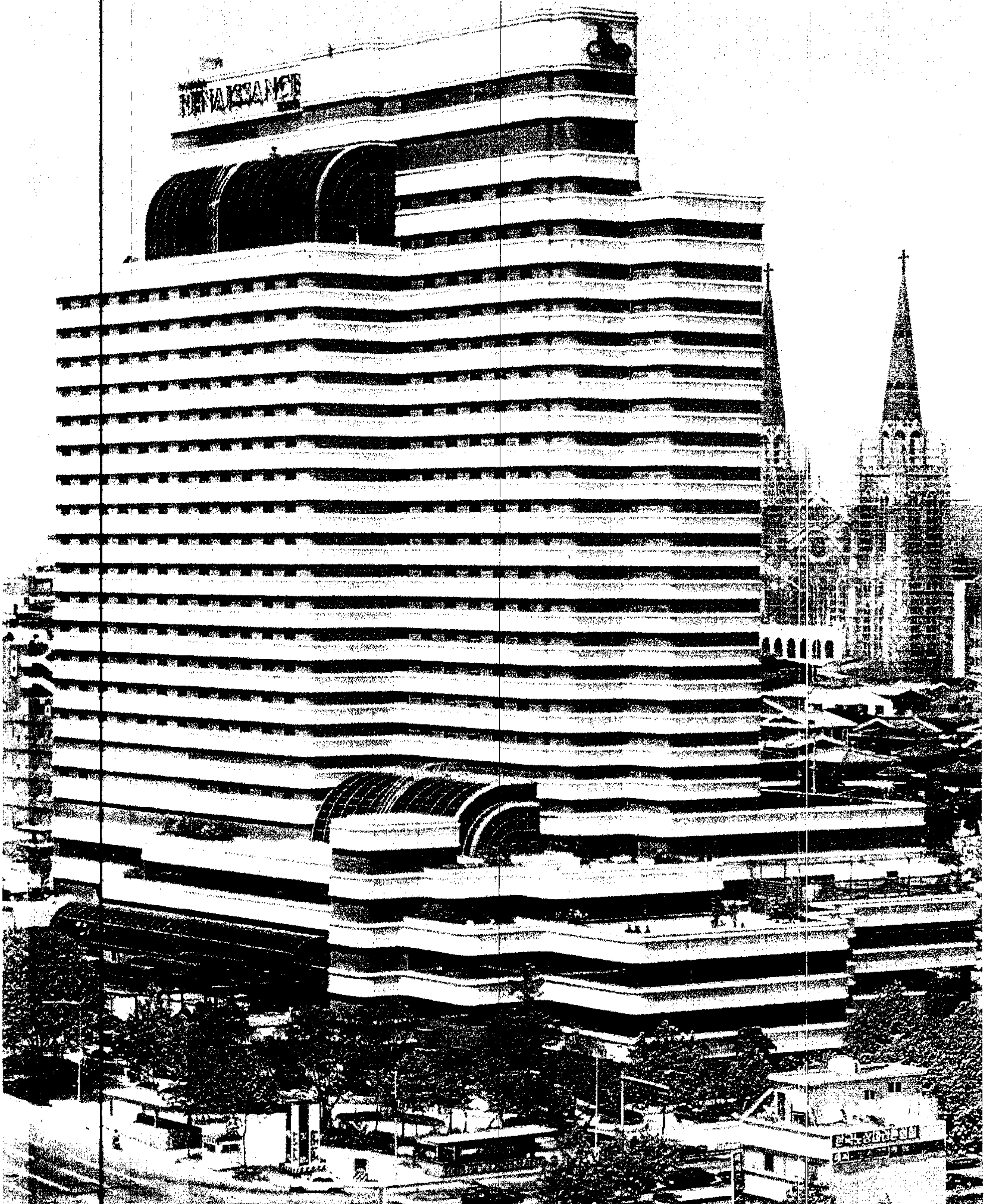
Cheongju Public Prosecutors' Office Building



Central Election Management Commission BuildingTheater

*** MAJOR PROJECTS**

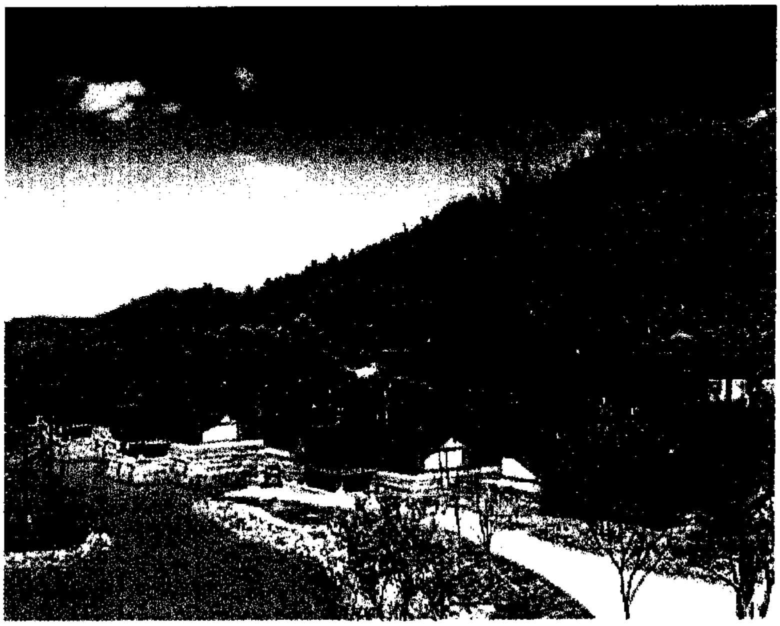
- Kookmin Bank's headquarters building
- Central Election Management Commission building
- Korea Medical Insurance Corporation building
- SAMBU Building at Yeoksam-dong
- Korea Social Welfare Hall (Renaissance Tower in Mapo)
- Anyang Post Office
- Gwanghwamun Post Office and other public buildings
- Yeoi Shopping Center
- Cheonan Express Bus Terminal
- AAAID headquarters building in Sudan
- Public Prosecutors Office and various other legal administration buildings
- SAMBU Plaza in Daejeon
- Happy-I building
- MBF Finance Headquarters building in Malaysia
- Daehan Theater
- Sunshine Building in Myeong-dong
- Underground Shopping Mall in Sogong-dong
- Tribhuvan International Airport in Nepal
- MBC building in Gangneung
- Olympic Shopping Center
- Gwanghwamun Post Office
- Yongin Donbaek Shopping Center(Junwave)
- Seifullina Office Project in Almaty, Kazakhstan
- Cheongju Public Prosecutors' Office Building
- Cold Storage Installation Center for SEJ in Fukuoka, Japan




Renaissance Seoul Hotel

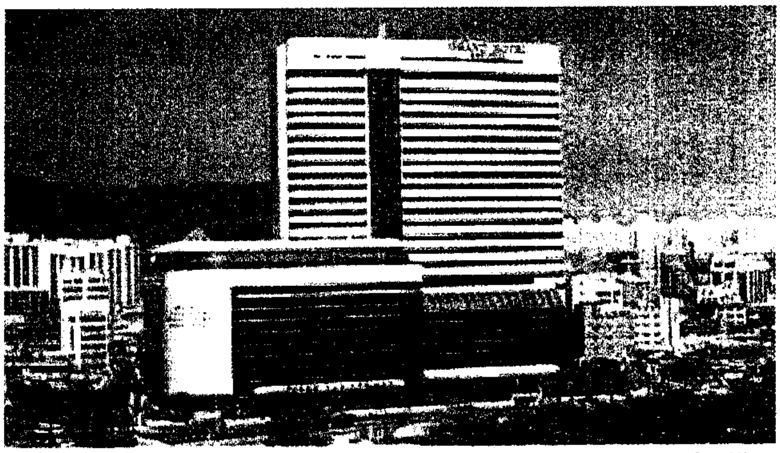
# HOTELS

Yet another area where SAMBU's outstanding technical strength is amply demonstrated is hotel construction. SAMBU, which has built the Renaissance Seoul Hotel and numerous other hotels, creates maximum value as an expert hotel contractor, drawing on the technologies accumulated in a wide range of fields from development to renovations. SAMBU is determined to provide the best space of refinement and convenience to meet the diverse needs of clients in this era of the global village.

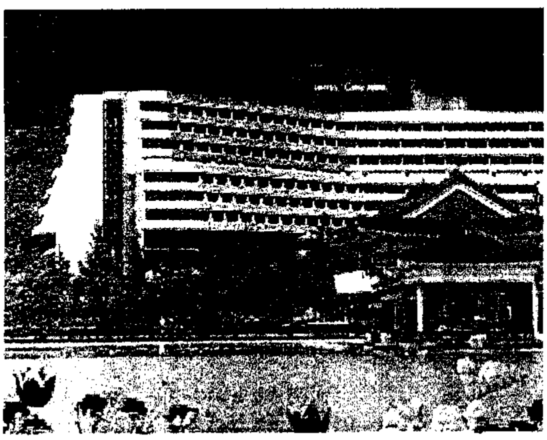


Ragung (Millennium Palace Resort & Spa in Shilla Millennium Park, Gyeongju

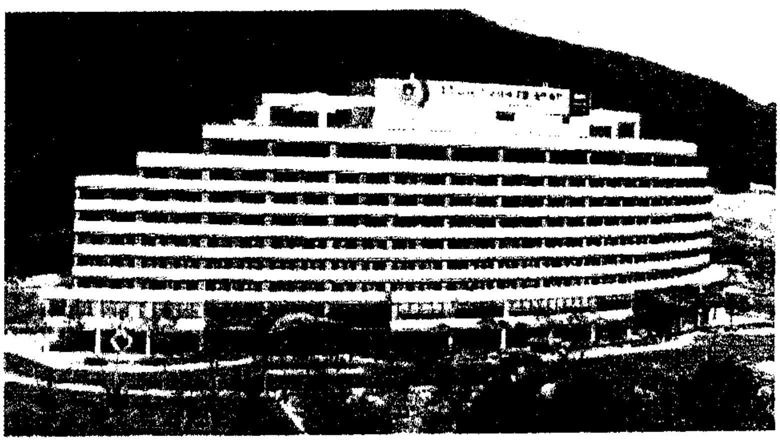
Spapia Hotel in Yuseong



Haeundae Grand Hotel



Gyeongju Concorde Hotel



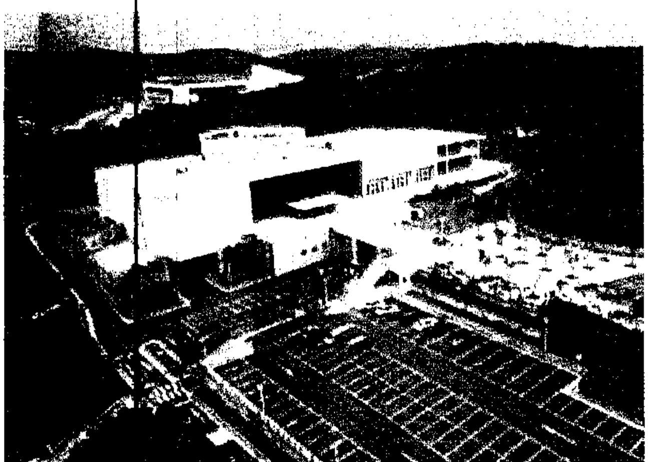
Educational & Cultural Center in Gyeongju

* MAJOR PROJECTS

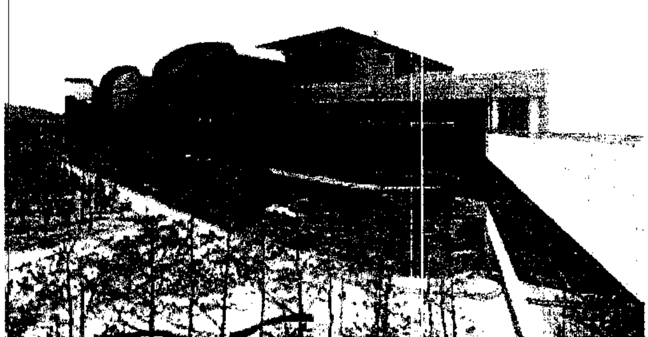
- Renaissance Seoul Hotel
- Haeundae Grand Hotel
- Gyeongju Concorde Hotel
- Jeungpyeong Park Tourist Hotel
- Hanrok Resort Hotel in Cheongpyeong
- Sorak Youth Hotel
- Ansan Mariko Hotel
- Educational & Cultural Center in Gyeongju
- Spapia Hotel in Yuseong
- Ragung (Millennium Palace Resort & Spa in Shilla Millennium Park, Gyeongju

## Museums · Cultural Properties

Seoul Namsan Gugakdang(The Classical Theater of Korean Traditional Music)



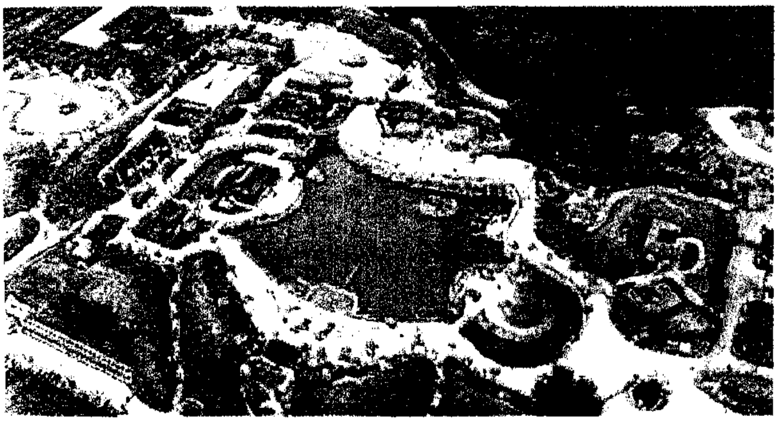
National Museum in Chuncheon



National Institute of Biological Resources in Incheon

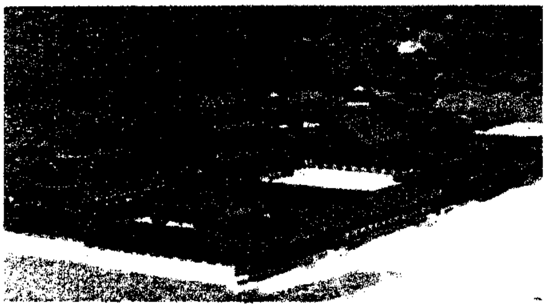
# MUSEUMS · CULTURAL PROPERTIES

As depositories of important cultural assets and sites for preserving irreplaceable relics, museums require highly delicate and precise architectural technologies. It is a cultural space where SAMBU's artisanship is in full bloom. SAMBU has helped perfectly preserve the nation's traditional cultural heritage with the artisanship and a sense of mission.

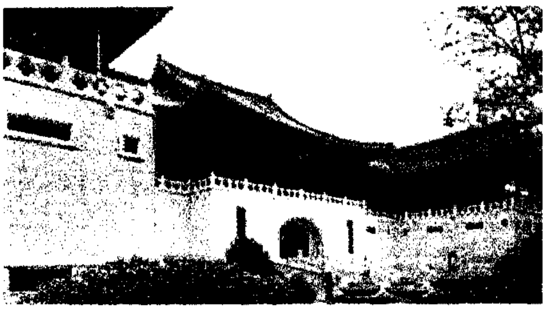


Shilla Millennium Park in Gyeongju

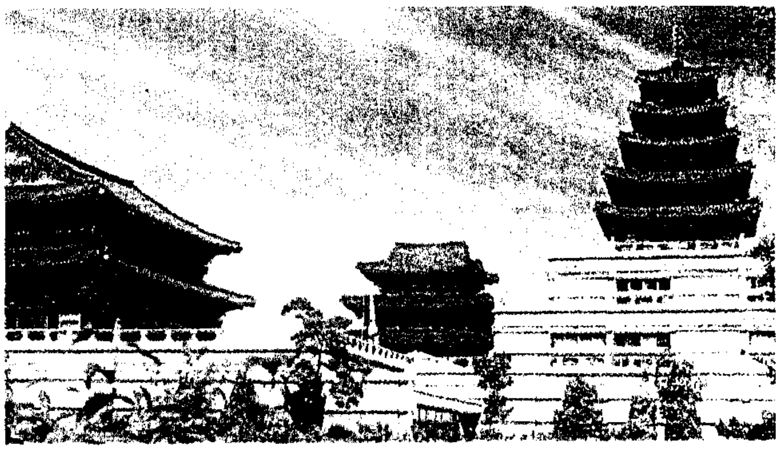
National Museum in Gyeongju



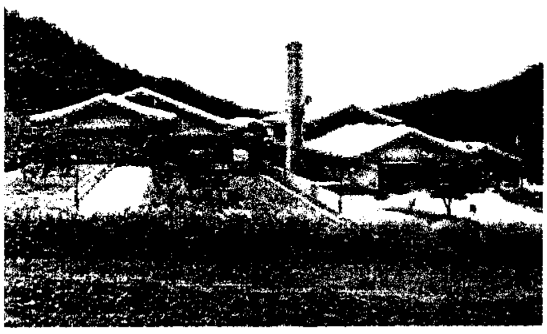
Baekje History Village in Buyeo



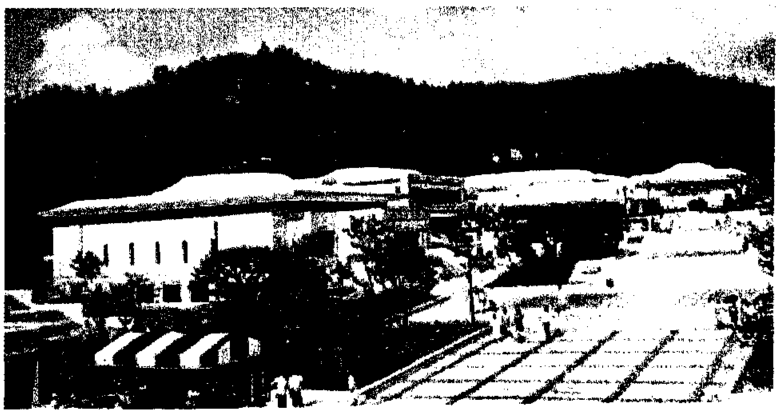
Seongbo Museum at Tongdo Temple



National Folk Museum of Korea



National Museum in Cheongju

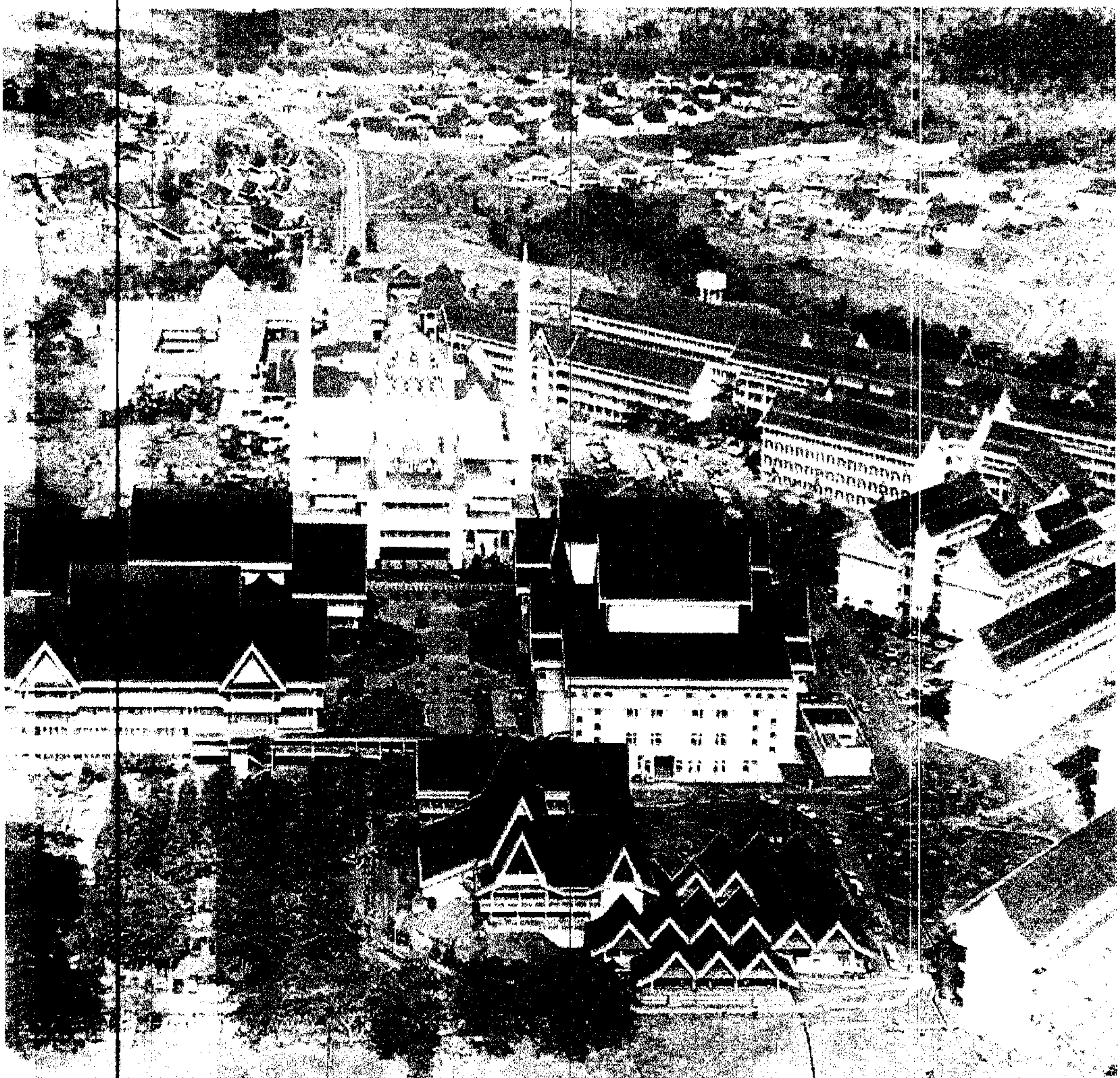


National Museum in Buyeo

*** MAJOR PROJECTS**

- The National Museum in Buyeo
- Refurbishment of the Heungryemun Gate at Gyeongbok Palace
- Refurbishment of the National Museum of Korea
- Restoration of the Heunginmun Gate in Seoul
- Seongbo Museum at Tongdo Temple
- Restoration of Baekje History Village
- Refurbishment of the National Folk Museum of Korea
- The National Museum in Cheongju
- Repairs on the Yanggwan at Unhyeon Palace
- Expansion of the exhibition hall and storage space at the National Museum in Gyeongju
- Relocation and Restoration of the Independence Gate
- The National Museum in Chuncheon
- Repairs on the Yakhyeon Cathedral in Jungrim-dong
- National Institute of Biological Resources in Incheon
- Seoul Namsan Gugakdang(The Classical Theater of Korean Traditional Music)
- Shilla Millennium Park in Gyeongju
- Ewha School
- Cultural Properties Hospital

## Educational & Research Facilities



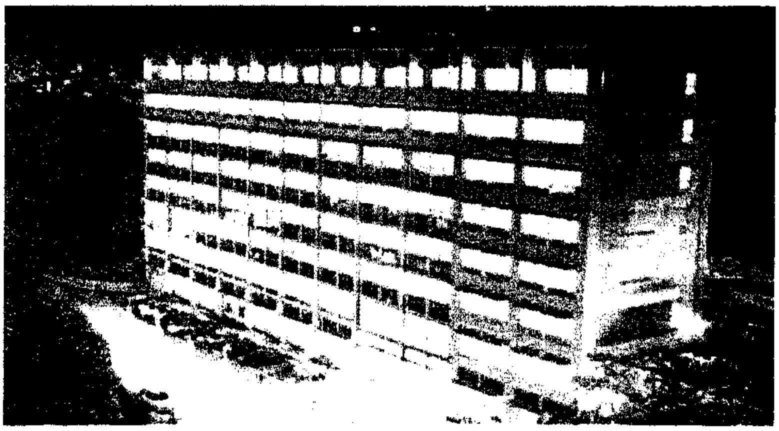
UTM in Malaysia

UTM Dormitory

UTM Administration building

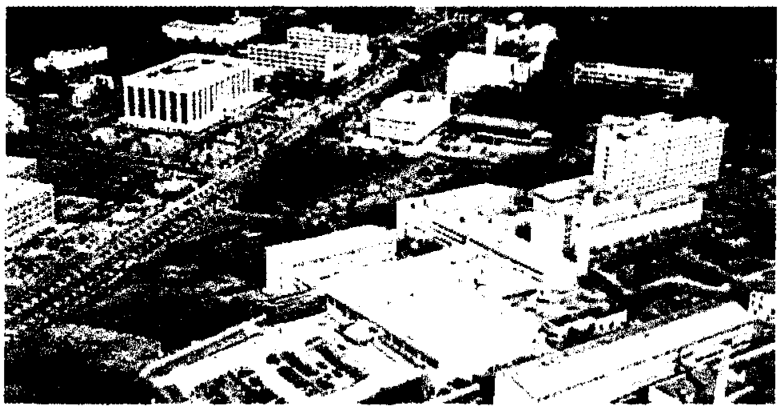
# EDUCATIONAL & RESEARCH FACILITIES

SAMBU's uncompromising dedication to quality is well demonstrated by the educational and research facilities it has built where the nation's future is being shaped. SAMBU has built numerous elementary, junior and senior high schools, as well as university buildings in Korea. Abroad, SAMBU built the UTM (University of Technology Malaysia) and various other high-tech research facilities with special care and exceptional principles.

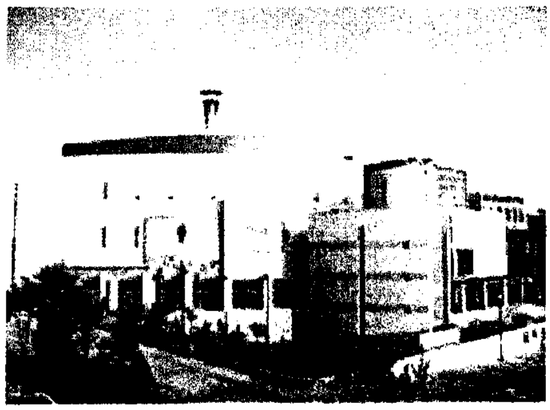


Joint University-Industry Research Building #2 at Korea University

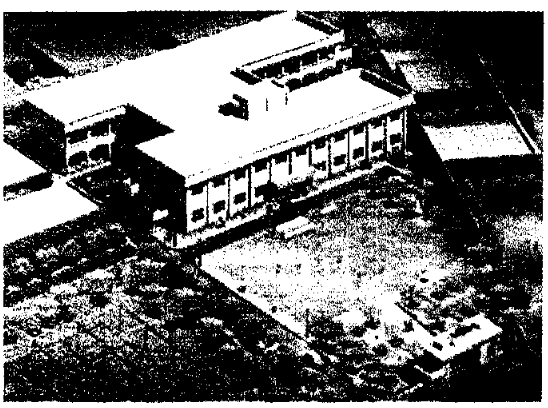
Kyung Moon College



Yonsei University



Kyunghyang Academy

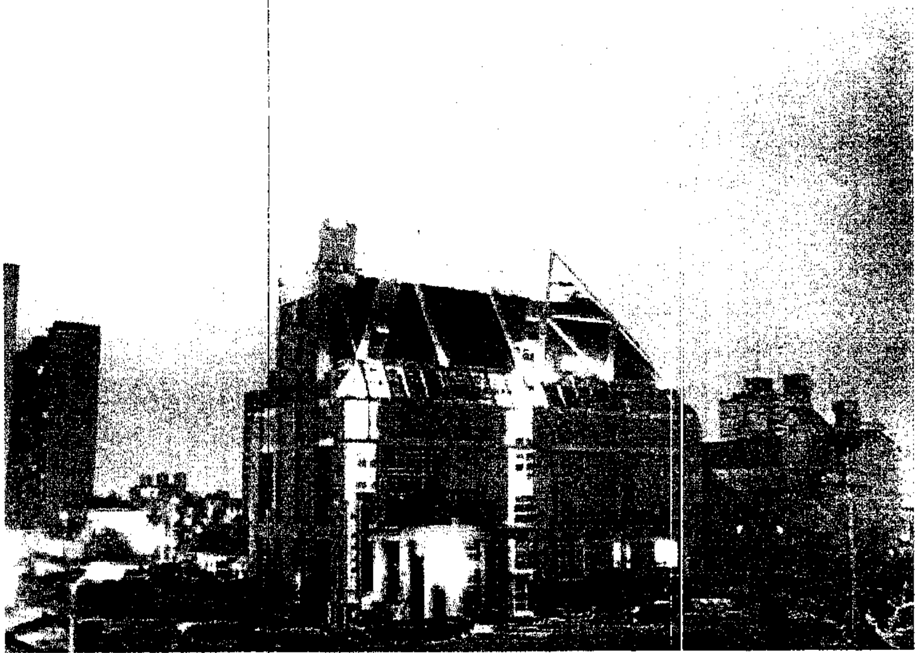


Government College of Commerce and Management Science Mansehra in Pakistan

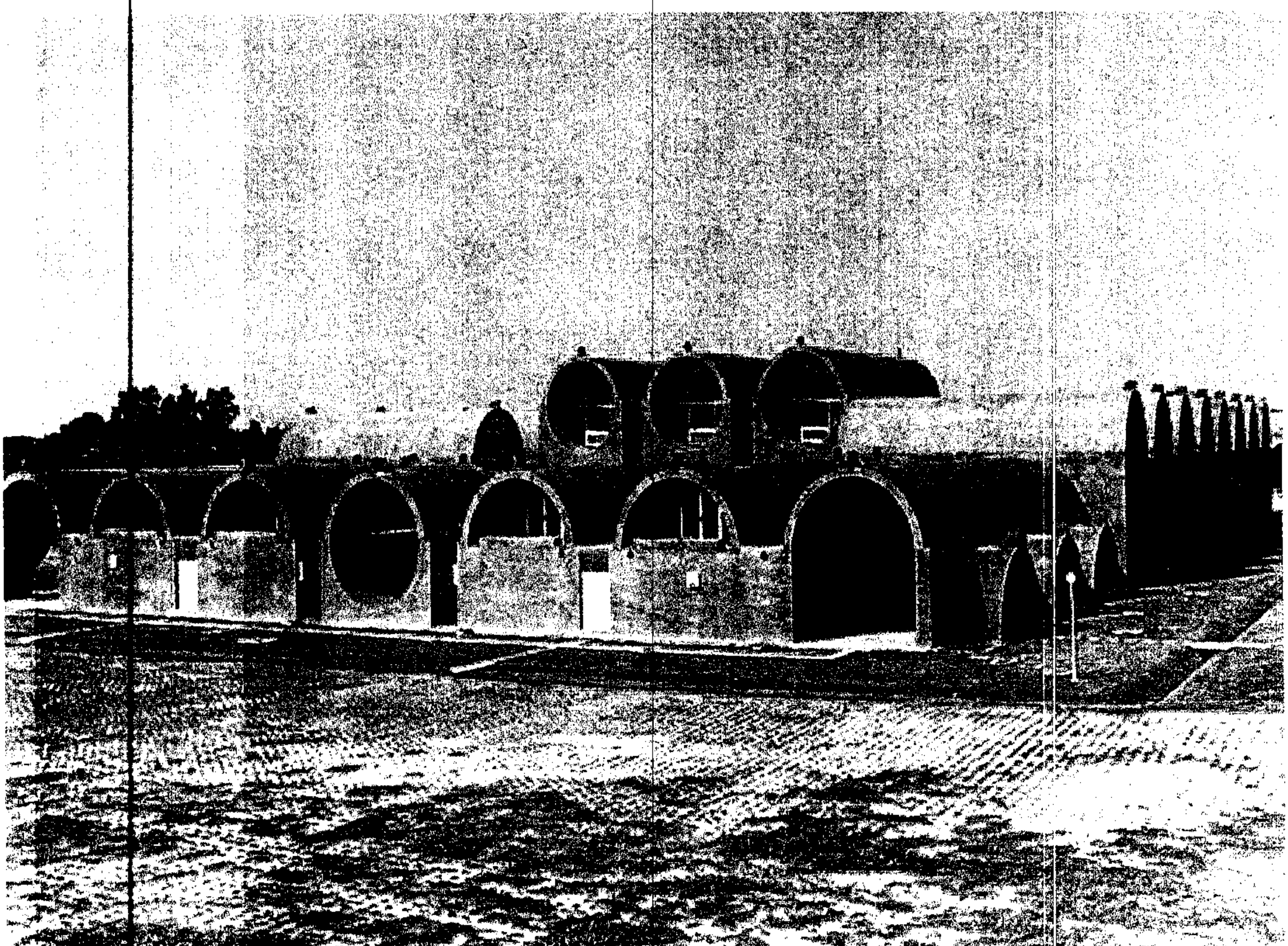
Samyang Group's Comprehensive Institute in Daejeon

* MAJOR PROJECTS

- Konkuk University
- Sungrye Hall at Kyung Moon College
- Joint University-Industry Research Building #2 at Korea University
- Yonsei University
- Expansion of Yuhan-Kimberly's Gimcheon Plant
- Chungbuk National University
- Kyunghyang Hall of the Kyunghyang Academy
- Jeil-Otsuka Pharmaceutical Co., Ltd.'s GMP Plant
- Sunil Industrial Co., Ltd.'s Suwon Plant
- Jeonbuk National University
- Seoul Industrial High School
- Samyang Group's Comprehensive Institute
- Dongjin's Freezing Plant in Guryongpo
- Naval Academy
- Moohak Girls' High School
- Samyang GENEX
- University of Technology in Malaysia
- Air Force Academy
- Kyungbok Girls' Commercial High School
- Expansion of Choongwae Parma Corporation's GMP
- Kookmin University
- Solgye Elementary School building and ancillary facilities
- POSCO's high-tech FA Plant S/W Center
- Government College of Commerce and Management Science Mansehra in Pakistan



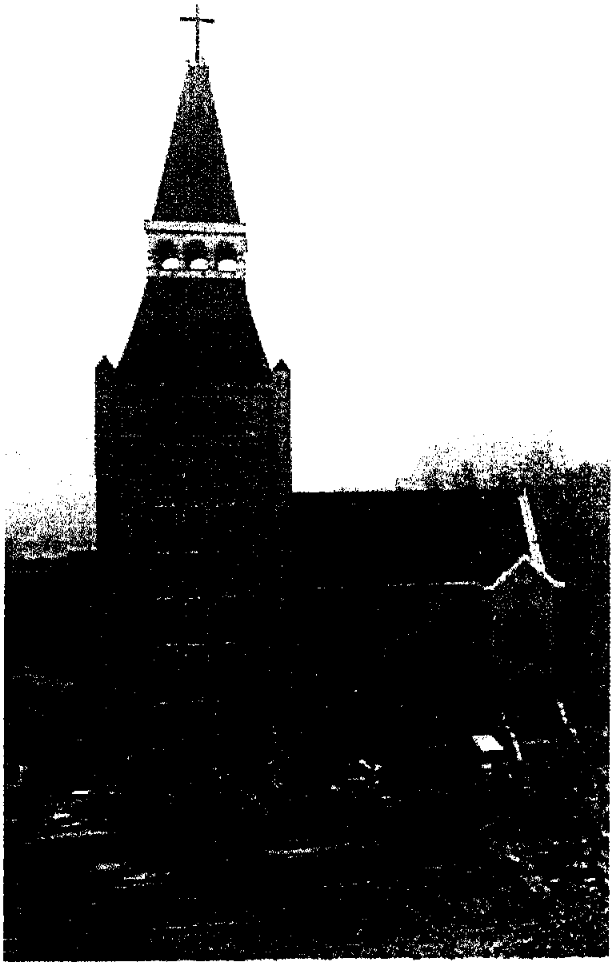
Jeja Church in Mokdong



Buddhism Monumental Buildings in Lumbini, Nepal

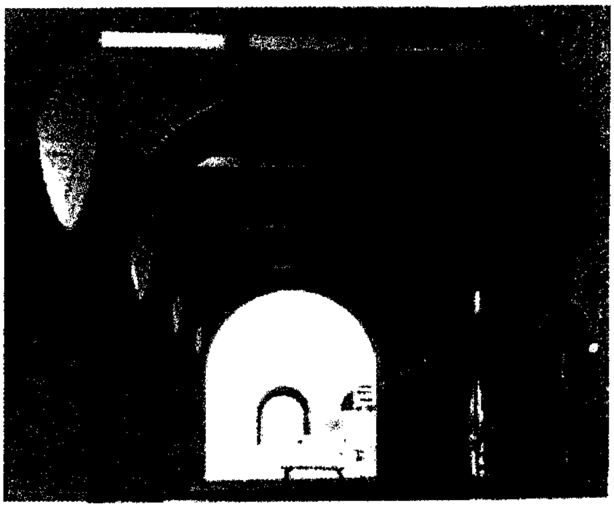
# RELIGIOUS FACILITIES

Many consecrated structures, where man congregates to meet a higher authority, are steeped in SAMBU's tradition of dedication and care. SAMBU has built temples and churches, both at home and abroad, as religious structures of faith and belief, and sublimated them into meeting places brimmed with the life of truth, which are to last a millennium.



Seomun Church in Seoul

The Mosque at the University of Technology in Malaysia



Buddhism Monumental Buildings, Interior View

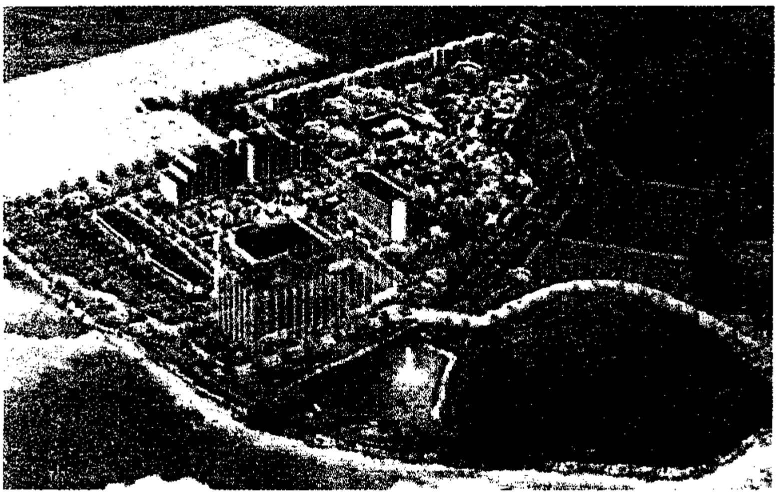
* MAJOR PROJECTS
- Jeja Church in Mokdong
- The Mosque at the University of Technology in Malaysia
- Kyunghyang Church
- Seomun Church in Seoul
- Buddhism Monumental Buildings at Lumbini in Nepal

Jeju Bokwang Phoenix Island Development

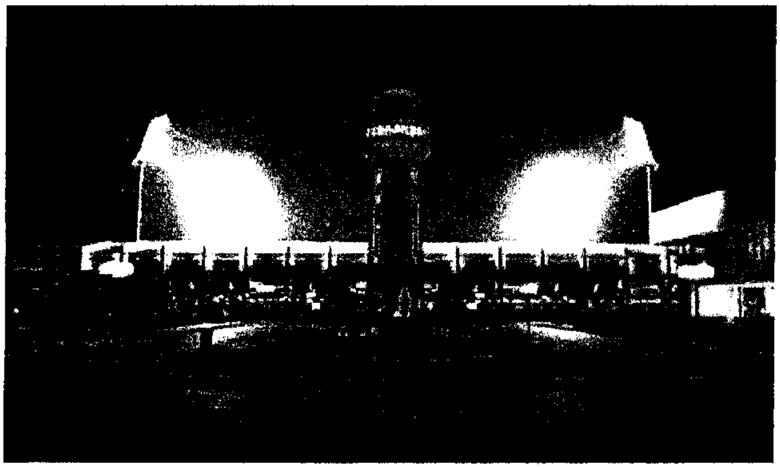
Tani Country Club

# SPORTS · LEISURE FACILITIES

SAMBU has steadily strengthened its technological prowess to develop a variety of services to enhance the quality of contemporary lifestyles by providing state-of-the-art spaces for sports and leisure activities where people can recharge their batteries to reinvigorate themselves. In the belief that outstanding sports facilities are created through a harmony of man, nature, and technology, SAMBU has engaged in construction of baseball parks, gymnasiums, indoor swimming pools and various other sports and leisure facilities. It has also made efforts to establish a wide range of sports and leisure facilities in preparation of the coming era of social welfare, sports and leisure.

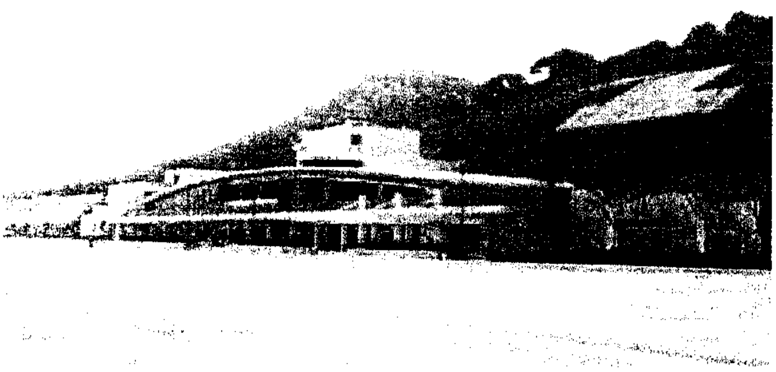


European Complex Theme Resort

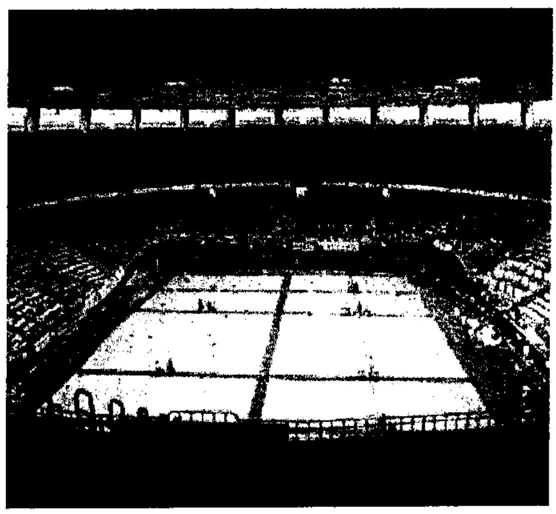


King Fahd Sports City in Saudi Arabia

Club House at Bear Creek Golf Course



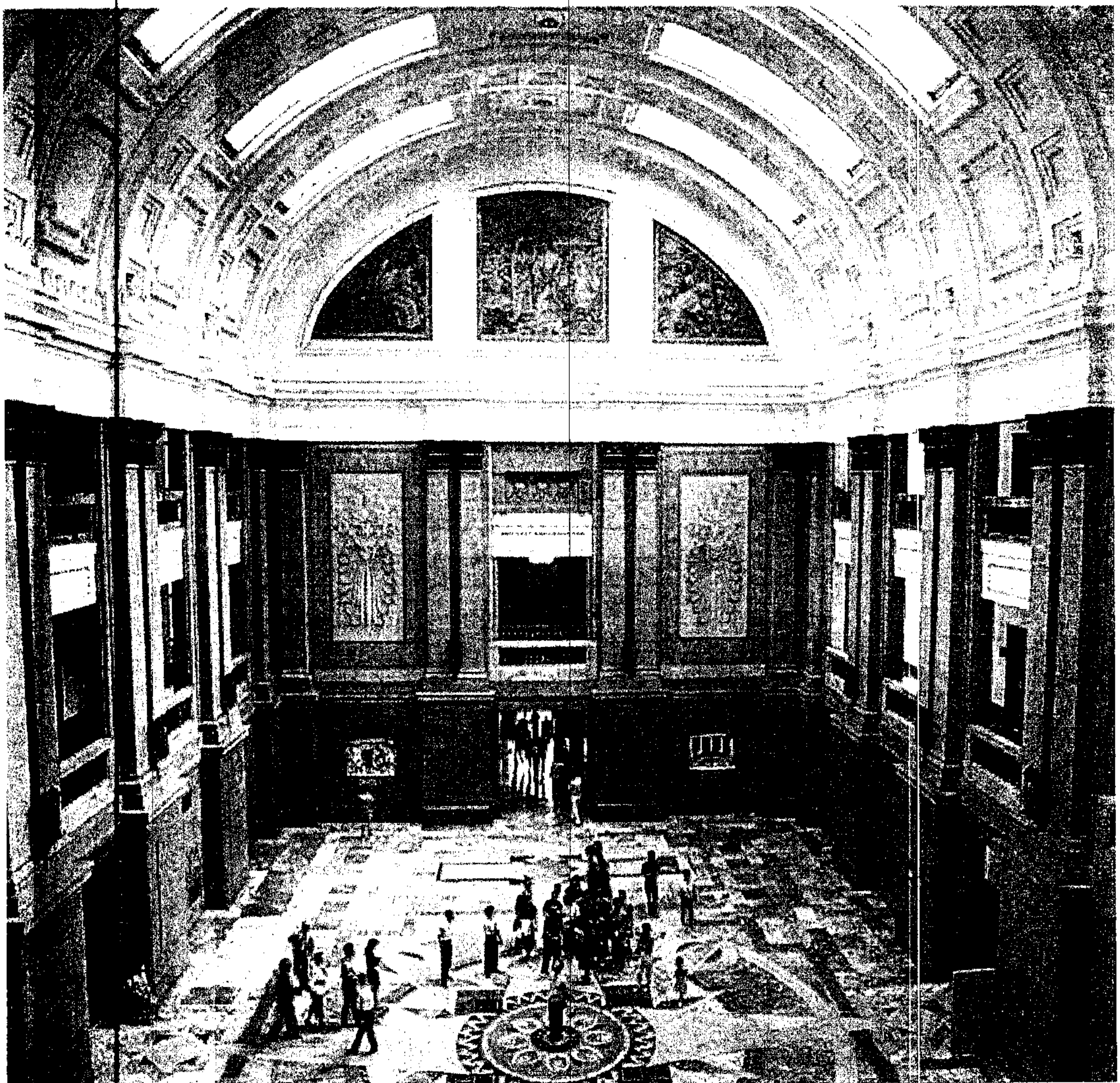
Moongyung Way-stop



Jangchung Gymnasium

*** MAJOR PROJECTS**

- Jangchung Gymnasium
- Incheon Stadium
- Incheon Sea Side Golf Course
- SAMBU Sporex, Daejeon
- Gymnasium for the Handicapped
- King Fahd Sports City in Saudi Arabia
- Hyochang Stadium
- East Gate Baseball Park
- Olympic Athletes Village Gymnasium and Swimming Pool
- Masan Stadium
- Vision Hills Country Club
- Bear Creek Golf Club House
- Moongyung Way-stop
- Jeju Bokwang Phoenix Island Development
- Tani Country Club
- European Complex Theme Resort



Inside the National Museum of Korea

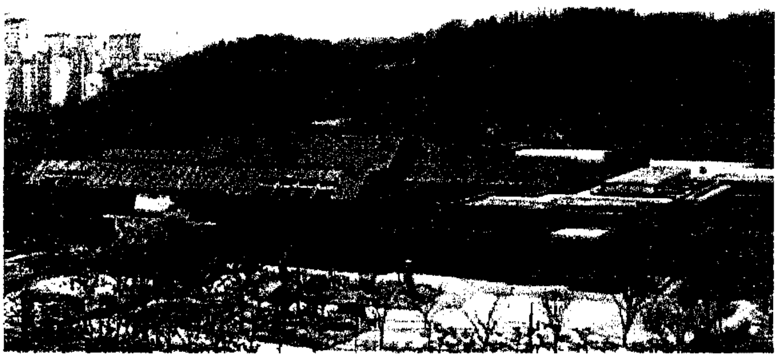
The National Museum of Korea

Frontal View of the National Museum of Korea

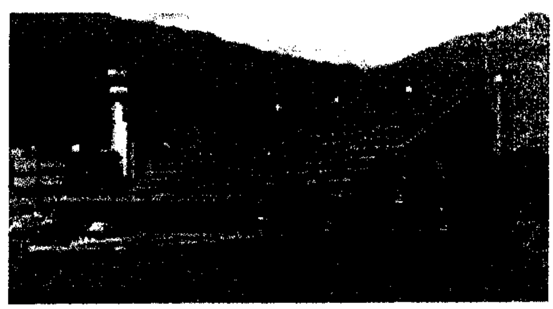
# RENOVATIONS

SAMBU has demonstrated outstanding architectural technologies in renovation works by achieving maximum spatial value and efficiency at minimum cost. SAMBU's renovation technologies and know-how accumulated from a variety of projects, small and large, guarantee customers maximum satisfaction. Not only the exterior of a building, but also its interior involving electrical wiring, facilities, piping, phased repairing, etc. are refurbished to ensure its durability and optimal functionality. SAMBU's renovation works have produced buildings with enhanced value, where a human-oriented spirit is sought after to achieve a pleasant, comfortable space.

Renaissance Seoul Hotel (Royal Suite)

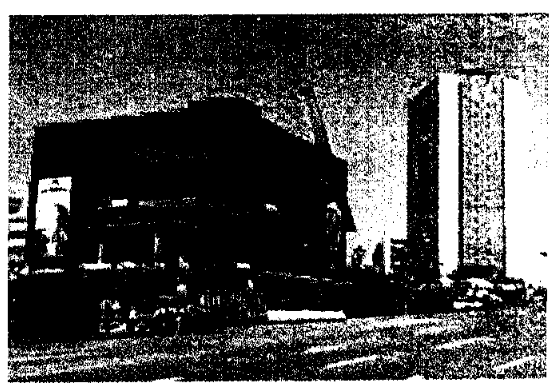


Daegu National Museum Social & Educational Building



Tribhuvan International Airport in Nepal

Seoul Olympic Memorial Hall

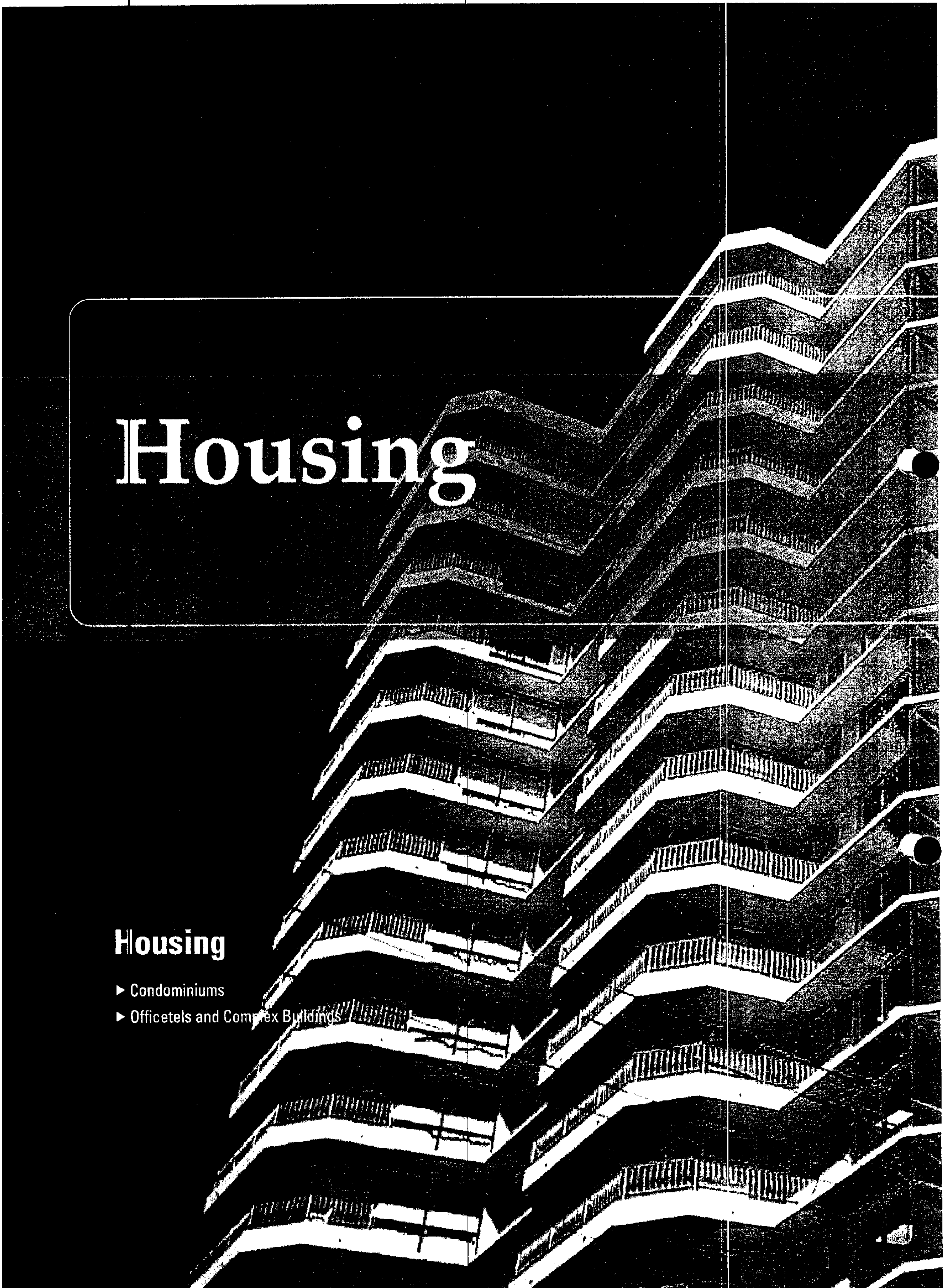


Arario Gallery in Cheonan

* MAJOR PROJECTS

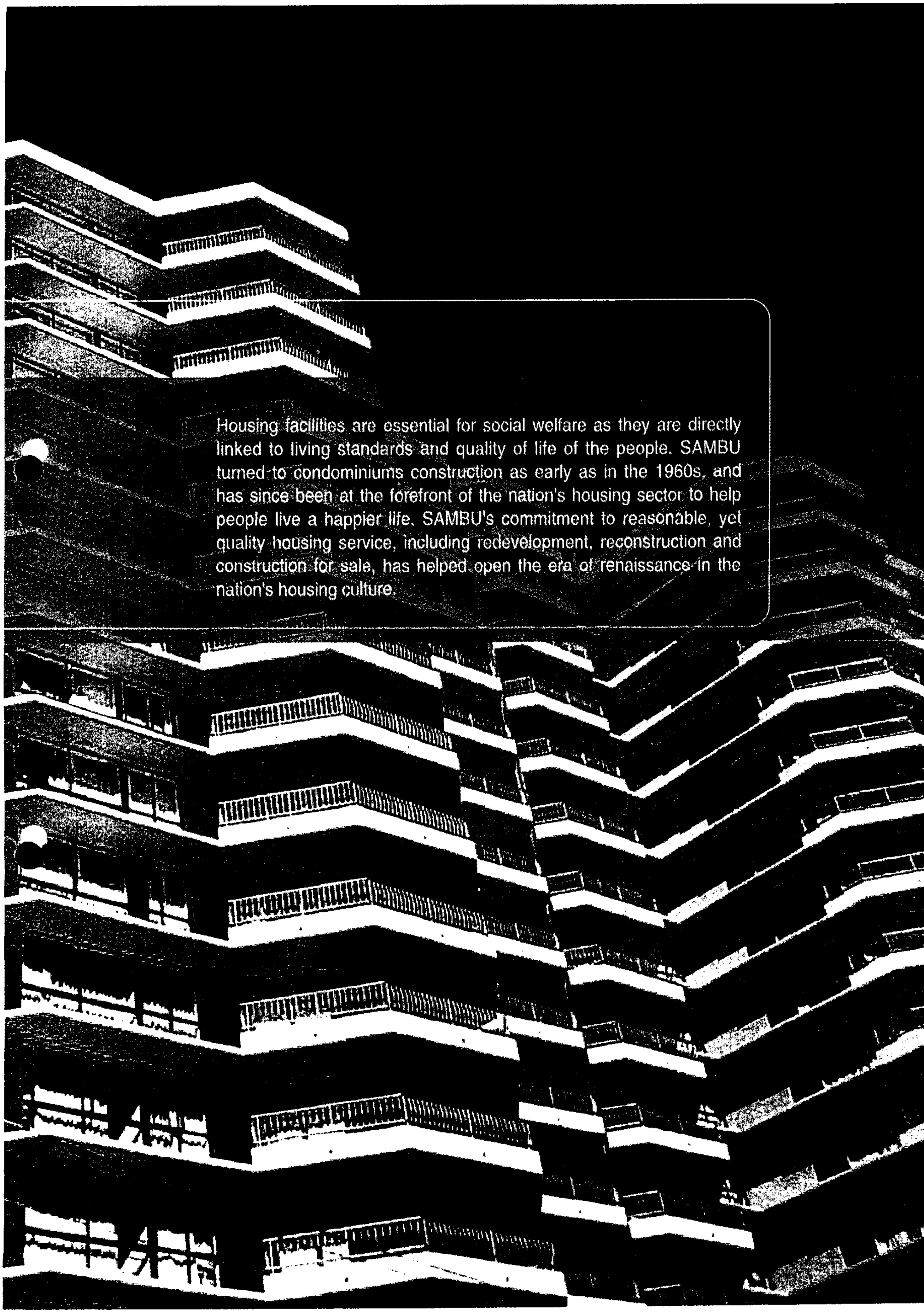
- Refurbishment of the Renaissance Seoul Hotel rooms
- Relocation of the Seoul Olympic Memorial Hall
- Tribhuvan International Airport in Nepal
- Expansion of Arario Gallery in Cheonan
- Improvement of the National Museum of Korea
- Repairing of Sanbon Station building
- Daegu National Museum Social & Educational Building
- Refurbishment of Hotel Concorde rooms

# Housing



## Housing

- Condominiums
- Officetels and Complex Buildings

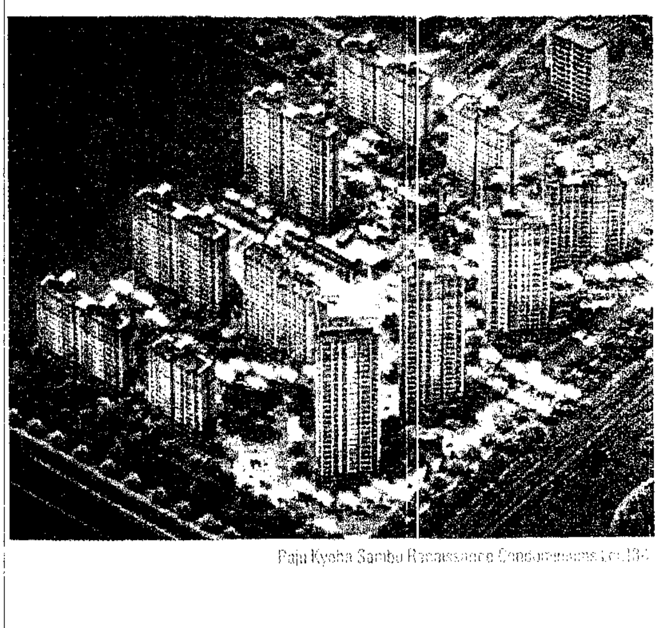


# Housing

Housing facilities are essential for social welfare as they are directly linked to living standards and quality of life of the people. SAMBU turned to condominiums construction as early as in the 1960s, and has since been at the forefront of the nation's housing sector to help people live a happier life. SAMBU's commitment to reasonable, yet quality housing service, including redevelopment, reconstruction and construction for sale, has helped open the era of renaissance in the nation's housing culture.

Hwasung Dongtan Sambu Renaissance Condominiums

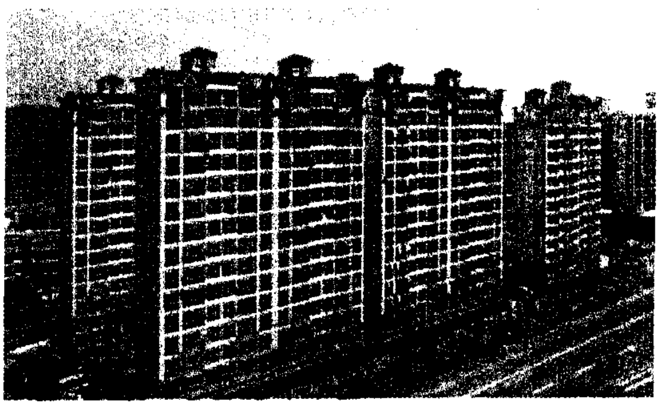
Hanam Pungsan Area, Sambu Renaissance Condominiums



Paju Kyoha Sambu Renaissance Condominiums Lot 13[illegible]

# CONDOMINIUMS

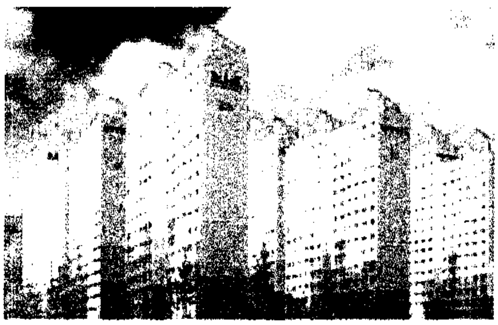
Since it delved into the condominiums construction business in Yeoido in the 1960s, SAMBU has built a reputation as the strongest condominiums contractor through steady efforts toward improvement in housing. SAMBU is now determined to take the lead in the nation's housing industry by supplying the so-called "cyber condominiums" equipped with high-tech communications facilities, quality finishing materials, nature-friendly landscape architecture and outstanding designs, befitting the information and high-tech era. SAMBU has accepted the challenge of providing the people a comfortable living environment that serves as a haven in this hectic, modern life. The pioneering and creative spirit that began with the construction of the SAMBU Condominiums buildings in Yeoido, Seoul, has been revived with the SAMBU Renaissance Condominiums. The creation of more fulfilling residential spaces through redevelopment and reconstruction has also contributed to a balanced urban development.



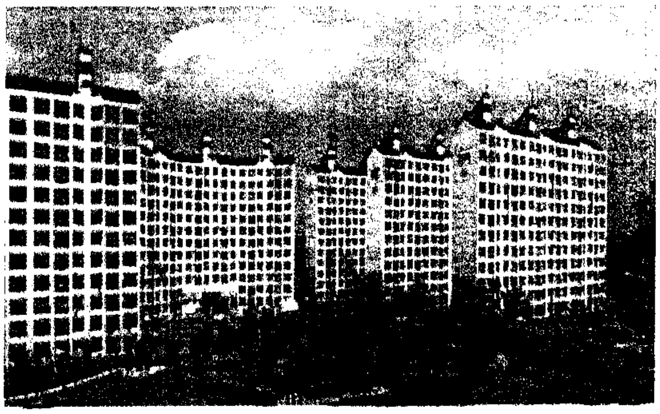
Asan Gwongok Sambu Renaissance Condominiums

Turf View Apartment in Malaysia

Dongback Koaru Condominiums



Daejeon Noeun District 2, Sambu Renaissance I Condominiums

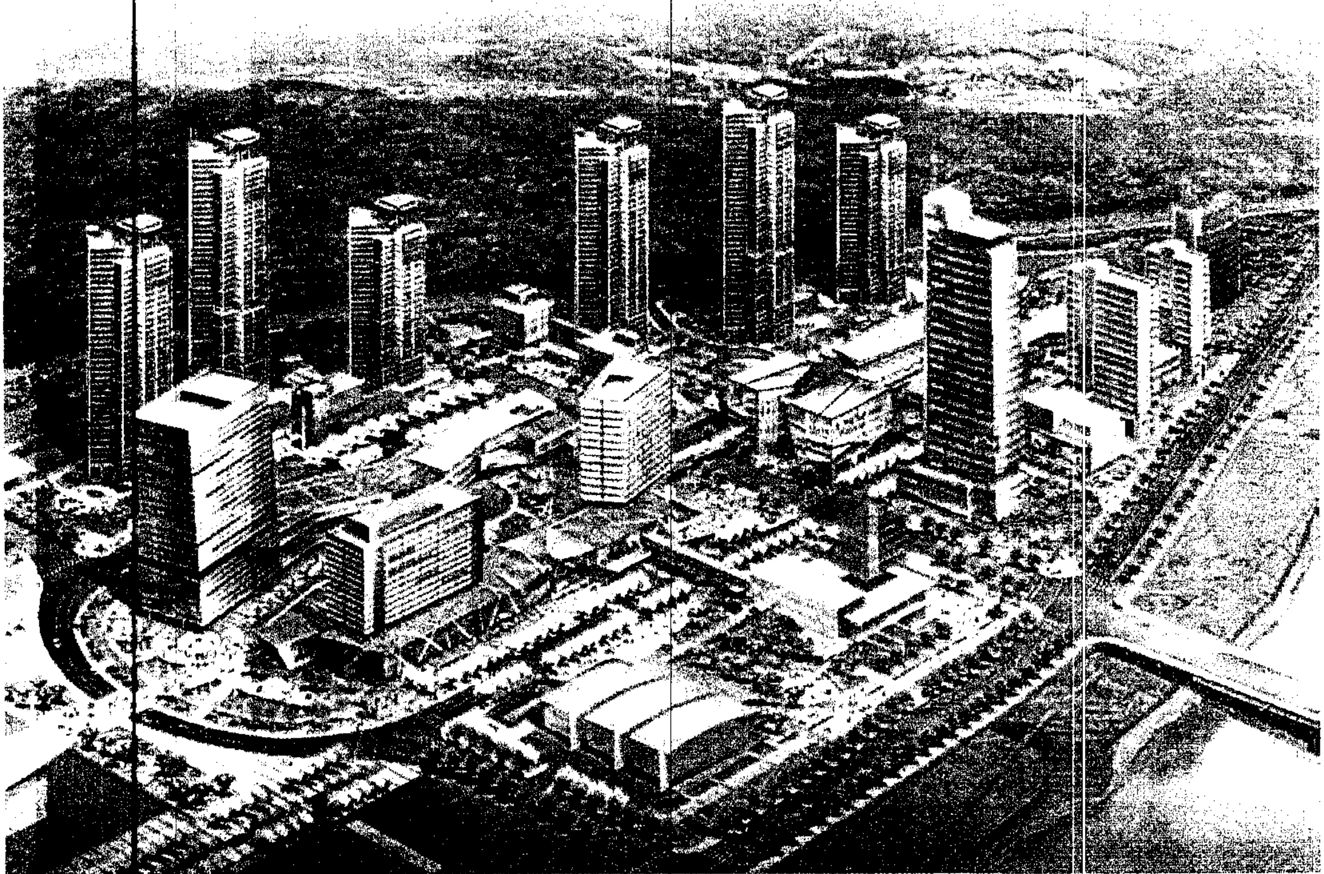


Pyeongtaek Poseung Sambu Renaissance Condominiums

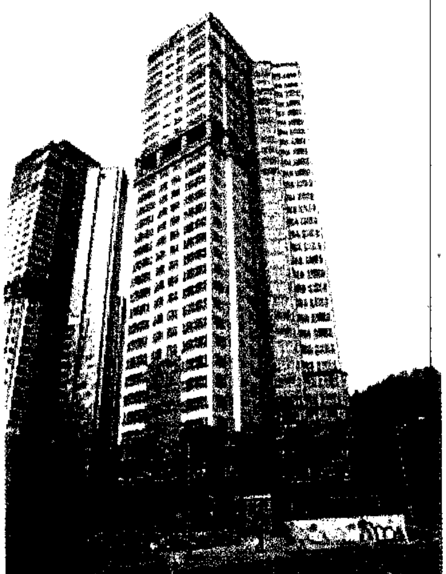
Sambu Bundang Condominiums

## MAJOR PROJECTS

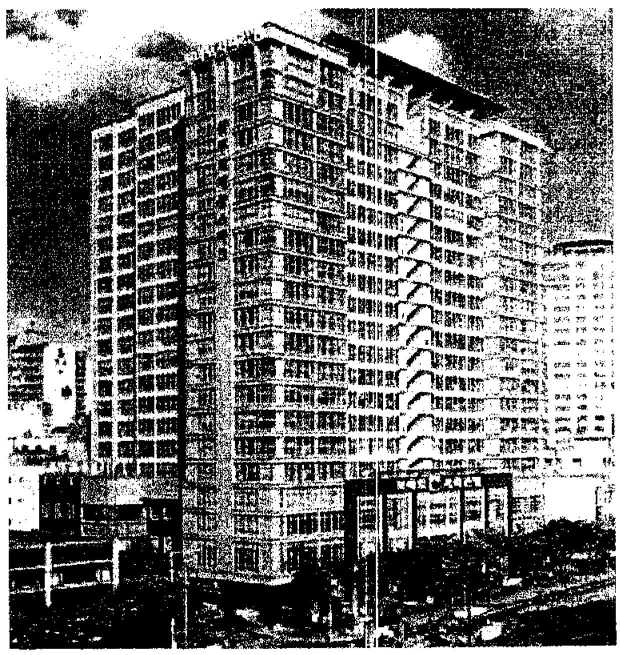
- Yeouido Sambu Condominiums
- Seongnam Sujin Sambu Condominiums
- Gaepo Jugong Condominiums
- Haengdang Sambu Condominiums
- Daejeon Noeun District, Sambu Renaissance Condominiums
- Daejeon Dunsan Nuri Sambu Condominiums
- Mansoo Jugong Condominiums Lot No. 2
- Daejeon Sintanjin Sambu Condominiums
- Jinhae Housing Complex
- Uijeongbu Shingok Sambu Condominiums
- Sanbon jugong Condominiums Lot. 4
- Samsungdong Housing Complex
- Bundang Sambu Condominiums Lot. 3-12-4
- Incheon Bugae Sambu Condominiums
- Mokdong Sambu Condominiums Lot 18
- Sunglawon Old Man Welfare Facilities
- Daejeon Gwanjeo Sambu Condominiums
- Daegu Hayang Condominiums
- Housing Oevelopment at Lot 6001 Jalan Tebrau, Johor, Malaysia
- Ilsan Sambu Condominiums Lot. 11-1
- Daejeon Taepyeong Sambu Condominiums
- Donam Sambu Condominiums
- Turf View Apartment in Malaysia
- Hwasung Dongtan Sambu Renaissance Condominiums
- Hanam Poongsan Area, Sambu Renaissance Condominiums
- Asan Gwongok Sambu Renaissance Condominiums
- Pyeongtaek Poseung Sambu Renaissance Condominiums
- Dongback Koaru Condominiums
- Paju Kyoha Sambu Renaissance Condominiums Lot.12,18-2



Daejeon Residential and Commercial Buildings in EXPO Convention Complex Cente[illegible]



High-rise residential building Smart-City in Daejeon

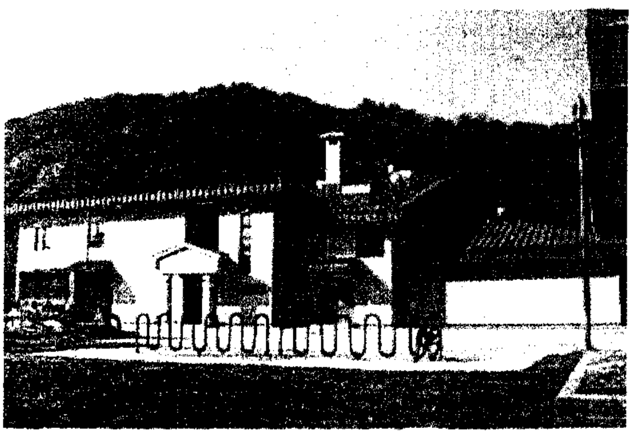


Sinhaung Residential and Commercial Complex Sanbo Renaissance Park [illegible]

# OFFICETELS · COMPLEX BUILDINGS

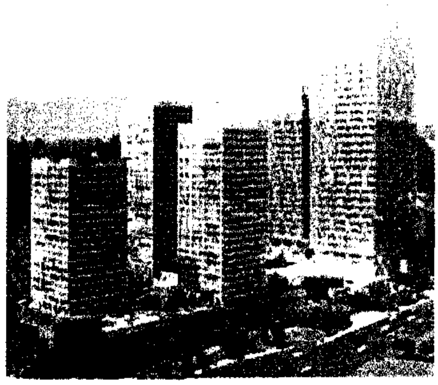
An environment for efficient work and pleasant living conditions is a necessity for the contemporary lifestyle. SAMBU Renaissance has offered top quality complex buildings and profitable officetels in optimum locations. SAMBU Renaissance's architectural works are places where one can live and work, enjoying the full breath of life. They offer a complex environment, where easy access, fantastic views, high-tech networking, and various health & leisure facilities, restaurants and shops are all available.

Ogeum Sambu Renaissance Ville



Battalion Headquaters, Camp Hovey in Dongducheon

Deungchon Sambu Renaissance Hangang Officetel



CBD-Redevelopment Multi-use Elite Residential & Office in Almaty, Kazakhstan

Garibong Sambu Renaissance Officetel

## MAJOR PROJECTS

- Mapo Sambu Golden Tower
- Bundang Geumgok City of Angels 1 and 2
- Ogeum Sambu Renaissance Ville
- Doksan Sambu Renaissance Officetel
- Yatop Sambu Renaissance Dfficetel
- Inkye Sambu Renaissance Officetel
- Yangpyeong Sambu Renaissance Hangang Officetel
- Deungchon Sambu Renaissance Hangang Officetel
- Battalion Headquaters, Camp Hovey in Dongducheon
- Sinbudong Sambu Renaissance Home Officetel
- Garibong Sambu Renaissance Officetel
- Daejeon Residential and Commercial Buildings in EXPO Convention Complex Center
- CBD-Redevelopment Multi-use Elite Residential & Office in Almaty, Kazakhstan

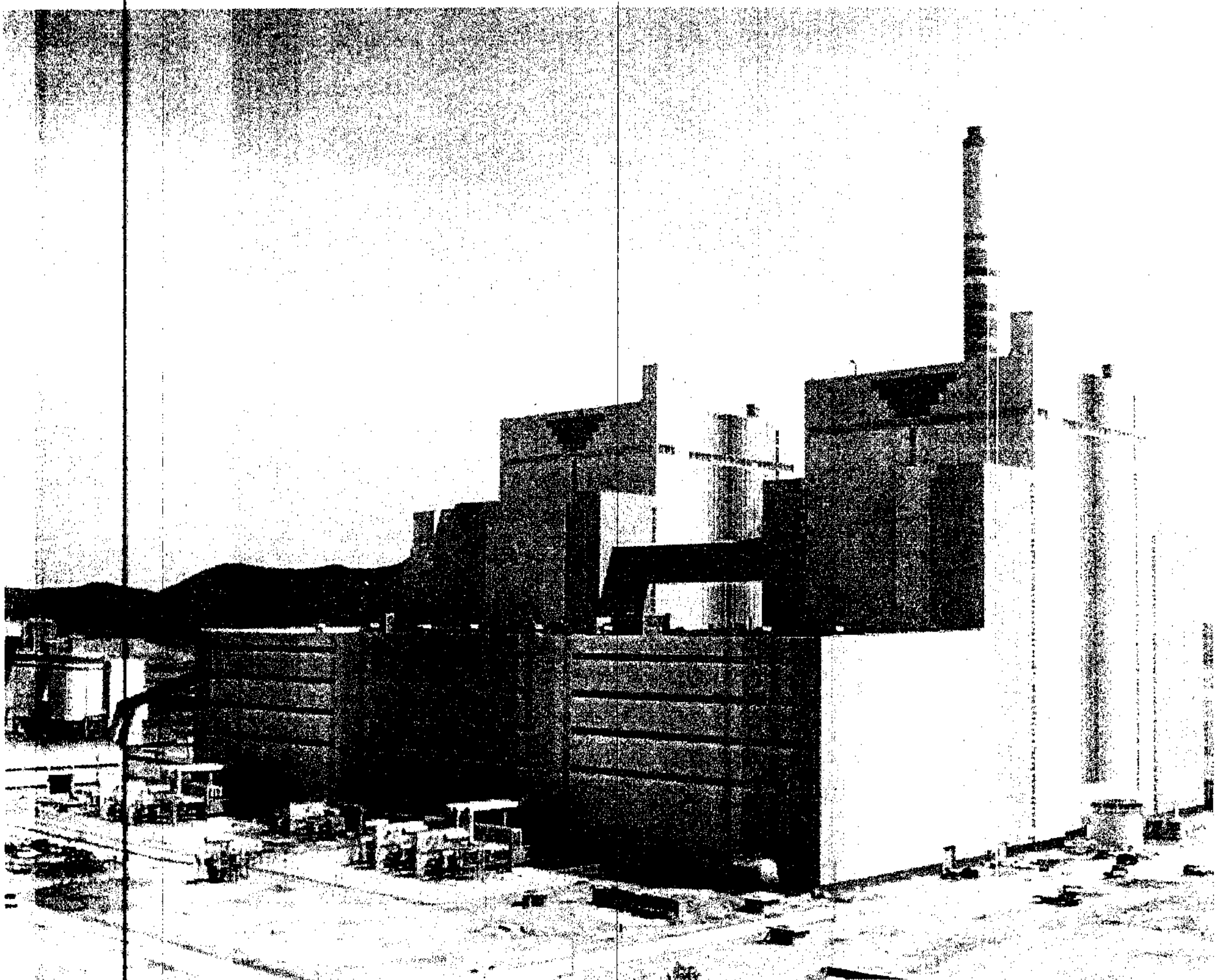
# Plant Works

## Plant Works

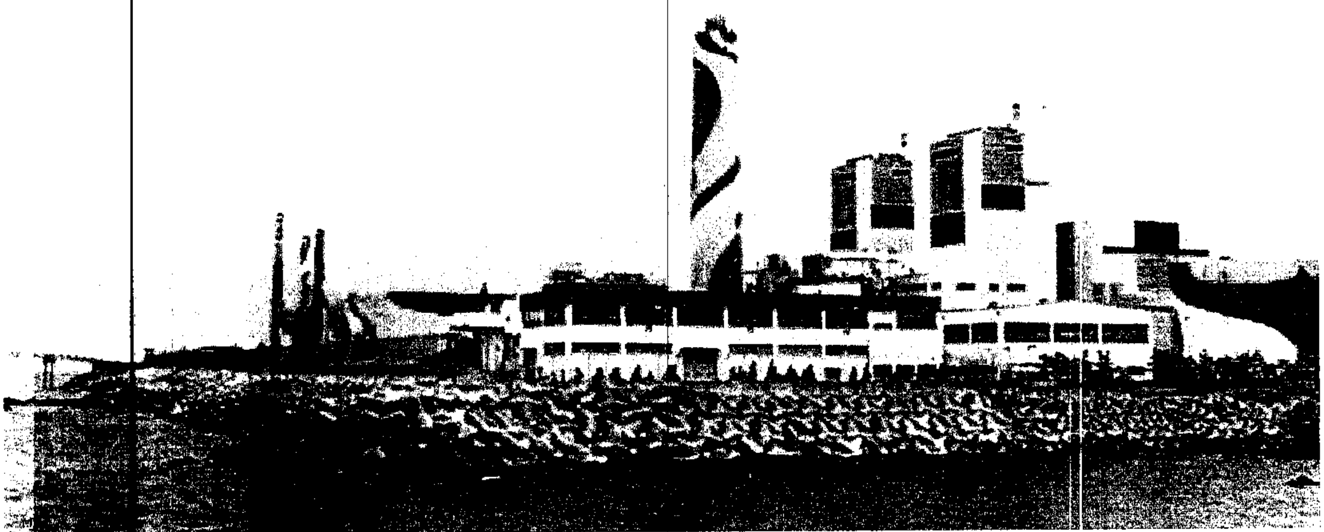
- Thermal Power Plants
- Industrial Plants
- Environmental Plants
- Power Transmission Lines

# Plant Works

SAMBU's excellent capabilities have been demonstrated at high technology-intensive plant works. Having successfully completed numerous plant works involving iron & steel, oil refinery, cement, chemicals, textiles and pharmaceutical products, SAMBU has been recognized both at home and abroad as a general contractor of uncompromising quality.



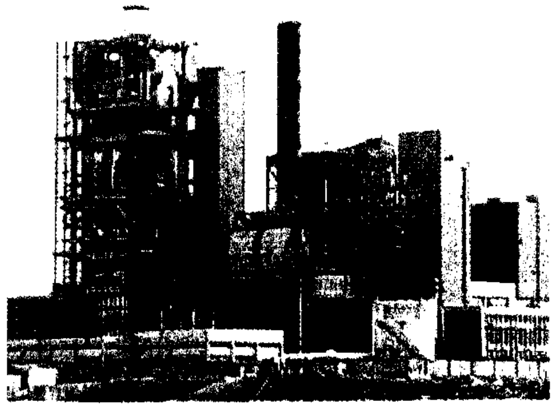
Youngheung Thermal Power Plant #3 & #4



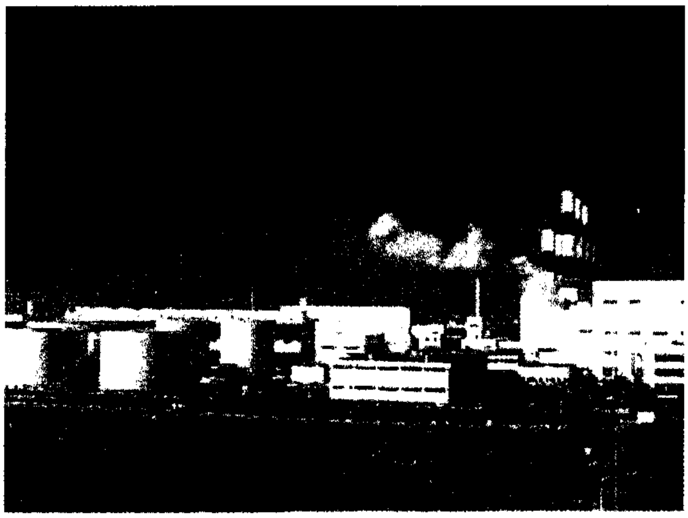
North Jeju Thermal Power Plant

# POWER PLANTS

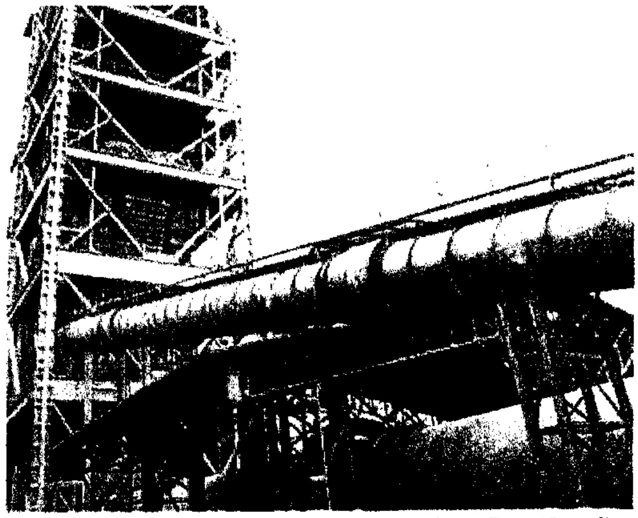
SAMBU boasts of a long tradition of building hydro, thermal and combined heat & power plants, as evidenced by the Yeongnam Thermal Power Plant, Bucheon Combined Heat and Power Plant, Sancheong Pumping-up Power Plant, North Jeju Thermal Power Plant, etc. SMBU builds power plants with a solemn sense of mission, responsibility and artisanship. Drawing on its past experiences and expertise, SAMBU is actively involved in power plant construction and is fully qualified to participate in atomic power plant construction.



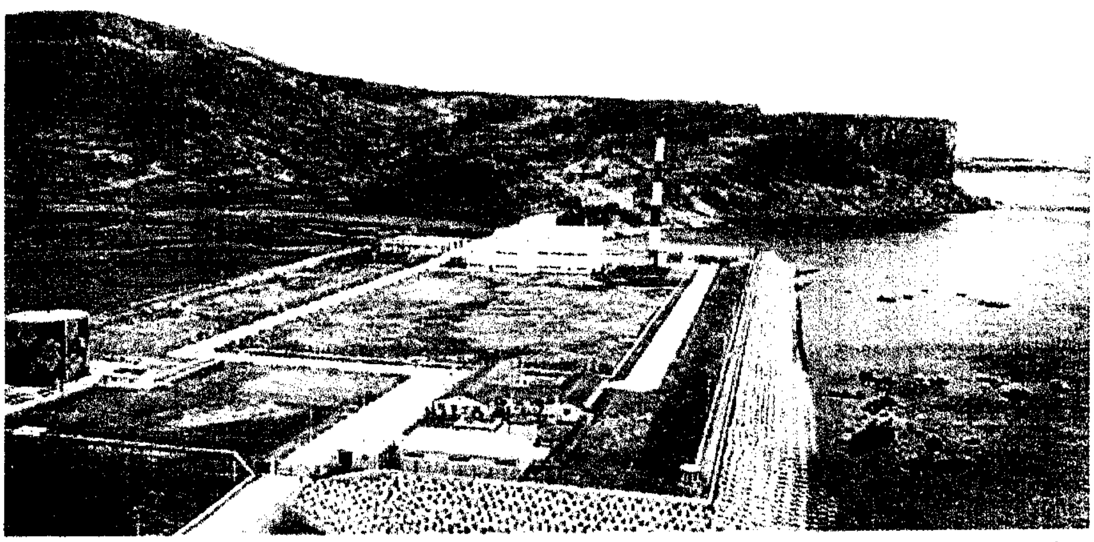
Yeongnam Thermal Power Plant



Bucheon Combined Heat and Power Plant



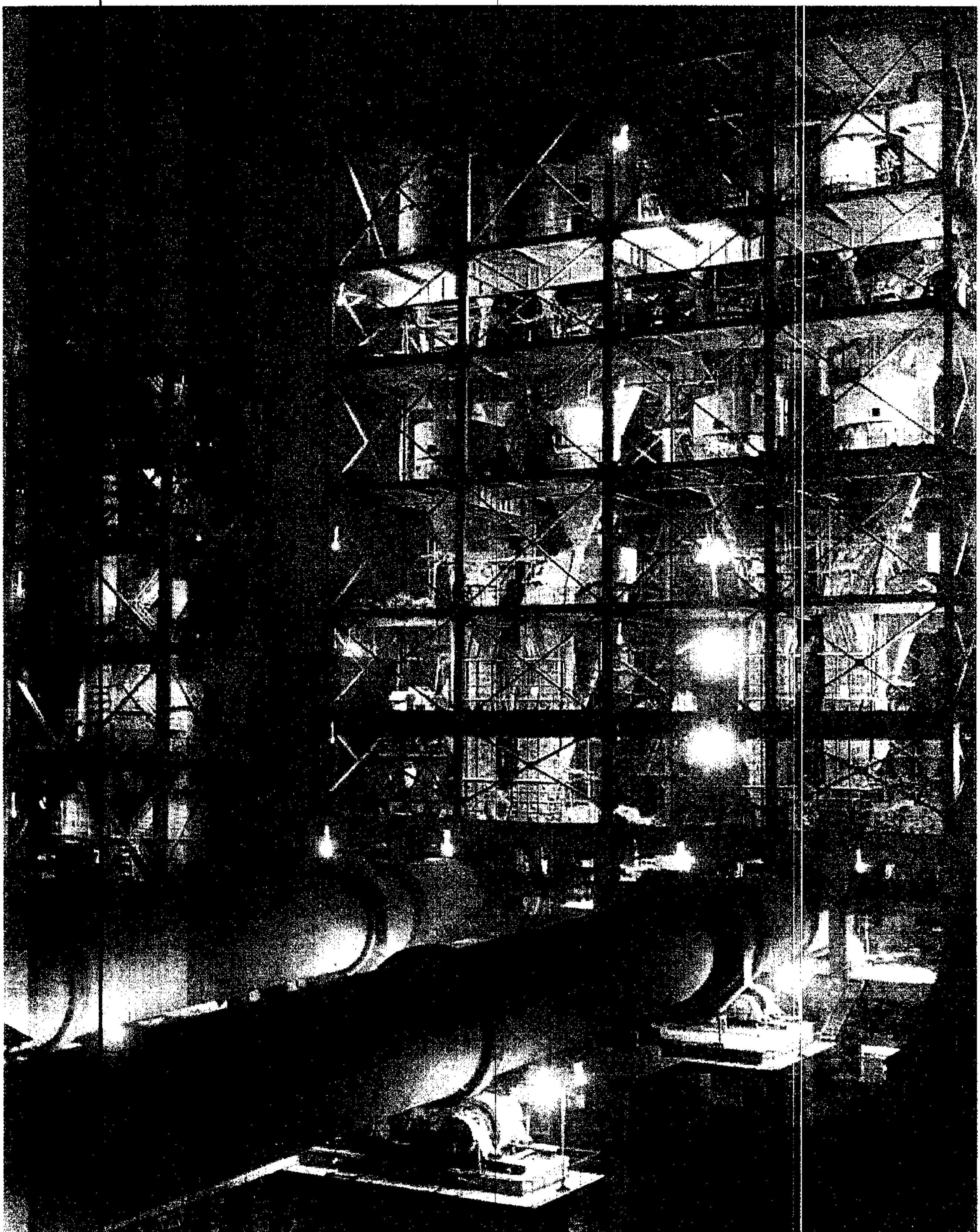
Gunsan Thermal Power Plant



South Jeju Thermal Power Plant

✻ MAJOR PROJECTS

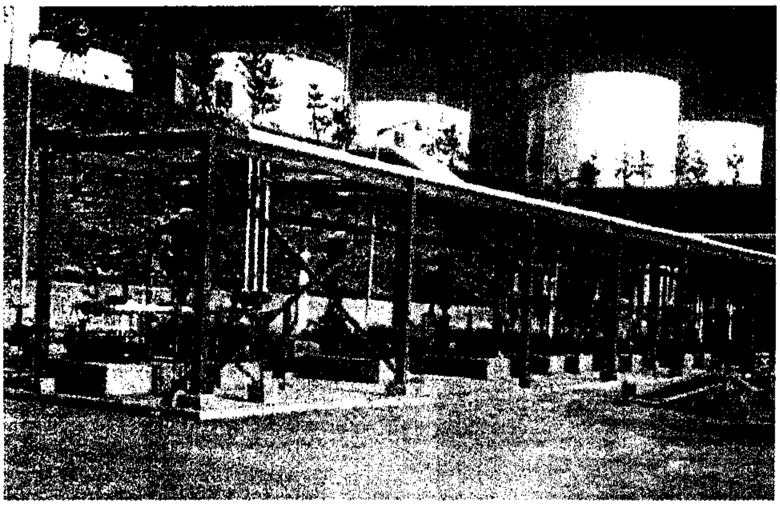
- South Jeju Thermal Power Plant
- Gunsan Thermal Power Plant
- Yeongnam Thermal Power Plant
- Youngheung Thermal Power Plant #3 & #4
- Bucheon Combined Heat and Power Plant
- North Jeju Thermal Power Plants 2 and 3
- Dangjin Small Hydro Power Plant
- Pyeongtaek Integrated Energy System



Ssangyong Cement Plant

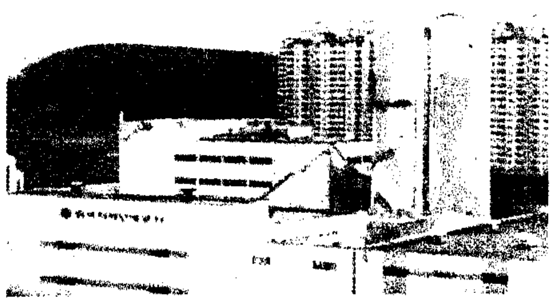
# INDUSTRIAL PLANTS

SAMBU has long been involved in quality construction of the nation's major industrial facilities, including cement plants, iron & steel works, oil storage facilities, oil pipes, etc. It is also involved in heat-generating facilities, another important source of energy. Drawing on accumulated technologies, experiences and know-how, SAMBU is firmly resolved to take the lead in construction of industrial facilities both at home and abroad with faith, sincerity and incessant efforts.



Oil Pipes between Seosan and Cheonan

Yeongnam Chemicals



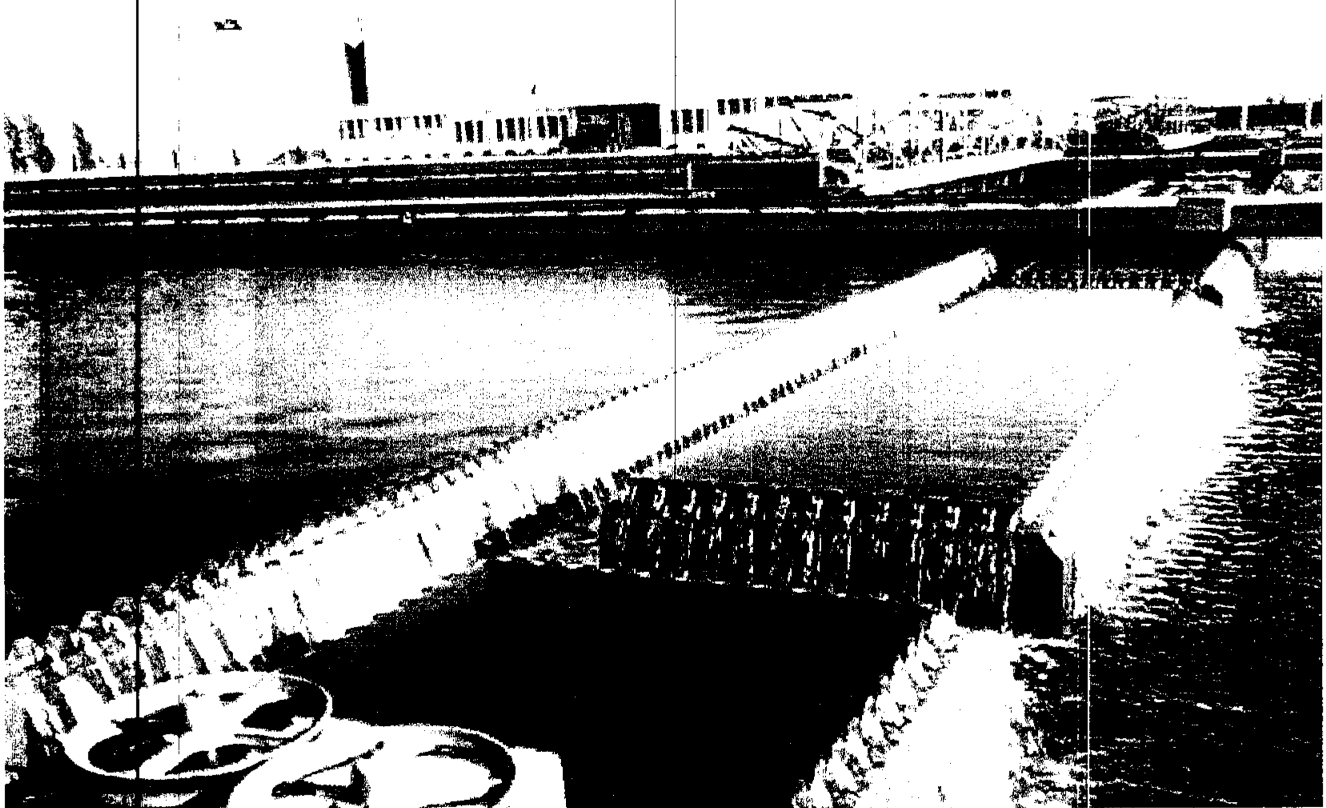
Yongin Heat-Generating Facilities in Bundang

Ssangyong Cement Plant

* MAJOR PROJECTS

- Oil Pipes between Seosan and Cheonan
- Yeongnam Chemicals
- L-1 Extra Storage Facilities
- Yongin Heat-Generating Facilities in Bundang
- Ssangyong Cement Plant

# Environmental Plants

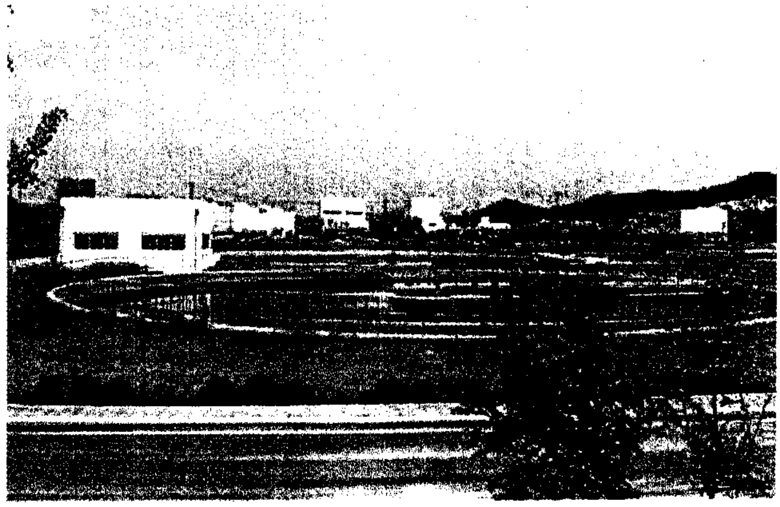


Water Treatment Plant in Bupyeong

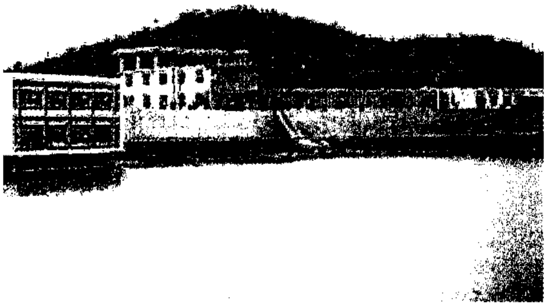
Alkhobar Sewage Treatment Plant in Saudi Arabia

# ENVIRONMENTAL PLANTS

SAMBU has a long tradition of constructing water pipes and water & sewage treatment facilities nationwide, including the Incheon water supply system, Wolpyeong water treatment plant, and many others. SAMBU's impeccable works with outstanding expertise and experiences has enhanced the reputation of Korean contractors' technological prowess in providing water supply systems in the international market. It has accrued a brilliant record of building water supply/treatment systems, such as the Daejeon sewage treatment plant, Jeju sewage treatment facilities, and Nonsan sewage treatment facilities, thus contributing greatly to supplying clean water and environment to the people. SAMBU's capabilities and technological prowess are highly acclaimed both at home and abroad.

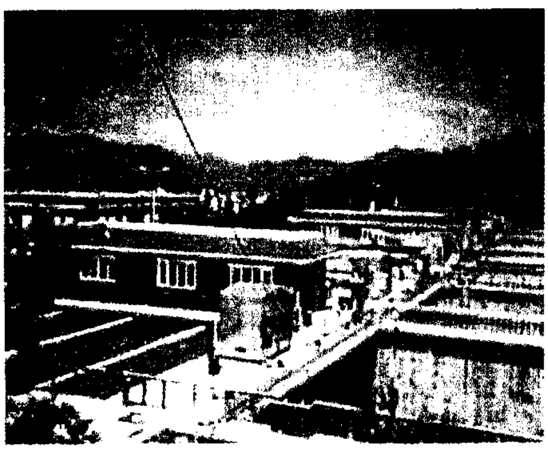


Daejeon Sewage Treatment Plant

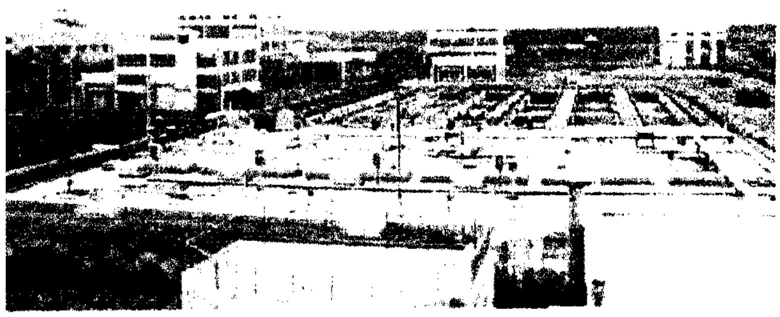


Incheon Water Supply System

Jeju Sewage Treatment Plant



Wolpyeong Water Purification Plant

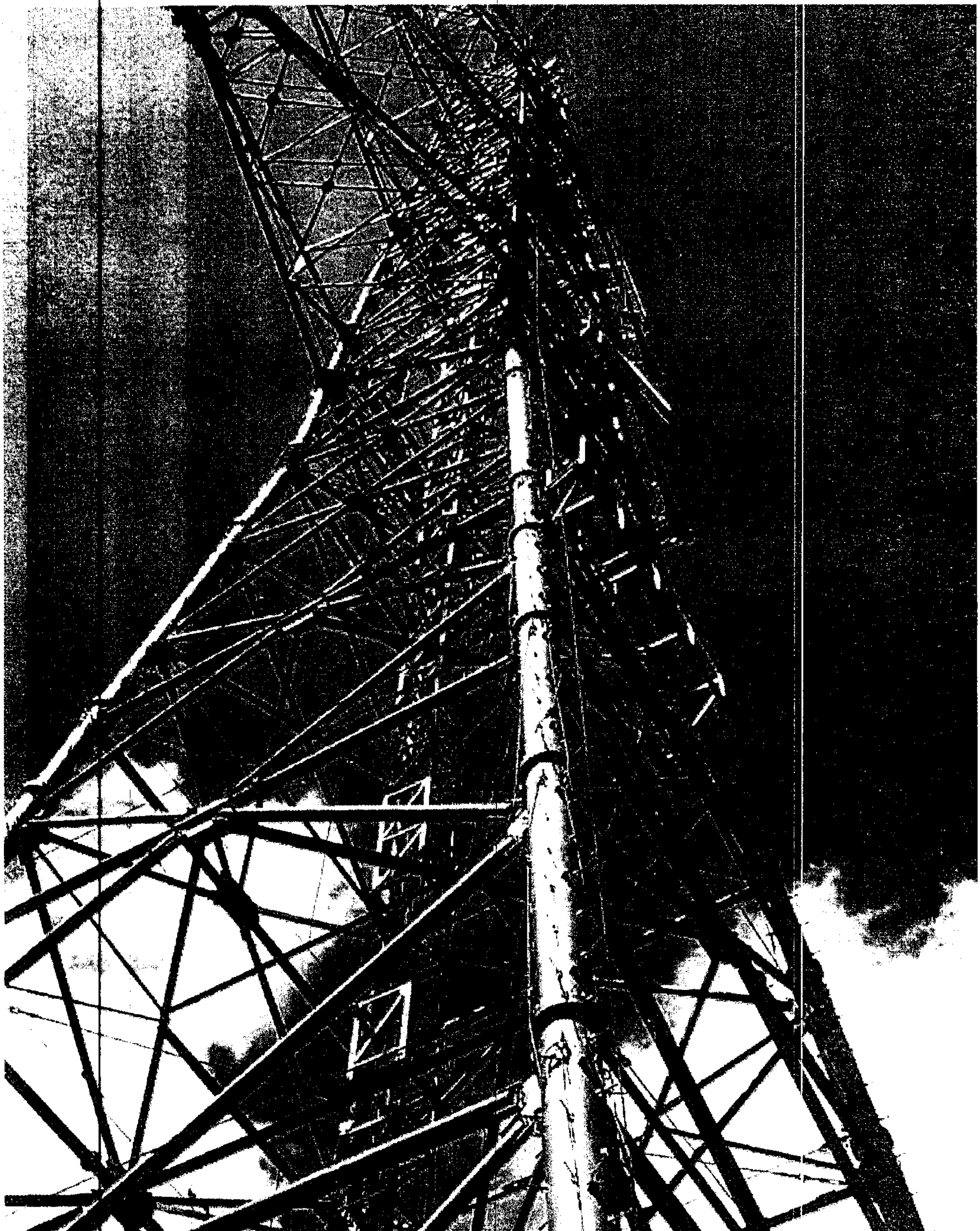


Nonsan Sewage Treatment Plant

* MAJOR PROJECTS

- Jeonju Water Supply System
- Bupyeong Water Purification Plant
- Jeonju Sewage Treatment Plant
- Alkhobar Sewage Treatment Plant in Saudi Arabia
- Incheon Water Supply System
- Wolpyeong Water Purification Plant
- Jeju Sewage Treatment Plant
- Icheon Water Supply system
- Riyadh Water Treatment & Distribution System (Buwayb & New Area Part 2)
- Expansion of the Geumho River Water Supply System
- Changnyeong Sewage Treatment Plant
- Al-Jubail Sanitary Sewer & Stormwater Drainage Systems
- Mokpo Water Supply System
- Expansion of the Jeju Water Supply System
- Jeomchon Sewage Treatment Plant
- Al-Kharj Sewage Treatment System
- Buyeo Water Supply System
- Daejeon Sewage Treatment Plant
- Nonsan Sewage Treatment Plant
- Seocheon Sewage pipe maintenance
- Geochang Sewage pipe maintenance
- Banwol Water Purification Plant

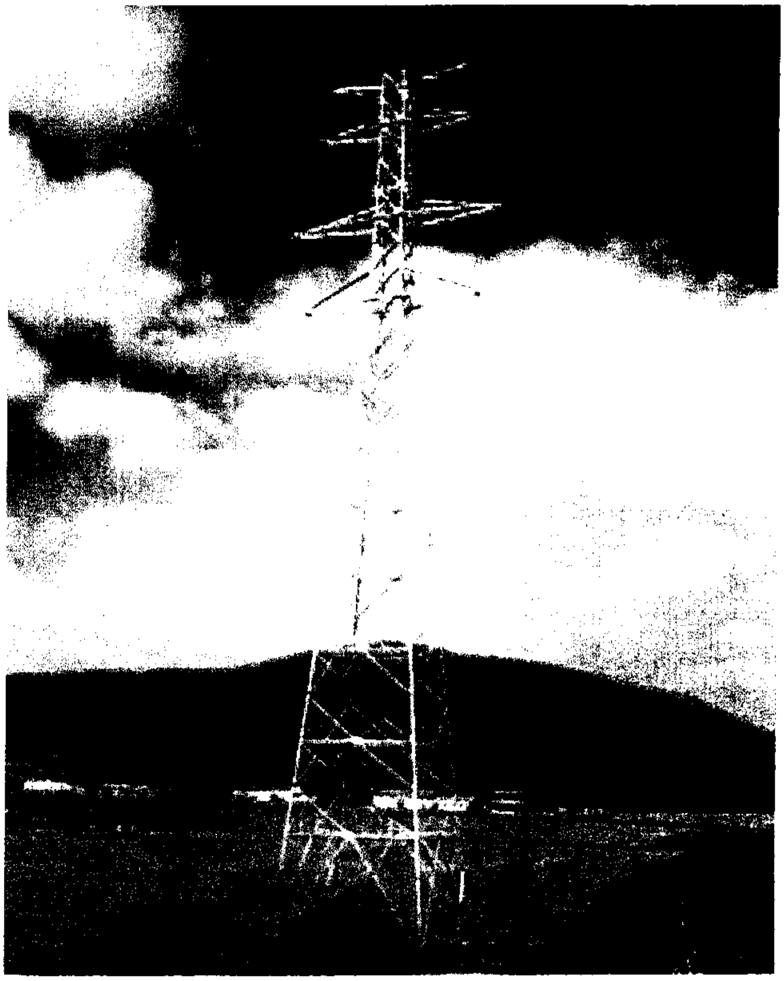
# Power-Transmission Lines



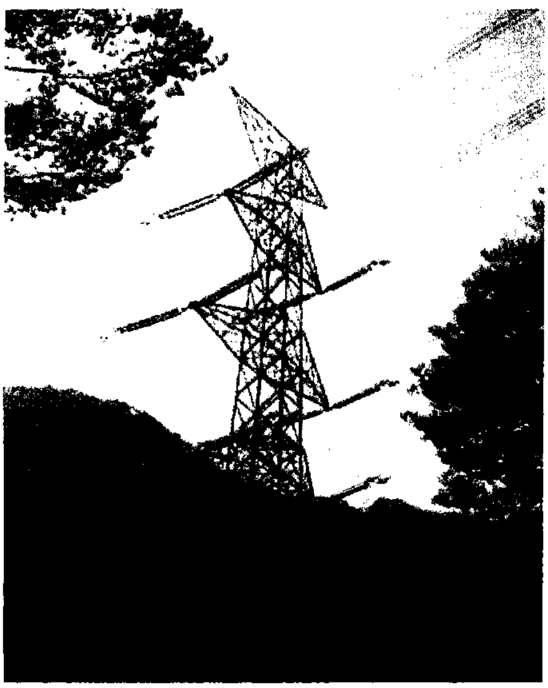
765 KV Sintaebaek Transmission Lines

# POWER-TRANSMISSION LINES

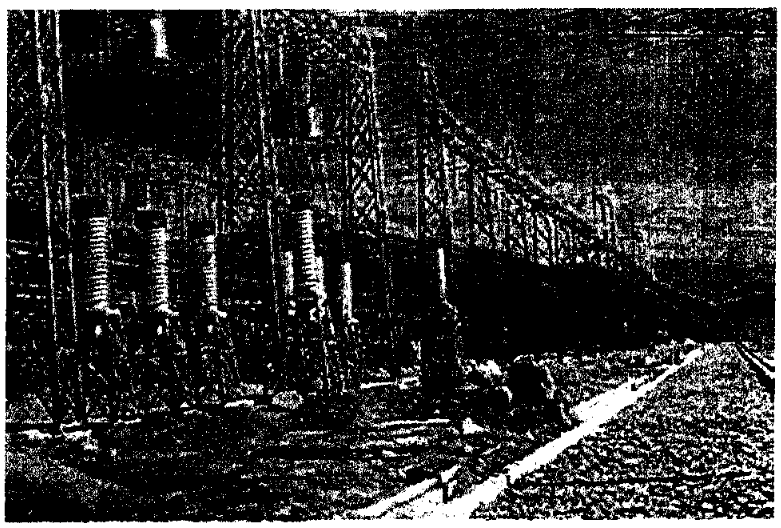
SAMBU has built numerous 154-765 KV power-transmission lines nationwide. SAMBU's construction of power-transmission lines, the nation's key industrial facilities, has contributed greatly to the nation's overall industrial development. It built the New Okcheon Sub-Station, the nation's first-ever 345 KV-class sub-station, and various other thermal power plant systems. It has also been actively involved in diverse projects in a wide range of fields, including the Mugunghwa District 2 facility works, Jeju optical cable installation, and various other information and telecommunications infrastructure facilities.



154KV T/L between Geumchon and Munsan



345 KV Gimhae T/L



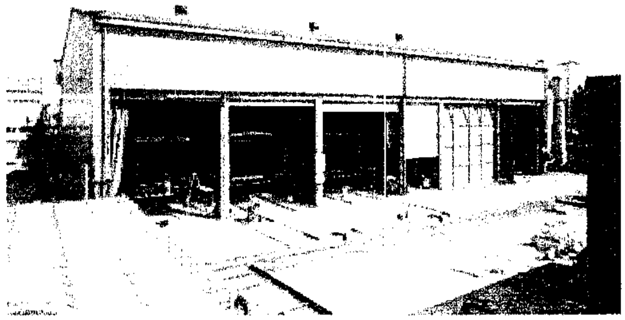
345 KV Sinokcheon Sub-station

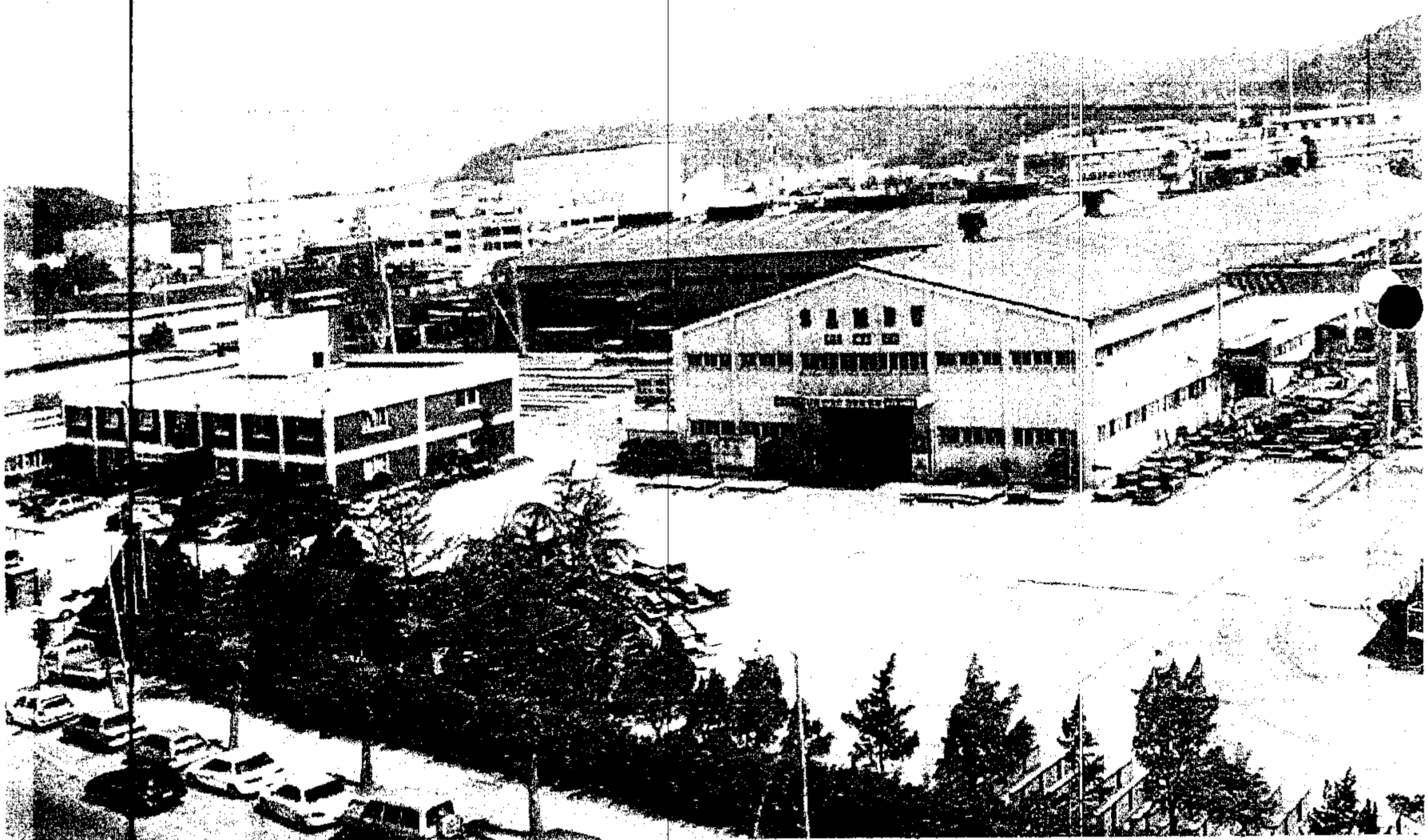
*** MAJOR PROJECTS**

- 345 KV Sinokcheon Sub-station
- 765 KV Sintaebaek T/L
- Mugunghwa District 2 Facilities
- 154 KV T/L between Geumchon and Munsan
- 154 KV T/L between Haenam and Jindo
- Communications pipeline works between Seongsan and Okpo
- 345 KV T/L between Taean and Sinan
- 345 KV Gimhae T/L
- Optical cable installation in the Jeju water supply system
- 765KV Power Transmission Line, Sinanseong-Singapyeong
- 345KV Power Transmission Line, Sinkimhae-Sinnoksan
- Electric Works along Hwaseong Taean Highway Lot.1-2, 1-3

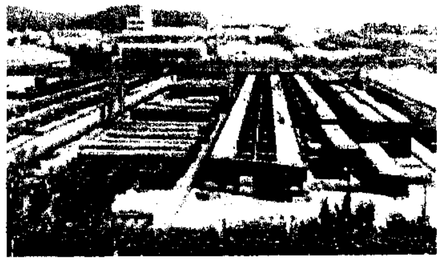
# STEEL STRUCTURE MILL

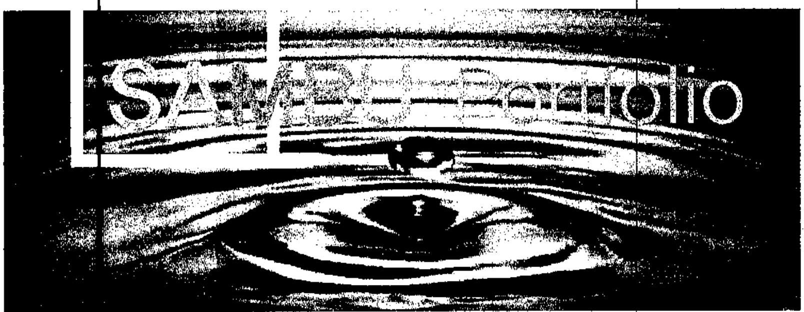
SAMBU's steel structure mill in Ansan, certified as a Grade I bridge plant, focuses on building high quality steel bridges utilizing a computerized system, producing architectural steel frames and various other steel structures.










# Major Projects

### Dams and Hydropower Projects
- Andong Multipurpose Dam
- Sayeonje Rockfill Dam
- Geumho River Unmun Rockfill Dam
- Daegok Dam
- Nam River Multipurpose Dam
- Sueocheon Dam
- Sancheong Dam
- Kulekhani Dam in Nepal
- Buhang Dam
- Hwabuk Dam
- Cheongpyeong Hydro Power Plant Extension(Unit 4)
- New Bong Escape Hydro-electric Power Complex in Pakistan

### Ports and Harbors
- Incheon Port
- Berthing Facilities at Jinhae Naval Base
- Breakwater for Hwasun Port, Jeju Island
- Fishing Port at Yeongil Bay New Harbor
- Asan Naval Port
- Jeodong Port, Ulleung Island
- Donghae Port North-Breakwater Rehabilitation & Reinforcement
- Breakwater for Jo Island, Busan
- Pohang New Port
- Yeongil Bay New Harbor
- Soheuksan Island Port
- Ulleung Island Sadong Port Breakwater Project
- Mukho Port
- Breakwater of Donghae Port
- Yeosu Port, East Breakwater
- Pyeongtaek-Dangjin Port

### Highways
- Seoul-Busan Expressway
- Seoul-Incheon Expressway
- Yeongdong Expressway
- Namhae Expressway
- Jungbu Expressway
- Jeju Island Highway & Ring Road
- Angang-Pohang Highway
- Yeongdong and Donghae Expressways
- Daejeon-Tongyeong Expressway
- Cheongha-Ganggu Highway
- Nonsan-Sangwol Highway
- Baekje Keungil Highway
- Sangnim-Haepyeong Highway
- Federal Highway #2 in Malaysia
- Kuala Lumpur-Petaling Jaya Traffic Diversion Scheme (Sections #3 and #4 under Stages I and II)
- Multan-Mianchannu Additional Carriageway in Pakistan
- Bhatkanda-Silgadhi Highway in Nepal
- Hwacheon Industrial Road
- Kwangmyung Highway
- Removal Road for Daegok Dam
- Mogok-Balsan Highway
- Iksan-Pohang Expressway Expansion Iksan-Changsu (Lot. 8)
- Cheongwon-Sangju Expressway Lot. 1, 8
- Gochang-Damyang Expressway Expansion Jangsung-Damyang (Lot. 3)
- Seocheon-Gongju Expressway Lot. 3
- Changsung Combined Freight Terminal Access Road
- Nammyeon-Yangmok Highway
- Doam-Kangjin Highway
- Incheon Int'l Airport Highway Phase Ⅱ, Southern & Northern Roads and Main Drainage Facilities
- Dogye-Chojeong Highway
- Pohang Circuitous Highway
- Pungdeokcheon-Geumgok I/C Highway
- Cheonan Circuitous Highway
- Jangheung-Songchu Highway
- Angang-Cheongnyeong Highway
- Donghongcheon-Yangyang Expressway Lot.5
- Socheon-Seomyeon Highway
- Jangheung-Gwangyang Expressway Lot.4,7
- Jumunjin-Sokcho Expressway Lot.7

### Bridges
- Yanghwa Bridge
- Hyeongsan River New Steel Bridge
- Geumnam Bridge
- Baekma River Bridge
- Yulji Bridge
- Connection Bridge forUpper and Lower Jo islands
- New Yanghwa Bridge
- Goryeong Bridge
- Seomjin River Bridge
- Hwangsan Bridge
- Jiktang Bridge
- Yukang Depal Bridge
- Mapo Bridge
- Baekje Bridge
- Connection Bridge for Yeocheon-Hwayang
- Nakdong Bridge
- Bakjin Bridge
- Connection Bridge for Jeo Island (T/K Project)
- Babai Weir-cum-Bridge in Nepal
- Beopheung Bridge
- Suyeong No. 4 Bridge
- Baekya Bridge
- Cheongnam Bridge
- Pailas Bridge in Santa Cruz, Bolivia
- Buyeo Bridge

### Subways and Railroads
- Yemi-Jeongseon Line
- Nonsan-Ganggyeong Line
- Bukpyeong-Imhang line
- East Daegu-Cheongcheon line
- Double-track Geumjeong-Sadang electric railroad
- Yusu-Dasolsa line
- Metropolitan Railroad Line 1 (section #1-8)
- Gwangju Metropolitan Line No. 1 (Section 1-5)
- Daejeon Metropolitan Railroad Line 1 (section #1-11)
- Seoul-Busan high-speed railroad (section #7-1)
- Nowon Subway Station
- Yeoui Naru Station
- Seoul Subway (Lines 1~8)
- Sinpung-Yeocheon Line
- Incheon Int.1 Airport Railroad
- Double-track Seongnam-Yeoju electric railroad(Section #4)

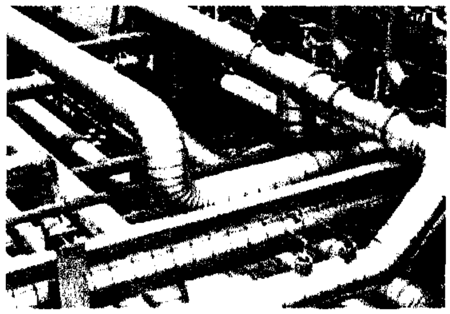
### Tunnels
- Hamyang Tunnel (Sasang-Hamyang)
- Cheongam Tunnel (Cheongam-Sicheon)
- Yeoido Under-Riverbed Subway Tunnel (Section #5-18)
- Daejeon Tunnel (Cheongwon-Jungyak, Seoul-Busan Expressway)
- Naengjeong Tunnel (Naeseo-Naengjeong, Namhae Expressway)
- Jinju Tunnel (Sangmun-Jungchon, Namhae Expressway)
- Munsan Tunnel (Sangmun-Jungchon, Namhae Expressway)
- Hoam Tunnel (Sillim-Anyang)
- Geumhwa Tunnel
- Yu River Depal Bridge Tunnel
- Twin Tunnel (Seoul Subway Line 3)
- Sanwoi-Sangbuk Highway, Neungdong Tunnel
- Maebara No. 1 Tunnel in Maebara, Japan
- Jangheung-Songchu Highway, Jangheung Tunnel
- Jinju No.1,2 Tunnel(Jinju-Masan Highway)
- Lowari Tunnel in Chitral, Pakistan

### Irrigation Projects
- Comprehensive Agricultural Development Canal in the Sapgyo River
- Agricultural Development Canal in the Geum River
- Agricultural Development Canal in Boryeong
- Agricultural Development Canal in Seocheon
- Agricultural Development Canal in Jito
- Nam River Dam Channel Improvement and Reclamation
- Farmland Reclamation in Buyeo
- Babai Irrigation, Nepal

### Office and Commercial Buildings
- Kookmin Bank's headquarters building
- SAMBU Building at Yeoksam-dong
- Gwanghwamun Post Office and other public buildings
- Public Prosecutors Office and various other legal administration buildings
- Daehan Theater
- MBC building in Gangneung
- Central Election Management Commission building
- Anyang Post Office
- Yeoi Shopping Center
- SAMBU Plaza in Daejeon
- Sunshine Building in Myeong-dong
- Olympic Shopping Center
- Cheonan Express Bus Terminal
- Happy-1 building
- Underground Shopping Mall in Sogong-dong
- Gwanghwamun Post Office
- Korea Medical Insurance Corporation building
- Korea Social Welfare Hall (Renaissance Tower in Mapo)
- AAAID headquarters building, Sudan
- MBF Finance Headquarters building, Malaysia
- Tribhuvan International Airport, Nepal
- Yongin Dongbaek Shopping Center (Junwave)
- Seifullina Office in Almaty, Kazakhstan
- Cold Storage Installation Center for SEJ in Fukuoka, Japan
- Cheongju District Public Prosecutors' Office Building

### Hotels
- Renaissance Seoul Hotel
- Haeundae Grand Hotel
- Gyeongju Concorde Hotel
- Jeungpyeong Park Tourist Hotel
- Hanrok Resort Hotel in Cheongpyeong
- Sorak Youth Hotel
- Ansan Mariko Hotel
- Educational & Cultural Center in Gyeongju
- Spapia Hotel in Yuseong
- Ragung (Millennium Palace Resort & Spa) in Shilla Millennium Park, Gyeongju

### Museums and Cultural Properties
- The National Museum in Buyeo
- Seongbo Museum in Tongdo Temple



- The National Museum in Cheongju
- The National Museum in Chuncheon
- Refurbishment of the Heungryemun Gate at Gyeongbok Palace
- Restoration of Baekje History Village
- Repairs on the Yanggwan at Unhyeon Palace
- Repairs on the Yakhyeon Cathedral in Jungrim-dong
- Refurbishment of the National Museum of Korea
- Refurbishment of the National Folk Museum of Korea
- Expansion of the exhibition hall and storage space at the National Museum in Gyeongju
- Restoration of the Heunginmun Gate in Seoul
- Relocation and Restoration of the Independence Gate
- National Institute of Biological Resources in Incheon
- Seoul Namsan Gugakdang (The classical theater of Korean traditional music)
- Ganghwa National Biology Resources Center in Incheon
- Shilla Millennium Park, Gyeongju

### Educational & Research Facilities

- Konkuk University
- Chungbuk National University
- Jeonbuk National University
- Naval Academy
- Air Force Academy
- Kookmin University
- Sungrye Hall at Kyung Moon College
- Kyunghyang Hall of the Kyunghyang Academy
- Seoul Industrial High School
- Moohak Girls' High School
- Kyungbok Girls' Commercial High School
- Solgye Elementary School building and ancillary facilities
- Joint University-Industry Research Building #2 at Korea University
- Yonsei University
- Jeil-Otsuka Pharmaceutical Co., Ltd.'s GMP Plant
- Samyang Group's Comprehensive Institute
- Samyang GENEX
- Expansion of Choongwae Parma Corporation's GMP
- PDSCD's high-tech FA Plant S/W Center
- Expansion of Yuhan-Kimberly's Gimcheon Plant
- Sunil Industrial Co., Ltd.'s Suwon Plant
- Dongjin's Freezing Plant in Guryongpo
- University of Technology Malaysia
- Government College of Commerce and Management Science Mansehra,Pakistan

### Religious Facilities

- Jeja Church in Mokdong
- Seomun Church in Seoul
- Buddhism Monumental Buildings, The Mosque at the University of Technology Malaysia
- Buddhism Monumental Buildings, Lumbini, Nepal
- Kyunghyang Church

### Sports and Leisure Facilities

- Jangchung Gymnasium
- SAMBU Sporex, Daejeon
- Hyochang Stadium
- East Gate Baseball Park
- Gymnasium for the Handicapped
- Masan Stadium
- Incheon Stadium
- Olympic Athletes Village Gymnasium and Swimming Pool
- Vision Hills Country Club
- Incheon Sea Side Golf Course
- King Fahd Sports City, Saudi Arabia
- Bear Creek Golf Club House
- Moongyung Way-stop
- Jeju Bokwang Phoenix Park Island Development
- Tani Country Club
- European Complex Theme Resort

### Renovations

- Refurbishment of the Renaissance Seoul Hotel rooms
- Relocation of the Seoul Olympic Memorial Hall
- Tribhuvan International Airport, Nepal
- Expansion of Arario Gallery, Cheonan
- Improvement of the National Museum of Korea
- Repairing of Sanbon Station building
- Daegu National Museum Social & Educational Building
- Refurbishment of Hotel Concorde rooms

### Condominiums

- Yeouido Sambu Condominiums
- Daejeon Noeun District, Sambu Renaissance Condominiums
- Jinhae Housing Complex
- Bundang Sambu Condominiums Lot. 3-12-4
- Ilsan Sambu Condominiums Lot. 11-1
- Seongnam Sujin Sambu Condominiums
- Daejeon Dunsan Nuri Sambu Condominiums
- Uijeongbu Shingok Sambu Condominiums
- Incheon Bugae Sambu Condominiums
- Daejeon Gwanjeo Sambu Condominiums
- Gaepo Jugong Condominiums
- Mansoo Jugong Condominiums Lot No. 2
- Sanbon jugong Condominiums Lot. 4
- Mokdong Sambu Condominiums Lot 18
- Daegu Hayang Condominiums
- Donam Sambu Condominiums
- Haengdang Sambu Condominiums
- Daejeon Sintanjin Sambu Condominiums
- Samsung Housing Complex
- Sungnawon Old Man Welfare Facilities
- Housing Development at Lot 6001 Jalan Tebrau, Johor, Malaysia
- Turf View Apartment, Malaysia
- Hwasung Dongtan Sambu Renaissance Condominiums
- Hanam Poongsan Area, Sambu Renaissance Condominiums
- Asan Gwongok Sambu Renaissance Condominiums
- Pyeongtaek Poseung Sambu Renaissance Condominiums
- Dongback Koaru Condominiums
- Paju Kyoha Sambu Renaissance Condominiums Lot.12,18-2

### Officetels and Complex Buildings

- Mapo Sambu Golden Tower
- Bundang Geumgok City of Angels 1 and 2
- Ogeum Sambu Renaissance Ville
- Doksan Sambu Renaissance Officetel
- Yatop Sambu Renaissance Officetel
- Inkye Sambu Renaissance Officetel
- Yangpyeong Sambu Renaissance Hangang Officetel
- Deungchon Sambu Renaissance Hangang Officetel
- Battalion Headquaters, Camp Hovey, Dongducheon
- Sinbudong Sambu Renaissance Home Officetel
- Garibong Sambu Renaissance Officetel
- Daejeon Residential and Commercial Buildings in EXPO Convention Complex Center
- CBD-Redevelopment Multi-use Elite Residential & Office, Almaty, Kazakhstan

### Power Plants

- South Jeju Thermal Power Plant
- Gunsan Thermal Power Plant
- Yeongnam Thermal Power Plant
- Youngheung Thermal Power Plant #3 & #4
- Bucheon Combined Heat and Power Plant
- North Jeju Thermal Power Plants 2 and 3
- Dangjin Small Hydro Power Plant
- Pyeongtaek Integrated Energy System

### Industrial Plants

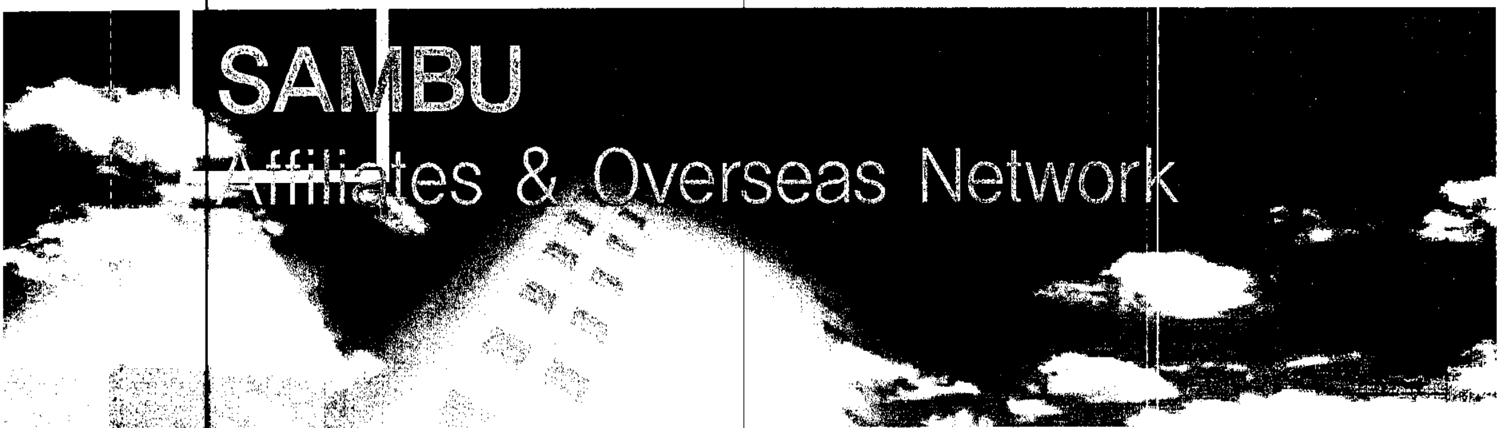
- Oil Pipes between Seosan and Cheonan
- L-1 Extra Storage Facilities
- Yeongnam Chemicals
- Ssangyong Cement Plant
- Yongin Heat-Generating Facilities in Bundang

### Environmental Plants

- Jeonju Water Supply System
- Incheon Water Supply System
- Icheon Water Supply system
- Mokpo Water Supply System
- Buyeo Water Supply System
- Bupyeong Water Purification Plant
- Wolpyeong Water Purification Plant
- Expansion of the Geumho River Water Supply System
- Expansion of the Jeju Water Supply System
- Daejeon Sewage Treatment Plant
- Jeonju Sewage Treatment Plant
- Jeju Sewage Treatment Plant
- Changnyeong Sewage Treatment Plant
- Jeomchon Sewage Treatment Plant
- Nonsan Sewage Treatment Plant
- Alkhobar Sewage Treatment Plant in Saudi Arabia
- Riyadh Water Treatment & Distribution System (Buwayb & New Area Part 2)
- Al-Jubail Sanitary Sewer & Stormwater Drainage Systems
- Han River Water Supply No.1, Lot 4 (Conveying water pipe & pipe installation)
- Banwol Water Supply Facilities
- Al-Kharj Sewage Treatment System
- Seocheon Sewage pipe maintenance
- Geochang Sewage pipe maintenance
- Banwol Water Purification Plant

### Power-Transmission Lines

- 345 KV Sinokcheon Sub-station
- 154 KV T/L between Geumchon and Munsan
- 345 KV T/L between Taean and Sinan
- 765 KV Sintaebaek T/L
- 154 KV T/L between Haenam and Jindo
- 345 KV Gimhae T/L
- Mugunghwa District 2 Facilities
- Communications pipeline works between Seongsan and Okpo
- Optical cable installation in the Jeju water supply system
- 765KV Power Transmission Line, Sinanseong-Singapyeong
- 345Kv Power Transmission Line, Sinkimhae-Sinnoksan
- Electric Works along Hwaseong Taean Highway Lot.1-2, 1-3




## Affiliates

### Renaissance Seoul Hotel / Namwoo Tourism Co., Ltd.

The Renaissance Seoul Hotel, selected as Korea's best urban hotel by readers of the Korea Times, an influential English daily published in Korea, is located on Tehran Street, often called the Venture Valley of Seoul. The hotel is in close proximity to the COEX building, Korea City Airport Terminal and various other trade, financial, and venture firms. It is also close to the fashion and cultural districts of Nonhyeon-dong, Apgujeong-dog, etc. The Renaissance Seoul Hotel, which opened on July 6, 1988, boasts 500 rooms, including 19 suites, and 15 deluxe restaurants, a grand banquet hall which can accommodate up to 1,200 people, and other first-class facilities.

**www.renaissance-seoul.com**

### Gyeongju Concorde Hotel / Bomun Tourism Co., Ltd.

Gyeongju, the ancient capital of the Silla Kingdom, has been designated by UNESCO as one of the world's 10 cultural heritages. Gyeongju, often called "a museum without walls," is blessed with fantastic scenic beauty. The Gyeongju Concorde Hotel is a five-star luxury hotel at the center of the beautiful Bomun Lake area. With unmatched customer service, it spares no efforts in providing an unforgettable impression to all its guests.

**www.concorde.co.kr**

### SAMBU Construction Industrial Co., Ltd.

SAMBU Construction Industrial Co., Ltd. was founded on August 1, 1972 as an affiliate of SAMBU Construction Co., Ltd. Upholding the three principles of faith and diligence, harmony and cooperation, and development of capability, SAMBU Construction Industrial Company has produced and wholly supplied concrete poles, important materials for power transmission and distribution for electric works, to KEPCO. It also produces concrete piles, the basis of construction works, and supplies them to the customers' needs, in a safe and faithful manner.

## Shilla Millennium Co., Ltd.

Shilla Millennium Co., Ltd. is the operator of Shilla Millennium Park, which opened on March 30, 2007. Shilla Millennium Park, located within the Bomun Complex (lake resort) in Gyeongju, consists of a theme park featuring the Shilla Kingdom and Korea' s first hanok (traditional Korean house) resort hotel 'Ragung', both of which sprawl over 165,000 square meters. In particular, the theme park presents spectacular performances, 'Secret of Legendary Ark' and 'Tears of the Queen,' on mammoth floating & land stages. 'Art of the Hwarang,' mounted martial art performances, and puppet show 'Tiger Girl' s Love" are also performed every day. Emile Polis, where Shilla architectures are restored, and Craftia with 12 studios and workshops offer a variety of historical and handicraft experiences.
**www.smpark.co.kr**

## Yeoi Trading Co., Ltd.

Since its inception in 1975, Yeoi Trading Company, a logistics company, has rendered constant efforts to increase turnover and maximize profits by researching the increasingly complex purchase and sales systems of the information era. The company specializes in mass purchases from production sites, bulk sales at reasonable prices, and nurturing partnership relations with suppliers. With the introduction of POS, it has been fully committed to provide total customer satisfaction and full service.

# Overseas Subsidiaries, Branches & Site Offices

### Pakistan Branch
ADD : Bungalow No. 81, Khayaban-E-Shujjat, D.H.A., Phase 6, Karachi, Pakistan
TEL : 92-21-35348750/1
FAX : 92-21-35847453

### Sambu (Pakistan) (Pvt.) Ltd.
ADD : 256-CCA, 2nd Floor, Block-FF, Phase Ⅳ, Defence Housing Authority, Lahore Cantt., Pakistan
TEL : 92-42-35740180/1
FAX : 92-42-35892256

### Pakistan Islamabad Office
ADD :House # 211, ST # 20, Sector G-10/2, Islamabad, Pakistan
TEL : 92-51- 2100811, 2516083/4
FAX : 92-51-2101774

### Pakistan Lowari Site Office
ADD : Nirgah, 17 km from Dir, Chitral Road, Upper dir, N.W.F.P., Pakistan
TEL : 92-944-892-201/202/203/204/205
FAX : 92-944-892-206

### Pakistan New Bong Site Office
ADD : Adjacent Mumtz Inn Guest House Sector D-4, Mirpur Azad Kashmir, Pakistan
TEL : 92-5827-437-400
FAX : 92-5827-438-020

### Sambu (Nepal) Pvt. Ltd.
ADD : P.O.Box 1616, Tangal, Gahanapokhari Word 5, Kathmandu 100-20, Nepal
TEL :977-1-4-444793/422193
FAX : 977-1-4-420575

### Oman Branch
ADD : P.O.Box 1959, Azaiba, Postal Code 130, Sultanate of Oman
TEL :968-2449-1476
FAX : 968-2449-1571

### Oman Salalah Road Site Office
ADD : P.O.Box 2946, Postal Code 211, Salalah, Sultanate of Oman
TEL :968-2328-1109
FAX : 968-9986-9188

### Kazakhstan Branch
ADD : No.404, 4th Floor, Business Center "Nurly Tau", Block 1 "V", 13 Al-Farabi st., 050012, Almaty, Kazakhstan
TEL :7-727-311-1137~8
FAX : 7-727-311-1135

### Sambu Kazakhstan L.L.P.
ADD : No.404, 4th Floor, Business Center "Nurly Tau", Block 1 "V", 13 Al-Farabi st., 050012, Almaty, Kazakhstan
TEL :7-727-311-1136
FAX : 7-727-311-1133

### Libya Tripoli Office
ADD : Janzour Taracan Jilla, Tripoli, Libya
TEL :218-21-722-9336
FAX : 218-21-489-4116

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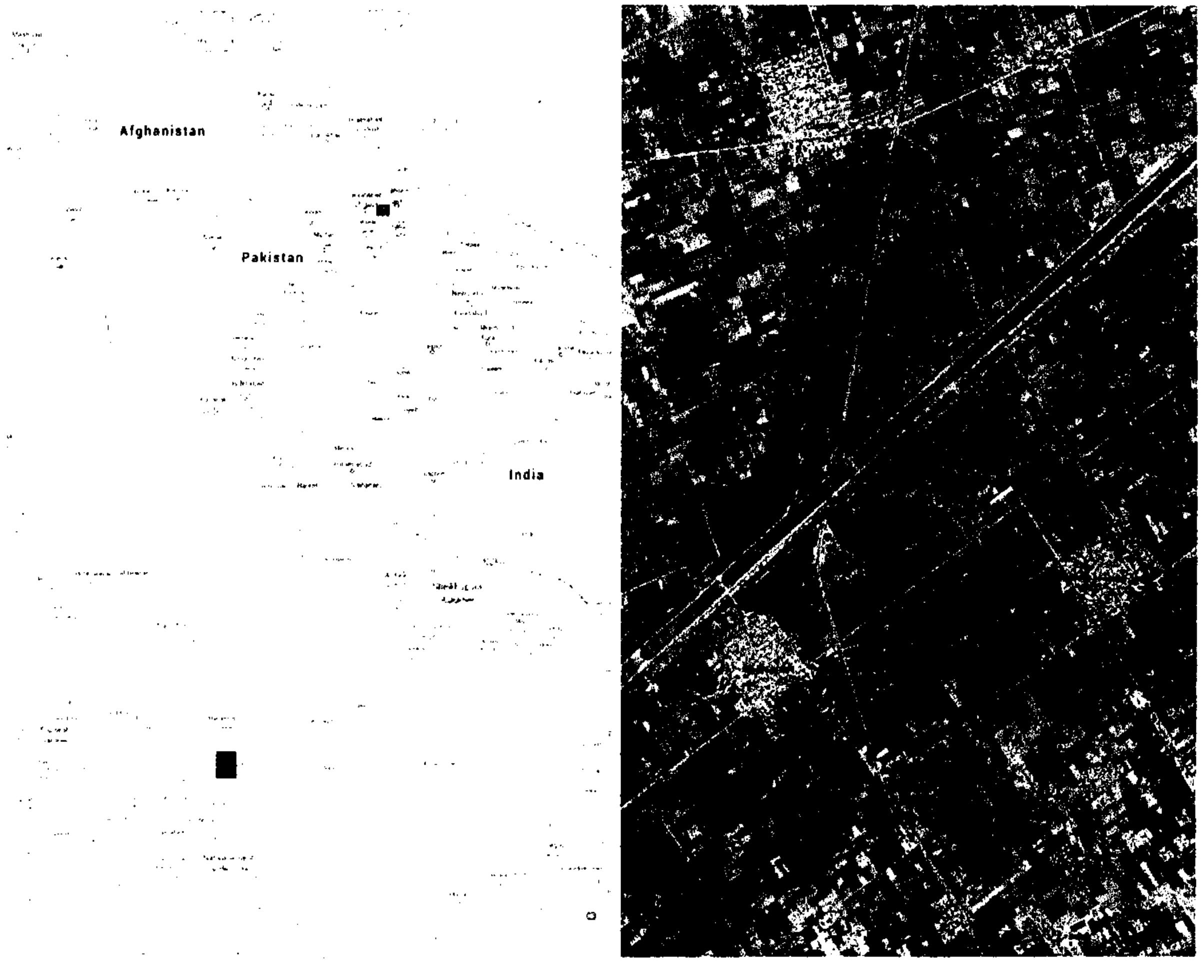
TEL:(822)3706-2114 FAX:(822)756-3901

# 4- Project Description

## Location of Project

The Project is located at RD214+500 along upper Gugera Canal which is off-taking from Lower Chenab Canal at RD 140+050. The Lower Chenab Canal is off-taking from left bank of Khanki Headworks on river Chenab. The project site is located near the center of Lahore-Faisalabad dual Carriageway on Manawala-Nankana road in District Nankana. The site is located in Upper Punjab which is the heart of agriculture crops, especially producing rice of excellent quality. The project location map is as under:




Gugera Hydro Power Co.

## Environmental & Social Aspects of the Project

The potential social and environmental impacts are likely to occur due to development of Gugera Hydro Electric Power Project. The company is conscious with its environmental obligations under Pakistan laws as well as environment and safeguard policies of loan-giving banks. The Initial Environmental Examination (IEE) was done to ascertain the environmental potential hazards and its mitigation for construction of Gugera Hydropower Project.

The Gugera Electric Power Plant falls under Category B as per schedules of Pakistan Environmental Assessment Regulations in terms of its anticipated potential impacts. The proponents of the projects that have more adverse environmental impacts are required to submit a complete Environmental Impact Assessment (EIA). Therefore, detailed Environmental Impact Assessment (EIA) is not required for this project and only Initial Environmental Examination (IEE) has been performed. So IEE of Gugera Hydro Electric Power Project District Nankana, Punjab, Pakistan has been carried out to fulfill the requirements of the Government of Punjab, Pakistan. Summary of Environmental Mitigation measurements included in the EMP, are mentioned as below:

| Potential Impact | Mitigation Measurement |
|---|---|
| Construction Impacts | Implementation through detailed EMP given in the IEE Report including provision of drinking water & compensation of trees etc |
| Permanent loss of small amount of agricultural land and some trees. | Compensation package for permanent loss of land and trees.<br>Implement tree planting program. |

## Social Benefits:

The project will save substantial amount of precious foreign exchange annually that would otherwise be required for import of oil needed for an equivalent thermal plant. The revenues of the government would increase due to direct and indirect taxation, duties and levies on the production of goods and services that will result from the power generation benefits within the project area as well as from the electricity duty collected by the Federal Government, Government of Punjab or any other agency. Water Use Charges will be paid to Irrigation Department, Government of the Punjab.

Indirect or the secondary benefits would include creation of employment opportunities and improved standard of living of the people Nankana District and vicinity. There will be multiple effects on socio-economic development of the region as well. Communication, infrastructures, livestock, forestry, cottage industry, livestock development and other opportunities would open up with construction of the proposed project. Most of the indirect benefits are difficult to quantify in monetary terms but should not be ignored while making the decision for the implementation of the Project.

## Hydrology

Chenab River is part of Indus Basin River system and the third river of the Western river on which water Pakistan has the right under Indus Basin Treaty Signed between India and Pakistan under the office of World Bank. It contributes a good part of water supply to the irrigated agriculture system in Pakistan. The river Chenab originates in the Kulu and Kangra Districts of the Himachal Pardesh Province of India. Its two Chief streams are Chandra and Bhaba. These Streams join at Tandi in the state of Jammu and Kashmir at an elevation of 2770 m (9,090 ft) above mean sea level. Khanki Head-Works, on river Chenab, situated about 14.5 km downstream from Town of Wazirabad, was built and made operational in the year 1892. This was the first weir in Punjab which had been founded on alluvial bed of the river. The Gugera Branch Canal originates from the Lower Chenab Canal (LCC) from its RD140+050.The LCC itself off-takes from Khanki Head-Works. The main areas to which it supplies water are Toba Take-Singh and Faisalabad. Upper Gugera Branch after travelling a distance of about 85.95 km, it further bifurcates at RD280+000 into two canals namely Lower Gugera Branch (LGB) and Burala Branch. The tail of LGB is at RD387+566 and Burala Branch is at RD485+755.

### Availability of Water Flows

Flow duration analysis is made on daily basis for each year separately and Presented in Figure 5.16 of Feasibility Report VOL 1. The flow duration curve for full period starting from 2008 till 2013 on daily basis is also prepared and presented in Figure 2.17. It shows the following:

- Discharge of 05 m3/s is available for 91.81% of Time
- Discharge of 22 m3/s is available for 91.18% of Time
- Discharge of 45 m3/s is available for 90.08% of Time
- Discharge of 75 m3/s is available for 82.76% of Time
- Discharge of 100 m3/s is available for 56.76% of Time
- Discharge of 120 m3/s is available for 8.11% of Time
- On the basis of above, the following is concluded:

The average canal closure period is 26 days. Therefore to get more benefits of energy it is proposed that closure period be kept up to 20 to 26 days in future.

The upstream level will be kept constant at designed full supply level.

The Energy Potential has been worked out on daily basis for a period between year 2008 and 2013 for which record was available.

### Technical Details of Project

The proposed hydroelectric power project will have installed capacity of 3.6 MW and would generate 20.80 GWh annually. The project would be equipped with three (3) horizontal kaplan turbines, each having capacity of 1.2MW. The project would be connected with LESCO 132/11 kV Grid at Walgan Suhai which is about 07 km from the Project site. The plant would be connected through two 11kV TLs having Osprey Conductor. The location and layout of the preferred layout has been selected on the basis of unit cost analysis. The preferred layout is such which offers minimum cost per kWh. Therefore, the project physical arrangement and overall characteristics have been configured for optimum hydropower development of the Gugera Hydro Electric Power Project. The project features have been selected considering foundation conditions, cost and schedule, constructability and environmental issues. The preferred layout is the powerhouse and spillway placed in the bypass arrangement just upstream of the existing fall at RD 216+100 along its right bank. The Spillway is placed along the left bank of powerhouse structures. The powerhouse and spillway are placed at RD 214+500 due to constraint of space on right side of the canal near RD 216+100 because of existence of Manawala-Nankana Sahib Road Bridge. There is no need of canal diversion for construction of powerhouse and spillway. Powerhouse/spillway would be constructed under dry-condition along right bank. After construction of the Powerhouse and Spillway, the canal flows will be diverted towards Powerhouse by connecting the Headrace with Tailrace from Upstream to Downstream.

### Major Components

The Gugera Hydro Electric Power Project comprises the following main components:

- -Headrace
- -Powerhouse and spillway Intake Bay
- -Powerhouse (Machine hall and Service bay)
- -Turbine and Generators
- -Main/Unit Transformers and Switchgear
- -Transmission line and interconnection facilities
- -Erection bay on right side of the Powerhouse
- -Gated Spillway along left bank of Powerhouse structure
- -Powerhouse Outlet bay
- -Tailrace
- -Access Road on left and right banks of Lower Gugera Branch Canal
- -Colony for O&M staff and Rest House and other Civic Facilities

### Headrace Canal

The Headrace Canal starts from the existing Gugera Branch Canal at RD 212+000 to the proposed powerhouse location at RD 214+500 along the right hand side of existing Gugera Canal. The Headrace starts at 200.0 m.a.s.l and ends at 199.90 m.a.s.l before powerhouse inlet bay starts. The length of the headrace is about 762 m. The slopes and bed of headrace are protected by stones laid over geo-textile to protect the fines from movement and in order to run the headrace without major maintenance cost. If geo-textile is not used below the stones then fine under the pitching would be removed by fluctuation due to load rejection and tripping of turbines.

The headrace has been designed by using Manning's formula. The water surface profile and bed slope 1:8333 of the existing canal were kept constant. The water level at the entrance into the headrace is 203.16 m.a.s.l being the designed Full Supply level of the Existing Canal at RD 216+100. The water level at power house is at 203.16 m.a.s.l. The canal's designed bed width is 54.88 m with 3.26m water depth and a bed slope of 1:8333. A road of 4.5 m shall be constructed at the crest of the embankments along right and left banks of the headrace. The embankments and bed of the canal are protected by stones over geo-textile.

### Powerhouse Inlet Bays and Retaining Walls

The in-take bay in front of powerhouse and spillway consists of concrete slabs bounded by concrete cantilever retaining walls. Concrete slab in front of powerhouse and spillway with 18.0 m width starts at level 199.90 m.a.s.l (bed level of headrace canal) and slopes down to a level 192.80 m.a.s.l (invert level of powerhouse intake). The transition to the slopes of the headrace canal is carried out with circular concrete retaining walls. Cement slurry trench walls are foreseen underneath the retaining walls and underneath the intake bay to minimize uplift and avoid piping underneath these structures and powerhouse structure.

### Power-House Complex

The Turbine Unit and Spillway are so placed that they become hydraulically more efficient. The Spillway is placed along the left hand side of the Powerhouse. An access is provided over the powerhouse and spillway to connect the left bank with right bank. The powerhouse is constructed in the bypass arrangement along right side of the existing Gugera Branch. Cofferdams at upstream and downstream side are provided to protect the foundation excavation and construction areas from entering of ground water or rain water. The coffer dams have to be constructed at starts of construction/excavation and consist of soil excavated from the powerhouse excavation pit. Excavation of powerhouse foundation requires deep well dewatering under protection of cement slurry trench wall all around the powerhouse, spillway and underneath the retaining walls and upstream and downstream concrete floor in order to avoid piping underneath the powerhouse and spillway foundation.

The powerhouse structure includes inlet and outlet bay, machine hall (three (3) unit blocks). The loading bay is provided along right side of the Machine Hall. The substructure and superstructure is constructed of cast-in-place reinforced concrete. The roof consists of pre-cast and post tensioned concrete girder with composite metal deck and 20 cm thick cast-in-place lightweight reinforced concrete slab. The machine hall extends along the entire unit blocks and loading bay. It houses the turbine and generator and other E&M equipment as generator terminals, AC/DC distribution and oil cooling units. Its floor level is at 198.70 m.a.s.l with a length of about 23m and a width of 17.2m. The necessary height is defined by the hoisting requirement and is estimated at 8.5 m.

The stairs in the control room area connect the floors between 192.53 m.a.s.l and 223.23 m.a.s.l. Mechanical workshops, turbine pits and sumps area are equipped with necessary hoists for handling of equipment. The service area comprises the control room, offices and storage areas, kitchens/lunchroom, locker and washrooms. The walls are constructed of concrete. Interior walls and concrete ceiling are painted; the floors are sealed by natural concrete or by using ceramic tiles. Doors are standard steel doors with required fire rating. Windows are made of single glasses with pressed steel frames. Insulation is provided where required for energy conservation. All items are selected for durability, cost effective and ease of maintenance.

**Loading Bay**
A separate loading bay is provided on the right hand side of the powerhouse. The loading bay floor level is 200.92 m.a.s.l. At entrance roll-up gate of 7.0 m width is located in the right side wall for vehicle access to machine hall. The loading block is used as platform during erection and maintenance of turbines, generators and other E&M equipment. Additionally, a local workshop is established in service bay.

**Service Bay**
A service bay is located on the right side of the powerhouse. It is multi-storey building for housing control room, conference room, offices, kitchen, bathrooms, workshop and rooms for batteries, etc. Control room is provided at 204.16 m.a.s.l. A stair is provided to link the floors.

**Spillway**
A Spillway is located along the left bank of the powerhouse building. The discharging capacity of the spillway is equal to full supply discharge of the Gugera Canal. It will be a gated structure. Radial gates having remote control system would be provided. The control of gates for opening and closing would be done from main control room. It will pass flows during tripping of turbine due to faults in the system or in the unit. A concrete deck bridge would be provided for vehicle traffic. The gates would be radial and operated from elevated deck of steel structure. The gates could be flap gates and would be operated from inside the crest of the spillway. Exact selection of type of gates would be done during detailed design phase by EPC Contractor. Spillway Gates are foreseen on downstream and upstream side of the machine hall for their operation. Gates are radial and operated hydraulically and operation will be controlled from machine hall control room.

**Trashracks & Stoplogs**
Trashracks are installed at the intake at an angle of $78^0$ to facilitate mechanical cleaning and to reduce hydraulic losses. The size of the intake is 4.37 m x 8.32 m. As no intermediate pier is provided, therefore three horizontal steel beams installed behind the trash racks will act as support structures. For cleaning of the Trash Rack, a Crane for each intake is foreseen or trash racking machine moving on rails.
Stoplogs are foreseen at the intake and at the end of the draft tube. Stoplogs are also provided on upstream and downstream of spillway gates. These are required in order to facilitate erection, repair and maintenance of turbines and gates. Placing and removing of stop logs at intake would be by trashrack cleaning machine and at draft tube are foreseen by mobile crane of suitable capacity.

**Construction Pit**
Powerhouse and spillway would be constructed in single excavation pit. A designed dewatering system would be installed for lowering down the groundwater level in order to cast concrete under dry conditions. Dewatering system will remain in operation till the concrete work is finalized. However, cement slurry trench walls all around the powerhouse would be constructed first before start of excavation. Therefore, these cut-off walls have significant effects on reduction of inflow water ultimately result in less operation and maintenance cost of dewatering.

**Outlet Bay and Retaining Walls**
The Outlet Bay consists of concrete slabs bounded by concrete cantilever retaining walls. Concrete slab starts at downstream of powerhouse at level 192.63 m.a.s.l (invert level of draft tube) and sloping up to level 196.91 m.a.s.l (bed level of tailrace canal). It is hinged to the powerhouse foundation with an expansion joint. The retaining walls also provide transition to the tailrace cross section. The tail-water level is such that the draft tube remains submerged even in minimum tail-water level to avoid cavitation.

**Tailrace Canal**

The powerhouse outlets discharge directly into outlet bay which is directly linked with the tailrace canal which is ultimately is Gugera Canal. The Tailrace Canal extends from the powerhouse outlet bays to the existing canal up to RD 221+500. Channel is formed in trapezoidal section, with a bed width and bed slope equal to the existing Gugera Branch Canal. The side slopes are 1:2. The tailrace canal bed is covered with stone over geo-textile having length of about 770 m.

**Service Roads and O&M Staff Colony**

A 4.50 m wide access road shall be constructed over the left bank of the Gugera Branch Canal to access the canal and strengthen the existing access to villages. A metalled road along left bank would be provided up to RD 221+500. O&M staff will be stationed in a colony to be constructed near to the powerhouse. The Colony is proposed along the right bank of the headrace canal. It would consist of residential building, community building, masjid, etc, to serve the daily requirement of the operation and maintenance staff.

**Major Electrical and Mechanical (E&M) Equipment**

a) Following are the E&M facilities of the Hydro Power Plant.

b) Three (3) sets of Horizontal Kaplan Turbines, each of 1.2 MW capacity with a rated head of 3m, rated flow of 47 m3/s complete with all auxiliary equipment including regulating gear, turbine casing, guide vanes, thrust & guide bearings, etc.

c) Three (3) sets of Digital Electro-Hydraulic Governors complete with all accessories including governor oil pumps, pressure tanks and air compressors.

d) Three (3) sets of draft tubes with 3 hydraulically operated roller gates.

e) Three (3) sets of power intake trash racks and stop logs.

f) Power plant mechanical auxiliaries including, station drainage system, turbine dewatering system, station water services, compressed air services, station HVAC system, oil handling facilities, firefighting protection and detection system. These should also include miscellaneous mechanical auxiliary equipment such as mobile air-compressors, oil filters and submersible pumps for emergency duties.

g) One 10 ton powerhouse overhead bridge crane.

h) Three (3) trash rack cleaning machines.

i) One 15 ton mobile crane and one 10 ton truck trailer.

j) Hydraulically operated spillway gates.

k) Two (2) sets of flow- measuring equipment for turbines.

l) One (1) set of headrace and tailrace water level measuring equipment.

m) Three (3) sets of Synchronous Generators each rated at 1.5 MVA, 0.69 kV, 0.85PF and 750 rpm complete with three Dry type excitation transformers, static excitation and AVR equipment current transformers, potential transformers, lightning arrestors and all standard auxiliary equipment and accessories.

n) Three (3) sets of Generator-Neutral earthing Enclosures including neutral earthing transformers, current transformers, and accessories.

o) Three (3) oil-filled Power Transformers, each of 1.5 MVA, 0.69/11 KV rating, main connection XLPE-Cables with complete termination kits and accessories.

p) One (1) complete set of Unit-Auxiliary Power Supply System comprising three dry-type 100 kVA, 0.69/0.4 kV Unit-auxiliary transformers, circuit breakers and 400/230V auxiliary boards etc.

q) Three (3) sets of Protection Relays and equipment along with all auxiliary equipment, mounting racks and cabinets for complete protection of Generators and Power Transformers and connected equipment.

r) Two (2) sets of Energy Metering System (SMS) for two out-going Feeders, three (3) sets of Energy Meters for Generators output and two (2) sets of Energy Meters for station auxiliary supply system, all rated at 11KV voltage, complete with mounting racks and cabinets including other Energy Meters as required.

s) One (1) set of metal clad 11 kV Switchgear comprising drawable Vacuum Circuit-Breakers (08 No.), load break fused switches, fuses, CTs, PTs, protection and metering equipment, synchronizing equipment, complete in every respect for all incoming and outgoing feeders.

t) One (1) complete set of Auxiliary Power Supply System comprising two 100 kVA, 11/0.4 kV station auxiliary transformers, air circuit breakers, 400V auxiliary boards and one (1) Standby Diesel-Generator of 100 KVA, 0.4 KV rating, all with complete protection and metering.

u) One (1) set of Lightning Arrestors and Potential Transformers for 11kV outgoing lines to LESCO grid station.

v) Two (2) Sets of 110 V main station batteries with chargers, complete with fuses, MCCBs and MCB, bus bars with protective and alarm system.

w) 11kV, 400V/ 230V AC and 110V DC Power Cables & multi-core protection, control and communication Cables for the Power Plant.

x) One (1) set of Lighting and Small Power System for normal, essential and emergency lighting.

y) Complete earthing network comprising earthing meshes, earthing rods, interconnecting earthing conductors/cables and all fittings, clamps and appurtenances for connecting with the draft tubes, power intake and spillway structures, transformer bays, switchgear including all risers and equipment earthing.

z) Computerized Control and Monitoring System for the Plant.

aa) Telecom System including internal intercom facilities within the project, PABX with 3 trunk lines for public network connection and 30 extensions and pilot cable between the power plant and the LESCO/NTDC grid station for speech and inter-tripping / alarms, all complete with telephone sets, modems, intercommunication equipment and DC Un-interruptible Power Supply.

bb) Mimic Diagrams in the Central Control Room Depicting Electrical Quantities, flows, levels measurements, spillway gates positions and auxiliary power supply system etc.

cc) Sequential events and data recording systems.

dd) Station potable water, sanitary and sewerage system.

ee) Workshop with all necessary machine tools and equipment for maintenance of the power plant.

ff) Two 11kV Interconnection Transmission Lines of 7KM length between Powerhouse and LESCO Grid Station at Walgan Suhail.

gg) 400 V distribution line for colony.

hh) Spare parts storage-facilities.

ii) Spare parts, erection, testing & commissioning of E&M equipment.

**Salient Features of the Project**

The Very Low Head (VLH) Gugera Hydro Power Project has been designed for a maximum design discharge of 142 $m^3$/sec available in Kharif and will get reduced in Rabi, with a variable head up to 3 meters. The design capacity is 3.6 MW with estimated annual generation of 20.8 GWh having Plant Factor 67%. The technology selected involves three (3) units of Horizontal Kaplan Turbines with double regulation arrangements.

**Technical Parameters** of the Project mentioned below have been selected based on the detailed Planning analysis, Economic decision criteria & Economic parameters of internationally accepted practice and Safety considerations:

| | |
|---|---|
| Gross Capacity | 3.6 MW |
| Net Capacity | 3.56 MW |
| Net Annual Generation | 20.592 GWh |
| Design Head | 3 meters |
| Design Discharge | 142 $m^3$/ sec |
| Plant Factor | 67% |
| Number of Units | 3 |
| Turbine Speed | 214.3 rpm |
| Generator Speed | 750 rpm |

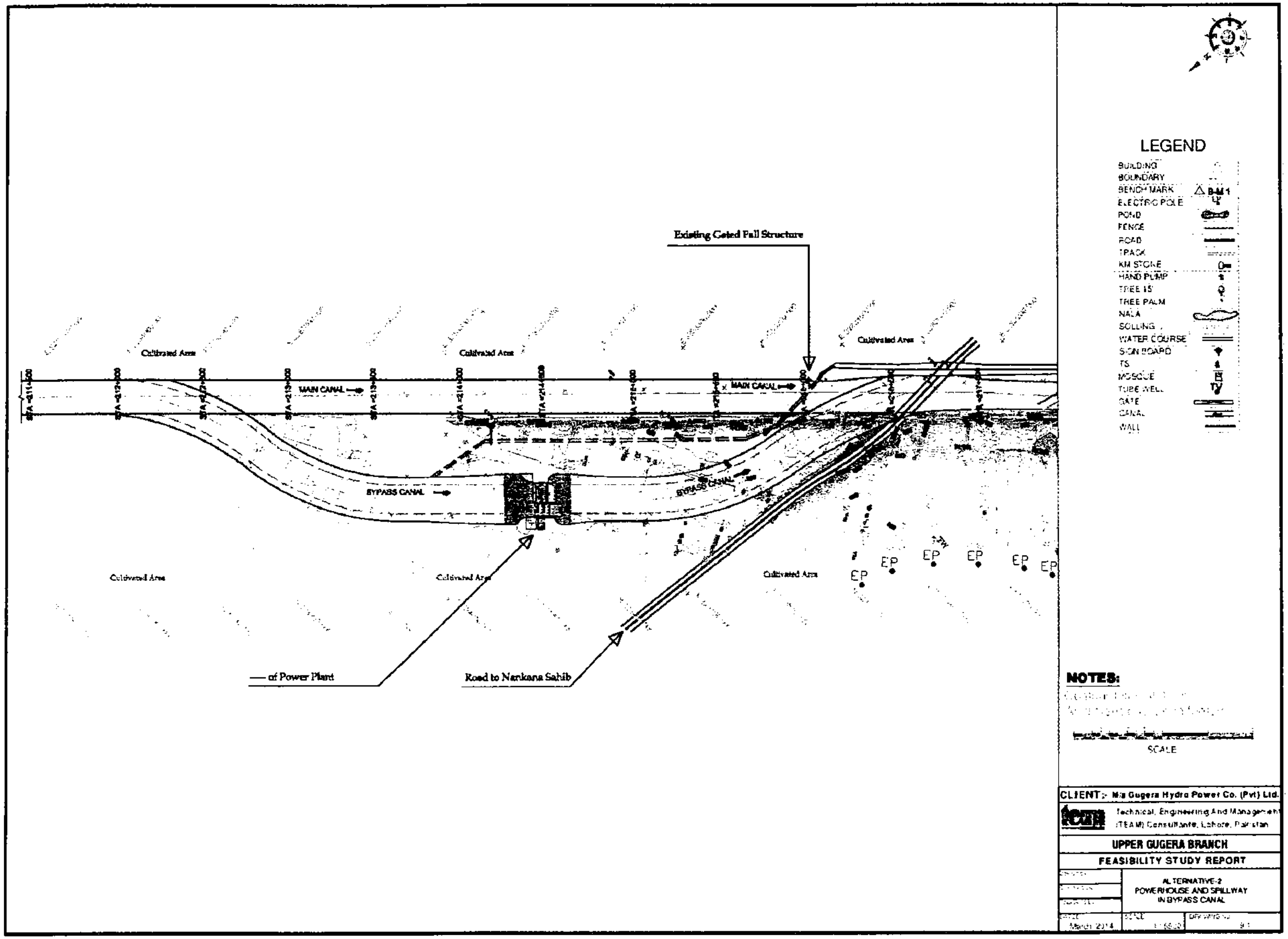
## SALIENT FEATURES

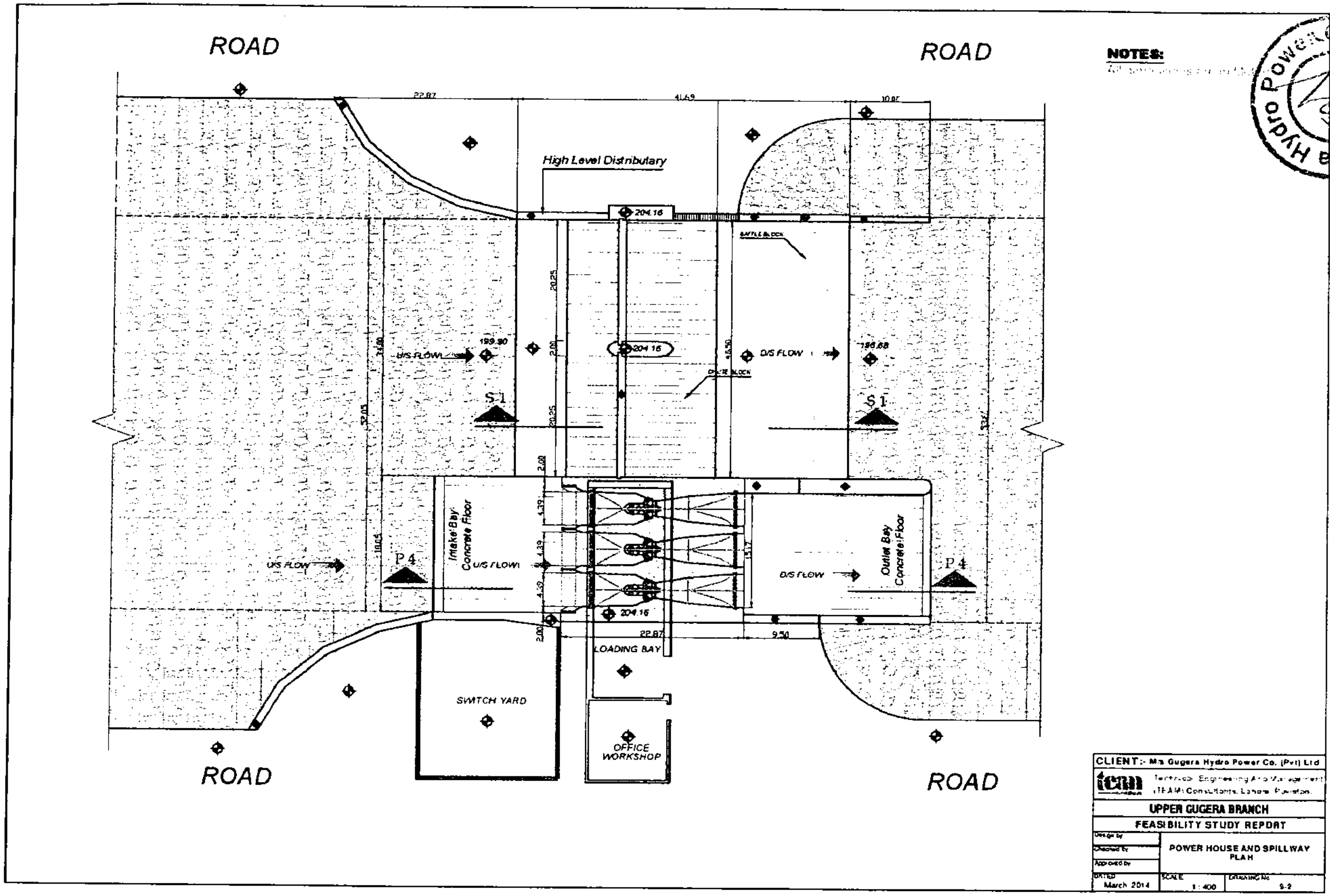
| | | |
|---|---|---|
| **1.** | Location of the Project | Located 10 km from Nankana City and 70 km of Lahore. |
| **2.** | Plant Factor | 67% |
| **3.** | Head Race Canal | Bed Width = 30 m , Side Slopes = 2 : 1, Length=762m |
| **4.** | Powerhouse | Width =17.2, Length=23m, Height=8.5m |
| **5.** | Tailrace Canal | Bed Width = 29 m, , Side Slopes = 2 : 1, Length=770m |
| **6.** | Hydro-Mechanical Equipment | No. of Units = 3, Installed Capacity = 3.6 MW<br>Energy Generation Potential = 20.8 GWh<br>Type of Turbine = Horizontal Kaplan Turbine<br>Runner Dia = 2.1 m , Turbine Speed = 214.3 rpm,<br>Rated Discharge = 142 $m^3$/sec , Rated Head = 3 m |
| **7.** | Interconnection of Plant | The Plant shall be connected to LESCO 132/11KV Grid Station at Walgan Suhail through two 11Kv TLs of 7KM length. |

**Interconnection of Plant with LESCO System for Power Dispersal**

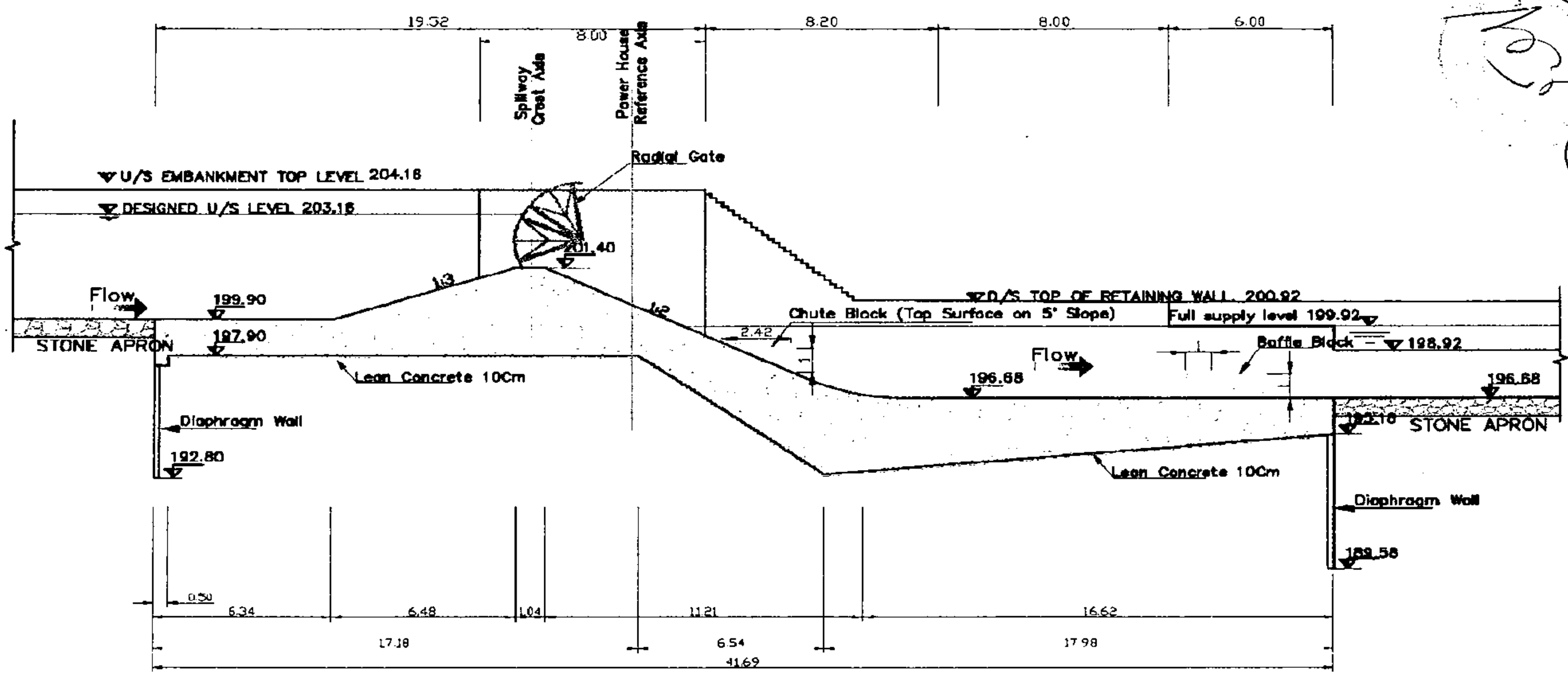
The Plant is proposed to be interconnected with the nearest LESCO 132/11KV Grid Station at Walgan Suhail. Two 11kV transmission-lines on Osprey Conductor (ACSR), have been proposed for dispersal of the power generated from the HPP. Synchronizing with LESCO grid system shall be done in the powerhouse control room. The powerhouse is the point of energy delivery to LESCO System. Energy Meters have been provided at the Power Plant Switchgear for measurement of power/energy delivered to LESCO. The proposed 11KV TLs are equipped with directional distance protection system with relays both in the 132kV Substation and in the Powerhouse on Gugera Canal. A back-up protection at both stations with directional over-current relay is also included. Additional lightning arrestors are also foreseen at the outgoing section of Power Plant.

For evacuation of Energy generated by the Plant, our Consultants M/s PPI Lahore have carried-out load Flow Study, Short- Circuit Study and Dynamic Stability Study. The load-flow study-report was submitted to LESCO for its validation/vetting. The Power Policy 2002 allows the Company to construct the Transmission line from its own sources and include its cost in Total Cost of the Project. These arrangements have been incorporated in the Project's physical scope to ensure the energy dispersal and inter-connectivity on the immediate basis after commissioning of the Power House, as traditional arrangements regarding construction of the transmission line, are likely to cause delay the energy evacuation/dispersal.


Existing Gated Fall Structure
Cultivated Area
MAIN CANAL
BYPASS CANAL
EP
of Power Plant
Road to Nankana Sahib
LEGEND
BUILDING
BOUNDARY
BENCH MARK
ELECTRIC POLE
POND
FENCE
ROAD
TRACK
KM STONE
HAND PUMP
TREE
TREE PALM
NALA
SOLLING
WATER COURSE
SIGN BOARD
TS
MOSQUE
TUBE WELL
GATE
CANAL
WALL
NOTES:
SCALE
CLIENT:- M/s Gugera Hydro Power Co. (Pvt) Ltd.
Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan
UPPER GUGERA BRANCH
FEASIBILITY STUDY REPORT
ALTERNATIVE-2
POWERHOUSE AND SPILLWAY
IN BYPASS CANAL
March 2014


ROAD
ROAD
NOTES:
22.87
41.69
10.87
High Level Distributary
204.16
BAFFLE BLOCK
U/S FLOW
199.90
204.16
D/S FLOW
S 1
S 1
Intake Bay Concrete Floor
U/S FLOW
U/S FLOW
P 4
P 4
204.16
D/S FLOW
Outlet Bay Concrete Floor
22.87
9.50
LOADING BAY
SWITCH YARD
OFFICE WORKSHOP
ROAD
ROAD
CLIENT:- M/s Gugera Hydro Power Co. (Pvt) Ltd
UPPER GUGERA BRANCH
FEASIBILITY STUDY REPORT
Design by
Checked by
Approved by
POWER HOUSE AND SPILLWAY PLAN
DATED March 2014
SCALE 1 : 400
DRAWING No S-2

Page: 34




Note:- 1. All levels and [illegible]
2. Survey Generated by MIA Associates, Lahore.

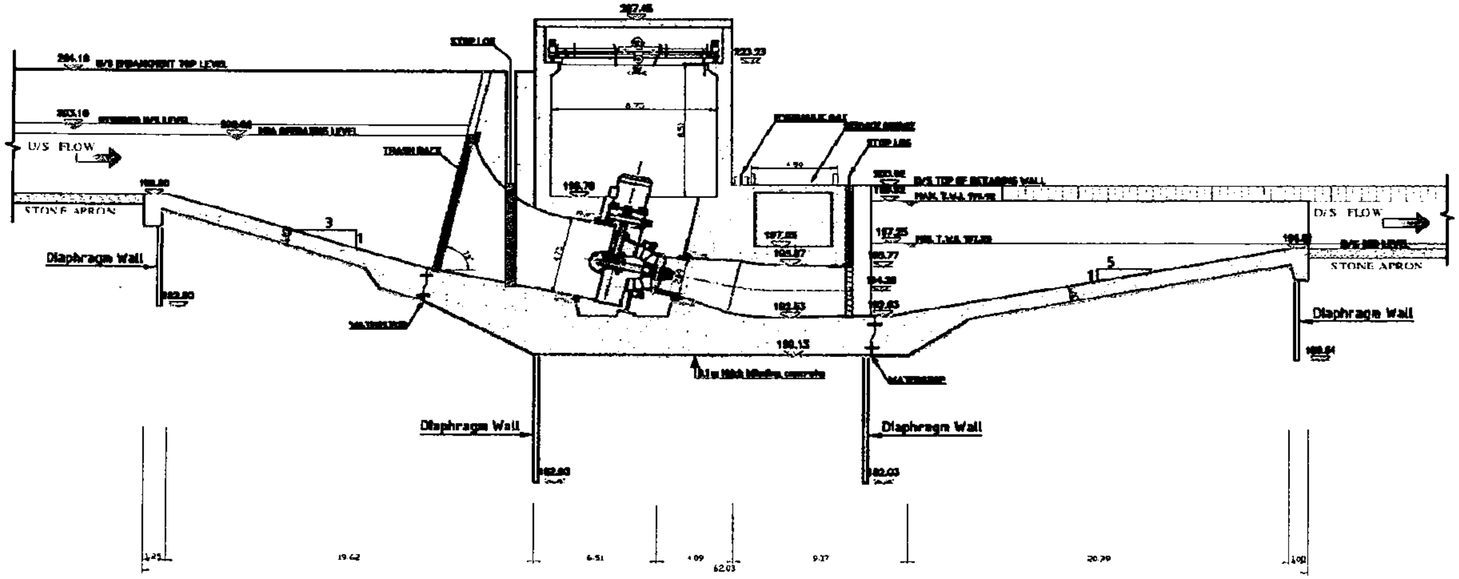
CLIENT:- PUNJAB HYDROPOWER CO. PRIVATE LIMITED

team Technical Engineering And Management (TEAM) Consultants Lahore Pakistan

UPPER GOGERA BRANCH

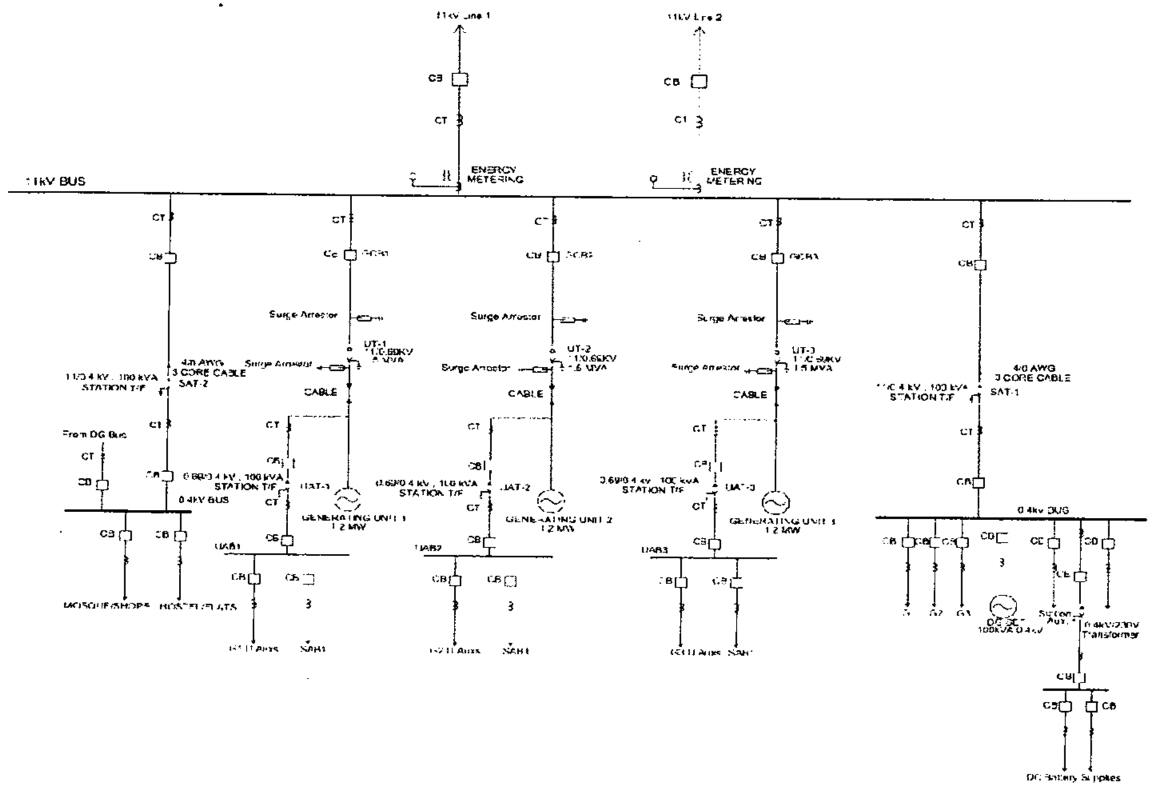
FEASIBILITY STUDY REPORT

| Design by. | SPILWAY LONGITUDINAL SECTION S 1 - S 1 | |
|---|---|---|
| Checked by. | | |
| Approved by. | | |
| DATED: Sept. 2012 | SCALE: 1 : 150 | DRAWING No: 9-3 |




Note:-
1. All levels and dimensions are in meters. (masl)
2. Survey Generated by MIA Associates, Lahore.

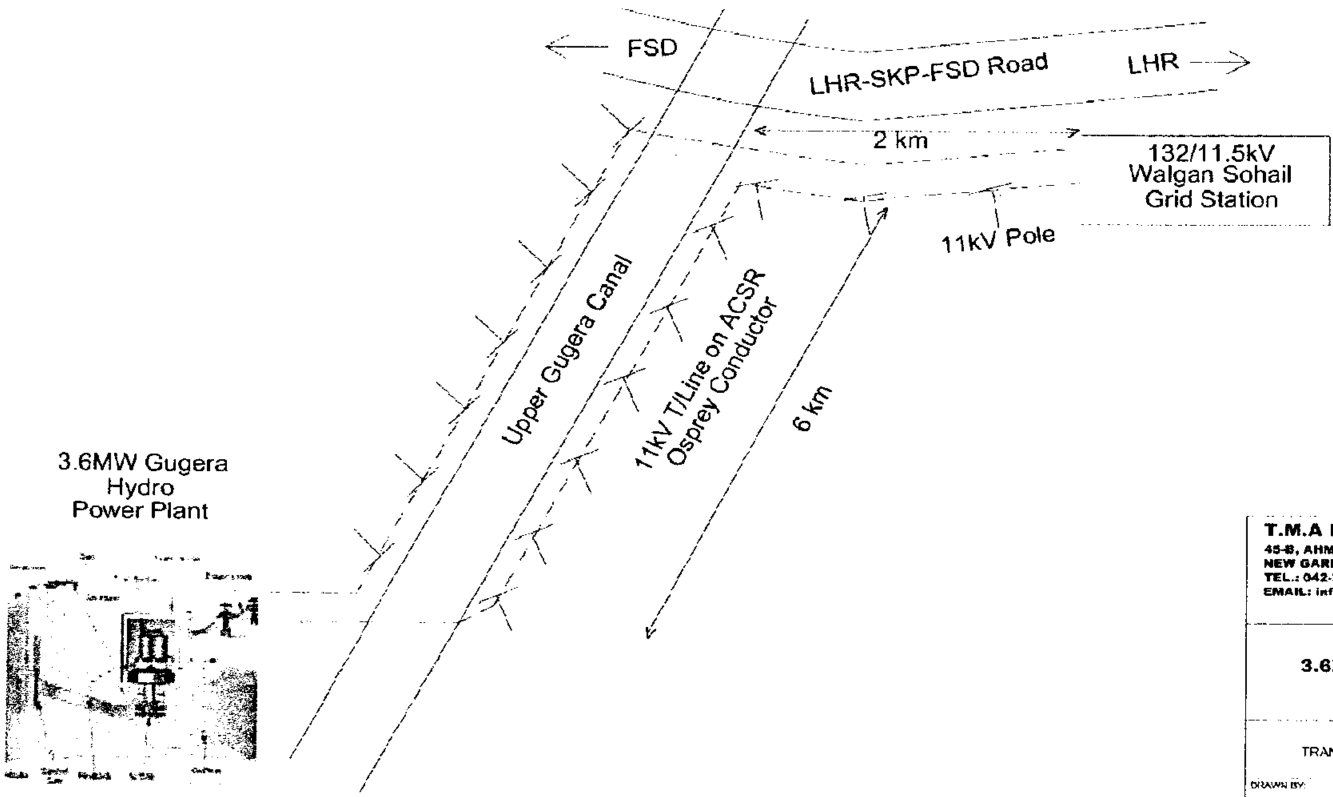
| | |
|---|---|
| CLIENT:- PUNJAB HYDROPOWER CO. PRIVATE LIMITED | |
| Technical Engineering And Management (TEAM) Consultants, Lahore, Pakistan | |
| UPPER GOGERA BRANCH | |
| FEASIBILITY STUDY REPORT | |
| Design by | POWERHOUSE LONGITUDINAL SECTION P 4 - P 4 |
| Checked by. | |
| Approved by. | |
| DATED: Sept. 2012 | SCALE: 1 : 225 — DRAWING No: 9-4 |




**T.M.A INTERNATIONAL**
45-B, AHMED BLOCK, NEW GARDEN TOWN, LAHORE.

**3.6MW GUGERA HYDRO POWER PLANT**

SINGLE LINE DIAGRAM

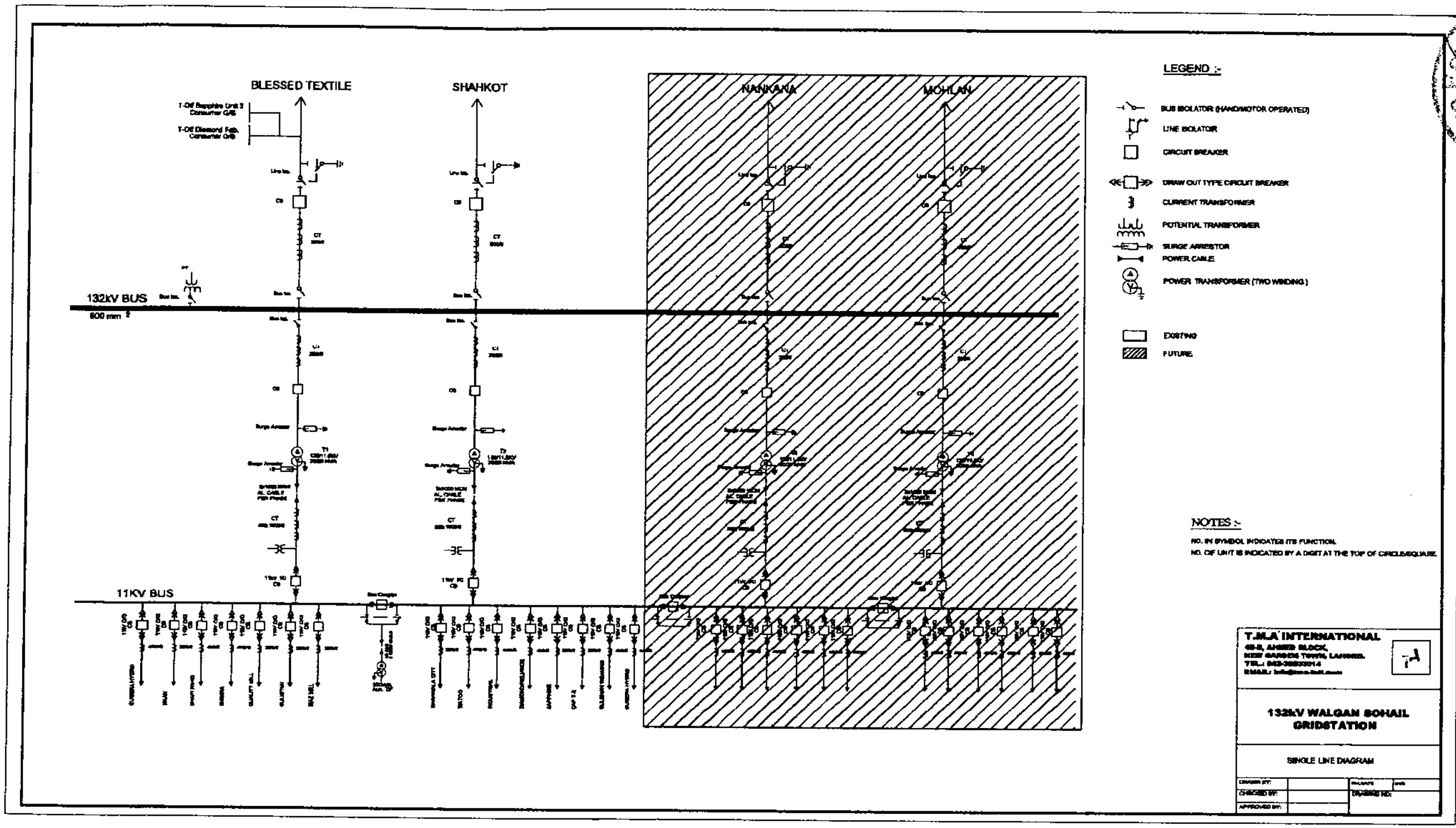



**T.M.A INTERNATIONAL**
45-B, AHMED BLOCK,
NEW GARDEN TOWN, LAHORE.
TEL.: 042-35833014
EMAIL: info@tma-intl.com

**3.6MW GUGERA HYDRO POWER PLANT**

TRANSMISSION LINE ROUTE PROFILE

| | | | |
|---|---|---|---|
| DRAWN BY: | | | |
| CHECKED BY | | DRAWING NO | |
| APPROVED BY | | | |


BLESSED TEXTILE
SHAHKOT
NANKANA
MOHLAN
132kV BUS
11KV BUS
LEGEND :-
BUS ISOLATOR (HAND/MOTOR OPERATED)
LINE ISOLATOR
CIRCUIT BREAKER
DRAW OUT TYPE CIRCUIT BREAKER
CURRENT TRANSFORMER
POTENTIAL TRANSFORMER
SURGE ARRESTOR
POWER CABLE
POWER TRANSFORMER (TWO WINDING)
EXISTING
FUTURE
NOTES :-
NO. IN SYMBOL INDICATES ITS FUNCTION.
NO. OF UNIT IS INDICATED BY A DIGIT AT THE TOP OF CIRCLE/SQUARE.
T.M.A INTERNATIONAL
132kV WALGAN SOHAIL GRIDSTATION
SINGLE LINE DIAGRAM

## 5- General Informations & Plant Details

| Sr No | Description | Remarks |
|---|---|---|
| 1 | **General Information** | |
| a) | Name of Applicant | Gugera Hydropower Company (Pvt) Ltd (GHC) |
| b) | Registered Office Address | 64 - Ahmed Block, New Garden Town, Lahore |
| c) | Plant Location | Upper Gugera Canal at RD 214+500, District Nankana |
| d) | Type of Facility | Very Low Head Small Hydro Power Plant, Water turbines |
| | | |
| 2 | **Plant Configuration** | 3 Units (Each has One Turbine + One Generator + One Transformer) |
| a) | Gross Capacity of the Power Plant | 3*1.2 MW |
| b) | Type of Technology | Hydro Power Plant with Kaplan Type Water turbines. |
| c) | Number of Units / Capacity | 3 units each of 1.2 MW Capacity |
| d) | Power Plant Make and Model | Horizontal Kaplan Turbines, make and model shall be provided after detailed EPC Design |
| e) | Commissioning Date | Dec 2019 |
| | | |
| 3 | **Fuel Details** | |
| a) | Type of Fuel | Hydro Power Generation needs no fuel except Water flows |
| b) | Fuel (Imported /Indigenous) | Indigenous Canal Water flow |
| c) | Fuel Supplier | N.A |
| d) | Water Use Agreement | An Agreement will be signed With Irrigation Department, Govt. of Punjab. |

Gugera Hydro Power Co.

| | | |
|---|---|---|
| **4** | **Emission values** | |
| a) | Sox | NA |
| b) | NOx | NA |
| c) | CO | NA |
| d) | PM 10 | NA |
| | | |
| 5 | **Gross Installed Capacity** | 3.6 MW |
| | | |
| 6 | **De-rated Capacity** | No de-rating, if any shall be provided later |
| | | |
| 7 | **Expected Life of the Facility** | 3 years of Construction phase & 30 years of Operation phase. |
| a) | Operation Record | There is no Operation Record as this is new plant |
| **8** | **Plant Characteristics** | |
| a) | Generating Voltage | 11 KV |
| b) | Frequency | 50 Hz |
| c) | Power Factor | Leading 0.95 and Lagging 0.85 |
| d) | Automatic Generation Control | Yes |
| e) | Ramping Rate | Quick Start (to be provided at EPC design stage) |
| f) | Alternative Fuel | Only UGC water flows required. |
| g) | Auxiliary Consumption | 36KW (1%) |
| h) | Time required synchronizing | Very Quick Start (to be provided at EPC design stage) |

Gugera Hydro Power Co.

| | | |
|---|---|---|
| 9 | **Schedule H** | |
| | The Net Capacity of the Licensee's Generation Facility | |
| a) | Gross Installed Capacity of the Plant (ISO) | 3.6 MW |
| b) | De-rated Capacity of the Plant | No de-rating, if any shall be provided later |
| c) | Auxiliary Consumption of the Plant | 36 kW (1%) |
| d) | Net Capacity of the Plant | 3564 kW |
| e) | Construction Period | 1080 days (3 years) including EPC Design |
| f) | Expected C O D of the Plant | December 2019 |

## 6- Availability of Land, Its Acquisition and Compensation

As per approved Feasibility Report by PPDB, Govt. of Punjab, the Gugera HPP shall be constructed on the by- pass of Gugera Canal to its right side. 15 hectares of land will be required for construction of the Project comprising Headrace, Power House Complex, Tailrace and allied infrastructure. The Land is available for its acquisition, although it is under cultivation by the local farmers. Based on the site visit observations, it is certified that there is no worth-mentioning structure at site.

Regarding ownership of the land, project site has been visited many times and interview of the farmers has been conducted. For verification of the ownership of the cultivated land, Canal Patwari of the Area was also consulted. The land is owned by many farmers, size of the individual piece of land ranges between 1 Kanal to 10 Acres. In this regard the list of the owners of the land is attached herewith.

Against acquisition of land, compensation to the farmers will be made in two phases. During construction phase, temporary compensation will be made for the land required for construction of the Project, temporary camps of labor/staff, storage of the E&M equipment and construction machinery at site. Construction period from mobilization at site to COD of the Plant is expected 3 to 4 years. During this construction phase, **the farmers will be compensated through payments on annual lease basis at more than prevailing rates around the project area.**

During construction of the Plant, the land essentially required for the Project over its life cycle shall be evaluated and compensation to the farmers shall be made against the land occupied on permanent basis (2nd phase of land compensation). The rates of the cultivated land shall either be determined by the district Govt. of Nankana sahib or direct negotiation between the concerned farmers and the project company Owner. Regarding land compensation rates, we don't foresee any sort of enforcement or harassment of any kind to the farmers. We pledge to make the payments to the farmers/land owners at the fairly reasonable rates acceptable to them.

It is pointed out that environmental impact regarding use of cultivated land by the Project, shall be kept at minimum by reviewing the overall Layout of the Project during detailed design and selection stage of the EPC Contractor. It would be more prudent if Gugera HPP is constructed right on the Gugera Canal either at RD 214 + 500 or RD 220+750, thereby virtually requiring no cultivated land being owned & used by the private farmers, however, it will be only Irrigation Canal and its ROW on both side of the banks.

Gugera Hydro Power Co.

| Sr. No. | Owner Name | Land Size |
|---|---|---|
| 1. | Mohammad Nawaz Bhatti S/o Abdul Haq Bhatti | 3 Acres |
| 2. | Tariq Mehmood S/o Mohammad Ishaaq | 2 Acres+4 Kanal |
| 3. | Ilyaas S/o Nazir Arain | 3 Acres |
| 4. | Mushtaq S/o Nazir Arain | 2 Acres |
| 5. | Sarwa S/o Mohammad Shafi Rajpoot | 1 Acre+4Kanal |
| 6. | Fayyaz S/o Sadiq Rajpoot | 2 Acres+4Kanal |
| 7. | Arshad S/o Sadiq Rajpoot | 2 Acres+4Kanal |
| 8. | Abdul Haq Bhatti S/o Anwar Rajpoot | 1 Acre |
| 9. | Mohammad Anwar Bhatti S/o Lal Din Rajpoot | 1 Acres+4Kanal |
| 10. | Ishaq S/o Lal Din Rajpoot | 2 Acres |
| 11. | Imran Bhatti S/o Sarwar Bhatti | 1 Acre |
| 12. | Bashir S/o Noor Mohammd Arain | 2 Kanals |
| 13. | Lateef S/o Noor Mohammad Arain | 2 Kanal |
| 14. | Mohammad Mukhtar | 1 Kanal |
| 15. | Fayyaz S/o Shoukat Ali Rajpoot | 10 Acres |
| 16. | Mohammad Farooq S/o Riaz | 5 Acres |
| 17. | Sardar S/o Chiragh Din Arain | 7 Acres |
| 18. | Shahjahaan S/o Jhangir Khan Rajpoot | 4 kanals<br>45Acres+4Kanal |

Gugera Hydro Power Co.

## 7- Cost of Project

Hydropower is a capital-intensive technology with long lead-times for development and construction due to the significant feasibility, planning, design and civil engineering works required. The capital costs of large hydropower projects are dominated by the civil works, the costs of which are influenced by numerous factors pertaining to the site, the scale of development and the technological solution that is most economical. Hydropower is a highly site-specific technology where each project is tailor-made for a particular location within a given canal/river-basin to meet with specific needs for energy and water management accordingly. An analysis reveals that around three-quarters (75%) of the total investment costs of hydropower projects are driven by site-specific elements that impact on the civil engineering design and costs. Proper site selection and hydro scheme design are therefore, key challenges and detailed work at the design stage can avoid expensive mistakes.

In some instances the hydropower capital cost is compared with other technologies and "capital cost comparison" is considered as one of the key factors in decision making. In our view, comparing the capital cost of various technologies in isolation without considering other factors (like fuel cost impact) may lead to wrong decision making at policy levels. While the Power Purchaser and the regulator have all the right and mandate to validate the prudency of the capital cost, however, due consideration should be given to the substantial fuel cost savings in the decision making. It would not be prudent decision to discard or delay the hydropower on account of high capital cost when a typical 100 MW hydro project will recover its full capital cost only in three years on account of fuel savings only. Conclusively, it is expressed that whenever power-project options are considered, not only capital specific cost Per KW or MW but also Energy Cost Per KWh over the entire life span, should also be taken into account for the sake of true comparison and prudent decision making for the benefits of electricity consumers, in general and the Nation, in particular.

Keeping in view the above mentioned facts, total Project Cost at the price level of December 2014, has been calculated after thorough analysis and understanding of the factors that affect the development, construction and operation of a hydro power project. Break-up of the Total Project Cost is provided below:

| **Cost Head** | **Project Cost (Rs Million)** |
|---|---|
| EPC Cost | 1223 |
| Project Base Cost | 1398 |
| Total Financial Cost of Project | 1797 |

# PLANNING AND DEVELOPMENT PROPOSAL

## 8.1 Understanding of Project Development and Planning

## 8.2 Timeline for Major Milestones

## 8.3 Methodology

## 8.1 Understanding of Project Development

### Pakistan's Energy Scenario

The economic stability of developing countries like Pakistan depends upon the growth of the energy sector to influence social prosperity and long-term planning for utilization of domestic energy resources. Pakistan has been facing an unprecedented energy crisis since last few years. Its current energy demand far exceeds its indigenous supplies, fostering dependency on imported oil that places substantial burden on economy of the country.

In order to ensure security of our energy supplies, the Government of Pakistan are required to pursue policies of increasing our domestic supplies, attracting foreign investment, diversifying imports to include natural gas, coal and electricity, encouraging economic inter-fuel substitution, promoting energy efficiency and renewable energy, and supporting regional and interregional cooperation. In order to make Pakistan an ideal location for foreign private investment, it requires providing a deregulated transparent and level playing field to all.

Hydel power is considered as one of the cheapest and environment friendly sources of energy, however, after construction of Mangla and Tarbela reservoir-based power generation projects, no major project was constructed with the exception of Ghazi Barotha Hydropower Project which is a peaking plant.

National demand of electricity has been and would keep on growing rapidly. Based on the present generation capacity, the hydel : thermal mix in the country is 29.4:67.3, which is almost the reverse of an ideal hydel – thermal mix, which should be 70:30 for overall economic development of Pakistan. Though induction of thermal generation initially helped in overcoming load shedding, it resulted in substantial increase in power tariff. Therefore, a sizeable injection of cheap hydropower is a viable option to keep the cost of electricity within affordable limits.

To achieve the above objectives, the GOP plans to concentrate on the water and power projects in the next few years that includes; (i) Construction of large dams for Public/Private Partnership; (ii) Construction of medium/small water storage dams (iii) construction of medium/small run-of-river hydropower projects (iv) construction of canals (v) construction of transmission lines for dispersal of power from hydropower project to load centres of national grid. These projects would create additional water storages, generate cheap indigenously developed electricity and prevent flood damages. All these measures would also ensure food security, employment generation and above all poverty alleviation.

Gugera Hydro Power Co.

## The Project

The Sponsors understand that 3.6 MW Gugera Hydropower Project will be developed in private sector and will be awarded through a competitive bidding process for **a raw site** as elaborated in Punjab Power Generation Policy 2006 (the "Power Policy") on BOOT basis (Build, Own, Operate and Transfer) with concession terms of around 30 Years plus construction period and will be transferred to Government after completion of term.

The Project is having following merits:

i) Relatively better law and order situation in Punjab
ii) Government of Pakistan keen interest for fast-track development of the Project;
iii) Robust Power Policy with good fiscal/financial incentives for investors;
iv) Availability of Sovereign Guarantee to cover the payment obligations of power purchaser and governmental entities;
v) Relatively easy accessibility for Project site.
vi) Fast-track development is possible.

## The Power Policy

Under Punjab Power Generation Policy 2006 announced by Government of Punjab, Private Power Development Board ("PPDB") will provide One Window Facility to the Private Investors for development of project.

Salient features of the Power Policies are as follows:

i) Exploitation of indigenous resources including hydel, coal, gas and renewable resources.

ii) '*Hydropower*' projects on BOOT basis;

iii) Balanced risk profile for investors, lenders and government agencies through time-tested institutional and legal framework

iv) Independent Regulator for balancing interests of consumers and power companies

v) Multi-Year, Long-term Tariff approved by the regulator NEPRA

vi) Attractive and competitive return on investment allowed by the NEPRA

vii) Long-term Security Package including Implementation and Power Purchase Agreements, and Water Use Agreement (for Hydropower Projects)

viii) Two-part tariff structure consisting of fixed '*Capacity*' and variable '*Energy*' components

ix) *Capacity Payments* to cover fixed costs, i.e. Fixed O&M, Debt Servicing, and Return on Equity (ROE); independent of project/energy despatch

x) 5% concessionary Customs/Import Duty on Plant & Equipment not manufactured locally

xi) No levy of Sales Tax on such plant, machinery, and equipment

xii) Exemption from corporate *Income Tax* and *Turnover Tax*

xiii) Exemption from *Withholding Tax* on imports

xiv) 100% foreign ownership allowed with minimum 20% equity contribution requirements

xv) Sponsors can divest equity after six (6) years of project commissioning

xvi) Conversion of Pak Rupee and remittance of Foreign Exchange for project-related payments ensured by GOP

xvii) Responsibility of power transmission facilities rests with the Power Purchaser

xviii) Continuity of payments in case of Political Force Majeure

xix) Bailout Opportunity for the lenders and investors through Compensation payments in case of political force majeure, changes in law and GOP/Power Purchasers events of default

xx) Pass-through of additional taxes/costs incurred due to Change in Law

xxi) Adjustments in Tariff for changes in Benchmark Interest Rates (LIBOR/KIBOR)

xxii) Compensation Payment in case of project termination due to GOP default

xxiii) Foreign component of fixed and variable O&M Cost to be indexed with US CPI

xxiv) Term of concession period for hydropower projects is up to 30 years

xxv) For hydropower projects, *Hydrological Risk* to be borne entirely by the Power Purchaser (CPPAG)

xxvi) Foreign debt may be obtained by IPP in US Dollar, Pound Sterling, Euro and Yen; periodic adjustments in the Debt Service Component of tariff will be made to cover exchange rate variation for these currencies

xxvii) For foreign O&M costs, adjustment for exchange rate variations between Pak Rupee and US Dollar have been allowed

xxviii) Upfront Tariff regime whereby NEPRA allows a reasonable tariff after taking into account reasonable cost of the low head hydropower;

xxix) ROE will be adjusted for variations in US Dollar / Pak Rupee rates

**Concession Documents**

The Concession Documents includes Implementation Agreement, Power Purchase Agreement and Water Use Agreement. The Concession Documents entails the responsibilities of the parties and translate the above referred Policy concessions as contractual obligations of government entities. Above all, in order to make project bankable, a sovereign guarantee is to be provided by GOP to guarantee the payment obligations of Power Purchaser and Punjab government and for indemnification of cost, loss and liability of Company in case obligations under the concession documents becomes unenforceable, illegal or invalid.

**Required Consents & Permissions**

| | |
|---|---|
| 1. | Generation License for SPV from NEPRA |
| 2. | Approval of Upfront Tariff from NEPRA |
| 3. | Environment Impact Assessment NOC from EPA, |
| 4. | Land Acquisition Notifications from Land Collector |
| 5. | Price Assessment & Land Lease Agreements with Land Collector |
| 6. | NOC from Government Entities requiring resettlement i.e. Railway Line, Highways, Transmission Line, Gas Pipeline etc. |
| 7. | Company Registration with SECP |
| 8. | Insurance Consents from Ministry of Commerce, GOP |
| 9. | Consents from SBP for Foreign Currency Accounts |
| 10. | Consent from SBP for registration of loan |
| 11. | Consent from SBP for registration of Re-payment schedule |
| 12. | Consent from SBP for repatriation of dividends |
| 13. | Consent from SBP for availability of Foreign Exchange |
| 14. | Consent from SBP for pledging the Shares in favour of Lenders |
| 15. | Consent from Government of Punjab for supplying electricity, use of electricity within complex and to connect the complex to earth |
| 16. | Registration of Company as Industrial Consumer |
| 17. | Approval of Term Sheets from PPDB |
| 18. | Approval of EPC Contract and EPC Contractor (sub-contractors), from PPDB |
| 19. | Approval of O&M Contractor and O&M Contract from PPDB |
| 20. | Consent to store petroleum products |
| 21. | Permission to obtain armed license |
| 22. | Exemption to the Company from excavation tax |
| 23. | Arrangement of visas and security for foreign delegation |

**Stages Involved in developing Project**

i) Approval of Feasibility Study from PPDB;
ii) Application and approval of Generation License from NEPRA;
iii) Preparation and approval of Interconnection Study from LESCO;
iv) Incorporation of SPV to carry out the Project;
v) Preparation and approval of Upfront Tariff by NEPRA;
vi) Tender Documents and Bidding Process for EPC Contract;
vii) Financing arrangements;
viii) Preparation of and approval of Initial Environmental Examination (IEE);

Gugera Hydro Power Co.

ix) Land Acquisition & Resettlement;
x) Finalization of all concession documents including Implementation agreement and Water Use Agreement;
xi) Due Diligence of Lenders;
xii) Power Purchase Agreement;
xiii) Projects budgets and costs;
xiv) Commercial and contractual matters of EPC Contract;
xv) Insurance arrangements for the Project;
xvi) Commercial and contractual matters of O&M arrangements;
xvii) Commercial and contractual maters of Owner's Engineer;
xviii) Land lease arrangements;
xix) Environment, health and safety approvals and compliance;
xx) Government relationships and community relationships;
xxi) Issuance of all consents and approvals required for the Project.

- **Potential Difficulties & Remedies**

The Project Sponsors foresee major impediments in following:

i) Land Acquisition and its requirements from relevant authorities
ii) Resettlement of Government Structures and NOC from relevant authorities
iii) Environment Approval/NOC from EPA
iv) Interconnection & Transmission Issues
v) Negotiation with Power Purchaser & NEPRA for tariff including timeline
vii) VISA & security arrangements of Ex-pats
viii) State Bank's approval

## 8.2 Timeline of Major Milestones

- A detailed timeline for major activities and sub-activities in shape of monthly bar chart with respect to development/implementation of the Project is attached.

According to the Sponsors, following is the project implementation schedule:

| | | |
|---|---|---|
| 1 | Submission of PQD to PPDB, Issuance of LOI, Preparation of Feasibility Report by Sponsors & approval by PPDB. | 12 Months |
| 2 | Grant of Generation Licence & Tariff approval by NEPRA, EPA signing with CPPAg, Financial Closing, EPC Contractor selection, Approval of Detail Design & EPC Contractor mobilization at Project site | 18 Months |
| 3 | Physical Construction activities of the Project leading to testing and commission of the plant. | 24 Months |
| 4 | Target COD of Plant | June 2020 |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# 8.3 Methodology

The methodology for development of the Project would include the various activities and the 10 major areas of control and responsibility are:

(i) Obtaining LOI from concerned agency (PPDB, Govt Punjab)
(ii) Preparation of feasibility report by sponsors & approval by Govt Punjab.
(iii) Environment, health and safety approvals and compliance.
(iv) Submission of application for generation license for approval by NEPRA.
(v) Tariff arrangements & NEPRA approval.
(vi) Singing of Energy Purchase Agreement.
(vii) Financing arrangements
(viii) Selection of EPC Contractor.
(ix) Owners Engineer arrangements
(x) Concession Agreements
(xi) Land Acquisition & Resettlement entitlement framework
(xii) O&M Contract & arrangements
(xiii) Placement of Project Insurances;

## Financing

The Sponsors plans to involve Local banks in the financing of the Project. In addition, possibility of involvement of multilaterals like ADB and IFC shall also be explored. Since the framework for development of private hydro power project is now fairly stable and under place; coupled with robust Power Policy; the Sponsors foresee that local and international banks would be interested in the transaction. The prime activities involved in the financing are:

- ✓ Arrangement of financing of the Project
- ✓ Appointment of Lenders Technical Advisor, Legal Counsel, Insurance Advisors and Financial Model Auditors
- ✓ Managing the due diligence (technical, financial and legal) by the Lenders
- ✓ Preparation of Information Memorandum and development of Financial Model
- ✓ Negotiations and finalization of Term sheets
- ✓ Negotiations and finalization of all Finance and Security Documents
- ✓ Satisfaction of conditions precedents to achieve the Financial Closing

## EPC Contract

As customary in limited recourse project financing, the construction of the Project shall be carried out based on "fixed price, time certain and turnkey" EPC Contract. The EPC Contractor shall be selected and appointed through "competitive bidding process" to ensure transparency and competitiveness. To make the bidding process transparent and meaningful, the Sponsors shall prepare detailed tender design along with the proposed EPC Contract (including detailed project requirements). A standard RFP will be issued to all the bidders and bidders shall be required to include at the minimum following information in their bids (i) Technical Proposal, (ii) Financial Proposal, (iii) BOQs, (iv) any deviations from Tender Design and the (v) vendors list for the E&M equipment. Following the receipt of bids from contractors, a detailed evaluation (technical as well as financial) shall be carried out by an independent party which shall serve as the basis for selection of EPC Contractor. The key milestones involved are:

- ✓ Preparation of Tenders Design and Documents
- ✓ Preparation of EPC Contract and detailed Project Requirements
- ✓ Issuance of RFP to contractors
- ✓ Independent evaluation following receipt of bids
- ✓ Award Letter to selected EPC Contractor
- ✓ Ensuring all technical specifications are in line with prudent practices and NEPRA Grid Code
- ✓ Negotiations of EPC Price and EPC Contract
- ✓ Approval of the EPC Contract and its terms and conditions from the Government, Power Purchaser and the Lenders
- ✓ Signing of EPC Contract

## Owner's Engineer

The Owner's Engineer role is pivotal in successful implementation of a hydropower project. Owner's Engineer role is primarily to carry out design review, construction monitoring, QA/QC and milestone completion certifications after physical check. Owner's Engineer ensures that Project is being constructed according to design, project requirements, EPC Contract and international and prudent practices. The Owner's Engineer role is critical for the fact that each hydropower project has unique site conditions and distinctive features and involves a high content of civil works which demands stringent construction monitoring.

To effectively play its role Owner's Engineer requires strong team of experts and professionals on site (for construction monitoring) and offsite (for design review). The Sponsors shall appoint a consultant consisting of a mix of foreign expats and local expertise for the construction monitoring and design reviews of the Project. The activities to be done for this are:

- ✓ Selection and appointment of most suitable Owner Engineer through competitive bidding
- ✓ Estimation of budgets and resources
- ✓ Drafting and negotiations of Owners Engineer Contract
- ✓ Getting the approval of OE Cost from the Power Purchaser & NEPRA
- ✓ Approval of the OE structure and contract from the Lenders
- ✓ Signing of OE Contract

## Concession Documents

Concession Documents will comprise of Implementation Agreement and Water Use Agreement with Government of Punjab. Implementation Agreement provides the framework under which the Company will implement the Project and sets out fundamental obligations of the Company and Government with respect to implementation of the Project. In the event that the Government terminates the Implementation Agreement it is obliged to pay compensation to the Company, thus securing the investments made in the Project. The Water Use Agreement between the Company and the Government of Punjab primarily is a consent given to the Company to utilize the water for the generation of electricity.

The GOP shall, at Financial Closing, execute and deliver to the Company, the Guarantee. The GOP Guarantee is an irrevocable and unconditional guarantee and the key document in the overall structure. Under this document the GOP guarantees the payment obligations (including monetary damages assessed) of all the Power Purchaser under the Power Purchase Agreement, and the Government of Punjab under the Water Use Agreement. The key activities involved in this milestone are:

- ✓ Drafting of Concession Agreements
- ✓ Negotiations of Agreements with the Government
- ✓ Approval of the concession documents from Lenders
- ✓ Signing of Concession Agreements

**Power Purchase Agreement**

The Power Purchase Agreement shall be signed with CPPAG for a term of 30 years after Commercial Operations Date. Under this Agreement, the Company shall be obligated to make available to the Power Purchaser, the Tested Capacity (as applicable from time to time) from the Plant.

The Power Purchaser is obligated to purchase and the Company is obligated to deliver NEO (the net electrical energy delivered by the Company to the Interconnection Point for sale to the Power Purchaser) produced (i) after Commercial Operations Date at agreed tariff (ii) during testing and commissioning prior to COD rate to be mutually agreed. The key activities involved are:

- ✓ Approval of upfront tariff by NEPRA
- ✓ Drafting and negotiations of Power Purchase Agreement
- ✓ Ensuring that PPA is consistent with technical and commercial requirements of the Project
- ✓ Signing of PPA

**Tariff Arrangements**

The Upfront Tariff approved by NEPRA has two basic components: Energy Purchase Price ("EPP"-Variable Component) and Capacity Purchase Price ("CPP"-Fixed Component). The EPP component of the tariff is based on the actual dispatch of the plant. It comprises of Water Use Charges and variable O&M costs. The CPP is the payment made for components that are independent of the amount of actual generation and ensures the smooth functioning of the plant and returns of the investors. The CPP comprises of (i) Fixed O&M cost, (ii) Insurance cost, (iii) Return on Equity (ROE), (iv) Return on Equity During Construction (ROEDC), (v) Debt Servicing (Principal and interest). Along with EPP and CPP, certain indexations and one-time adjustments are also allowed under the Power policy 2002 to maintain 17% IRR stream of the investors. The key activities involve are:

- ✓ Development, drafting and finalization of "Upfront Tariff Proposal"
- ✓ Approval of Upfront Tariff by NEPRA
- ✓ Acceptance of approved Upfront Tariff by CPPAG
- ✓ Ensuring that Project Tariff covers all the legitimate costs incurred for the benefit of the Project

**Land Lease**

Site/Land acquisition is one of the most critical processes in the development of the Project. The area required for the construction of the Project (as per design criteria) shall be



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demarcated through installation of monuments. The listing of ownership shall be done to identify the land owned by Government and the land owned by private parties.

The Government land shall be leased to the Company for a period of thirty (30) years after COD i.e. the term of the Project. However, the private land shall be acquired from the private parties under the provisions of Land Acquisition Act 1894. The key activities to be carried out are:

- ✓ Demarcation of the Land as per required NOL
- ✓ Listing of ownership record of the land with the coordination of local administration of Government
- ✓ Filing of land lease applications
- ✓ Public consultation with the community to take them on board for the Project
- ✓ Negotiations of the rates of the land lease and compensation with the Government
- ✓ Negotiations and finalization of land lease agreements
- ✓ Ensuring that all land lease costs are part of approved tariff
- ✓ Approval of the lenders for overall land lease arrangements

## Insurance Arrangements

An overall Project Insurance Program, covering certain risks of construction and operations phase of the Project, shall be arranged by the Company; however construction phase insurances shall be largely placed offshore. To assist in this, the Company shall appoint and seek guidance of international reputable insurance broker/advisor. The typical insurances placed during construction and operational phase of the Project are given below:

| ***Construction Phase*** | ***Operational Phase*** |
|---|---|
| *Construction "All Risks" Insurance* | *"All Risks" of Physical Damage Insurance* |
| *Construction Delay in Start-Up Insurance* | *Business Interruption Insurance* |
| *Marine Transit Insurance* | *Terrorism Asset & Revenue Protection* |
| *Marine Transit Delay in Start-Up Insurance* | *Third Party Liability Insurance* |
| *Terrorism Asset & Revenue Protection* | |
| *Third Party Liability Insurance* | |

- ✓ Appointment of Company Insurance Advisor
- ✓ Arrangement of the insurance of the Project on best suitable rates under advise of the Insurance Advisor
- ✓ Arrangement of all reinsurances of the Project
- ✓ Approval of the insurance terms from the Power Purchaser and the Lenders

## O & M Arrangements

An Operations and Maintenance Contractor shall be appointed by the Company for the operations of the Plant following commercial operations date. The Operator shall be mobilized at site six to eight months prior to commercial operations to ensure smooth taking-over of the Plant from the EPC Contractor. During this mobilization phase the Operator shall run the individual units (partial completion) under the supervision of the

EPC Contractor. However, following COD, the Operator shall be responsible for all the on-going maintenance and repair works of the Plant and will bear all the cost of routine work. The activities involved in this process are:

- ✓ Circulation of RFP for O&M of the Project
- ✓ Evaluation of bids and selection of O&M Contractor
- ✓ NOC of O&M Contract and Contractor from Government
- ✓ Negotiations of the O&M Contract
- ✓ Ensuring the O&M Costs are consistent with the approved tariff and project budgets
- ✓ Approval of O&M Contract and O&M Budget from the Lenders

## Environment Health & Safety

Under Section 11 of the 2000 Act, a Project falling under any category (qualifying IEE or EIA) requires the proponent to file IEE or EIA with the Pak-EPA. The Pak-EPA has published a set of environmental guidelines for conducting environmental assessments and the environmental management of different types of development projects. Other important policy documents and legal requirements of the project are: National Environmental Quality Standards (NEQS), National Resettlement Policy and Ordinance, The Land Acquisition Act, 1894, The Forest Act, 1927 and the Forest (Amendment) Act 2010, The Motor Vehicles Ordinance, 1965, and Rules, 1969, The Factories Act, 1934, The Pakistan Penal Code, 1860, The Explosives Act, 1884. Besides providing overview of Policy, Legal and Administrative Framework, the section 2 also adumbrates guidelines of ADB and requirements of IFC related to the project. Additionally to save time and effort the IEE shall be prepared in compliance with IFC Performance Standards and ADB Guidelines. To ensure environmental compliance, various studies to be conducted by the Company are:

i. Initial Environmental Examination (IEE Study)
ii. Land and Resettlement Action Plan (LARP)
iii. Ecological Flow Assessment including Drift Model
Health & Safety Plan
iv. Contingency Plan
v. Environment and Social Issue Management Plan

In addition to this, the Company shall be required to:

- ✓ Get approval of above documents from various stake holders including Government and Lenders
- ✓ Ensuring compliance with health and safety requirements for the Project and the Company
- ✓ Managing community relationships and implementation of the CSR program

## Project Implementation Schedule

Implementation Period for the Project is anticipated 48 months (24 months for planning, designing and tendering+24 months for construction) which includes revision of Feasibility Reports/development of Plant Design, preparation of Bid Documents, Evaluation of Bids and award of EPC Contract, mobilization at site, detailed-design, procurement, transportation, construction, testing & commissioning of the Plant and Equipment. It is anticipated that the Project will be constructed in a period of 36 months under the terms of turnkey EPC Contract for

Civil-Works, E&M equipment supply, installation and commissioning including 12 months for detailed designing and mobilization at site.

## 9- Annexures & Attachments

Supporting documents required in the **Check List Schedules,** are attached in the form of **Annexures**.

**Three sets of Feasibility Report** each comprising Vol I&II duly approved by PPDB, **IEE Report** duly approved by EPA Punjab and **Grid Interconnection Study Report** duly approved by LESCO, are attached with the Application being submitted to NEPRA for the grant of Generation License to the Company.

## 9- Annexures & Attachments

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# Gugera Hydro Power Co.

64-Ahmad Block, New Garden Town, Lahore, Pakistan
**Tel:** +92 42 35851559-60 **Fax:** +92 42 35832796


**Regulation No 3(1) Annexure 2.1**

September 15, 2016

## Resolution of Board of Directors

The Gugera Hydropower Company (Pvt) Ltd (GHC) has been established in pursuance of Section-32 of the Companies Ordinance 1984. The Board of Directors resolved as under:

"Resolved to authorize the Chief Executive Officer of the Gugera Hydropower Company (Pvt) Ltd to file the Application for Generation License with NEPRA on behalf of GHC".

With best regards

Tariq Mahmood

Company Secretary
Gugera Hydropower Company (Pvt) Ltd. (GHC)

SAMBU
CONSTRUCTION CO.,LTD.

Da. 60

H856564

100
Rupees

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روپیہ

Annexure 2.1 (a)

Before

The NATIONAL ELECTRIC POWER REGULATION AUTHORITY (NEPRA), Islamabad

AFFIDAVIT

I, Nasir Ahmed Malik s/o Tahir Ahmed Malik, Chief Executive Officer of Gugera Hydropower Company (Pvt) Ltd(GHC) , 64-Ahmed Block , New Garden Town, Lahore do hereby solemnly affirm and declare that

a) I am the CEO and authorized representative of the Gugera Hydropower Company (Pvt) Ltd (GHC).

b) The contents of the accompanying Application dated 25-09-2016 for approval of the Generation License by NEPRA, including all the documents in support of 3.6 MW Gugera Hydropower Project, are true and correct to the best of my knowledge and belief and that no material or relevant thereto has been concealed or withheld therefrom.

c) I also affirm that all further documentation and information, if any, to be provided by me in connection with the accompanying Application for the Generation License (Hydro Electric Project), shall be true to the best of my knowledge and belief.

DEPONENT

Nasir Ahmed

**AL-SHAHZAD Associates**

شہزاد خان اشٹام فروش

لائسنس نمبر (723) دکان نمبر 11 ڈسٹ شان آرکیڈ برکت مارکیٹ نیو گارڈن ٹاؤن لاہور

تاریخ 23.9.16 نمبر شمار 4242 مالیت 100/-

نام [illegible] ولد [illegible]

بذریعہ [illegible]

برائے [illegible] سکنہ NEPRA

دستخط اشٹام فروش

0300-8050378

Annex-2.2

A007353

SECURITIES AND EXCHANGE COMMISSION OF PAKISTAN

SECP

COMPANY REGISTRATION OFFICE, LAHORE

Company Registration Office Lahore

Securities and Exchange Commission of Pakistan

SECP

# CERTIFICATE OF INCORPORATION

[Under section 32 of the Companies Ordinance, 1984 (XLVII of 1984)]

Corporate Universal Identification No.**0096649**

I hereby certify that **GUGERA HYDRO POWER COMPANY (PRIVATE) LIMITED** is this day incorporated under the Companies Ordinance, 1984 (XLVII of 1984) and that the company is **Limited by Shares.**

Given under my hand at **Lahore** this **Eleventh** day of **December,** Two **Thousand** and **Fifteen**.

**Fee Rs.52,000/-**

CERTIFIED TO BE TRUE COPY

29/12/

DEPUTY REGISTRAR OF COMPANIES
COMPANY REGISTRATION OFFICE
LAHORE.

**( SHAUKAT HAMEED )**
**Joint Registrar**

**No.ARL/** 12933 **DATED: 11-12-2015**

(2)

Annex-2.3



# THE COMPANIES ORDINANCE, 1984

Company Registration Office Lahore
Securities and Exchange Commission of Pakistan
SECP

## (COMPANY LIMITED BY SHARES)

# MEMORANDUM

# AND

# ARTICLES OF ASSOCIATION

# OF

# GUGERA HYDRO POWER COMPANY (PVT.) LIMITED

# THE COMPANIES ORDINANCE, 1984

--: 0 :--

## (Company Limited by Shares)

--: 0 :--

## MEMORANDUM OF ASSOCIATION

## OF

# GUGERA HYDRO POWER COMPANY (PVT.) LIMITED

I. The name of the Company is **GUGERA HYDRO POWER COMPANY (PVT.) LIMITED.**

II. The registered office of the Company will be situated in the province of Punjab.

III. The objects for which this company is formed are all or any of the followings (and in construing the following such clauses the scope of no one clause or sub-clauses shall be deemed to limit or effect the scope of any other sub-clauses) subject to the restriction or permission required under the law.

1) To set up Hydro Electric Power Generation project and complex which includes, to supply and sell Electricity, and undertake all such functions as are associated, linked or ancillary thereto and do all such acts, deeds or things as would be required for effective discharge of this object subject to permission from NEPRA/other regulatory authorities.

2) For the purposes of achieving the said object, the Company is authorized to do all and everything necessary, suitable, proper, incidental or conducive to the accomplishment of the foregoing object and to do every other act or thing incidental or appurtenant to or arising out of or connected with the foregoing object, provided that the same shall be lawful, including the following:

a) To acquire land, buildings, machinery, plant, equipment, spare parts, raw materials, natural fuel supplies and related goods and services necessary and/or incidental to the development, ownership, Construction, Management, Operation and maintenance of the Complex.

b) To establish and maintain housing, transportation, communication and utility lines and other requisite logistic facilities for the construction, operation and maintenance of the Complex subject to approval of concerned authority.

c) To secure, subject to approval of the Government of Pakistan, foreign equity and technical collaboration of the development ownership, construction, operation and management of the Complex.

d) To obtain loans, credit and financial facilities in local and/or foreign currency from banks and other financial institutions operating in Pakistan and subject to necessary approval of the Government of Pakistan, financing from international sources, proceeds of which are to be used for the development, ownership, construction, operation and maintenance of the Complex

e) To secure loan, credit and financial facilities obtained for the development, ownership, construction, management, operation and maintenance of the Complex by creating mortgages, charges, hypothecation and other encumbrances on the properties and assets, immovable, movable and intangibles, of the Company in such manner and on such terms and conditions as the Directors of the Company may determine or approve.

f) To enter into any arrangement or agreement with purchasers of power from the Complex.

g) To enter Into contracts for the purchase of fuel for the Complex, for construction of the Complex, for operation and maintenance of the Complex and other agreements as may be necessary in the conduct and furtherance of business of the Company and to take all actions before competent forums for the enforcement of such agreements and contracts.

h) To take out any insurance that the Company deems necessary or appropriate in connection with the ownership, construction operation and maintenance of the Complex and to pay the premium thereof.

i) To enter into any arrangement with, obtain consents and approvals of secure interim and final orders from the Government of Pakistan, and any other governmental agency or body and to undertake efforts to promote or modify laws, regulations and policies, and where required, to seek like dispensation from any government or public authority or any corporation or private persons, or any foreign government, authority or person to further the development, ownership, construction, management, operation or maintenance of the Complex and to oppose by legal means within or outside Pakistan any actions or measures as are taken by any governmental or other authority which the Company considers likely to adversely affect the development, ownership construction, management, operation or maintenance of the Complex and to obtain or endeavor to obtain from any governmental or other public authority any charters, contracts, rights, grants, loan, subsidies, privileges, concessions indemnities, sanctions or consents as the Board of Directors may think proper for the development, ownership, construction, operation or maintenance of the Complex.

j) To guarantee the performance of contracts and obligations (including payment of loans) of any person providing goods or services in connection with the construction, operation or maintenance of the Complex or purchasing electricity generated by the Complex but not in any event to carry on the business of banking.

k) To institute and defend for promoting or protecting the interests of the Company in any legal forum or proceedings, enter into arbitration agreements and refer disputes to arbitration, pay, satisfy or receive payments in respect of or compound or compromise any claim, demand, action, suit or proceedings of any nature made or brought by or against the Company.

l) To support and subscribe to any charitable and benevolent funds and any institution, society or club which may be for the benefit of the Company or its employees, or may be connected with or for the benefit and welfare of any town or place where the Company carries on business; to give pension, gratuities or charitable aid to any persons who may have been employees, Officers or Directors of or may have served the Company, or the wives, children or other relatives or dependents of such persons: to make payments towards insurance and to form and contribute to provident, gratuity, pension and superannuation funds for the benefit of any such persons, or of their wives, children or other relatives or dependents.

m) As may be necessary or appropriate in connection with the development, ownership, construction, management, operation or maintenance of the Complex, to sell, exchange, mortgage or let on lease all or any of the property of the Company and to grant licenses, easements, options, or other rights over the same and to accept such consideration as may be deemed fit for the same, but not to act as a leasing company.

n) To construct, purchase, take on lease or otherwise acquire and provide residential accommodation, recreational, educational and medical facilities for persons engaged and employed for the business of the Company.

o) In connection with the business of the Company, to draw, make, accept, discount, endorse, execute and issue promissory notes, bills of exchange, bills of lading and only in connection with the business of the Company to advance, securities or property to such governmental or other authority, person, firm or company and on such terms, with or without security, as the Company deems fit but in any event not to carry on the business of banking or insurance.

p) To invest in accordance with law any surplus monies of the Company not for the time being required and to hold, sell or otherwise deal with such investments, but not to act as an Investment Company.

q) To obtain any patents, rights, trademarks, licenses, concessions and the like conferring any exclusive non exclusive or limited rights to use any information, invention, process or privilege which may seem capable of being used in connection with the construction, management, operation and maintenance of the Complex and to support research and development in the science and technology employed for the generation of electricity.

r) To pay all costs, charges and expenses, which the Company may lawfully pay with respect to the formation and registration of the Company and in connection with the issuance of its shares.

s) To open, operate and maintain accounts of the Company, whether in local or foreign currency, with banks and other financial institutions within and outside Pakistan, subject to law for the time being in force for retaining, holding and remitting funds of the Company.

t) To hire, engage or employ technical, professional, advisors, consultants and experts to scene guidance, advice or reports in connection with the affairs of the Company and to otherwise hire, engage or employ from time to time such other personnel staff and workers as may be necessary or expedient for conduct and furtherance of the business of the Company.

u) To adopt and ratify any action taken or things done for the promotion of the Company and for the development of the Complex prior to incorporation of the Company and to reimburse any expenses incurred on such behalf up to the date of commencement of business of the Company.

3) Notwithstanding anything stated in any object clause, the company shall obtain such other approval or license from the competent authority, as may be required under any law for the time being in force, to undertake a particular business.

4) It is declared that notwithstanding anything contained in the foregoing object clauses of this Memorandum of Association nothing contained therein shall be construed as empowering the company to undertake or to indulge in the business of banking company, investment, NBFC, leasing, managing agency, payment receipt scheme and insurance business directly or indirectly as restricted under the law or any other unlawful operation. The company shall not launch multilevel marketing, pyramid and ponzi schemes.

IV. The liability of the members is limited.

V. The Authorized Share Capital of the Company is Rupees 10,000,000/- only. (Rs. Ten Million only) divided into 100,000 (one hundred thousand only) ordinary shares having a par value of 100 Rupees (Rs. One hundred only) each. The Company shall have the power to increase, reduce or re-organize the Capital of the Company, subdivide the Share Capital of the Company, into different classes in accordance with the provisions of the Companies Ordinance, 1984.



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We, the several persons whose names and addresses are subscribed below, are desirous of being formed into a Company, in pursuance of this Memorandum of Association, and we respectively agree to take the number of shares in the Capital of the Company as set opposite to our respective names.

| | Name and Surname (Present & Former) In Full (In Block Letters) | Father's/Husband's Name in Full | Nationality with any former Nationality | Occupation | Residential Address (In Full) | Number of shares taken by each subscriber | Signature |
|---|---|---|---|---|---|---|---|
| 1 | Mr. Nasir Ahmad Malik CNIC # **35202-6097137-9** | s/o Tahir Ahmad Malik | Pakistani | Businessman | 64-Ahmed Block, New Garden Town, Lahore | 9,900 (Nine thousand nine hundred) | |
| 2 | Mr. Muhammad Aslam CNIC # **35202-2744007-5** | s/o Muhammad Irshad | Pakistani | Businessman | House # 1, Street # 3-B, Asif Block, Allama Iqbal Town, Lahore | 100 (One Hundred) | |
| | | | | | Total No. of Shares Taken | 10,000 TEN THOUSAND ONLY | |

Dated this 30th day of November, 2015.

Witness to the above Signatures:

National Institutional Facilitation Technologies (Pvt.) Limited
5th Floor, AWT Plaza
I. I. Chundrigar Road,
Karachi, Pakistan

Company Registration Office ★ Lahore ★ Securities and Exchange Commission of Pakistan SECP

1. COMPANY REGISTRATION NO:
2. SERIAL NO OF DOCUMENTS.
3. NAME OF THE COMPANY.
4. BRIEF DESCRIPTION OF THE DOCUMENT INCLUDING ITS ENCLOSURES.
5. THE DATE ON WHICH THE DOCUMENT REGISTERED, FILED OR RECORDED 11-12-15

JOINT REGISTRAR OF COMPANIES
LAHORE REGION

CERTIFIED TO BE TRUE COPY

DEPUTY REGISTRAR OF COMPANIES
COMPANY REGISTRATION OFFICE
LAHORE.



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9

*THE COMPANIES ORDINANCE, 1984*

-:o:-

**(PRIVATE COMPANY LIMITED BY SHARES)**

-:o:-

Company Registration Office Lahore
Securities and Exchange Commission of Pakistan
SECP

# Articles of Association

# of

# GUGERA HYDRO POWER COMPANY (PRIVATE) LIMITED

## PRELIMINARY

1. Subject as hereinafter provided, the Regulations contained in Table 'A' of the First Schedule to the Companies Ordinance, 1984, (hereinafter referred to as Table 'A') shall apply to the Company so far as those are applicable to private Companies, with the exception of the Regulations which are modified, altered or added hereunder.

## PRIVATE LIMITED COMPANY

2. The Company is a Private Company within the meaning of Clause (28) of Section 2(1) of the Companies Ordinance, 1984 and accordingly: -

   (a) No invitation shall be issued to the public to subscribe for any shares, debentures or debenture-stocks of the Company.

   (b) The number of members of the Company (exclusive of persons in the employment of the Company) shall be limited to fifty provided that for the purpose of this provision when two or more persons hold one or more shares in the Company jointly they shall, for the purposes of this clause, be treated as a single member; and

   (c) The right to transfer shares in the Company is restricted in the manner and to the extent hereinafter appearing.

## BUSINESS

3. The Company is entitled to commence business from the date of its incorporation.

4. The business of the Company shall include all or any of the objects enumerated in the Memorandum of Association.

5. The business of the company shall be carried out at such place or places in the whole of Pakistan or elsewhere as the Directors may deem proper or advisable from time to time.

## CAPITAL

6. The Authorized Capital of the Company is Rs. 10,000,000/- (Rupees Ten million only) divided into 100,000 (One hundred thousand only) ordinary shares of Rs.100/- (Rupees One hundred only) each, with powers to increase, reduce, consolidate, sub-divide or otherwise re-organize the share capital of the Company.

7. The shares shall be under the control of the Board of Directors who may allot or otherwise dispose off the same to such persons, firms, corporation or corporations on such terms and conditions and at any such time as may be thought fit.

8. The shares in the capital of the Company may be allotted or issued in payment of any property, land, machinery or goods supplied or any services rendered to the Company or promotion or formation of the Company or conduct of its business and any shares so allotted may be issued as fully paid shares.

## SHARES, TRANSFER AND TRANSMISSION

9. Every person whose name is entered as a member in the Register of Members shall without payment be entitled to a certificate under the Common Seal of the Company specifying the shares held by several persons. The Company shall not be bound to issue more then one certificate and delivery of a share certificate to any one of several joint holders shall be sufficient delivery to all.

10. The Directors may decline to register any transfer of share to transferee of whom they do not approve and shall be bound to show any reasons for exercising their discretion subject to the provision of Section 77 ~~and 78 of~~ the Companies Ordinance, 1984.

11. No share can be mortgaged, pledged, sold, hypothecated, transferred or disposed off by any member to a non-member without the previous sanction of the Board of Directors.

12. The legal heirs, executors or administrators of a deceased holder shall be the only persons to be recognized by the Directors as having title to the shares. In case of shares registered in the name of two or more holders ~~the~~ survivors and the executors of the deceased shall be the only persons to be recognized by the Company as having any title to the shares.

## GENERAL MEETING

13. The First Annual General Meeting shall be held within 18 months from the date of incorporation of the Company in accordance with the provisions of Section 158 and thereafter once at least in every year and within a period of four months following the close of its financial year and not more than fifteen months after the holding of its last preceding Annual General Meeting as may be determined by Directors. The Directors may, whenever they think fit, call an Extraordinary General Meeting of the shareholders in terms of Section 159 of the Companies Ordinance, 1984.

## PROCEEDINGS AT GENERAL MEETING

14. Twenty one days' notice at least specifying the place, day and hour of the General Meeting and in case of special business the general nature of such business, shall be given to the members in the manner provided in Table "A" but accidental omission to give such notice to or non-receipt of such notice by the member shall not invalidate the proceedings of the General Meeting.

15. The Chief Executive, with the consent of a meeting in which quorum is present and shall if so directed by the meeting may adjourn the meeting from time to time and from place to place, but no business shall be transacted at any adjourned meeting other than the business left unfinished at the meeting from which the adjournment took place.

## QUORUM

16. No business shall be transacted at any General Meeting unless a Quorum of members is present at the time when the meeting proceeds to business. Two members, present in person, representing not less than 25% of the total voting power either on their own account or as proxies, shall form a Quorum for a General Meeting.

## VOTES OF MEMBERS

17. At any General Meeting a resolution put to the vote of the General Meeting shall be decided on a show of hands, unless a poll is demanded in accordance with the provisions of Section 167 of the Companies Ordinance, 1984.

18. On a show of hands every member present shall have one vote and on a poll, every member present in person or by proxy shall have one vote in respect of each share held by him.

19. The instrument appointing a proxy and the power of attorney or other authority under which it is signed or notarially certified copy of that power of attorney or authority shall be deposited at the Registered Office of the Company not less than forty-eight hours before the time for holding the meeting at which the person named in the instrument proposes to vote and in default, the instrument of proxy will not be treated as valid.

## CHAIRMAN

20. The Directors may from time to time appoint one of their members to be the Chairman of the Company for a period not exceeding three years on such terms and conditions as they deem fit. The Chairman shall preside over the meetings of the Board of Directors and members of the Company. In his absence, the Directors may elect one of them to preside over Board's/General Meetings. The questions arising at the meeting of the Directors shall be decided by a majority of votes. In the case of equality of votes, the Chairman or the Director presiding over the meeting, as the case may be, shall have a casting vote.

## CHIEF EXECUTIVE

21. The first Chief Executive of the Company will be appointed by the Board of Directors within fifteen days from the date of incorporation of the Company who shall hold office till the first Annual General Meeting.

## DIRECTORS

22. Unless otherwise determined, the number of Directors shall not be less than two. The following are the first Directors of the Company:

   a) Nasir Ahmad Malik
   b) Muhammad Aslam

23. The election of the Directors shall be held in accordance with the provisions of Section 178 of the Companies Ordinance, 1984.

24. The first Directors including the Chief Executive shall hold office up to the First Annual General Meeting in accordance with the provisions of the Companies Ordinance, 1984, unless any one of them resigns earlier or becomes disqualified for being Director or otherwise ceases to hold office.

25. A resolution for removing a Director shall not be deemed to have been passed if the number of votes against him is equal to, or less than the number of votes that would have been necessary for the election of Directors at the immediately preceding annual election of Directors in the manner aforesaid but as provided under Section 181 of the Companies Ordinance, 1984.

26. The remuneration of Directors except regularly paid Chief Executive and full time working Directors shall, from time to time, be determined by the Board of Directors but it shall not exceed Rs.500/- per meeting at which the Directors are present.

27. The Directors may sanction the payment of such additional sums as they may think fit to any Director for any special service he may render to the Company or be thought capable of rendering either by fixed sum or in any other from as may be determined by the Directors subject to the provisions of the Companies Ordinance, 1984.

28. The Director who resides out of station shall also be entitled to be paid such traveling and other expenses for attending the meeting of the Company as may be fixed by the Directors from time to time according to the provisions of the Companies Ordinance, 1984.

29. Any casual vacancy occurring on the Board of Directors shall be filled in by a resolution of the Board of Directors and the person so appointed shall hold office for the remainder of the term of the Directors in whose place he is appointed.

30. No Director shall be disqualified from his office by contracting with the Company either as vender, purchaser or otherwise nor shall any Director be liable to account for any profit realized from any such contract or arrangement or the fiduciary relation thereby established, but the nature of his interest must be disclosed by him at the first meeting of the Directors after acquisition of his interest.

## NOMINEE DIRECTOR

31. In addition to the elected Directors, the Financial Institution shall be entitled, during the currency of their respective loan(s) to the Company to appoint one person of the Board of Directors of the Company to be called Nominee Director and to recall and/or replace such a person from time to time. Such Nominee Director on the Board of Directors of the Company may not be holders of share(s) in the Capital of the Company and regulations and/or rules pertaining to the election, retirement, qualification and/or disqualification of Directors shall not apply to him.

## NOTICES

32. Notices for every meeting of the Board of Directors will be given in writing and there must be given a reasonable time in advance. The nature of the business to be transacted at an intended Board meeting will be specified in the notice.

## MANAGEMENT

33. The whole business and affairs of the Company shall, subject to the control and supervision of the Board of Directors, be managed and controlled by the Chief Executive.

34. Subject to the limit fixed by the Directors, the Chief Executive may from time to time raise or borrow any sums of money for and on behalf of the Company from other companies, firms, persons, banks or financial institutions on such terms as may be approved by the Board of Directors from time to time.

35. Without prejudice to the powers conferred by these Articles, the Board of Directors shall have the following powers:-

(a) To take on lease, purchase, erect or otherwise acquire for the Company any assets, stocks, lands, buildings, property, rights or privileges which the Company is authorized to acquire at such price and generally on such terms and conditions as they think fit.

(b) To let, mortgage, sell, exchange or otherwise dispose of absolutely or conditionally all or any part of the assets, stocks, raw materials, properties, privileges and undertaking of the Company upon such terms and conditions and for such consideration as they think fit.

(c) To appoint any person or persons to be attorney or attorneys of the Company for such purposes and with such powers, authorities and discretions and for such period and subject to such conditions as they may, from time to time, think fit.

(d) To enter into, carry out, rescind or vary all financial arrangements with any bank, person, company, firm or corporation or in connection with such arrangements to deposit, pledge or hypothecate property of the Company or the documents representing or relating to the same.

e) To make and give receipts, release and discharge all moneys payable to the Company and for the claims and demands of the Company.

f) To compound or allow time to the payment or satisfaction of any debt due to or by the Company and any claim and demands by or against the Company and to refer claims or demands by or against the Company to arbitration and observe and perform the awards.

(g) To institute, prosecute, compromise, withdraw or abandon any legal proceedings by or against the Company or its affairs or otherwise concerning the affairs of the Company.

(h) To raise and borrow money from time to time for the purposes of the Company, on the mortgage of its property or any part thereof and/or on any bond or debenture payable to bearer otherwise repayable in such a manner and generally upon such terms as they think fit.

(i) To open, operate and maintain bank/banks account(s) individually or jointly as the Board may authorize or to any other person on its behalf.

## BORROWING POWERS

36. The Directors may from time to time raise, borrow or secure the payment of any sums for the purposes of the Company in such manner and upon such terms and conditions as they think fit and in particular by the issue of debentures, debenture-stock or other securities charged upon all or any part of the property of the Company present or future.

37. Debentures, debenture-stock, or other securities may be issued with any special privileges as to redemption, surrender, allotment of shares, attending and appointment of Directors or other privileges subject to any permission required by law.

## THE SEAL

38. The Company shall have a Common Seal and the Directors shall provide for the safe custody of the same. The Seal shall not be applied on any instrument except by the authority of the Board of Directors and in the presence of at least two Directors or one director and company secretary who shall sign every instrument to which the Seal shall be affixed in their presence. Such signatures shall be conclusive evidence of the fact that the Seal has been properly affixed.

## ACCOUNTS

39. The Directors shall cause to be kept proper books of account as required under Section 230 of the Companies Ordinance, 1984.

40. The books of account shall be kept at the registered office of the Company or at such other place as the Directors shall think fit subject to the provisions of Section 230 of the Companies Ordinance, 1984.

## AUDIT

41. Once at least in every year the accounts of the Company shall be audited and correctness of the Balance Sheet shall be ascertained by one or more Auditors. The Auditors shall be appointed and their duties regulated in accordance with the provisions of Section 252 to 255 of the Companies Ordinance, 1984.

## INDEMNITY

42. In connection with carrying on the business of the Company, the Chief Executive, every Director or other officers of the Company shall be indemnified by the Company for all losses and expenses occasioned by error of judgment or oversight on his part, unless the same happens through his own dishonesty or willful act and defaults.

## SECRECY

43. No member shall be entitled to visit and inspect the Books of the Company without the permission of the Chief Executive or one of the Directors or to require discovery of any information regarding any detail of the Company's business or any matter which is or may be in the nature of trade secret, or secret process which may relate to the conduct of the Company's business and which in the opinion of the Directors, will not be in the interest of the members of the Company to communicate to the public.

## ARBITRATION

44. In the event that a dispute, claim or controversy arises between the company, its management and its shareholders, or between the shareholders inter-se , or the directors inter-se, all steps may be taken to settle the dispute and resolve the issue through mediation by an accredited mediator before taking recourse to formal dispute resolution such as arbitration or litigation.

Whenever any such difference arises between the Company on the one hand and the members, their executors, administrators or assignee on the other hand, touching the true intent or construction or the incident or consequence of these present or of the statutes or touching any thing thereafter done, executed, omitted or suffered in pursuance of these presents or otherwise relating to these presents or to any statutes affecting the Company, every such difference shall be referred for the decision of the arbitrator who will be qualified in Islamic law.

45. The cost incidental to any such reference and award shall be at the discretion of the arbitrator or umpire respectively who may determine the amount thereof and direct the same to be shared between the attorney and client or otherwise and may award by whom and in what manner the same shall be borne and paid.

## WINDING UP

46. If the Company is wound up whether voluntarily or otherwise the liquidator may, with the sanction of a special resolution, divide amongst the contributories in specie any part of the assets and liabilities of the Company, subject to Section 421 and other provisions of the Companies Ordinance, 1984 as may be applicable.

We, the several persons whose names and addresses are subscribed below, are desirous of being formed into a Company, in pursuance of this Articles of Association, and we respectively agree to take the number of shares in the Capital of the Company as set opposite to our respective names.

| | Name and Surname (Present & Former) In Full (In Block Letters) | Father's/Husband's Name in Full | Nationality with any former Nationality | Occupation | Residential Address (In Full) | Number of shares taken by each subscriber | Signature |
|---|---|---|---|---|---|---|---|
| 1 | Mr. Nasir Ahmad Malik CNIC # **35202-6097137-9** | s/o Tahir Ahmad Malik | Pakistani | Businessman | 64-Ahmed Block, New Garden Town, Lahore | 9,900 (Nine thousand nine hundred) | |
| 2 | Mr. Muhammad Aslam CNIC # **35202-2744007-5** | s/o Muhammad Irshad | Pakistani | Businessman | House # 1, Street # 3-B, Asif Block, Allama Iqbal Town, Lahore | 100 (One Hundred) | |
| | | | | | Total No. of Shares Taken | 10,000 TEN THOUSAND ONLY | |

Dated this 30th day of November, 2015.

Witness to the above Signatures:

National Institutional Facilitation Technologies (Pvt.) Limited
5th Floor, AWT Plaza
I. I. Chundrigar Road,
Karachi, Pakistan

1. COMPANY REGISTRATION NO:
2. SERIAL NO OF DOCUMENTS.
3. NAME OF THE COMPANY.
4. BRIEF DESCRIPTION OF THE DOCUMENT INCLUDING ITS ENCLOSURES.
5. THE DATE ON WHICH THE DOCUMENT REGISTERED, FILED OR RECORDED 11-12-15

JOINT REGISTRAR OF COMPANIES
LAHORE REGION

Company Registration Office Lahore ★ Securities and Exchange Commission of Pakistan ★ SECP

CERTIFIED TO BE TRUE COPY
29/12/2015
DEPUTY REGISTRAR OF COMPANIES
COMPANY REGISTRATION OFFICE
LAHORE.

2015

# INITIAL ENVIRONMENTAL EXAMINATION

## Gugera Canal Hydro Electric Power Project

Screening and Environmental Assessment of Gugera Canal Hydro Electric Power Project in Nankana District of Punjab, Pakistan

APPROVED FEASIBILITY STUDY
Granted by POEs in their meeting
held on 03-12-2015

MANAGING DIRECTOR
PUNJAB POWER DEVELOPMENT BOARD

Sustainable Solutions
IEE-GCHPP-PHC-DV1
16/02/2016

ENVIRONMENT PROTECTION DEPARTMENT
Government of the Punjab
National Hocky Stadium, Lahore.

NO. DD (EIA)/EPA/F-634(IEE)/2903/2015/144
Dated: 04 /04/ 2016

To

Mr. Nasir Malik,
Proponent / CEO,
M/s Gugera Canal Hydro Electric Power Project,
64-Ahmad Block, New Garden Town,
Lahore

Subject: **DECISION OF EPA PUNJAB FOR THE INSTALLATION OF HYDRO POWER PROJECT UPTO 3.6-MW AT UPPER GUGERA CANAL AT RD 214+500 NEAR NANKANA CITY, DISTRICT NANKANA SAHIB**
(Under Section 12 of PEPA, 1997 (Amended 2012) read with IEE/EIA Regulations, 2000)

1. Description of Project: Installation of Hydro Power Project upto 3.6-MW

2. Location of Project: The site is located at Upper Gugera Canal at 214+500 Near Nankana City, District Nankana Sahib

3. Date of filing of IEE: 15.06.2015

4. After careful review of Initial Environmental Examination (IEE) Report, Site Inspection Report of District Officer (Environment), recommendations of Committee of Experts constituted under Regulation 11(2) of IEE / EIA Regulations, 2000 read with Section 12 of the Act ibid on 10.03.2016 and recommendations of the committee constituted under Section 5(5) of the Punjab Environmental Protection Act, 1997 (Amended – 2012) in its meeting dated 29.03.2016 and other relevant record, the Environmental Protection Agency, Punjab accords approval for installation of the above mentioned project at the aforementioned sites to safeguard the environmental issues subject to the following conditions:

i. The proponent shall ensure compliance of National Environmental Quality Standards (NEQS).
ii. Mitigation Measures suggested in the IEE report and Environmental Management Plan (EMP) shall be strictly adhered to minimize any negative impacts on soil, ground water, air and biological resources of the project area.
iii. Monitoring shall be carried out during the entire period of the project activities. Monitoring reports of the whole operation shall be submitted to EPA, Punjab on monthly basis.
iv. Camping sites shall be located at suitable distance away from any settlement to avoid disturbance to the local people. Sewage generated from camping sites shall be treated in septic tanks.
v. The proponent shall take measures to control dust.
vi. The area around the project site shall be kept clean.
vii. The proponent shall dispose of solid waste, electronic waste, discarded solar panels and condemn batteries etc. in a proper scientific way in consultation with TMA / District Government.
viii. The proponent shall ensure efficient health and first aid treatment facilities for protection of workers.
ix. The proponent shall avoid cutting of trees.
x. The proponent shall plant at least 5000 fruit trees of indigenous species of minimum height 6 to 7 feet around the project area in consultation with District Officer (Environment) on available space within six months and shall take measures for the protection of these trees.
xi. The proponent shall do proper landscaping after completion of the project.
xii. The construction material shall be piled / stored in such a way that it shall not destroy the flora / environment of the locality.
xiii. The proponent shall care about noise issues during construction and operation stage of the project.
xiv. The objections / complaints of the locals / stakeholders (if any) shall be redressed on priority basis.

xv. The proponent shall provide compensation to the inhabitants in case of loss of agricultural land, crop, property, etc. in accordance with the rates that are agreed upon. All conflicting issues regarding compensation, etc. shall be settled amicably before the start of the project activities.

xvi. The proponent shall obtain NOC / clearance from all other concerned departments before commencement of work.

xvii. The proponent shall appoint Environmental Manager having (at least qualification of B.S. Environmental Sciences / B.Sc. Environmental Engineering) for the project and shall convey his name along with his complete Mailing Address and Phone Numbers.

xviii. The proponent shall ensure that strict and efficient health and safety measures are in place for protection of workers backed by a comprehensive emergency response system while working on super structure.

xix. At least 90% unskilled and to the extent possible skilled jobs shall be given to locals after providing them proper training.

xx. The proponent shall take effective measures for safe transportation of Photovoltaic Cell / Solar Panel.

xxi. The proponent shall dispose of wastewater after treatment.

xxii. The proponent shall adopt latest techniques for the cleanliness of the solar panels to minimize water use as much as possible.

xxiii. The proponent shall ensure all necessary measures for the protection of sensitive / protected areas in the vicinity.

xxiv. The proponent shall prepare a Community Development Plan and implement it for the benefit of communities of the project area.

xxv. The proponent shall follow the SOPs regarding dengue larvae eradication and shall ensure removal of stagnant water on daily basis.

xxvi. The proponent shall install independent online monitoring system equipment with SCADA capabilities providing unhindered access to EPA Punjab.

5. The proponent shall be liable for correctness and validity of information supplied to this department by the environmental consultant.

6. The proponent shall be liable for compliance of Regulations 13, 14, 18 and 19 of IEE/EIA Regulations, 2000, regarding approval, confirmation of compliance, entry, inspections and monitoring.

7. This approval is accorded only for the construction phase of the project. The proponent shall apply for confirmation of compliance under Regulation 14 of IEE / EIA Regulation, 2000 by submitting Environmental Management Plan for operational phase along with compliance status report of the Environmental Approval of the construction phase of the project.

8. Any change in the approved project shall be communicated to EPA, Punjab and shall be commenced after obtaining the approval.

9. This approval shall be treated as null and void if all or any of the conditions mentioned above, is/are not complied with. This approval does not absolve the proponent of the duty to obtain any other approval or consent that may be required under any law in force and is subjudice to legal proceedings in any legal fora / court.

10. This approval shall be valid (for commencement of construction) for a period of three years from the date of issue under Regulation 17 of IEE / EIA Regulations, 2000.

11. This approval can be withdrawn at anytime without any prior notice if deem necessary in the public / national interest.

**ASSISTANT DIRECTOR (EIA)**
*for* Director General, EPA, Punjab
Ph: # 042-99232228

<u>NO. & DATE EVEN.</u>

A copy is forwarded for information to:

The District Officer (Environment), Nankana Sahib w.r.t his letter No.508/DOE/EPA/NNS/15, dated 15.08.2015. He is requested to ensure compliance of the above mentioned conditions / measures under intimation to this office.

**ASSISTANT DIRECTOR (EIA)**
*for* Director General, EPA, Punjab

# LIST OF ACRONYMS

| | |
|---|---|
| ADB | Asian Development Bank |
| AC/DC | Alternating Current/Direct Current |
| BHU | Basic Health Units |
| CBD | Convention on Biological Diversity |
| CDM | Clean Development Mechanism |
| CFCs | Chlorofluorocarbons |
| CITES | Convention on International Trade in Endangered Species |
| CMS | Conservation of Migratory Species |
| CP | Contracting Party |
| DHQ | District Head quarter |
| E&M | Electrical and Mechanical |
| EIA | Environmental Impact Assessment |
| EPA | Environmental Protection Agency |
| ESIA | Environmental and Social Impact Assessment |
| FGDs | Focal Group Discussions |
| GEPCO | Gujranwala Electric Power Company |
| GOP | Government of Pakistan |
| GNP | Gross National Product |
| GWh | Giga Watt hours |
| HCFCs | Hydro chloro fluoro carbons |
| HH | Household |
| IDC | Interest during Construction |
| IDIs | In-Depth Interviews |
| IEE | Initial Environmental Examination |
| ILO | International Labour Organization |
| IUCN | International Union for Conservation of Nature |
| KM | Kilometer |
| Kv | Kilo-volt |
| LACs | Land Acquisition Collectors |
| LCC | Lower Chenab Canal |
| LGB | Lower Gugera Branch |
| LOI | Letter of Interest |
| M | Meter |
| m.a.s.l | Meters above sea level |
| M.C.H | Mother Child Health |
| MW | Megawatt |
| NCS | National Conservation Strategy |
| NEQS | National Environmental Quality Standards |
| NOC | No-Objection Certificate |

| | |
|---|---|
| NTDC | National Transmission & Dispatch Company |
| PEPD | Punjab Environmental Protection Department |
| PEPA 1997 | Pakistan Environmental Protection Act 1997 |
| PEPC | Pakistan Environmental Protection Council |
| PIC | Prior Informed Consent |
| PM10 | Particulate Matter up to 10 micrometers |
| PPDP | Punjab Private Power Development Board |
| RHC | rural health centers |
| RoR | run-of-the-river |
| SRO | Statutory Regulation Order |
| SNGPL | Sui Northern Gas Pipelines Limited |
| TB | Tuberculosis |
| UNECE | United Nations Economic Commission for Europe |
| UNEP | United Nations Environment Programme |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| WAPDA | Water and Power Development Authority |
| WHO | World health Organization |

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# EXECUTIVE SUMMARY

## Introduction

This document presents the Initial Environmental Examination (IEE) of Gugera Canal Hydro Electric Power Project, 'the proposed project' to be constructed at RD 214+500 (31°32'44.42"N, 73°41'34.14"E) of Upper Gugera Canal (See map in **Figure 1**). The project facilities are proposed to be located near Nankana Sahib of lately declared District Nankana, was previously in Sheikhupura District of Punjab Province. This study covers an area under both districts and data obtained from secondary literature is presenting the information of previous Sheikhupura District. The proposed hydroelectric power project will have installed capacity of 3.6 MW and will generate 21.3 GWh annually. The project has been proposed near RD 214+500 (31°32'44.42"N, 73°41'34.14"E) of Upper Gugera Brach Canal by combining head available on fall structure at RD 216+100 and at fall structure at RD 220+750 (31°32'20.78"N, 73°40'57.26"E). The project would be equipped with 3 bevel gear bulb turbines each has capacity of 1.2 MW. The project would be connected with LESCO/NTDC Grid at Walgan Sohail which is about 7 km from project site. The Grid is 132/11kV. The project would be connected through two single circuit 11 kV transmission lines.

The proposed project is being carried out by Gugera Hydropower Company Private Limited. The company has completed the feasibility study report for implementation of Gugera Hydro Electric Power Project and approval of the same by Punjab Private Power Development Board (PPDB) of government of Punjab is now in place. "The Project" under the terms of a Letter of Interest (LOI) issued on June 2013 by the PPDB. The PPDB's authorization is in accordance with the Government of Punjab's "Punjab Power Generation Policy, Year 2006" (the Policy) revised during 2009 to encourage private-sector infrastructure investments.

To ensure that proposed activities adhere the environmental obligations, the company conducted environmental screenings and assessments as required. Environmental assessments will be completed for relevant project activities to ensure environmentally sustainable development by mitigating negative and increasing positive impacts. In line with the national policy, a preliminary screening of project activities is proposed to assess whether or not an environmental assessment is required, recommended or not required. Based on this screening the proposed project requires an initial environmental examination.

The goal of this IEE is to ensure an environmentally and socially sustainable project. This IEE will :

- Assess the existing environmental conditions in the project 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 in Pakistan and requirements of national policy on environmental sustainability.

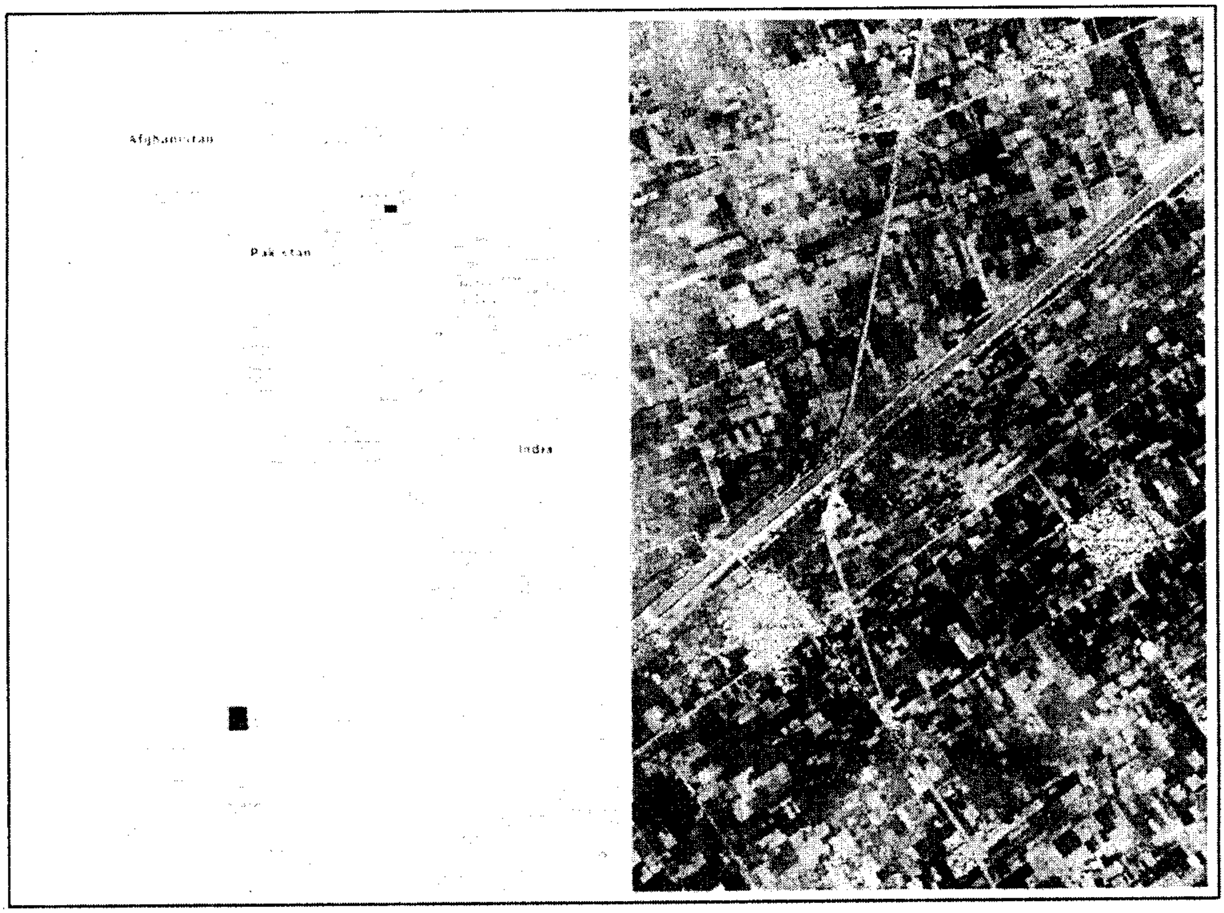


Figure 1: Project Area and Location of Project

## National Policy, Legal and Administrative Framework

The applicable regulations and guidelines for this IEE include laws in Punjab. The Punjab Environmental Protection Act, 2012 is the principal legislative tool used for regulating environmental protection in Punjab. This legislation provides for two types of environmental assessments: IEEs and EIAs. EIAs are carried out for projects that have a potentially 'significant' environmental impact, and IEEs are conducted for relatively smaller projects with a relatively less significant impact. An IEE was prepared and submitted to the Punjab Environmental Protection Department (Punjab EPD) for the Project under this legislation. The Punjab EPD reviewed the IEE and granted an approval for construction of the Project.

The Pakistan Environmental Protection Agency has published a set of environmental guidelines for conducting environmental assessments and environmental management of projects, which have been adopted by the Punjab EPD. The relevant guidelines are guidelines for the Preparation and Review of Environmental Reports, Pakistan Environmental Protection Agency, 1997

The National Environmental Quality Standards (NEQs) specify the following standards:

- Maximum allowable contamination of pollutants (32 parameters) in emission and liquid industrial effluents discharged to inland water.
- Maximum allowable concentration of pollutant (16 parameters) in gaseous emission from sources other than vehicles.
- Maximum allowable concentration of pollutants in gaseous emissions from vehicle exhaust and noise emission from vehicles.
- Maximum allowable noise level from vehicles.
- Ambient noise standards
- Ambient air quality standards.

The subject of 'environmental pollution and ecology' is included in the constitution of Pakistan, enabling both the national and provincial governments to enact laws on the subject. The Pakistan National Conservation Strategy (NCS) which was approved by the federal cabinet in March 1992 is the principal policy document on environmental issues in the country. The NCS outlines the country's primary approach towards encouraging sustainable development, conserving natural resources, and improving efficiency in the use and management of resources. The NCS has 68 specific programs in 14 core areas in which policy intervention is considered crucial for the preservation of Pakistan's natural and physical environment. The core areas that are relevant in the context of the project are pollution prevention and abatement, restoration of rangelands, increasing energy efficiency, conserving biodiversity, supporting forestry and plantations, and the preservation of cultural heritage.

The Ministry of Environment regulates the environment and wildlife at the national level, with two organizations primarily responsible for administering the provisions of the Pakistan Environmental Protection Act 1997 (PEPA 1997), namely:

- Pakistan Environmental Protection Council (PEPC), which oversees the functioning of the Pakistan Environmental Protection Agency with representatives from the government, industry, non-governmental organizations and the private sector ;and
- Pakistan Environmental Protection Agency or EPA (established in 1984), which is the primary implementing agency ensuring compliance with National Environmental Quality Standards (NEQS), establishing monitoring and evaluation systems, and both identifying the need to and initiating legislation when necessary.

Significant work on developing environmental policy was carried out in the late 1980s, which culminated in the Pakistan National Conservation Strategy in 1992. Provincial environmental protection agencies were established at about the same time and the NEQS were established in 1993.The national EPA is authorized to delegate powers to its provincial counter parts. With the enactment of PEPA in 1997, broad-based enforcement powers were conferred to the national and provincial EPAs.

Section 12(1) of PEPA requires that: "No proponent of a project shall commence construction or operation unless he has filed with the Federal Agency an initial environmental examination (IEE) or, where the project is likely to cause an adverse environmental effect, an environmental impact assessment (EIA), and has obtained from the Federal Agency approval in respect thereof." The Pakistan EPA has delegated the power of review and approval of IEEs and EIAs to the provincial EPAs. A number of supporting rules and regulations relevant to the Project have been promulgated under the PEPA1997.

The NEQS prescribe effluent and emission limits for various activities and have been amended twice, in 1995 and 2000, since they were first promulgated in1993.

The scope of environmental law implied by the legal definition of 'environment' given in PEPA 1997 results in numerous laws enacted since the nineteenth century being classified as environmental laws.

## Project Overview

The proposed hydroelectric power project will have installed capacity of 3.6 MW and would generate 20.8 GWh annually. The project physical arrangement and overall characteristics have been configured for optimum hydropower development of the Gugera Hydro Electric Power Project having head available at RD 216+100 and RD 221+500. The selected layout is powerhouse and spillway placed in the bypass arrangement just upstream of Existing fall at RD 216+100 along its right bank. The spillway is placed along the left bank of powerhouse structures. The powerhouse and spillway are placed at RD 214+500 due to constraint of space on right side of the canal near RD 216+100 because of existence of Nankana Sahib Bridge. There is no need of canal diversion for construction of powerhouse and spillway. Powerhouse/spillway would be constructed under dry condition along right bank. After completion of construction of powerhouse and spillway the canal flows will be diverted toward them after connecting the headrace and tailrace on upstream and downstream of project components.

According to the approved feasibility study of the project an overall area of 15 hectares will be used for the project which includes both existing infrastructure of the canal with the head regulator, its right of way and some of the adjacent private land. An effort in the design has been made to minimize the use of private land which is generally under cultivation.

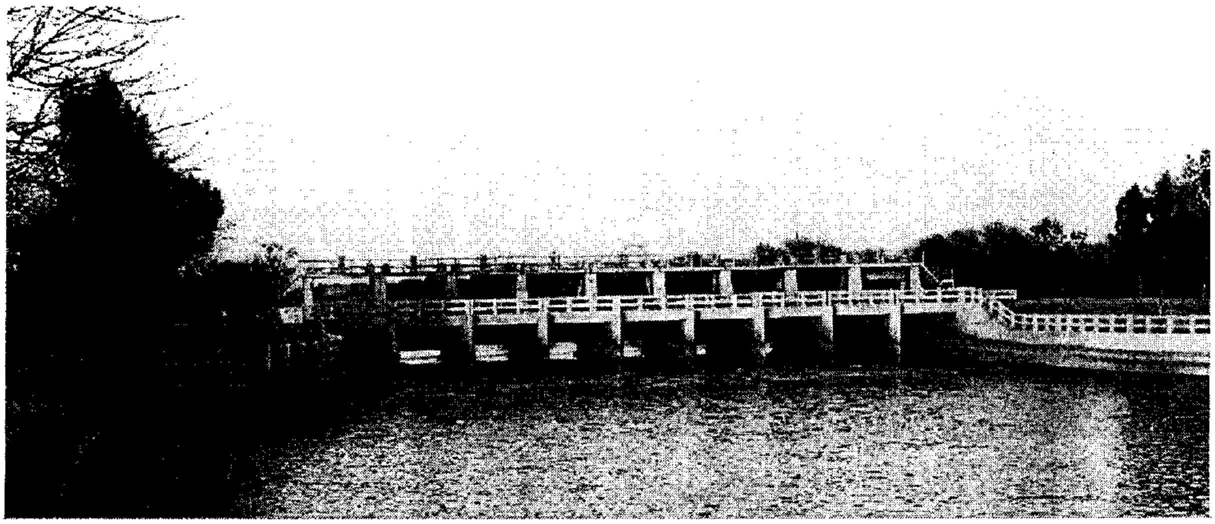


**Figure 2: Head Regulator near the Project Site**

The part between RD 212+000 and proposed powerhouse is called headrace canal. It's length would be 762 m. The headrace would be remodeled and also constructed new. The powerhouse and spillway are placed at RD 214+500. The tailrace starts from downstream powerhouse transition and link the existing Gugera Branch canal just upstream of the Highway Bridge at same alignment with lowered bed level conditions.

Therefore, the Gugera Hydro Electric Power Project comprises the following main components:

- Headrace;
- Powerhouse and spillway Intake Bay;
- Powerhouse (Machine hall and Service bay) structure housing three Bevel
- Gear type turbines and generators with a total installed capacity of 3.6MW;
- Erection bay on right side of the Power house;
- Gated spillway along left bank of Power house structure;
- Powerhouse Outlet bay;
- Tailrace;
- Access road on left and right bank of Lower Gugera Branch Canal;
- Operation and maintenance staff colony and rest house and other civic facilities;
- Turbine and generators;
- ,Main/unit transformers and Switchgear ,and
- Switchyard and transmission line and interconnection facilities.

## Power Grid Interconnection

The project is proposed to be interconnected to the nearest LESCO/NTDC132/11KV grid at Walgan Sohail. Two 7 km long11 kV single circuit transmission lines have been proposed for dispersal of energy generated. Steel reinforced Osprey conductors with steel lactic towers are foreseen which are according to the national standards. Synchronizing with L E S C O / NTDC grid system shall be done in the powerhouse control room. The powerhouse is the point of energy delivery to the LESCO/CPPA. Power meters have been provided at the switchgear- room for measurement of energy delivered to LESCO/NTDC.

The proposed 11 kV transmission lines are equipped with directional distance protection system with relays both in the 11 kV Substation and in the powerhouse. A back-up protection at both stations with directional over current relays is also included. Additional lightning arrestors have been provided at the outgoing section of Power Plant.

### Project Duration and Cost

It is anticipated that the project will be constructed under the terms of turnkey contract, with the expectation that design, construction of the civil works, equipment supply and installation would be carried out in a period of about 36months.

The estimated base cost is about 1398.4 million PKR, expressed at the 2013 price level, without escalation and interest during construction (IDC) but inclusive of cost of transmission line has been considered in financial calculations described later. Estimates reflect aggressive cost control and services contracts negotiations, and a management and design philosophy to minimize costs

## Environmental Baseline

### Physical Environment

The area is a part of Rachna Doab, and consists of some recent sediment brought by spill channel from Chenab River. There are some old channel levee remnants and old basins filled up with clay materials. It is probably of late Pleistocene age derived from mixed calcareous, sedimentary and metamorphic rocks of the lower Himalayas. The only mineral products of the District are Kankar and Kallar. The small particles of Kankar may be burnt into lime. These are the features of all bare lands and are found on the surface or a little below it. Kallar is found on mounds, which are sites of old ruined habitations, and is used for the manufacture of crude saltpeter. The District has extreme climate; the summer season starts from April and continues till October. During the summer season, temperature ranges from 30 to 45 degrees Celsius. The winter season starts from November and continues till March. December and January are the coldest months with a mean minimum temperature of 5degrees.

According to the land use map of Nankana town the proposed project lies outside the municipal boundary. Land-use in the project area is dominated by cultivation, fruit growing and livestock rising. There is a small but growing service sector, particularly in private/government employment, transportation, and trading. Although in the project area fisheries resources appear to be significant, this potential has remained largely untapped. Agricultural in the area is mostly carried out through tube wells. Total cultivated area in Sheikhupura is about 359,000 Hectares, which is mostly used for cultivation of sugarcane, rice and wheat.

The project area falls in the vast alluvial plain of upper Indus basin consists of sand, silt and clay. No rocks outcrop/exposed in the close vicinity of the project area. Tectonic deformation has not been recorded/reported in this area. According to the modified seismic hazard zones map of Pakistan published by Geological Survey – 2006, the project area is situated in minor to no damage zone where seismic factor is considered to be less than 0.03g. These are generalized values which may be used as a guideline only. Overall the project is located in a stable region which is more than 200 km away from the collision boundary of the Indian and the Eurasian plates.

The area's air appears good based on the observation during the study period. Domestic sources of air pollution, such as emissions from wood and kerosene burning stoves as well as small diesel standby generators in some households are well dissipated. There are no other industrial pollution sources present in the vicinity. The other major source of air pollution is dust arising from traffic and other ground or soil disturbances. Near the access roads along the banks of canal Feeder, when vehicles pass, dust levels increase. Some part of the road is paved and rest is unpaved but dust levels are elevated when vehicles pass intermittently over these roads.

Noise from vehicles and other powered mechanical equipment is intermittent. There are no significant disturbances to the quiet rural setting. Flowing water in the canal especially over the fall structures is source of noise otherwise the area is generally quiet.

## Ecological Environment

The existing habitats within the project area include the mostly agricultural land, though there is some wetland around the canal system and small water impoundments. The flora in Riverian tract, especially in pond area the succession of vegetation, first colonizes are grasses and Typha followed by Tamarix as the soil become consolidated and is raised by the new silt deposition in the scrub, so that the vegetation is no longer completely submerged and erect tree growth becomes possible.

As the soil gets stabilized and drained the forest community normally progresses to *Acacia nilotica* and *Dalbergia Sissao*. In its present state, the flora of Riverian Alluvial deposits can be Lai (Tamarix dioca), Pilchi (*Tamarix gallica*), Babool (*Acacia nilotica*), Shisham (*Dalbergia sissoo*), Beri (*Zizyphus yujuba*), Jand (*Prospis spicigera*), Mesqette (*Prosopis juliflora*), Mesquette (*Prosopis glandulosa*), Bhen/Poplar (*Populus euphratica*), Khabbal (*Cynodon dactylon*), Kanwal (*Melolotus oralifolia*), Munj (*Erianthus munja*), Kia (*Sacchrum spontaneum*), Kunder (*Typhaelephantine*)

The proposed project area is inhabited by various mammals like Mongoose (*Herpestes edwardsi*), Porcupine (*Hystrise indica*), Fox (*Valpes bengalensis*), Jackal (*Canis aureus*), Hare (*Lepus nigricollis*) and Wild Boar (*Sus scrofa*). Though some of the larger mammals and reptilian species are quite rare in the area, but there are no endangered or vulnerable species in the area. The waterways and small ponds in the area provide the habitat for many species of migrating and local birds. The area is home to common avifauna like White breasted kingfisher (*Halcyon smyrnensis*), Cattle egret (*Bubulcus ibis*), Pond heron (*Areleola grayii*), Red-vented bulbul (*Pyenonotus cafer*), Black drongo (*Dicrurus macrocercus*), Common myna (*Acridotheres tristis*), House crow (*Corvas splendens*), Indian roller (*Coracias benghalensis*), Greater coucal (*Centropus sinensis*), Barn owl (*Tyto alba*), River tern (*Sterna aurantia*), Common coot (*Fulica atra*), Many species of waterfowl also visit the project area during winter. The most common type of aquatic fauna found in the Chenab canal system are Mori (*BariliusVagra*),Gulfam(*Cyprinuscarpio*),Khagga(*Ritarita*),Raho(*Labeorohita*),Mullee(*Wallago* *attu*) and River catfish (*Clupisoma naziri*). No ecologically important species were recorded from the area.

### Social Baseline

The proposed project is located near Manawala Town (31°32'20.78", 73°40'57.26"E), in Sheikhupura District of Punjab, Pakistan. The project area is located about 75 km from Lahore, 35 km from Sheikhupura city, 67 km from Faisalabad and 11 km from Nankana Sahib.

According to the 1998 census of Pakistan, the district had a population of 3,321,029 of which 25.45% were urban. Third Mughal emperor Akbar fondly called his Son (later reigned as 4th Mughal Emperor Jahangir) Sheikhu, the origin for the name of this district and headquarter. The rulers of this area were virk Jats and their biggest village was called Virkgarh. Sheikhu razed down Virkgarh and renamed the Virk city to Sheikhupura. Even today all around Sheikhupura the biggest population is of the Virk Jat tribes. Punjabi language is spoken by more than 95 percent population in both the districts. Punjabi is very important language which is very common in study area. Though a major portion of the population understands and speaks Urdu, but only about 3.0 percent are native speakers in the district and 4.5 percent in Punjab province.

Preservation of archaeological and historical heritage is obligatory under the Pakistan Antiquities Act 1975. All the artifacts, monuments, petrography and building of historical importance come under archaeological heritage. Even old mosques, temples, churches and graveyards are covered under this Act. No item of archaeological or historical importance has been found near the powerhouse site or in the areas likely to be used for project works. Therefore, there will be no impact on historical heritage due to construction of the project.

## Impact Assessment and Mitigation

There are several guidelines and textbooks on identification and description of environmental and social impacts. These documents use various types of tools in an attempt to define a comprehensive and consistent method to capture all potential impacts of a proposed project. However, it is now widely recognized by environmental assessment practitioners that impact evaluation is not a purely objective and quantitative exercise. It has a subjective element; often based on judgment and values as much as scientific criteria. Recognizing this, a uniform system of impact description is used to enable the reviewers to understand how impacts have been interpreted. The description of each impact will have the following features:

- a definition of the impact using an impact statement.
- the impact statement clearly identifying the project activity or activities that causes the impact, the pathway or the environmental parameter that is changed by the activity, and the potential receptors of the impact.
- establishing the sensitivity of the receiving environment or receptors.
- based on the stakeholder consultations undertaken, outlining of the level of public concern regarding the specific impact.

- eating of the significance of the impact.
- description of the mitigation and management measures and the effectiveness of proposed measures.
- characterization of the level of uncertainty in the impact assessment.

The significance of an impact is determined based on the product of the consequence of the impact and the probability of its occurrence. The consequence of an impact, in turn, is a function primarily of three impact characteristics: magnitude; spatial scale; and duration.

Magnitude is determined from quantitative or qualitative evaluation of a number of criteria discussed further below. Where relevant, this includes comparison with standards or thresholds. Examples of thresholds include:

- legal thresholds—established by law or regulation.
- functional thresholds—if exceeded, the impacts will disrupt the functioning of an ecosystem sufficiently to destroy resources important to the nation or biosphere irreversibly and/or irretrievably.
- normative thresholds—established by social norms, usually at the local or regional level and often tied to social or economic concerns.
- preference thresholds—preferences for individuals, groups or organizations only, as distinct from society at large.
- reputational thresholds—the level of risk a company is willing to take when approaching or exceeding the above thresholds.

Once the impact consequence is described on the basis of the above impact characteristics, the probability of impact occurrence is factored in to derive the overall impact significance. The probability relates to the likelihood of the impact occurring, not the probability that the source of the impact occurs. For example, a continuous Project activity may an unlikely probability of impact, if there are no receptors within the area influenced by that activity.

The resulting significance rating may be further qualified by explaining the effectiveness of proposed management measures designed to mitigate or enhance the impact, and by characterizing the level of confidence or uncertainty in the assessment.

The impact significance rating process serves two purposes: firstly, it helps to highlight the critical impacts requiring consideration in the approval process; secondly, it serves to show the primary impact characteristics, as defined above, used to evaluate impact significance.

- Part A: Define impact consequence using the three primary impact characteristics of magnitude, spatial scale and duration.
- Part B: Use the matrix to determine a rating for impact consequence based on the definitions identified in Part A ;and
- Part C: Use the matrix to determine the impact significance rating, which is a function of the impact consequence rating (from Part B) and the probability of occurrence.

Using the matrix, the significance of each described impact is rated.

Wherever, the Project is likely to result in unacceptable impact on the environment, mitigation measures are proposed. In addition, in certain cases good practice measures are proposed.

**Table 1: Method for Rating the Significance of Impacts**

| ***PARTA:DEFINING CONSEQUENCE IN TERMS OF MAGNITUDE, DURATION AND SPATIAL SCALE*** | | | |
|---|---|---|---|
| **Impact characteristics** | **Definition** | **Criteria** | |
| **MAGNITUDE** | Major | Substantial deterioration or harm to receptors; receiving environment has an inherent value to stakeholders; receptors of impact are of conservation importance; or identified threshold often exceeded | |
| | Moderate | Moderate/measurable deterioration or harm to receptors; receiving environment moderately sensitive; or identified threshold occasionally exceeded | |
| | Minor | Minor deterioration (nuisance or minor deterioration) or harm to receptors; change to receiving environment not measurable; or identified threshold never exceeded | |
| | Minor+ | Minor improvement; change not measurable; or threshold never exceeded | |
| | Moderate+ | Moderate improvement; within or better than the threshold; or no observed reaction | |
| | Major+ | Substantial improvement; within or better than the threshold; or favorablepublicity | |
| **DURATION/ FREQUENCY** | | **Continuous aspects** | **Intermittent aspects** |
| | Short term/ low frequency | Less than 4years | Occurs less than once a year |
| | Medium | More than 4 years up to end of life of project | Occurs less than 10 times a year but more than once a year |
| | Long term/ High frequency | Beyond the life of the project | Occurs more than 10 times a year |
| **SPATIALSCALE** | | **Biophysical** | **Socio-economic** |
| | Small | Within 200 meters (m) of the Project foot print | Within the Study Area |
| | Intermediate | Within 3 kilometer (km) of the Project footprint | 10 km from the Project facilities |
| | Extensive | Beyond 3 km of the Project footprint | Beyond 10 km from the Project facilities |

***PART B: DETERMINING CONSEQUENCE RATING***

***Rate consequence based on definition of magnitude, spatial extent and duration***

| | | | **SPATIALSCALE** | | |
|---|---|---|---|---|---|
| | | | **Small** | **Inter-mediate** | **Extensive** |
| MAGNITUDE | | | | | |
| Minor | **DURATION/ FREQUENCY** | **Long /high** | Medium | Medium | Medium |
| | | **Medium** | Low | Low | Medium |
| | | **Short /low** | Low | Low | Medium |
| | | | | | |
| Moderate | **DURATION/ FREQUENCY** | **Long /high** | Medium | High | High |
| | | **Medium** | Medium | Medium | High |
| | | **Short /low** | Low | Medium | Medium |

| | | | | | |
|---|---|---|---|---|---|
| Major | DURATION/ FREQUENCY | **Long /high** | High | High | High |
| | | **Medium** | Medium | Medium | High |
| | | **Short /low** | Medium | Medium | High |
| **PART C: DETERMINING SIGNIFICANCERATING** *Rate significance based on consequence and probability* | | | | | |
| | | | **CONSEQUENCE** | | |
| | | | **Low** | **Medium** | **High** |
| **PROBABILITY (of exposure to impacts)** | | **Definite** | Low | Medium | High |
| | | **Possible** | Low | Medium | High |
| | | **Unlikely** | Low | Low | Medium |

+ denotes a positive impact.

The physical environmental aspects that may be affected by the project activities include the following:

- Soil contamination and erosion from construction.
- Noise and dust associated with construction.
- Use of water for Project activities during construction.
- Generation of waste by the Project activities during construction and operation.
- Vehicular traffic during construction.

Given the technology of the Project and limited number of staff that will be accommodated at the camp at the Project site during operation, impacts related to soil quality, soil erosion, noise, dust, emissions to air, use of water in the offices and the camps, and traffic during the operation phase are considered to be insignificant. Use of pesticides and weedicides is not anticipated in either construction or operation phase of the project.

The closest residential areas are about 0.5 km east and north of proposed site. The structures are not expected to have a visual impact on the local community. The camp and the offices will consist of low profile structures with heights not exceeding 8 meters. During consultation, the local community did not express any concerns related to visual impacts of the Project.

As stated in earlier sections, the transmission line to which the project will be connected to for evacuation of power generated passes through the Project site. The transmission interconnection will be constructed adjacent to the project site.

The impact of operation of the project on quality of the canal water was not considered to be significant. The change in temperature of the water across the dam is not anticipated as this is a run of the river project with no storage capacity.

The Project is a run-of-the-river (RoR) type and will require construction of project on the canal. The Area of Habitat Loss is defined as the areas that will be occupied due to construction and operation of Project infrastructure. It has been demarcated taking into consideration the footprint of each Project facility and a 50 m zone around each facility.

The terrestrial ecological resources of the Study Area are described in baseline in description of Environment. The aspects affecting ecology in the study area are discussed in discussion.

Forest trees do not exist on project work site. Some trees on the right bank of Gugera Canal and mesquite bushes on common bank between the two canals are likely to be removed for the preparation of the site for the construction of powerhouse and related facilities. Wild life habitat exists on upstream of existing head regulator so there will be no significant impacts on existing wild life however, it may have a minor impact on migratory birds.

The Contractors must be prohibited to use explosives, or electric current, to kill fish in the canal. His workers may also be prohibited to catch fish from the canal by netting or any other method, unless agreed with the Fisheries Department, or their local contractor.

In the Project area, forests and terrestrial plants do not contain any forest trees and there are no protected areas or trees in the project vicinity. Small numbers of trees of mesquite are likely to be removed for the preparation of land for construction of small power house colony and related facilities. No fish found in the canal is recorded. Impact on ecology on the project area is very minor or of no significance. Some trees found on the bank of the canal upstream of the powerhouse location will have to be removed for raising the canal banks. Buffalos and goats from village graze or browse these bushes. The growth of bushes and vegetation cover will increase on the canal banks. This will be a positive impact on the flora of the area.

The project area is dominated by cultivated fields. There is a wildlife habitat in the vicinity of the project site, which may not have impacts at large, because a limited labour force would be mobilized due to small size of the project. Effect of noise created by construction machinery would be less than the already existing noise of flowing water over the canal falls and the barrage itself.

As Gugera Canal Hydro Electric Power Plant is located at RD 2+500 to replace the fall at RD 8+626, the navigation of fish from head-regulator to powerhouse and back may not be possible. As no fish record is available, therefore a complete study should be conducted at detailed engineering design stage and if needed, fish ladder of appropriate size may be provided. The major impact has already occurred due to construction of the barrage and its off-taking canals and there will be no significant impact on wild life and bird population.

The potential socioeconomic impacts of the Project are identified and assessed in this section. The potential socioeconomic impacts of the Project are categorized into the following three impact groups:

- **Macroeconomic**: Impacts related to the national economy;
- **Local Livelihoods and Wellbeing**: Economic benefits to the community residing in the vicinity of the Project ;and
- **Socio-Cultural**: Social and cultural impacts on the local communities due to the Project.

Following mitigation measures have been proposed to avoid or minimize all potential impacts from the proposed project.

| Aspect | Mitigation Measure/ Good Practices |
|---|---|
| Soil Erosion | Vegetation loss will be limited to demarcated construction area. |
| | Areas such as muck disposal area, batching plant, labor camp and quarry sites after the closure shall be covered with grass and shrubs. |
| | Slope stabilization measures will be adopted such as adequate vertical and horizontal drains, drainage along roadsides, cross drainage and retaining walls. |
| | Slope movements will be monitored around excavation work areas. |
| Waste Disposal | Wastewater treatment system will be made to ensure that the effluents during construction and operation comply with NEQS standards and the conditions of lenders. |
| | Release of camp effluents directly to the water channels or land will be prohibited. |
| | Waste generated will be collected at designated waste dumping area and cleared from site by contractor during construction and by the company during operation. |
| | Lining of all effluent channels with cement at all working areas will be done to prevent seepage. |
| Water Resource Depletion | Water for different construction activities will be arranged from the canal or from a source approved by the local authorities. |
| | Water conservation techniques will be developed and implemented by the EPC contractor. |
| | Accessofcommunitytowatersourcesshallbekeptclearsothatthecommunity's ability to meet its water requirements is not compromised |
| Fugitive Dust Emissions | Water will be sprinkled on unpaved project areas in dry weather for fugitive dust Control. |
| | Gradingoperationwillbesuspendedwhenthewindspeedexceeds20km/hr. |
| | All storage piles with fine material shall be adequately wetted or covered with plastic to ensure protection of ambient air from fugitive emission during windstorm. |
| | Batching plants and associated machinery will be installed with suitable dust control arrangements. |
| | Speed limits and defensive driving policies will be strictly implemented. |
| | Road damage caused by Project activities will be promptly attended to with proper repair and maintenance |
| Vehicular and Machinery Exhaust Emissions | Equipment and vehicles in good working condition and low emission levels will be used. A visual check will be performed when the equipment is mobilized and periodically later to screen out equipment and vehicles that emit unacceptable levels of smoke. |
| | Batching plant machinery will be maintained and exhaust emissions will be minimized. |
| | Batching plant will be set up considering the wind direction so that the nearby communities are not affected by the emissions from batching plant. |
| | Regular maintenance and service of vehicles and equipment will be conducted. |
| Noise Nuisance | Construction equipment that could potentially generate high noise levels will have an adequate muffler system. |
| | All stationary noise generating equipment such as power generators will be placed at least 200 m away from the residential area. |
| | In case threshold values are exceeded then adjusting the distances for the equipment on the basis of monitoring report. |
| | A preventive maintenance procedure for Project vehicles and equipment will be set andfollowedwhichwillhelppreventnoiselevelsfromdeterioratingwithuse. |
| | Provision of Personal Protective Equipment (PPEs), i.e. ear muffs and plugs, will reduce noise impact on personnel. |
| | Restriction on pressure horn. |
| | Sirens will be used to warn the locals prior to blasting and will only be carried out |

| Aspect | Mitigation Measure/ Good Practices |
|---|---|
| | During daytime. |
| Traffic | Contractor's vehicle will follow strict speed limits within city and all applicable local traffic rules and regulations imposed by National Highway Authority (NHA) especially near sensitive receptors (schools, hospital, mosques ,etc.). |
| | Over speeding will be subject to disciplinary actions. |
| | Local traffic will be allowed to overtake and drivers will be encouraged to make way for the local commuters, ambulances, army and special persons conveys in all cases. |
| | Alternative roads shall be provided to local communities. |
| | Large vehicles that can slow down the local traffic significantly will only travel in the night time or a special permission from the district administration will be obtained. |
| | Contractor's vehicles and equipment will be parked at identified designated area. |
| | Vehicles and machinery will be appropriately parked/placed to avoid inconvenience to local commuters and pedestrians. |
| | Prior communication to residents and safety signs will be installed well before the commencement of any activity at site. |
| | The vehicles will be encouraged to leave the local area as quickly as possible after the delivery of material to the Project site. |
| | Vehicle maintenance work will only be carried out in designated workshops. |
| | Contractor's vehicle will follow strict speed limits within city and all applicable local traffic rules and regulations imposed by National Highway Authority (NHA) especially near sensitive receptors (schools, hospital, mosques, etc.). |
| | Over speeding will be subject to disciplinary actions. |
| Bird Communities | Vegetation clearance shall be minimized. |
| | Re-vegetation shall be enforced where required. |
| | Noise shall be minimized |
| | No fishing or hunting shall be allowed |
| Local Livelihoods and Wellbeing | Ensure preferential recruitment of local candidates provided they have the required skills and qualifications. |
| | Include an assessment of the contractor's demonstrated commitment to domestic and local procurement and local hiring in the tender evaluation process. |
| | Coordinate recruitment efforts related to non-skilled labour, including for non-skilled labour positions required by contractors. |

## Environmental Management and Monitoring Plan

The environmental management plan (EMP) developed to effectively implement the mitigation measures identified in the IEE are presented in this section. The EMP satisfies the requirements of the Pakistan Environmental Protection Agency Initial Environmental Examination and Environmental Impact Assessment Review Procedures, 2000.

An EMP provides a delivery mechanism to address the adverse environmental impact of a project during its execution, to enhance project benefits, and to introduce standards of good practice to be adopted for all projects works.

The primary objectives of the EMP are to:

1. Facilitate the implementation of the mitigation measures identified in the IEE

2. Define the responsibilities of the project proponents, contractors, and environmental monitors, and provide a means of effectively communicating environmental issues among them
3. Define a monitoring mechanism and identify monitoring parameters in order to:
    - Ensure the complete implementation of all mitigation measures
    - Ensure the effectiveness of the mitigation measures
4. Provide a mechanism for taking timely action in the face of unanticipated environmental situations
5. Identify training requirements at various levels.
6. Monitor the implementation of the project during construction phase and maintain the compliance

A team of specialists shall be deputed to carry out monitoring during construction and operation stages.Theproponentshallberesponsiblefordeputingtheteamanditsadministrativecontrol.

The primary responsibilities for the environmental performance of the project proponents, the EPC contractor and sub-contractors will be assumed by their respective highest-ranking officers in on the project.

The mitigation plan is a key component of the EMP. It lists all the potential effects of the project and their associated mitigation measures identified in the IEE. Many measures have been recommended during the impact assessment but in this plan a summary of critical measures are listed. However the implementation of all other measures recommended to be implemented. For each impact, the following information is presented in the plan:

- Environmental Aspect
- Mitigation measures and good practices
- Monitor the compliance of the plan during construction of the project

The proposed project activities were reviewed and their potential impact on the area's natural, socioeconomic, and cultural environment was assessed using both qualitative and quantitative assessment methods. Where appropriate, mitigation measures were recommended to keep the adverse environmental impact within acceptable limits.

After assessing the significance of potential impacts, it has been concluded that if the project activities are carried out as described in this report, and the suggested mitigation measures are implemented, the proposed project will not have a significant impact on the area's natural and socioeconomic environments. The project will also comply with all relevant statutory requirements and standards listed in related sections. The project will be monitored during the construction phase to ensure the necessary compliance of the plan.

# MAIN REPORT

# 1 INTRODUCTION

The Gugera Canal Hydro Electric Power Project is proposed to be constructed at RD 214+500 (31°32'44.42"N, 73°41'34.14"E) of Upper Gugera Canal. It is located near Nankana Sahib in in District Nankan (previously Sheikhupura), Punjab Province. The proposed hydroelectric power project will have installed capacity of 3.6 MW and will generate 21.3 GWh annually. The project has been proposed near RD 214+S00 (31°32'44.42"N, 73°41'34.14"E) of Upper Gugera Brach Canal by combining head available on fall structure at RD 216+100 and at fall structure at RD 220+750 (31°32'20.78"N, 73°40'57.26"E). The project would be equipped with 3 bevel gear bulb turbines each has capacity of 1.2 MW each. The project would be connected with LESCO/NTDC Grid at Walgan Sohail which is about 7 km from project site. The Walgan Sohail Grid is 132/11 kV. The project would be connected with Walgan Sohail Grid through two single circuit 11 kV transmission lines.

Upon solicitation by Gugera Hydropower Company Private Limited, the sustainable solutions private limited (SSPL) has carried out the Initial Environmental Examination (IEE) of the proposed project. This documents presents the process and findings of the same for necessary environmental approvals from regulators and financiers where required. The SSPL is a consortium of consultants and renowned professionals from development and corporate sector having expertise in human and social development, environmental management, environmental law and institutional and organizational development. SSPL is a corporate entity registered in Islamabad Pakistan under Companies Ordinance 1984. The company specializes in Environmental Assessment, Capacity Building, Research, Monitoring and Evaluation and Project Management and offers wide ranging consulting services to private, public and corporate sector institutions, donor community, NGOs and other civil society organizations, helping them in their pursuit of Sustainable Development. The company has its head office in Islamabad and regional offices.

## 1.1 Background

The proposed project is being carried out by Gugera Hydropower Company Private Limited. The company is in the process of preparation of feasibility study report leading to implementation of the Upper Gugera Brach Canal Hydro Electric Power Project "the Project" under the terms of a Letter of Interest (LOI) issued on June 2013 by the Punjab Private Power Development Board (PPDB). The PPDB's authorization is in accordance with the Government of Punjab's "Punjab Power Generation Policy, Year 2006" (the Policy) revised during 2009 to encourage private-sector infrastructure investments.

The Punjab Hydropower Company, Lahore hired the Services of the Consultants, M/S Technical, Engineering and Management – TEAM Consultants Pakistan, to conduct feasibility studies for the Upper Gugera Brach Canal Hydro Electric Power Project. The studies were commenced during December 2013 and the report was completed.

The project site and area is located in the central Punjab and lies in Sheikhupura District. The project area is located about 75 km from Lahore, 35 km from Sheikhupura city and 67 km from Faisalabad. The area is accessible by good roads' network of Motorway, National highway and district road. The site is accessible by Motorway M2 as well as the GT road. The area is accessible via railway network and the nearest Railway station is Sheikhupura. The nearest airports are Allama Iqbal International Airport Lahore and Benazir Bhutto International Airport, Islamabad.

The proposed project will utilize water flow from Chenab River. Chenab River is part of Indus Basin River system and the third river of the western river on which water Pakistan has the right under Indus Basin Treaty signed between India and Pakistan under the office of World Bank. It contributes a good part of water supply to the irrigated agriculture system in Pakistan. The river Chenab originates in the Kulu and Kangra Districts of the Himachal Pardesh Province of India. The Two Chief streams of the Chenab - the Chandra and the Bhaba - rise on the opposite sides of Baralcha Pass at an elevation of about 4877 m (16,000 ft). These join at Tandi in the state of Jammu and Kashmir, nearly 2,770.6 m (9,090 ft) above mean sea level.

Khanki Headwork on river Chenab situated about 14.5 km downstream from Town of Wazirabad was built and made operational in the year 1892. This was the first weir in Punjab which had been founded on alluvial bed of the river. During 1932, sudden collapse of some major part was apprehended to take place. A lot of research was carried out by irrigation and hydraulic engineers especially work of Khosla wrote a theory which even today is considered to a bible for the design of hydraulic structures on alluvial/permeable soils. The weir 1336.24 m long was constructed in the year 1892 with some latter additions consisted.

The Gugera Branch Canal originates from the Lower Chenab Canal from its RD 140+050. The main areas to which it supplies water are Toba Tek Singh and Faisalabad. Upper Gugera Branch after travelling a distance of about 85.95 km. It is further bifurcated at RD 280+000 into two canals namely Lower Gugera Branch (LGB) and Burala Branch. The tail of Lower Gugera Branch is at RD 387+566 and Burala Branch is at RD485+755.

## 1.2 The Purpose

To ensure that project activities adhere to the environmental requirements of country, the company conducted environmental screenings and assessments as required. Environmental assessments will be completed for relevant project activities to ensure environmentally sustainable development by mitigating negative and increasing positive impacts. In line with the national policy, a preliminary screening of project activities is proposed to assess whether or not an environmental assessment is required, recommended or not required.

### 1.2.1 Research Objectives

The goal of this IEE is to ensure an environmentally and socially sustainable project. This IEE will:

- Assess the existing environmental conditions in the project 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 in Pakistan and requirements of national policy on environmental sustainability.

## 1.3 Project Area

The project area is defined as the geographical region where the environmental and social impacts of the project, both during development and operation, are likely to occur. For this IEE the project area is defined as the area located within vicinity of project components. To assess that the projects are not located within any ecologically sensitive, archaeologically significant or socially and culturally important area, it is therefore expected that the environmental and social impact of the project on the project areas would be fairly temporary and mainly benefit the local population. Maps of the project area are presented as **Figure1-1**.

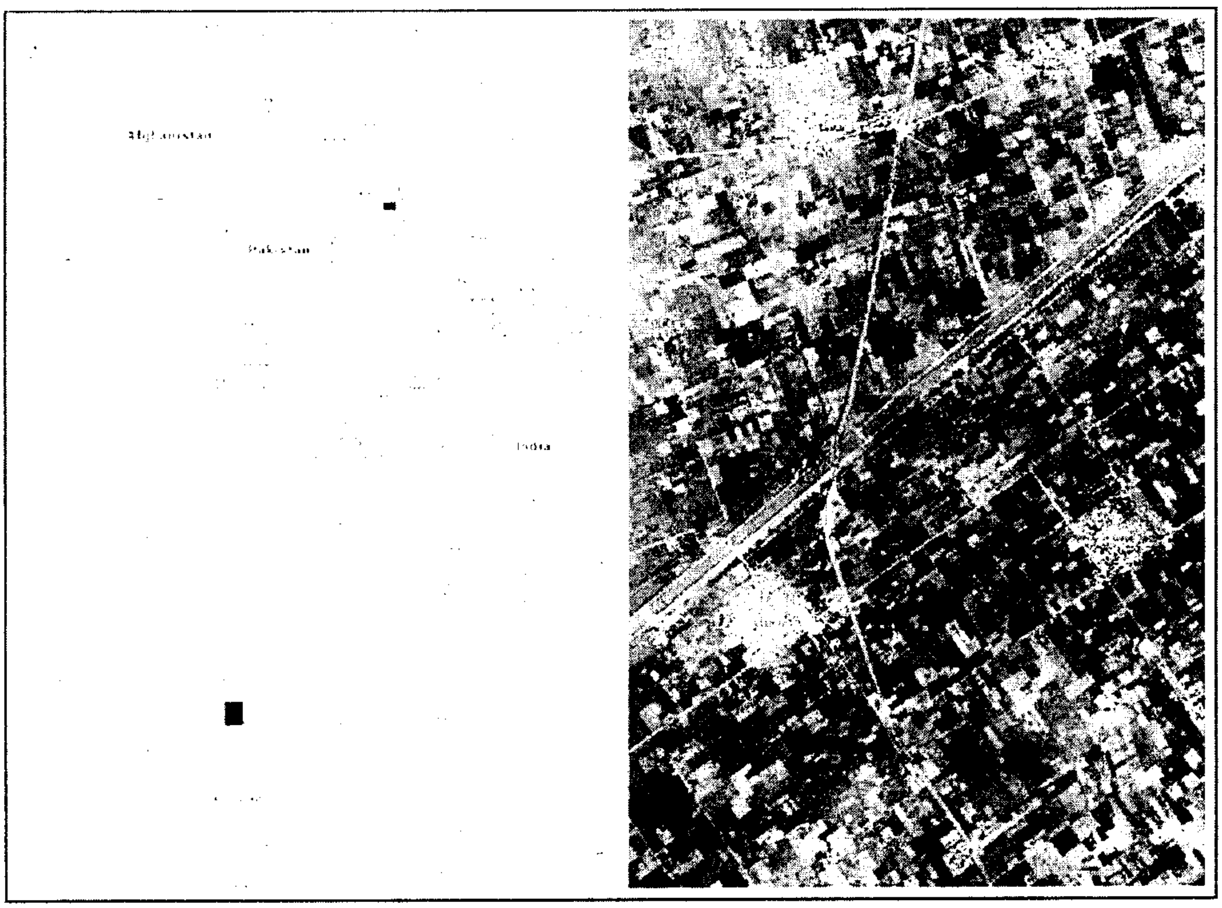


**Figure 1-1: Project Locatior**

## 1.4 Methodology

The environment assessment will mainly focus on physical verification of existing conditions in the area and qualitative aspects (FGDs and IDIs) to determine the extent to which the project was able to meet environmental requirements. The partners, stakeholders, project staff and community beneficiaries in respective projects area will be involved in data gathering and information collection processes. The overall process of the assessment would be as follows:

### 1.4.1 Scoping

The key activities of this phase included:

- Project Data Compilation: A generic description of the proposed activities relevant to environmental assessment was compiled with the help of the proponent.
- Published Literature Review: Secondary data on weather, soil, water resources, wildlife, and vegetation were reviewed and compiled.
- 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 were identified.

### 1.4.2 Baseline Data Collection

No considerable amount of baseline information on the project area was available from existing literature. Therefore a detailed field visit was conducted to collect primary data on the proposed site and alternatives of the power plant.

### 1.4.3 Tools Development

Appropriate tools and formats will be developed for secondary and primary data gathering. The tools would include:-

- Checklist for environmental parameters
- Guidelines / Checklist for Focus Group Discussions(FGDs)
- Preliminary Environment Assessment Form
- Environment Assessment Form

### 1.4.4 Meetings with Staff and Stakeholders

Secondary information which is already available would be reviewed during the assessment.

- Meetings with relevant project staff
- Meetings with local stakeholders

### 1.4.5 Primary Data Gathering (Field)

Both qualitative and quantitative information and data will be gathered for the assessment. The major activities will be as follows:

- Identify the sources of information

- Schedule and plan the field visit to project/ program site
- Physical verification of sites. Observations related to environment assessment will be recorded and analyzed for integration in the final report.
- Conduct FGDs/ interviews/ meetings. FGDs will be held with a group of 8-10 people at each project site.
- Analysis of the information

### 1.4.6 Compilation of Data (Analysis)

Data compilation and analysis of information would be part of the revaluation before report is drafted.

- Analysis of data gathered through secondary and primary sources
- Tabulate/ articulate data. Results of the qualitative research will be then triangulated with the findings of the literature review.

### 1.4.7 Impact Assessment and Mitigation

The environmental, socio-economic, and project information collected was used to assess the potential impacts of the proposed activities. The issues studied included potential project impacts on:

- Land Resource and Geomorphology
- Groundwater and surface water quality
- Ambient air quality, greenhouse gas emissions and ambient noise levels
- The ecology of the area, including flora and fauna especially theaquatic ceco system
- Local communities

Wherever possible and applicable, the discussion covers the following aspects:

- The present baseline conditions
- The potential change in environmental parameters likely to be effected by project related activities
- The identification 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-term and short-term, direct and indirect, and beneficial and adverse impacts
- The monitoring of residual impacts.

For Impact assessment and mitigation the following matrix will be used to identify, assess and propose the mitigation options for the potential environmental impacts.

Table 1-1: Impact Assessment and Mitigation Matrix

| ***PARTA:DEFINING CONSEQUENCE IN TERMS OF MAGNITUDE, DURATION AND SPATIAL SCALE*** | | | |
|---|---|---|---|
| Impact characteristics | Definition | Criteria | |
| MAGNITUDE | Major | Substantial deterioration or harm to receptors; receiving environment has an inherent value to stakeholders; receptors of impact are of conservation importance; or identified threshold often exceeded | |
| | Moderate | Moderate/measurable deterioration or harm to receptors; receiving environment moderately sensitive; or identified threshold occasionally exceeded | |
| | Minor | Minor deterioration (nuisance or minor deterioration) or harm to receptors; change to receiving environment not measurable; or identified threshold never exceeded | |
| **DURATION/ FREQUENCY** | | Continuous aspects | Intermittent aspects |
| | Short term/ low frequency | Less than 4years | Occurs less than once a year |
| | Medium | More than 4 years up to end of life of project (approximately 56years) | Occurs less than 10 times a year but more than once a year |
| | Long term/ high frequency | Beyond the life of the project (greater than 30years) | Occurs more than 10 times a year |
| SPATIALSCALE | | Biophysical | Socio-economic |
| | Small | Within 200 meters (m) of the Project footprint | Within the Study Area |
| | Intermediate | Within 3 kilometer (km) of the Project footprint | 10 km from the Project facilities |
| | Extensive | Beyond 3 km of the Project footprint | Beyond 10 km from the Project facilities |

***PART B: DETERMINING CONSEQUENCE RATING***

***Rate consequence based on definition of magnitude, spatial extent and duration***

| | | | SPATIALSCALE | | |
|---|---|---|---|---|---|
| | | | Small | Inter-mediate | Extensive |
| MAGNITUDE | | | | | |
| Minor | DURATION/ FREQUENCY | Long /high | Medium | Medium | Medium |
| | | Medium | Low | Low | Medium |
| | | Short /low | Low | Low | Medium |
| Moderate | DURATION/ FREQUENCY | Long /high | Medium | High | High |
| | | Medium | Medium | Medium | High |
| | | Short /low | Low | Medium | Medium |
| Major | DURATION/ FREQUENCY | Long /high | High | High | High |
| | | Medium | Medium | Medium | High |
| | | Short /low | Medium | Medium | High |

***PART C: DETERMINING SIGNIFICANCE RATING***

***Rate significance based on consequence and probability***

| | | CONSEQUENCE | | |
|---|---|---|---|---|
| | | Low | Medium | High |
| PROBABILITY (of exposure to impacts) | Definite | Low | Medium | High |
| | Possible | Low | Medium | High |
| | Unlikely | Low | Low | Medium |

### 1.4.8 Report Writing

Based on the data collected, report has been prepared covering all the components of environmental assessment. Following steps were followed while preparing the report:

- Based on the data/ information, the evaluation report has been drafted and shared with project staff for comments/inputs.
- The comments / inputs have been incorporated in the final report.

## 1.5 Project Classification

The Gugera Canal Hydro Electric Power Plant falls under Category requiring an IEE as per schedules of Pakistan Environmental Assessment Regulations in terms of its anticipated potential impacts. The proponents of the projects that have more adverse environmental impacts are required to submit a complete Environmental Impact Assessment (EIA). Therefore, detailed Environmental Impact Assessment (EIA) is not required for this project and only Initial Environmental Examination (IEE) is required. So IEE has been carried out to fulfill the requirements of the Government of Punjab / Pakistan. Rapid Environmental Assessment Guidelines of the ADB (May 2003) have been used to assist in systematic consideration of all potential impacts.

## 1.6 The Report Structure

This IEE document is structured as follows:

Chapter - 1: Introduction containing general information about the project and process of carrying out the study.

Chapter - 2: Legislative and Policy Framework describes the policy, laws and regulations governing this ESIA.

Chapter - 3: The Project Description describes overall details of the proposed activities to be carried out as the two phases of this project.

Chapter - 4: The Baseline Study gives information on physical, biological and social conditions collected through survey of the project area.

Chapter - 5: Public Consultation and Disclosure explains the process of public consultation and disclosure of the report at the District Council Office as well as important public library(s). It makes this document a legal public document.

Chapter - 6: Environmental and Social Impact Assessment identifies various environmental and social impacts and their suggested mitigations. This makes the basis of the Environment and Social Management Plan.

Chapter – 7: Environment Management Plan (EMP) contains comprehensive prescriptions regarding environmental and social impacts and their mitigation. This also includes institutional arrangements and Environmental Management Monitoring Plan.

# 2 NATIONAL POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

'Sustainable Development' is a concept that has emerged over the past three decades to describe a new framework that aims 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 section describes the current legal responsibilities of the proponent in the context of the environment and sustainable development, and the requirements of the institutions that may influence the environmental management of the project.

Based on the legal requirements / prescribed rules discussed hereunder and preliminary screening of the project, the regulations of Punjab do mandate submission of an Environmental Impact Assessment (EIA) or Initial Environmental Examination (IEE). Punjab Environmental Protection Act, (GoP 2000) Schedule I requires IEE of projects in the major categories of transport infrastructure, processing industries, agriculture, livestock and fisheries, energy, water management (dams), water supply treatment, waste disposal and urban development. Schedule II requires EIA for projects of greater magnitude. The minimum requirements for submission of IEE or EIA under Schedule are:

For Water management, dams, irrigation and flood protection; the dams and reservoirs with storage volume no less than 50 million cubic meters of surface area no less than 8 square kilometers; or irrigation and drainage projects serving no less than 15,000 hectares; or small-scale irrigation systems with total cost no less than Rs.50 million. Specifically for water supply and treatment projects the supply schemes and treatment plants with total cost of no less than Rs.25million.

## 2.1 National Policy and Administrative Framework

The following sections summarize the environmental and social obligation arising from Pakistan's environmental, highways, water, labor and health and safety legislation.

### 2.1.1 Overview

The subject of 'environmental pollution and ecology' is included in the constitution of Pakistan, enabling both the national and provincial governments to enact laws on the subject. The Pakistan National Conservation Strategy (NCS) which was approved by the federal cabinet in March 1992 is the principal policy document on environmental issues in the country. The NCS outlines the country's primary approach towards encouraging sustainable development, conserving natural resources, and improving efficiency in the use and management of resources. The NCS has 68 specific programs in 14 core areas in which policy intervention is considered crucial for the preservation of Pakistan's natural and physical environment. The core areas that are relevant in the context of the project are pollution prevention and abatement, restoration of rangelands, increasing energy efficiency, conserving biodiversity, supporting forestry and plantations, and the preservation of cultural heritage.

The Ministry of Environment regulates the environment and wildlife at the national level, with two organizations primarily responsible for administering the provisions of the Pakistan Environmental Protection Act 1997 (PEPA 1997), namely:

- Pakistan Environmental Protection Council (PEPC), which oversees the functioning of the Pakistan Environmental Protection Agency with representatives from the government, industry, non-governmental organizations and the private sector ;and
- Pakistan Environmental Protection Agency or EPA (established in 1984), which is the primary implementing agency ensuring compliance with National Environmental Quality Standards (NEQS), establishing monitoring and evaluation systems, and both identifying the need to and initiating legislation when necessary.

Significant work on developing environmental policy was carried out in the late 1980s, which culminated in the Pakistan National Conservation Strategy in 1992. Provincial environmental protection agencies were established at about the same time and the NEQS were established in 1993. The national EPA is authorized to delegate powers to its provincial counterparts. With the enactment of PEPA in 1997, broad-based enforcement powers were conferred to the national and provincial EPAs.

Section 12(1) of PEPA requires that: "No proponent of a project shall commence construction or operation unless he has filed with the Federal Agency an initial environmental examination (IEE) or, where the project is likely to cause an adverse environmental effect, an environmental impact assessment (EIA), and has obtained from the Federal Agency approval in respect thereof." The Pakistan EPA has delegated the power of review and approval of IEEs and EIAs to the provincial EPAs. A number of supporting rules and regulations relevant to the Project have been promulgated under the PEPA1997.

The NEQS prescribe effluent and emission limits for various activities and have been amended twice, in 1995 and 2000, since they were first promulgated in1993.

The scope of environmental law implied by the legal definition of 'environment' given in PEPA 1997 results in numerous laws enacted since the nineteenth century being classified as environmental laws. These include laws pertaining to forests, water resources, wildlife, land, agriculture, health and town planning. In addition, the Pakistan authorities have issued guideline documents supporting specific pieces of legislation or relevant to a particular industry, for example, the Guidelines for the Preparation and Review of Environmental Reports (GoP 1997) and the Sectoral Guidelines for Environmental Reports: Major Thermal Power Stations (GoP1997).

Pakistan is a signatory to the Convention on Biological Diversity, and is thereby obligated to develop a national strategy for the conservation of biodiversity. The Government of Pakistan has constituted a Biodiversity Working Group under the auspices of the Ministry of Environment, Local Government and Rural Development to develop a Biodiversity Action Plan for the country. After an extensive consultative exercise, a draft Action Plan has been developed. The draft Plan, which has been designed to complement the NCS and the proposed provincial conservation strategies, identifies the causes of biodiversity loss in Pakistan and suggests a series of proposals for action to conserve biodiversity in the country.

### 2.1.2 The Pakistan Environmental Protection Act, 1997

The Pakistan Environmental Protection Act, 1997 empowers the EPA to:

- Administer and implement the provisions of the Act and the rules and regulations made there-under to comply with the environmental policies approved by the Council;
- Enforce the provisions of the Act through environmental protection orders and environmental tribunals headed by magistrates with wide-ranging powers, including the right to fine violators of the Act.
- Prepare or revise, and establish the Environmental Quality Standards with the approval of the Council;
- Develop environmental emission standards for parameters such as air, water and land.
- Identify categories of projects to which the Initial Environment Examination (IEE) or Environmental Impact Assessment (EIA) will apply.
- Develop guidelines for conducting initial environmental examinations (IEE) and EIA's and procedures for the submission, review and approval of the same.
- Review IEE or EIA with the objectives that these meet the requirements of the Act.
- Public participation shall be ensured during review process of IEE or EIA reports.

### 2.1.3 Regulations for Environmental Assessment

Under Section 12 of Environmental Protection Act 1997, a project falling under any category specified in Schedule I (SRO 339, 10/2000) requires proponent to file an Initial Environment Examination (IEE) report with concerned provincial or federal agency (Pak – EPA). Projects falling under any category specified in schedule the proponent will submit an EIA with the Provincial Agency. Within 10 working days of IEE or EIA having been deposited, the empowered agency will confirm that the document submitted is complete for the purpose of review. During this time should the empowered agency require the proponent for revision, clearly citing those aspects that need further discussion the proponent will carry out necessary revision. Subsequently, the federal agency will make every effort to complete process for an IEE review within 40 days and an EIA within 90 days of filing.

Pak – EPA regulation (SRO 339(1)/2000) states that an IEE is required for federal or provincial projects (except in case of maintenance, rebuilding or reconstruction case) with a total cost of less than 45 million. An EIA on the other hand is required for federal or provincial project (except in the cases of maintenance, rebuilding or reconstruction) with a total cost of 50 million or more. EIAs are also required where projects are to be implemented in environmentally sensitive areas, or are likely to cause adverse environmental effects.

Recognizing that the Pak – EPA has delegated powers to provincial EPAs to enforce the provision of Environment Protection Act 1997, wherever required an EIA must be submitted to the provincial agencies in whose jurisdiction the project falls.

### 2.1.4 Guidelines for Environmental Assessment

The Pak-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 project are listed below, followed by comments on their relevance to the project:

*A. Guidelines for the Preparation and Review of Environmental Report:*

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

- The nature of the information to be included in environmental reports
- The minimum qualifications of the EIA team 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 project area, detailed assessment thereof, and mitigation measures.

*B. Guidelines for Public Consultation:*

These guidelines 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 that their concerns are incorporated in any impact assessment study.

### 2.1.5 National Environmental Quality Standards (NEQS)

The National Environmental Quality Standards (NEQs) specify the following standards:

- Maximum allowable contamination of pollutants (32 parameters) in emission and liquid industrial effluents discharged to inland water.
- Maximum allowable concentration of pollutant (16 parameters) in gaseous emission from sources other than vehicles.
- Maximum allowable concentration of pollutants in gaseous emissions from vehicle exhaust and noise emission from vehicles.
- Maximum allowable noise level from vehicles.
- Ambient noise standards
- Ambient air quality standards.

These standards apply to gaseous emissions and liquid effluents discharged by batching plants, asphalt plants, camp sites, construction machinery, and vehicles. The standards for vehicle, noise wastewater and drinking water will apply during the construction as well as operational phase of the project.

These NEQS are presented in **Annexure I**.

### 2.1.6 The Forest Act, 1927 and the Forest (Amendment) Act2010

The Act, inter alia, deals with the matters related with protection and conservation of natural vegetation/habitats. In that matter it empowers the concerned agency to declare protected and reserved forest areas and maintaining these. In spite of the fact that it recognizes the right of people for access to the natural resources for their household use, it prohibits unlawful cutting of trees and other vegetation.

Therefore, for cutting trees for the construction purposes or otherwise, prior permission is required from the forest department of the concerned province.

### 2.1.7 Water law

Most of the law on water allocations and use in Pakistan applies to water needed for irrigation and is not relevant to the project. Historically and throughout Pakistan, the law links groundwater rights to the surface right holders.

In the last decade, water law in Pakistan has been under review with a draft National Water Policy published in 2003, which identifies the following needs for the regulation of industrial use of water:

- Make available and reserve sufficient supplies of water for industry on priority basis to promote industrial development and economicgrowth ;and
- Enact legislation to formally allow and define the use of water abstraction licenses and water rates for industrial use.

### 2.1.8 Labour and health and safety legislation

The Constitution of Pakistan contains a range of provisions with regards to labour rights, in particular:

- Article 11 of the Constitution prohibits all forms of slavery, forced labour andchild labour ;
- Article 17 provides for a fundamental right to exercise the freedom of association and the right to form unions;
- Article 25 lays down the right to equality before the law and prohibition of discrimination on the grounds of sex alone ;and
- Article 37(e) makes provision for securing just and humane conditions of work, ensuring that children and women are not employed in vocations unsuited to their age or sex, and for maternity benefits for women in employment.

Labour law is enforced at both provincial and national levels .The employment agreement must comply with the applicable labour laws. There are various laws containing health and safety requirements including: Factories Act 1934; Provincial Factories Rules; Hazardous Occupations Rules 1963; Provincial Employees Social Security Ordinance 1965; Workmen's Compensation Act 1923 and Dock Laborers Act 1934.No single comprehensive piece of legislation deals with occupational or community safety and health.

### 2.1.9 The Antiquities Act,1975

The Act deals with the matters relating to the protection, preservation and conservation of archaeological/ historical sites and monuments. It prohibits construction (or any other damaging) activity within 200 meters of such sites unless prior permission is obtained from the Federal Department of Archaeology and Museums. Invariably, for the implementation of new projects an archeological survey is required and in the light of this, clearance is sought from the federal. In spite of the fact that Provincial Archaeological Departments exists, the pertinent authority for issuing clearance is the Federal Department.

### 2.1.10 The Pakistan Penal Code, 1860

The Act deals with the offences where public or private properties and human lives are affected due to intentional or accidental misconduct of an individual or a mass of people. It also addresses violation to any law of the country.

### 2.1.11 The Explosives Act, 1884

It provides regulations for handling, transportation and use of explosives. The contractors have to abide by the regulations during quarrying, blasting and for other purposes.

Sector-wise legislation applicable in Pakistan is given in **Table**2-1.

**Table 2-1: Sector-Wise Legislation**

| *Serial* | *Sector* | *Legislation* |
|---|---|---|
| 1 | Environmental protection | The Pakistan Penal Code(1860) |
| | | Pakistan Environmental Protection Act(1997) |
| 2 | Land use | The Land Improvement Loans Act(1883) |
| | | The West Pakistan Agricultural Pests Ordinance (1959) and Rules (1960) |
| | | The Regulation of Mines and Oil-Fields and Mineral Development (Government Control) Act, 1946. |
| 3 | Water quality and resources | The Pakistan Penal Code(1860) |
| | | The Canal and Drainage Act(1873) |
| | | The Factories Act(1934) |
| | | On-Farm Water Management and Water Users' Associations Ordinance(1981) |
| | | Indus River Water Apportionment Accord(1991) |
| 4 | Air quality | The Pakistan Penal Code(1860) |
| | | The Factories Act(1934) |
| | | The Motor Vehicles Ordinance (1965) and Rules(1969) |
| 5 | Noise | The West Pakistan Regulation and Control of Loudspeakers and Sound Amplifiers Ordinance(1965) |
| | | The Motor Vehicle Ordinance (1965) and Rules(1969) |
| | | NEQS,2000 |
| 6 | Toxic or hazardous substance | The Pakistan Penal Code(1890) |
| | | The Explosives Act(1884) |
| | | The Factories Act(1934) |
| | | The Agricultural Pesticides Ordinance (1971) and Rules(1973) |
| 7 | Solid wastes and effluents | The Factories Act(1934) |
| | | Pakistan Environmental Protection Act(1997) |

| | | |
|---|---|---|
| 8 | Forest conservation | The Forest Act(1927) |
| | | The West Pakistan Firewood and Charcoal (Restrictions) Act(1964) |
| | | The Cutting of Trees (Prohibition) Act(1975) |
| 9 | Parks and wildlife conservation protection | The West Pakistan Ordinance(1959) |
| 10 | Cultural environment | The Antiquities Act(1975) |
| 11 | Livestock | West Pakistan Goats (Restriction) Ordinance(1959) |
| | | The Grazing of Cattle in the Protected Forests (Range Lands) Rules (1978) |
| | | Pakistan Animal Quarantine (Import and Export of Animals and Animal Products) Ordinance(1979/80) |
| 12 | Public health and safety | The Pakistan Penal Code(1860) |
| | | The Boilers Act(1923) |
| | | The Public Health (Emergency Provisions) Ordinance(1944) |
| | | The West Pakistan Factories Canteen Rules(1959) |
| | | The West Pakistan Epidemic Diseases Act(1979/80) |

## 2.2 Interaction with Other Agencies

The proponent is responsible for ensuring that the project complies with the laws and regulations controlling the environmental concerns of construction and operation, and that all pre- construction requisites, such as permits and clearances are met. This section describes the nature of the relationship between the proponent and line departments.

### 2.2.1 Environmental Protection Agency

The proponent is responsible for preparing the complete environmental documentation required by the EPA and remain committed for getting clearance from it. Moreover, it is also desirable that once clearance from EPA is obtained, the proponent should remain committed to the approved project design. No deviation is permitted in design and scope of rehabilitation during project implementation without the prior and explicit permission ofthe EPAs.

### 2.2.2 Revenue Departments

Under the national law, matters relating to land use and ownership are provincial subjects, and for the purposes of this project, the respective Revenue Departments are empowered to carry out the acquisition of private land or built-up property for public purposes. In order to depute land acquisition collectors (LACs) and other revenue staff who will be responsible for handling matters related to acquisition of land and the disbursement of compensation, the proponent must lodge applications with the Governments.

### 2.2.3 Forestry and Wildlife Departments

If the project is expected to involve clearing of vegetation and trees within the project area, the project contractor will be responsible for acquiring a 'No-Objection Certificate' (NOC) from the respective Forest Departments and Local Administration depending upon the type of forest, viz., demarcated, un-demarcated or individual forests under threat. The application for an NOC will need to be endorsed by the proponent.

Where construction is to be carried out in close proximity of protected forests and wildlife areas, the proponent is required to coordinate with the departments to ensure that impacts on vegetation and wildlife are minimized.

### 2.2.4 Local Government and Municipalities

The proponent and its contractors must ensure that the project meets the criteria of the government for the establishment of construction camps and plants, use of the water resources, the safe disposal of wastewater, and toxic materials. These matters lie in the jurisdiction of Local Governments. Therefore, the Contractor should liaise closely with the concerned body. The project Proponent will coordinate and monitor environment-related issues.

The project proponent will liaise with local government/administration and municipalities on the matters related to resettlement of squatters and removal of encroachments or sources of congestion. In specific cases, the project proponent will enter into agreements with the municipality, local government, or other service provider on the resettlement of displaced squatters.

## 2.3 Applicable International Conventions

Environmental problems which migrate beyond the jurisdiction (Trans-boundary) require power to controlsuchissuesthroughinternationalco-operationbyeitherbecomingaContractingParty(CP) i.e. ratifying treaties or as a signatory by officially signing the treaties and agreeing to carry out provisions of various treaties on environment and social safeguards. The relevant international conventions are as provided.

### 2.3.1 Montreal Protocol

Pakistan ratified its accession of the Montreal Protocol on Substances that Deplete the Ozone Layer along with its London Amendment on 18 Dec 1992 and also ratified the Copenhagen, Montreal and Beijing Amendments of 2003. The Montreal Protocol on Substances that Deplete the Ozone Layer regulates many radioactively powerful greenhouse gases for the primary purpose of lowering stratospheric chlorine and bromine concentrations. These gases include the CFCs, HCFCs, chloro-carbons, bromo-carbons and halons.

### 2.3.2 UN (Rio) Convention on Biological Diversity

Pakistan is a signatory to this convention since 5 June 1992 and ratified the convention on 26 July 1994. The Convention on Biological Diversity (CBD) entered into force on 29 December 1993. It has 3 main objectives: 1. the conservation of biological diversity, 2. the sustainable use of the components of biological diversity and 3. The fair and equitable sharing of the benefits arising out of the utilization of geneticre sources

### 2.3.3 Ramsar Convention

Pakistan ratified the Convention on Wetlands of International Importance Especially as Waterfowl Habitat, 1971 (Ramsar Convention) in 1975 and there are currently 19 Ramsar sites in Pakistan, covering an area of 1,343,627 hectares (3,320,170 acres). The convention requires protection of identified wetlands of international importance as identified under Ramsar convention. The Ramsar

Convention (formally, the Convention on Wetlands of International Importance, especially as Waterfowl Habitat) is an international treaty for the conservation and sustainable utilization of wetlands.

### 2.3.4 CMS Convention

The Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or Bonn Convention) aims to conserve terrestrial, aquatic and avian migratory species throughout their range.

### 2.3.5 CITES

Pakistan is a party to CITES, with the conventions implementation through "Pakistan Trade Control of Wild Fauna and Flora Act (2012)". CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.

### 2.3.6 Kyoto Protocol

The Kyoto protocol was signed by Pakistan in 2005 and in February, 2006, the national CDM operational strategy was approved. The convention pertains to the United Nations framework on Climate Change. The 3rd Conference of the Parties to the Framework Convention on Climate Change (FCCC) in Kyoto in December 1997 introduced the Clean Development Mechanism (CDM) as a new concept for voluntary greenhouse-gas emission reduction agreements between industrialized and developing countries on the project level.

### 2.3.7 The Rotter Dam Convention

Pakistan signed the Rotterdam Convention on the Prior Informed Consent (PIC) Procedure on 9 September 1999 and subsequently ratified the convention on 14 July 2005. The Rotterdam Convention (formally, the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade) is a multilateral treaty to promote shared responsibilities in relation to importation of hazardous chemicals. The convention promotes open exchange of information and calls on exporters of hazardous chemicals to use proper labeling, include directions on safe handling, and inform purchasers of any known restrictions or bans. Signatory nations can decide whether to allow or ban the importation of chemicals listed in the treaty, and exporting countries are obliged make sure that producers within their jurisdiction comply.

### 2.3.8 International Labour Organization conventions

Pakistan has also ratified many of the International Labor Organization conventions that are relevant to the Project including:

- C1 Hours of Work (Industry) Convention,1919;
- C5 Minimum Age (Industry) Convention,1919:
- C11 Right of Association (Agriculture) Convention,1921:
- C14 Weekly Rest (Industry) Convention,1921;

- C29 Forced Labor Convention, 1930 & C105 Abolition of Forced Labor Convention,1957;
- C100 Equal Remuneration Convention,1951;
- C107 Indigenous and Tribal Populations Convention,1957
- C111 Discrimination (Employment and Occupation) Convention,1958

## 2.4 Customary Law

Several declarations profoundly influence accepted international approaches to environmental management and sustainable development. Declarations are generally not immediately legally binding, but can acquire the force of international customary law if they continue to express an international consensus that states adhere to over time. Those that influence environmental management and sustainable development are listed below in order of their relative importance to these fields.

- The 1992 Declaration on Environment and Development (or "Rio Declaration) - the Rio Declaration and Agenda 21, which were both products of the 1992 United Nations Conference on Environment and Development, effected the introduction and/or revision of environmental legislation in countries throughout the world resulting in the ESIA process becoming established as a key tool for environmental decision making. According to the United Nations Environment Programme or UNEP (UNEP 2005), many of the Rio Declaration principles are acquiring the force of international customary law, including: transparency, public participation and access to information and remedies; precaution, prevention of environmental harm and polluter pays principles; and good governance.
- The 1972 Declaration on the Human Environment (or "Stockholm Declaration") –Principle 21 (repeated in Principle 2 of the Rio Declaration) has the status of customary law and asserts that States have responsibility to ensure activities within their jurisdiction or control do not cause damage to the environment of other States.
- The 1948 Universal Declaration of Human Rights - the principles contained in this Declaration are considered as international customary law and do not require signature or ratification by the state to be recognized as a legal standard (UNEP2005).
- The 1998 Declaration on Fundamental Principles and Rights at Work - requires both states and businesses to observe International Labour Organization (ILO) Conventions that are of fundamental importance from a human rights perspective. These conventions pertain to: freedom of association, collective bargaining, and industrial relations; forced labour; elimination of child labour and protection of children and young person's; and equality of opportunity and treatment/ elimination of discrimination in respect of employment and occupation.

There are also two conventions of the United Nations Economic Commission for Europe (UNECE) considered to have global significance, even though they are only regional in scope. These are:

- The UNECE Convention on Environmental Impact Assessment in a Trans-boundary Context (Espoo 1991), which sets an international precedent on trans boundary impact assessment and public involvement ;and
- The UNECE Convention on Access to Information, Public Participation in Decision Making and Access to Justice in International Environmental Matters (Aarhus 1998, entered into force 2001), which is considered to be of global importance as an elaboration of Principle 10 of the Rio Declaration.

# 3 DESCRIPTION OF THE PROJECT

## 3.1 Location

The project facilities are proposed to be located near Nankana Sahib (32°34'60N 73°30'0E) of lately declared District Nankana, was previously part of Sheikhupura District of Punjab Province. This study covers an area under both current districts and data obtained from secondary literature presenting the information of previous Sheikhupura District is now applicable to both. The project site is approximately 70 kilometers from Lahore, the Capital of Punjab and 30 kilometers from Sheikhupura, the district headquarters. The project site is located about 12 km from Nankana Sahib. The project area is located almost center of Lahore-Faisalabad Dual Carriageway. The nearest airports are Allama Iqbal International Airport Lahore and International Airport Faisalabad. (See map in **Figure**3-1).

The project is located at RD 214+500 along Gugera Canal which is off-taking from Lower Chenab Canal at RD 104+500. The Lower Chenab Canal is off-taking from left bank of Khanki Headwork along Chenab River, the second river flows controlling structure in Pakistan.

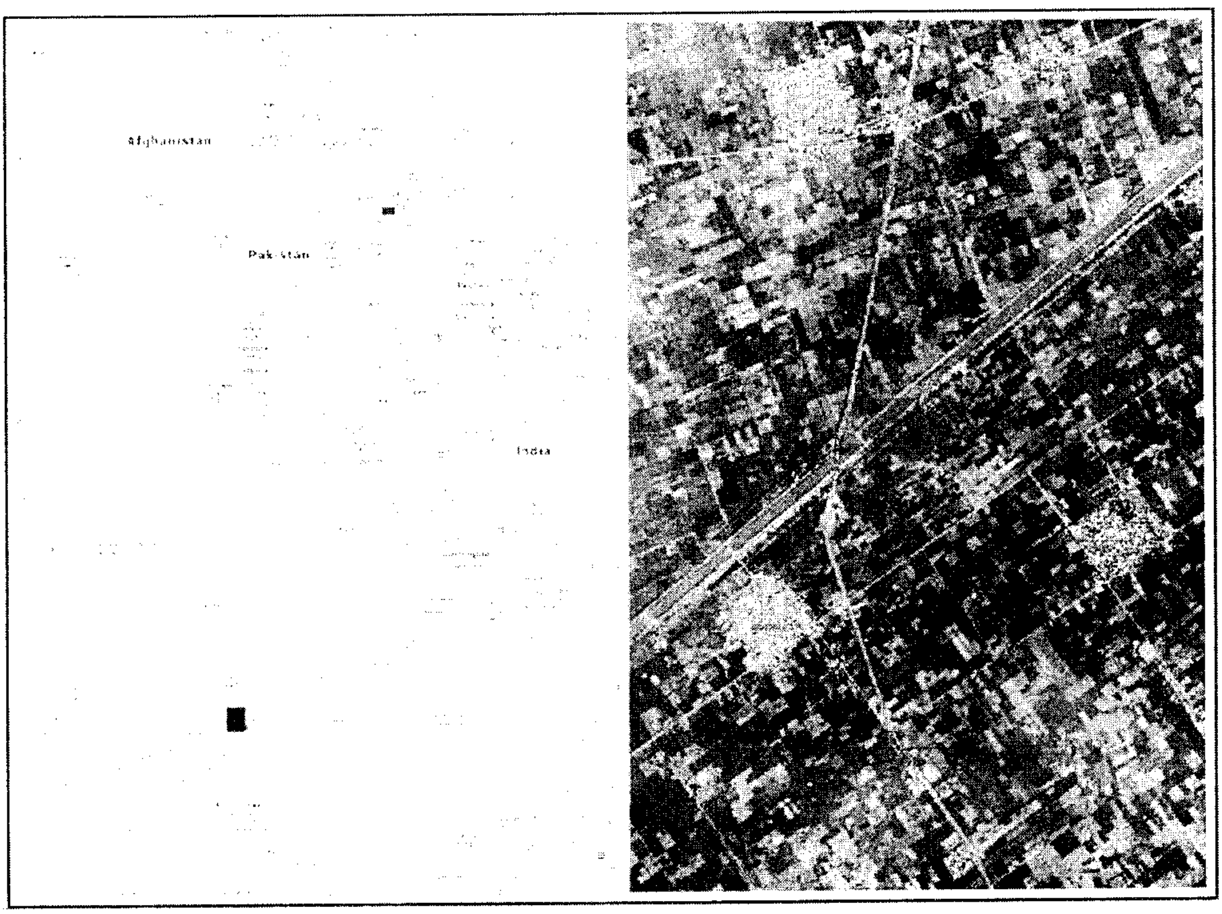


**Figure 3-1: Project Area and Location of Project**

## 3.2 Project Overview

The proposed hydroelectric power project will have installed capacity of 3.6 MW and would generate 20.8 GWh annually. The project physical arrangement and overall characteristics have been configured for optimum hydropower development of the Gugera Hydro Electric Power Project having head available at RD 216+100 and RD 221+500. The selected layout is powerhouse and spillway placed in the bypass arrangement just upstream of Existing fall at RD 216+100 along its right bank. The spillway is placed along the left bank of powerhouse structures. The powerhouse and spillway are placed at RD 214+500 due to constraint of space on right side of the canal near RD 216+100 because of existence of Nankan Sahib Bridge. There is no need of canal diversion for construction of powerhouse and spillway. Powerhouse/spillway would be constructed under dry condition along right bank. After completion of construction of powerhouse and spillway the canal flows will be diverted toward them after connecting the headrace and tailrace on upstream and downstream of project components.

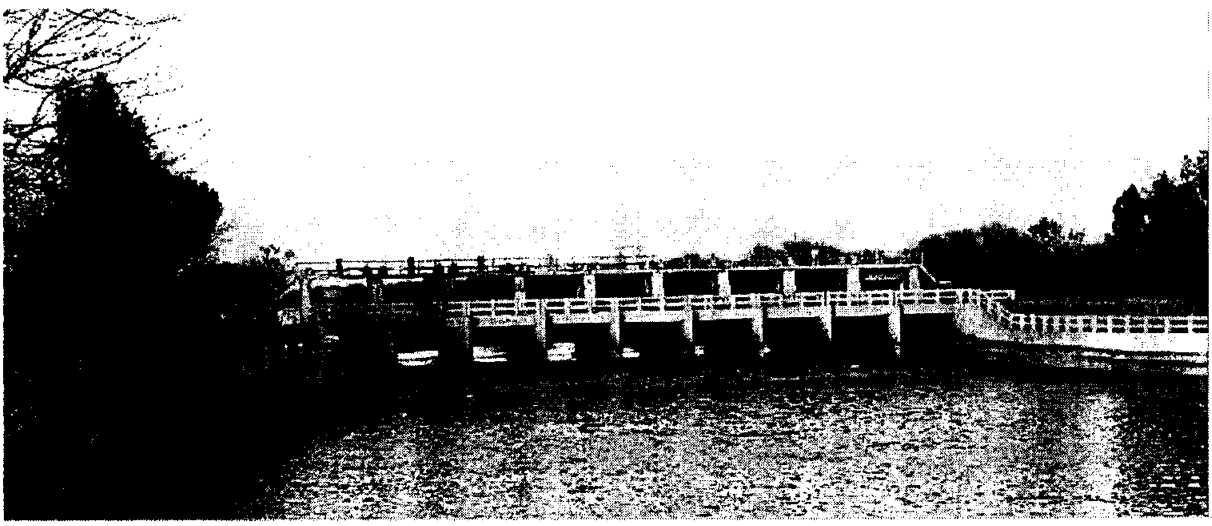


Figure 3-2: Head Regulator near the Project Site

The part between RD 212+000 and proposed powerhouse is called headrace canal. It's length would be 762 m. The headrace would be remodeled and also constructed new. The powerhouse and spillway are placed at RD 214+500. The tailrace starts from downstream powerhouse transition and link the existing Gugera Branch canal just upstream of the Highway Bridge at same alignment with lowered bed level conditions.

Therefore, the Gugera Hydro Electric Power Project comprises the following main components:

- Headrace;
- Powerhouse and spillway Intake Bay;
- Powerhouse (Machine hall and Service bay) structure housing three Bevel
- Gear type turbines and generators with a total installed capacity of 3.6MW; Erection bay on right side of the Powerhouse;
- Gated spillway along left bank of Powerhouse structure;

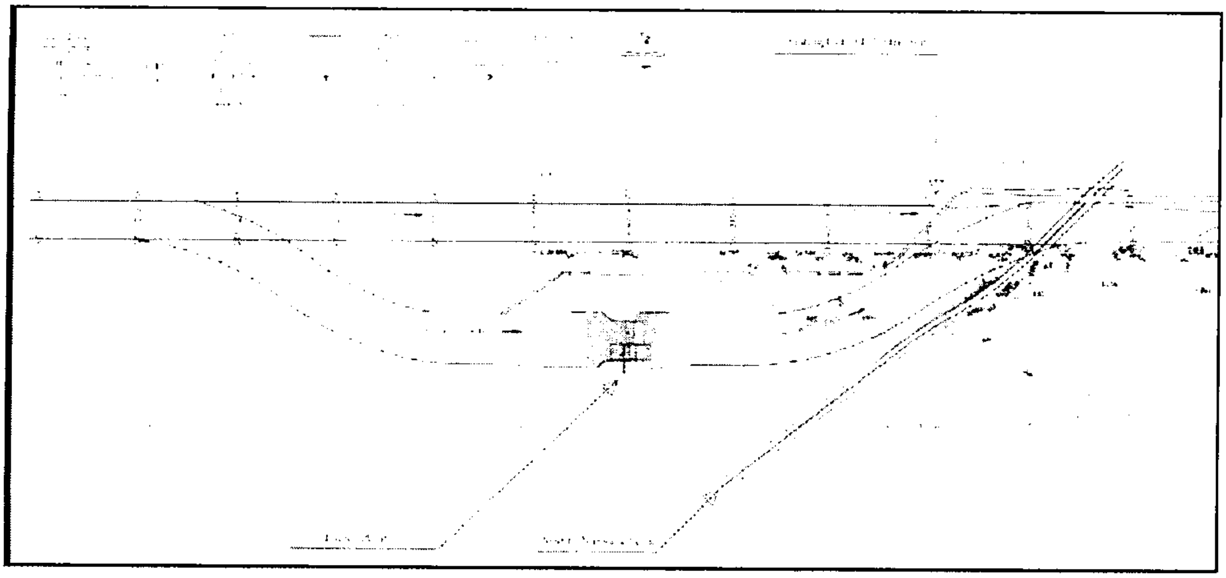


Figure 3-3: Proposed Project Layout

A brief discussion of project major components is given hereunder;

### 3.3.1 Headrace Canal

The headrace canal starts from the existing Gugera Branch Canal at RD 212+000 to the proposed powerhouse location at RD 214+500 along the right hand side of existing Gugera Canal. The headrace starts at 200.0 m.a.s.l and ends at 199.90 masl before powerhouse inlet bay starts. The length of the headrace is about 762 m. The slopes and bed of headrace are protected by stones laid over geo textile to protect the fines from movement and in order to run the headrace without major maintenance cost. If geo-textile is not used below the stones then fine under the pitching would be removed by fluctuation due to load rejection and tripping of turbines.

The water surface profile and bed slope 1:8333 of the existing canal were kept constant. The water level at the entrance into the headrace is 203.16 m.a.s.l being the designed Full Supply level of the Existing Canal at RD 216+100. The water level at power house is at 203.16 m.a.s.l. The canal's designed bed width is 54.88 m with 1.51 m water depth and a bed slope of 1:8333. The n coefficient used is 0.17. A free board of 1.0 m has been provided. The embankments of the canal show a top width of 6 m and are made of compacted earth with 1:2 inward & 1:2 outward slopes. A road of 4.0 m is constructed at the crest of the embankments along right and left bank of the headrace. The embankments and bed of the canal are protected by stones over geo-textile.

### 3.3.2 Powerhouse Inlet Bays and Retaining Walls

The in-take bay in front of powerhouse and spillway consists of concrete slabs bounded by concrete cantilever retaining walls. Concrete slab in front of powerhouse and spillway with 18.0 m width starts at level 199.90 m.a.s.l (bed level of headrace canal) and slopes down to a level 192.80 masl (invert level of powerhouse intake). The transition to the slopes of the headrace canal is carried out with circular concrete retaining walls.

Cement slurry trench walls are foreseen underneath the retaining walls and underneath the intake bay to minimize uplift and avoid piping underneath these structures and powerhouse structure.

### 3.3.3 Powerhouse Complex

The turbine units are located at RD 214+500 approximately. The turbine unit and spillway are so placed that it becomes hydraulically more efficient. The spillway is placed along the left hand side of the powerhouse. An access is provided over the powerhouse and spillway to connect the left bank with right bank.

The general arrangements of powerhouse are shown in **Figure** 3-4, **Figure** 3-5 and **Figure**3-6.

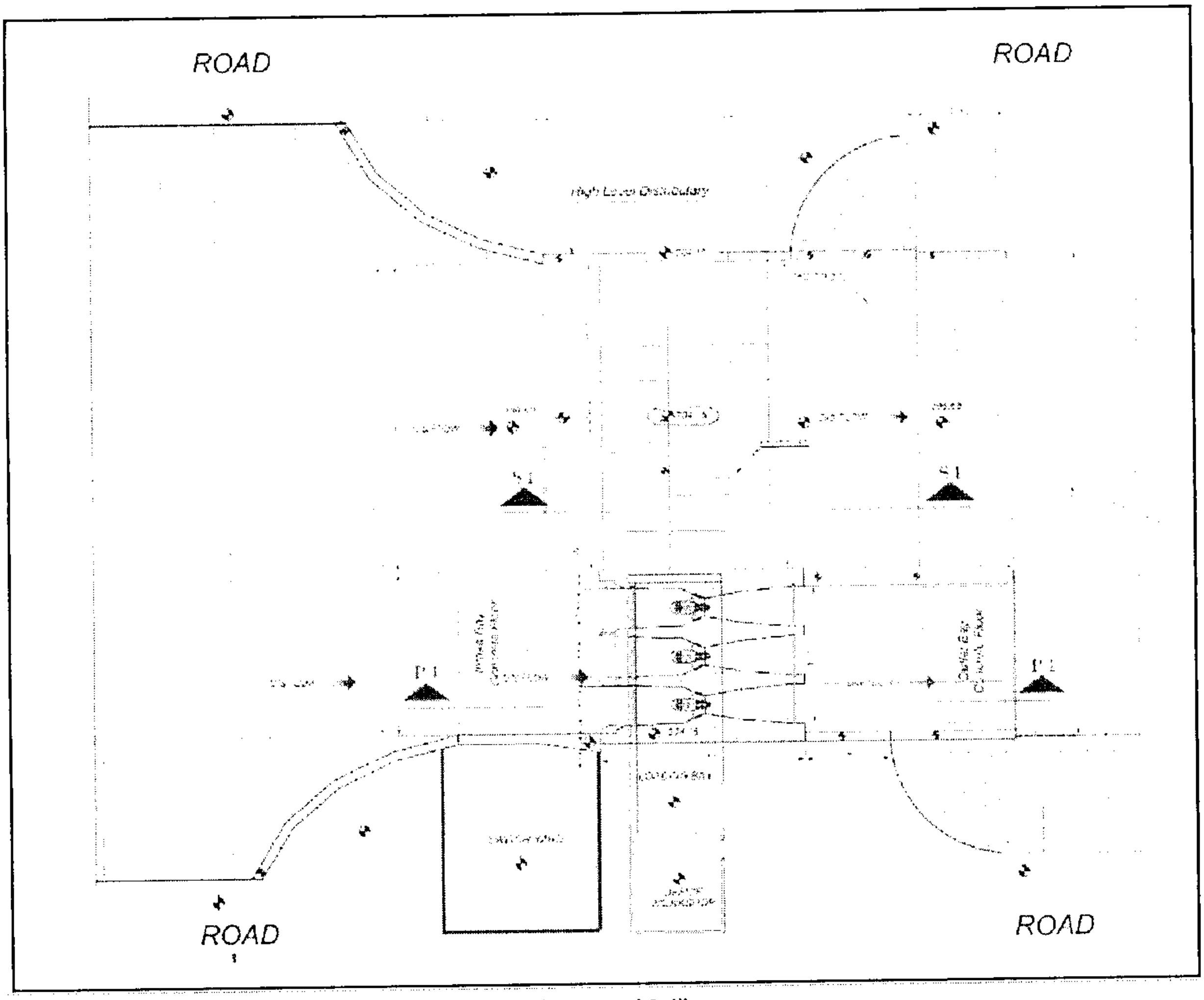



Figure 3-4: Powerhouse and Spillway

The powerhouse is constructed in the bypass arrangement along right side of the existing Gugera Branch. Cofferdams at upstream and downstream side are provided to protect the foundation excavation and construction areas from entering of ground water or rain water. The coffer dams have to be constructed at starts of construction/excavation and consist of soil excavated from the powerhouse excavation pit. Excavation of powerhouse foundation requires deep well dewatering under protection of cement slurry trench wall all around the powerhouse, spillway and underneath the retaining walls and upstream and downstream concrete floor in order to avoid piping underneath the powerhouse and spillway foundation.

The powerhouse structure includes inlet and outlet bay, machine hall (three (3) unit blocks). The loading bay is provided along right side of the Machine Hall. The substructure and superstructure is constructed of cast-in-place reinforced concrete. The roof consists of pre-cast and post tensioned concrete girder with composite metal deck and 20 cm thick cast-in-place lightweight reinforced concrete slab.

The powerhouse yard is located adjacent to service bay. Roll-up door allow easy access of vehicles and semi-trailers required for delivery of major electrical and mechanical equipment. The yard is asphalted with adequate drainage features to accommodate yard drainage. The switchyard and yard are enclosed by fencing and a lockable gate at the roadside.

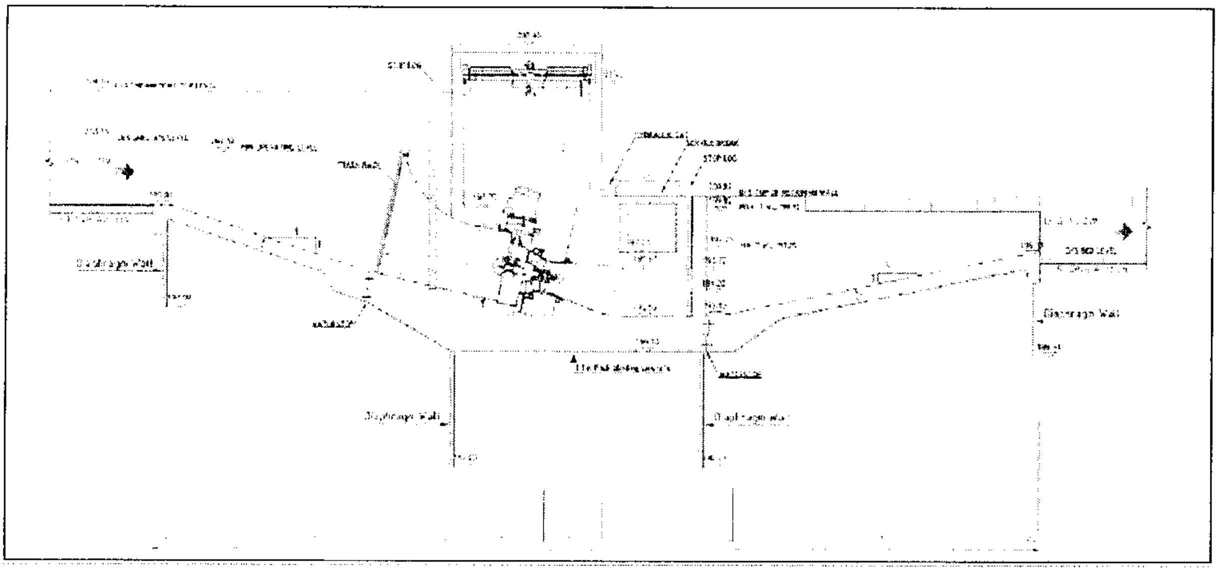


**Figure 3-5: Powerhouse Cross Section**

The powerhouse yard is located adjacent to service bay. Roll-up door allow easy access of vehicles and semi-trailers required for delivery of major electrical and mechanical equipment. The yard is asphalted with adequate drainage features. The switchyard and the main yard are enclosed by fencing and a lockable gate at the roadside.

Additionally the powerhouse complex will consist of the following components:

- The machine hall extending along the entire unit and bottom outlet blocks. It houses the turbine and generator and other E&M equipment as generator terminals, AC/DC distribution and oil cooling units. Its floor level is at 198.70 m.a.s.l with a length of about 23 m and a width of 17.2 m. The necessary height is defined by the hoisting requirement and is estimated at being 8.5m.

- A separate loading bay is provided on the right hand side of the powerhouse. The loading bay floor level is 200.92 m.a.s.l. At entrance roll-up gate of 7.0 m width is located in the right side wall for vehicle access to machine hall. The loading block is used as platform during erection and maintenance of turbines, generators and other E&M equipment. Additionally, a local workshop is established in service bay.
- A service bay is located on the right side of the powerhouse. It is multi-story building for housing control room, conference room, offices, kitchen, bathrooms, workshop and rooms for batteries, etc. Control room is provided at 204.16 m.a.s.l. A stair is provided to link the floors.
- A spillway is located along the left bank of the powerhouse building. The discharging capacity of the spillway is equal to full supply discharge of the Gugera Canal. It will be gated structures. Radial gates having remote control system would be provided. The control of gates for opening and closing would be done from main control room. It will pass flows during tripping of turbine due to faults in the system or in the unit. A concrete deck bridge would be provided for vehicle traffic. The gates would be radial and operated from elevated deck of steel structure. The gates could be flap gates and would be operated from inside the crest of the spillway. Exact selection of type of gates would be done during detailed design phase by EPC Contractor.
- Trash racks are installed at the intake at an angle of 780 to facilitate mechanical cleaning and to reduce hydraulic losses. The size of the intake is 4.37 m x 8.32 m. As no intermediate pier is provided, therefore three horizontal steel beams installed behind the trash racks will act as support structures. For cleaning of trash rack a crane for each intake is foreseen or trash racking machine moving on rails.
- Stop logs are foreseen at the intake and at the end of the draft tube. Stop logs are also provided on upstream and downstream of spillway gates. These are required in order to facilitate erection, repair and maintenance of turbines and gates. Placing and removing of stop logs at intake would be by trash rack cleaning machine and at draft tube and bottom outlets are foreseen by mobile crane of suitable capacity. Because there will be only one unit and bottom outlet closed at the same time one complete set of stoplogs is provided.
- Powerhouse and spillway would be constructed in single excavation pit. A designed dewatering system would be installed for lowering down the groundwater level in order to cast concrete under dry conditions. Dewatering system will remain in operation till the concrete work is finalized. However, cement slurry trench walls all around the powerhouse would be constructed first before start of excavation. Therefore, these cut-off walls have significant effects on reduction of inflow water; ultimately result in less operation and maintenance cost of dewatering.
- Spillway gates are foreseen on downstream and upstream side of the machine hall for their operation. Gates are radial and operated hydraulically and operation will be controlled from machine hall control room. Size of gate is given in the respective Drawing.

### 3.3.4 Remedial Design Measures for Fish Injuries.

Trash racks shall be installed at the intake at an inclined angle to facilitate mechanical cleaning and reduction of hydraulic losses. For cleaning of trash rack, trash racking machine moving on rails is recommended. Vertical and horizontal steel bars shall be installed behind the trash racks which will help stop the movement of the Fish coming towards Turbines.

In addition, moving-screens with washing nozzles are suggested having close-mesh through which Fish in canal water will not be able to pass down to Turbines, in this way fish will remain safe without any injury.

### 3.3.5 Outlet Bay and Retaining Walls

The outlet bay consists of concrete slabs bounded by concrete cantilever retaining walls. Concrete slab starts at downstream of powerhouse at level 192.63 m.a.s.l (invert level of draft tube) and sloping up to level 196.91 m.a.s.l (bed level of tailrace canal). It is hinged to the powerhouse foundation with an expansion joint. The retaining walls also provide transition to the tailrace cross section. The tail-water level is such that the draft tube remains submerged even in minimum tail-water level to avoid cavitations.

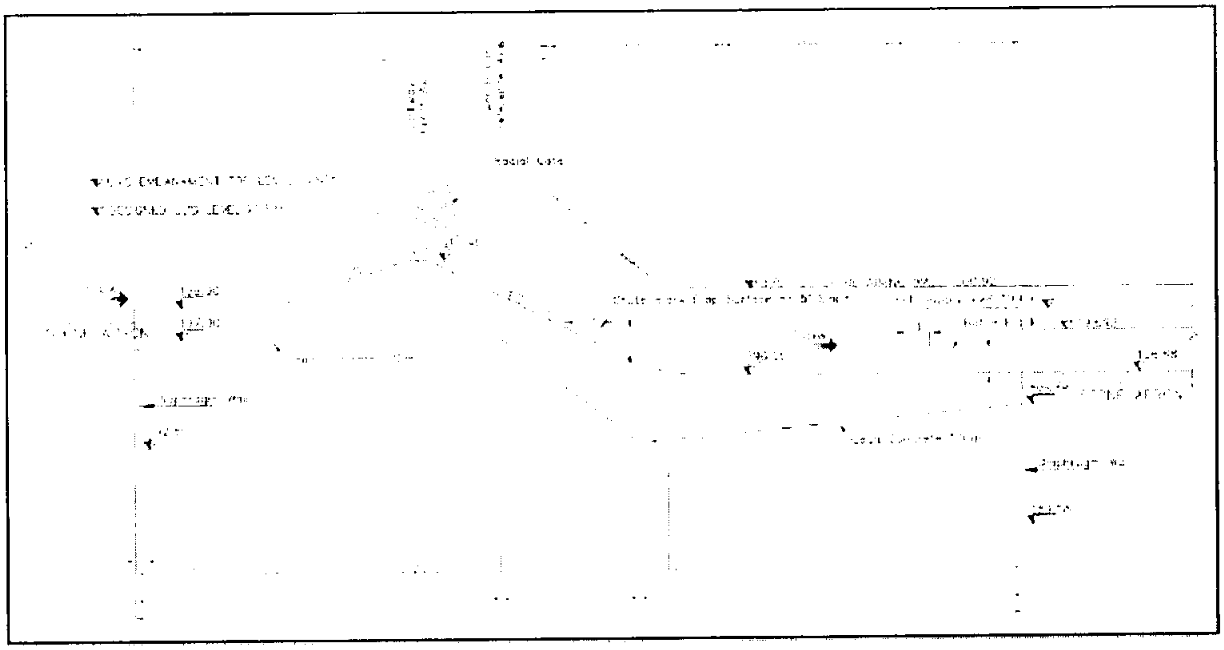


Figure 3-6: Spillway Cross-section

### 3.3.6 Tailrace Canal

The powerhouse and bottom outlets discharge directly into outlet bay which is directly linked with the tailrace canal which is ultimately Gugera Canal. The tailrace canal extends from the powerhouse outlet bays to the existing canal up to RD 221+500. Channel is formed in trapezoidal section, with a bed width and bed slope equal to the existing Gugera Branch Canal. The side slopes are 1:2. The tailrace canal bed is covered with stone over geo-textile having length of about 770m.

### 3.3.7 Service Roads and O&M Staff Colony

A 4.50 m wide access road is constructed over the left bank of the Gugera Branch Canal to access the canal and strengthen the existing access to villages. A metaled road along left bank would be provided up to RD221+500.

Operation and maintenance staff will be stationed in a colony constructed near to the powerhouse. Colony is proposed along the right bank of the headrace canal. It would consist of residential building, community building, masjid, etc., to serve the daily requirement of the operation and maintenance staff.

## 3.4 Hydrology and Power Potential

The existing flow in the canal will be utilized for the power generation of the project without interruptions or alterations in flow regime. The water discharges and corresponding estimated power generations are as under:

### 3.4.1 Discharge

The flows availability was processed for the period of 2008 through 2013. It is concluded that the flows availability in Gugera Branch after its re-modeling is the right option to use in power and energy estimation. The criterion adopted for the powers estimation is that the minimum discharge to be accepted by a turbine is 40% of its design discharge capacity and for a net of head of 2.8 m at full supply level on upstream and downstream side. Moreover, it is clarified that the design discharge of Upper Gugera Branch Canal is 160.67 cums (5675cs). By considering the present flows; discharge 142 cums has been selected for plant size. Overall Plant efficiency is 91.25% and Plant total output (gross) has been worked-out as3.6MW.

### 3.4.2 Head

No data available for upstream water level and downstream of the both fall structures. It is therefore concluded that power and energy estimation would be performed for 2.8 m net head by considering 0.2 m head loss due to trash rack, slots for stop logs and intake transition. It is mentioned that this will be the minimum head and would increase when level on downstream of the fall would be available for all discharges.

### 3.4.3 Efficiencies

Power and energy estimation have been carried out keeping in view the overall constant efficiencies for turbines, gearing system, generators and transformers such as follows:

| | | |
|---|---|---|
| Hydraulic Turbine | 95% | 93.57% |
| Gearing system | 98.5% | |
| Generators | 98.5% | |
| Unit Transformers | 99% | |

Overall plant efficiency 91.25%

### 3.4.4 Head Loss

A constant head loss of 0.20 m has been taken for intake transition, stop logs slot, trash rack etc. However, head loss will be investigated during detailed engineering design when a turbine manufacturer has been selected.

### 3.4.5 Power and Energy Estimation

The power and energy calculations have been performed by using the daily data of discharge for the years 2008 to 2013 and constant net head of 2.8 m. The average maximum power output during the year 2008-2013 was 3.6 MW. The average annual energy generation during the year 2008-2013 was 20.8GWh.

### 3.4.6 Flooding Possibility

Flooding and breach of canal may result in suspension of power generation and flooding of powerhouse facility. As the canal is manmade structure and being regulated at its head, chances of flooding through head regulator are remote or negligible. The only possibility for flooding is the up doab floods or excessive rainfall in the project Area. Historically the Rechna Doab has been subjected to frequent and severe flood damages in the vicinity of Ravi and Chenab River. The site is almost in the middle reach of Rechna Doab and therefore never subject to flood damages. Breach of canal may be also remote possibility; therefore suspension of power generation will not be a problem.

## 3.5 Power Grid Interconnection

The project is proposed to be interconnected to the nearest LESCO/NTDC 132KV grid at Walgan Sohail. Two 7 km long 11 kV single circuit transmission lines have been proposed for dispersal of energy generated. Steel reinforced Osprey conductors with steel lactic towers are foreseen which are according to the national standards. Synchronizing with NTDC grid system shall be done in the powerhouse control room. The powerhouse switchyard is the point of energy delivery to the LESCO/NTDC. Energy Meters have been provided at the switchgear room for measurement of Power and Energy delivered to LESCO/NTDC.

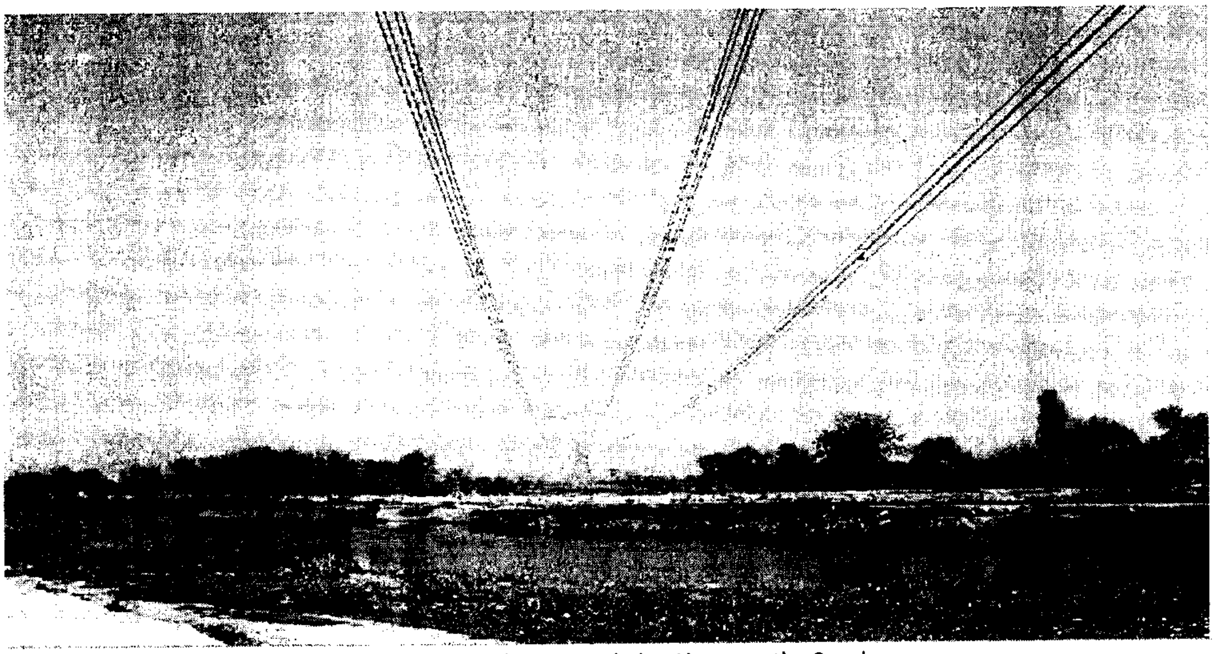


Figure 3-7: Existing Transmission Line over the Canal

The proposed 11 kV transmission lines are equipped with directional distance protection system with relays both in the 132 kV Substation and in the powerhouse. A back-up protection at both stations with directional over current relays is also included. Additional lightning arrestors have been provided at the outgoing section of Power Plant.

Design and layout of steel towers will be finalized during detailed design of the project. However it has been proposed that the new lines will be installed along the existing right of way (RoW) of the canal upto 7 kilometers from the powerhouse to the existing grit at Walgon Sohail.

There are two 11 KV transmission lines running in parallel along the right of way(row) of Gugera Canal, before crossing the Faisalabad Lahore road, the towers will be installed along the road right of way(row) up to Walgan Sohail 132 KV grid station. The layout/ single line diagram of 3.6 MW Gugera HPP and layout/single line diagram of Walgan Sohail 132 KV for interconnection of Gugera HPP with the LESCO/NTDC electric network for dispersal of power generated is shown in **Figures 3-8** and **Figure 3-9**.

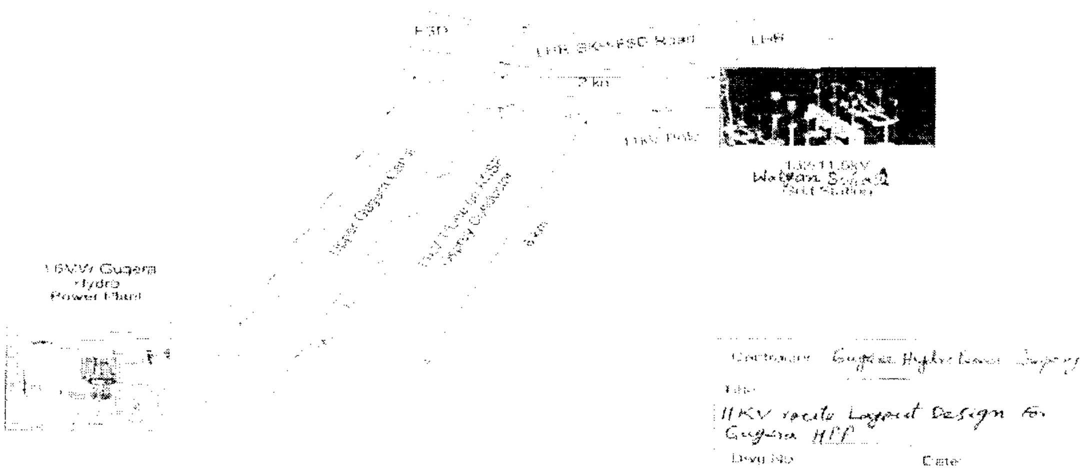


**Figure 3-8: 11KV Transmission Lines Layout/Route Design Along the Canal & Road**

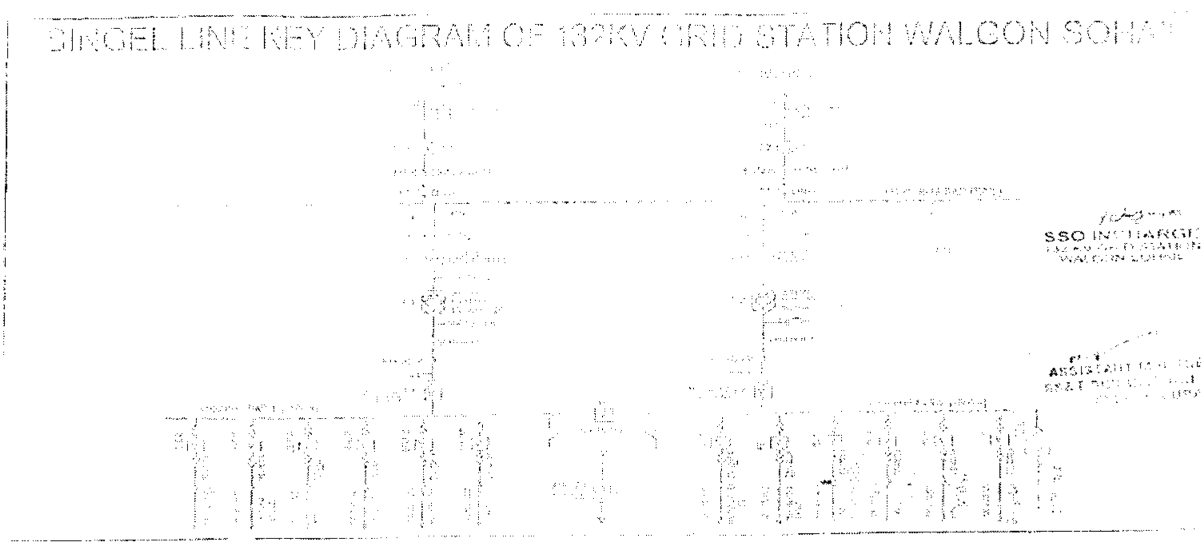


**Figure 3-9: Single Line Diagram/Layout of 132/11Kv Grid Station at Walgan Sohail**

## 3.6 Construction Duration

The Gugera Hydro Electric Power Project is a base load plant and will contribute during peak hours also. It will generate electricity throughout the year except during closure period when canal is closed for annual repair and maintenance. The ultimate capacity of the project is 3.6 MW. Based on the specified construction material and their quantities, type and kind of construction equipment involved, techniques of construction, sequence of construction, procurement and installation activities and their dependence on the flows in Upper Gugera Branch, a 36 month construction (24 months construction and 6 months design) period is anticipated.

## 3.7 Construction Camp and Work force

A large workforce, together with supervisory and support staff, will be required for the Project. Majority of unskilled and to some extent semi-skilled and skilled workforce will be employed from the local area. However, the contractor will engage specialized workforce including engineers, geologists and construction management staff from the outside area. While most of the local workforce will go back to their dwellings on daily basis, the remaining will be accommodated in three camps located near construction sites. Adequate temporary camps, offices and ancillary facilities at convenient locations near the site will be required. Due to the cultivated land in the area, there may be limitation in the availability of ample areas at the sites near the construction for establishing residences, workshops, batching plants and material storage areas separately. However, a sizeable area is available near the site in the form of marsh land, where the contractor can establish residential colony as well as other facilities. Moreover, modern houses are also available in Nankana Sahib and Sheikhupura on rental basis. The contractor may hire these for establishing main office and hostels for the work force.

## 3.8 Estimated Water Requirements Other Than Power Needs

It is stated that total power generation capacity of Gugera HPP is 3.6MW, comprising three turbine-generator sets each of 1.2MW. The project consists of three major components, Headrace Canal, Power House/Spillway and Tailrace Canal. Construction of these components shell be carried-out by Cranes & other heavy machines. Manual work will be only on E&M equipment. Keeping in view the construction and O&M activities, manpower requirement of 125-150 is anticipated at site during construction phase and 25-30 during Operation phase of the plant. If family members are also included for O&M phase, then drinking/washing water requirements during both the phases shall be same. Project water requirements for different activities are briefly given as under.

**Construction Phase (3Years)**

| | | |
|---|---|---|
| i. | Cooling vehicle/machinery engines (make-up water) | 1-2 ton per day |
| ii. | Drinking, washing & cooking etc (250ltr/day/person) | 31-38tonper day |
| iii. | Batching plant, concrete mixing plant & material compaction | 5-20ton per day |
| iv. | Sprinkling water on unpaved roads. | 10-20 ton per day |
| v. | Total water requirements at project | 47-77 ton per day |
| vi. | Minimum water requirements | 47 ton per day |
| vii. | Maximum water requirement | 77 ton per day |

**O&M phase of the Project (Plant life cycle 100Years)**

| | | |
|---|---|---|
| i. | Machinery cooling(makeup) | 0.1-0.25 ton per day |
| ii. | Drinking, washing & cooling etc (including family members) | 30-40ton per day |
| iii. | Grassy Lawns/ground, flower plants and trees | 100-150 ton per day |
| iv. | Total water requirements of Plant | 130-190 ton per day |

| | | |
|---|---|---|
| v. | Minimum water requirements | 130 ton per day |
| vi. | Maximum water requirements | 190 ton per day |

The water requirement shall be met by installing a tube well of 1-2 cusec capacity with sufficient storage capacity, sprinkling water may also be supplied from the existing upper Gugera Canal through mobile tanker.

Drinking, washing & cooking water shell contribute to the waste production which will be managed as per environmental standards, capacity of the Sewage treatment plant shall be $40M^3$/day.

## 3.9 Waste water Treatment

Keeping in view the water usage for different activities, waste water quantities have been estimated on the basis of manpower deployed at site. In Construction Phase, it is calculated that approximate 125-150 Person shall be involved in construction of project. Construction phase shall be for 3 years. Work force of 125-150 persons shall be deployed during this phase. Similarly, for O&M phase, 25-30 persons shall be involved in operating plant. Sewage water treatment plant 40 M3/day capacity has been selected.

### 3.9.1 Treatment Methodology

Waste Water Technology used for project is Activated Sludge Process (ASP). ASP is divided into 3 phases:

- Primary Treatment
- Secondary Treatment
- Tertiary Treatment

Primary Treatment removes suspended solids by screening and sedimentation process.

The secondary treatment involves air or oxygen combined with microorganisms to remove organic contamination and pollutants from the water in the form of sludge. Coagulation and flocculation methods are used to make flocs and sludge.

After secondary settlement is done, territory treatment of water is made to make free from bacteria and pathogens using disinfectants.

### 3.9.2 Design Basis:

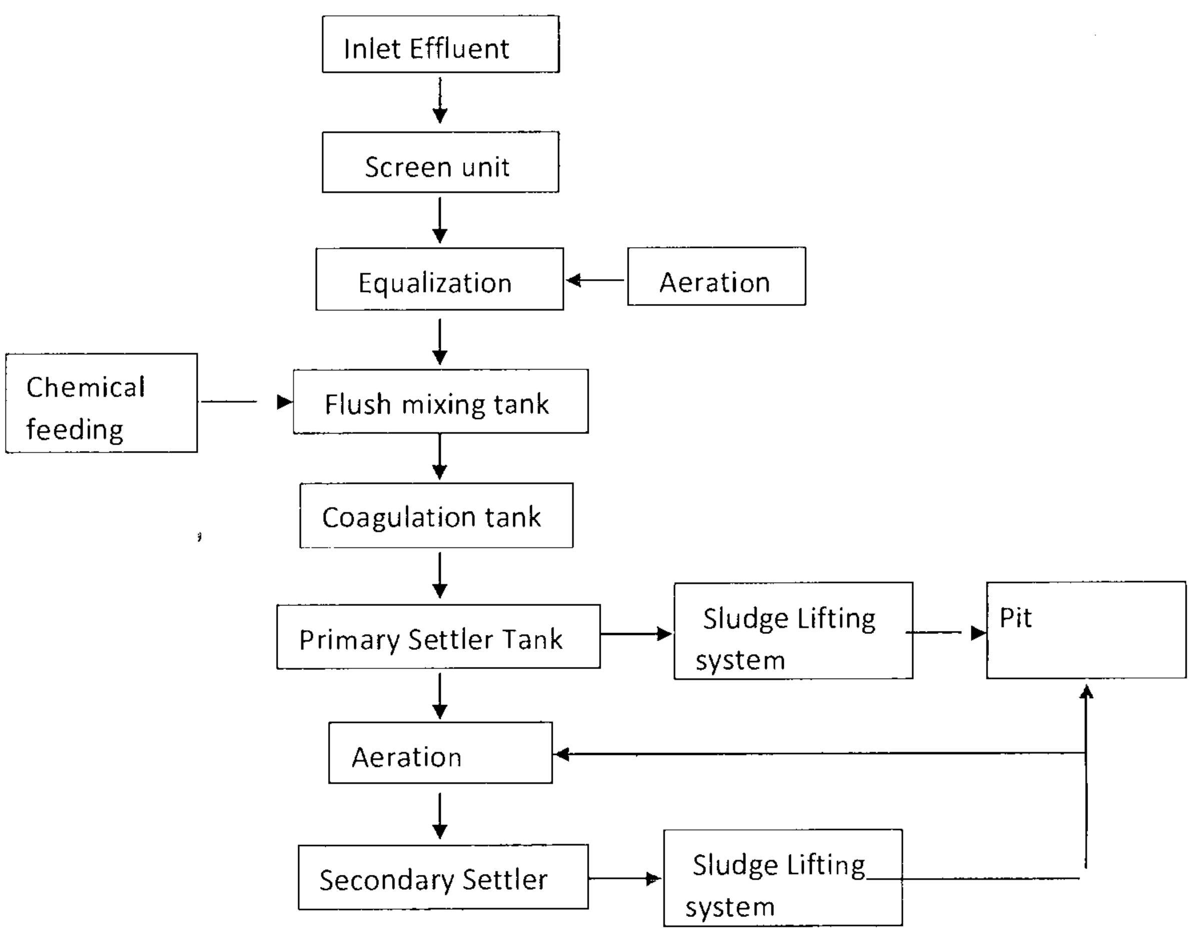
- Daily Flow Rate $40M^3$
- Working Hours per Day 24Hours
- Average Hourly Flow Rate 1600 – 1700Liters
- UNTREATED EFFLUENT NATURE Biodegradable Waste Water
- pH11.6
- Biochemical Oxygen Demand (BOD) Mean 400mg/L
- Chemical Oxygen Demand (COD)Mean 1000mg/L
- Total suspended solids (TSS) 200mg/L

**TREATED EFFLUENT QUALITY (Complying with NEQSLIMITS)**

| | | |
|---|---|---|
| **pH** | 6—8.5 | ------ |
| **$BOD_5$** | ≤ 80 | mg/l |
| **COD** | ≤ 150 | mg/l |
| **TSS** | ≤ 100 | mg/l |
| **Colour** | Almost colour less | |

The treated effluent shall be discharged into nearest existing drain. It shall meet the NEQS standards given above. The area required for the suggested plant is 25 m x 30 m approximately. It has been assumed that the incoming effluent will be available at 1m below average ground level and the treated effluent shall be discharged at ground level. The Sewage Treatment Plant will run for 24 hours per day as designed.

**Process Flow Diagram**



↓

Chlorination → Balance tank

↓

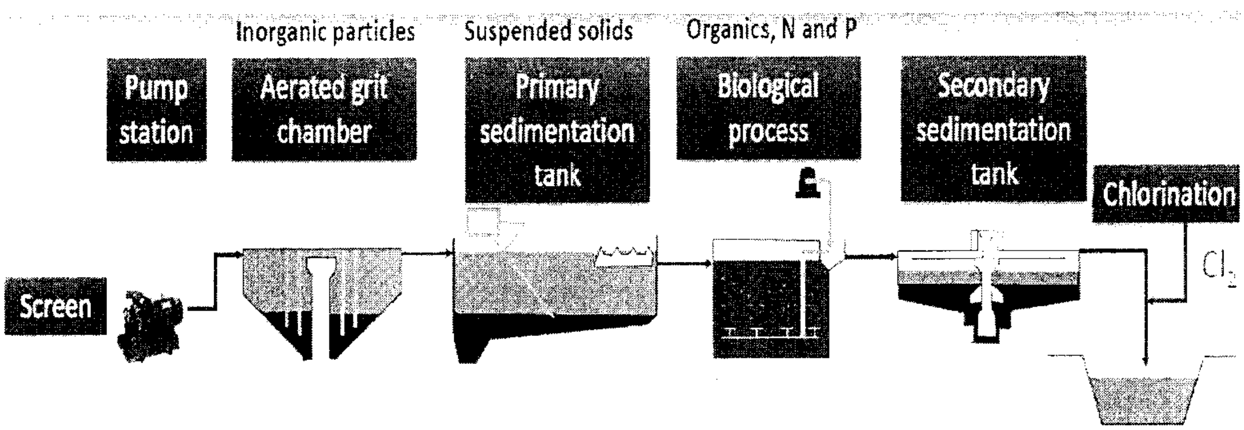
Filter feed Pump

↓

Sand Filter +

↓

Disposal of treated water



### 3.9.3 TREATMENT DESCRIPTION:

Sewage is created by residences, institutions, commercial and industrial establishments. Raw influent (sewage) includes household waste liquid from toilets, baths, showers, kitchens, sinks and so forth that is disposed of via sewers.

It is assumed that the incoming effluent is available at approx. 1m below average ground level.

### 3.9.4 PRIMARY TREATMENT:

Pre treatment removes materials that can be easily collected from the raw waste water before they damage or clog the pumps (Trash, tree limbs, leaves, etc.) The effluent from household will come to a basket type screen chamber. The basket type screen will be provided here for screening removal. Screenings will have to be manually removed periodically and disposed at suitable place. The screen removes any material larger than 10 mm size. After screening the effluent falls inequalization tank.

- **Equalization tank:**

An equalization tank equalizes quality and quantity variations. Suitable aeration by blowers is incorporated in the scheme to keep the effluent mixed and to maintain an aerobic environment in the tank.

- **Flush Mixing tank:**

The mixed water from the equalization tank will be treated with the suitable polymer.

- **Primary settler Tank:**

Lamella Separator is a rectangular tank (primary settler) having cone shaped bottom and top oneside collection arrangement. The cone shaped bottom ensures proper sludge collection at center pit. Collected sludge is sent to sludge pit. Clarified effluent from lamella settler flows by gravity to the aeration tank.

The sludge lifting system is activated and discharges to the sludge pit manually operated sludge lifting system, while the sludge is manually collected, whenever required, the sludge is hauled away for external disposal.

### 3.9.5 BIOLOGICAL TREATMENT:

By the time the effluent comes out of the lamella settler, most of the sludge is removed. In aeration tank effluent for BOD reduction activated sludge process (biological treatment) is followed. This reduces the BOD content by more than 80 %. In Aeration Tank the BOD / COD load reduction takes place. In this tank the bacterial culture is added as returned activated sludge. There is a sufficient incorporation of air by diffused aeration.

The bacteria degrade/eat up complex organic matters from effluent and grow in number and size and become heavier. The mixture of bacterial mass and dissolved organic matter free water is transferred to Secondary Clarifier.

- **Secondary Settler Tank:**

Secondary Settler Tank is a rectangular tank in which sufficient slope has been ensured for proper collection of sludge. There is a cone shaped bottom and one side entry for incoming effluent and other side discharge for a discharge of clarified effluent. The cone shaped bottom ensures proper sludge collection in a sludge collection pit. Collected sludge is re-circulated in aeration tanks for maintaining the MLSS content in the aeration tank. Only the excess sludge is like to dispose to the sludge pit. Clarified effluent from secondary the clarifier goes to chlorine contact tank.

### 3.9.6 Chlorination:

The purpose of disinfection in the treatment of sewage water is to substantially reduce the number of microorganisms in the water to be discharged back into the environment. Chlorination remains the most common form waste water disinfection due to its low cost and effectiveness. In Chlorination tank Sodium Hypochlorite solution is continuously dosed. There is a Sodium hypochlorite tank with a dosing pump, which regularly pumps desired quantity of Chlorine in the tank. Chlorination is done to sanitize the effluent and oxidize some organics of the effluent. Here sufficient quantity of NaCl is added for sanitation purpose. In this tank treated water meets desired treated effluent parameters. This treated water can be suitably discharged.

- **Sand and carbon Filters:**

Sand filtration removes much of the residual suspended matters; filtration over activated carbons removes residual toxins (organic matters).

## 3.10 Access Routes for Construction Sites

The project site and area is located in the province of Punjab in District Sheikhupura which is accessible by air, good roads and railway network. Allama Iqbal International Airport Lahore and International Airport Faisalabad are the nearest airports to the project area and site.

The road distance from these airports are:

3.10 Lahore to Site via Lahore-Faisalabad dual carriage way = 70km
3.11 Faisalabad to Site via Lahore-Faisalabad dual carriage way= 67km

The nearest railway is Sheikhupura which lies on the Lahore-Faisalabad Railway network. The nearest railway stations where loading and unloading of heavy equipment is possible are Sheikhupura and Lahore. These stations are along Main Railway track from Karachi and Lahore. The Lahore is on the main track of Lahore-Karachi section and is the terminal point of this section.

Loading and unloading facility is available at Sheikhupura railway station but cranes of suitable capacity are not available. Usually consignee is responsible for the arrangements of crane if required from local market. Lahore is 1092 km from Karachi seaport and Sheikhupura is about 40 km from Lahore.

Karachi to Lahore 1092 km via N-5. The National Highway 05 or the N5 is Pakistan's longest highway running from the port city of Karachi to the border crossing at Torkham. Its total length is 1756 km and it runs north from Karachi located in Sindh to Hyderabad, Moro and Khairpur before entering to Punjab province where it passes through Bhawalpur, Multan, Sahiwal and reaches at Lahore. The site is lying along road leads to Nankansahib which off-take from dual carriageway near the village of Khambian Wala short of 2.74 km from Mananwala a small town along Faisalabad-Lahore dual carriageway. Alternatively Karachi to Multan via Bhawalpur travel along N-5 which is a 4 lanes good quality road. From Multan to Faisalabad via Jhang a 2 lanes road and from Faisalabad to site via Lahore - Faisalabad dual carriageway.

## 3.11 Construction Material

The materials used for the construction of the proposed project include coarse aggregates, fine aggregates (sand), rock for stone pitching and riprap, earth, water, cement and steel. Tentative quantities of various materials along with the source are depicted in **Table**3-2:

**Table 3-2: Quantities and Sources of Construction Material**

| *Sr. No.* | *Item* | *Quantity* | *Sou* |
|---|---|---|---|
| 1 | Coarse Aggregate | 14,400 cum | The material will be borrowed from various sources including river bed boulders, gravels, cobles. The main source of coarse aggregate will be;<br>• Kirana hills located about 12 km south of the town of Sargodha are the most widely used and nearest source of aggregate. From the project site, it is about 150 km hauling distance.<br>• Margalla hill limestone located near Taxilla and is situated about 200 Km hauling distance from |
| 2 | Fine Aggregate(Sand) | 7,200 cum | Sand is though available in the river bed, its quality is not suitable for the Project construction. Moreover its quantities are small.<br>Therefore, the nearest source of fine aggregates (sand) |
| 3 | Rock Material for Stone pitching and Riprap | 3,000 cum | Rock material will generally be available from the excavation for the construction of power house and canal. |
| 4 | Cement (including Portland and Slag) | 164 tonnes | The Portland cement will be transported from nearby cement factories on the average located at a distance of 50 to 100 km from project site. Slag Cement will be transported from Karachi (about 1500 km from the site) through rail and road transportation. The road network is available from the factories up to construction sites. |
| 5 | Reinforcement Steel | 680tons | The steel of the desired specification will be transported from re- rolling mills located at Lahore and Rawalpindi. |
| 6 | Water (including concreting, water sprinkling, compaction of earth/rock fill for Coffer dams) | 30,000 cum | The Canal is viable sources for water. The water from the river and canal would however need some sort of treatment to make it silt and sulphate free for its use in concreting. |

## 3.12 Construction Machinery

The Project will deploy various types of machineries for construction purposes. These will include bulldozers, excavators, shovels, tunneling machine, dumpers, batching plant, tankers, trucks, etc.

## 3.13 Excavated Material

The Project will generate about 200,000 cum of excavated material (mostly constituted of soils, sandstone and siltstone) from excavation for the project components. Depending upon the quality of the excavated stone material, some quantity will be used to meet the requirement of aggregate, rock fill at cofferdams, stone pitching, etc. However, bulk of the excavated material will be needed to dispose. The configuration of the land mass in vicinity of the project structures and in the surroundings is such that limited appropriate area would be available for disposal of the waste material.

## 3.14 Project Cost

It is anticipated that the project will be constructed under the terms of turnkey contract, with the expectation that design, construction of the civil works, equipment supply and installation would be carried out in a period of about 36months.

The estimated base cost is about 1398.4 million PKR, expressed at the 2013 price level, without escalation and interest during construction (IDC) but inclusive of cost of transmission line has been considered in financial calculations described later. Estimates reflect aggressive cost control and services contracts negotiations and a management and design philosophy to minimize costs.

# 4 ENVIRONMENTAL BASELINE

## 4.1 Regional Settling

District Nankana and Sheikhupura District are districts of Punjab province, Pakistan having their respective the head quarter in Nankana and Sheikhupura is the headquarters of Sheikhupura District. According to the 1998 census of Pakistan, the district had a population of 3,321,029 of which 25.45% were urban. Sheikhupura is bounded by 6 other districts of Pakistani Punjab namely: Lahore, Nankana Sahib, Narowal, Hafizabad, Faisalabad and Gujranwala.

The area is a part of Rachna Doab, and consists of some recent sediment brought by spill channel from Chenab River. There are some old channel levee remnants and old basins filled up with clay materials. It is probably of late Pleistocene age derived from mixed calcareous, sedimentary and metamorphic rocks of the lower Himalayas. The only mineral products of the District are Kankar and Kallar. The small particles of Kankar may be burnt into lime. These are the features of all bare lands and are found on the surface or a little below it. Kallar is found on mounds, which are sites of old ruined habitations, and is used for the manufacture of crude saltpeter. The District has extreme climate; the summer season starts from April and continues till October. During the summer season, temperature ranges from 30 to 45 degrees Celsius. The winter season starts from November and continues till March. December and January are the coldest months with a mean minimum temperature of 5degrees.

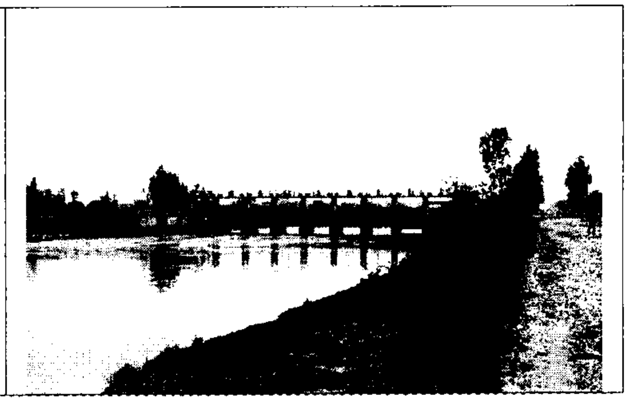


Figure 4-1: Environment at the Project Site

## 4.2 Physical Baseline

### 4.2.1 Physiography and Landscape

The project area is a part of vast alluvial plain of Chaj Doab in upper Indus basin, which can further be classified into three unit's namely active flood plain, abandoned flood plain and bar uplands. MainriversintheareaareChenabandRavi.Theseriversandtheircanalsarethemainsourceof surface water supplies for irrigated agriculture as well as for recharge of groundwater. The elevation in the area varies from 203 to 204 m above mean sea level. The area has a gentle slope towards south.

The alluvial deposits in the area range in age from Pleistocene to recent and are widely distributed. These deposits are composed of clay, silt and sand extending in general to a depth of 300 m and are overlain by recent surficial coarser deposits along the river channels.

The project site is covered with thick alluvial deposits of Quaternary age laid down by Jhelum and Chenab rivers. The geological map of the project area published by the Geological Survey of Pakistan is shown in **Figure** 4-2. The Quaternary sediments of the Punjab plain comprise the following:

- Stream Deposits
    - Qm - Streambed and meander-belt deposits
    - Qf - Flood plain deposits
- Deposits of Extinct Streams
    - Qmx - Streambed and meander-belt deposits
    - Qfx - Floodplain deposits (lower terrace)
- Older Terrace Deposits
    - Qc - Chung Formation; mostly loess deposits of the upper terrace
    - Qcm - Loess and floodplain deposits of the middle terrace.

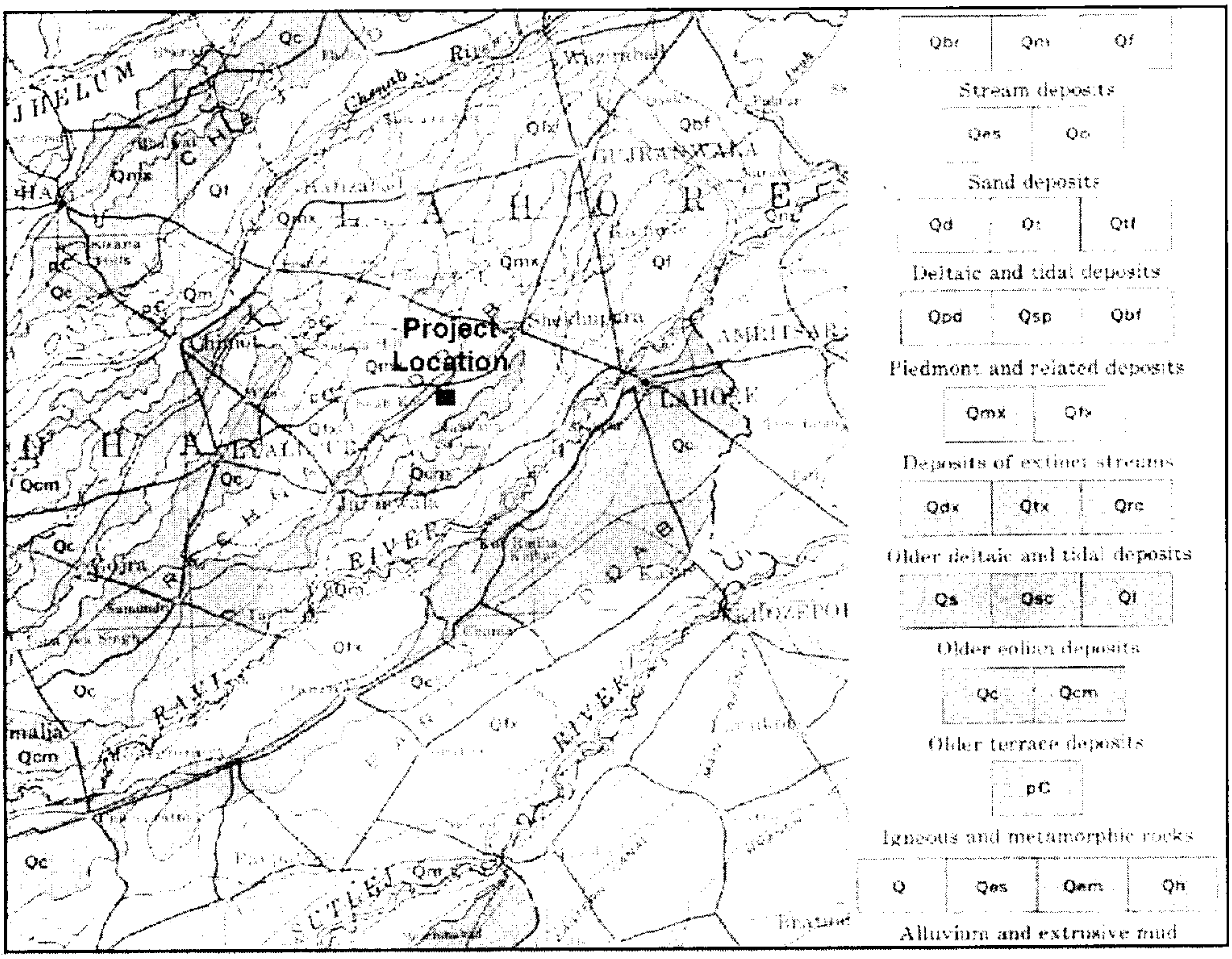


Figure 4-2: Geology of the Project Area

The alluvial deposits are underlain by the basement rocks of the Indian shield, exposed at places in area between Shahkot and Sargodha. The project site lies on the south-eastern side of this Basement High. Based on the contours of depth to basement rocks, the thickness of alluvial deposits at the project site is more than 335 meters (1100ft.).

### 4.2.2 Land-Use

According to the land use map of Nankana town the proposed project lies outside the municipal boundary. Land-use in the project area is dominated by cultivation, fruit growing and livestock rising. There is a small but growing service sector, particularly in private/government employment, transportation, and trading. Although in the project area fisheries resources appear to be significant, this potential has remained largely untapped.

Agricultural in the area is mostly carried out through tube wells. Total cultivated area in Sheikhupura is about 359,000 Hectares, which is mostly used for cultivation of sugarcane, rice and wheat.

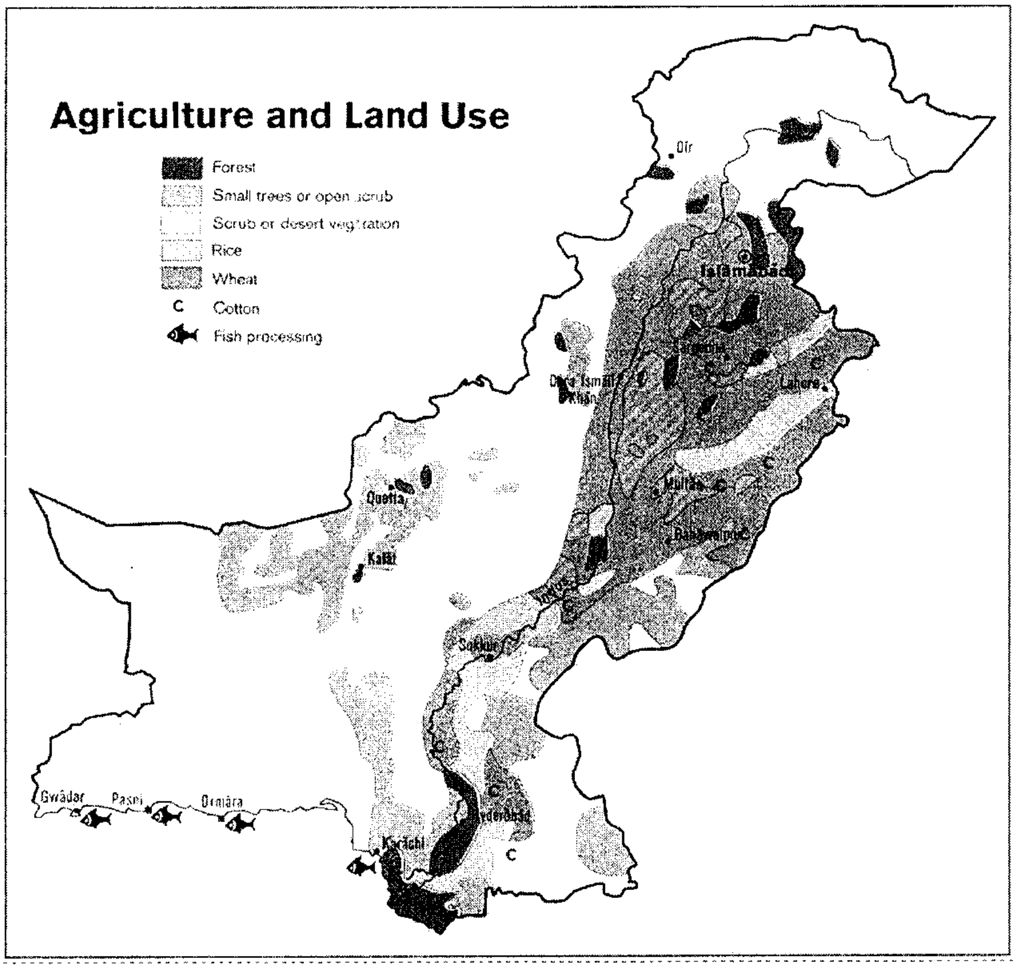



Figure 4-3: Land Use Map of Pakistan

### 4.2.3 Seismicity

The geodynamic framework of northern Pakistan is characterized by the collision and coalescence of Eurasian and Indian continental plates, which were once separated by the oceanic domains, and creation of the Kohistan island arc in the late Cretaceous. The collision process started in the late Eocene to early Oligocene with the formation of the Himalayan Ranges and this process still continues. Relative to Eurasia, the Indian plate is still moving northwards at a rate of about 4 cm/year. The subduction of the Indian plate beneath the Eurasian plate has resulted in folding and thrusting of the upper crustal layers near the collision boundary which lead to the formation of high Himalayan Mountains. The thrusting has been depicted from north to south in the shape of MKT (Main Karakoram Thrust), MMT (Main Mantle Thrust), MBT (Main Boundary Thrust) and SRT (Salt Range Thrust).

Pakistan is classifies into fifteen seismo-tectonic provinces. Out of these the three distinct provinces which are influencing the project site are:

- Salt Range province;
- Himalayas province ;and

• Indus basin province

The project area falls in the vast alluvial plain of upper Indus basin consists of sand, silt and clay. No rocks outcrop/exposed in the close vicinity of the project area. Tectonic deformation has not been recorded/ reported in this area. According to the modified seismic hazard zones map of Pakistan published by Geological Survey – 2006 (**Figure** 4-4), the project area is situated in minor to no damage zone where seismic factor is considered to be less than 0.03g. These are generalized values which may be used as a guideline only. Overall the project is located in a stable region which is more than 200 km away from the collisional boundary of the Indian and the Eurasian plates.

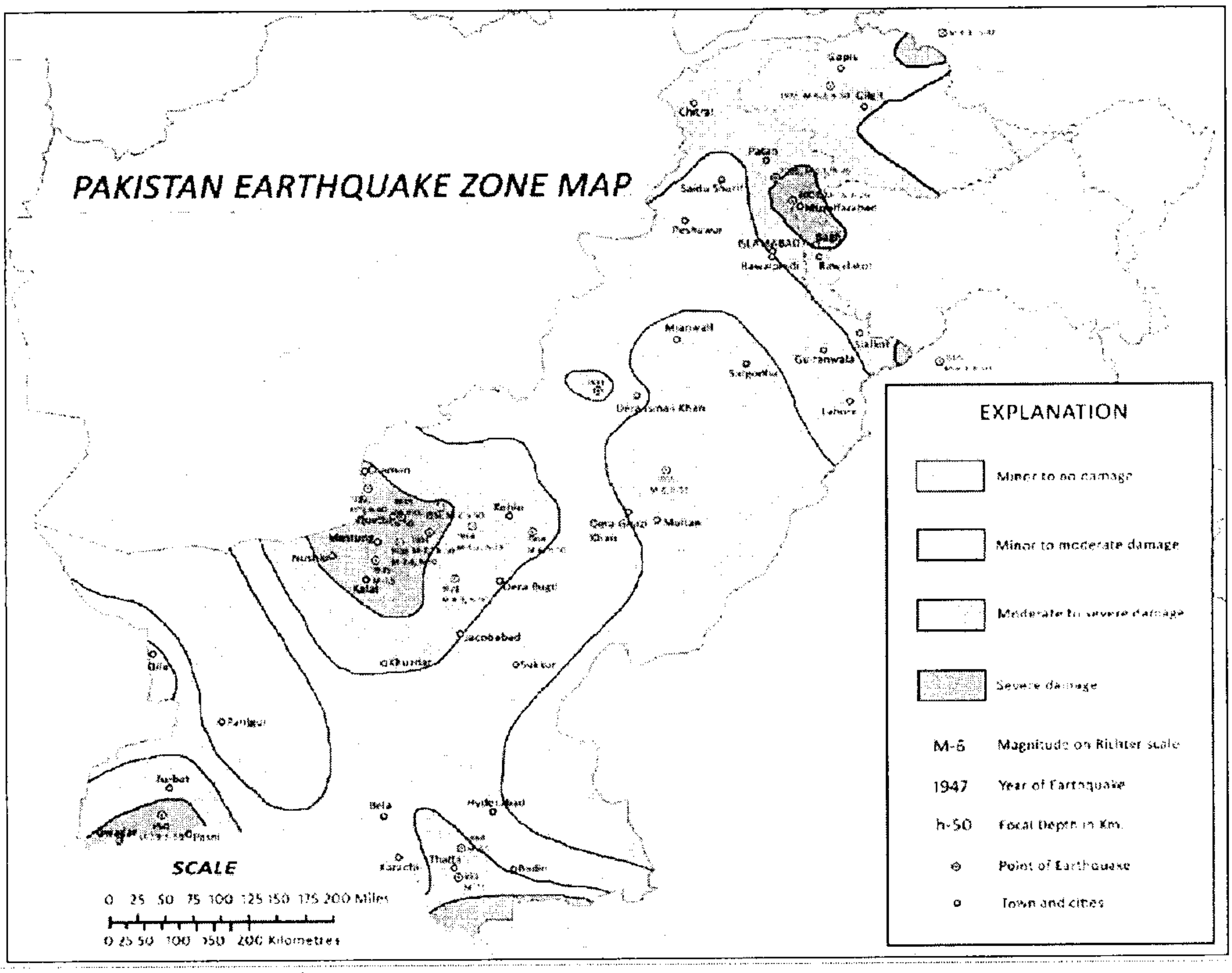



Figure 4-4: Seismic Hazards Map of Pakistan

### 4.2.4 Climate

Four seasons are being experienced in the project area i.e. winter, spring, summer and autumn. The climate of the project area is generally hot and dry in summer and moderately cold in winter. Summer starts in April and continues until September. July and August are the months of summer monsoon. Winter begins in October and lasts until February. Monsoons affect the area in July & August while March and April are pleasant months.

Metrological data (Temperature, Rainfall, Humidity and Wind Speed) for Faisalabad and Lahore was collected from the office of the Director, Pakistan Metrological Department Lahore for the last 10 years (2004-2013) as no other climatologically station exists in the project vicinity.

Meteorological data was collected from Lahore and Faisalabad stations. The data is observed at site during working days only and no observations are made on Sundays and official holidays etc. The data of other years starting from operation of stations is also available. The mean annual rainfall is about 470 mm, received mostly during July and August. The maximum annual rainfall recorded so far (2004-2013) is 565 mm and 656.8 mm in the year 2008 at Lahore and Faisalabad, respectively. Irrigation is based on water resources from canals and ground water (**Figure** 4-5 and **Figure** 4-6) whereas the temperature in the area varies between 12 °C in January to about an average of 33 °C in June. The hot dry spell is followed by rains in July and August. Monsoons hit the area in July, August and till first week of September. Heavy rains are expected in these months. Considerable rains are also expected in December and January due to western disturbance. During the peak of summer the temperature may rise to 45°C during the day, but in the winter months the minimum temperature may fall below 0°C. The average monthly rainfall in the area about is40mm.

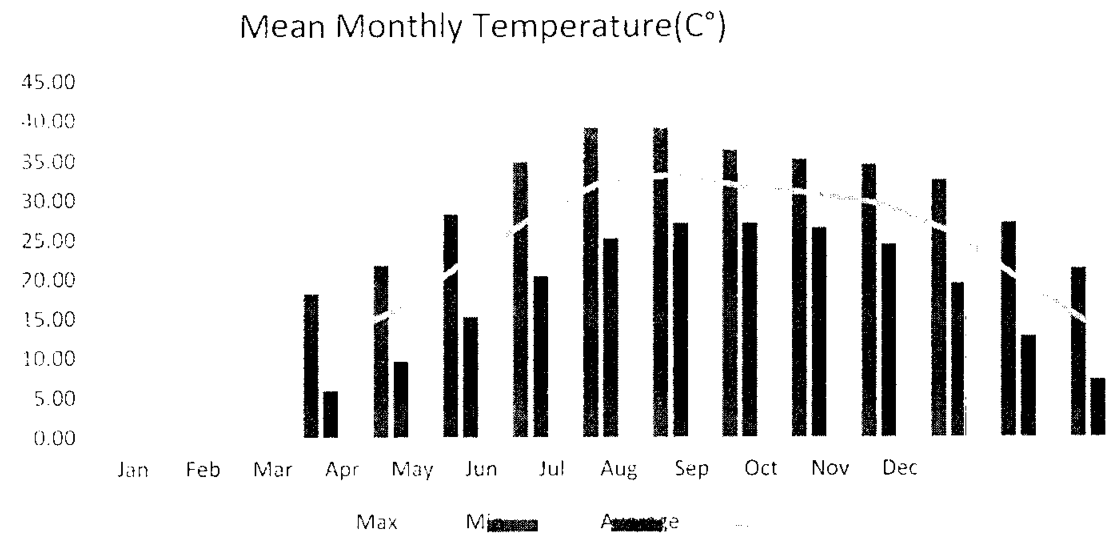



**Figure 4-5: Mean Monthly Temperatures (°C)**

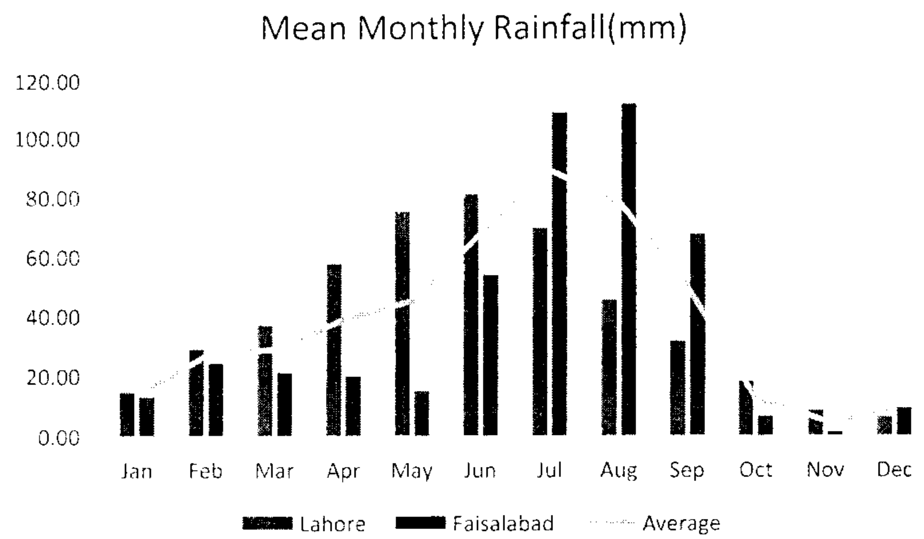



**Figure 4-6: Monthly Precipitation(mm)**

### 4.2.5 Wind and Humidity

Predominant wind direction is north to northwest from October to May, while during the monsoon period (June to September); it is from east to southeast. Average maximum wind speed recorded at Faisalabad has been 30 km/hr in June. Humidity is measured at 0800 Hrs in the morning and 1700 Hrs in the evening. Mean monthly maximum and minimum humidity for the period 2004-2013 are compiled in **Figure** 4-7. The figures indicate variation in humidity ranging from 32% in May to 69% in January.

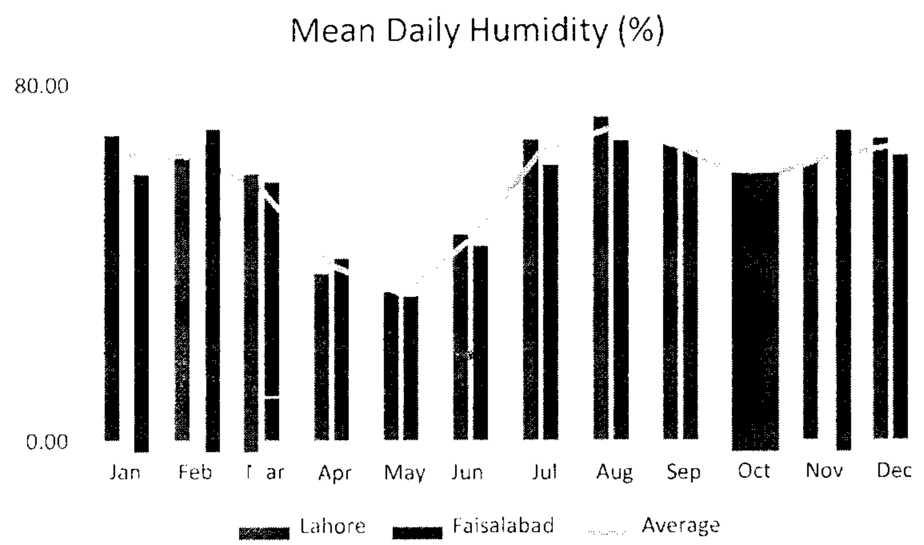



**Figure 4-7: Maximum, Minimum and Average Relative Humidity**

### 4.2.6 Water Resources

Chenab River is part of Indus Basin River system and the third river of the western river on which water Pakistan has the right under Indus Basin Treaty signed between India and Pakistan under the office of World Bank. It contributes a good part of water supply to the irrigated agriculture system in Pakistan.

The river Chenab originates in the Kulu and Kangra Districts of the Himachal Pardesh Province of India. The Two Chief streams of the Chenab - the Chandra and the Bhaba - rise on the opposite sides of Baralcha Pass at an elevation of about 4877 m (16,000 ft). These join at Tandi in the state of Jammu and Kashmir, nearly 2,770.6 m (9,090 ft) above mean sealevel.

Chenab River fed by innumerable tributaries on the long journey from its headwaters, the river gains immense power and momentum on entering the Jammu/Kashmir region above Kishtwar. From Kishtwar to Thatri (about 50 km) the Chenab runs through class V and Class VI gorges. The combined streams, traversing about 216.0 km (135 miles), take a sharp turn along Pir Panjal near Kishtwar. The Chenab River then flows along northern base of Pir Panjal range before entering the Doab area of Jammu and Kashmir. It cuts across this range through a spectacular gorge and then flows along its southern base, before flowing southwards and entering the plains. After traversing about 640 km (400 miles) of mountains regions and flowing at nearly 39 feet per mile, the Chenab opens out in to the plains near Akhnur. It enters Pakistan through the Sialkot District, near Diawara Village. The total length of the Chenab River is about 1,235.2 km (772 miles), of which about 724.8 km (453 miles) in Pakistan. The catchment area is about 67,430 km2 (26,035 miles2) of which 28,166 km2 (10,875 miles2) lies in the State of Jammu and Kashmir, 4,494 km2 (1,735 miles2) in India and 34,367 km2 (13,269 miles2) in Pakistan. The hilly catchment area above Marala Barrage is about 32,660 km2 (12,610miles2).

The Annual Average flows are 12.38 MAF (10.07 Kharif and 2.31 Rabi). The discharges of the Chenab starts rising in the late part of May and pass the 1415.48 m3/s (50,000 ft3/s) mark in June. A high flow above 1415.48 m3/s (50,000 ft3/s) continues till the middle of September, the peak discharge months being July and August. The important structures along Chenab River in Pakistan are Marala Barrage constructed in1968 with design discharge of 31,148.53 m3/s (1.1 million ft3/s), Khanki Headwork constructed in 1891 with design discharge of 22,653.48 m3/s (800,000 ft3/s), Qadirabad constructed in 1967 have design discharge capacity of 25,485.16 m3/s (900,000 ft3/s), Trimmu Barrage constructed in 1939 with deign discharge of 15,414.86 m3/s (615,000 ft3/s) and Panjnad Barrageconstructedin1932withdesigndischargeof19,821.79m3/s(700,000ft3/s).

The Chenab has twelve major tributaries namely; Chandra, Bhaga, Bhut Nallah, Maru, Jammu Tawi, Manwar Tawi, Doara Nullah 1, Doara Nullah 2, Halse Nallah, Bhimber Nullah, Palkhu Nullah and Aik and Bhudi Nullah. The last eight tributaries join the Chenab in Pakistan.

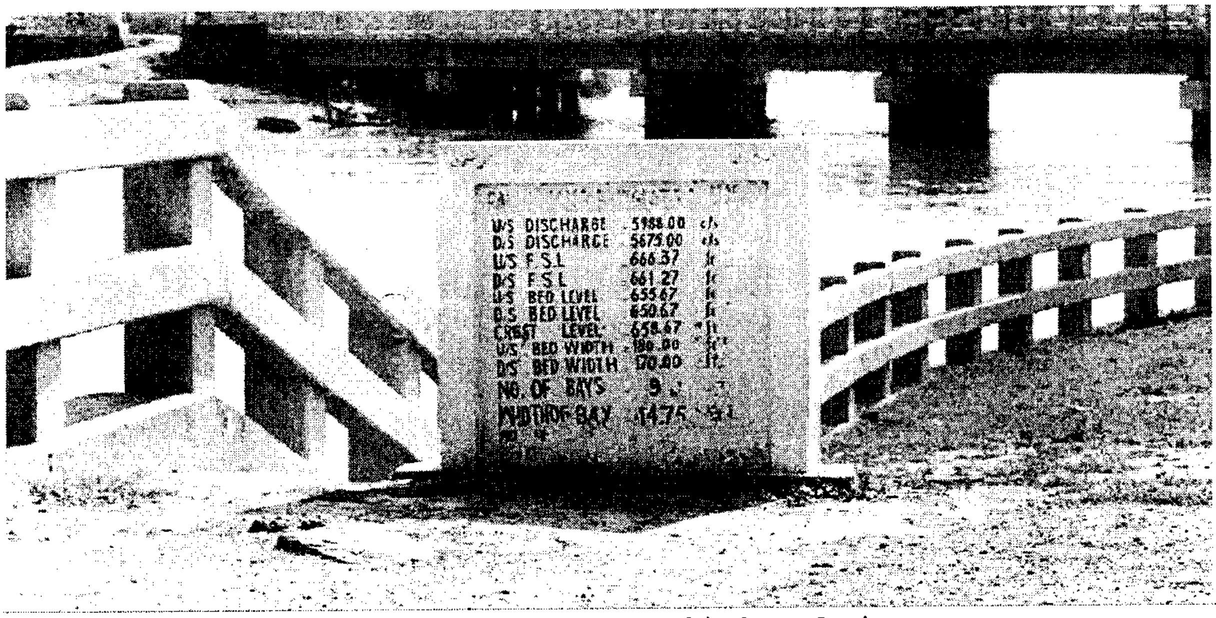



**Figure 4-8: Flow and other Data of the Gugera Canal**

Khanki Headwork on river Chenab situated about 14.5 km downstream from Town of Wazirabad was built and made operational in the year 1892. This was the first weir in Punjab which had been founded on alluvial bed of the river. During 1932, sudden collapse of some major part was apprehended to take place. A lot of research was carried out by irrigation and hydraulic engineers especially work of Khosla wrote a theory which even today is considered to a bible for the design of hydraulic structures on alluvial/permeable soils. The weir 1336.24 m long constructed in the year 1892 with some latter additions consisted of;

- Two canal head regulators at the left flank with crest of subsidiary regulator 1.524 m lower than the Head regulator;
- The left under-sluice of 12 spans of 6.09 m opening each;
- A weir of 8 spans with widths of each ranging from 134.42 m to 156.97 m on which shutters had been provided to head up the water;
- Bridges on two regulators and left under-sluice with 3.048 m wide road way. A rope way cradle over 8 weir spans had been made for to and from movement of the supervisory and operation/maintenance staff from one end of the river to the other.

Lower Chenab Canal (L.C.C)isoneoftheoldestsystemsofirrigationinthePunjabProvince.The L.C.C off-taking from Khanki Headwork located in Gujranwala District on the river Chenab was constructed in 1892-98 and is supplying irrigation water to about 3.031 million acres of cultivable command area of 7 districts; Gujranwala, Hafizabad, Sheikhupura, Nankana Sahib, Faisalabad, Jhang and Toba Tek Singh through network of canals, branches, distributaries and minors. The design discharge of the canal at head-regulator is 440m3/s.

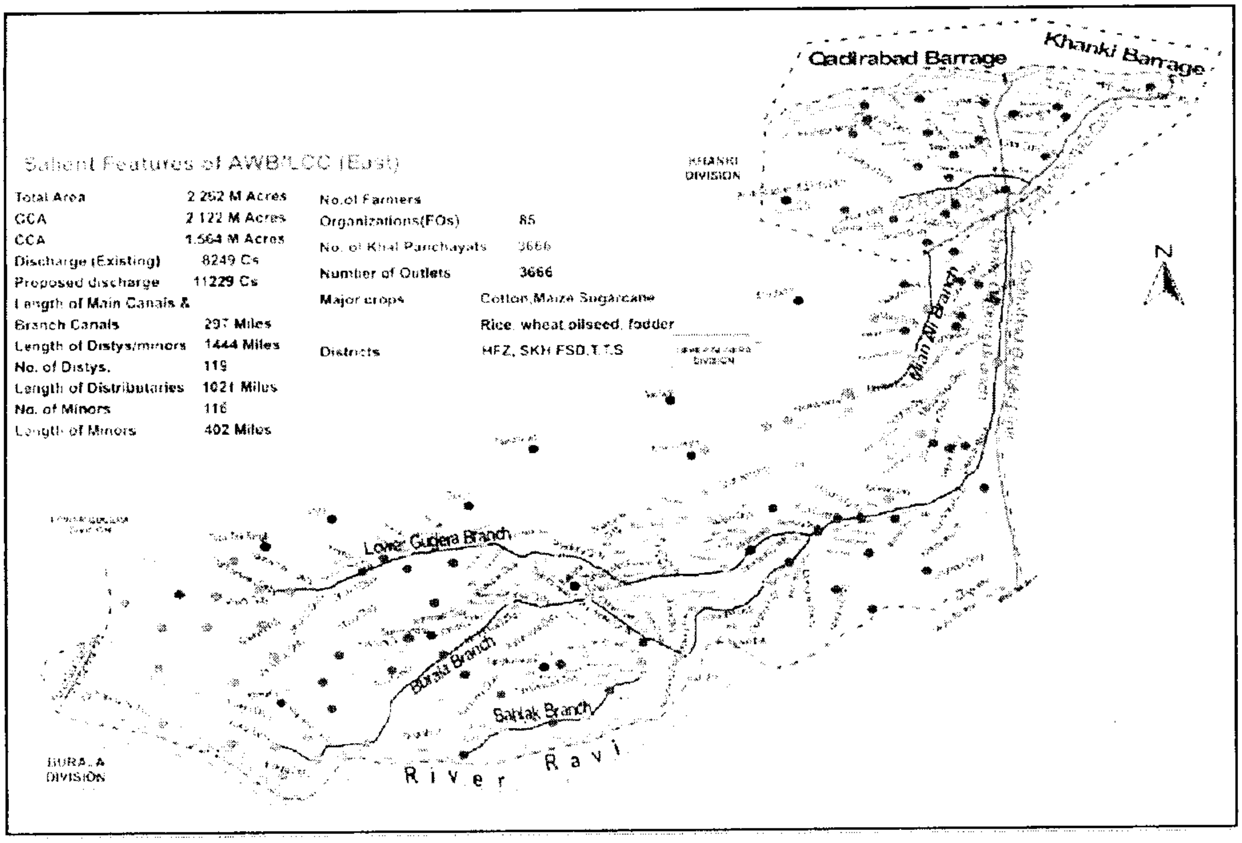



Figure 4-9: Lower Chenab Canal (L.C.C) Command Area

### 4.2.7 Air Quality

Air quality in the project area appears good based on the observation during the study period. Domestic sources of air pollution, such as emissions from wood and kerosene burning stoves as well as small diesel standby generators in some households are well dissipated. There are no other industrial pollution sources present in the vicinity.

The other major source of air pollution is dust arising from traffic and other ground or soil disturbances. Near the access roads along banks of Gugera Canal, when vehicles pass, dust levels increase. Some part of the road is paved and rest is unpaved but dust levels are elevated when vehicles pass intermittently over these roads.

### 4.2.8 Noise

Noise from vehicles and other powered mechanical equipment is intermittent. There are no significant disturbances to the quiet rural setting. Flowing water in the canal especially over the fall structures is source of noise otherwise the area is generally quiet.

## 4.3 Ecological Baseline

The existing habitats within the project area include the mostly agricultural land.

### 4.3.1 Flora

The flora in Riverian tract, especially in wetland areas the succession of vegetation, first colonizes are grasses and Typha followed by Tamarix as the soil become consolidated and is raised by the new silt deposition in the scrub, so that the vegetation is no longer completely submerged and erect tree growth becomes possible.

As the soil gets stabilized and drained the forest community normally progresses to *Acacia nilotica* and *Dalbergia Sissoo*. In its present state, the flora of Riverian Alluvial deposits can be Lai (Tamarix dioca), Pilchi (*Tamarix gallica*), Babool (*Acacia nilotica*), Shisham (*Dalbergia sissoo*), Beri (*Zizyphus yujuba*), Jand (*Prospis spicigera*), Mesqette (*Prosopis juliflora*), Mesquette (*Prosopis glandulosa*), Bhen/Poplar (*Populus euphratica*), Khabbal (*Cynodon dactylon*), Kanwal (*Melolotus oralifolia*), Munj (*Erianthus munja*), Kia (*Sacchrum spontaneum*), Kunder (*Typhaelephantine*)

Whereas the trees provide a habitat for birds the solid ground below is the houses of mammals. The margin line of Typha and grasses becomes a good habitat for reptiles while the fish occupy the adjacent waters.

Adjacent area is either on the river banks or on risen parts of the consolidated alluvial deposits within the pond. The natural flora of inland area is as follows:-

Trees: *Salvadora oleoides* (Peelo), *Prosopis juliflora* (Jangli kiker), *Tamarix aphylla* (Farash), *Dalbergia sisso* (Shishm), *Acacia nilotica* (Kiker), *Albizzia lebbec* (Sars), Kiker, Shishm, Sufaida and Tarmail were the main type of trees found along the embankments.

Other smaller species in the area include;

**Table 4-1: Herbs, Shrubs and Grasses of the Project Area**

| ***Sr.No.*** | ***Botanical Name*** | ***Local Name*** |
|---|---|---|
| 1 | *Aristidaadscensionis* | Lamb a |
| 2 | *Arundodonax* | Narabans, |
| 3 | *Avenafatua* | JangliJai |
| 4 | *Bambusaglaucescens* | Bans |
| 5 | *Bothriochloabladhii* | Palvan |
| 6 | *Brachiariaramosa* | Sawari |
| 7 | *Cenchrusbiflorus* | Bhurat |
| 8 | *Cenchrussetigerus* | Anjan, |
| 9 | *Chrysapoganserrulatus* | Chita Gha |

| Sr.No. | Botanical Name | Local Name |
|---|---|---|
| 10 | *Cymbopogon* | Khavi, |
| 11 | *Cynodondactylon* | Khabbal, |
| 12 | *Dactylocteniumaegyptium* | Madhana |
| 13 | *Desmostachyabipinnata* | Dabh,Kusa |
| 14 | *Dichanthiumannulatum* | Palwan,Marvel |
| 15 | *Digitariaciliaris* | Shamokha |
| 16 | *Digitarialongiflora* | Indian CrabGrass |
| 17 | *Digitariasetigera* | Ungli Gha,Fonio |
| 18 | *Diplachnefusca* | JhangSari, |
| 19 | *Echinochloacolona* | Cockspur |
| 20 | *Echinochloacrus-galli* | Sanwak |
| 21 | *Enneapogonpersicus* | Jiu |
| 22 | *Eragrostisminor* | ChotiGhas |
| 23 | *Eragrostispilosa* | Nikasanwak |
| 24 | *Imperatacylindrical* | Dabh,Siru |
| 25 | *Leptochloachinensis* | Naru |
| 26 | *Leptochloapanacea* | Paja |
| 27 | *Lolium temulentum*Linn. | Cockle |
| 28 | *Ochthochloacompressa* | Phalwan,Chhimbar |
| 29 | *Panicumantidotale* | Gharam |
| 30 | *Saccharumbengalense* | Kana, |
| 31 | *Saccharumspontaneum* | Khai,Kaan |
| 32 | *Setariaintermedia* | Chirchira |
| 33 | *Setariaverticillata* | Barchittas |

| Sr.No. | Botanical Name | Local Name |
|---|---|---|
| 34 | *Tetrapogonvillosus* | Sager |
| 35 | *Urochloapanicoides* | Harat,Jhun |

Near the banks some exotic tree species have been introduced over the time. Some of these are Mulberry (*Morus alba*), Bakain (*Melia azadarach*), Shirin/siris (*Albizzia lebeck*), Sufaida (*Eucalyptus camaldulensis*), Ipal ipal (Minosifolia), Burr (*Ficus bengalensis*), Pipal (*Ficus religiosa*), Mango (*Mangifera indica*), Jaman (*Eugenia Jambolana*), Toot (*MorisAlba*)

**Economic Ecological Value of the Flora**

The above listed flora consist of trees-shrubs-herbs and grasses. The flora on the whole has following economic and ecological values:

1. Production Value: Timber, fuel wood and non-timber produce.
2. Protection Values: Soil conservation, wind breaks and protection and habitatsfor fauna.
3. Environmental Values: Production of oxygen, carbon absorption, cooling of air temperature.
4. Aesthetic Values: Trees as green dimension tool of landscape the other vegetation supplements that.
5. Cultural Values: Various produce available out of the flora shape the habits and culture of the adjacent population.
6. Strategic Value: Near the project area there is Rangers out post and the scale vegetation on the site provides camouflage as well as obstacle value to the area.
7. Rehabilitation Value: Succession of vegetation on alluvial soil in the river builds up the soil at advance stage this process can add more lands to agriculture use.

### 4.3.2 Terrestrial Fauna

The proposed project area is inhabited by various mammals like Mongoose (*Herpestes edwardsi*), Porcupine (*Hystrise indica*), Fox (*Valpes bengalensis*), Jackal (*Canis aureus*), Hare (*Lepus nigricollis*) and Wild Boar (*Sus scrofa*). Though some of the larger mammals and reptilian species are quite rare in the area, but there are no endangered or vulnerable species in the area. The rich fauna of central Punjab, especially near the canal systems, cultivated lands, pond and downstream in the released waters, is as follows:

### Mammals

Table 4-2: Mammals in the Project Area

| *Species* | *Scientific Name* | *Status* |
|---|---|---|
| Mongoose | *Herpestesedwardsi* | Common |
| Mongoose | *Herpestesanropunctatous* | Common |
| Porcupine | *Hystriseindica* | Common |
| Hedge Hog | *Hemiechinusspp.* | Common |
| Fox | *Valpesbengalensis* | Less Common |
| Jackal | *Canisaureus* | Common |
| Wild Boar | *Susscrofa* | Common |
| House Rat | *Rattusrattus* | Common |
| Yellow House Bat | *Scotphilus* | Common |
| Hare | *Lepusnigricollis* | Common |
| Hog Deer | *Axisporcinus* | Rare |
| Black Buck | | Rare |

### Reptiles &Amphibian

Table 4-3: Reptiles & Amphibian in the Project Area

| *Species* | *Scientific Name* | *Status* |
|---|---|---|
| Frogs | | Common |
| Toads | | Common |
| Sand Boa or Du-muhi | *ErysJohnii* | Common |
| Chequared | *keel* | back |
| Snake | *Natrixpiscator* | Common |
| Dark-bellied marsh Snake | *Xenochrophiscerasogaster* | Common |
| Striped river Snake | *Enhydrispakistanica* | Rare |
| Gecko | *Hemidactylus* | Common |
| Dhaman | *Ptyasmucosus* | Rare |
| Striped Keel back | *Amphiosmaestolata* | Rare |
| Indian Cobra | *Najanaja* | Common |
| Indian Monitor Lizard | *Veranusbengalensis* | Common |
| Variety of lizards, krait and viper | | Common |

## 4.3.3 Avi Fauna

The waterways and small ponds in the area provide the habitat for many species of migrating and local birds. The area is home to common avifauna like White breaşted kingfisher (*Halcyon smyrnensis*), Cattle egret (*Bubulcus ibis*), Pond heron (*Areleola grayii*), Red-vented bulbul (*Pyenonotus cafer*), Black drongo (*Dicrurus macrocercus*), Common myna (*Acridotheres tristis*), House crow (*Corvas splendens*), Indian roller (*Coracias benghalensis*), Greater coucal (*Centropus sinensis*), Barn owl (*Tyto alba*), River tern (*Sterna aurantia*), Common coot (*Fulica atra*), Many species of waterfowl also visit the project area during winter.

Table 4-4: Avifauna of the Project Area

| *Species* | *Scientific Name* | *Status* |
|---|---|---|
| Asiankoel | *Eudynamysscolopacea* | Common |
| Bankmyna | *Acridotheresginginianus* | Common |

| Species | Scientific Name | Status |
|---|---|---|
| Barnowl | *Tytoalba* | Common |
| Black drongo | *Dicrurusmacrocercus* | Common |
| Black Headed goose | *Anserindicus* | Rare |
| Black Winged stilt | *Himantopushimantopus* | Common |
| Black-crowned night heron | *Nycticoraxnycticorax* | Common |
| Blue-rock pigeon | *Columbalivia* | Common |
| Cattle egret | *Bubulcusibis* | Common |
| Common coot | *Fulicaatra* | Common |
| Common myna | *Acridotherestristis* | Common |
| Common pochard | *Aythyaferina* | Common |
| Common sandpiper | *Actitishypaleucus* | Common |
| Copper smith barbest | *Megalaimarubricapilla* | Common |
| Golden-back wood pecker | *Dinopiumjavanense* | Common |
| Greater coucal | *Centropussinensis* | Common |
| House crow | *Corvassplendens* | Common |
| Indian robin | *Saxicoloidesfulicata* | Common |
| Indian roller | *Coraciasbenghalensis* | Common |
| Large pied wagtail | *Motacillamaderaspatensis* | Common |
| Little bittern | *Ixobrychusminutes* | Common |
| Little brown dove | *Streptopeliasenegalensis* | Common |
| Little egret | *Egrettagarryetta* | Common |
| Pied kingfisher | *Cerylerudis* | Common |
| Plain prinia | *Priniainornata* | Common |
| Pond heron | *Areleolagrayii* | Common |
| Purple sunbird | *Nectariniaasiatica* | Common |
| Red crested pochard | *Nettarufina* | Rare |
| Red-vented bulbul | *Pyenonotuscafer* | Common |
| Ringdove | *Streptapeliadecaocto* | Common |
| River tern | *Sternaaurantia* | Common |
| Rose-ringed parakeet | *Psittaculakrameri* | Common |
| Rosy starling | *Sturnusvulgaris* | Common |
| Sind sparrow | *Passerpyrrhonatus* | Common |
| Spotted owlet | *Athenebrama* | Common |
| Tufted duck | *Aythyfuligula* | Rare |
| White breasted kingfisher | *Halcyonsmyrnensis* | Common |
| White spoonbill | *Platalealeucorodia* | Rare |
| White tailed plover | *Vanellusleucurus* | Rare |
| Yellow-crowned woodpecker | *Dendrocoposmahrattensis* | Common |
| Yellow-throated sparrow | *Petroniaxanthocollis* | Common |

### 4.3.4 Aquatic Fauna

The most common type of fish found in the canal system are Mori (*Barilius Vagra*), Gulfam (*Cyprinus carpio*), Khagga (*Rita rita*), Raho (*Labeo rohita*), Mullee (*Wallago attu*) and River catfish (*Clupisoma naziri*). The data included in this section is collected during the site meeting with the fishing contractors and visit at the local office of Fisheries Department. Mainly the fish is exported to big cities or sold by the vendors along the roads. Specially designed net (Jal) by the fishermen is the common tool of catching fish.

Fisheries play a significant role in Pakistan economy and contribute in full filling the food requirements of the country. The fishing season commences from October and finishes by mid of February. During off season local people get involved with agricultural work or temporarily move to the cities to avail money earning opportunities.

Fishes Commonly Found in River Chenab are;

**Table 4-5: Major Fish Species in the Project Area**

| *Local Name* | *Scientific Name* |
|---|---|
| **Herbivorous Species** | |
| Gulfam | *Cyprinuscarpio* |
| Thaila | *Catlacatla* |
| Rohu | *Labeorohita* |
| Carp | *Cirrhinusmrigale* |
| Reba carp | *Cirrhinusreba* |
| Mori | *BariliusVagra* |
| | |
| **Carnivorous Species** | |
| Khagga | *Ritarita* |
| River catfish | *Clupisomagarua* |
| River shad | *Gudusiachapra* |
| River catfish | *Clupisomagarua* |
| ----- | *Securicolagora* |
| Mullee | *Wallagoattu* |
| Daula | *Channamarulius* |
| River catfish | *Clupisomanaziri* |
| Tire trackeel | *Mastacembalisaramtus* |
| Singhi | *Heteropneustesfosslis* |

## 4.4 Social Baseline

A survey was carried out to appraise prevailing socio-economic conditions of the related community in the project areas and to assess the impacts of envisaged project on local settlements to cover all the possible options of work scheme. To achieve the project objectives, it is imperative to study the prevailing socioeconomic and socio cultural aspects of their livelihood. For this purpose a socioeconomic survey was conducted to assess the socio-economic condition of the people. The study was completed by March2015.

The proposed category "B" project is located near Manawala Town (31°32'20.78", 73°40'57.26"E), in Sheikhupura District of Punjab, Pakistan. The project area is located about 75 km from Lahore, 35 km from Sheikhupura city, 67 km from Faisalabad and 11 km from Nankana Sahib.

## 4.4.1 Area Background

### *4.4.1.1 Sheikhupura District*

According to the 1998 census of Pakistan, the district had a population of 3,321,029 of which 25.45% were urban. Third Mughal emperor Akbar fondly called his Son (later reigned as 4th Mughal Emperor Jahangir) Sheikhu, the origin for the name of this district and headquarter. The rulers of this area were virk Jats and their biggest village was called Virkgarh. Sheikhu razed down Virkgarh and renamed the Virk city to Sheikhupura. Even today all around Sheikhupura the biggest population is of the Virk Jattribes.

Sheikhupura District was agricultural region with forests during the Indus Valley Civilization. The Vedic period is characterized by Indo-Aryan culture that invaded from Central Asia and settled in Punjab region. The Kambojas, Daradas, Kaikayas, Madras, Pauravas, Yaudheyas, Malavas and Kurus invaded, settled and ruled ancient Punjab region. After overrunning the Achaemenid Empire in 331 BCE, Alexander marched into present-day Punjab region with an army of 50,000. The Sheikhupura was ruled by Maurya Empire, Indo-Greek kingdom, Kushan Empire, Gupta Empire, White Huns, Kushano-Hephthalites and Shahi kingdoms.

In 997 CE, Sultan Mahmud Ghaznavi, took over the Ghaznavid dynasty empire established by his father, Sultan Sebuktegin, in 1005 he conquered the Shahis in Kabul in 1005, and followed it by the conquests of Punjab region. The Delhi Sultanate and later Mughal Empire ruled the region. The Punjab region became predominantly Muslim due to missionary Sufi saints whose dargahs dot the landscape of Punjab region.

After the decline of the Mughal Empire, the Sikh invaded and occupied Sialkot District. During the period of British rule, Sheikhupura district increased in population and importance. The predominantly Muslim population supported Muslim League and Pakistan Movement. After the independence of Pakistan in 1947, the minority Hindus and Sikhs migrated to India while the Muslim refugees from India settled in the Sheikhupura District.

The other places of interest nearby are Sheikhupura Fort (Qila Sheikhupura), Tomb of Shah Jamal, Hiran Minar which is located about 3 km from Sheikhupura city. Tahir Bagh is in city Sheikhupura. Shrine of Syed Pir Bahar Shah, Syed Waras Ali Shah and Mian Sher Muhammad Sharaq puri are located in Sheikhupura District. Some sacred places of non-Muslims are also situated in this district such as Muqadssa-e-Mariam (Sacred Place for Christian Community) an old temple (Gurudawara) is located here which is holly place for Sikh community.

The District has extreme climate; the summer season starts from April and continues till October. During the summer season, temperature ranges from 30 to 45 degrees Celsius. The winter season starts from November and continues till March. December and January are the coldest months with a mean minimum temperature of 5degrees.

Sheikhupura District comprises of 5 tehsils (Sheikhupura, Ferozewala, Muridke, Sharaqpur and Safdarabad) which are further divided into 112 union councils and 664 mauzas.

#### 4.4.1.2 *Nankana Sahib District*

During the Indus Valley Civilization Nankana District was an agricultural region with forests. The Vedic period is characterized by Indo-Aryan culture that invaded from Central Asia and settled in Punjab region. The Kambojas, Daradas, Kaikayas, Madras, Pauravas, Yaudheyas, Malavas, and Kurus invaded, settled and ruled ancient Punjab region. After overrunning the Achaemenid Empire in 331 BCE, Alexander marched into present-day Punjab region with an army of 50,000. The Nankana was ruled by Maurya Empire, Indo-Greek kingdom, Kushan Empire, Gupta Empire, White Huns, Kushano-Hephthalites and Shahi kingdoms.

In 997 CE, Sultan Mahmud Ghaznavi took over the Ghaznavid dynasty empire established by his father, Sultan Sebuktegin. In 1005 he conquered the Shahis in Kabul and the Punjab region. The Delhi Sultanate and later Mughal Empire ruled the region. The Punjab region became predominantly Muslim due to missionary Sufi saints whose dargahs dot the landscape of Punjab region.

After the decline of the Mughal Empire, the Sikh Empire occupied Gujranwala. The Muslims faced restrictions during the Sikh rule. After the Battle of Chillianwala on 22 February 1849 the British declare victory in Punjab. During the period of British Raj, Nankana district increased in population and importance.

The predominantly Muslim population supported Muslim League and Pakistan Movement. After the independence of Pakistan in 1947, the minority Hindus and Sikhs migrated to India while the Muslim refugees from India settled in the Nankana district. In 1958 the great personality named Hadhrat Khawajah Muhammad Sardar Ahmad Naqshbandi Came in Bucheki (the small town of Nankana Sahib) and laid the foundation of an Islamic International Spiritual School of Naqshbandi Sardaria, Which made the Nankana Sahib an international City because he has the several followers over the world.

Nankana Sahib District comprises of 3 tehsils (Nankana Sahib, Sangla Hill and Shahkot) which are further divided into 57 union councils and 426 mauzas for administrative purposes.

### 4.4.2 Towns and Villages in the Project Area

The project is located near Manawala Town (31°32'20.78", 73°40'57.26"E), in Sheikhupura District of Punjab, Pakistan. The project area is located about 75 km from Lahore, 35 km from Sheikhupura city, 67 km from Faisalabad and 11 km from Nankana Sahib. The directly affected settlements are Katware in Sheikhupura District; Chandar Kot and Mehmoodpura in Nankana Sahib District.

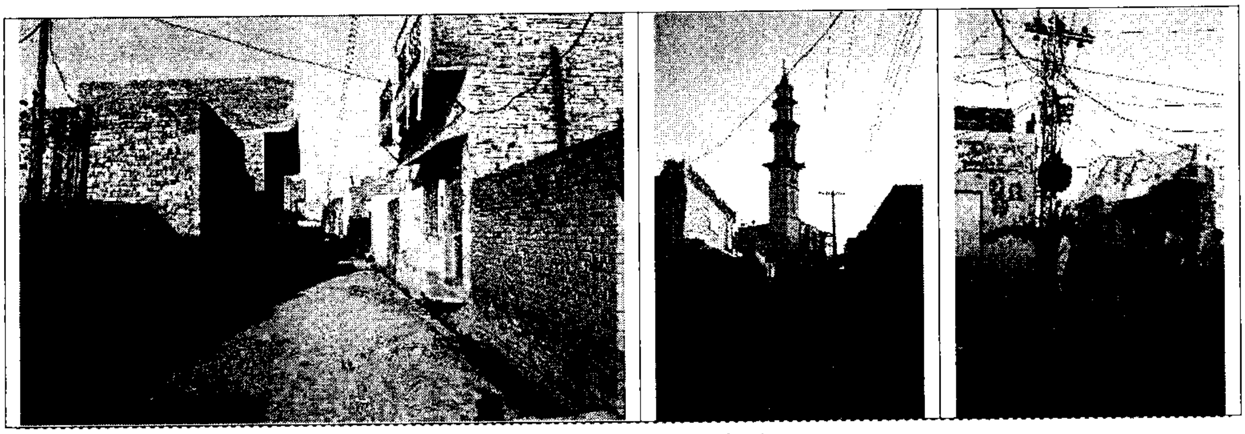


Figure 4-10: Settlements in the Area

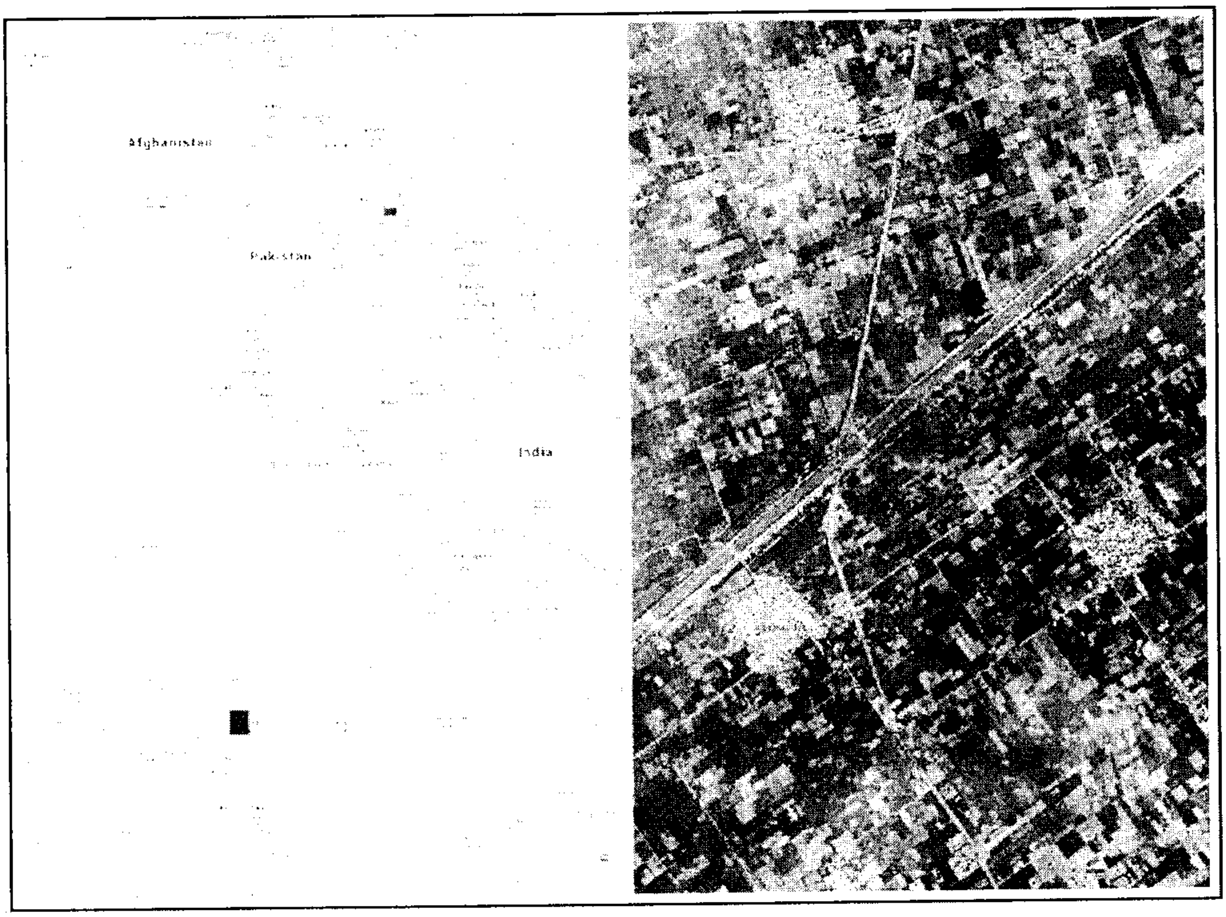



Figure 4-11: Project Area and Location of Project

### 4.4.3 Population

The demographic characteristics of study area comprising affected villages and comparison with the statistics of Sheikhupura and Nankana Sahib District; and Punjab Province are shown in **Table** 4-6. According to the 1998 census the population of the Sheikhupura and Nankana Sahib Districts is 2.27

and 1.05 million inhabitants respectively. The annual population growth rate of Punjab province is estimated as 2.58 percent on the basis of inter-censal period of1981-1998.

The table indicates that current population is 3.00 million in Sheikhupura District and 1.27 million in Nankana Sahib District. The population density based on the projected figure for 2013 is calculated as 495 persons per sq. km in Punjab, whereas 926 persons per sq. km in Sheikhupura District and 427 persons per sq. km in Nankana Sahib District. The population density Sheikhupura District is much higher as compared to Punjab and neighboring Nankana Sahib District.

Household size may also effects the economic situation of the household. Bigger household size may mean more hands to do farm work or non-farm work. It can also mean more mouths to feed. **Table** 4-6 reveals that the average household size greater than 8 to 11 in project area. 7.35, 4.99and 6.98 in Sheikhupura District, Nankana Sahib District and Punjab province respectively. Cross pounding to the population density figures compared to Punjab and neighboring Nankana Sahib District, Sheikhupura District has higher household size. Similarly, the household size in the project area settlements is significantly higher. The relative proportion of two sexes in the total population is an important demographic feature. Sex composition profoundly affects the social and economic behavior of population. The male female ratio in the study area is(50:50).

**Table 4-6: Demographic Characteristics**

| | Area(Sq. Km) | Population | | Population Density | House -hold Size | Gender Ratio (%age) | | Rural Proportion (%age) |
|---|---|---|---|---|---|---|---|---|
| | | 1998 | Latest* | | | Male | Female | |
| Punjab | 205,345 | 73,621,000 | 101,690,000 | 495.22 | 6.98 | 51.69 | 48.31 | 68.12 |
| Sheikhupura District | 3,242 | 2,276,000 | 3,003,000 | 926.57 | 7.35 | 52.15 | 47.85 | 68.59 |
| Nankana Sahib District | 2,720 | 1,045,000 | 1,266,000 | 427.7 | 4.99 | 51.92 | 48.08 | 84.87 |
| Project Area Settlements | | | | | | | | |
| Kotwar | | | 4,500 | | 11.25 | 51 | 49 | 100 |
| Chandar Kot | | | 2,500 | | 8.62 | 50 | 50 | 100 |
| Mehmood pura | | | 2,300 | | 9.20 | 50 | 50 | 100 |

* The latest for Punjab is 2013 estimates (Population Welfare Department, Government of the Punjab), for the district is 2013 estimates (Government of the Punjab, Planning & Development Department) and 2015 for the settlement.

Age is another important demographic characteristic which has a bearing on the employment and mobility. A study of distribution of population by age will throw some light on the type of strategies which may be helpful in raising their income and employment. The data about age of population in study area as presented in **Table** 4-7 indicates that majority of the population fall in age group of under 19 years fallowed of the youth of 20 to 39 years. The pattern is almost identical at local, district and provincial level.

**Table 4-7: Age Distribution of Population**

| | Population | | Age Distribution(%age) | | | |
|---|---|---|---|---|---|---|
| | 1998 | Latest* | 1 to19 | 20 to39 | 40 to59 | 60+ |

| | Population | | Age Distribution(%age) | | | |
|---|---|---|---|---|---|---|
| | 1998 | Latest* | 1 to19 | 20 to39 | 40 to59 | 60+ |
| Punjab | 73,621,000 | 101,690,000 | 42.15 | 30.97 | 20.36 | 6.51 |
| Sheikhupura District | 2,276,000 | 3,003,000 | 36.17 | 35.59 | 22.49 | 5.76 |
| Nankana Sahib District | 1,045,000 | 1,266,000 | 40.62 | 28.23 | 21.66 | 9.49 |
| Project Area Settlements | | | | | | |
| Kotwar | | 3,500 | 46 | 28 | 21 | 5 |
| Chandar Kot | | 2,500 | 51 | 26 | 14 | 9 |
| Mehmood pura | | 2,300 | 48 | 25 | 20 | 7 |

* The latest for Punjab is 2011 estimates (Population Welfare Department, Government of the Punjab), for the district is 2008 estimates (Government of the Punjab, Planning & Development Department) and 2015 for the settlement.

### 4.4.4 Ethno-Linguistics

Punjabi language is spoken by more than 95 percent population in both the districts. Punjabi is very important language which is very common in study area. Though a major portion of the population understands and speaks Urdu, but only about 3.0 percent are native speakers in the district and 4.5 percent in Punjab province as given in **Table**4-8.

Table 4-8:Languages

| Area | Urdu | Punjabi | Sindhi | Balochi | Pushto | Siraiki | Others |
|---|---|---|---|---|---|---|---|
| Project Area Settlements | -- | 100.0 | -- | -- | -- | -- | -- |
| Sheikhupura District | 3.0 | 95.0 | * | * | * | 1.8 | 0.2 |
| Nankana Sahib District | 3.5 | 94.0 | * | * | 0.2 | 2.0 | 0.2 |
| Punjab Province | 4.5 | 73.6 | 0.2 | 0.9 | 0.9 | 21.4 | 1.0 |

The baradri (brotherhood) is an important aspect of the rural society. Various branches of baradri may not be living in the same locality. Mostly baradries are formed on the basis of blood relation, caste and occupation. Baradri plays an important role in the farm events e.g. birth, death, marriage etc. in the study area. If a ceremony is done properly it adds prestige to the baradri and enhances the beauty of the occasion. People of the same baradri usually have sympathetic feelings for each other. Related to baradari is the concept of caste. The word caste comes from the Portuguese casta, meaning lineage. Majority of the Kotwar area households (50 percent) belong to Arain, 25 percent Rajput, 10 percent Mochi, whereas the remaining belongs to other castes like Lohar, Kamyar, Butt, etc. Likewise in Chandar Kot and Mehmoodpura area majority households (40 percent) belong to Shiekh, 25 percent Phatan, 15 percent Rajput, whereas the remaining belong to other castes like , Syed, Kamyar, Ansarietc.

### 4.4.5 Religion/Sects

Religion is instinctive to man. It is inseparable from human society. Religion affects human behavior deeply. Religion helps to knit the social values of a society into cohesive whole. It is the ultimate source of social cohesion. The primary requirement of society is the common possession of social values by which individuals control the actions of self and others and through which society is perpetuated. These social values emanate from religious faith. Religion is the foundation upon which these values rest. Survey in the area shows the total population of the Kotwar is 100 percentMuslim belonging to Ahle-Sunnat Sect of Islam, whereas population in Chandar Kot and Mehmoodpura area are 97 percent belong to Ahle-Sunnat Sect and 3 present to Ahle-Tashi sect of Islam. Muslims constitute 99 percent in Sheikhupura District, 98 percent in Nankana Sahib District and 97.70 percent in Punjab Province. Percentage of Christian population is 1.90 percent in Punjab Province.

### 4.4.6 Housing Patterns

Housing facilities of the households reflect their financial position and living standard. Habitation is identified as a space occupied for residential purposes and is further classified according to the type of structure into two categories i.e. "pucca" and kacha". Pucca houses are constructed with baked bricks/ blocks / stones with cement and concrete bounded. Kacha houses are made of unbaked bricks / earth bounded whereas wood houses are made of wood / bamboos. Thought it's difficult to simply categorize houses as one type or other as many are hybrid structures. But generally speaking about 90 percent houses are pacca and the remaining 10 percent are kacha. As shown in **Table** 4-9 the average numbers of rooms per household are 2.25. The numbers of rooms in all the cases are not sufficient.

**Table 4-9:Habitation**

| *Location* | *Baked Bricks/ Blocks/(Stones Pacca Housing) (%age)* | *Unbaked Bricks/ Earth Bounded (Kacha Housing) (%age)* | *Persons per Room* | *Rooms per House* |
|---|---|---|---|---|
| Punjab | 88 | 12 | 3.50 | 2.25 |
| Sheikhupura District | 91 | 09 | 3.26 | 2.25 |
| Nankana Sahib District | 81 | 19 | 2.22 | 2.25 |
| Project Area Settlements | | | | |
| Kotwar | 90 | 10 | | |
| ChandarKot | 95 | 5 | | |
| Mehmoodpura | 90 | 10 | | |

### 4.4.7 Industries and Livelihoods

It is useful to have information about occupational distribution of members of the sample households. Such information will facilitate better planning and execution of the project. The rural community in the study area consists of two groups i.e. farmers and those who are landless / non-farm households and farmers, who own or lease /encroach land, derive their living by cultivating the farm land. This community may also supplement the farms income by raising animals and off farm work. As seen in **Table** 4-10 more than 90 percent of the available land is utilized for cultivation in the project area settlements, whereas the cultivation usage is about 70 percent on district level and 60 percent on provincial level.

**Table 4-10: Land-use Patterns**

| | *Total Area (hectares)* | *Cultivated Area (hectares)* | *Cultivable Waste (hectares)* | *Forest (hectares)* | *Non-Cultivable (hectares)* | *Not Reported (hectares)* |
|---|---|---|---|---|---|---|
| Punjab | 20,534,500 | 12,568,000 | 1,591,000 | 489,000 | 3,032,000 | 2,854,500 |
| Sheikhupura District | 324,200 | 239,000 | 41,000 | 4,000 | 29,000 | 11,200 |

| | Total Area (hectares) | Cultivated Area (hectares) | Cultivable Waste (hectares) | Forest (hectares) | Non-Cultivable (hectares) | Not Reported (hectares) |
|---|---|---|---|---|---|---|
| Nankana Sahib District | 272,000 | 193,000 | 25,000 | 0 | 19,000 | 35,000 |
| Project Area Settlements | | | | | | |
| Kotwar | 911 | 830 | 51 | 0 | 30 | 0 |
| ChandarKot | 364 | 344 | 0 | 0 | 20 | 0 |
| Mehmoodpura | 405 | 374 | 0 | 0 | 30 | 0 |

The members of non-farm community generally do agriculture labour, business, services, operating small shops, daily wage work, milk processing and sales and other services to earn the income to fulfill their living necessities. They conduct such business in their own village and nearby villages and in urban areas. About 70 percent and 30 percent of the sample head of households of the area are engaged in agriculture and non-farm activities respectively (**Table**4-11).

**Table 4-11: Occupational Patterns in Area**

| *Occupation* | *Major* | *Minor* |
|---|---|---|
| Agriculture | 70 | 25 |
| Labor | 15 | 50 |
| Business | 10 | 5 |
| Service(Employment) | 4 | 5 |
| Fish Farm | 0 | 0 |
| Other | 1 | 15 |
| Total | 100 | 100 |

Sugarcane, Wheat and Rice (cleaned) are the main crops grown in the districts. Production of these crops during the period 2011-12 was 189 thousand for sugarcane, 658 thousand tons for wheat and 368 thousand tons for rice in Sheikhupura District. Production of crops in Nankana Sahib District during the period 2011-12 was 1033 thousand for sugarcane, 352 thousand tons for wheat and 175 thousand tons for rice. Besides, Vegetables, Jawar, Bajra, Tobacco, Mash, Moong Masoor , Gram, Maize, Oil Seed such as Rape / Mustard are also grown in minor quantities in the district. Citrus and Guava are main fruits grown in thedistrict.

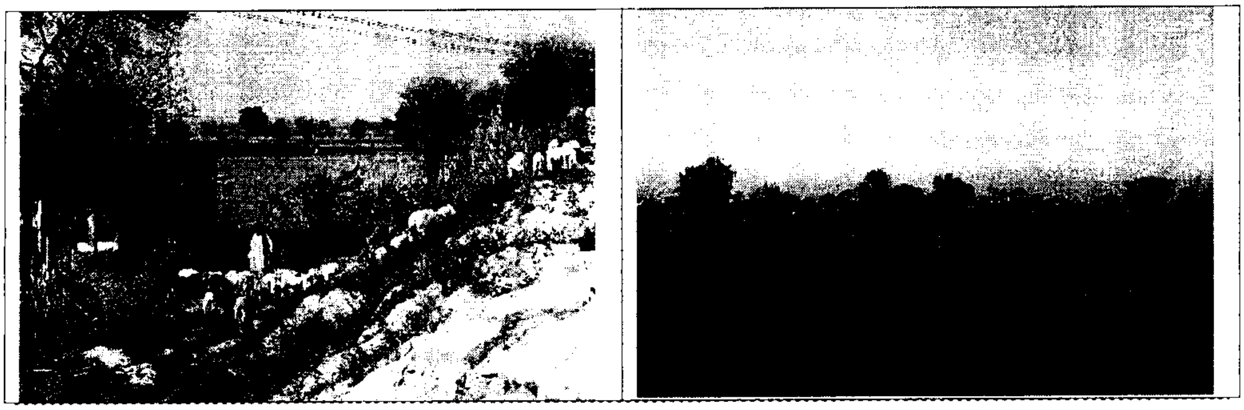


Figure 4-12: Livelihood Activities

### 4.4.8 Health

The population settle on embankment have no proper access to health facilities in the area and have to travel to Nankana Sahib for their treatment at the distance of 12 km. All population takes treatment from Doctors. Health condition of the people is generally very poor due to commonly prevalent health issues i.e. mal nutrition, high rate of child birth, typhoid, cholera, malaria, and skin diseases etc.

Table 4-12: Health Facilities

| *Area* | *Hospitals* | | *Dispensaries* | | *R.H. Center* | | *B.H.Units* | | *T.B.Clinics* | | *S.H. Centers* | | *M.C.H. Centers* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *No.* | *Beds* | *No.* | *Beds* | *No.* | *Beds* | *No.* | *Beds* | *No.* | *Beds* | *No.* | *Beds* | *No.* | *Beds* |
| **Punjab** | **340** | **39185** | **1201** | **438** | **337** | **6026** | **2606** | **4936** | **42** | **82** | **388** | **42** | **282** | **34** |
| **Nankana Sahib Distt.** | **3** | **130** | **21** | **0** | **9** | **216** | **63** | **124** | **1** | **0** | **9** | **0** | **6** | **0** |
| Shahkot | - | - | 4 | - | 1 | 24 | 8 | 16 | - | - | 1 | - | - | - |
| Sangla Hill | 1 | 10 | 3 | - | 1 | 24 | 10 | 20 | - | - | 1 | - | 2 | - |
| Nankana Sahib | 2 | 120 | 12 | - | 5 | 120 | 31 | 60 | 1 | - | 4 | - | 4 | - |
| Safdarabad | - | - | 2 | - | 2 | 48 | 14 | 28 | - | - | 3 | - | - | - |
| **Sheikhupura Distt.** | **8** | **651** | **5** | **0** | **7** | **168** | **75** | **130** | **1** | **0** | **15** | **0** | **4** | **0** |
| Ferozewala | - | - | 4 | - | 1 | 24 | 24 | 28 | - | - | 4 | - | - | - |
| Muridke | 1 | 68 | - | - | 1 | 24 | 17 | 34 | - | - | 4 | - | - | - |
| Sharaqpur | - | - | - | - | 1 | 24 | 6 | 12 | - | - | - | - | - | - |
| Sheikhupura* | 7 | 583 | 1 | - | 4 | 96 | 28 | 56 | 1 | - | 7 | 4 | - | |

There are a district headquarter hospitals in Sheikhupura and Nankana Sahib, besides there are tehsil headquarter hospitals at Sangla Hill and Muridke Tehsils. Over all in districts there are 26 dispensaries, 16 rural health centers, 138 Basic Health Units, etc. are providing healthcare services to the population. In the district health facilities for TB and Mother Child are also available. For project and its surrounding villages, hospitals are available in Nankana Sahib.

### 4.4.9 Drinking and Domestic Water

The main cause of most of the communicable and abdominal disease is non-availability of clean drinking water. About 20-30 different diseases may be caused by water supply for example, viral, bacterial, protozal and helminthic diseases. Suitable safe drinking water is an important factor in promoting human health and productivity.

During survey it was found that all families had installed hand pumps and electric motors inside and outside their houses. The proportion of hand pumps for drinking water in the rural areas of Punjab Province households is estimated as 78 percent, which is also quite high as compared to other sources (Pipe, Well, Pond, etc.) of drinking water. At present about 92 percent of the population in Punjab have access to drinking water, but only 14 percent in urban and less than 1 percent in rural areas is treated. As a result half the population uses water that's not fit for drinking. In the project area access to water is 100 percent but no treatment facilities were reported. Additionally there are no waste water and solid waste disposal facilities in the project area settlements increasing the risks of contamination.

**Table 4-13: Access to Water and Waste Disposal**

| | *Physical access to drinking water* | *Use of properly treated water* | *Safe drinking water without* | *Use of sanitary means of excreta* | *Waste water disposal* | *Solid waste disposal* |
|---|---|---|---|---|---|---|
| Punjab | 92 | 4.8 | 51 | 70 | 57 | 14 |
| Punjab Rural | 92 | 0.8 | 53 | 58 | 41 | 0.4 |
| Punjab Urban | 93 | 14 | 48 | 93 | 92 | 44 |
| Sheikhupura District | 98 | 4.8 | 47 | 83 | 82 | 11 |
| Nankana Sahib District | 95 | 1.7 | 36 | 69 | 71 | 7.4 |
| Project Area Settlements | | | | | | |
| Kotwar | 100 | 0 | - | 80 | 0 | 0 |
| ChandarKot | 100 | 0 | - | 60 | 0 | 0 |
| Mehmoodpura | 100 | 0 | - | 50 | 0 | 0 |

The water supply sector in Pakistan is characterized by extremely low level of coverage particularly in the rural areas. Presently, only 80% of the urban population has access to the piped water supply, whereas 11% of rural population is benefiting from this facility (GWP2000).

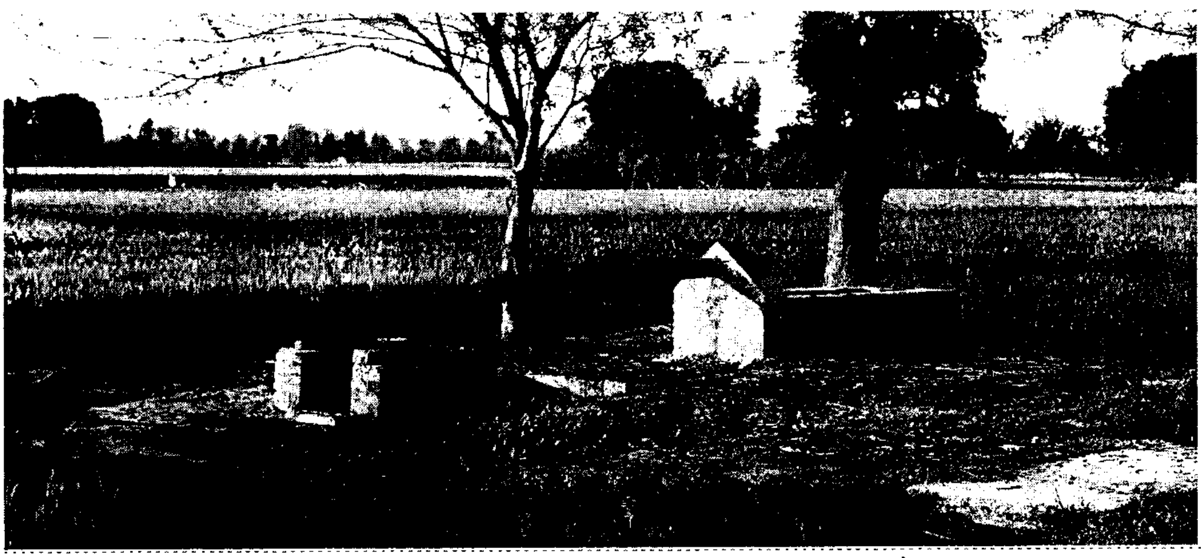


**Figure 4-13: A Typical Tube well**

For domestic and agricultural use the project area settlement mostly rely on tube wells, but a very limited amount of canal water is also available.

### 4.4.10 Social Organization and Conflict Resolution

Majority of the local population revealed that they don't have any disputes with others. But a small percent of the households informed that they had disputes with other i.e. land, livestock, fodder stealing, house, water turn, women and children related and resolved through Biradaries, Religious Leader, MPAs and at Police Station.

Majority of the villagers still rely on baradari and caste system for the resolution of conflicts and managing the day to day affairs in the village. However, clergy has some influence in the decision making process thereby bringing about change in the power structure and relations of the rural system. Since most of the people are engaged with agriculture sector, the social setup is still relevant to great extent because the villages were established by the old pattern. Every caste/family has its elder, who is responsible for settling disputes and securing the interests of the population. In the rural setup women do not have any role in decision making process. Every problem of the community is resolved by elders.

During the survey it was found that people still prefer settlements through local setup, than modern institutions including judicial system. The major cause of reliance on local setup is the lack of trust in modern institutions. However, the major towns of the region have more open approach and acceptability of modern institutions because of increasing influence of entrepreneur class and diversity of people who have been migrating from other areas and running business.

### 4.4.11 Education

The adult literacy ratio in Punjab was 46.6 percent in 1998. The literacy ratio for males was 57.2 percent against 35.1 for females. The ratio for urban areas was 64.5 percent compared to 38.0 percent in rural areas of Punjab. Latest estimates of 2010-11 project literacy ratio of the province at 59.8 percent with male literacy ratio 69.0 percent against 50.7 for females. Both the districts lag behind the provincial figures of literacy ratio with 43.8 in 1998 and latest projected at56.2percent.

**Table 4-14: Educational Facilities**

| *School Type* | *Area* | *Number* | | | *Enrolment* | | | *Teaching Staff* | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *Total* | *Boys* | *Girls* | *Total* | *Boys* | *Girls* | *Total* | *Male* | *Female* |
| Govt. Mosque Schools | Punjab | 1,897 | 1,897 | | 122,159 | 122,159 | | 2,496 | 2,496 | |
| | Nankana | 1 | 1 | | 18 | 18 | | 1 | 1 | |
| | Sheikhup. | 28 | 28 | | 2,868 | 2,868 | | 81 | 81 | |
| Govt. Primary Schools | Punjab | 42,048 | 21,286 | 20,762 | 4,472,344 | 2,439,627 | 2,032,717 | 109,147 | 58,281 | 50,866 |
| | Nankana | 723 | 448 | 275 | 81,442 | 45,170 | 36,272 | 1,922 | 1,153 | 769 |
| | Sheikhup. | 1,089 | 653 | 436 | 116,619 | 61,727 | 54,892 | 3,019 | 1,771 | 1,248 |
| Govt. Middle Schools | Punjab | 7,756 | 3,261 | 4,495 | 2,102,240 | 996,404 | 1,105,836 | 70,711 | 32,033 | 38,678 |
| | Nankana | 131 | 52 | 79 | 35,909 | 15,459 | 20,450 | 1,447 | 555 | 892 |
| | Sheikhup. | 204 | 77 | 127 | 58,721 | 24,031 | 34,690 | 2,025 | 812 | 1,213 |

| School Type | Area | Number | | | Enrolment | | | Teaching Staff | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Boys | Girls | Total | Boys | Girls | Total | Male | Female |
| Govt. High Schools | Punjab | 5,589 | 3,207 | 2,382 | 3,373,930 | 1,939,604 | 1,434,326 | 108,111 | 62,843 | 45,268 |
| | Nankana | 65 | 48 | 17 | 43,777 | 29,501 | 14,276 | 1,454 | 1,017 | 437 |
| | Sheikhup. | 124 | 75 | 49 | 86,251 | 52,727 | 33,524 | 2,486 | 1,547 | 939 |
| Higher Secondary Schools | Punjab | 798 | 379 | 419 | 92,024 | 43,257 | 48,767 | 8,025 | 4,385 | 3,640 |
| | Nankana | 7 | 3 | 4 | 928 | 515 | 413 | 61 | 36 | 25 |
| | Sheikhup. | 24 | 10 | 14 | 4,101 | 1,347 | 2,754 | 282 | 134 | 148 |
| Inter. & Degree College | Punjab | 930 | 457 | 473 | 740,885 | 342,087 | 398,798 | 23,790 | 12,659 | 11,131 |
| | Nankana | 7 | 3 | 4 | 6,424 | 2,947 | 3,477 | 102 | 68 | 34 |
| | Sheikhup. | 18 | 7 | 11 | 14,151 | 6,654 | 7,497 | 399 | 222 | 177 |
| Inter. Colleges | Punjab | 212 | 113 | 99 | 52,724 | 23,810 | 28,914 | 4,057 | 2,256 | 1,801 |
| | Nankana | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Sheikhup. | 2 | 0 | 2 | 382 | 0 | 382 | 18 | 0 | 18 |
| Degree Colleges | Punjab | 718 | 344 | 374 | 688,161 | 318,277 | 369,884 | 19,733 | 10,403 | 9,330 |
| | Nankana | 7 | 3 | 4 | 6,424 | 2,947 | 3,477 | 102 | 68 | 34 |
| | Sheikhup. | 16 | 7 | 9 | 13,769 | 6,654 | 7,115 | 381 | 222 | 159 |
| Total | Punjab | 59,948 | 30,944 | 29,004 | 11,644,467 | 6,225,225 | 5,419,242 | 346,070 | 185,356 | 160,714 |
| | Nankana | 941 | 558 | 383 | 174,922 | 96,557 | 78,365 | 5,089 | 2,898 | 2,191 |
| | Sheikhup. | 1,505 | 857 | 648 | 296,862 | 156,008 | 140,854 | 8,691 | 4,789 | 3,902 |

There are more than 1500 educational institutions in District Sheikhupura and 940 in Nankana Sahib District, imparting education from Mosque/primary school to post graduate level. About 27 colleges and 23 post graduate colleges in the two districts. About 31 high schools of all important school systems are present in the districts, which are both for girls and boys. Separate schools and colleges for girls are also available.

During survey it was revealed that the settlements of Kotwar, Chandra Kot and Mehmoodpura have following education facilities;

- Govt. Boys Middle School, (Kotwar) up to class 8 with total enrollment of450
- Govt. Girls Middle School, (Kotwar) up to class 8 with total enrollment of500
- Hira Public School, (Kotwar) up to class 8 with total enrollment of100
- Gazali Public School, (Kotwar) up to class 8 with total enrollment of250
- Pak Village Public School, (Kotwar) up to class 8 with total enrollment of200
- Govt. Boys High School, (Chandra Kot) up to class 10 with total enrollment of600
- Govt. Girls High School, (Chandra Kot) up to class 10 with total enrollment of550
- Chandar Public School, (Chandra Kot) up to class 8 with total enrollment of85
- Rise Public School, (Chandra Kot) up to class 5 with total enrollment of50
- Govt. Boys Primary School, (Mehmoodpura) up to class 5 with total enrollment of200
- Govt. Girls Primary School, (Mehmoodpura) up to class 5 with total enrollment of150
- Al-Awan School, (Mehmoodpura) up to class 8 with total enrollment of200
- Nankana Public School, (Chandra Kot) up to class 10 with total enrollment of150

The locals also revealed that in the population under the age of 10 the enrollment is almost 95% which is a very healthy sign though in overall population the area statistics are almost the same of rural Punjab.

### 4.4.12 Energy/Power Sources

Energy is vital for Socio-economic development. In the project area both the settlements have 100% electricity coverage. The project area settlements of Kotwar, Chandra Kot and Mehmoodpura are also supplied with natural gas by Sui Northern Gas Pipelines Limited (SNGPL). As these are rural settlements a major portion about 50% of cooking and heating is still done through fuel wood. About 5% of the well-off households also use LPG in gas shortages.

### 4.4.13 Gender Issues

The number of women in the households is more than male members, as many of the male members work in other areas of the country. Sixty five percent populations, male and female together are under 30 years of age. In rest of 35% the age groups taper off as they go towards high age. Due to ethnic and social reasons most of the times only male population appears in streets and bazars. The main occupation of women in project rural areas is house-keeping which includes attending to the cattle, extracting butter and Ghee from milk, weaving and sewing of family clothes. In addition they generally help their men folk on farms with the lighter duties like planting of seedlings, threshing and winnowing of grains and sometimes they also help in harvesting. Majority of the women prefer independent life as housewives.

There is a tendency to marry early (men 21 – 25 years, women 18 – 21 years). There are no teen age marriages. Because of family bonds social values and caste pressures the rate of divorce is rather low. Most males are contented with one wife through a small minority of Jut brotherhood have 2 – 3 wives.

The role of women is crucial for any sustainable development process. The women situation survey shows that 42 percent respondent are literate while 58 percent respondent is illiterate. The most pressing need of the women of the area is the basic health facilities and the educational facilities for the girls of the project area. The construction of project will definitely promote the above mentioned needs and also other social development works.

Average age for men is 60 years, within a range of 35 – 89 years. Average are of women is 65 years within a range of 25 – 100 years. Infant mortality is 35% because of lack of gynecological and antenatal facilities in BHU's People cooperate with Polio drops campaign every year. Courses of vaccines against small pox, cholera, typhoid and hepatitis are offered but are ignored by many village households.

### 4.4.14 Transportation and Accessibility

The project site and area is located in the province of Punjab in District Sheikhupura which is accessible by air, good roads and railway network. A number of airports are operating in Pakistan and receiving International and national flights. Allama Iqbal International Airport Lahore, International Airport Faisalabad is the nearest airports to the project area and site. The road distance from these airports are:

- Lahore to Site via Lahore-Faisalabad dual carriage way = 70km
- Faisalabad to Site via Lahore-Faisalabad dual carriageway= 67km

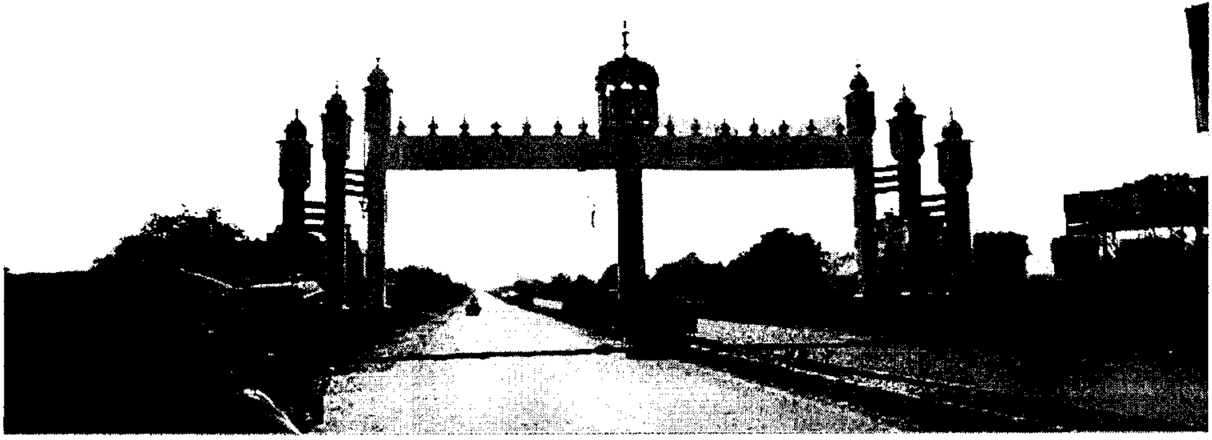


**Figure 4-14: Road to Nankana Sahib and Project Location from Manawala**

Pakistan is also linked with International community via sea and at present three shipping ports are operating. Karachi port and Port Qasim are in or near the port city of Karachi and Port of Gawadar is in Province of Balochistan. These ports are linked with other parts of the country through good network of railway and roads. Karachi the port city is linked with Lahore, Sahiwal, Faisalabad, Gujrat, and Islamabad via Highways, National Highway and Motorway.

The nearest railway is Sheikhupura which lies on the Lahore-Faisalabad Railway line. The nearest railway stations where loading and unloading of heavy equipment is possible are Gujrat, Wazirabad, Sialkot Dry port, Sargodha and Lahore. These stations are along Main Railway track between Lahore and Sarghodha. Lahore is the terminal point on the main track of Lahore-Karachi section.

### 4.4.15 Archaeological Sites

Preservation of archaeological and historical heritage is obligatory under the Pakistan Antiquities Act 1975. All the artifacts, monuments, petrography and building of historical importance come under archaeological heritage. Even old mosques, temples, churches and graveyards are covered under this Act. No item of archaeological or historical importance has been found near the powerhouse site or in the areas likely to be used for project works. Therefore, there will be no impact on historical heritage due to construction of the project.

# 5 STAKEHOLDER CONSULTATION AND PARTICIPATION

## 5.1 General

This section describes the outcomes of the stakeholder consultation process as part of the IEE. This ensures that feedback from communities and other stakeholders directly or indirectly affected by the project is collected so that it may be used to cater for their needs at the time of project execution. In addition to ensuring that the construction activities do not have negative impacts on the environment. The objectives of this process were:

- To disseminate information on the project and its expected impact, long-term as well as short-term, among primary and secondary stakeholders,
- To gather information on relevant issues so that the feedback received could be used to address these issues at an early stage,
- To determine the extent of the negative impacts of different project activities and suggest appropriate mitigation measures.

Stakeholders consultation is mandated under Pakistan's environmental law. The Environmental Department, under Regulation 6 of the IEE-EIA Regulations 2000, has issued a set of guidelines of general applicability and Sectoral guidelines indicating specific assessment requirements. These guidelines have been adopted by the Punjab EPD for use in its jurisdiction. This includes Guidelines for Public Consultation, 1997 (the 'Guidelines'), that are summarized below:

- **Objectives of Public Involvement**: 'To inform stakeholders about the proposed project, to provide an opportunity for those otherwise unrepresented to present their views and values, providing better transparency and accountability in decision making, creating a sense of ownership with the stakeholders'.
- **Stakeholders**: 'People who may be directly or indirectly affected by a proposal will clearly be the focus of public involvement. Those who are directly affected may be project beneficiaries, those likely to be adversely affected, or other stakeholders. The identification of those indirectly affected is more difficult, and to some extent it will be a subjective judgment. For this reason it is good practice to have a very wide definition of who should be involved and to include any person or group who thinks that they have an interest. Sometimes it may be necessary to consult with a representative from a particular interest group. In such cases the choice of representative should be left to the group itself. Consultation should include not only those likely to be affected, positively or negatively, by the outcome of a proposal, but should also include those who can affect the outcome of a proposal'.
- **Mechanism**: 'Provide sufficient relevant information in a form that is easily understood by non-experts (without being simplistic or insulting), allow sufficient time for

Stakeholders to read, discuss, and consider the information and its implications and to present their views, responses should be provided to issues and problems raised or comments made by stakeholders, selection of venues and timings of events should encourage maximum attendance'.

- **Timing and Frequency**: Planning for the public consultation program needs to begin at a very early stage; ideally it should commence at the screening stage of the proposal and continue throughout the IEE process.
- **Consultation Tools:** Some specific consultation tools that can be used for conducting consultations include; focus group meetings, needs assessment, semi-structured interviews; village meetings and workshops.
- **Important Considerations**: 'The development of a public involvement program would typically involve consideration of the following issues; objectives of the proposal and the study; identification of stakeholders; identification of appropriate techniques to consult with the stakeholders; identification of approaches to ensure feedback to involved stakeholders; and mechanisms to ensure stakeholders' consideration are taken into account'.

## 5.2 Stakeholder Consultation Process

In addition consultations were also held with the project staff in order to obtain details on the projects and the planned works.

## 5.3 Primary Stakeholders Consultation

Consultations with the Project stakeholders were undertaken. The feedback from the communities was recorded. Separate meetings with stakeholders were arranged at all villages in the impact zone. The primary stakeholders are the general public and women residing in the project area and the direct beneficiary of the project. Accordingly, the consultations/ focus group discussions were made with all stakeholders for sharing of information about the proposed project and expected impacts and understanding about the concerns by the stakeholders.

Apart from gathering of quantitative data through household survey of the area of influence of the project and settlement survey of project affected area were conducted with the communities representing the project sites in order to share the information about the project and record their concerns/ feedback associated with this project. In this context, the communities shared their view point regarding the assessment. A list of public consultations is presented in the below table:

**Table 5-1: List of Primary Stakeholder's Consultations in the Project Area**

| *Sr.No.* | *Site* | *District* | *Date* |
|---|---|---|---|
| 1 | Kotwar | Sheikhupura | 21 March2015 |
| 2 | ChandraKot | Nankana Sahib | 21 March2015 |
| 3 | Mehmoodpura | Nankana Sahib | 22 March2015 |
| 4 | Kotwar | Sheikhupura | 22 March2015 |
| *Sr.No.* | *Site* | *District* | *Dat* |
| 5 | ChandraKot | Nankana Sahib | 23 March2015 |

### 5.3.1 Topics for Discussion

The topics discussed in the consultations were

- Gender and women issues
- Environmental issues

### 5.3.2 Outcomes of Consultations

The consultations identified some potential environmental and social impacts and perceptions of the affected communities. The community supports the construction of the power project. Residents in the Kotwar and Chander Kot villages, gathered at site and inhabitants of nearby localities of the project site expect more stable power supply in the area, with lesser complaints of load shedding, with the provision of power from Gugera Canal Hydro Electric Power Project. Poor people requested for unskilled and semi-skilled jobs on priority basis with the contractors during implementation of the project. Land acquisition on permanent and temporarily basis may be involved while resettlement is not involved in this project.

**Figure 5-1: Consultation with the Villagers**

On the basis of the consultations so far, it appears that the project will have no insurmountable environmental and social impacts but the client will have to make sure that compensation amounts are assessed justifiably and that skilled and unskilled employment should be preferentially given to the affectees or locals of villages.

Additionally during the consultations the villagers also highlighted the following local needs;

- Provision health facilities in the settlements
- Up gradation of government schools to metric level
- Reduction in the electricity load shedding timings
- Provision of sanitation facilities to the settlements
- Filtered drinking water

### 5.3.3 Consultation Teams

There were 3 members team including for the focus group discussions. The IEE specialist conducted the Focused Group Discussions (FGDs) with the communities.

## 5.4 Addressing Stakeholders Concerns

To address the issues and concerns raised by the stakeholders a mitigation plan has been developed and made part of this IEE report so that these concerns can consider at the time of implementation of the project rehabilitation activities.

# 6 IMPACT ASSESSMENT AND MITIGATION

This section summarizes the impacts of Project design, construction and operation on the physical environment, terrestrial ecological resources and the socio-economic environment.

## 6.1 Methodology

The methodology used for the assessment of Project related impacts is outlined below:

### 6.1.1 Impact Description

There are several guidelines and textbooks on identification and description of environmental and social impacts. These documents use various types of tools in an attempt to define a comprehensive and consistent method to capture all potential impacts of a proposed project. However, it is now widely recognized by environmental assessment practitioners that impact evaluation is not a purely objective and quantitative exercise. It has a subjective element; often based on judgment and values as much as scientific criteria. Recognizing this, a uniform system of impact description is used to enable the reviewers to understand how impacts have been interpreted. The description of each impact will have the following features:

- a definition of the impact using an impact statement.
- the impact statement clearly identifying the project activity or activities that causes the impact, the pathway or the environmental parameter that is changed by the activity, and the potential receptors of the impact.
- establishing the sensitivity of the receiving environment or receptors.
- based on the stakeholder consultations undertaken, outlining of the level of public concern regarding the specific impact.
- eating of the significance of the impact.
- description of the mitigation and management measures and the effectiveness of proposed measures.
- characterization of the level of uncertainty in the impact assessment.

The significance of an impact is determined based on the product of the consequence of the impact and the probability of its occurrence. The consequence of an impact, in turn, is a function primarily of three impact characteristics: magnitude; spatial scale; and duration.

Magnitude is determined from quantitative or qualitative evaluation of a number of criteria discussed further below. Where relevant, this includes comparison with standards or thresholds. Examples of thresholds include:

- Legal thresholds—established by law or regulation.
- Functional thresholds—if exceeded, the impacts will disrupt the functioning of an ecosystem sufficiently to destroy resources important to the nation or biosphere irreversibly and/or irretrievably.

- Normative thresholds—established by social norms, usually at the local or regional level and often tied to social or economic concerns.
- Preference thresholds—preferences for individuals, groups or organizations only, as distinct from society at large.
- Reputational thresholds—the level of risk a company is willing to take when approaching or exceeding the above thresholds.

Once the impact consequence is described on the basis of the above impact characteristics, the probability of impact occurrence is factored in to derive the overall impact significance. The probability relates to the likelihood of the impact occurring, not the probability that the source of the impact occurs. For example, a continuous Project activity may an unlikely probability of impact, if there are no receptors within the area influenced by that activity.

The resulting significance rating may be further qualified by explaining the effectiveness of proposed management measures designed to mitigate or enhance the impact, and by characterizing the level of confidence or uncertainty in the assessment.

### 6.1.2 Impact Significance Rating

The impact significance rating process serves two purposes: firstly, it helps to highlight the critical impacts requiring consideration in the approval process; secondly, it serves to show the primary impact characteristics, as defined above, used to evaluate impact significance. The impact significance rating system is presented in **Table6-1**.

- Part A: Define impact consequence using the three primary impact characteristics of magnitude, spatial scale and duration.
- Part B: Use the matrix to determine a rating for impact consequence based on the definitions identified in Part A ;and
- Part C: Use the matrix to determine the impact significance rating, which is a function of the impact consequence rating (from Part B) and the probability of occurrence.

Using the matrix, the significance of each described impact is rated.

### 6.1.3 Mitigation and Good Practice Measures

Wherever, the Project is likely to result in unacceptable impact on the environment, mitigation measures are proposed. In addition, in certain cases good practice measures are proposed.

Table 6-1: Method for Rating the Significance of Impacts

| PARTA:DEFININGCONSEQUENCEINTERMSOFMAGNITUDE,DURATIONANDSPATIALSCALE | | | |
|---|---|---|---|
| **Impact characteristics** | **Definition** | **Criteria** | |
| MAGNITUDE | Major | Substantial deterioration or harm to receptors; receiving environment has an inherent value to stakeholders; receptors of impact are of conservation importance; or identified threshold often exceeded | |
| | Moderate | Moderate/measurable deterioration or harm to receptors; receiving environment moderately sensitive; or identified threshold occasionally exceeded | |
| | Minor | Minor deterioration (nuisance or minor deterioration) or harm to receptors; change to receiving environment not measurable; or identified threshold never exceeded | |
| | Minor+ | Minor improvement; change not measurable; or threshold never exceeded | |
| | Moderate+ | Moderate improvement; within or better than the threshold; or no observed reaction | |
| | Major+ | Substantial improvement; within or better than the threshold; or favorablepublicity | |
| DURATION/ FREQUENCY | | **Continuous aspects** | **Intermittent aspects** |
| | Short term/ low frequency | Less than 4years | Occurs less than once a year |
| | Medium | More than 4 years up to end of life of project | Occurs less than 10 times a year but more than once a year |
| | Long term/ highfrequency | Beyond the life of the project | Occurs more than 10 times a year |
| SPATIALSCALE | | **Biophysical** | **Socio-economic** |
| | Small | Within 200 meters (m) of the Project footprint | Within the Study Area |
| | Intermediate | Within 3 kilometer (km) of the Project footprint | 10 km from the Project facilities |
| | Extensive | Beyond 3 km of the Project footprint | Beyond 10 km from the Project facilities |

*PART B: DETERMINING CONSEQUENCERATING*

*Rate consequence based on definition of magnitude, spatial extent and duration*

| **MAGNITUDE** | | | **SPATIALSCALE: Small** | **Inter-mediate** | **Extensive** |
|---|---|---|---|---|---|
| Minor | DURATION/ FREQUENCY | Long /high | Medium | Medium | Medium |
| | | Medium | Low | Low | Medium |
| | | Short /low | Low | Low | Medium |
| Moderate | DURATION/ FREQUENCY | Long /high | Medium | High | High |
| | | Medium | Medium | Medium | High |
| | | Short /low | Low | Medium | Medium |
| Major | DURATION/ FREQUENCY | Long /high | High | High | High |
| | | Medium | Medium | Medium | High |
| | | Short /low | Medium | Medium | High |

PART C: DETERMINING SIGNIFICANCE RATING

| *Rate significance based on consequence and probability* | | | | |
|---|---|---|---|---|
| | | **CONSEQUENCE** | | |
| | | **Low** | **Medium** | **High** |
| **PROBABILITY (of exposure to impacts)** | **Definite** | Low | Medium | High |
| | **Possible** | Low | Medium | High |
| | **Unlikely** | Low | Low | Medium |

+ denotes a positive impact.

## 6.2 Assessment of Impacts on Physical Environment

The physical environmental aspects that may be affected by the project activities include the following:

- Soil contamination and erosion from construction.
- Noise and dust associated with construction.
- Use of water for Project activities during construction.
- Generation of waste by the Project activities during construction and operation.
- Vehicular traffic during construction.

Given the technology of the Project and limited number of staff that will be accommodated at the camp at the Project site during operation, impacts related to soil quality, soil erosion, noise, dust, emissions to air, use of water in the offices and the camps, and traffic during the operation phase are considered to be insignificant. Use of pesticides and weedicides is not anticipated in either construction or operation phase of the project.

The closest residential areas are about 0.5 km east and north of proposed site. The structures are not expected to have a visual impact on the local community. The camp and the offices will consist of low profile structures with heights not exceeding 8 meters. During consultation, the local community did not express any concerns related to visual impacts ofthe Project.

As stated in earlier sections, the transmission line to which the project will be connected to for evacuation of power generated passes through the Project site. The transmission interconnection will be constructed adjacent to the project site.

The impact of operation of the project on quality of the canal water was not considered to be significant. The change in temperature of the water across the dam is not anticipated as this is a run of the river project with no storage capacity.

The potential physical impacts are provided in **Table6-2**.

**Table 6-2: Potential Physical Impacts of the Project**

| **Identified Potential PhysicalImpacts** |
|---|
| **Impact PE1**: Accidental release of solvents, oils and lubricants can potentially result in the contamination of soil and consequent deterioration of groundwater and surface water quality. Soil contamination may also reduce the fertility of soil reducing suitability for agricultural purposes. |
| **Impact PE2**: Land clearing, excavation, diversion channel and other construction activities may loosen the top soilintheProjectarearesultinginlossofsoilandpossibleaccelerationofsoilerosionandlandsliding, |

| |
|---|
| especially in the wet season. |
| **Impact PE3**: Water and soil contamination due to releases from the camp during construction and operation such as solid waste and wastewater, and other solid and liquid waste. |
| **Impact PE4**: Use of local water resources for construction activities may reduce the water availability for the local communities. |
| **Impact PE5**: Excavation, material storage, material transportation, batching, and vehicular movement will create fugitive dust emissions specially while off road driving. |
| **Impact PE6**: Exhaust emissions from construction machinery, project traffic and concrete batching plant may lead to deterioration in the local ambient air quality. |
| **Impact PE7**: Noise from excavation, generators and batching plant may cause nuisance in the vicinity of the Project facilities. |
| **ImpactPE8:** Traffic congestion,reducedroadsafety,andhigherlevelsofnoise,dustandotherpollutants. |

### 6.2.1 Soil Quality

No major contamination was identified at the visual observations in the area. In case of oil spills during construction process, poor soil quality will result in contamination of soil and as well as ground water. Currently, the community is using land around settlements for agricultural purposes. Soil contamination will make this land unsuitable for agriculture and vegetation. Such spills can occur during construction process when tankers will access the area for refueling of excavation and other construction machinery.

Improper handling of oils, lubricants and other such solvents may result during machinery refueling. Storage in areas with no lining and low quality storage containers poses another threat of soil contamination. The impact will be minimized by adopting mitigation measures and extra caution during refueling and machinery maintenance at on site workshops.

| ***Impact PE1: Accidental release of solvents, oils and lubricants can potentially result in the contamination of soil and consequent deterioration of ground water and surface water quality. Soil contamination may also reduce the fertility of soil reducing suitability for agricultural purposes.*** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Applicable Project Phase** | | | | | | | | |
| *Construction* | | | | | | | | |
| **Impact Rating** | | | | | | | | |
| | Magnitude | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |
| Initial Impact | Moderate | Medium | Intermediate | Medium | Possible | Medium | - | High |
| **Mitigation Measures:**<br>• Fuel tanks will be appropriately marked by content and will be stored in dyked areas with an extra 10% of thestorage capacity of the fuel tank. The area will be lined with animpervious base.<br>• Grease traps will be installed on the site, wherever needed, to prevent flow ofoily water.<br>• Spill cleaning kit (shovels, plastic bags and absorbent materials) will be available near fuel and oil storage areas.<br>• Emergencyplanforspillmanagementwillbepreparedandinductedtothestaffforanyincidentofspill. | | | | | | | | |
| | Magnitude | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |
| Residual Impact | Minor | Medium | Intermediate | Low | Unlikely | Low | | High |
| **Good Practice Measures:**<br>The bottom of any soak pit or septic tank shall be at least 10 m above the groundwater table. The distance can be reduced, based on the soil properties, if it is established that distance will not result in contamination of ground water. | | | | | | | | |

### 6.2.2 Soil Erosion

Earlier sections explained that the area is general flat with very limited slopes. Soil erosion during construction shall be confined and limited to temporary diversion channel. It is expected that minor level of risk is associated with the type of construction activities that are likely to take place. The current land formation is fairly stable therefore no major risk is associated with regards to slope stability. The duration of the risk is expected to be short and the spatial scale of risk is small because the excavation effects are not likely to affect areas further than 50 meters from the Project facilities. The probability of this risk is estimated to be unlikely due to minimum excavation activities expected for the diversion channel.

| ***ImpactPE2: Land clearing, excavation, diversion channel and other construction activities may loosen the top soil in the Project area resulting in loss of soil and possible acceleration of soil erosion and land sliding, especially in the wet season.*** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Applicable Project Phase** | | | | | | | | |
| *Construction* | | | | | | | | |
| **Impact Rating** | | | | | | | | |
| | Magnitude | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |
| Initial Impact | Moderate | Short | Small | Low | Definite | Low | - | High |
| **Mitigation Measures:**<br>• Vegetation loss will be limited to demarcated construction area.<br>• Areas such as muck disposal area, batching plant, labor camp and quarry sites after the closure shall be covered with grass and shrubs.<br>• Slope stabilization measures will be adopted such as adequate vertical and horizontal drains, drainage along roadsides, cross drainage and retaining walls.<br>• Slope movements will be monitored around excavation work areas. | | | | | | | | |
| | Magnitu | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |
| Residual Impact | Minor | Short | Small | Low | unlikely | Low | - | High |
| **Good Practice Measures:**<br>Local species shall be selected for plantation to restore the vegetation of the area in consultation with Forest Department after completion of respective activities. | | | | | | | | |

### 6.2.3 Waste Disposal

There is a risk that when untreated wastewater and solid waste is dumped into the canal from the construction camp, the concentration of contaminants may increase above the WHO and NEQS guideline limits. The construction of the Project will require mobilization of labor in the area. This will require development of adequate infrastructure and camp facilities for the construction staff. It is expected that many of the people will be accommodated on the construction site during the construction period. Waste such as sewage, wastewater, construction waste, chemical waste and other solid waste pose a risk in the area if not disposed carefully.

Due to the planned construction activities and the number of labor expected at camp site during construction and operation, a moderate level of impact risk to water and land resources in the area is estimated. It is expected that the impact will last more than a year but not beyohd the life of the Project. It is possible that if the waste generated during construction and operation is disposed of in the canals, the spatial scale of the impact will be intermediate.

| ***Impact PE3: Water and soil contamination due to releases from the camp during construction and operation such as solid waste and wastewater, and other solid and liquid waste.*** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Applicable Project Phase** | | | | | | | | |
| *Construction and Operation* | | | | | | | | |
| **Impact Rating** | | | | | | | | |
| | Magnitude | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Initial Impact | Moderate | Medium | Intermediate | High | Possible | High | - | High |

**Mitigation Measures:**

- Wastewater treatment system will be made to ensure that the effluents during construction and operation comply with NEQS standards and the conditions of lenders.
- Release of camp effluents directly to the water channels or land will be prohibited.
- Waste generated will be collected at designated waste dumping area and cleared from site by contractor during construction and by the company during operation.
- Lining of all effluent channels with cement at all working areas will be done to prevent seepage.

| | Magnitude | Duration | Scale | Consequen | Probability | Significance | +/- | Confidence |
|---|---|---|---|---|---|---|---|---|
| Residual Impact | Minor | Short | Small | Low | Possible | Low | | High |

**Good Practice Measures:**

All waste shall be collected and recycled or sent to an Incinerator.

### 6.2.4 Water Resource Depletion

The quantity of water required for the Project is given in earlier sections. Surface and groundwater are used in the area both for drinking and agricultural purposed.

***Impact PE4: Use of local water resources for construction activities may reduce the water availability for the local communities.***

Applicable Project Phase

*Construction*

Impact Rating

| | Magnitude | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |
|---|---|---|---|---|---|---|---|---|
| Initial Impact | minor | Short | Small | Low | unlikely | Low | - | High |

**Mitigation Measures:**

- Water for different construction activities will be arranged from the canal or from a source approved by the local authorities.
- Water conservation techniques will be developed and implemented by the EPC contractor.
- Access of community to water sources shall be kept clear so that the community's ability to meet its water requirements is not compromised.

| | Magnitude | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |
|---|---|---|---|---|---|---|---|---|
| Residual Impact | Minor | Short | Small | Low | Unlikely | Low | | High |

**Good Practice Measures:**

- Records of water usage will be maintained.

### 6.2.5 Fugitive Dust Emissions

The NEQS guidelines for particulate matter concentration ($PM_{10}$) are 150 ug/m3. The current concentration levels of dust in the region are expected to below the maximum standards set in NEQS.

Most of the top soil cover in the area is fine clay therefore excavation, material movement activities and material storage will result in spread of fine particulate matter in the air. Excessive particulate matter in the air could result in breathing problems for the community in the area. It is estimated that a moderate level of risk is associated with construction activities and material movement that will be taking place around the construction site. The duration of the impact is expected to be short because the particulate matter in air is not normally on long-term basis and is dependent upon

Weather conditions. The weather conditions lead to dispersion and spread of dust particles therefore it is expected that the spatial scale of the impact will be intermediate.

| ***Impact PE5: Excavation, material storage, material transportation, batching, and vehicular movement will create fugitive dust emissions specially while off road driving.*** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Applicable Project Phase** | | | | | | | | |
| *Construction* | | | | | | | | |
| **Impact Rating** | | | | | | | | |
| | Magnitude | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |
| Initial Impact | Moderate | Short | Intermediate | Medium | Definite | Medium | - | High |
| **Mitigation Measures:**<br>• Water will be sprinkled on unpaved project areas in dry weather for fugitivedust control.<br>• Grading operation will be suspended when the wind speed exceeds20km/hr.<br>• All storage piles with fine material shall be adequately wetted or covered with plastic to ensure protection of ambient air from fugitive emission duringwindstorm.<br>• Batchingplantsandassociatedmachinerywillbeinstalledwithsuitabledustcontrolarrangements.<br>• Speed limits and defensive driving policies will bestrictly implemented.<br>• Road damage caused by Project activities will be promptly attended to with proper repairand maintenance. | | | | | | | | |
| | Magnitude | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |
| Residual Impact | Minor | Short | Small | Low | Unlikely | Low | | High |

### 6.2.6 Vehicular and Machinery Exhaust Emissions

According to NEQS standards the maximum allowed limit is 5 ug/m3. Emissions from the exhaust of construction vehicles and concrete batching plant pose a potential risk which will affect ambient air quality. Use of low grade fuels and lubricants also increases the emission levels from the construction machinery. A moderate level of risk is estimated. The duration of the risk is expected to be more than one year and the spatial scale of the impact is estimated to be within 1 km radius of the project facilities due to the dispersion of pollutantsfrom wind.

| ***Impact PE6: Exhaust emissions from construction machinery, project traffic and concrete batching plant may lead to deterioration in the local ambient air quality.*** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Applicable Project Phase** | | | | | | | | |
| *Construction* | | | | | | | | |
| **Impact Rating** | | | | | | | | |
| | Magnitude | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |
| Initial Impact | Moderate | Medium | Intermediate | Medium | Definite | Medium | - | High |
| **Mitigation Measures:**<br>• Equipment and vehicles in good working condition and low emission levels will be used. A visual check will be performed when the equipment is mobilized and periodically later to screen out equipment and vehiclesthat emit unacceptable levelsof smoke.<br>• Batching plant machinery will be maintained and exhaust emissions willbe minimized.<br>• Batching plant will be set up considering the wind direction so that the nearby communities are not affected by the emissions from batching plant.<br>• Regular maintenance and service of vehicles and equipment willbe conducted. | | | | | | | | |
| | Magnitude | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |
| Residual Impact | Minor | Short | Small | Low | Possible | Low | | High |
| **Good Practice Measures:**<br>• Catalyticexhaustconvertorsshallbeinstalledwhereveravailableinvehiclesandequipment.<br>• All stacks shall be at least 8ft high to protect the labor and passersby from direct exposureto emissions. | | | | | | | | |

### 6.2.7 Noise Nuisance

The NEQS limit for daytime noise in residential areas is 55 dBA and for nighttime is 45 dBA. The construction and related activities for the Project, including, excavation, use of generators and operation of the batching plant, are expected to cause an increase in noise in the area. Noise control measures will be adopted by the construction contractor to make sure that noise levels are maintained close to the baseline noise levels. The impact duration from noise is expected to be short. As the topography is undulating with obstructions, it is expected that the noise impact will not be beyond 200 meters of the activities.

| ***Impact PE7: Noise from excavation, generators and batching plant may cause nuisance in the vicinity of the Project facilities.*** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Applicable Project Phase** | | | | | | | | |
| *Construction* | | | | | | | | |
| **Impact Rating** | | | | | | | | |
| | Magnitude | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |
| Initial Impact | Moderate | Short | Small | Low | Definite | Low | - | High |
| **Mitigation Measures:**<br>• Constructionequipmentthatcouldpotentiallygeneratehighnoiselevelswillhaveanadequatemufflersystem.<br>• All stationary noise generating equipment such as power generators will be placed at least 200 m awayfrom the residential area.<br>• In case threshold values are exceeded then adjusting the distances for the equipment on the basisof monitoring report.<br>• A preventive maintenance procedure for Project vehicles and equipment will be set and followed which will help prevent noise levels from deterioratingwith use.<br>• Provision of Personal Protective Equipment(PPEs),i.e.earmuffsandplugs,willreducenoiseimpactonpersonnel.<br>• Restriction on pressure horn.<br>• Sirens will be used to warn the local sprior to blasting and will only be carried out duringdaytime. | | | | | | | | |
| | Magnitude | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |
| Residual Impact | Minor | Short | Small | Low | Possible | Low | | High |

### 6.2.8 Traffic

While the risk of congestion is low in view of the rated capacity of the roads and anticipated Project related traffic, the following are the potential impacts envisaged:

- Traffic congestion at the junction of Project access roadand barrage.
- Blockage of access road to nearby villages due to construction activities and diversion channel.
- Noise due to the movement of heavy traffic especially while loading and offloading near community areas.
- Increased risk of road side accidents as the traffic would have to pass through several small and large settlements where the shops, schools, mosques and other such types of places are located close to the road shoulder.
- Exhaust emissions from vehicles would impact the ambient air quality as well and in case of traffic blockages or congestion it may be a nuisance for the community.

| ***ImpactPE8: Traffic congestion, reduced road safety, and higher levels of noise, dust and other pollutants.*** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Applicable Project Phase** | | | | | | | | |
| *Construction* | | | | | | | | |
| **Impact Rating** | | | | | | | | |
| | Magnitude | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |
| Initial Impact | Moderate | Short | Extensive | Medium | Definite | Medium | - | High |
| **Mitigation Measures:**<br>Contractor's vehicle will follow strict speed limits within city and all applicable local traffic rules and regulations imposed by National Highway Authority (NHA) especially near sensitive receptors (schools, hospital, mosques, etc.).<br>Over speeding will be subject to disciplinary actions.<br>Local traffic will be allowed to overtake and drivers will be encouraged to make way for the local commuters, ambulances, army and special persons conveys in all cases.<br>Alternative roads shall be provided to local communities.<br>Large vehicles that can slow down the local traffic significantly will only travel in the night time or a special permission from the district administration will be obtained.<br>Contractor's vehicles and equipment will be parked at identified designated area.<br>Vehicles and machinery will be appropriately parked/placed to avoid inconvenience to local commuters and pedestrians.<br>Prior communication to residents and safety signs will be installed well before the commencement of any activity at site.<br>The vehicles will be encouraged to leave the local area as quickly as possible after the delivery of material to the Project site.<br>Vehicle maintenance work will only be carried out in designated workshops. | | | | | | | | |
| | Magnitude | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |
| Residual Impact | Minor | Medium | Small | Low | Possible | Low | - | High |
| Good Practice Measures:<br>Diversion plans shall be developed to minimize disturbance to local population during occasional high activity timings / days. These plans shall be communicated to residents well in advance and proper diversion signs will be placed to inform locals.<br>Movement of contractor's vehicles for transportation of material and wastes from and to the site shall be restricted to low traffictimings. | | | | | | | | |

## 6.3 Assessment of Impacts on Ecological Resources

The Project is a run-of-the-river (RoR) type and will require construction of project on the canal. The Area of Habitat Loss is defined as the areas that will be occupied due to construction and operation of Project infrastructure. It has been demarcated taking into consideration the footprint of each Project facility and a 50 m zone around each facility.

The terrestrial ecological resources of the Study Area are described in baseline in description of Environment. The aspects affecting ecology in the study area are discussed in discussion.

Forest trees do not exist on project work site. Some trees on the right bank of Gugera Canal and mesquite bushes on common bank between the two canals are likely to be removed for the preparationofthesitefortheconstructionofpowerhouseandrelatedfacilities.Wildlifehabitat exists on upstream of existing head regulator so there will be no significant impacts on existing wild life however, it may have a minor impact on migratory birds.

The Contractors must be prohibited to use explosives, or electric current, to kill fish in the canal. His workers may also be prohibited to catch fish from the canal by netting or any other method, unless agreed with the Fisheries Department, or their local contractor.

### 6.3.1 Ecological Impacts

In the Project area, forests and terrestrial plants do not contain any forest trees and there are no protected areas or trees in the project vicinity. Small numbers of trees of mesquite are likely to be removed for the preparation of land for construction of small power house colony and related facilities. No fish found in the canal is recorded. Impact on ecology on the project area is very minor or of no significance. Some trees found on the bank of the canal upstream of the powerhouse location will have to be removed for raising the canal banks. Buffalos and goats from village graze or browse these bushes. The growth of bushes and vegetation cover will increase on the canal banks. This will be a positive impact on the flora of the area.

### 6.3.2 Wildlife Habitat

The project area is dominated by cultivated fields. There is a wildlife habitat in the vicinity of the project site, which may not have impacts at large, because a limited labour force would be mobilized due to small size of the project. Effect of noise created by construction machinery would be less than the already existing noise of flowing water over the canal falls and the barrage itself.

### 6.3.3 Fish Habitat

The variety of fish in the Gugera Canal and its Feeder is an extension of their greater habitats in the Chenab River. This is probably also true for turtles, otters, eels and some other aquatic mammals, reptiles and other amphibians, about which no information is available.

Fish in the River enter the canal from its head-regulator and travel as far downstream as possible. However, while coming upstream, they cannot navigate the canal falls as they are too high and without any steps or fish ladders. The falls, therefore define a boundary of their habitat (for upstream movement).

Due to the location of the project on the canal, the navigation of fish from downstream to powerhouse and back may not be possible. As no fish record is available, therefore a complete study should be conducted at detailed engineering design stage and if needed, fish ladder of appropriate size may be provided.

### 6.3.4 Bird Communities

The major impact has already occurred due to construction of the regulators and canals and there will be no significant impact on wild life and bird population.

| *ImpactPE4: Vegetation clearance, temporary diversion of water and influx of people in the area may impact on plants, fishes* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Applicable Project Phase** | | | | | | | | |
| *Construction* | | | | | | | | |
| **Impact Rating** | | | | | | | | |
| | Magnitude | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |
| Initial Impact | minor | Short | Small | Low | unlikely | Low | - | High |
| **Mitigation Measures:**<br>• Vegetation clearance shall be minimized.<br>• Re-vegetation shall be enforced where required.<br>• Noise shall be minimized<br>• No fishing or hunting shall be allowed | | | | | | | | |
| | Magnitude | Duration | Scale | Consequence | Probability | Significance | +/- | Confidence |
| Residual Impact | Minor | Short | Small | Low | Unlikely | Low | - | High |
| **Good Practice Measures:**<br>Ecological observations shall be recorded. | | | | | | | | |

## 6.4 Assessment of Impacts on Socioeconomic Environment

The potential socioeconomic impacts of the Project are identified and assessed in this section. The potential socioeconomic impacts of the Project are categorized into the following three impact groups:

- **Macroeconomic**: Impacts related to the national economy;
- **Local Livelihoods and Wellbeing**: Economic benefits to the community residing in the vicinity of the Project ;and
- **Socio-Cultural**: Social and cultural impacts on the local communities due tothe Project.

The identified socioeconomic impacts are summarized in **Table 6-3**. In this section, the term 'local' is used in the context of the Study Area, whereas 'domestic' pertains to national level.

Table 6-3: Potential Socioeconomic Impacts of the Project

| Impact Group | Identified Potential Socioeconomic Impacts |
|---|---|
| Macroeconomic | **Impact ME1**: Availability of power to meet the growing demand in the economy and reduction in power outages. |
| | **Impact ME2**: Government revenues from the Project in the form of taxes and royalties leading to increased developmental spending. |
| **Local Livelihoods and Wellbeing** | **Impact LW1**: Direct, indirect and induced employment at the domestic and local levels, resulting in increased prosperity and wellbeing due to higher and stable incomes of people. |
| | **Impact LW2**: Increase in the stock of skilled human capital due to transfer of knowledge and skill under the Project resulting in enhanced productivity. |
| Socio-cultural | **Impact SC1**: Increase in population due to in-migration of job seekers (in-migrants) leading to pressure on existing infrastructure and services. |
| | **Impact SC2**: Disputes over distribution of Project benefits within local community and between local community and the in-migrants, resulting in social unrest. |
| | **Impact SC3**: Potential social unrest in the Project area due to conflicting socio-cultural norms amongst the local community and in-migrants. |

### 6.4.1 Macro economic Impacts

**Availability of Power and Reduction in Load Shedding**

The gap between supply and demand has crossed 5,000 MW. The proposed Project will supply the much needed power to reduce the current gap. Improved availability of power will directly and indirectly benefit all sectors of the economy and will enhance economic growth.

| ***ImpactME1:Availability of power to meet the growing demand in the economy and reduction in power outages*** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Applicable Project Phase** | | | | | | | | |
| *Operation* | | | | | | | | |
| **Impact Rating** | | | | | | | | |
| | *Magnitude* | *Duration* | *Scale* | *Consequence* | *Probability* | *Significance* | *+/-* | *Confidence* |
| | Major+ | Long-term | Extensive | High | Definite | High | + | High |

**Increase in Government Revenues**

The Project will invest in equipment, construction materials, infrastructure and human resources. This investment and the return generated from the Project will be circulated within the AJK economy through the following mechanisms:

- Payments made to domestic suppliers against the goods and services procured under the Project.
- Expenditures made by Project staff on purchasing local goods and services, using the income earned under the Project.
- Government spending on developmental activities against the taxes and royalties collected under the Project.

The circulation of income through increased spending on purchase of domestic goods and services, i.e., goods produced within Punjab, will result in economic growth and generation of employment opportunities.

The Project's suppliers of goods and services, and formal businesses that would be created or expand because of induced economic impacts, would pay taxes on their profits and payrolls. The positive fiscal impact (both direct and indirect) would form a sustainable source of income for the government.

The increased government income from the Project would carry a high rate of social return if invested in infrastructure such as roads, educational institutions, hospitals, and public services. The term "rate of social return" reflects the total value of all benefits associated with an investment that accrue to members of society. The increased government revenue could be used to meet this objective by improving infrastructure and services in areas local to the Project. The realization of this impact relies on government decisions regarding the allocation of its revenues.

| *Impact ME2: Government revenues from the Project, in the farm of taxes and royalties, leading to increased developmental spending in the country* |
|---|

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Applicable Project Phase** | | | | | | | | |
| *Operation* | | | | | | | | |
| **Impact Rating** | | | | | | | | |
| | *Magnitude* | *Duration* | *Scale* | *Consequence* | *Probability* | *Significance* | *+/-* | *Confidence* |
| | Moderate+ | Long-term | Extensive | High | Definite | High | + | High |

### 6.4.2 Local Livelihoods and Wellbeing

During the consultation for the Project the community expressed a need for provision of employment to the locals.

**Employment**

The skill set of the local community will be developed through involvement on the project. The incomes of people employed by the Project are likely to lead to improved nutritional status, better housing, access to education and improvement in overall well-being of their families. Poverty cycles in poor families could be broken if children in the families become better educated and have more livelihood options than their parents had. The Project will provide employment to local persons in the construction stage and in the operations stage. The Project will directly and through indirect and induced mechanisms contribute to alleviating poverty and vulnerability in the area, and to prosperity and well-being of the people employed bythe Project.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Impact LW1: Direct, indirect and induced employment at the local levels, resulting in increased prosperity and well-being due to higher and stable incomes of people.*** | | | | | | | | |
| **Applicable Project Phase** | | | | | | | | |
| *Construction and Operation* | | | | | | | | |
| | | | | | | | | |
| **ImpactRating** | | | | | | | | |
| | *Magnitude* | *Duration* | *Scale* | *Consequence* | *Probability* | *Significance* | *+/-* | *Confidence* |
| Initial Impact | Minor+ | Long-term | Extensive | Medium | Possible | Medium | + | High |
| **Enhancement Measures:**<br>• Ensurepreferentialrecruitmentoflocalcandidatesprovidedtheyhavetherequiredskillsandqualifications.<br>• Include an assessment of the contractor's demonstrated commitment to domestic and local procurement and local hiring in the tender evaluation process.<br>• Coordinate recruitment efforts related to non-skilled labour, including for non-skilled labour positions required by contractors.<br>**Good practice measures:**<br>• Determine what is considered to be 'fair and transparent' in recruitment and in distribution of jobsbetween different community groups, in consultation with local communities andtheir leaders.<br>• Set long-term (10 to 15 year) targets for local representation at the managerial level. Implement training and development to meet these targettimeframes. | | | | | | | | |
| Enhanced Impact | Moderate+ | Long-term | Extensive | High | Definite | High | + | Medium |

### 6.4.3 Socio-cultural Impacts

The Project stakeholders expressed concerns on the potential socio-cultural changes that can be induced by the Project including enhancement or possible degradation of social and economic landscape, and hindrance in mobility of the people due to location of project facilities such as construction camp and storage areas.

**Pressure on Social Infrastructure and Services**

There is a potential for an influx of job seekers in the area due to the jobs created by the Project and by service providers to the Project as well as due to the prevalence of unemployment and a lack of job opportunities in the Study Area. Greater influx of in-migrants is expected in the Study Area due to its vicinity to the Project. The influx of job seekers will pose pressure on the availability of infrastructure and services, such as those pertaining to education, health care and medication, water and communication in the Project area.

| ***Impact SC1: Increase in population due to in-migration of job seekers (in-migrants) leading to pressure on existing social infrastructure and services in the Study Area.*** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Applicable Project Phase** | | | | | | | | |
| *Construction* | | | | | | | | |
| | | | | | | | | |
| **Impact Rating** | | | | | | | | |
| | *Magnitude* | *Duration* | *Scale* | *Cansequence* | *Probability* | *Significance* | *+/-* | *Confidence* |
| Initial Impact | Moderate | Medium | Intermediate | Medium | Possible | Medium | - | Medium |
| **Mitigation measures:**<br>• SeeLW1.<br>**Good practice measures:**<br>• Encourage local communities to use the grievance procedure for concerns related to deterioration of local services.<br>• Supportlocalgovernmentintheimplementationofinfrastructureprojects.<br>• SupportNGOsspecializingindevelopmentofinfrastructuretoassistlocalgovernment. | | | | | | | | |
| Residual Impact | Minor | Medium | Intermediate | Low | Possible | Low | - | Medium |

Conflicts Due to Provision of Employment to Outsiders

A potential source of conflict is real or perceived unequal access to Project opportunities. Complaints can be expected from local communities residing in the area if the distribution of jobs among local communities is perceived to be unfair. Objections can also be expected if people from outside the area are seen to usurp opportunities created by the Project, as the area inhabitants may consider themselves as the rightful owners to the Project benefits owing to their vicinity to the Project. This increases the need for open communication between company and the various community heads, as well as within the community heads themselves.

| ***Impact SC2: Disputes over distribution of Project employment within ond between area inhabitants and the in-migrants resulting in social unrest.*** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Applicable Project Phase** | | | | | | | | |
| *Construction* | | | | | | | | |
| | | | | | | | | |
| **Impact Rating** | | | | | | | | |
| | *Magnitude* | *Duration* | *Scale* | *Consequence* | *Probability* | *Significance* | *+/-* | *Confidence* |
| Initial Impact | Moderate | Medium | Inter-mediate | Medium | Possible | Medium | - | High |
| **Good Practice Measures:**<br>o A grievance redressal system shall be made available in access ofthe people. | | | | | | | | |
| Residual Impact | Minor | Short | Intermediate | Low | Possible | Low | - | Medium |

# 7 ENVIRONMENTAL MANAGEMENT PLAN

The environmental management plan (EMP) developed to effectively implement the mitigation measures identified in the IEE are presented in this section. The EMP satisfies the requirements of the Pakistan Environmental Protection Agency Initial Environmental Examination and Environmental Impact Assessment Review Procedures, 2000.

## 7.1 Purpose and Objectives of the EMP

An EMP provides a delivery mechanism to address the adverse environmental impact of a project during its execution, to enhance project benefits, and to introduce standards of good practice to be adopted for all projects works.

The primary objectives of the EMP are to:

- Facilitate the implementation of the mitigation measures identified in the IEE
- Define the responsibilities of the project proponents, contractors, and environmental monitors, and provide a means of effectively communicating environmental issues among them
- Define a monitoring mechanism and identify monitoring parameters in order to:
- Ensure the complete implementation of all mitigation measures
- Ensure the effectiveness of the mitigation measures
- Provide a mechanism for taking timely action in the face of unanticipated environmental situations
- Identify training requirements at various levels.

## 7.2 Components of the EMP

The EMP consists of the following:

- Organization and responsibilities
- Mitigation plan
- Environmental monitoring plan

## 7.3 Organization and Responsibilities

A team of specialists shall be deputed to carry out monitoring during construction and operation stages. The proponent shall be responsible for deputing the team and its administrative control.

The primary responsibilities for the environmental performance of the project proponents, the EPC contractor and sub-contractors will be assumed by their respective highest-ranking officers on the project.

## 7.4 Mitigation Plan

The mitigation plan is a key component of the EMP. It lists all the potential effects of the project and their associated mitigation measures identified in the IEE. Many measures have been recommended during the impact assessment but in this plan a summary of critical measures are listed. However, the implementation of all other measures recommended to be implemented. For each impact, the following information is presented in the plan:

- Environmental Aspect
- Mitigation Measures and good practices

The mitigation plan for the activities proposed project is presented in **Table7-1**.

Table 7-1: Mitigation Plan

| *Aspect* | *Mitigation Measure/ Good Practices* |
|---|---|
| Soil Erosion | Vegetation loss will be limited to demarcated construction area. |
| | Areas such as muck disposal area, batching plant, labor camp and quarry sites after the closure shall be covered with grass and shrubs. |
| | Slope stabilization measures will be adopted such as adequate vertical and horizontal drains, drainage along roadsides, cross drainage and retaining walls. |
| | Slope movements will be monitored around excavation work areas. |
| Waste Disposal | Wastewater treatment system will be made to ensure that the effluents during construction and operation comply with NEQS standards and the conditions of lenders. |
| | Release of camp effluents directly to the water channels or land will be prohibited. |
| | Waste generated will be collected at designated waste dumping area and cleared from site by contractor during construction and by the company during operation. |
| | Lining of all effluent channels with cement at all working areas will be done to prevent seepage. |
| Water Resource Depletion | Water for different construction activities will be arranged from the canal or from a source approved by the local authorities. |
| | Water conservation techniques will be developed and implemented by the EPC contractor. |
| | Access of community to water sources shall be kept clear so that the community's ability to meet its water requirements is not compromised |
| Fugitive Dust Emissions | Water will be sprinkled on unpaved project areas in dry weather for fugitive dust control. |
| | Grading operation will be suspended when the wind speed exceeds 20 km/hr. |
| | All storage piles with fine material shall be adequately wetted or covered with plastic to ensure protection of ambient air from fugitive emission during windstorm. |
| | Batching plants and associated machinery will be installed with suitable dust control arrangements. |
| | Speed limits and defensive driving policies will be strictly implemented. |
| | Road damage caused by Project activities will be promptly attended to with proper repair and maintenance |

| Aspect | Mitigation Measure/ Good Practices |
| --- | --- |
| Vehicular and Machinery Exhaust Emissions | Equipment and vehicles in good working condition and low emission levels will be used. A visual check will be performed when the equipment is mobilized and periodically later to screen out equipment and vehicles that emit unacceptable levels of smoke. |
| | |
| | Batching plant will be set up considering the wind direction so that the nearby communities are not affected by the emissions from batching plant. |
| | Regular maintenance and service of vehicles and equipment will be conducted. |
| Noise Nuisance | Construction equipment that could potentially generate high noise levels will have an adequate muffler system. |
| | All stationary noise generating equipment such as power generators will be placed at least 200 m away from the residential area. |
| | In case threshold values are exceeded then adjusting the distances for the equipment on the basis of monitoring report. |
| | A preventive maintenance procedure for Project vehicles and equipment will be set and followed which will help prevent noise levels from deteriorating with use. |
| | Provision of Personal Protective Equipment (PPEs), i.e. ear muffs and plugs, will reduce noise impact on personnel. |
| | Restriction on pressure horn. |
| | Sirens will be used to warn the locals prior to blasting and will only be carried out during day time. |
| Traffic | Contractor's vehicle will follow strict speed limits within city and all applicable local traffic rules and regulations imposed by National Highway Authority (NHA) especially near sensitive receptors (schools, hospital, mosques, etc.). |
| | Over speeding will be subject to disciplinary actions. |
| | Local traffic will be allowed to overtake and drivers will be encouraged to make way for the local commuters, ambulances, army and special persons conveys in all cases. |
| | Alternative roads shall be provided to local communities. |
| | Large vehicles that can slow down the local traffic significantly will only travel in the night time or a special permission from the district administration will be obtained. |
| | Contractor's vehicles and equipment will be parked at identified designated area. |
| | Vehicles and machinery will be appropriately parked/placed to avoid inconvenience to local commuters and pedestrians. |
| | Prior communication to residents and safety signs will be installed well before the commencement of any activity at site. |
| | The vehicles will be encouraged to leave the local area as quickly as possible after the delivery of material to the Project site. |
| | Vehicle maintenance work will only be carried out in designated workshops. |
| | Contractor's vehicle will follow strict speed limits within city and all applicable local traffic rules and regulations imposed by National Highway Authority (NHA) especially near sensitive receptors (schools, hospital, mosques, etc.). |

| Aspect | Mitigation Measure/ Good Practices |
|---|---|
| | Over speeding will be subject to disciplinary actions. |
| Bird Communities | Vegetation clearance shall be minimized. |
| | Re-vegetation shall be enforced where required. |
| | Noise shall be minimized |
| | No fishing or hunting shall be allowed |
| Local Livelihoods and Wellbeing | Ensure preferential recruitment of local candidates provided they have the required skills and qualifications. |
| | Include an assessment of the contractor's demonstrated commitment to domestic and local procurement and local hiring in the tender evaluation process. |
| | Coordinate recruitment efforts related to non-skilled labour, including for non-skilled labour positions required by contractors. |

### 7.4.1 Land Owner And Compensation

As per approved Feasibility Report by PPDB, Govt. of Punjab, the Gugera HPP shall be constructed on Gugera Canal By-pass to its right side on the land presently owned by the farmers of Kotwar village. As per approved plan, 15 hectares of land will be required for construction of the Project comprising Powerhouse, Headrace, Tailrace and allied facilities.

Regarding ownership of the land, project site has been visited many times and interview of the farmers has been conducted. For verification of the ownership of the cultivated land, Canal Patwari of the site was also consulted. The land is owned by many farmers, size of the individual piece of land owned by the individual farmer ranges between 1 Kanal to 10 Acres. In this regard the list of the owners of the land is attached herewith.

Compensation to the farmers against acquisition of land will be made in two phases. During construction phase, temporary compensation will be made for the land required for construction of the Project, temporary camps of labor/staff, storage of E&M equipment and construction machinery at site. Construction period from mobilization at site till commissioning of the Plant is expected between 3 to 4 years. During this construction phase, the farmers will be compensated through payments on annual lease basis at more than prevailing rates around the project area.

During construction of the Plant, the land essentially required for the project over its life cycle, shall be evaluated and compensation to the farmers shall be made against the land occupied on permanent basis ($2^{nd}$ phase of land compensation). The rates of the cultivated land shall either be determined by the district Govt. of Nankana sahib or direct negotiation between the concerned farmers and the project company Owner. Regarding land compensation rates, we don't foresee any sort of enforcement or harassment of any kind to the farmers. We pledge to make the payments to the farmers/land owners at the fairly reasonable rates acceptable to them.

It is pointed out that environmental impact regarding use of cultivated land by the Project, shall be kept at minimum by reviewing the overall Layout of the Project during detailed design and selection stage of the EPC Contractor. It would be more prudent if Gugera HPP is constructed right on the Gugera Canal either at RD 214 + 500 or RD 220+750, thereby virtually requiring no cultivated land being owned & used by the private farmers, however, it will be only Irrigation Canal and its ROW on both side of the banks.

## VERIFIED LAND-OWNERSHIP RECORD

| Sr. No. | Owner Name | Land Size |
|---|---|---|
| 1. | Mohammad Nawaz Bhatti S/o Abdul Haq Bhatti | 3 Acres |
| 2. | Tariq Mehmood S/o Mohammad Ishaaq | 2 Acres+4 Kanal |
| 3. | Ilyaas S/o Nazir Arain | 3 Acres |
| 4. | Mushtaq S/o Nazir Arain | 2 Acres |
| 5. | Sarwa S/o Mohammad Shafi Rajpoot | 1 Acre+4Kanal |
| 6. | Fayyaz S/o Sadiq Rajpoot | 2 Acres+4Kanal |
| 7. | Arshad S/o Sadiq Rajpoot | 2 Acres+4Kanal |
| 8. | Abdul Haq Bhatti S/o Anwar Rajpoot | 1 Acre |
| 9. | Mohammad Anwar Bhatti S/o Lal Din Rajpoot | 1 Acres+4Kanal |
| 10. | Ishaq S/o Lal Din Rajpoot | 2 Acres |
| 11. | Imran Bhatti S/o Sarwar Bhatti | 1 Acre |
| 12. | Bashir S/o Noor Mohammd Arain | 2 Kanals |
| 13. | Lateef S/o Noor Mohammad Arain | 2 Kanal |
| 14. | Mohammad Mukhtar | 1 Kanal |
| 15. | Fayyaz S/o Shoukat Ali Rajpoot | 10 Acres |
| 16. | Mohammad Farooq S/o Riaz | 5 Acres |
| 17. | Sardar S/o Chiragh Din Arain | 7 Acres |
| 18. | Shahjahaan S/o Jhangir Khan Rajpoot | 4 kanals<br>45Acres+4Kanal |

## 7.5 Environmental Monitoring

Proponent and EPC contractor shall be responsible to conduct the compliance monitoring of the project. The objective of environmental monitoring during the project to monitor the compliance with the requirements of the EMP will be checked by monitoring the activities of the project contractors on regular basis.

The compliance monitoring of the project is principally a tool to ensure that the environmental control measures required in the IEE are strictly adhered to during the project activity. The objectives of the IEE compliance monitoring will be to:

- Systematically observe the activities undertaken by the EPC contractors or any other person associated with the project
- Verify that the activities are undertaken in compliance with the IEE and other conditions identified
- Document and communicate the observations to the concerned person(s) in proponent so that any corrective measures, if required, can be taken in a timely fashion
- Maintain a record of all incidents of environmental significance and related actions and corrective measures

## 7.6 Communication and Documentation

An effective mechanism for storing and communicating environmental information during the project is an essential requirement of an EMP. The key features of such a mechanism are:

- Precise recording and maintenance of all information generated during the monitoring in a predetermined format
- Communicating the information to a central location
- Processing the information to produce periodic reports
- Providing information and answering queries on monitoring originating from various stakeholders

## 7.7 Environmental Training

Environmental training will help to ensure that the requirements of the IEE and EMP are clearly understood and followed by all project personnel throughout the project period. The primary responsibility for providing training to all project personnel will be that of the EPC contractor.

## 7.8 Restoration and Rehabilitation

All temporary facilities including camps and other sites shall be restored to bring closer to the original position.

## 7.9 Emergency Response and Contingency Plan

### 7.9.1 Objective

Emergency Plan has been prepared in accordance with the best industry practices, where a plan will be in place to effectively respond to emergencies associated with project hazards and that local communities are involved in the planning process.

Emergency Plan of Gugera HPP is designed to maximize human safety and preserve property, minimize danger, keep continuity of Activities of the Project and assure responsive communication to all appropriate parties. This Program is also intended to ensure compliance with applicable local, Provincial and federal regulations and cooperation with relevant public bodies charged with disaster control. Within this program are safety advisories for the formal Emergency Operations Plan, the emergency communication system, the locations of all emergency telephones and Automated External Defibrillators (AEDs) and information for the Areas. The Emergency Operations Plan may be activated in the event of local, regional or national emergencies. It applies to all units of the Project and provides the basic framework for critical incident preparedness.

Summary of the Plan and Details of the Emergency Action Plan are given as under:

### 7.9.2 Scope

The purpose of this very Emergency Response and Contingency Plan is to establish an Organizational Structure and Procedures for the Response to Major Emergencies. It assigns roles and responsibilities for implementation of the Plan during an Emergency-Incident. The Plan has been prepared to address all types of emergencies in a coordinated and systematic manner. The Gugera HPP Management is committed for the Safety & Security of its Workforce/Manpower, Plant Equipment/Construction Machinery and Surrounding Area.

### 7.9.3 Authority

Emergency events do not always require the same level of response and are dictated by the severity of the event and its effect on the health and safety of Human Resources and Project Property. Events will be evaluated by an Assessment-Team/Committee in consultation with one or more members of the Team, as appropriate. Only the Project Manager/CEO or his designated Representative has the authority to declare an Emergency and activate the Emergency Response Plan. Depending upon the nature of the Emergency, the Director of environmental health and safety or his designee, will act as the on-scene Safety and Security Officer until, if necessary, relieved by the Nankana City Response officials, or others if the emergency requires a higher level of response (e.g., Province or federal).

### 7.9.4 Emergency Operation Center

An Emergency Operation Center shell be established for coordination of all Emergency Responses.

### 7.9.5 Roles, Responsibilities and Resources

Responsibilities in an Emergency are delegated among response teams and resource teams as indicated below. Response teams will activate resource teams in their respective areas of responsibility.

### 7.9.6 Response Teams

Assessment Team: These individuals are typically the first to respond to an incident. They will assess the severity and level of the Emergency and communicate immediately to the PM Office and others as appropriate.

Environmental Health & Safety: EH&S coordinates response for emergencies involving hazardous materials, such as fire or explosion, chemical, biological, or radiological incidents. They serve as communication interface with city hazardous materials teams and the fire department on such incidents. EH&S is on call 24 hrs. a day, 7 days a week, 365 days a year.

PM's Emergency Response Team: The PM's Emergency Response Team is comprised of members of Owner's administration and EPC representatives. This team is the decision-making and policy-setting body during a crisis. Decisions regarding continuity or stopping of the construction activities are the purview of this group.

Public Information and Communications: The Principal media contact Spokesperson is the public information officer. This team's responsibility is 1) to maintain public relations and crisis communications counsel and principles to institutional decision making; and 2) to share information and communicate effectively with Project Staff, the media and external bodies in order to help ensure the health and safety of the workforce at site and other related publics.

Security: Gugera HPP Security manages general site security and controls site access. The Security Officer provides a liaison with local law enforcement and fire departments. They are on call 24 hrs a day, 7 days a week, 365 days a year.

### 7.9.7 Resource Teams

Computing Services and Telecommunications: Computing Services is responsible for telephone and voicemail service, email and network services, and cable TV during an emergency.

Dining Services: Dining Services is responsible for providing food required by the members of the Project.

Facilities Management Services: FMS personnel are expected to respond by providing safety of the Project occupants and for protecting the structural integrity of the facilities. Functionally, this means protecting building occupants from hazardous conditions by identifying and managing appropriately the causes of those hazards, such as operating or shutting down building systems.

Housing Services: Housing Services is responsible for assuring the continuing shelter needs.

Medical Services: Workforce Health Services provides medical support and acts as a liaison with the medical community.

### 7.9.8 Field First Aid Locations

Locations will be designated at site for Field First Aid Stations during Project Construction and O&M. The location(s) for any specific incident will be determined by the location and severity of the incident.

### 7.9.9 Recovery Operations

When emergency conditions have been stabilized and control has been returned to the Project Management by external emergency responders, recovery operations will be initiated. Appropriate announcements of the resumption of Project Activities will be issued by the public information officer pursuant to the communications protocol.

### 7.9.10 Psychological Counseling

Recognizing that traumatic events often produce short and long term psychological concerns, counseling will be available to all workers and Management staff who desire such intervention.

Report No. PPI-143.4-Final 16

# INTERCONNECTION STUDY

***For***

# 3.6 MW Gugera Hydropower Plant District Nankana Sahib, Punjab

APPROVED FEASIBILITY STUDY
Granted by
held on 03-12-2015

MANAGING D
PUNJAB POWER DEVELOPMENT BOARD

*Final Report*
*(May 2016)*

Power Planners International Ltd.

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LAHORE ELECTRIC SUPPLY COMPANY LIMITED
CUSTOMER SERVICES DIRECTOR
22-A, Queens Road, Lahore
Ph: 9204820-30, Fax: 9204831

Subject: **GRID INTERCONNECTION STUDY OF 3.6 MW HYDRO POWR PROJECT-ON UPPER GUGERA CANAL AT RD-214-500 DISTRICT NANKANA.**

Ref:

1. Chief Engineer (Development) PMU LESCO letter No.7831-35/CE(DEV)P&S/PMU/559 dated 01-05-2016.(Copy enclosed)
2. Your office letter dated 14-05-2016.

The Final Interconnectivity Report of the subject cited plant submitted by you after removal of discrepancies has been vetted by Chief Engineer (Development) PMU LESCO as mentioned vide letter referred above at Sr. No. 01.

It has further been clarified by Chief Engineer (Development) PMU that the report has been vetted only for interconnectivity aspect of the plant and it should not be considered as a go ahead signal to execute the project. Any commitment regarding project execution or consent of power purchase, tariff etc. has to be discussed with the concerned quarters. Moreover in case of any change in the parameters assumed in the interconnection study, the same should be revised accordingly.

DA: As above.

Adnan Riaz Mir

Engr. Adnan Riaz Mir
Addl. Chief Engineer (Marketing & Tariff)
LESCO

To

**M/s Gugera Hydro Power Co.**
**64-Ahmad Block, New Garden Town,**
**Lahore**

Copy:

1. Technical Director LESCO.
2. Customer Services Director LESCO.
3. Chief Engineer (Development) PMU, 132-KV Qartaba Grid Station, Lahore w.r.t his letter dated 01-06-2016.
4. Master File

Dispatcher LESCO HQ
22/A, Queens Road,
Lahore.

No. 25649-52/MMT-240 Dated: 07 JUN 2016 / /2016

LAHORE ELECTRIC SUPPLY COMPANY
Office of Chief Engineer (Development) LESCO
Qartaba Grid Station Bahawalpur Road Lahore.
Ph:042-99214410 FAX 042-99214412

No. 2831-35 /CE(DEV)/P&S/PMU/556 Dated: 01/05/2016

To

**Customer Services Director,**
**LESCO.**

Sub: **Grid Interconnection Study of 3.6 MW Hydro Power Project on Upper Gugera Canal at Rd-214-500 District Nankana**

Ref: 1- M/s Gugera Hydro Power Co. office letter dated: 14-05-2016 addressed to your office with a copy to this office.
2-This office letter no. 1291-95/CE(DEV)/P&S/PMU/556 dated: 11-02-2016.

Please refer to the letter referred at sr. no. 1 above vide which the final grid interconnection study report of the subject cited power plant was submitted to this office after addressing the discrepancies pointed out by this office vide letter at sr. no. 2.

This office has reviewed final grid interconnection study report. In this regard it has been found that the consultant has incorporated the comments offered vide this office letter at sr. no. 2, therefore the final report is being vetted.

However, it is clarified that the report has been vetted only for interconnectivity aspect of the subject cited power plant. It should not be considered as a go-ahead signal to execute the project. Any commitment regarding project execution or consent of power purchase, tariff etc. has to be discussed with the concerned quarters.

It is further intimated that if there will be any change in the parameters assumed in the interconnection study then the study should be revised accordingly.

CSD
Mgr (MKT)
3/6
3/6/16

**(Engr. Asgher Reza Ch)**
**Chief Engineer (Dev.)**
**PMU LESCO**
01-6-16

**Info:**

1. Technical Director, LESCO.
2. Chief Engineer (P&D) LESCO.
3. MD (PPDB), Energy Department, Irrigation Secretariat, old Anarkali, Lahore.
4. M/s Gugera Hydro Power Co. 64-Ahmad Block, New Garden Town.
5. Master File.

Add. Mgr (Tariff)
For n.a
6/6/2016

## Executive Summary

- ❖ The study objective, approach and methodology have been described and the plant's data received from the client is validated.
- ❖ The LESCO system data as available with PPI for other studies have been used.
- ❖ The interconnection study of Gugera HPP to evacuate its maximum power of 3.6 MW is envisaged and studied in detail for M/s Gugera Hydro power Co.
- ❖ Due to the location of Gugera HPP, two options have been considered for this study.
- ❖ In Option-I the following scheme of interconnection of Hydro Power Plant with Nankana Sahib to evacuate its maximum power of 3.6 MW is envisaged and studied in detail:
    - Two direct 11 kV transmission lines of 11 km length using Osprey conductor to be laid from 11 kV Bus Bar of Gugera HPP till Nankana Sahib 132/11 kV substation. One circuit to be connected to Nankana Sahib 132/11 kV T-1 and the other to be connected to Nankana Sahib 132/11 kV T-2.

The proposed scheme will require the following equipment at 11 kV switchgear of Gugera HPP:

- Three breaker panels of 11 kV for connecting three Generating Units
- Two 11 kV breaker/line bays need to be added with 11 kV Bus Bar of Gugera HPP.

- ❖ In Option-II the following scheme of interconnection of Hydro Power Plant with Walgan Sohail to evacuate its maximum power of 3.6 MW is envisaged and studied in detail:
    - Two direct 11 kV transmission lines of 07 km length using Osprey conductor to be laid from 11 kV Bus Bar of Gugera HPP till Walgan Sohail 132/11 kV substation. One circuit to be connected to Walgan Sohail 132/11 kV T-1 and the other to be connected to Walgan Sohail 132/11 kV T-2.

The proposed scheme will require the following equipment at 11 kV switchgear of Gugera HPP:

- Three breaker panels of 11 kV for connecting three Generating Units

- Two 11 kV breaker/line bays need to be added with 11 kV Bus Bar of Gugera HPP.

- Detailed load flow studies have been carried out for the peak load conditions of September 2018 for both the schemes considered under normal and N-1 contingency conditions to meet the reliability criteria for the contingencies performed. After the Load Flow Analysis the second Scheme of Interconnection has been found to be more feasible for the evacuation of power from Gugera HPP and is proposed to be adopted, therefore the second option of connectivity has been studied in detail.

  Load flow studies have also been carried out for Winter Scenario and Future Year Scenario of 2020-21.
- Steady state analysis by load flow reveals that proposed schemes are adequate to evacuate the maximum power of 3.6 MW of the plant under normal and contingency conditions for the contingencies performed but the second option is more feasible and is therefore recommended to be adopted and studied in detail. In case of the line outage from Shah Kot to Halmor the single circuit between Shah Kot to Walgan Sohail becomes overloaded. This is an inherent problem of the LESCO network and with the plant interconnected in the system the overloading on this line is slightly reduced for option-I and eliminated for option-II.
- The power and energy loss calculations have also been done for the plant.
- The short circuit analysis has been carried out to calculate maximum fault levels at Gugera HPP at 11 kV and the substations of 132 kV and 11 kV in its vicinity. We find that the fault currents for the proposed scheme are much less than the rated short circuit capacities of switchgear installed at these substations. There are no violations of the equipment ratings due to contribution of fault current from Gugera HPP.
- The maximum short circuit levels of Gugera HPP 11 kV have been evaluated for the peak case of 2018 to evaluate the maximum fault currents on Gugera HPP and the 132 kV Substations in its vicinity. The maximum short circuit level of the Gugera HPP 11 kV is 6.27 and 0.00002 kA and 6.23 kA and 0.00002for 3-phase and 1-phase faults respectively in the year 2018 and 2021 respectively. Therefore

industry standard switchgear of the short circuit rating of 25 kA would be fine to be installed at 11 kV switchroom of Gugera HPP as per LESCO/NTDC requirement taking care of any future generation additions and system reinforcements in its electrical vicinity.

- The dynamic stability analysis of proposed scheme of interconnection has been carried out. The stability check for the worst case of three phase fault right on the 11 kV bus bar of Gugera HPP substation followed by the final trip of 11 kV circuits emanating from this substation, has been performed for fault clearing within 9 cycles (180 ms). The system is found strong enough to stay stable and recovered with fast damping. The stability of system for far end faults of 3-phase has also been checked. The proposed scheme successfully passed the dynamic stability checks for near and far-end faults.
- The proposed scheme of interconnection has no technical constraints or problems, it meets all the criteria of reliability and stability under steady state load flow, short circuit currents and dynamic/transient conditions; and is therefore recommended to be adopted.

# Report Contents

**Appendices**

# 1. Introduction

## 1.1. BACKGROUND

The proposed project is Gugera Hydropower Plant to be located at RD. 214+500 of Upper Gugera Branch Canal, District Nankana, Punjab situated in the concession area of Lahore Electricity Supply Company (LESCO). The location of Gugera-HPP is shown in Appendix-A. The net output planned to be generated from the site is about 3.6 MW of electrical power. The project is expected to start commercial operation by the year 2018. The electricity generated from this project would be supplied to the grid system of LESCO through the 132/11 kV Walgan Sohail grid available in the vicinity of this project.

## 1.2. OBJECTIVES

The overall objective of the Study is to develop an interconnection scheme between Gugera Hydropower Project and LESCO network, for stable and reliable evacuation of 3.6 MW of electrical power generated from this plant, fulfilling N-1 reliability criteria. The specific objectives are:

1. To develop schemes of interconnections at 11 kV of which right of way (ROW) and space at the terminal substations would be available.
2. To determine the performance of interconnection scheme during steady state conditions of system, normal and N-1 contingency, through load-flow analysis.
3. To check if the contribution of fault current from this new plant increases the fault levels at the adjoining substations at 11 kV and 132 kV voltage levels to be within the rating of equipment of these substations, and also determine the short circuit ratings of the proposed equipment of the substation at Gugera HPP.
4. To check if the interconnection withstands dynamic stability criteria of post fault recovery with good damping after 3-phase faults on the system.

### 1.3. PLANNING CRITERIA

The planning criteria required to be fulfilled by the proposed interconnection is as follows:

## Steady State:

| | |
|---|---|
| Voltage | ± 5 %, Normal Operating Condition |
| | ± 10 %, Contingency Conditions |
| Frequency | 50 Hz, Continuous, ± 1% variation steady state |
| | 49.5 - 50.5 Hz, Short Time |
| Power Factor | 0.85 Lagging; 0.9 Leading |

## Dynamic/Transient:

The system should revert to normal condition after dying out of transients without losing synchronism with good damping.

- For 132 kV and above, the total normal fault clearing time from the instant of initiation of fault current to the complete interruption of current, including the relay time and breaker interruption time to isolate the faulted element, is equal to 100 ms (5 cycles).

- For 11 kV the total normal fault clearing time from the instant of initiation of fault current to the complete interruption of current, including the relay time and breaker interruption time to isolate the faulted element, is equal to 180 ms (9 cycles).

## 2. Assumptions of Data

The detailed electrical parameters of the generators at Gugera would be designed at the EPC stage. However for the purposes of this study, following assumptions have been made:

### 2.1. GUGERA HPP DATA

Generator data:

| | |
|---|---|
| Number of Generating Units | = 3 |
| Normal rating of generating units | = 1.2 MW |
| Lump sum maximum generating capacity | = 3 x 1.2 =3.6 MW |
| Power factor | = 0.85 lagging, 0.9 leading |
| Lump sum MVA capacity | = 3x 1.41 MVA (at PF 0.85) = 4.23 MVA |
| Generating Voltage | = 0.69 kV |
| Sub transient reactance, $X_d''$ | = 0.16 PU |

**Generator Step-up Transformer Data:**

| | |
|---|---|
| Voltage Ratio | = 0.69/11kV |
| GSU Percent Impedance | =10 % at rated MVA |

For dynamic stability analysis, we have assumed the following parameters:

| | |
|---|---|
| Inertia Constant H (turbine + generator) | = 2.5 (MWs/MVA) |

A salient pole machine has been assumed

| | |
|---|---|
| Synchronous reactance, Xd | = 1.095 PU |
| Transient reactance, Xd' | = 0.30 PU |
| Sub transient reactance, Xd" | = 0.16 PU |
| Open Circuit Transient Time Costant T' d0 | = 6.0 Sec |
| Open Circuit Sub-Transient Time Costant T'' d0 | = 0.0680 Sec |

## 2.2. NETWORK DATA

The 11 kV and 132 kV networks available for interconnection to Gugera Hydro Power Plant are as shown in Appendix-A.

The NTDC/LESCO system data of National Grid have been assumed in the study as already available with PPI.

# 3. Study Approach and Methodology

## 3.1. UNDERSTANDING OF THE PROBLEM

Gugera 3.6 MW HPP is going to be a low head hydropower project embedded in the distribution network of LESCO.

Given the nearest interconnection facility is the 132/11 kV substation for Gugera HPP two options have been considered for the interconnection. In Option-I, two direct 11 kV transmission lines of 11 km length using Osprey conductor to be constructed from 11 kV Bus Bar of Gugera HPP till Nankana Sahib 132/11 kV substation. One circuit is to be connected to Nankana Sahib 132/11 kV T-1 and the other is to be connected to Nankana Sahib 132/11 kV T-2.

In Option-II, the connection is made at Walgan Sohail to evacuate its maximum power of 3.6 MW. Two direct 11 kV transmission lines of 07 km length using Osprey conductor to be constructed from 11 kV Bus Bar of Gugera HPP till Walgan Sohail 132/11 kV substation. One circuit to be connected to Walgan Sohail 132/11 kV T-1 and the other to be connected to Walgan Sohail 132/11 kV T-2.

## 3.2. APPROACH TO THE PROBLEM

The consultant has applied the following approaches to the problem:

- A base case network model has been prepared for the year 2018, which is the commissioning year of Gugera HPP, comprising all 500kV, 220kV and 132 kV system, envisaging the load forecast, the generation additions and transmission expansions for that year particularly in LESCO.
- Month of September 2018 has been selected for the study of the base case because it is high water season and we can judge the maximum impact of the plant on the network in these conditions.
- Interconnection schemes without any physical constraints, like right of way or availability of space in the terminal substations, have been identified.
- Performed technical system studies for peak load conditions to confirm technical feasibility of the interconnection schemes. It is found that the second option is more viable for the interconnection therefore the scheme has been subjected to standard analysis like load flow, short circuit, and transient

stability study to check the strength of the machines and the interconnection scheme under disturbed conditions.

- Determine the relevant equipment for the proposed technically feasible scheme.
- Recommend the technically most feasible scheme of interconnection from the options considered.

# 4. Development of Schemes of Interconnection

## 4.1 THE EXISTING AND ONGOING NETWORK

The nearest existing LESCO interconnection facilities at the time of commissioning of Gugera Hydro Power Project would be as follows:

- Nankana Sahib 132/11 kV Substation
- Walgan Sohail 132/11 kV Substation

The existing 132 kV network available around the 132/11 kV grid station is shown in Sketch-I & II in Appendix-A. Due to the location of Gugera HPP, two options have been considered for this study.

## 4.2 THE SCHEMES OF INTERCONNECTION OF GUGERA HPP

### 4.2.1 Interconnection Scheme – Option-I

In Option-I, two direct 11 kV transmission lines of 11 km length using Osprey conductor to be constructed from 11 kV Bus Bar of Gugera HPP till Nankana Sahib 132/11 kV substation. One circuit to be connected to Nankana Sahib 132/11 kV T-1 and the other to be connected to Nankana Sahib 132/11 kV T-2.

The proposed scheme will require the following equipment at 11 kV switchgear of Gugera HPP:

- Three breaker panels of 11 kV for connecting three Generating Units
- Two 11 kV breaker/line bays need to be added with 11 kV Bus Bar of Gugera HPP.

### 4.2.2 Interconnection Scheme – Option-II

In Option-II the following scheme of interconnection of Hydro Power Plant with Walgan Sohail to evacuate its maximum power of 3.6 MW is envisaged and studied in detail:

Two direct 11 kV transmission lines of 07 km length using Osprey conductor to be laid from 11 kV Bus Bar of Gugera HPP till Walgan Sohail 132/11 kV substation. One circuit to be connected to Walgan Sohail 132/11 kV T-1 and the other to be connected to Walgan Sohail 132/11 kV T-2.

The proposed scheme will require the following equipment at 11 kV switchgear of Gugera HPP:

- Three breaker panels of 11 kV for connecting three Generating Units
- Two 11 kV breaker/line bays need to be added with 11 kV Bus Bar of Gugera HPP.

# 5 Detailed Load Flow Studies

A base case has been developed for the peak load of September 2018, which is the high water season and will allow us to judge the maximum impact of Gugera on the LESCO network, using the network data supplied/authorized by LESCO/NTDC.

## 5.1 BASE CASE 2018, WITHOUT GUGERA HPP

The results of load flow for this base case are plotted in Exhibit 0.0 of Appendix-B. The system plotted in this Exhibit comprises 132 kV network feeding Nankana Sahib 132/11 kV Substation and Walgan Sohail 132/11 kV Substation and its surrounding substations.

The load flow results for the normal case show that the power flows on all the circuits are within their normal rating. We find that there are no capacity constraints in terms of power flow or voltage ratings in the 11 kV or 132 kV network available in the vicinity of Gugera HPP for its connectivity under normal conditions.

The following N-1 contingency tests were run:

| | |
|---|---|
| Exhibit 0.1 | Walgan Sohail to Nankana Sahib 132kV Single Circuit Out |
| Exhibit 0.2 | Walgan Sohail to Mohlan 132kV Single Circuit Out |
| Exhibit 0.3 | Nankana Sahib to Warburton 132kV Single Circuit Out |
| Exhibit 0.4 | Sheikhupura to Warburton 132kV Single Circuit Out |
| Exhibit 0.5 | Shahkot to Walgan Sohail 132kV Single Circuit Out |
| Exhibit 0.6 | Shahkot to Halmor-P 132kV Single Circuit Out |

In case of the line outage from Shah Kot to Halmor, the single circuit between Shah Kot and Walgan Sohail becomes overloaded. This is an inherent problem of the LESCO network.

Apart from the overloading on this line, the load flow results show that there are no capacity constraints in the area surrounding and the voltage rating of the bus bars remain within their limits.

## 5.2 PEAK LOAD CASE 2018: WITH GUGERA HYDRO POWER PLANT

The base cases have been developed for the peak conditions of September 2018 using the network data of NTDC and LESCO available with PPI. The peak loads of the year

2018 for LESCO have been modeled as per the latest PMS Demand forecast as provided by NTDC.

Given the location of Gugera HPP two options have been considered for this study.

### 5.2.1 With Gugera HPP – Option-I

In Option-I, two direct 11 kV transmission lines of 11 km length using Osprey conductor to be constructed from 11 kV Bus Bar of Gugera HPP till Nankana Sahib 132/11 kV substation. One circuit to be connected to Nankana Sahib 132/11 kV T-1 and the other to be connected to Nankana Sahib 132/11 kV T-2.

Detailed load flow studies have been carried out for September 2018. The results of load flows with Gugera HPP – Option-I under normal conditions have been plotted in Exhibit 1.0 in Appendix-B.

The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 5 % of the nominal. We find no capacity constraints on 132 kV circuits under normal conditions i.e. without any outages of circuits.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – B as follows;

| | |
|---|---|
| Exhibit 1.1 | Gugera HPP to Nankana Sahib T-2 11kV Single Circuit Out |
| Exhibit 1.2 | Walgan Sohail to Nankana Sahib 132kV Single Circuit Out |
| Exhibit 1.3 | Walgan Sohail to Mohlan 132kV Single Circuit Out |
| Exhibit 1.4 | Nankana Sahib to Warburton 132kV Single Circuit Out |
| Exhibit 1.5 | Sheikhupura to Warburton 132kV Single Circuit Out |
| Exhibit 1.6 | Shahkot to Walgan Sohail 132kV Single Circuit Out |
| Exhibit 1.7 | Shahkot to Halmor-P 132kV Single Circuit Out |

In case of the line outage from Shah Kot to Halmor the single circuit between Shah Kot to Walgan Sohail becomes overloaded. This is an inherent problem of the LESCO network and with the plant interconnected in the system the overloading on this line is slightly reduced.

Apart from the overloading on this line, we find that power flows on the circuits are well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 10 % of the nominal for contingency conditions' criteria.

### 5.2.2 With Gugera HPP – Option-II

In Option-II, the scheme of interconnection of Hydro Power Plant with Walgan Sohail to evacuate its maximum power of 3.6 is to construct two direct 11 kV circuits of 07 km length using Osprey conductor from 11 kV Bus Bar of Gugera HPP till Walgan Sohail 132/11 kV substation. One circuit to be connected to Walgan Sohail 132/11 kV T-1 and the other to be connected to Walgan Sohail 132/11 kV T-2.

Detailed load flow studies have been carried out for September 2018. The results of load flows with Gugera HPP – Option-II under normal conditions have been plotted in Exhibit 2.0 in Appendix-B.

The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 5 % of the nominal. We find no capacity constraints on 132 kV circuits under normal conditions i.e. without any outages of circuits.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – B as follows;

| | |
|---|---|
| Exhibit 2.1 | Gugera HPP to Walgan Sohail T-2 11kV Single Circuit Out |
| Exhibit 2.2 | Walgan Sohail to Nankana Sahib 132kV Single Circuit Out |
| Exhibit 2.3 | Walgan Sohail to Mohlan 132kV Single Circuit Out |
| Exhibit 2.4 | Nankana Sahib to Warburton 132kV Single Circuit Out |
| Exhibit 2.5 | Sheikhupura to Warburton 132kV Single Circuit Out |
| Exhibit 2.6 | Shahkot to Walgan Sohail 132kV Single Circuit Out |
| Exhibit 2.7 | Shahkot to Halmor-P 132kV Single Circuit Out |
| Exhibit 2.8 | Walgan Sohail T-1 and T-2 Load Switched Off |

We find that power flows on the circuits are well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 10 % of the nominal for contingency conditions' criteria.

## 5.3 PEAK LOAD WINTER CASE 2018:WITH GUGERA HYDRO POWER PLANT OPTION-II

Detailed load flow studies have been carried out for Winter 2018. The results of load flows with Gugera HPP – Option-II under normal conditions have been plotted in Exhibit 3.0 in Appendix-B.

The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 5 % of the nominal. We find no capacity constraints on 132 kV circuits under normal conditions i.e. without any outages of circuits.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – B as follows;

| | |
|---|---|
| Exhibit 3.1 | Gugera HPP to Walgan Sohail T-2 11kV Single Circuit Out |
| Exhibit 3.2 | Walgan Sohail to Nankana Sahib 132kV Single Circuit Out |
| Exhibit 3.3 | Walgan Sohail to Mohlan 132kV Single Circuit Out |
| Exhibit 3.4 | Nankana Sahib to Warburton 132kV Single Circuit Out |
| Exhibit 3.5 | Sheikhupura to Warburton 132kV Single Circuit Out |
| Exhibit 3.6 | Shahkot to Walgan Sohail 132kV Single Circuit Out |
| Exhibit 3.7 | Shahkot to Halmor-P 132kV Single Circuit Out |
| Exhibit 3.8 | Walgan Sohail T-1 and T-2 Load Switched Off |

We find that power flows on the circuits are well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 10 % of the nominal for contingency conditions' criteria.

## 5.4 PEAK LOAD CASE 2020-21: WITH GUGERA HYDRO POWER PLANT OPTION-II

Detailed load flow studies have been carried out for future scenario of 2020-21. The results of load flows with Gugera HPP – Option-II under normal conditions have been plotted in Exhibit 4.0 in Appendix-B.

The power flows on the circuits are seen well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 5 % of the nominal. We find no capacity constraints on 132 kV circuits under normal conditions i.e. without any outages of circuits.

N-1 contingency analysis has been carried out and the plotted results are attached in Appendix – B as follows;

| | |
|---|---|
| Exhibit 4.1 | Gugera HPP to Walgan Sohail T-2 11kV Single Circuit Out |
| Exhibit 4.2 | Walgan Sohail to Nankana Sahib 132kV Single Circuit Out |
| Exhibit 4.3 | Walgan Sohail to Mohlan 132kV Single Circuit Out |
| Exhibit 4.4 | Nankana Sahib to Warburton 132kV Single Circuit Out |
| Exhibit 4.5 | Sheikhupura to Warburton 132kV Single Circuit Out |
| Exhibit 4.6 | Halmor-P to Shahkot 132kV Single Circuit Out |
| Exhibit 4.7 | Walgan Sohail T-1 and T-2 Load Switched Off |
| Exhibit 4.5-A | Sheikhupura to Warburton 132kV Single Circuit Out |
| Exhibit 4.6-A | Halmor-P to Shahkot 132kV Single Circuit Out |

In case of the line outage from Sheikhupura to Warburton 132kV, two circuits in the network become overloaded as seen in Exhibit 4.5 and in case of the line outage from Halmor-P to Shahkot 132kV as well there's an overloading on the circuit between Blessed Textile and Halmor-P as seen in Exhibit 4.6. To counter this problem a line opening has been suggested from Blessed Textile to Halmor-P, with this line opening in the network the overloading of certain lines in the network is eliminated as seen in Exhibit 4.5-A and 4.6-A.

Apart from this, we find that power flows on the circuits are well within the rated capacities and the voltages on the bus bars are also within the permissible operating range of ± 10 % of the nominal for contingency conditions' criteria.

## 5.5 POWER AND ENERGY LOSS CALCULATIONS

5.6.1 NORMAL CASE (EXHIBIT 2.0)

**Power Loss**

$$Power\ Loss = \frac{Power\ Sent - Power\ Delivered\ (40kW)}{Total\ Power}$$

$$\%\ Power\ Loss = \frac{3.6 - 3.56}{3.6} X100$$

$$\%\ Power\ Loss = 1.1\ \%$$

**Energy Loss**

$$Energy\ Loss = \frac{Energy\ Sent - Actual\ Energy\ Received}{Energy\ Sent\ at\ Installed\ Capacity}$$

$$Actual\ Energy\ Received = 0.66\ (plant\ factor)\ X\ 3.56\ MW\ X\ 8760\ hrs$$

$$Actual\ Energy\ Received = 20582.496\ \text{MWh}$$

$$Energy\ Sent\ at\ Installed\ Capacity = 0.66\ (plant\ factor)\ X\ 3.6\ MW\ X\ 8760\ hrs$$

$$Energy\ Sent\ at\ Installed\ Capacity = 20813.76\ \text{MWh}$$

$$\%\ \text{Energy Loss} = \frac{20813.76 - 20582.496}{20813.76}$$

$$\%\ \text{Energy Loss} = 1.1\ \%$$

5.6.2 CONTINGENCY CASE (EXHIBIT 2.1)

**Power Loss**

$$Power\ Loss = \frac{Power\ Sent - Power\ Delivered (80kW)}{Total\ Power}$$

$$\%\ Power\ Loss = \frac{3.6 - 3.52}{3.6}\ \text{X}\ 100$$

$$\%\ Power\ Loss = 2.22\ \%$$

**Energy Loss**

$$Energy\ Loss = \frac{Energy\ Sent - Actual\ Energy\ Received}{Energy\ Sent\ at\ Installed\ Capacity}$$

$$Actual\ Energy\ Received = 0.66\ (plant\ factor)\ X\ 3.52\ MW\ X\ 8760\ hrs$$

$$Actual\ Energy\ Received = 20351.232\text{MWh}$$

$$Energy\ Sent\ at\ Installed\ Capacity = 0.66\ (plant\ factor)\ X\ 3.6\ MW\ X\ 8760\ hrs$$

$$Energy\ Sent\ at\ Installed\ Capacity = 20813.76\ \text{MWh}$$

$$\%\ \text{Energy Loss} = \frac{20813.76 - 20351.232}{20813.76}$$

% Energy Loss = 2.2 %

## 5.6 CONCLUSION OF LOAD FLOW ANALYSIS

From the analysis discussed above, we conclude that both the proposed interconnection schemes i.e. Option-I and Option-II are adequate to evacuate the 3.6 MW export of power from Gugera HPP under normal and contingency conditions in September 2018 cases. However Option-II i.e. interconnection at 11 kV with Walgan Sohail is recommended as it is more economical while being technically feasible at the same time because of a distance of 7 km from the grid as opposed to 11 km in Option-I. Due to a smaller line length in option-II, the cost will be marginally reduced.

In case of the line outage from Shah Kot to Halmor for Option-1 the single circuit between Shah Kot to Walgan Sohail becomes overloaded. This is an inherent problem of the LESCO network and with the plant interconnected in the system the overloading on this line is slightly reduced as compared to when the plan is not connected. Moreover the overloading on this line is completely eliminated in Option-II. Moreover, for the future year scenario a line opening has been proposed to counter the problem of overloading on certain lines as shown in the Appendix.

# 6 Short Circuit Analysis

## 6.1 METHODOLOGY AND ASSUMPTIONS

The methodology of IEC 909 has been applied in all short circuit analyses in this report for which provision is available in the PSS/E software used for these studies. The maximum fault currents have been calculated with the following assumptions under IEC 909:

- Set tap ratios to unity
- Set line charging to zero
- Set shunts to zero in positive sequence
- Desired voltage magnitude at bus bars set equal to 1.10 P.U. i.e. 10 % higher than nominal, which is the maximum permissible voltage under contingency condition.

For evaluation of maximum short circuit levels we have assumed contribution in the fault currents from all the installed generation capacity of hydel, thermal and nuclear plants in the system in the year 2018 i.e. all the generating units have been assumed on-bar in fault calculation's simulations.

The assumptions about the generator and the transformers data are the same as mentioned in Ch.2 of this report.

## 6.2 FAULT CURRENT CALCULATIONS WITHOUT GUGERA HPP

In order to assess the short circuit strength of the network of 132 kV and 11 kV without Gugera HPP for the grid of LESCO/NTDC in the vicinity of the site of the plant, fault currents have been calculated for balanced three-phase and unbalanced single-phase short circuit conditions. These levels will not only give us the idea of the fault levels of Nankana Sahib, Walgan Sohail and other grid stations in the vicinity without Gugera HPP but would also help us determine how much the contribution of fault current from Gugera HPP later on may add to the existing levels.

The results are attached in Appendix – C.

The short circuit levels have been represented graphically on the bus bars of 132 kV and 11 kV which are shown in the Exhibit 5.0 attached in Appendix-C.

The fault currents in the Exhibit are given in polar coordinates i.e. the magnitude and the angle of the current. The total fault current is shown below the bus bar.

The tabular output of the short circuit calculations is also attached in Appendix-C for the 132 kV and 11 kV bus bars of our interest i.e. the substations connecting in the 132 kV and 11 kV circuits lying close to Gugera HPP. The total maximum fault currents for 3-phase and 1-phase short circuit at these substations are summarized in Table 6.1. We see that the maximum fault currents do not exceed the short circuit ratings of the equipment at these 132 kV substations which normally are 20 kA, 25 kA or 31.5 kA for older substations and 40 kA for new substations.

**Table 6.1**
**Maximum Short Circuit Levels without Gugera HPP**

| Substation | 3-Phase fault current, kA | 1-Phase fault current, kA |
|---|---|---|
| Nankana Sahib 132kV | 14.46 | 13.51 |
| Mohlan 132kV | 12.77 | 10.88 |
| Walgan Sohail 132kV | 18.19 | 17.16 |
| Shah Kot 132kV | 18.35 | 17.18 |
| Warburton 132kV | 11.39 | 10.78 |
| Sheikhupura 132kV | 30.96 | 31.52 |
| Halmor-P 132kV | 24.55 | 24.34 |
| Sharaqpur 132kV | 10.54 | 8.93 |

## 6.3 MAXIMUM FAULT CURRENT CALCULATIONS WITH GUGERA HPP 2018

The fault currents have been calculated for the electrical interconnection of proposed scheme for the 2018 scenario. Fault types applied are three phase and single-phase at the 11 kV bus bar of Gugera HPP itself and other bus bars of the 132 kV and 11 kV substations in the electrical vicinity of Gugera HPP. The graphic results are shown in Exhibit 5.1.

The tabulated results of short circuit analysis showing all the fault current contributions with short circuit impedances on 132 kV and 11 kV bus bars of the network in the electrical vicinity of Gugera HPP and the 11 kV bus bars of

Gugera HPP are placed in Appendix-C. Brief summary of fault currents at significant bus bars of our interest are tabulated in Table 6.2

**Table 6.2**
**Maximum Short Circuit Levels with Gugera HPP- 2018**

| Substation | 3-Phase fault current, kA | 1-Phase fault current, kA |
|---|---|---|
| **Gugera HPP 11kV** | **6.27** | **0.00002** |
| **Nankana Sahib 132kV** | **14.48** | **13.51** |
| **Mohlan 132kV** | **12.79** | **10.89** |
| **Walgan Sohail 132kV** | **18.26** | **17.20** |
| **Shah Kot 132kV** | **18.37** | **17.19** |
| **Warburton 132kV** | **11.40** | **10.78** |
| **Sheikhupura 132kV** | **30.98** | **31.53** |
| **Halmor-P 132kV** | **24.58** | **24.36** |
| **Sharaqpur 132kV** | **10.55** | **8.93** |

Comparison of Tables 6.1 and 6.2 show slight increase in short circuit levels for three-phase and single – phase faults due to connection of Gugera HPP on the 11 kV bus bars in its vicinity; and some rise on the 132 kV substation of Nankana Sahib, and other substations in plant's vicinity. We find that even after some increase, these fault levels are much below the rated short circuit values of the equipment installed on these substations.

The short circuit level at Gugera HPP 11 kV bus bar is 6.27 kA and 0.00002 kA for 3-phase and 1-phase faults respectively. Therefore industry standard switchgear of the short circuit rating of 25 kA would be fine to be installed at the 11 kV substation of Gugera HPP. It would provide large margin for any future increase in short circuit levels due to future generation additions and network reinforcements in this area.

## 6.4 MINIMUM FAULT CURRENT CALCULATIONS WITH GUGERA HPP 2018

The minimum fault currents have been calculated for minimum dispatch of power in the grid system for the electrical interconnection of proposed scheme for the 2018 scenario. Fault types applied are three phase and single-phase at the 11 kV bus bar of Gugera HPP itself and other bus bars of the 132 kV and 11 kV substations in the electrical vicinity of Gugera HPP. The graphic results are shown in Exhibit 5.2.

The tabulated results of short circuit analysis showing all the fault current contributions with short circuit impedances on 132 kV and 11 kV bus bars of the network in the electrical vicinity of Gugera HPP and the 11 kV bus bars of Gugera HPP are placed in Appendix-C. Brief summary of fault currents at significant bus bars of our interest are tabulated in Table 6.3

**Table 6.3**
**Minimum Short Circuit Levels with Gugera HPP- 2018**

| Substation | 3-Phase fault current, kA | 1-Phase fault current, kA |
|---|---|---|
| **Gugera HPP 11kV** | **5.58** | **0.00002** |
| **Nankana Sahib 132kV** | **12.90** | **12.50** |
| **Mohlan 132kV** | **11.49** | **10.16** |
| **Walgan Sohail 132kV** | **15.67** | **15.38** |
| **Shah Kot 132kV** | **15.96** | **15.54** |
| **Warburton 132kV** | **10.38** | **10.12** |
| **Sheikhupura 132kV** | **24.17** | **26.24** |
| **Halmor-P 132kV** | **19.37** | **18.69** |
| **Sharaqpur 132kV** | **9.57** | **8.37** |

The short circuit level at Gugera HPP 11 kV bus bar is 5.58 kA and 0.00002 kA for 3-phase and 1-phase faults respectively. Therefore industry standard switchgear of the short circuit rating of 25 kA would be fine to be installed at the 11 kV substation of Gugera HPP. It would provide large margin for any future increase in short circuit levels due to future generation additions and network reinforcements in this area.

## 6.5 MAXIMUM FAULT CURRENT CALCULATIONS WITH GUGERA HPP 2020-21

The fault currents have been calculated for the electrical interconnection of proposed scheme for the future year scenario of 2020-21. Fault types applied are three phase and single-phase at the 11 kV bus bar of Gugera HPP itself and other bus bars of the 132 kV and 11 kV substations in the electrical vicinity of Gugera HPP. The graphic results are shown in Exhibit 5.3.

The tabulated results of short circuit analysis showing all the fault current contributions with short circuit impedances on 132 kV and 11 kV bus bars of the network in the electrical vicinity of Gugera HPP and the 11 kV bus bars of Gugera HPP are placed in Appendix-C. Brief summary of fault currents at significant bus bars of our interest are tabulated in Table 6.4

**Table 6.4**
**Maximum Short Circuit Levels with Gugera HPP-2020-21**

| Substation | 3-Phase fault current, kA | 1-Phase fault current, kA |
|---|---|---|
| Gugera HPP 11kV | 6.23 | 0.00002 |
| Nankana Sahib 132kV | 18.11 | 12.51 |
| Mohlan 132kV | 11.13 | 7.53 |
| Walgan Sohail 132kV | 18.74 | 16.24 |
| Shah Kot 132kV | 18.42 | 14.53 |
| Warburton 132kV | 12.20 | 8.12 |
| Sheikhupura 132kV | 41.66 | 34.24 |
| Halmor-P 132kV | 27.43 | 25.06 |
| Sharaqpur 132kV | 16.75 | 11.45 |
| Panwan 132kV | 13.20 | 10.80 |

The short circuit level at Gugera HPP 11 kV bus bar is 6.23 kA and 0.00002 kA for 3-phase and 1-phase faults respectively. Therefore industry standard switchgear of the short circuit rating of 25 kA would be fine to be installed at the 11 kV substation of Gugera HPP. It would provide large margin for any future increase in short circuit levels due to future generation additions and network reinforcements in this area.

It may be observed that the SC values at certain grids in 2020-21 are slightly less than those of 2018 SC. Change in the interconnection between LESCO and FESCO in the future causes this decrease in the SC values.

## 6.6 CONCLUSION OF SHORT CIRCUIT ANALYSIS

The short circuit analysis results show that for the proposed scheme of interconnection of Gugera-HPP Feeder, we don't find any violations of short circuit ratings of the already installed equipment on the 132 kV and 11 kV equipment of substations in the vicinity of Gugera-HPP Feeder due to fault current contributions from this power house under three-phase faults as well as single phase faults.

The short circuit level at Gugera-HPP Feeder 11 kV bus bar is 6.27 kA and 0.00002 kA for 3-phase and 1-phase faults respectively for 2018 and 6.23 kA and 0.00002 kA for 3-phase and 1-phase faults respectively for 2020-21. Therefore industry standard switchgear of the short circuit rating of 25 kA would be fine to be installed at 11 kV substation of Gugera-HPP Feeder taking care of any future generation additions in its electrical vicinity.

# 7 Dynamic Stability Analysis

7.1 ASSUMPTIONS & METHODOLOGY

### 7.1.1 Dynamic Models

The assumptions about the generator and its parameters are the same as mentioned in Ch.2 of this report.

We have employed the generic dynamic models available in the PSS/E model library for dynamic modeling of the generator, exciter and the governor as follows;

| | |
|---|---|
| Generator | GENSAL |
| Excitation System | EXST1 |
| Speed Governing System | HYGOV |

### 7.1.2 System Conditions

We have used the system conditions of September 2018, which represents the high water season. Most of the hydel generators in LESCO power system in the vicinity of Gugera HPP such as Chichoki Malian, Renala and Nandipur would be running nearly at their full output.

We have carried out the Dynamic Stability analysis for Gugera HPP with the proposed interconnection scheme. All the power plants of WAPDA /NTDC from Tarbela to Hub have been dynamically represented in the simulation model.

### 7.1.3 Presentation of Results

The plotted results of the simulation runs are placed in Appendix-D. Each simulation is run for its first one second for the steady state conditions of the system prior to fault or disturbance. This is to establish that the pre fault/disturbance conditions of the network under study were smooth and steady. Post fault recovery has been monitored for nine seconds. Usually all the transients due to non-linearity die out within 2-3 seconds after disturbance is cleared from the system.

### 7.1.4 Worst Fault Cases

Three phase faults are considered as the worst disturbances in the system. Normally we apply 3 phase fault on the bus bar of the power plant, followed by tripping of a circuit emanating from that bus, and trip one of the generators of the plant and / or trip one of the inter-bus transformers if there are two voltage levels in the switching station of the plant. Also we apply 3-phase fault at bus bars at far end of the interconnection of the plant and trip circuit or transformer as the case may be. The fault clearing time of 11 kV breakers has been assumed 9 cycles as the switchgear of the medium voltages are slow.

## 7.2 DYNAMIC STABILITY SIMULATIONS' RESULTS

The following scheme of interconnection of Gugera Hydro Power Plant with Walgan Sohail to evacuate its maximum power of 3.6 has been envisaged; two direct 11 kV transmission lines of 07 km length using Osprey conductor to be constructed from 11 kV Bus Bar of Gugera HPP till Walgan Sohail 132/11 kV substation. One circuit to be connected to Walgan Sohail 132/11 kV T-1 and the other to be connected to Walgan Sohail 132/11 kV T-2.

All the simulations have been run using H = 2.5 MWs/MVA as per original assumption mentioned in Ch.2.

### 7.2.1 Three-Phase Fault at 11 kV Gugera HPP: Trip of 11 kV circuit between Gugera HPP and Walgan Sohail-T2 11 kV

We applied three-phase fault on Gugera HPP 11 kV bus bar, cleared fault in 5 cycles (100 ms) followed by trip of 11 kV circuit between Gugera HPP and Walgan Sohail-T2 11 kV. We monitored different parameters for one second pre-fault and nine seconds after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – D and discussed as follows;

Fig. 1.1 Bus Voltages

The bus voltages of 11 kV bus bar of Gugera HPP, Walgan Sohail-T2, Walgan Sohail-T3 and 132 kV substations of Walgan Sohail, Mohlan and Nankana Sahib are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 1.2 Frequency

We see that the system frequency recovers its normal condition quickly after fault clearance.

Fig. 1.3 MW/MVAR Output of Generators of Gugera HPP

The pre-fault output of a generator at Gugera HPP was 3.6 MW and it gets back to the same output quickly after fast damping of the oscillations in its output. However MVAR output acquires equilibrium at a new value.

Fig. 1.4 Speed and mechanical power of Generators at Gugera HPP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed as of before fault. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 1.5 MW/MVAR Flow on Gugera to Walgan Sohail –T1 11 kV circuit

Followed by clearing of fault, the trip of the 11 kV circuit from Gugera to Walgan Sohail –T3 11 kV circuit caused the entire output of 3.6 MW to flow through the intact circuit of 11 kV between Gugera to Walgan Sohail –T1 11 kV. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 1.6 Rotor Angles

The rotor angles of the generators of Gugera HPP, Mangla, Orient-P, Halmor-P and Ghazi Brotha are plotted relative to machines at Tarbela. The results show that the rotor angle of Gugera recovers its normal condition after the first swing and damps down quickly. Similarly the rotor angles of other machines swing little after the fault and damp fast after clearing of fault. The system is stable and very strong in damping the post fault oscillations.

### 7.2.2 Three-Phase Fault at 11 kV Gugera HPP: Trip of 11 kV circuit between Gugera HPP and Walgan Sohail-T2 11 kV Stuck Breaker Case

We applied three-phase fault on Gugera HPP 11 kV bus bar, cleared fault in 9 cycles (180 ms) followed by trip of 11 kV circuit between Gugera HPP and Walgan Sohail - T2 11 kV. We monitored different parameters for one second pre-fault and nine seconds after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – D and discussed as follows;

Fig. 2.1 Bus Voltages

The bus voltages of 11 kV bus bar of Gugera HPP, Walgan Sohail-T2, Walgan Sohail-T3 and 132 kV substations of Walgan Sohail, Mohlan and Nankana Sahib are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 2.2 Frequency

We see that the system frequency recovers its normal condition quickly after fault clearance.

Fig. 2.3 MW/MVAR Output of Generators of Gugera HPP

The pre-fault output of a generator at Gugera HPP was 3.6 MW and it gets back to the same output quickly after fast damping of the oscillations in its output. However MVAR output acquires equilibrium at a new value.

Fig. 2.4 Speed and mechanical power of Generators at Gugera HPP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed as of before fault. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 2.5 MW/MVAR Flow on Gugera to Walgan Sohail –T1 11 kV circuit

Followed by clearing of fault, the trip of the 11 kV circuit from Gugera to Walgan Sohail –T2 11 kV circuit caused the entire output of 3.6 MW to flow through the intact circuit of 11 kV between Gugera to Walgan Sohail –T1 11 kV. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 2.6 Rotor Angles

The rotor angles of the generators of Gugera HPP, Mangla, Orient-P, Halmor-P and Ghazi Brotha are plotted relative to machines at Tarbela. The results show that the rotor angle of Gugera recovers its normal condition after the first swing and damps down quickly. Similarly the rotor angles of other machines swing little after the fault and damp fast after clearing of fault. The system is stable and very strong in damping the post fault oscillations

### 7.2.3 Three-Phase Fault at 132 kV Walgan Sohail: Trip of 132 kV circuit between Nankana Sahib and Walgan Sohail 132 kV

We applied three-phase fault on Walgan Sohail 132 kV bus bar, cleared fault in 5 cycles (100 ms) followed by trip of 132 kV circuit between Nankana Sahib and Walgan Sohail. We monitored different parameters for one second pre-fault and nine seconds after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – D and discussed as follows;

Fig. 3.1 Bus Voltages

The bus voltages of 11 kV bus bar of Gugera HPP, Walgan Sohail-T2, Walgan Sohail-T3 and 132 kV substations of Walgan Sohail, Mohlan and Nankana Sahib are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 3.2 Frequency

We see that the system frequency recovers its normal condition quickly after fault clearance.

Fig. 3.3 MW/MVAR Output of Generators of Gugera HPP

The pre-fault output of a generator at Gugera HPP was 3.6 MW and it gets back to the same output quickly after fast damping of the oscillations in its output. However MVAR output acquires equilibrium at a new value.

Fig. 3.4 Speed and mechanical power of Generators at Gugera HPP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed as of before fault. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 3.5 MW/MVAR Flow on Walgan Sohail to Mohlan 132 kV circuit

Followed by clearing of fault, the trip of the 132 kV circuit from Nankana Sahib to Walgan Sohail caused the entire output to flow through the intact circuit of 132 kV between Walgan Sohail to Mohlan. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 3.6 Rotor Angles

The rotor angles of the generators of Gugera HPP, Mangla, Orient-P, Halmor-P and Ghazi Brotha are plotted relative to machines at Tarbela. The results show that the rotor angle of Gugera recovers its normal condition after the first swing and damps down quickly. Similarly the rotor angles of other machines swing little after the fault and damp fast after clearing of fault. The system is stable and very strong in damping the post fault oscillations

## 7.2.4 Three-Phase Fault at 132 kV Walgan Sohail: Trip of 132 kV circuit between Nankana Sahib and Walgan Sohail 132 kV Stuck Breaker Case

We applied three-phase fault on Walgan Sohail 132 kV bus bar, cleared fault in 9 cycles (180 ms) followed by trip of 132 kV circuit between Nankana Sahib and Walgan Sohail. We monitored different paramcters for one second pre-fault and nine seconds after clearance of fault (post-fault) conditions and plotted the results attached in Appendix – D and discussed as follows;

Fig. 4.1 Bus Voltages

The bus voltages of 11 kV bus bar of Gugera HPP, Walgan Sohail-T2, Walgan Sohail-T3 and 132 kV substations of Walgan Sohail, Mohlan and Nankana Sahib are plotted. The results show quick recovery of the voltages after clearing of fault.

Fig. 4.2 Frequency

We see that the system frequency recovers its normal condition quickly after fault clearance.

Fig. 4.3 MW/MVAR Output of Generators of Gugera HPP

The pre-fault output of a generator at Gugera HPP was 3.6 MW and it gets back to the same output quickly after fast damping of the oscillations in its output. However MVAR output acquires equilibrium at a new value.

Fig. 4.4 Speed and mechanical power of Generators at Gugera HPP

The speed deviation of the generator, after clearing fault, damps down quickly returning to normal speed as of before fault. The transients in mechanical power also damp quickly and settle to a new equilibrium.

Fig. 4.5 MW/MVAR Flow on Walgan Sohail to Mohlan 132 kV circuit

Followed by clearing of fault, the trip of the 132 kV circuit from Nankana Sahib to Walgan Sohail caused the entire output to flow through the intact circuit of 132 kV between Walgan Sohail to Mohlan. We plotted the flows of MW and MVAR on this intact circuit and see that the power flows on this circuit attains to steady state level with power swings damping down fast.

Fig. 4.6 Rotor Angles

The rotor angles of the generators of Gugera HPP, Mangla, Orient-P, Halmor-P and Ghazi Brotha are plotted relative to machines at Tarbela. The results show that the rotor angle of Gugera recovers its normal condition after the first swing and damps down quickly. Similarly the rotor angles of other machines swing little after the fault and damp fast after clearing of fault. The system is stable and very strong in damping the post fault oscillations

### 7.3 CONCLUSION OF DYNAMIC STABILITY ANALYSIS

The results of dynamic stability show that the system is very strong and stable for the proposed schemes for the severest possible faults of 11 kV systems near Gugera-HPP Feeder. Therefore there is no problem of dynamic stability for interconnection of Gugera- HPP Feeder; it fulfills all the criteria of dynamic stability.

# 8 Conclusions

- The study objective, approach and methodology have been described and the plant's data received from the client is validated.
- The LESCO system data as available with PPI for other studies have been used.
- The interconnection study of Gugera HPP to evacuate its maximum power of 3.6 MW is studied in detail for M/s Gugera Hydrpower Co.
- Due to the location of Gugera HPP, two options have been considered for this study. The second option is preferable.
- In Option-II the following scheme of interconnection of Hydro Power Plant with Walgan Sohail to evacuate its maximum power of 3.6 MW is envisaged and studied in detail:
    - Two direct 11 kV transmission lines of 07 km length using Osprey conductor to be laid from 11 kV Bus Bar of Gugera HPP till Walgan Sohail 132/11 kV substation. One circuit to be connected to Walgan Sohail 132/11 kV T-1 and the other to be connected to Walgan Sohail 132/11 kV T-2.

The proposed scheme will require the following equipment at 11 kV switchgear of Gugera HPP:

- Three breaker panels of 11 kV for connecting three Generating Units
- Two 11 kV breaker/line bays need to be added with 11 kV Bus Bar of Gugera HPP.

- Detailed load flow studies have been carried out for the peak load conditions of September 2018 for both the schemes considered under normal and N-1 contingency conditions to meet the reliability criteria for the contingencies performed. After the Load Flow Analysis the second Scheme of Interconnection has been found to be more feasible for the evacuation of power from Gugera HPP and is proposed to be adopted, therefore the second option of connectivity has been studied in detail.

  Load flow studies have also been carried out for Winter Scenario and Future Year Scenario of 2020-21.

- Steady state analysis by load flow reveals that proposed schemes are adequate to evacuate the maximum power of 3.6 MW of the plant under normal and contingency conditions for the contingencies performed but the second option is more feasible and is therefore recommended to be adopted and studied in detail. In case of the line outage from Shah Kot to Halmor the single circuit between Shah Kot to Walgan Sohail becomes overloaded. This is an inherent problem of the LESCO network and with the plant interconnected in the system the overloading on this line is slightly reduced for option-I and eliminated for option-II.
- The power and energy loss calculations have also been done for the plant.
- The short circuit analysis has been carried out to calculate maximum fault levels at Gugera HPP at 11 kV and the substations of 132 kV and 11 kV in its vicinity. We find that the fault currents for the proposed scheme are much less than the rated short circuit capacities of switchgear installed at these substations. There are no violations of the equipment ratings due to contribution of fault current from Gugera HPP.
- The maximum short circuit levels of Gugera HPP 11 kV have been evaluated for the peak case of 2018 to evaluate the maximum fault currents on Gugera HPP and the 132 kV Substations in its vicinity. The maximum short circuit level of the Gugera HPP 11 kV is 6.27 and 0.00002 kA and 6.23 kA and 0.00002for 3-phase and 1-phase faults respectively in the year 2018 and 2021 respectively. Therefore industry standard switchgear of the short circuit rating of 25 kA would be fine to be installed at 11 kV switchroom of Gugera HPP as per LESCO/NTDC requirement taking care of any future generation additions and system reinforcements in its electrical vicinity.
- The dynamic stability analysis of proposed scheme of interconnection has been carried out. The stability check for the worst case of three phase fault right on the 11 kV bus bar of Gugera HPP substation followed by the final trip of 11 kV circuits emanating from this substation, has been performed for fault clearing within 9 cycles (180 ms). The system is found strong enough to stay stable and recovered with fast damping. The stability of system for far end faults of 3-phase has also been checked. The proposed scheme successfully passed the dynamic stability checks for near and far-end faults.

- The proposed scheme of interconnection has no technical constraints or problems, it meets all the criteria of reliability and stability under steady state load flow, short circuit currents and dynamic/transient conditions; and is therefore recommended to be adopted.

| COMMENTS | RESPONSE |
|---|---|
| 1- LESCO Network in the vicinity of the power plant has not been modelled correctly | Complied<br>Refer Appendix-A, Sketch No. 1 and 2 |
| 2- Detailed level modelling of the power plant should be done i.e. generators should be modeled at 0.69/11 kV | Complied<br>Refer Appendix-B, Exhibit No. 1 and 2 |
| 3- The parameters of the Osprey conductor which has been used in the study for modelling purpose should be supported with documents e.g. data sheets etc. | For low kV lines, the zero sequence parameters are measured after the lines are commissioned. In the absence of measured values, zero sequence values are assumed equal to the positive sequence values because for LV, these are nearly the same. If any such document is available with LESCO, it may kindly be provided.<br>In addition, the 11 kV Transformer is connected in delta-wye so the impact of the zero sequence parameters is negligible. |
| 4- Power and Energy loss should also be calculated with and without N-1 contingency and it should be made part of the report. | Complied<br>Refer Section 5.5 (Page-20) |
| 5- In the load flow analysis a contingency should also be carried out by switching off the load on both T-2 and T-3 to show the impact of the power from the subject cited power plant being fed into the grid system of LESCO | Complied<br>Refer Appendix-B, Exhibit No. 2.8<br>(The loads on T-1 and T-2 were switched off as the plant is now connected to these two as instructed by the client) |
| 6- Power flow analysis should also be carried out for winter 2018 scenario | Complied<br>Refer Appendix-B, Exhibit No. 3.0 to 3.8 |
| 7- Power flow and short circuit analysis should also be carried out for future year scenario | Complied<br>Refer Appendix-B, Exhibit No. 4.0 to 4.7<br>And Appendix-C, Exhibit No. 5.3 |
| 8- Minimum short circuit analysis should also be carried out and should be made part of the report | Complied<br>Refer Appendix-C, Exhibit No. 5.2 |
| 9- Comparison of the short circuit levels with the already installed equipment should also be done in the short circuit analysis. | The standard equipment rating is taken into account, which is 20 kA, 25 kA or 31.5 kA for older substations and 40 kA for new substations. |
| 10- In the plots of stability analysis the range of frequency should be 49.5 Hz to 50.5 Hz rather that 49 Hz to 51 Hz. Similarly the range of all the plots should be adjusted accordingly for all the parameters | Complied<br>Refer Appendix-D |

# Appendix - E

# Dynamic Data For Stability

Gugera Hydro Power Project

GENSAL

| Con Description | Con Value |
|---|---|
| T'do (> 0) | 6.0000 |
| T"do (> 0) | 0.0680 |
| T"qo (> 0) | 0.1000 |
| Inertia H | 2.5000 |
| Speed Damping D | 0.0000 |
| Xd | 1.0950 |
| Xq | 0.6500 |
| X'd | 0.3000 |
| X"d = X"q | 0.1600 |
| X1 | 0.1000 |
| S(1.0) | 0.1000 |
| S(1.2) | 0.5000 |

EXST1

| Con Description | Con Value |
|---|---|
| TR | 0.0100 |
| VIMAX | 99.0000 |
| VIMIN | -99.0000 |
| TC | 1.0000 |
| TB | 5.0000 |
| KA | 100.0000 |
| TA | 0.0000 |
| VRMAX | 5.0000 |
| VRMIN | -5.0000 |
| KC | 0.1000 |
| KF | 0.0000 |
| TF (> 0) | 1.0000 |

M/s GUGERA HYDROPOWER COMPANY

# Gugera Hydro Electric Power Project

(Upper Gugera Branch Canal RD 216+100 to 220+750)

# FEASIBILITY STUDY REPORT

## MAIN REPORT (Volume-I)

APPROVED FEASIBILITY STUDY
Gra[illegible] by [illegible] in [illegible] meeting
held on 03-12-2015

[illegible] PUNJAB POWER DEV[illegible] BOARD

team
Technical, Engineering and Management (TEAM) Consultants, Pakistan

No. PPDB/ 863 /2016

**PUNJAB POWER DEVELOPMENT BOARD**
**ENERGY DEPARTMENT**

Irrigation Secretariat, Old Anarkali, Lahore
(Ph: 042-99213879 Fax: 99213885)

Date: 23 / 06 /2016

M/s Gugera Hydropower Company
64-Ahmed Block New Garden Town
Lahore

Subject: **APPROVAL OF FEASIBILITY STUDY REPORT OF 3.6 MW GUGERA HYDROPOWER PROJECT ON UPPER GUGERA BRANCH CANAL AT RD. 216+100 to RD. 220+750, DISTRICT NANKANA**

It is conveyed that pursuant to Section 4.2 (Para 52 & 53) of the Punjab Power Generation Policy-2009 (the "Policy"), a Panel of Experts (POEs), comprising following members, was appointed by PPDB to monitor, review and approve feasibility study report (the "Report") of 3.6 MW Gugera Hydropower Project on Upper Gugera Branch Canal at RD. 2016+100 to RD. 220+750, District Nankana, being developed by your Company:

1. The Managing Director, Punjab Power Development Board (PPDB), Lahore.
2. The Managing Director, Private Power & Infrastructure Board (PPIB), Islamabad
3. Dr. Engineer Javed Yunas Uppal, Chairman EPDC, Lahore
4. The Chief Executive Officer, Lahore Electric Supply Company (LESCO)
5. The Project Director, Punjab Power Management Unit (PPMU), Lahore
6. The Superintending Engineer, LCC (East), Circle Office, Irrigation Department, Faisalabad

2. During the course, POEs held a number of meetings and made certain observations / suggestions paving the way towards ultimate completion of the Report. Accordingly, after thorough review, the POEs during their final meeting held on 03rd December 2015, approved the said feasibility study report subject to approval of Initial Environmental Examination (IEE) Report from Environment Protection Agency (EPA) and approval of Interconnection Study from Lahore Electric Supply Company (LESCO). POE also certified the duly filled Performa (Annex-II) regarding net annual plant factor to apply for NEPRA's Upfront Tariff for Small Hydropower Generation Projects, notified by GoP, Ministry of Water & Power on March 28, 2016. The POEs resolved that:

*(i) POE conditionally approved the feasibility study of 3.6 MW Gugera Hydropower Project, subject to the approval of Initial Environmental Examination (IEE) Report from Govt. of the Punjab, Environment Protection Agency and approval of Interconnection study from NTDC / concerned DISCO. POE further directed the Sponsor to get the said approvals from concerned Authorities and submit the same to PPDB within 15 days of issuance of minutes of POE meeting, since the progress of the Project is already delayed.*

*(ii) POEs certifies only the completion of the Feasibility Study. However, due to nature of data and resultant conclusions, POEs jointly and/or individually will not be responsible for reliability of data contents and conclusions given in the feasibility study.*

3. The Sponsor has submitted the approval of IEE from EPA on 23.04.2016 and approval of Interconnection Study from LESCO on 01.06.2016. Since the conditions of the approval of feasibility study have been fulfilled, the Feasibility study of subject cited Hydropower Project stands approved.

4. In view of the above and relevant stipulations of the Policy, now, your Company is required to approach National Electric Power Regulatory Authority (NEPRA) for grant of Generation License and acceptance of NEPRA's Upfront Tariff for Small Hydropower Generation Projects, notified by GoP, Ministry of Water & Power on March 28, 2016. Thereby, please note that your petition for acceptance of Upfront Tariff along with its terms & conditions. A copy of duly signed & stamped complete set of final feasibility study is being enclosed herewith.

5. PPDB appreciates your efforts towards completion of the Feasibility Study Report and hopes that the same pace and spirit would be kept by your Company for timely development of the project to meet the energy needs of the country.

*Regards,*

**SANIYA AWAIS**
*Managing Director*

**ENCL:** *Complete set of stamped & signed Final Feasibility Study Report*

CC:
1. The Chairman PPDB Board / Additional Chief Secretary, Government of the Punjab, Energy Department, Lahore
2. The Managing Director, Private Power & Infrastructure Board (PPIB), Islamabad
3. The Chief Executive Officer, Lahore Electric Supply Company (LESCO)
4. The Project Director, Punjab Power Management Unit (PPMU), Lahore
5. Dr. Engr. Javed Yunas Uppal, Chairman EPDC, 1-A, Aibak Block, Garden Town Lahore
6. The Superintending Engineer, LCC (East), Circle Office, Irrigation Department, Faisalabad

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# EXECUTIVE SUMMARY

# SECTION 1
# EXECUTIVE SUMMARY

## 1.0 General

Gugera Canal Hydro Electric Power Project is proposed to be constructed at RD 214+500 of Upper Gugera Branch Canal. It is located near Nankana Sahib in District Nankana Sahib of the Punjab Province. The proposed hydro electric power project has installed capacity of 3.6 MW and would generate 20.80GWh annually. The project has been proposed near RD 214+500 of Upper Gugera Branch Canal by combining head available on fall structure at RD 216+100 and at fall structure at RD 220+750. The project would be equipped with 3 bevel gear bulb turbines each has capacity of 1.2 MW. The project would be connected with LESCO Grid at Walgan Sohail which is about 06 km from project site.

## 1.1. Project Company

The Project Company in the name of **"Gugera Hydropower Company"** privately owned is being pursued for preparation of feasibility study report leading to implementation of the Upper Gugera Branch Canal Hydro Electric Power Project **"the Project"** under the terms of a Letter of Interest (LOI) issued on June 2013by the Punjab Power Development Board (PPDB). The PPDB's authorization is in accordance with the Government of Punjab's "Punjab Power Generation Policy, Year 2006" (the Policy) revised during 2009 to encourage private-sector infrastructure investments.

## 1.2. Engineering Consultants

The **Gugera Hydropower Company**, Lahore, hired the Services of the Consultants **M/S Technical, Engineering and Management - TEAM Consultants** Pakistan, to conduct feasibility studies for the Upper Gugera Branch Canal Hydro Electric Power Project. The studies were commenced on during December 2013 and completed the report.

## 1.3. Site Location and Accessibility

The project site and area is located in the central Punjab and lies in Nankana Sahib District. The project area is located about 70 km from Lahore, 35 km from Sheikhupura city and 67 km from Faisalabad.The area is accessible by good roads network of Motorway, National highway and district road. The site is accessible by Motorway M2 as well as the GT road. The area is accessible via railway network and the nearest Railway stations are Lahore, Sheikhupura and Nankana. The nearest airports are Allama Iqbal International Airport Lahore and Benazir Bhutto International Airport, Islamabad.

## 1.4. Chenab River and Khanki Barrage System

Chenab River is part of Indus Basin River system and the third river of the western river on which Pakistan has the water right under Indus Basin Treaty signed between India and Pakistan under the office of World Bank. It contributes a good part of water supply to the irrigated agriculture system in Pakistan.

The river Chenab originates in the Kulu and Kangra Districts of the Himachal Pardesh Province of India. The Two Chief streams of the Chenab - the Chandra and the Bhaba - rise on the opposite sides of Baralcha Pass at an elevation of about 4877 m (16,000 ft). These join at Tandi in the state of Jammu and Kashmir, nearly 2,770.6 m (9,090 ft) above mean sea level.

Khanki Headwork on river Chenab situated about 14.5 km downstream from Town of Wazirabad was built and made operational in the year 1892. This was the first weir in Punjab which had been founded on alluvial bed of the river. During 1932, sudden collapse of some major part was apprehended to take place. A lot of research was carried out by irrigation and hydraulic engineers especially work of Khosla wrote a theory which even today is considered to a bible for the design of hydraulic structures on alluvial/permeable soils. The weir 1336.24 m long constructed in the year 1892 with some latter additions consisted.

The Gugera Branch Canal originates from the Lower Chenab Canal from its RD 140+050. The main areas to which it supplies water are Toba Tek Singh and Faisalabad. Upper Gugera Branch after travelling a distance of about 85.95 km, it is further bifurcated at RD 280+000 into two canals namely Lower Gugera Branch (LGB) and Burala Branch. The tail of Lower Gugera Branch is at RD 387+566 and Burala Branch is at RD 485+755.

### 1.5. Preliminary Layout Studies

In the early 1990s, the hydropower potential of the canal system was first studied by the Hydro Electric Planning Organization (HEPO) of the Pakistan Water and Power Development Authority (WAPDA), in collaboration with the German Agency for Technical Cooperation (GTZ). This study identified low head hydropower projects of small capacity at canals. Two sites were located at the falls available at the Upper Gugera Branch Canal falls at RD 216+100 and 220+750.

It was concluded during the desk studies that construction of two powerhouses at each RD is not technically feasible considering existing upstream and downstream because available head is about1.5 m at each fall. Therefore it was decided to develop the project by combining both the falls and placing the project near RD 214+500.Before starting field investigations including of geology, geo-technical and environment. Detailed layout alternatives study was carried out on the basis of topographic survey conducted during this feasibility study at a scale of 1:1500. The following layout alternatives were studied in detail and alternative giving less cost of generation was selected for further engineering studies on the basis of field investigations.

- **Layout Alternative: 1 Powerhouse in Bypass and Remodelling of Existing Fall**
- **Layout Alternative: 2 Powerhouse with Spillway in Bypass Canal at RD 214+500**

Cost estimates were prepared on the basis of engineering drawings and concluded that Alternative:2 results in cheapest energy generation than alternatives as shown in Table below:

| | Base Cost (Rs Million) | Power (MW) | Energy (GWh) | Cost/KWh (Rs) |
|---|---|---|---|---|
| Alternative-1 | 1853.203 | 3.6 | 20.80 | 11.45 |
| Alternative-2 | 1398.436 | 3.6 | 20.80 | 8.62 |

## 1.6. Hydrology and Sediment

The Gugera Branch Canal originates from the Lower Chenab Canal from its RD 140+050. The main areas to which it supplies water are Toba Tek Singh and Faisalabad. Upper Gugera Branch after travelling a distance of about 85.95km, it is further bifurcated at RD 280+000 into two canals namely Lower Gugera Branch (LGB) and Burala Branch. The tail of Lower Gugera Branch is at RD 387+566 and Burala Branch is at RD 485+755.

Its purpose is to develop a Hydro Electric Power Project along RD 216+100 of Upper Gogera Branch Canal. The site is located 70 km south of Lahore and 67 Km from Faisalabad.

### Data Collection

Metrological data (Temperature, Rainfall, Humidity and Wind Speed) for Faisalabad and Lahore was collected from the office of the Director, Pakistan Metrological Department Lahore for the last 10 years (2004-2013) as no other climatologically station exists in the project vicinity.

### Data Analysis

Four seasons are being experienced in the project area i.e. winter, spring, summer and autumn. The climate of the project area is generally hot and dry in summer and moderately cold in winter. Summer starts in April and continues until September. July and August are the months of summer monsoon. Winter begins in October and lasts until February. Monsoons affect the area in July & August while March and April are pleasant months.

### Temperature

Daily maximum and minimum temperature data for Faisalabad and Lahore was collected and presented in Annexure: 5.2, 5.2B, 5.3A and Annexure: 5-3B. The data has been processed for mean monthly, daily maximum and minimum values and presented in Table: 5.2 and Table: 5.3 for Lahore and Table: 5.4 and Table: 5.5 for Faisalabad.

Tables show that the hot months are April, May, June July, August, September and October while November, December, January, February and March are the cold. Based on data for the period 2004 through 2013, the lowest and the highest values of mean monthly maximum temperature are 12.12°C and 45.5°C and 12.36°C and 44.2°C for Faisalabad and Lahore for the month of January and June & May, respectively **(Figure: 5.1)**. The minimum mean monthly temperature varies between 0.42°C and 22.3°C and 4.09°C and 22.46°C for Faisalabad and Lahore, respectively **(Figure: 5.4)**.

Over all the temperature will not affect the construction activity whole the year.

### Rainfall

Daily rainfall data for Faisalabad and Lahore was collected and presented in Annexure: 5.4 and Annexure 5.5, respectively. The data of rainfall has been processed on monthly and annual basis and placed in Table: 5.6 and Table 5.7 for Lahore and Faisalabad, respectively.

Monsoons hit the area in July, August and till first week of September. Heavy rains are expected in these months. Considerable rains are also expected in December and January due to western disturbance. Average monthly rainfall for (2004-2013) is presented in Table: 5.6 and 5.7.

Average annual total rainfall for the period of 2004 through 2013 at Faisalabad and Lahore is 450.9 mm and 482.2 mm, respectively. Most of the rainfall occurs during the summer monsoon period (July to August). November is the month of minimum rainfall and July is the month of maximum rainfall (Figure: 5.3). The maximum annual rainfall recorded so far (2004-2013) is 565 mm and 656.8 mm in the year 2008 at Lahore and Faisalabad, respectively

### Availability of Flows During 2008-2013

Flow duration analysis is made on daily basis for each year separately and presented in Figure: 5.16. It can easily be concluded that flow duration curve for year 2013 shows more discharge availability than other years. At the same time it also concluded that canal remained closed more days than other years. The flow availability during the year 2010 is less shows increasing trend during 2009 and 2008.

### Sediment Data

No sediment data is being collected at site. Sediment data at head regulator of Lower Chenab Canal is be recorded especially during flood season. It is important to note that the proposed project site is about 110 km downstream from Lower Chenab Canal Head regulator. Therefore, coarse sediment would not reach to site and will settle in the main Lower Chenab Canal reach. The only suspended sediment will reach the site. As the LCC bifurcate in to two at RD 140+050, therefore suspended sediment reaching at site would be half or even less.

As the low head turbines are slow moving machines, therefore suspended sediment may not be issue during operation.

### Conclusions

On the basis of above discussions, the following can be concluded:

- The average canal closure period is 26 days. Therefore to get more benefits of energy it is proposed that closure period be kept up to 20 to 26 days in future.
- The upstream level will be kept constant at designed full supply level. For downstream water level rating curve should be developed during detailed engineering design.
- The enegy potential will be worked out on daily basis for period 2008 to 2013 being less period of record.
- The sediment entering in to canal are smaller in size and hence not considered harmfull to turbines and other parts. However, sediment data should be recorded at site during detailed engineering design in order to give to turnbine manufactureres at the time of bidding.

## 1.7. Geology and Geo-technical Investigation

The project area is a part of vast alluvial plain of Chaj Doab in upper Indus basin, which can further be classified into three unit's namely active flood plain, abandoned flood plain and bar uplands. Main rivers in the area are Chenab and Ravi. These rivers and their canals are the main source of surface water supplies for irrigated agriculture as well as for recharge of groundwater. The elevation in the area varies from 203 to 204 m above mean sea level. The area has a gentle slope towards south.

The alluvial deposits in the area range in age from pliestocene to recent and are widely distributed. These deposits are composed of clay, silt and sand extending in general to a depth of 300 m and are overlain by recent surfacial coarser deposits along the river channels.

The scope of work consisted of straight rotary drilling of two boreholes on right side of Upper Gugera Canal (UGC) at the proposed powerhouse location to a depth of 40 m each. The locations of borehole are shown in Drawing: 7.1. The geotechnical investigations were executed on proposed powerhouse site located near RD 216+400 Upper Gugera Canal to determine sub-surface conditions and to evaluate the engineering properties of the foundation material. The investigation includes drilling, bore logging, field tests, sampling and laboratory tests. The details of geo-technical investigations are discussed hereafter. **Figure 7.1** shows location of borehole for field investigations plan for the proposed Construction of 3.6 MW HPP on Upper Gugara Canal at RD 216+000, Nankana road.

## 1.8. Seismic Hazard Analysis

The seismic hazard analyses were performed and concluded that the project lies is minor seismic hazard zone. However, during detailed design stage a detail analysis would be made and parameters so established will be used in structural and foundation design. The equipment design would also be required to cater for these seismic parameters.

## 1.9. Selected Layout

The location and layout of the preferred layout has been selected on the basis of unit cost analysis. The preferred layout is such which offers minimum cost per kWh. Therefore, the project physical arrangement and overall characteristics have been configured for optimum hydropower development of the Gugera Hydro Electric Power Project having head available at RD 216+100 and RD 220+750. The project features have been selected considering foundation conditions, cost and schedule, constructability and environmental issues.

The preferred layout is the powerhouse and spillway placed in the bypass arrangement just upstream of Existing fall at RD 216+100 along its right bank. The spillway is placed along the left bank of powerhouse structures. The powerhouse and spillway are placed at RD 214+500 due to constraint of space on right side of the canal near RD 216+100 because of existence of Nankana Sahib Bridge. There is no need of canal diversion for construction of powerhouse and spillway. Powerhouse/spillway would be constructed under dry condition along right bank. After completion of construction of powerhouse and spillway the canal flows will be diverted toward them after connecting the headrace and tailrace on upstream and downstream of them.

The part between RD 212+000 and proposed powerhouse is called headrace canal. Its length would be 762 m. The headrace would be constructed new. As already written that powerhouse and spillway are placed at RD 214+500. The tailrace starts from downstream powerhouse transition and link the existing Gugera Branch canal just upstream of the Highway Bridge at same alignment with lowered bed level conditions.

Therefore, the Gugera Hydro Electric Power Project comprises of the following main components:

Headrace;

Powerhouse and spillway Intake Bay;

Powerhouse (Machine hall and Service bay) structure housing three Bevel Gear type turbines and generators with a total installed capacity of 3.6 MW;

Erection bay on right side of the Powerhouse;

Gated spillway along left bank of Powerhouse structure;

Powerhouse Outlet bay;

Tailrace;

Access road on left and right bank of Gugera Branch Canal;

Operation and maintenance staff colony and rest house and other civic facilities;

Turbine and generators;

Unit transformers and Switchgear, and

Transmission line and interconnection facilities.

## 1.10. Power Grid Interconnection

The project is proposed to be interconnected to the nearest LESCO 11KV grid at Walgan Sohail. Two06 km long11KV single circuit transmission lines have been proposed for dispersal of the power and energy generated. Steel reinforced (ACSR) Osprey conductors are foreseen which are according to the national standards. Synchronizing with LESCO grid system shall be done in the powerhouse control room. The powerhouse switchgear is the point of energy delivery to the LESCO/CPPA. Energy meters have been provided at the outgoing 11KV TLs for measurement of net energy delivered to LESCO/CPPA.

The proposed 11kV transmission lines are equipped with directional distance protection system with relays both in the 11 kV Substation and in the powerhouse. A back-up protection at both stations with directional over current relays is also included. Additional lightning arrestors have been provided at the outgoing section of Power Plant.

As per Policy, the construction of transmission line is the responsibility of the Power Purchaser(LESCO) or Power Seller, to be agreed in the PPA.

## 1.11. Environmental Impacts Assessment

The only impact associated with the project is the land acquisition. The land requirements are small and hence manageable. All other social, biological and physical impacts should be manageable. The primary impacts occur during the construction phase, which can be managed by applying appropriate management practices such as: (1) avoid contamination from fuel spills; (2) manage noise levels; (3) minimize sediment runoff; and (4) promote health and safety of workers. The social pressures placed on the surrounding communities due to the temporary construction workers can be managed by providing additional services to the extent necessary.

## 1.12. Power and Energy Studies

Power and energy studies were made using a daily flow and water level data. Constant efficiencies for turbine (95%), gearing system (98.5%), generator (98.5%) and transformers (99%) were used in power and energy estimation. Flow data for the years 2008-2013 was used. The estimated average annual energy delivery to the power purchaser, at the powerhouse, is 20.80GWh per year, assuming historic canal flows. Power and energy was estimated by considering constant upstream water level and also the historicabs served pond level. The difference in energy generation is not significant.

## 1.13. Project Cost and Schedule

It is anticipated that the project will be constructed under the terms of turnkey contract, with the expectation that construction of the civil works, equipment supply and installation would be carried out in a period of about 36 months.

The estimated base cost is about Rs1398.436 million, expressed at the December 2014 price level, without escalation and interest during construction (IDC) but inclusive of cost of transmission line but has been considered in financial calculations described later. Estimates reflect aggressive cost control and services contracts negotiations, and a management and design philosophy to minimize costs.

### 1.14. Economic Analysis

An economic evaluation of the project clearly indicates that it can provide electricity at a reasonable cost that is competitive with other electrical generation alternatives and could be implemented to serve electricity demand in the area. In the analysis, the total life-cycle economic costs of the hydroelectric project are compared to the total life-cycle economic costs of generating an equivalent amount of electricity from combined-cycle gas turbine stations. Benefit cost ratios greater than one were obtained for all conditions and alternatives investigated.

### 1.15. Financial Analysis

The primary objective of undertaking this kind of analysis is to determine whether the contribution of a particular project in the shape of added value of benefits is adequate enough to justify the use of already scarce resources needed for construction and operation of the project in the form of project investment cost. As financial analysis is basically carried out from the view point of project owner rather than the economy as a whole, it specifically aims to:

- determine the costs and returns of the project under reasonable financing plan
- establish a framework demonstrating the financial viability of the project during financial negotiations for project financing and capital investment
- assess repayment capability of the project

### 1.16 Project Base Cost

The project base cost is a mix of local and foreign currency components. The local currency cost is required for payment of land compensation, construction, tools and supplies, inland transportation, insurance, etc. which, in this case, amounts to about 66.48% of the total base cost including transmission line cost. The foreign cost is required for import of electro-mechanical equipment like generators, turbines, auxiliaries, etc. which, in this case, amounts to about 33.52%of the total base cost. The year-wise phasing (during construction) of the project base cost and its break-up into local and foreign components is presented in Chapter 12 (Bill of Quantities and Cost Estimates).

### 1.17 Financial Cost

The financial cost of the project includes interest during construction (IDC) and custom duties. The power projects are exempted from import duties but are subjected to custom duties @ 5% on import of plant and equipment not manufactured locally (Refer hydel policy 2002). The escalation during construction has also been added @ 6.5% and 2.2% per annum on local and foreign components respectively. The IDC has been charged at the rate of 11.79% both on local and foreign currency components for the purpose of financial analysis only (not for tariff determination). The financial cost of the project is estimated as Rs1797.104 million

The project will yield both direct and indirect financial benefits. The direct benefits include annual power revenue obtained from sale of electricity generated by the project over its useful life. The indirect benefits will come in the form of savings of foreign exchange for importing an equivalent steam power plant, its annual maintenance cost and cost of fuel to be used for operating the plant. Only the direct benefits of the scheme via power revenues have been used to assess the financial viability of the project.

The proposed project may supply 3.6 MW of power and generate 20.80GWh per annum at its generation bus-bar but shall be able to deliver about 20.38GWhofenergyannuallyat LESCO/CPPA grid. The expected financial benefits throughout the life of the project are estimated as Rs356.42&355.12millionper annum with & without CDM respectively. Only 85% of the CDM benefits are attributed for the first ten years after the operation of the project, as the remaining 15% have to be paid as consultancy charges for the arrangement of CERs and after 10 years of plant operation, full CDM benefits are attributed to the project. CDM benefits are taken @ 1.5$/ton.

Energy from the project is assumed to be available at a constant rate throughout the life of the project. The power benefits from this project will thus be available from sale of power subject to the prevailing demand. Power benefits have been estimated by assuming likely constant sale price of energy and O&M costs. The likely sale price for estimation of power revenues has been obtained by escalating the average energy sale price of Rs8.94 per kWh in 2012-13 @ 10% per annum to Rs17.42 per kWh in the year 2019-20.

To determine the financial viability of the project 98% of gross power benefits have been attributed to generation facility and only 2% auxiliary losses have been assumed. The results of financial analysis are given in Tables15.2 and 15.3, which show that the project yields financial rate of returns of 18.87%and18.80% with and without CDM benefits respectively, which is greater than the prevailing interest rates and hence makes the project viable.

The financial analysis was designed primarily to establish a revenue stream meeting.

### 1.18 Tariff

The levelized tariff has been computed over 30 years of useful life of the project, which comes to Rs9.658 per kWh, equivalent to US Cents 9.469 per kWh. The tariff is subject to revision on the basis of firm EPC cost after COD.

## 1.19 Conclusions and Recommendations

The project is found to be technically sound, environmentally manageable, economically viable, and financially workable. The next steps of the project development should include:

(a) Establishing third-party services agreements for professional engineering, financial, and legal advisory services necessary to support on-going development efforts.

(b) Negotiating a preliminary power purchase agreement with Power Purchaser or CPPA, with transparency provisions to permit an adjusted tariff based on an agreed rate of return and procedure, once the project financing and procurement contracts are in place. This approach is required to avoid the fixing a tariff that cannot support financial feasibility, and is beneficial to both CPPA and Client.

(c) Tariff approval from NEPRA and PPDB

(d) Coordination with the Government of Punjab for managing and securing all necessary government clearances required for the project, and acquisition of all land required for the project.

(e) Soliciting and securing preliminary financing commitments for the debt portion of the financing plan.

(f) Soliciting prequalification packages for the equipment procurement. At the same time, conduct any additional studies and investigations as may be necessary to minimize design and construction risks, and prepare tender documents for construction services and equipment procurement.

(g) Establishing an aggressive, but reasonable, project completion schedule to minimize interest costs accumulating during construction.

(h) Finalizing contractor selection, tariff negotiations and financial closure, and proceeding with the construction, testing and commissioning of the facility as expeditiously as possible.

(i) The preliminary designs completed as part of this Feasibility Report are, in many respects, at a stage beyond what is customarily considered feasibility-level. Procurement can proceed based in part on the criteria, preliminary descriptions, and the drawings presented in this Feasibility Report. However, detailed performance specifications and testing guidelines need to be prepared.

(j) The project is consistent with current national Policy, which promotes development of economically feasible indigenous energy resources, and encourages private sector investment. The results of the financial analysis indicate that the tariffs required to support financial feasibility are in line with the real costs of other generating technologies that are available to Power Purchaser/ LESCO/CPPA.

# SECTION 2

# TOPOGRAPHIC AND HYDROGRAPHIC SURVEYS

# SECTION 2
# TOPOGRAPHIC AND HYDROGRAPHIC SURVEYS

## 2.1 Introduction

This section describes topographic survey and mapping including preparation of contour maps of Upper Gugera Branch Canal. These contour maps will be used for preparation of the project alternative layouts, design and quantities.

Bench marks has been installed in the project area. Details of bench mark points are presented in Annexure: 2-1 (Volume II of this Report). M/s IM Associates, Lahore was hired to carry out the topographic survey and canal cross sections and preparation of the topographic maps.

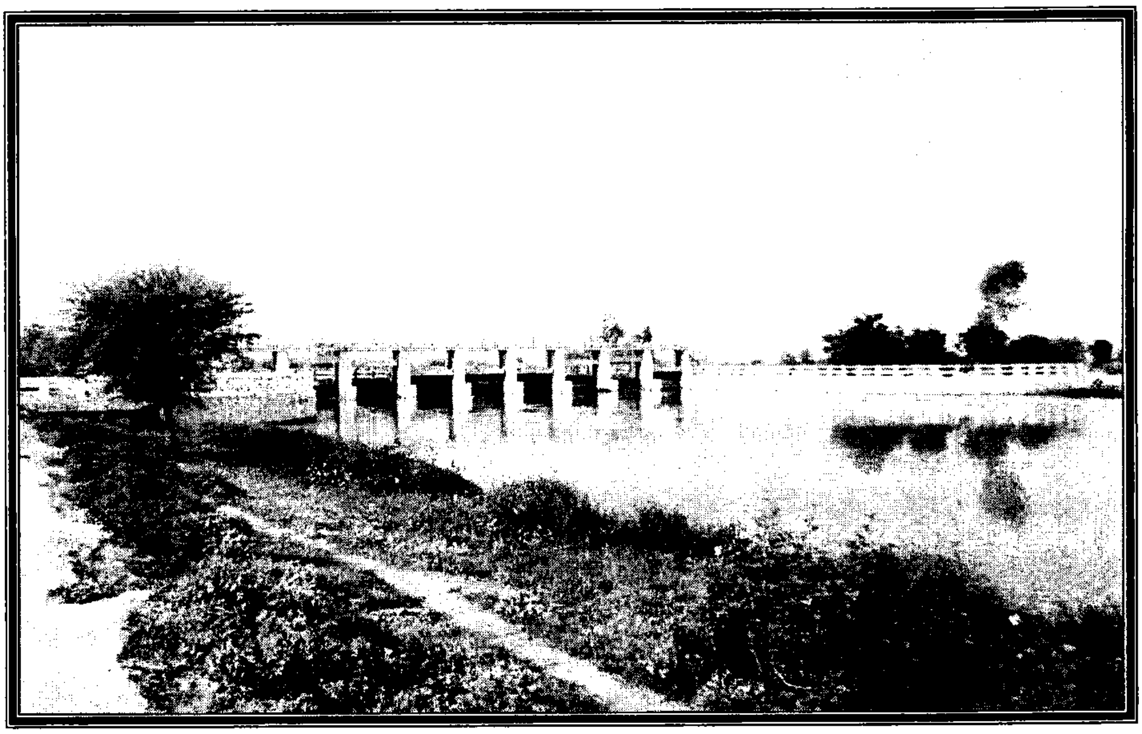


**Figure 2-1: Head Regulator and Fall Structure at RD 216+100 Upper Gugera Branch Canal**

## 2.2 Mapping and Cross Section Survey

### 2.2.1 Purpose and Scope of Work

Topographic and hydrographical surveying was carried out for preparing basic site plan and contour map of the project area. Mapping was used for project planning, quantity estimates, construction cost estimates and preparation of concept design documents for the project. Cross sectional surveying of Upper Gugera Branch Canal was also carried out to record the bed level and water depth in the canal.

Surveying and mapping included:

- Production and installation of ten survey markers along the both banks of Upper Gugara Branch Canal starting from RD 214+000 upstream of head regulator at RD 216+100 and up to RD 221+000 downstream of fall structure at RD 220+750.
- Traverse connection and vertical control of all control points.
- Topographic survey in sufficient detail of the proposed area to support preparation of 0.5 m contour interval maps at 1:1000 scale.
- Cross-section from RD 214+000 to RD 221+000 were observed at every 500 ft.

**Figure 2-2: Fall Structure at RD 220+750 Upper Gugera Branch Canal**

### 2.2.2 Description of Work

The topographic surveying was conducted with total station of Sokia Model 630 RK and Auto Level of Sokia B - 20 Magnification "32-X". Topographic maps were prepared using computer survey software. The maps contain planimetric features coming across during the field surveys, including houses, roads (paved and unpaved), cultivated lands, vegetation, electric and telephone lines, trees and other built-up properties. Topographic features such as roads, tracks, spot elevations of water surfaces of Upper Gugara Branch Canal as well as high and low points and depressions are shown on the maps to describe the project area.

All vertical positions are reported relative to SOP datum, and horizontal positioning is based on SOP Easting and Northing coordinates observed through Global Positioning System (GPS) and verified with the drawings received from Executive Engineer office of Irrigation and Power Department at Sheikhupura.

## 2.3 Benchmarks and Control Points

### 2.3.1 Primary Survey Control

Prior to the commencement of the topographic and levelling surveys, ten primary control Points (Survey Markers) have been established along the both sides of canal. A primary control survey was carried out to determine x and y co-ordinates of the primary control Points by traversing. The elevations of the primary control Points were also determined with reference to SOP datum.

Survey Markers shown in Annexure: 2-1(Volume II of this Report) have been established on stable position along the canal. The survey markers were embedded twenty four inches into the ground and six inches above the ground with steel rods, exposed 5mm above the surface so that they will not be disturbed during the construction works and maintained throughout the construction period. Sufficient space has been provided around each Survey Marker to enable survey instruments to be erected and operated.

Each Survey Marker has been marked with its reference number. Description sheet for each Survey Marker was prepared and attached in Annexure: 2-1 (Volume II of this Report).

### 2.3.2 Secondary Survey Control

Secondary control points to provide a suitable basis for the topographical survey along road and other sites were established. The survey was carried out to determine X, Y and Z co-ordinates of secondary control points by traversing.

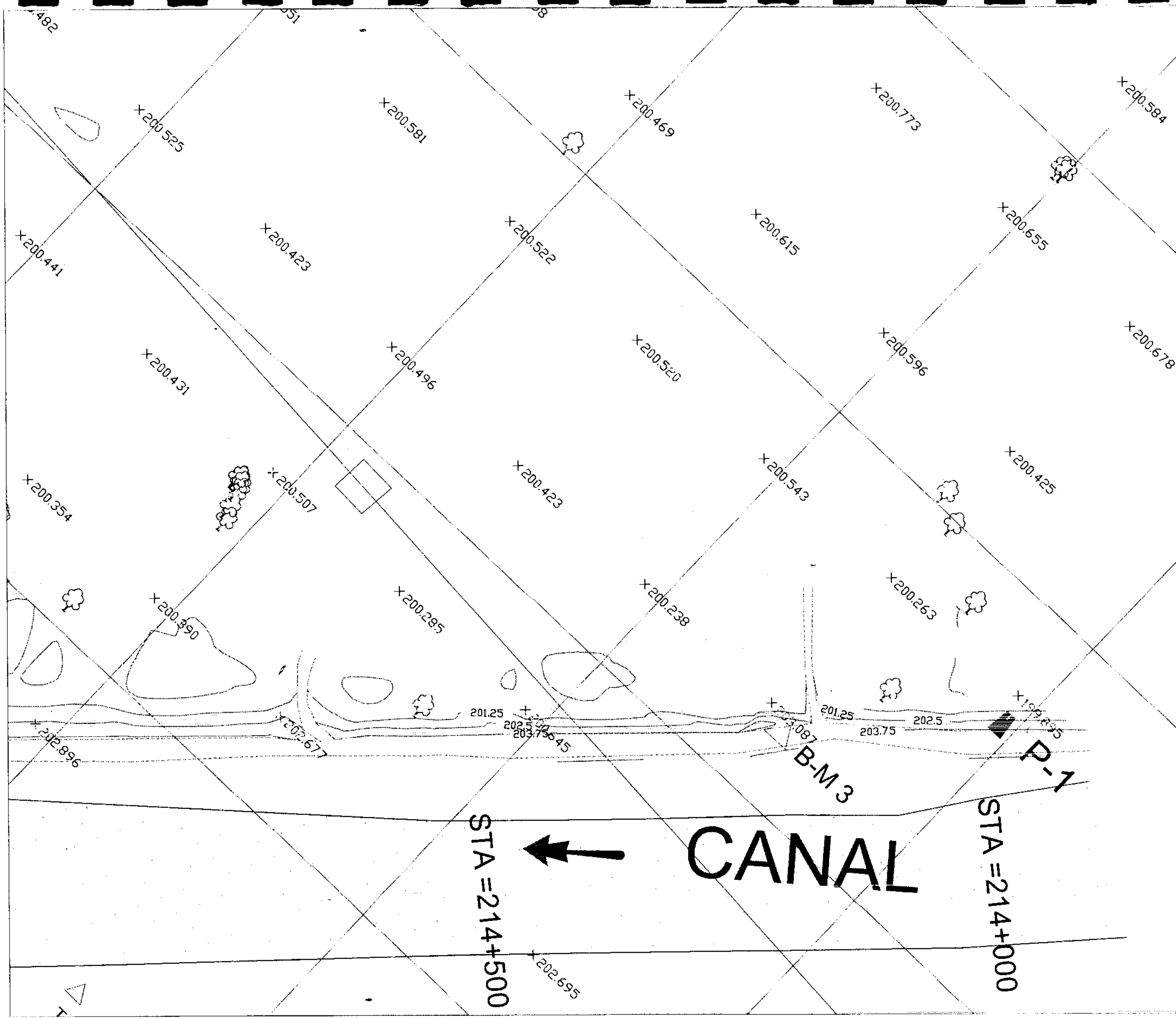
The secondary control points were located so that minimum of two adjacent points inter-visible. The points have been located to fully enclose the required area for topographic survey at sufficient distance from the proposed sites.

## 2.4 Topographic Mapping

A plane topographic survey incorporating man-made features such as roads, buildings, tracks, canals, trees, water levels, bridge cum fall structure at RD 216+100 and fall structure at RD 221+750 etc. was carried out to prepare map on scale 1:1000 by using the grid co-ordinates and heights of the established control points. Features for contouring, elevations were picked up at every change of slope and these are presented in Drawing:2-1 through Drawing: 2-7.

## 2.5 Canal Cross Sections

Cross-sections were observed at every 500ft of Upper Gagera Branch canal. The cross-sections cover both the canal banks up to the natural ground level and canal bed level. These cross-sections were observed to study the canal behaviour. These cross-sections would also be used for estimation of excavation quantities when combination of falls would be considered. These cross-sections are presented in Drawing: 2-8 through Drawing: 2-11.

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## LEGEND

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- TRACK
- KM STONE
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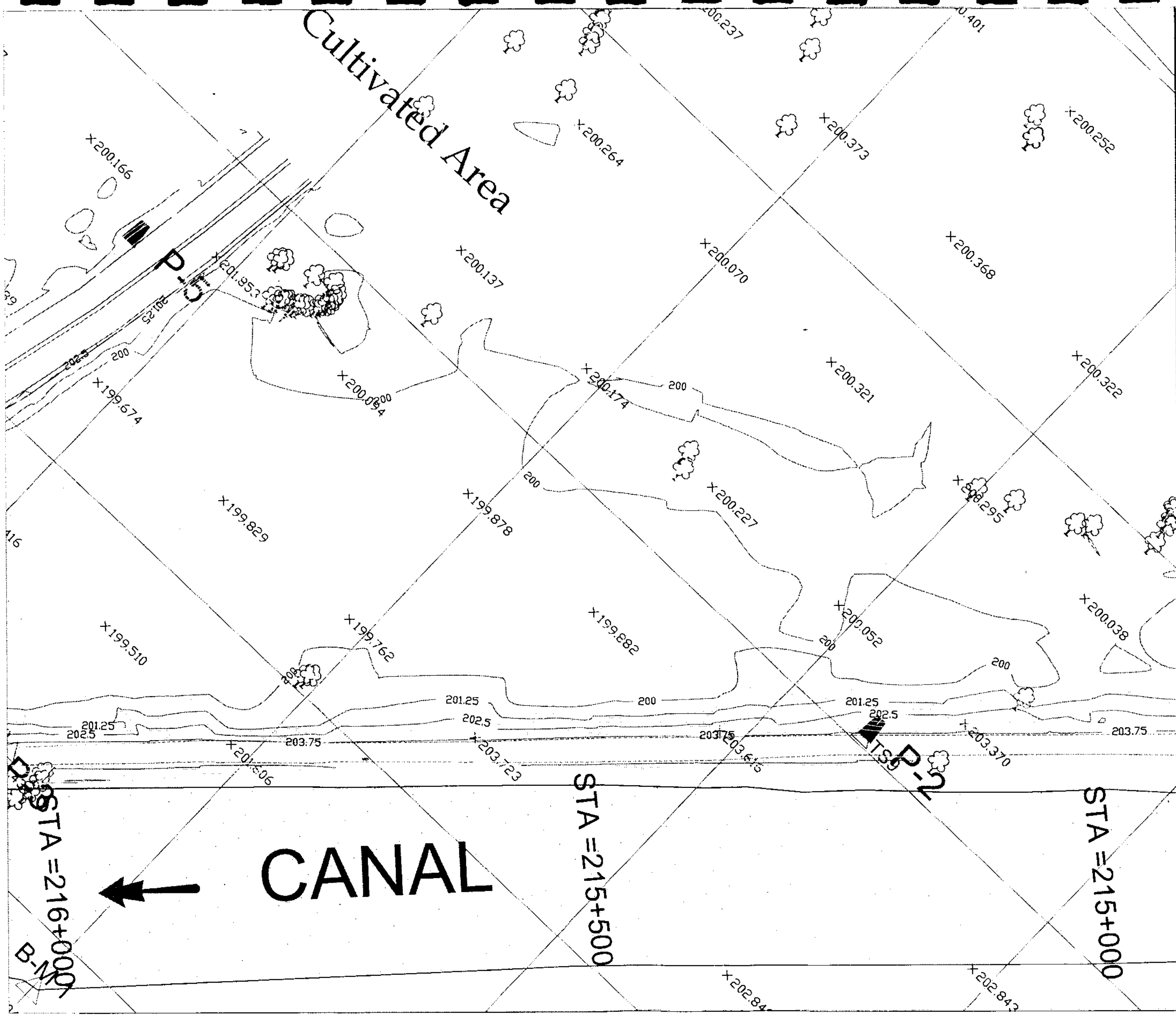
- TREE PALM
- NALA
- SOLLING
- WATER COURSE
- SIGN BOARD
- TS
- MOSQUE
- TUBE WELL — TW
- GATE
- CANAL
- WALL

**NOTES:**

Contour Interval 0.5 m
All dimensions are in Meters.

SCALE

| | |
|---|---|
| **CLIENT:- M/s Gugera Hydro Power Co. (Pvt) Ltd.** | |
| team | Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan. |
| **UPPER GUGERA BRANCH** | |
| **FEASIBILITY STUDY REPORT** | |
| Design by / Checked by / Approved by | **SITE TOPOGRAPHY (SURVEY)** |
| DATED: March 2014 | SCALE: 1 : 1000 — DRAWING No: 2-1 |

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## LEGEND

| | |
|---|---|
| BUILDING | |
| BOUNDARY | |
| BENCH MARK | B-M 1 |
| ELECTRIC POLE | EP |
| POND | |
| FENCE | |
| ROAD | |
| TRACK | |
| KM STONE | |
| HAND PUMP | |
| TREE 15' | |
| TREE PALM | |
| NALA | |
| SOLLING | |
| WATER COURSE | |
| SIGN BOARD | |
| TS | |
| MOSQUE | |
| TUBE WELL | TW |
| GATE | |
| CANAL | |
| WALL | |

**NOTES:**

Contour Interval 0.5 m

All dimensions are in Meters.

SCALE

**CLIENT:- M/s Gugera Hydro Power Co. (Pvt) Ltd.**

Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

**UPPER GUGERA BRANCH**

**FEASIBILITY STUDY REPORT**

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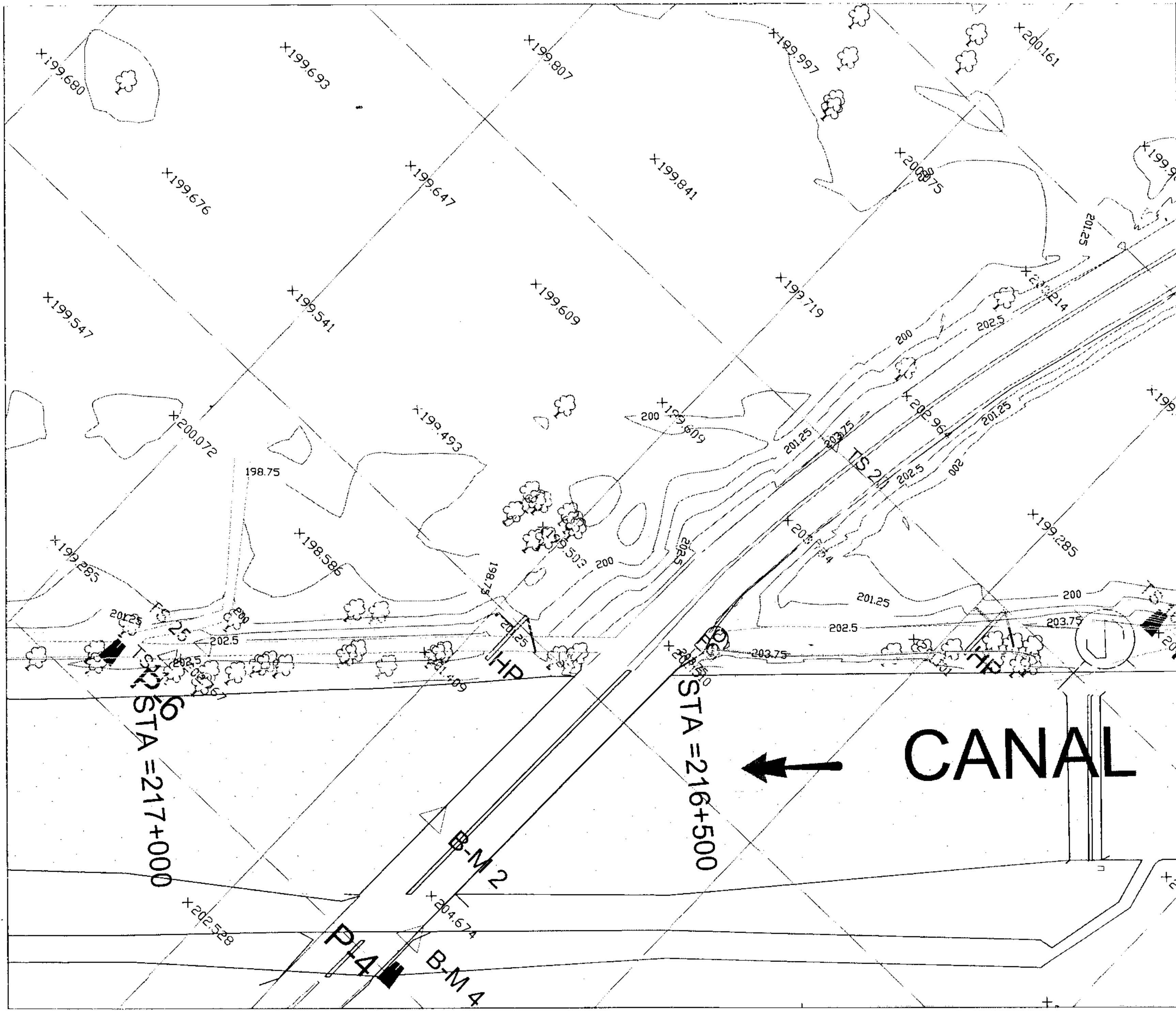


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**NOTES:**

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All dimensions are in Meters

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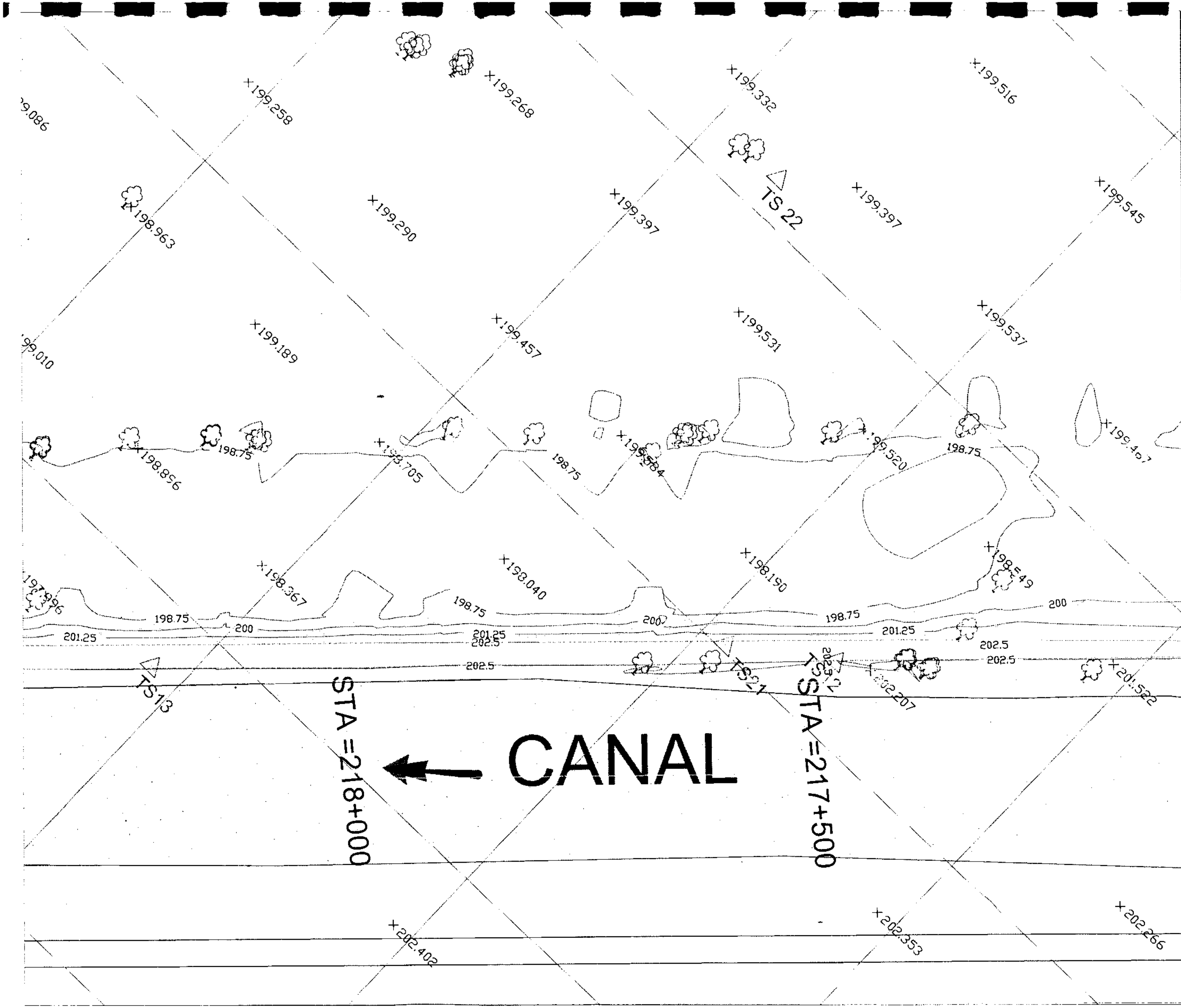


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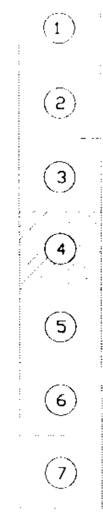


## LEGEND

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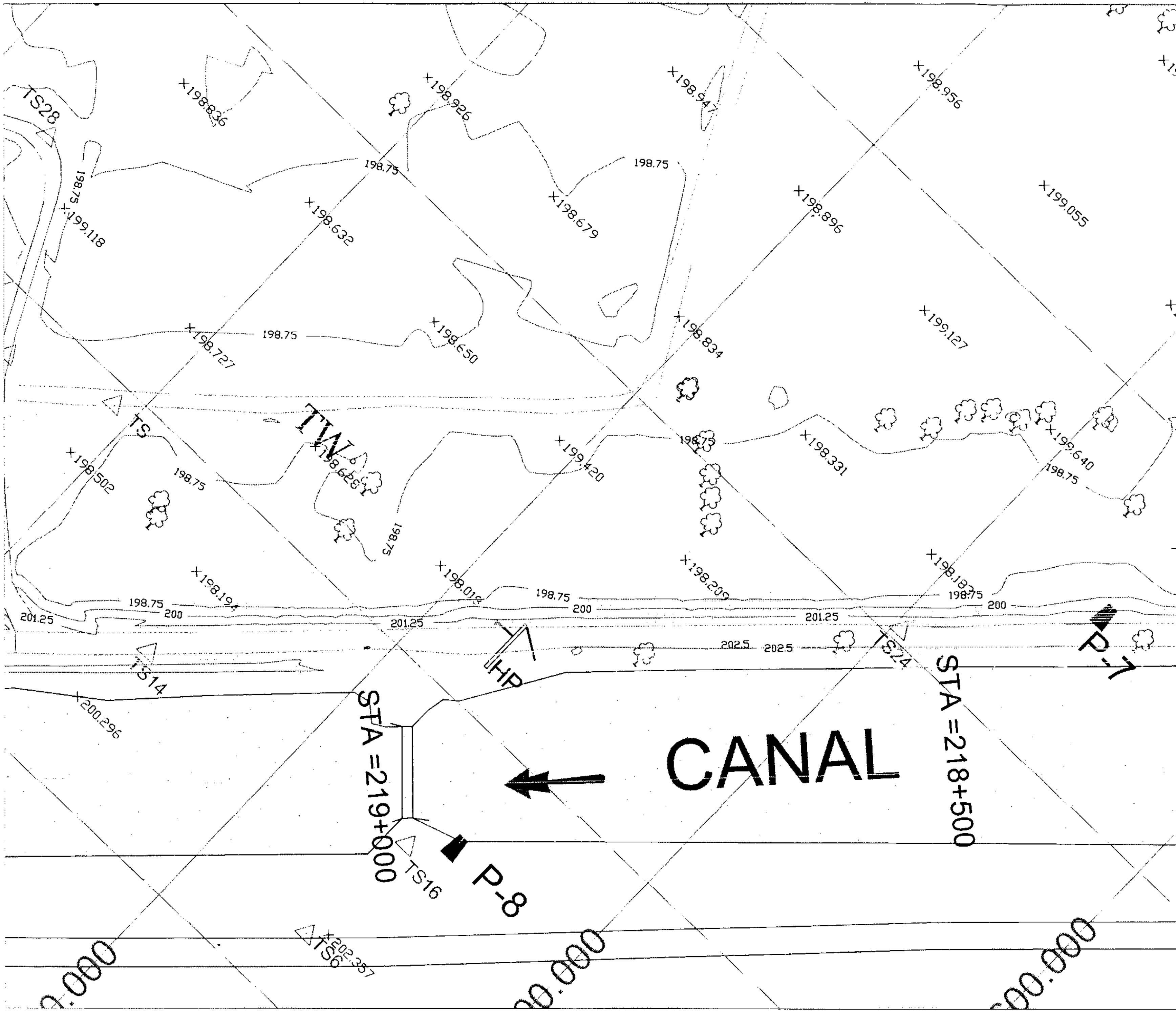


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**NOTES:**

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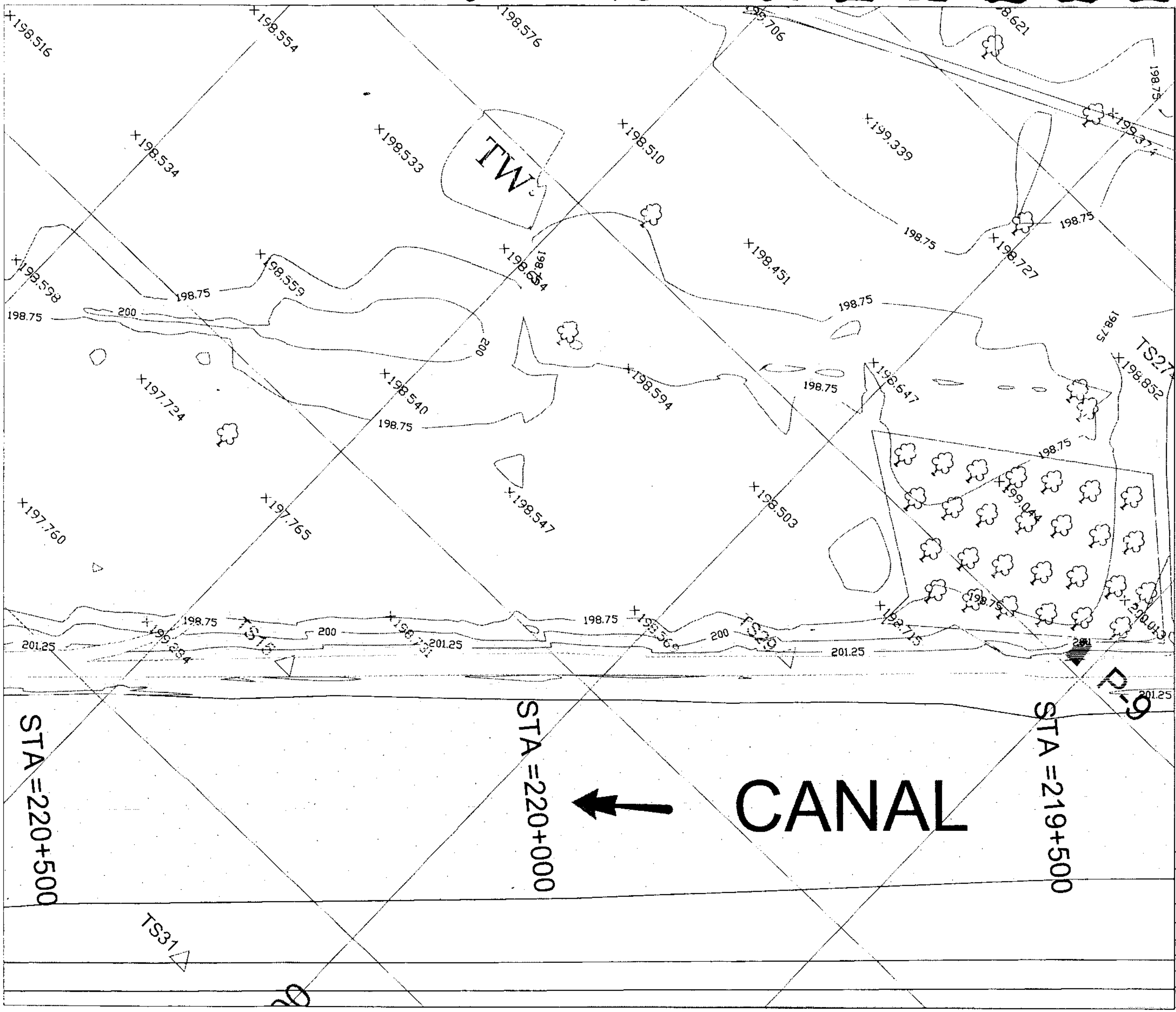


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| TUBE WELL | TW |
| GATE | |
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| WALL | |

**NOTES:**

Contour Interval 0.5 m

All dimensions are in Meters.

SCALE

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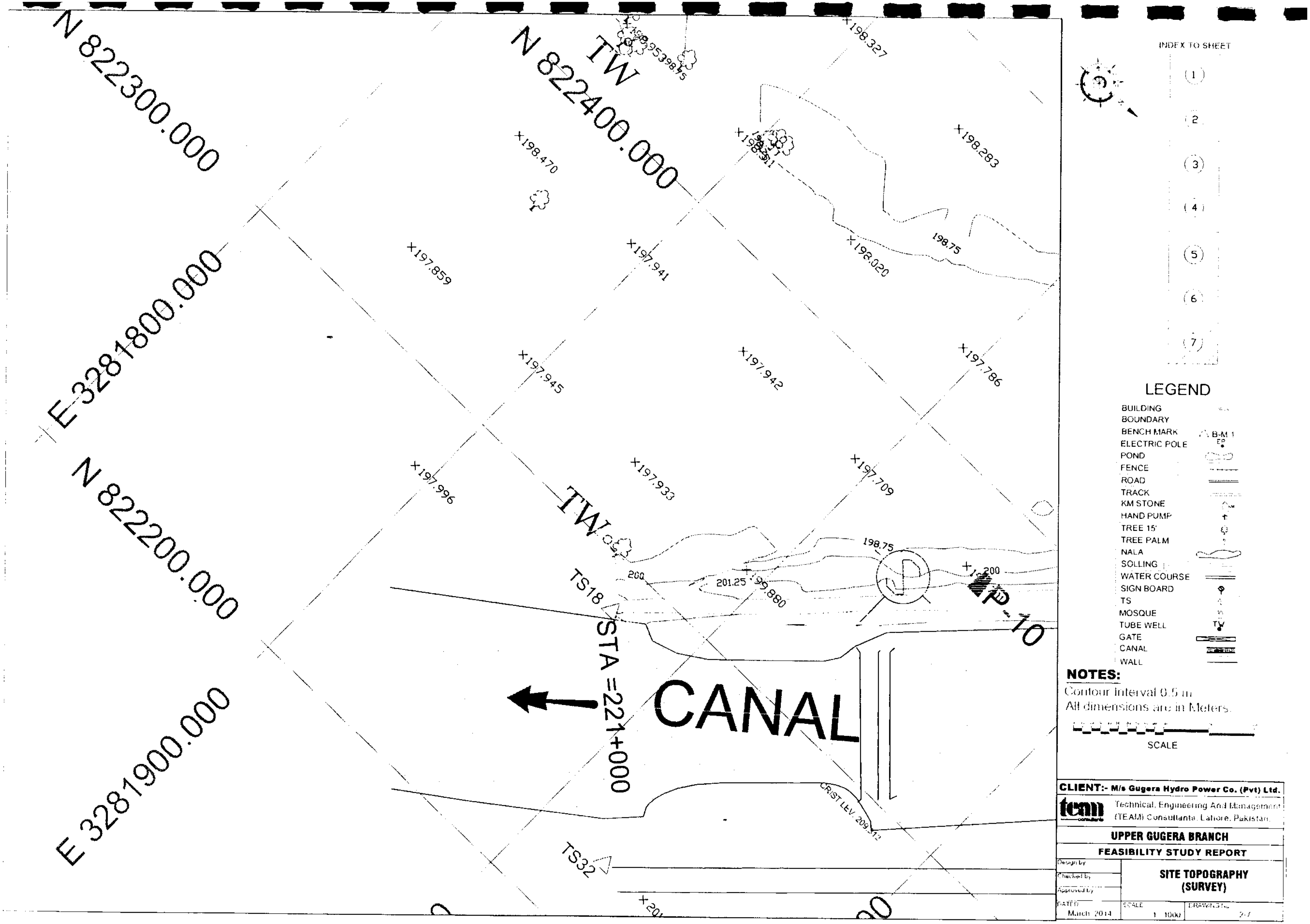


**NOTES:**

Contour Interval 0.5 m

All dimensions are in Meters.

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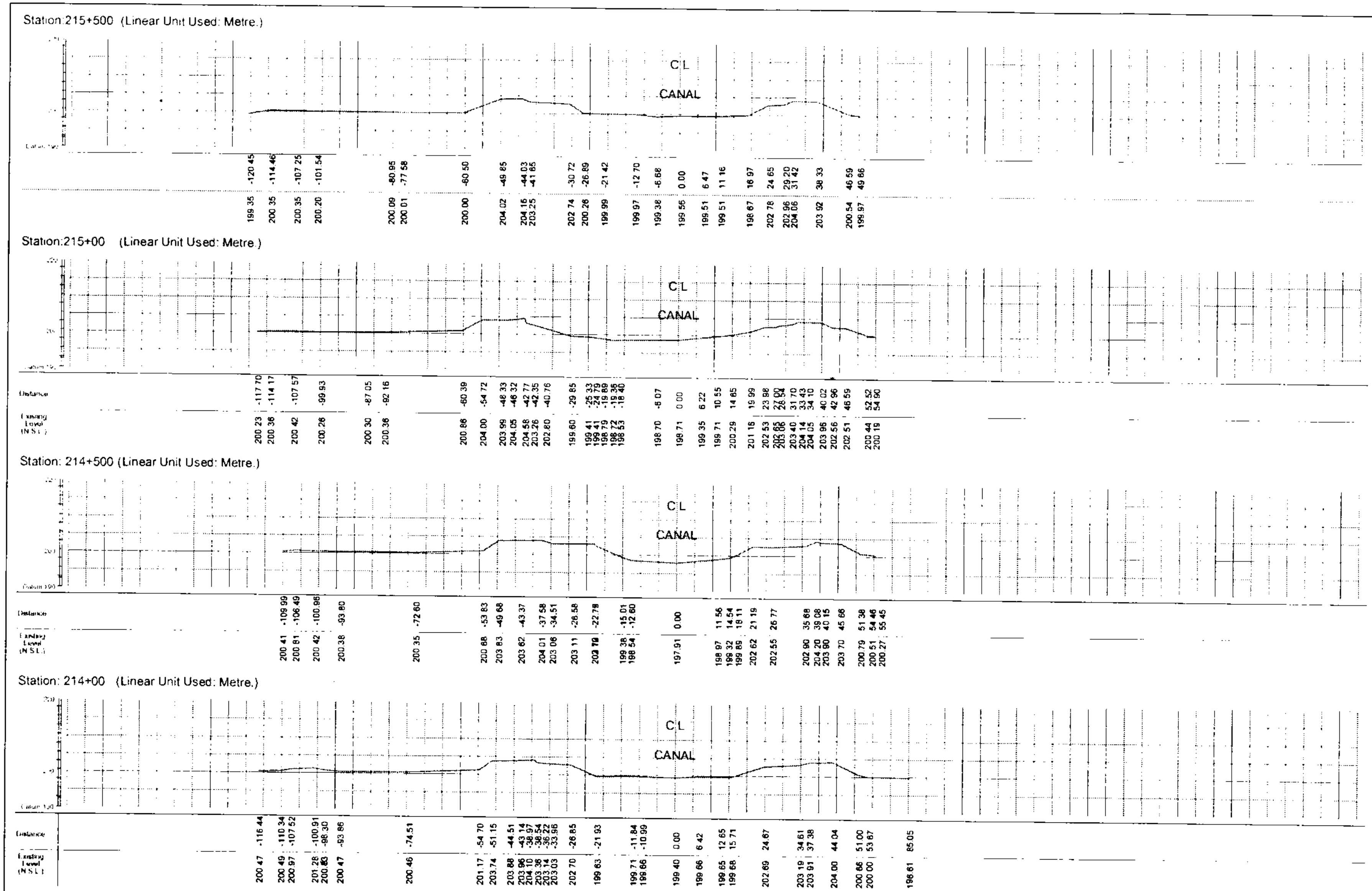


1. All dimensions are in meter.
2. All levels are in meter above sea level. (masl)

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| Approved by | |

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| March 2014 | 1 1000 | 2-8 |

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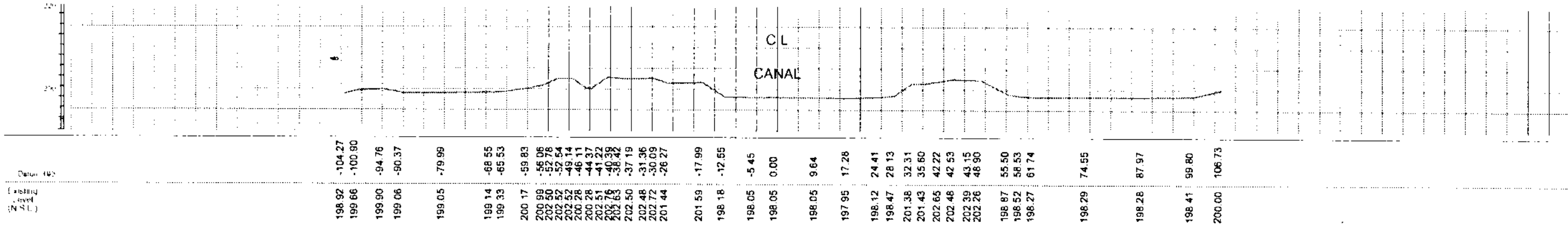


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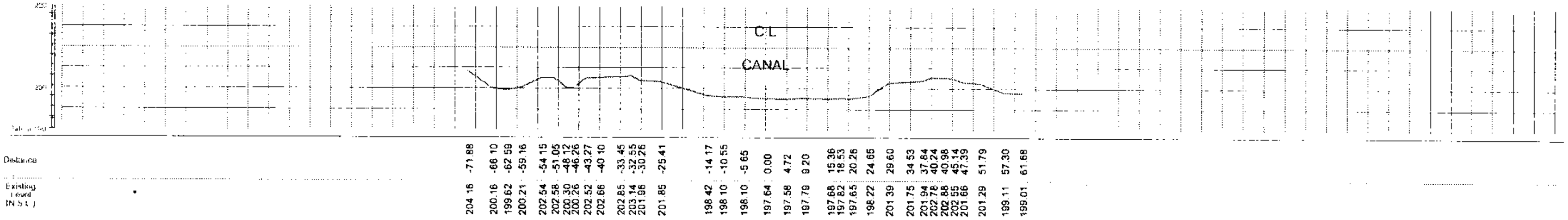


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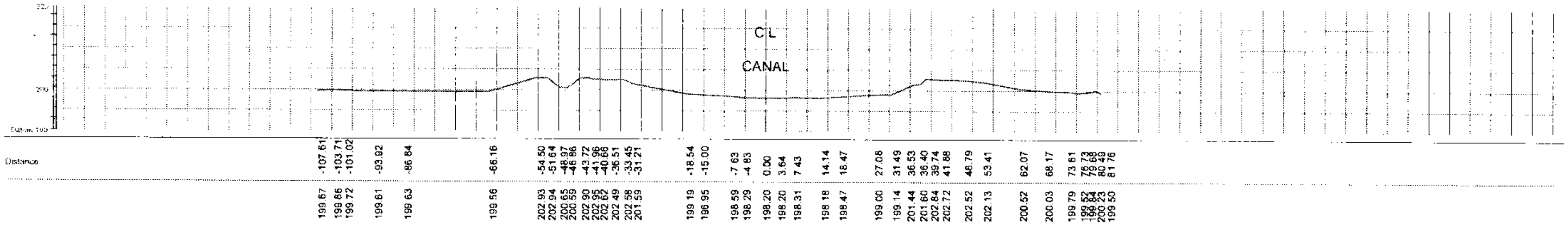


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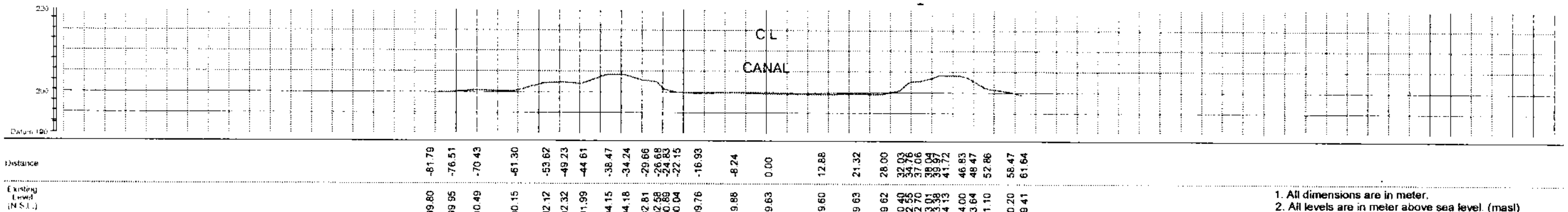


1. All dimensions are in meter.
2. All levels are in meter above sea level. (masl)

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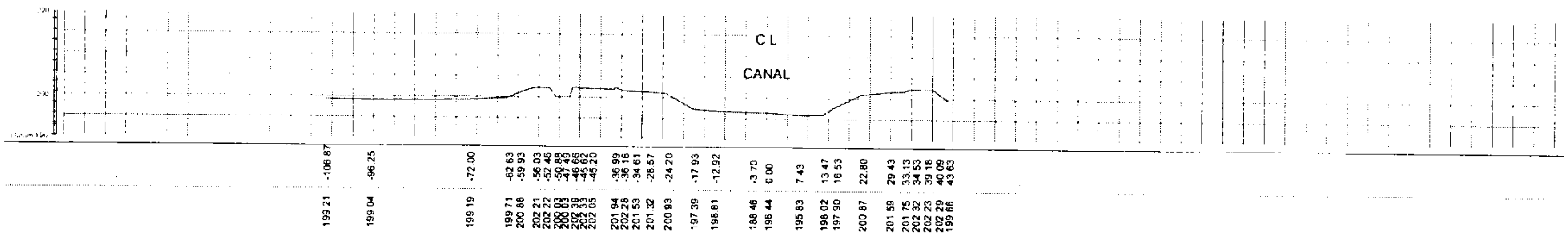
Station:219+500 (Linear Unit Used: Metre.)

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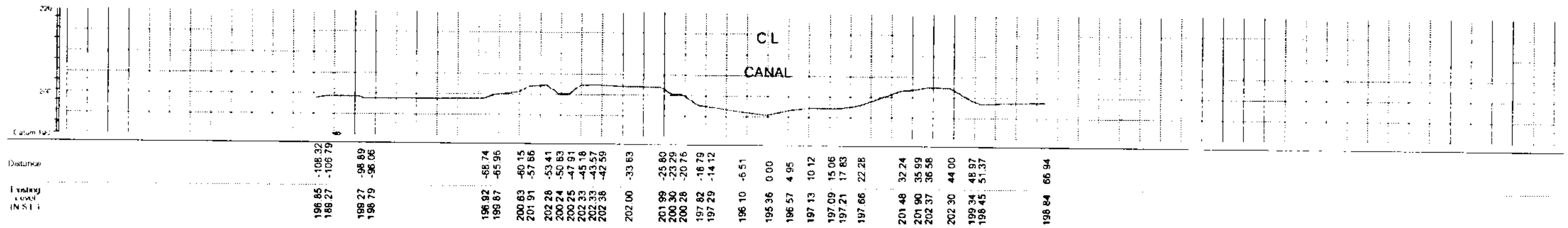


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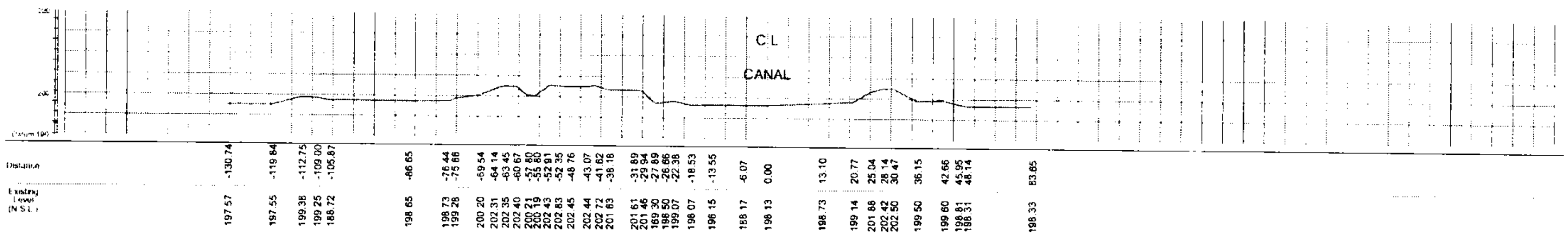


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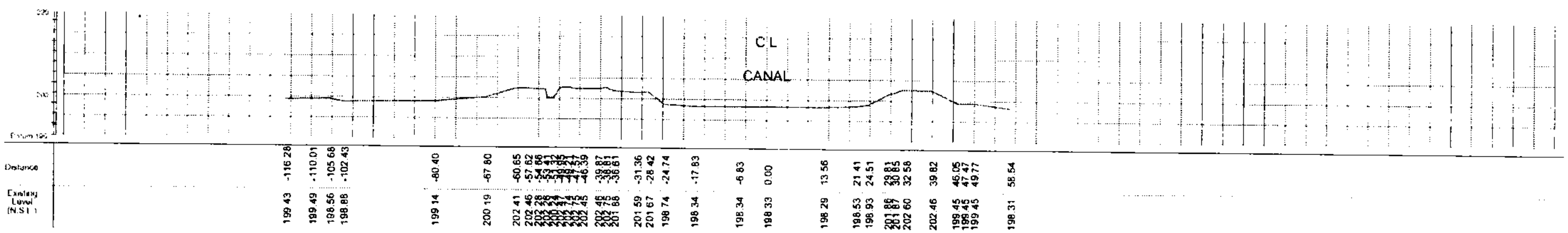


1. All dimensions are in meter.
2. All levels are in meter above sea level (masl)

| | |
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| team | Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan. |
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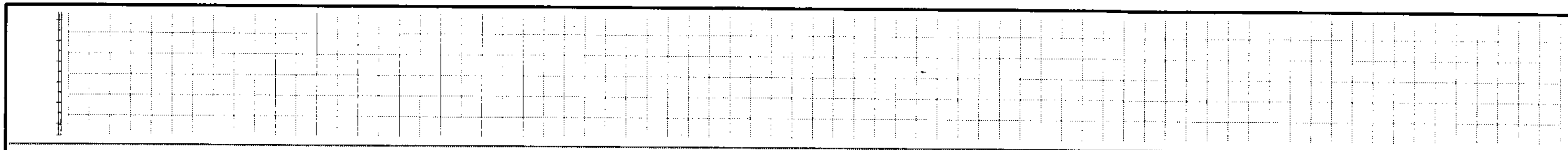
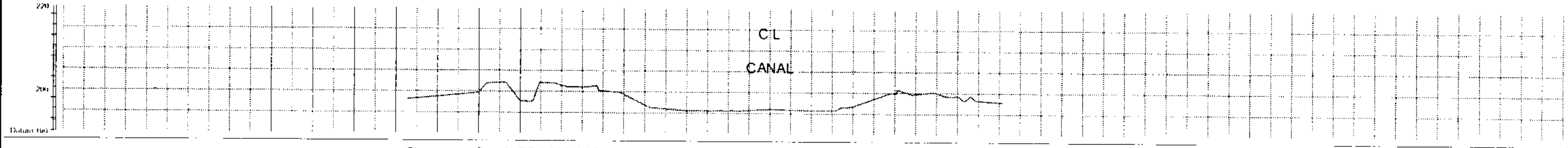
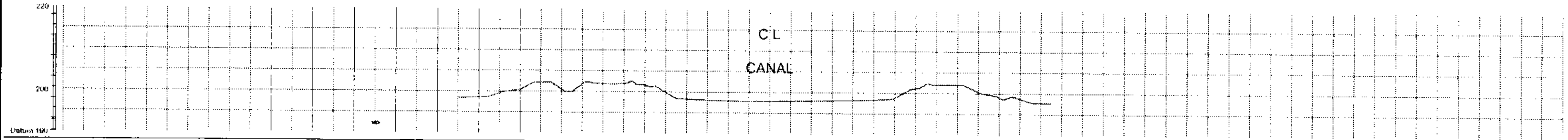


Station:221+00 (Linear Unit Used: Metre.)



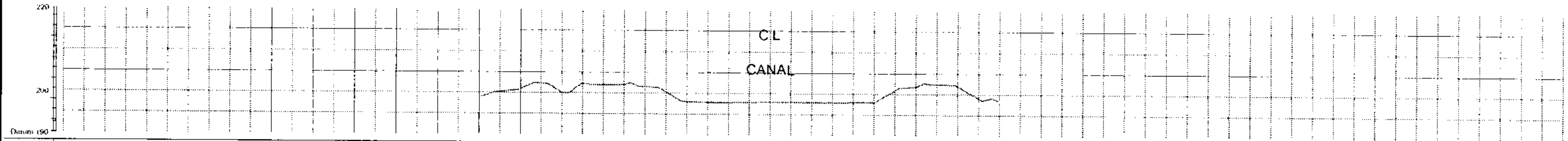

| Distance | Existing Level (N.S.L.) |
|---|---|
| -87.25 | 198.19 |
| -70.20 | 199.74 |
| -68.01 | 202.06 |
| -63.52 | 202.17 |
| -60.00 | 197.80 |
| -56.99 | 197.74 |
| -55.34 | 202.15 |
| -52.13 | 202.07 |
| -51.23 | 201.96 |
| -50.23 | 201.54 |
| -47.48 | 201.17 |
| -44.38 | 201.13 |
| -41.60 | 201.46 |
| -40.93 | 200.37 |
| -38.45 | 200.10 |
| -36.05 | 199.98 |
| -28.69 | 196.78 |
| -28.64 | 196.38 |
| -25.40 | 196.15 |
| -20.21 | 195.66 |
| -7.22 | 195.65 |
| 0.00 | 196.10 |
| 9.01 | 195.84 |
| 15.87 | 195.86 |
| 16.95 | 196.59 |
| 19.64 | 196.71 |
| 27.07 | 199.34 |
| 29.19 | 200.08 |
| 30.60 | 200.83 |
| 34.13 | 199.72 |
| 39.49 | 200.25 |
| 42.29 | 199.27 |
| 44.11 | 199.30 |
| 44.91 | 199.44 |
| 46.64 | 198.22 |
| 48.08 | 198.41 |
| 49.48 | 198.30 |
| 55.67 | 197.93 |

Station: 220+500 (Linear Unit Used: Metre.)




| Distance | Existing Level (N.S.L.) |
|---|---|
| -74.72 | 198.36 |
| -67.35 | 198.72 |
| -63.81 | 199.96 |
| -60.08 | 200.39 |
| -56.75 | 202.12 |
| -52.52 | 202.16 |
| -49.22 | 199.97 |
| -47.43 | 199.98 |
| -44.53 | 202.16 |
| -43.14 | 202.24 |
| -41.51 | 201.96 |
| -38.69 | 201.85 |
| -34.58 | 201.95 |
| -33.04 | 202.54 |
| -32.19 | 201.83 |
| -30.34 | 201.68 |
| -28.83 | 201.56 |
| -27.58 | 201.38 |
| -22.57 | 198.43 |
| -16.67 | 198.14 |
| -6.63 | 197.81 |
| 0.00 | 197.88 |
| 8.13 | 197.98 |
| 17.21 | 198.09 |
| 27.24 | 198.42 |
| 29.61 | 198.62 |
| 33.86 | 200.93 |
| 35.78 | 201.25 |
| 37.90 | 202.40 |
| 38.91 | 202.02 |
| 46.39 | 202.04 |
| 50.60 | 200.04 |
| 54.51 | 199.36 |
| 55.86 | 198.54 |
| 58.04 | 199.28 |
| 63.02 | 197.79 |
| 67.38 | 197.73 |

Station: 220+00 (Linear Unit Used: Metre.)




| Distance | Existing Level (N.S.L.) |
|---|---|
| -69.34 | 199.07 |
| -66.25 | 200.16 |
| -60.56 | 200.73 |
| -56.86 | 202.35 |
| -53.32 | 202.21 |
| -50.11 | 200.08 |
| -48.29 | 200.02 |
| -45.34 | 202.23 |
| -44.34 | 202.30 |
| -43.32 | 202.04 |
| -39.83 | 201.99 |
| -34.80 | 202.09 |
| -33.58 | 202.50 |
| -31.46 | 201.64 |
| -26.76 | 201.39 |
| -21.41 | 198.10 |
| -21.15 | 198.13 |
| -19.42 | 197.94 |
| -12.24 | 197.85 |
| 0.00 | 197.97 |
| 12.49 | 197.95 |
| 25.13 | 198.01 |
| 30.98 | 201.52 |
| 35.10 | 201.91 |
| 36.91 | 202.66 |
| 38.41 | 202.45 |
| 44.31 | 202.34 |
| 49.12 | 199.59 |
| 50.88 | 198.59 |
| 53.19 | 199.15 |
| 54.61 | 198.56 |

1. All dimensions are in meter.
2. All levels are in meter above sea level. (masl)

**CLIENT:- M/s Gugera Hydro Power Co. (Pvt) Ltd.**

team consultants — Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

**UPPER GUGERA BRANCH**

**FEASIBILITY STUDY REPORT**

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# SECTION 3

# PROJECT ACCESS, COMMUNICATION LINKS AND EXISTING FACILITIES

# SECTION 3

## PROJECT ACCESS, COMMUNICATION LINKS AND EXISTING FACILITIES

### 3.1 Introduction

In this chapter of the report, the access routes both via roads and railway starting from Karachi Port to the project site are described. It also covers other communication links such as telephone, telegraph, internet, etc available in the country and especially in the project area. Quality of drinking water and water require during project construction is also described in this chapter.

The project site is located in District Nankana Sahib of Punjab Province which is well populated and rich in agriculture.

### 3.2 Project Location

The project is located along Gugera Canal which is off-taking from Lower Chenab Canal at RD 104+500. The Lower Chenab Canal is off-taking from left bank of Khanki Headwork along Chenab River, the second river flows controlling structure in Pakistan.

The project site is located in District Nankana Sahib, located in North-South of city of Lahore, the Capital City of Punjab Province. The site is located in Upper Punjab which is the heart of agriculture. The project location map is place at **Drawing No. 3-1**.

The project vicinity map is placed in **Drawing No. 3-2** which shows that the project site is approximately 70 kilometers from Lahore, the Capital of Punjab and 30 kilometers from Sheikhupura. The project site is located about 12 km from Nankana Sahib, the district headquarters and the Holy City of Sakh Religion.

### 3.3 Project Access

The project site and area is located in the province of Punjab in District Nankana Sahib which is accessible by good roads and railway network (**Drawing: 3-2**). The air, road and railway access routes which are best to approach the site are defined below;

#### 3.3.1 Airport and Air Links

The Pakistan is linked with international community through air links. A number of airports are operating in Pakistan and receiving International and national flights. Allama Iqbal International Airport Lahore and International Airport Fasialabad are the nearest airport to the project area and site.

The road distance from these airports are such as:

i. Lahore to Site via Lahore-Faisalabad dual carriageway = 70 km

ii. Faisalabad to Site via Lahore-Faisalabad dual carriageway = 67 km

### 3.3.2 Ports of Shipment

Pakistan is also linked with International community via sea and at present three shipping ports are operating. Karachi port and Port Qasim are in or near the port city of Karachi and Port of Gawadar is in Province of Balochistan. All of these ports are being operated by Port Trust and capable of handling all types of ships and cargo. Port of Qasim is presently the biggest and capable of handling each and every type of cargos and goods. It is deep sea port and all kind of ships can enter into the port.

Gawader is the second port and is in process of expansion and would be the biggest port is South Asia and be serving the China and Central Asian States in the future.

These ports are linked with other part of the country through good network of railway and roads. Karachi the port city is linked with Lahore via Multan-Shahiwal and Bawalpur-Pakpattan. Karachi is linked with Lahore via Supper highway and National and in future would be linked via Motorway.

### 3.3.3 Railways Network

The project area is located in District Nankana Sahib of Punjab Province. The nearest railway is Sheikhupura which lies on the Lahore-Faisalabad Railway network. The nearest railway stations where loading and unloading of heavy equipment is possible are Sheikhupura and Lahore. These stations are along Main Railway track from Karachi and Lahore. The Lahore is on the main track of Lahore-Karachi section and is the terminal point of this section.

**Figure 3.1: Sheikhupura Railway Station-Loading & Unloading Bay**

Loading and unloading facility is available at Sheikhupura railway station but cranes of suitable capacity are not available. Usually consignee is responsible for the arrangements of crane if required from local market.

Lahore is 1092 km from Karachi seaport and Sheikhupura is about 40 km from Lahore.

Anyhow Lahore railway station has the facility of dry port and all kind of loading and unloading.

### 3.3.4 Roads Access Network

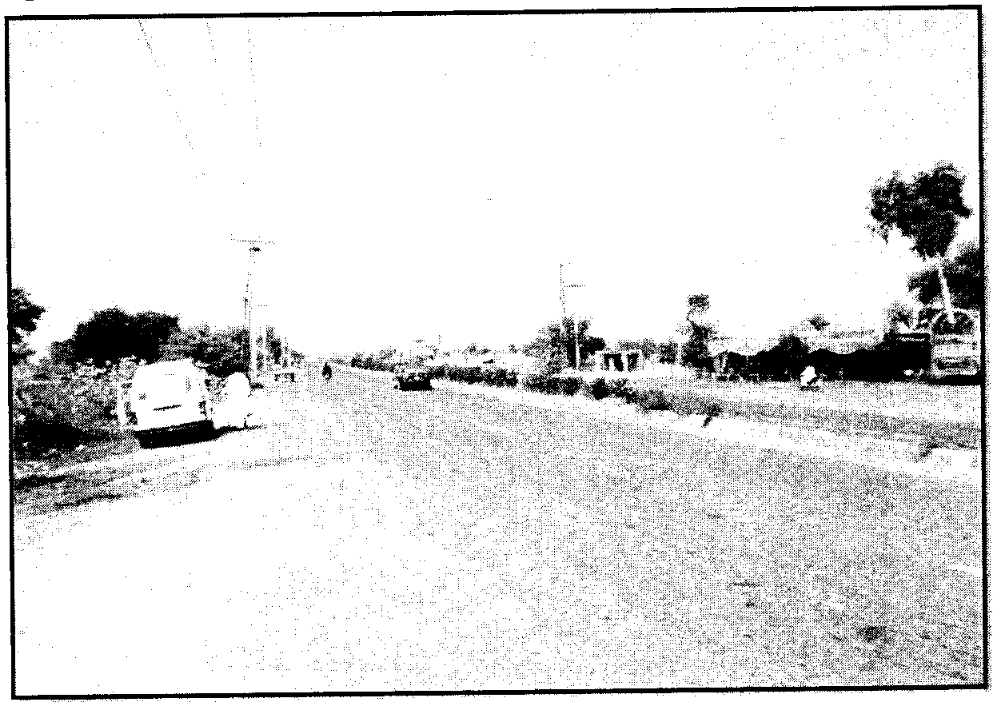
The following two (2) most suitable road routes are available to access the Project area and project site from port city of Karachi. However, there exist some other options which are not considered suitable.

**Roads Route 1 (Karachi-Lahore-Sheikhupura-Project Site Via GT Road)**

Karachi to Lahore 1092 km via N-5. The National Highway 05 or the N-5 is Pakistan's longest highway running from the port city of Karachi to the border crossing at Torkham. Its total length is 1756 km and it runs north from Karachi located in Sindh to Hyderabad, Moro and Khairpur before entering to Punjab province where it passes through Bhawalpur, Multan, Sahiwal and reach at Lahore. It is managed by National Highway Authority.

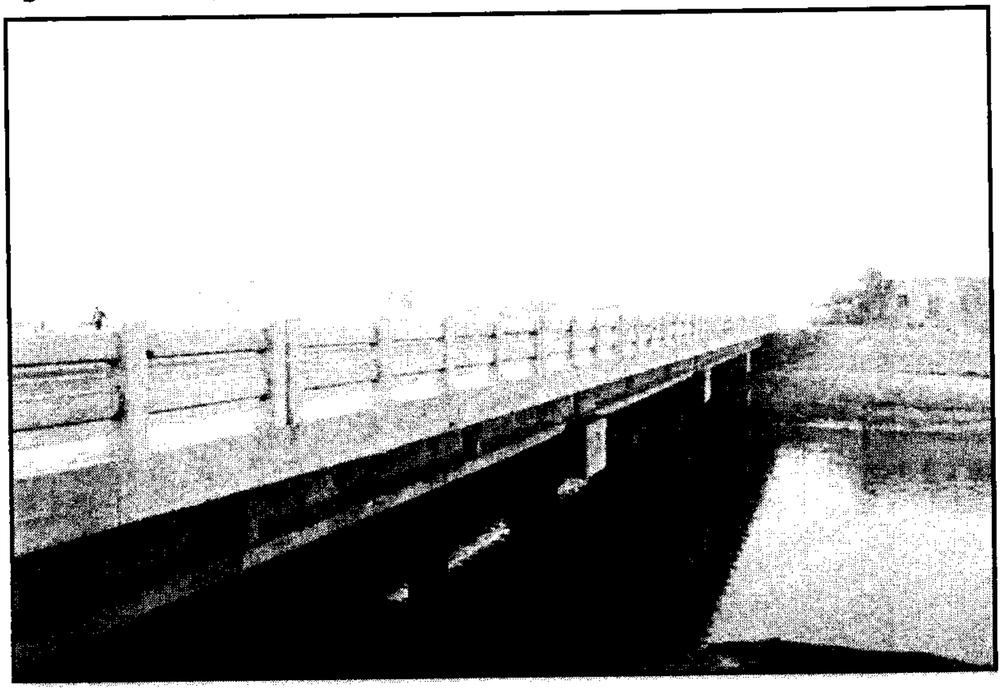
Karachi-Lahore GT Road, a 4 lanes road of good quality. Between Lahore and Sheikhupur and then to site its 4 lanes road called dual carriageway being maintained and operated under private sector.

**Figure 3.2 Lahore-Faisalabad Dual Carriageway**



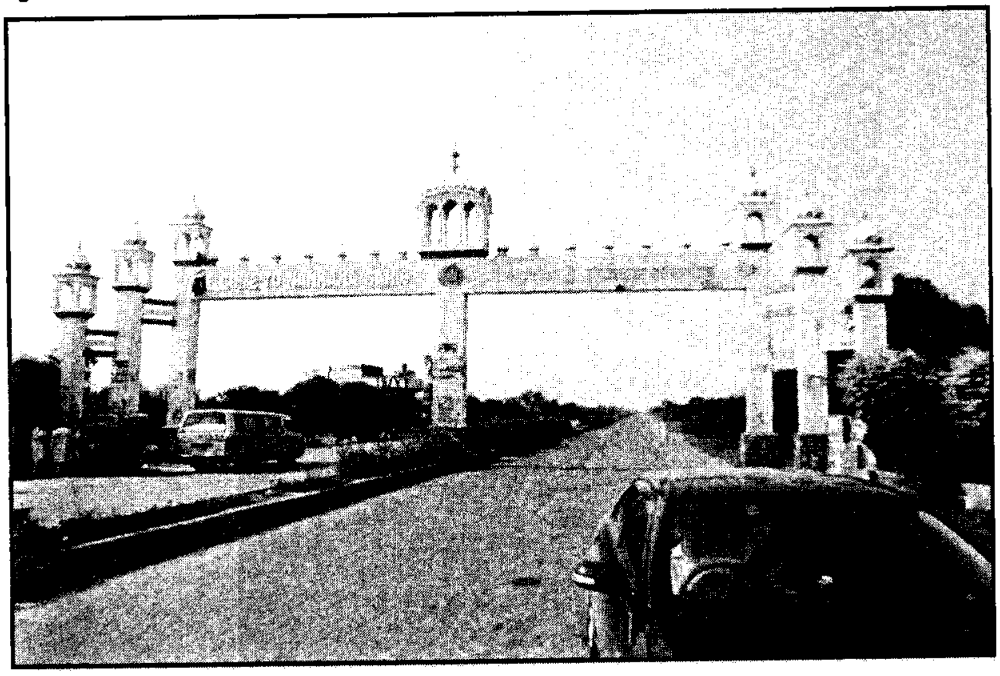
Lahore-Faisalabad dual carriageway crosses the Gugera Branch canal at RD 195+036 where a new concrete bridge has been constructed.

**Figure 3.3 Bridge along Gugera Branch Canal RD 195+036**



The site is lying along road leads to Nankansahib which off-take from dual carriageway near the village of Khambian Wala short of 2.74 km from Mananwala a small town along Faisalabad-Lahore dual carriageway.

**Figure 3.4 Nankan Sahib Road Off-taking From Lahore-Faisalabad Dual Carriageway**



Road to Nankansahib crosses the Gugera Canal at RD 216+150 about the possible location of the proposed Gugera Hydropower Project.

**Figure 3.5 Bridge along Gugera Branch Canal RD 216+150**

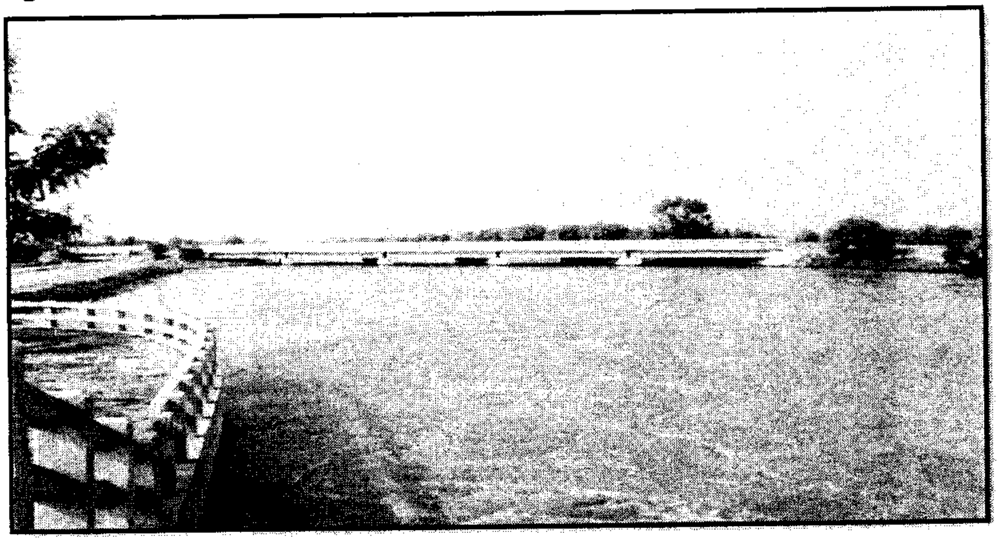
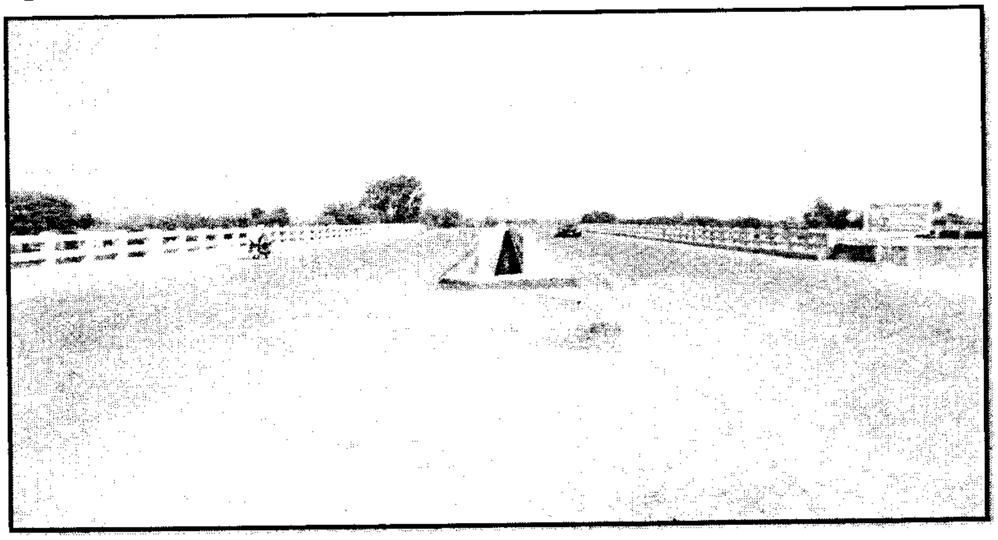


**Figure 3.6 Bridge along Gugera Branch Canal RD 216+150**



## Roads Route 2 (Karachi-Multan-Jhang-Faisalbad-Project Site)

Karachi to Multan via Bhawalpur travel along N-5 which is a 4 lanes good quality road. From Multan to Faisalabad via Jhang a 2 lanes road and from Faisalabad to site via Lahore - Faisalabad dual carriageway. This route may be shorter in distance than route -1 however, the road network of route-1 is better than this route.

### 3.4 Telephone/Internet

Telephone, telegraph and fax facilities are available in the project area, especially in the town of Ferozwatwan, Nankansahib, Sheikhupura and Lahore. Ferozwatowan grid station is about 3 km from proposed project site is connected to national grid of NTDC and also have the connection to all prominent town via telephone. The city of Ferozwatwan and Sheikhupura and Nankansahib are connected with other main towns of the country through the nationwide dialling system. International direct dialling (IDD) exists, too. Internet access is available with limited speed through the telephone network. Fast speed connections exist in the Nankansahib. In Lahore and Sheikhupura Internet facilities are much better than Ferozwatwan.

Further a number of Mobile Phone Companies and wireless phone companies are also operating in the project area. Now day mobile connection and its operation is much easier and cheaper in Pakistan.

### 3.5 Entertainment /Television

A number of television channels are being operated in Pakistan other than Pakistan Television Network. These are available via cable or dish. International channels are also available in the Project area. Cinemas are not available in the project area for films.

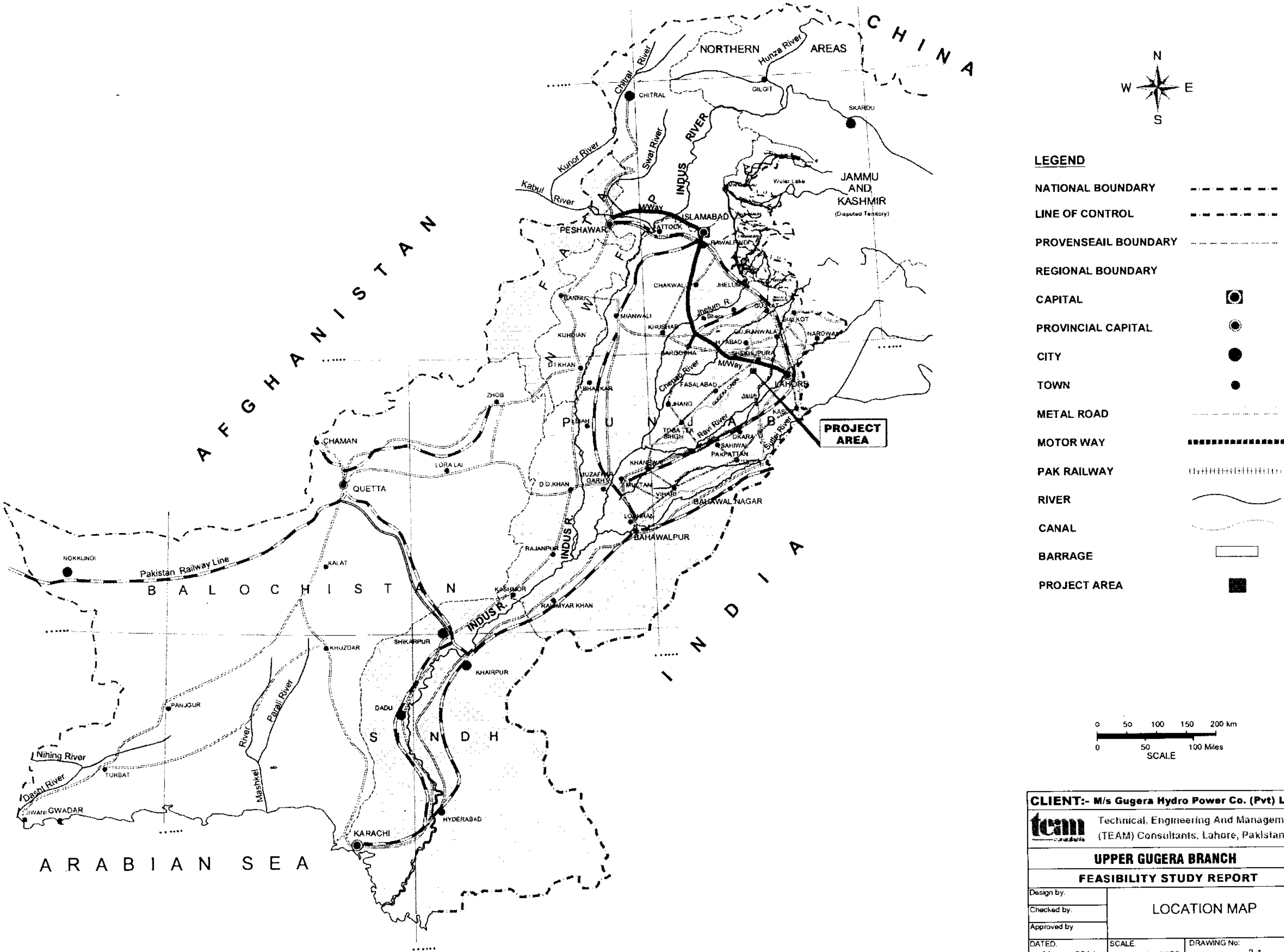
### 3.6 Drinking Water

Drinking water of good quality is available in the Project area. Gogera Canal is running through the area and acting as recharge source for the aquifer.

Ground water should also not at deep level and may of good quality due to existence of open water bodies in form of canals. However, there quality would be tested during geo-technical drilling and environmental investigation.

### 3.7 Petrol, Diesel and Lubricant

Shell Pakistan and Pakistan State Oil operating fuelling station along the Lahore-Faisalabad dual carriageway. The distance between project and these station is about 7 km and are approaching via Nankansahib road which has junction with Lahore-Faisalabad dual carriageway about 7.0 km.




**CLIENT:- M/s Gugera Hydro Power Co. (Pvt) Ltd.**

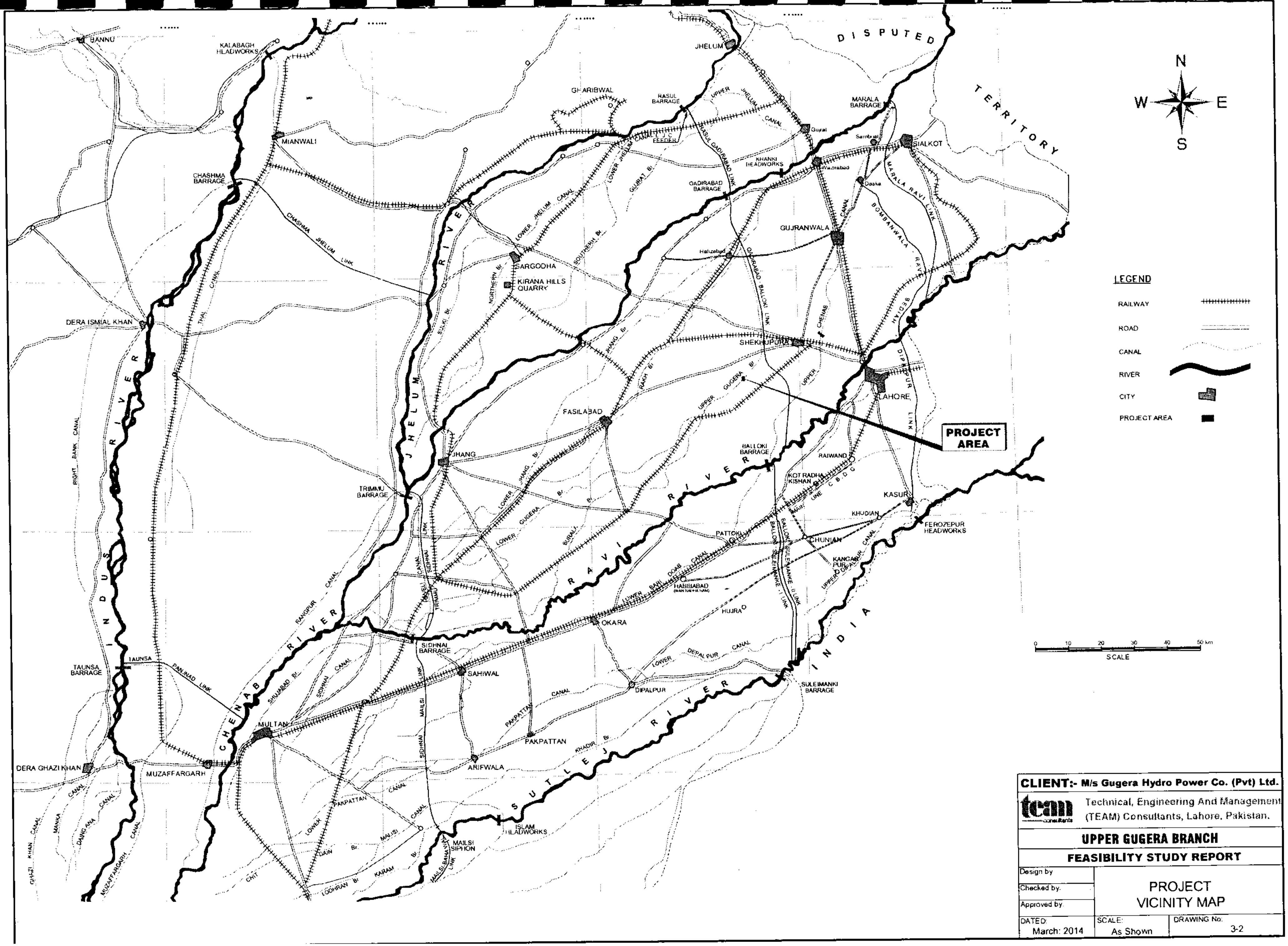
team consultants — Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

**UPPER GUGERA BRANCH**

**FEASIBILITY STUDY REPORT**

| | |
|---|---|
| Design by. | LOCATION MAP |
| Checked by. | |
| Approved by | |

| DATED. | SCALE. | DRAWING No: |
|---|---|---|
| March. 2014 | 1 : 5500 | 3-1 |




**CLIENT:- M/s Gugera Hydro Power Co. (Pvt) Ltd.**

team consultants — Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

**UPPER GUGERA BRANCH**

**FEASIBILITY STUDY REPORT**

| | |
|---|---|
| Design by | PROJECT VICINITY MAP |
| Checked by: | |
| Approved by: | |

| DATED: | SCALE: | DRAWING No: |
|---|---|---|
| March: 2014 | As Shown | 3-2 |

# SECTION 4

# LOWER CHENAB CANAL SYSTEM

# SECTION 4

# LOWER CHENAB CANAL SYSTEM

## 4.1 General

For assessment of availability of water at project location, it is necessary to understand the Lower Chenab Canal system which is off-taking from left abutment of Khanki Headworks. The Khanki Headworks exists along Chenab River and second diversion structure along Chenab River in Pakistan. Chenab River is one of the rivers of Indus Basin. This section of the report deals with Chenab River and structure built along it for storage and diversion of water for irrigated agriculture purposes.

## 4.2 Chenab River

Chenab river is part of Indus Basin River system and the third river of the western river on which Pakistan has water right under Indus Basin Treaty signed between India and Pakistan under the office of World Bank. It contributes a good part of water supply to the irrigated agriculture system in Pakistan.

The river Chenab originates in the Kulu and Kangra Districts of the Himachal Pardesh Province of India. The Two Chief streams of the Chenab - the Chandra and the Bhaba - rise on the opposite sides of Baralcha Pass at an elevation of about 4877 m (16,000 ft). These join at Tandi in the state of Jammu and Kashmir, nearly 2,770.6 m (9,090 ft) above mean sea level.

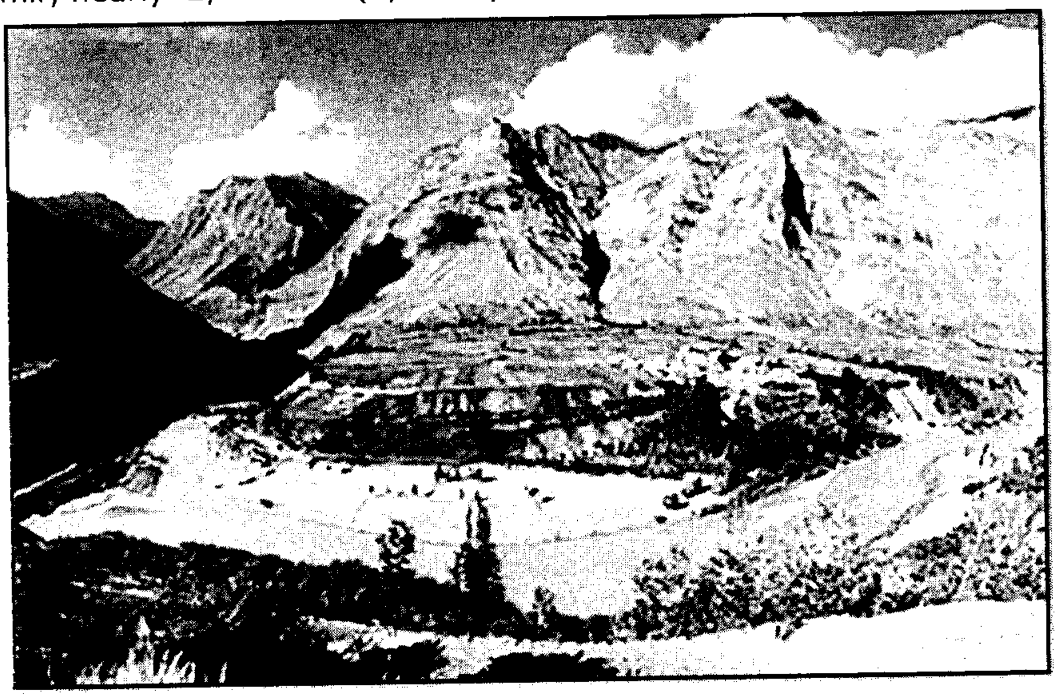


**Figure: 4.1 The Chenab River near Tandi in Jammu and Kashmir**

Chenab River fed by innumerable tributaries on the long journey from its headwaters, the river gains immense power and momentum on entering in

Jammu/Kashmir region above Kishtwar. From Kishtwar to Thatri (about 50 km) the Chenab runs through class V and Class VI gorges. The combined streams, traversing about 216.0 km (135 miles), take a sharp turn along Pir Panjal near Kishtwar. The Chenab River then flows along northern base of Pir Panjal range before entering the Doab area of Jammu and Kashmir. It cuts across this range through a spectacular gorge and then flows along its southern base, before flowing southwards and entering the plains. After traversing about 640 km (400 miles) of mountains regions and flowing at nearly 39 feet per mile, the Chenab opens out in to the plains near Akhnur. It enters Pakistan through the Sialkot District, near Diawara Village.

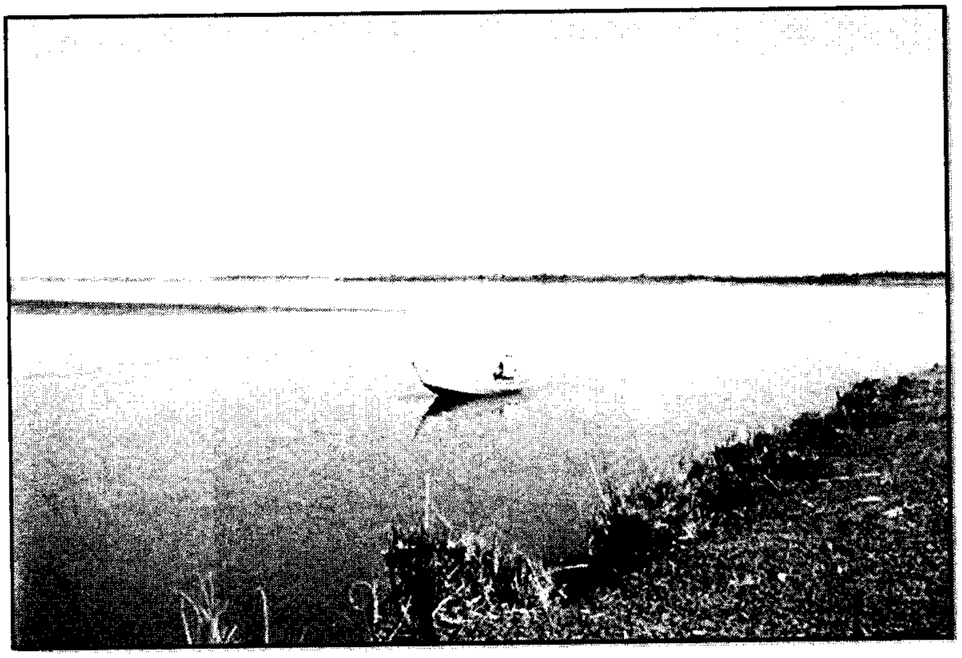


**Figure: 4.2 The Chenab River near Sialkot**

The Chenab flows through the alluvial plains of the Punjab Province in Pakistan for a distance of 661 km (413 miles). It is then join by the Jhelum River at Trimmu. The River Ravi join it 64 km (40 miles) downstream from Trimmu. The Sutlej River joins Chenab upstream of Punjnad and finally at about 64 km (40 miles) below Punjnad River Chenab meets the Indus River at Mithankot.

The total length of the Chenab River is about 1,235.2 km (772 miles), of which about 724.8 km (453 miles) in Pakistan. The catchment area is about 67,430 $km^2$ (26,035 $miles^2$)of which 28,166 $km^2$ (10,875 $miles^2$) lies in the State of Jammu and Kashmir, 4,494 $km^2$ (1,735 $miles^2$) in India and 34,367 $km^2$ (13,269 $miles^2$) in Pakistan. The hilly catchment area above Marala Barrage is about 32,660 $km^2$ (12,610 $miles^2$).

The Annual Average flows are 12.38 MAF (10.07 Kharif and 2.31 Rabi). The discharges of the Chenab starts rising in the late part of May and pass the 1415.48 $m^3/s$ (50,000 $ft^3/s$) mark in June. A high flow above 1415.48 $m^3/s$ (50,000 $ft^3/s$) continues till the middle of September, the peak discharge months being July and August. The important structures along Chenab River in Pakistan are Marala Barrage constructed in1968 with design discharge of 31,148.53 $m^3/s$ (1.1 million $ft^3/s$), Khanki Headwork constructed in 1891 with design discharge of 22,653.48 m³/s (800,000 ft³/s), Qadirabad constructed in 1967 have design discharge capacity of 25,485.16 m³/s (900,000 ft³/s), Trimmu Barrage constructed in 1939 with design discharge of 15,414.86 m³/s (615,000 ft³/s) and Panjnad Barrage constructed in 1932 with design discharge of 19,821.79 m³/s (700,000 ft³/s).

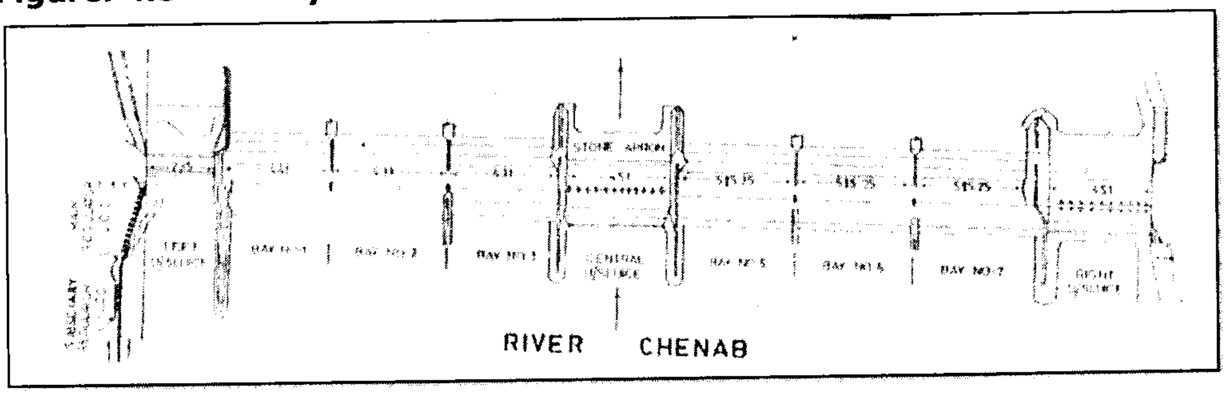
The Chenab has twelve major tributaries namely; Chandra, Bhaga, Bhut Nallah, Maru, Jammu Tawi, Manwar Tawi, Doara Nullah 1, Doara Nullah 2, Halse Nallah, Bhimber Nullah, Palkhu Nullah and Aik and Bhudi Nullah. The last eight tributaries join the Chenab in Pakistan.

## 4.3 Khanki Headwork

Khanki Headwork on river Chenab situated about 14.5 km downstream from Town of Wazirabad was built and made operational in the year 1892. This was the first weir in Punjab which had been founded on alluvial bed of the river. During 1932, sudden collapse of some major part was apprehended to take place. A lot of research was carried out by irrigation and hydraulic engineers especially work of Khosla wrote a theory which even today is considered to a bible for the design of hydraulic structures on alluvial/permeable soils. The weir 1336.24 m long constructed in the year 1892 with some latter additions consisted of;

a) Two canal head regulators at the left flank with crest of subsidiary regulator 1.524 m lower than the main regulator;
b) The left under-sluice of 12 spans of 6.09 m opening each;
c) A weir of 8 spans with widths of each ranging from 134.42 m to 156.97 m on which shutters had been provided to head up the water;
d) Bridges on two regulators and left under-sluice with 3.048 m wide road way. A rope way cradle over 8 weir spans had been made for to and from movement of the supervisory and operation/maintenance staff from one end of the river to the other.

**Figure: 4.3 Layout of Old Khanki Weir**




A new barrage is under construction. DESCON Engineering is the main contractor, however, a joint venture of local and international consultants lead by M/S SMEC Australia are the in-charge of design and construction supervision. The new barrage is proposed to be constructed about some kilometre downstream from the existing weir and head part of the Lower Chenab Canal would have to be remodelled. The new barrage would consists of two under-sluice having 5 bays on each bank and main weir in the centre having 55 bays. Width of each bay would be 18.3 m with pier width 2.133 m. Two fish ladders are provided along the under-sluice divide walls.

The Lower Chenab Canal off-takes from existing headwork left bank as shown in **Figure: 4.4.**

**Figure: 4.4 Lower Chenab Canal off-taking From Khanki Headwork**

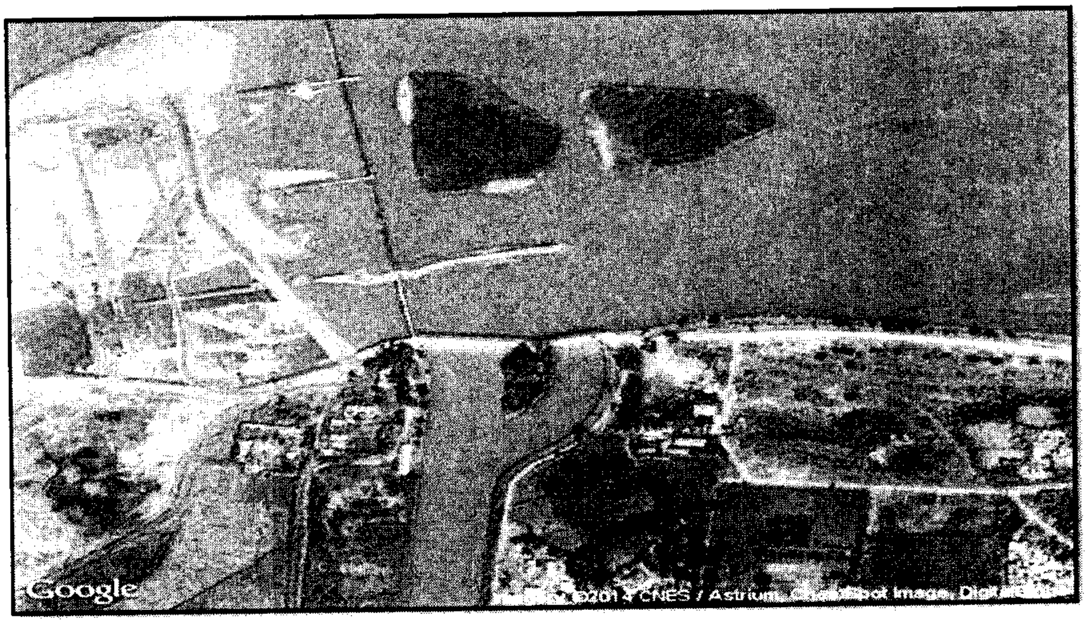



**Figure: 4.5 Khanki and Lower Chenab Canal Headwork**

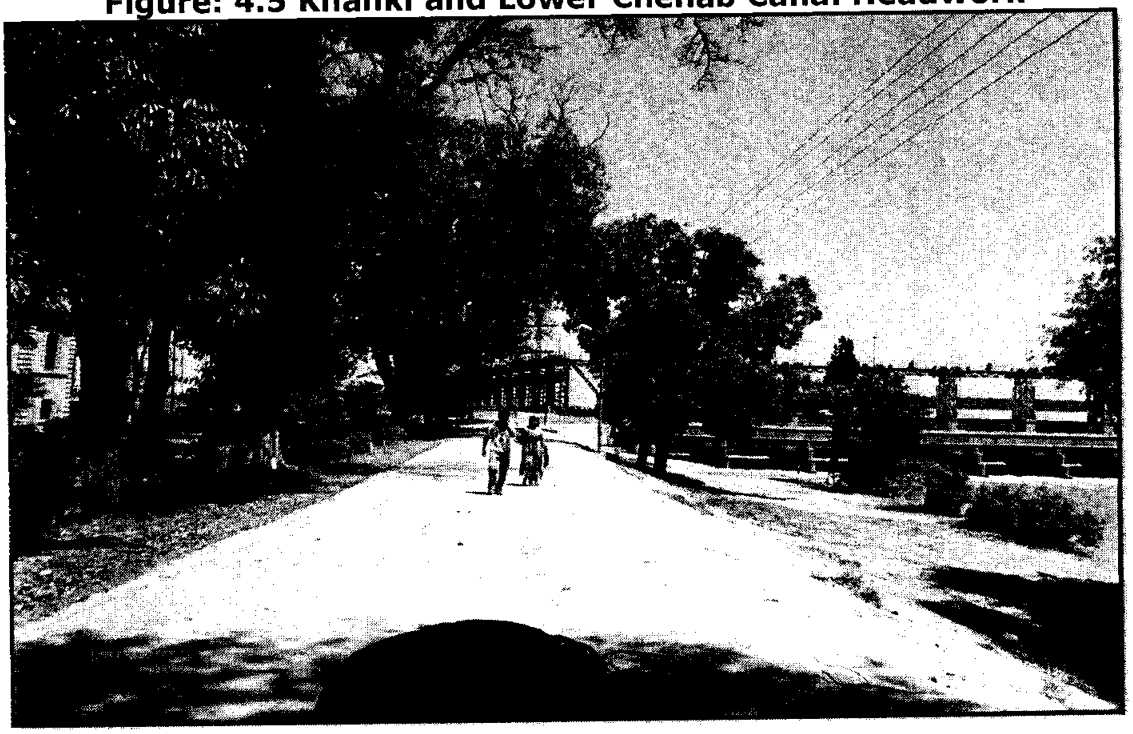
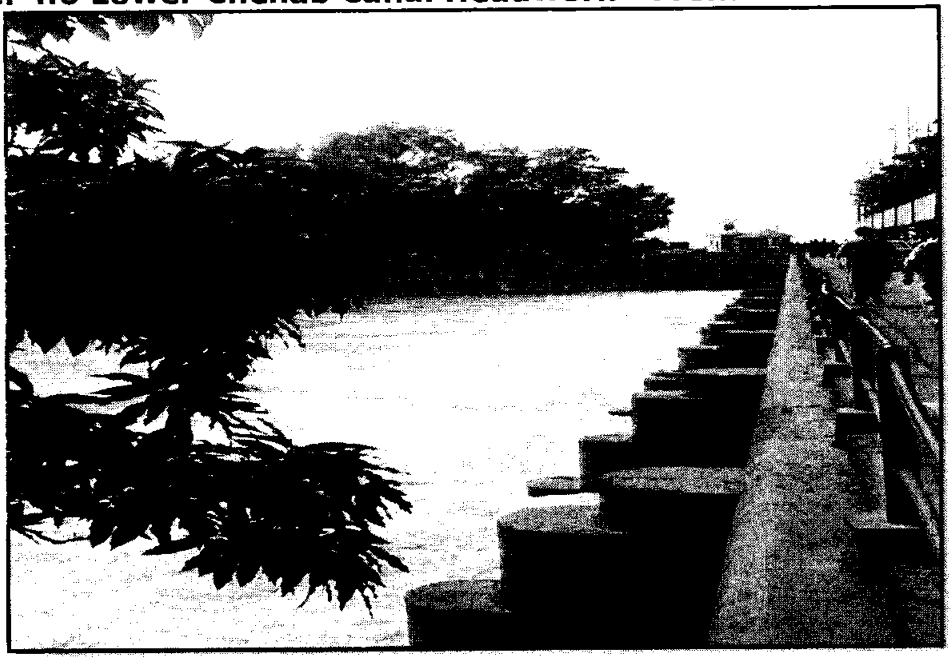


**Figure: 4.6 Lower Chenab Canal Headwork - From Downstream View**



## 4.4 Lower Chenab Canal System

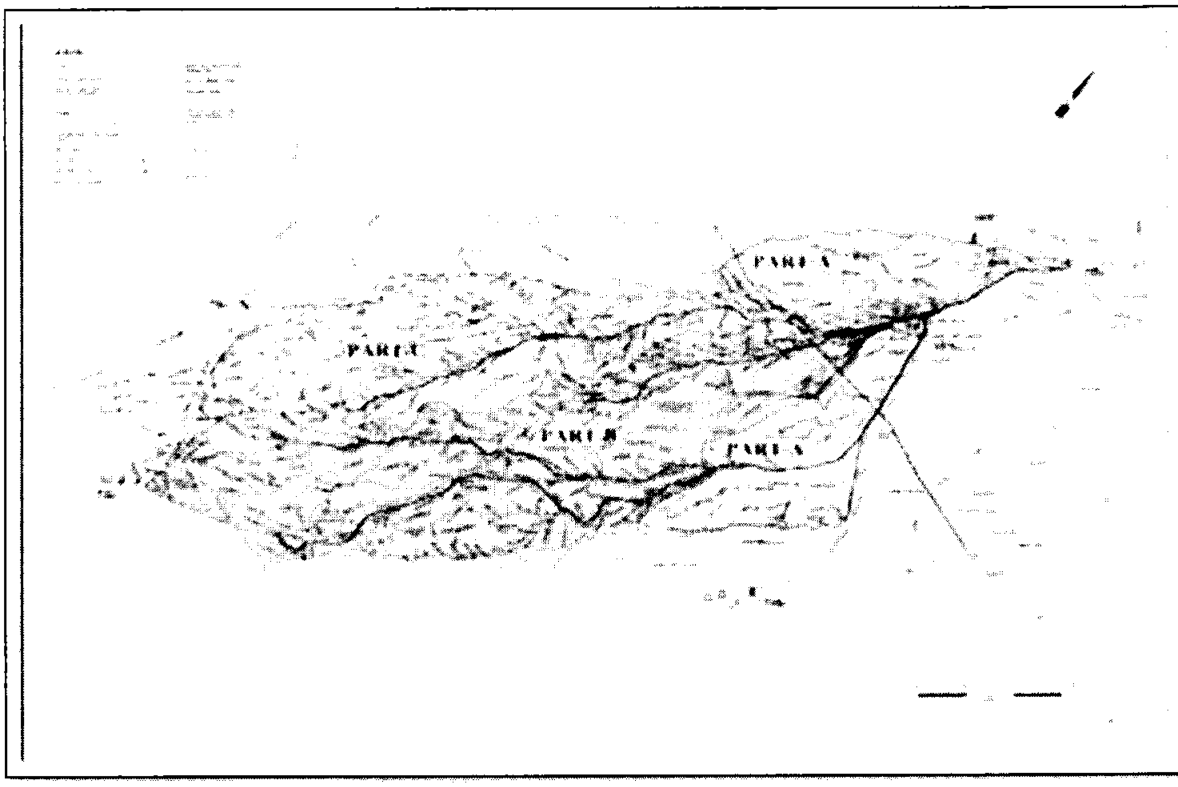
### 4.4.1 General

Lower Chenab Canal (L.C.C) is one of the oldest systems of irrigation in the Punjab Province. The L.C.C off-taking from Khanki Headwork located in Gujranwala District on the river Chenab was constructed in 1892-98 and is supplying irrigation water to about 3.031 million acres of cultivable command area of 7 districts; Gujranwala, Hafizabad, Sheikhupura, Nankana Sahib, Faisalabad, Jhang and Toba Tek Singh through network of canals, branches, distributaries and minors. The design discharge of the canal at head-regulator is 440 m3/s.

**Figure 4.7: Lower Chenab Canal Downstream of its Head-regulator**

The command area of L.C.C lies between the Rivers of Ravi and Chenab (Rechna Doab). It is bounded by Qadirabad-Balloki Link Canal on the eastern side while it terminates beyond Trimmun-Sidhnai Link Canal on the western side. The canal command area spread between latitude $30^{0}$-36' and $32^{0}$-09'N and longitude $72^{0}$-14' and 770-44'E (Figure 4.8).

**Figure: 4.8 Command Area of Lower Chenab Canal**



The major part of canal system has been remodelled by end of 2007, however remaining portion is under implementation on fast track basis under funding from Japan Bank for International Construction. The rehabilitation work involved of about 2500 km length of irrigation channels, 1000 allied structures and 458 km concrete lining of existing earthen canal.

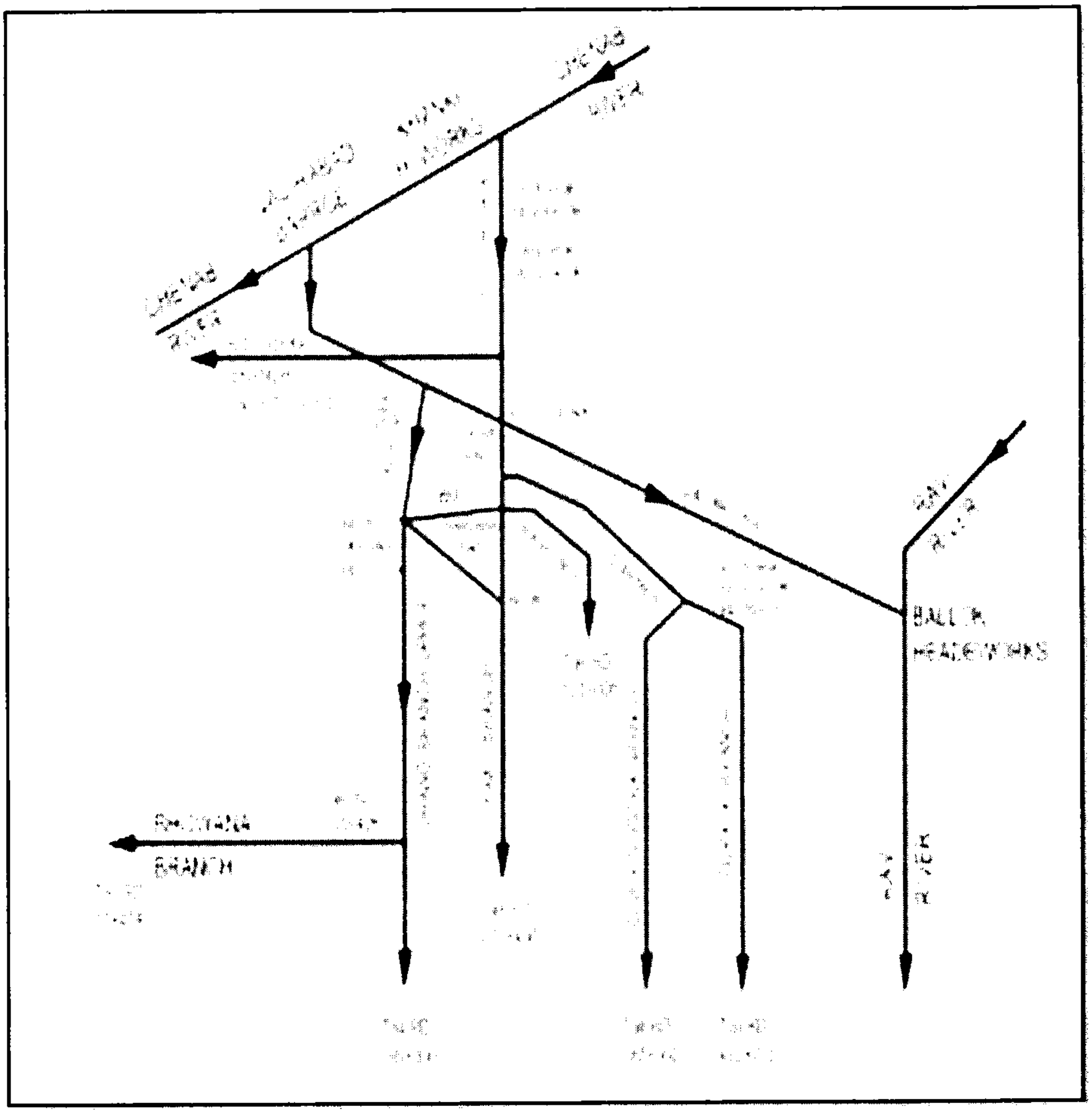
The Lower Chenab Canal off-takes from Khanki Headwork travel up to RD 140+050 where it bifurcate in to Upper Gugera Branch and Main Line Lower. The line diagram of the Lower Chenab Canal System is shown in Figure: 4.9

The following are the off-takes from Lower Chenab Canal before it bifurcate in to Upper Gugera and Main Line Lower Canal.

| | | |
|---|---|---|
| i | RD 000+500 | High Level Channel Distributory |
| ii | RD 040+200 | Mancher Distributory |
| iii | RD 076+200 | Vanike Distributory |
| iv | RD 076+223 | Gajar Gola Distributory |
| v | RD 119+800 | Muradian Distributory |
| vi | RD 119+950 | Kot Nika Branch |
| vii | RD 131+144 | Sagar 2 Distributory |
| viii | RD 136+417 | Sagar 1 Distributory |

| | | |
|---|---|---|
| ix | RD 139+000 | Hafizabad Distributory |
| x | RD 139+986 | Chak Chatta Distributory |
| xi | RD 140+050 | Main Line Lower Canal/Upper Gugera Branch |

**Figure: 4.9 Line Diagram of Lower Chenab Canal**



### 4.4.2 Upper Gugera Branch

The Gugera Branch Canal originates from the Lower Chenab Canal from its RD 140+050. The main areas to which it supplies water are Toba Tek Singh and Faisalabad. Upper Gugera Branch after travelling a distance of about 85.95 km it further bifurcated at RD 280+000 into two canals namely Lower Gugera Branch (LGB) and Burala Branch. The tail of Lower Gugera Branch is at RD 387+566 and Burala Branch is at RD 485+755.

The Upper Gugera Branch is unlined earth canal and after supplying a numbers of tributaries it ultimately bifurcates into Lower Gugera Branch and Burala Branch. It supply the water for the following branch/minor/tributaries;

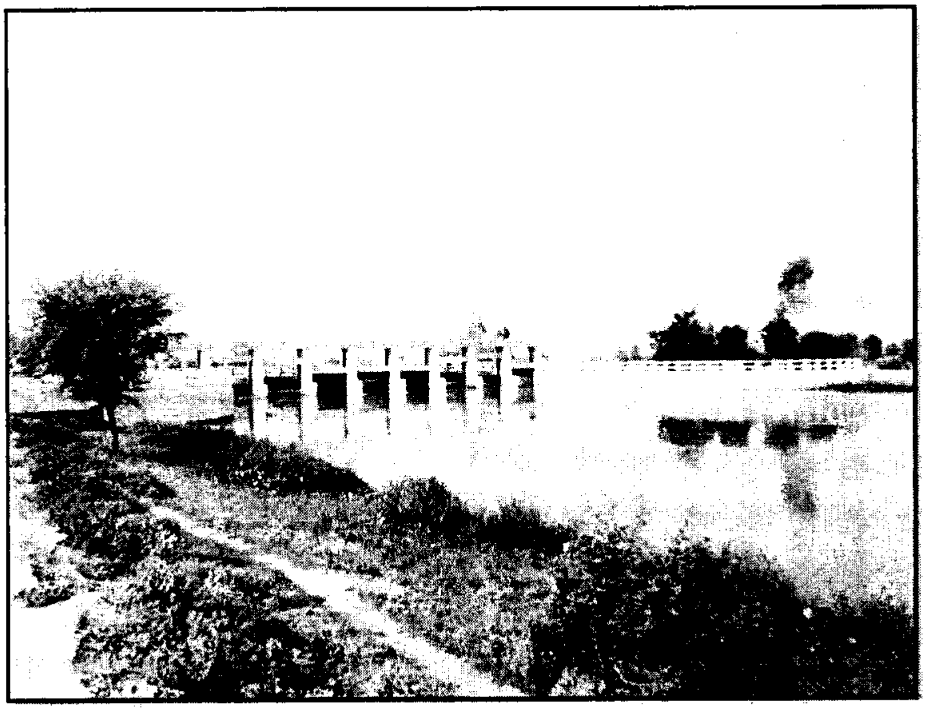
| | | |
|---|---|---|
| i | RD 019+300 | Jurian Distributory |
| ii | RD 037+048 | Kassoki Distributory |
| iii | RD 052+503 | Gaggina Distributory |
| iv | RD 065+000 | Bath Distributory |
| v | RD 091+511 | Manawala Distributory |
| vi | RD 101+000 | Ghour Distributory |
| vii | RD 113+000 | Lagar Distributory |
| viii | RD 140+332 | Machrala Distributory |
| ix | RD 205+500 | Mohlan Distributory |
| x | RD 213+485 | Kabirwala Distributory |
| xi | RD 213+508 | High Level Channel |
| xii | RD 244+495 | Nahra Distributory |
| xiii | RD 260+843 | Nillianwala Distributory |
| xiv | RD 269+031 | Rodi Distributory |
| xv | RD 281+500 | Dangali Distributory |
| xvi | RD 282+000 | Lower Gugera and Burala Branch |

The discharge capacity of Gugera Branch is 122 $m^3/s$ (4300 $ft^3/s$) at RD 220+750. The longitudinal section of the canal between RD 211+000 through RD 226+000 is shown on **Drawing No. 4-1**

## 4.5 Fall Structure at RD 216+100

The regulated fall structure at RD 216+100 of Upper Gugera Branch has a width of 52 m with eight bays equipped with eight manually operated vertical steel gates from elevated deck. A road passes over the structure on downstream side of the gates.

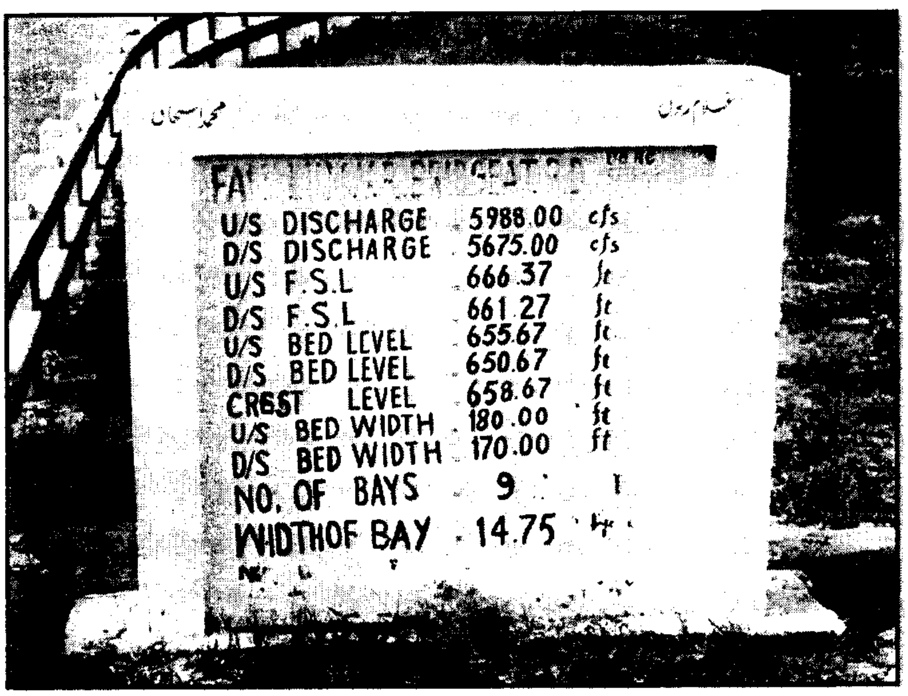
**Figure: 4.10 Fall Structure at RD 216+100 Looking From Upstream**



This structure is newly built during canal remodelling in place of old structure which was at RD 214+000. The structure at RD 216+000 was built in original canal alignment, by diverting canal flow toward right bank.

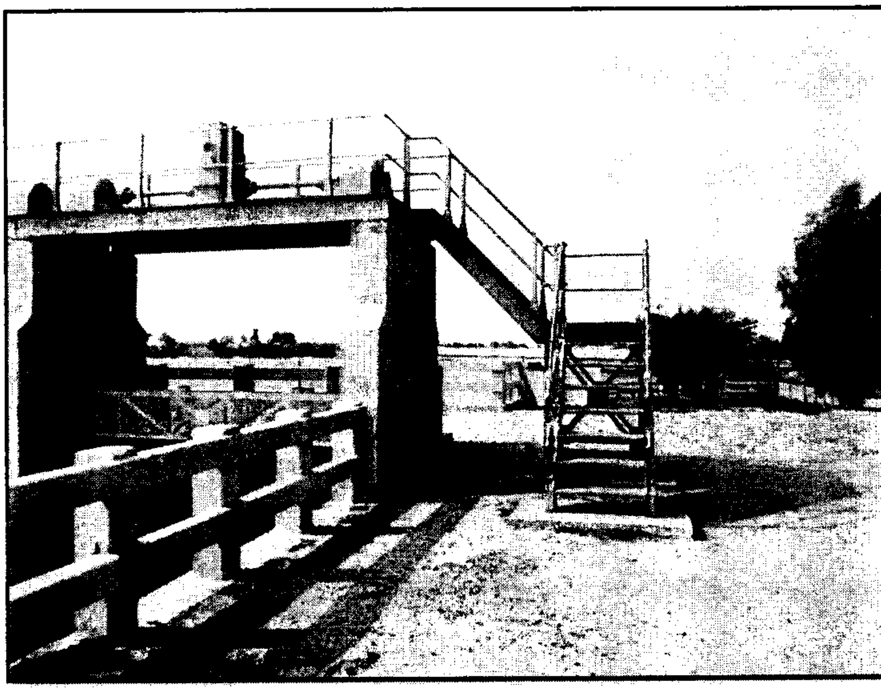
The fall has 9 bays having 4.5 m (14.75 ft) each. The data plaque near fall structures is shown in Figure: 4.11.

**Figure: 4.11 Data Plaque at Fall Structure at RD 216+100**



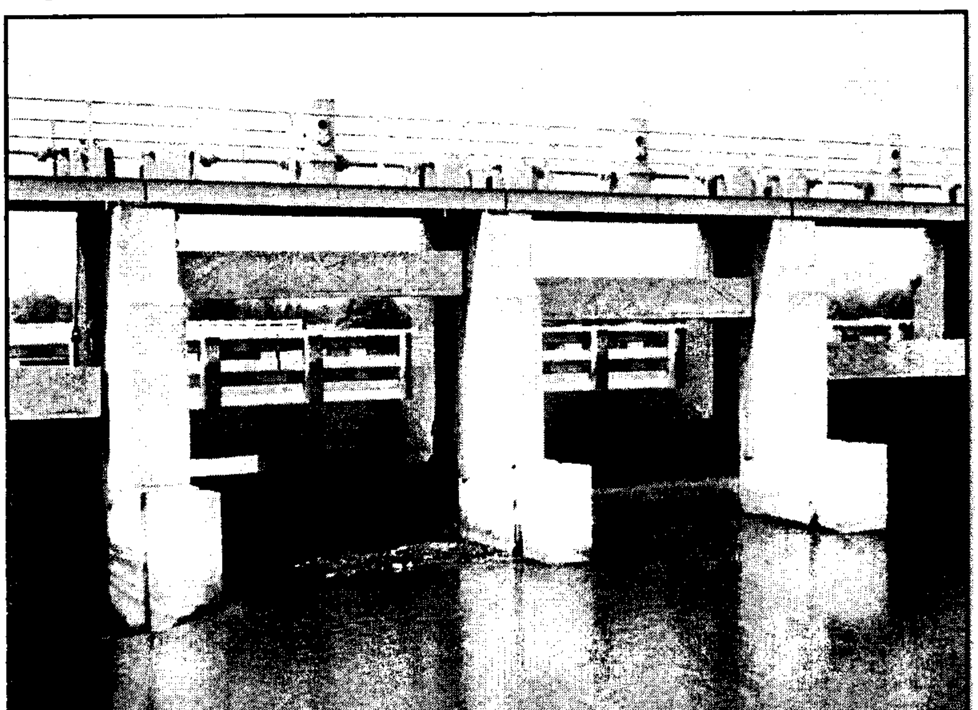
The access to elevated platform for operation of gates is provided through steel stair on both side of the platform Figure: 4.12.

**Figure: 4.12 Steel Stairs for access to Elevated Platform**



The piers have groves for installation of stoplogs on upstream and downstream of vertical steel gates which is being lifted by steel ropes on both ends of each gate. The counter weight is also provided for easy lifting and closing of gates (Figure: 4.13).

**Figure: 4.13 Stoplogs groves in Pier and Counter weights**



The basic hydraulic data of RD 216+100 are summarized as:

| Description | Unit | Designed |
|---|---|---|
| U/S Bed level | Masl | 199.90 |
| U/S FSL | Masl | 203.40 |
| D/S Bed level | Masl | 198.37 |
| D/S FSL | Masl | 201.89 |
| D/S Bed width | M | 54.88 |
| D/S Full supply depth | M | 1.51 |
| D/S Discharge | $m^3/s$ | 122.00 |

## 4.6 High Level Canal off-Taking at RD 216+045 of UGB

High Level Channel off taking from left bank of Upper Gugera Branch (UGB) at RD 216+000. In original canal it was off-taking from its RD RD 213+508 which was re-aligned at RD 216+045 when new fall structure was built at RD 216+100. Its head regulator is situated in the left retaining wall of the main fall structure which is constructed in reinforced concrete. The head regulator is equipped with two vertical operated steel gates. It is operated from steel truss through hand operated wench installed in the center of gate leaf. The upstream and downstream view of head regulator is shown in Figure: 4.14 and 4.15 respectively.

**Figure: 4.14 Head Regulator of High Level Channel - Upstream View**

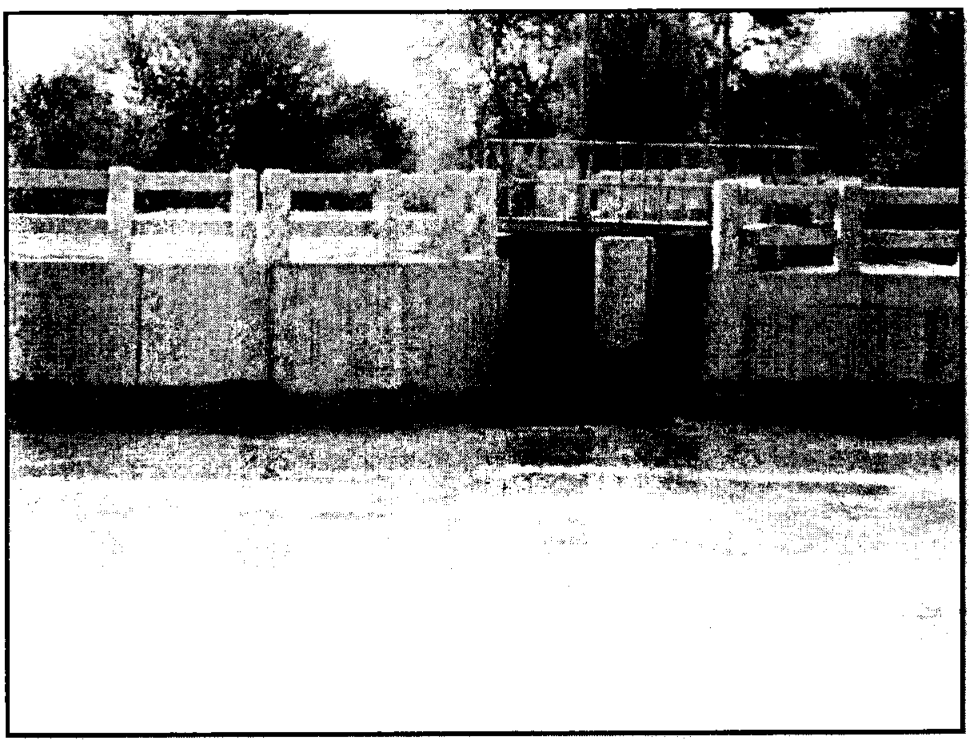
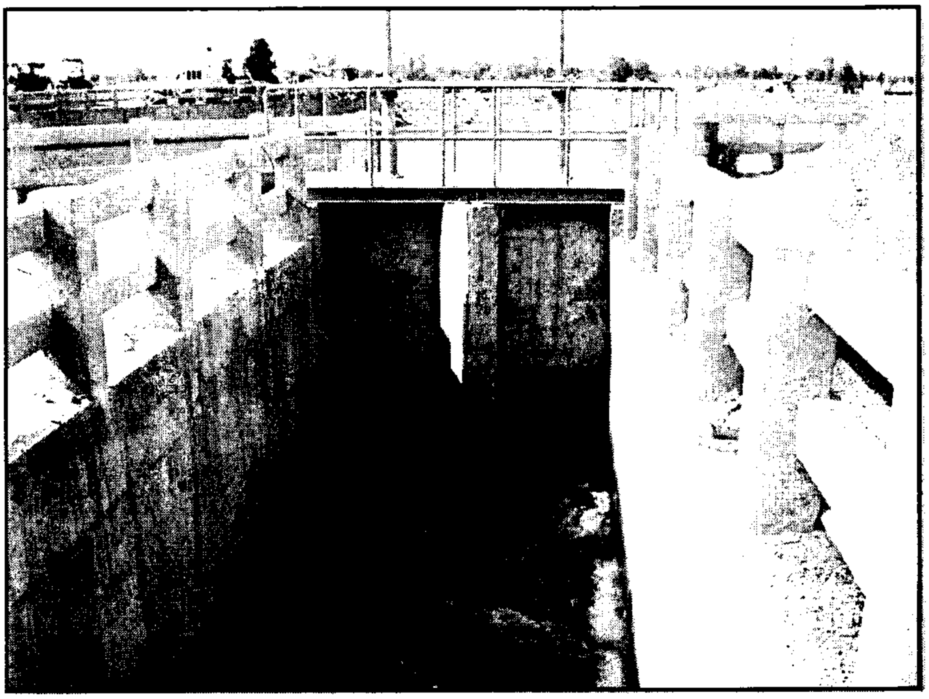


**Figure: 4.15 Head Regulator of High Level Channel-downstream View**



High Level Channel after off taking from left bank of Upper Gugera Branch (UGB) at RD 216+045 runs parallel to existing canal Figure: 4.16.

**Figure: 4.16 Upper Gugera Branch and High Level Channel**

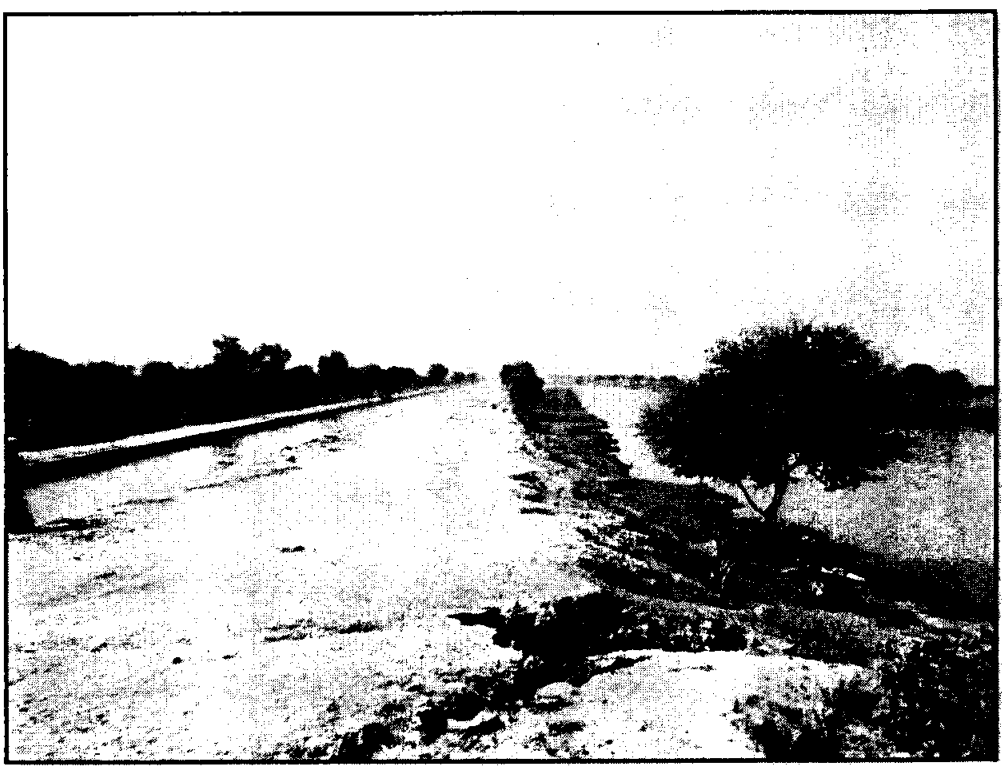
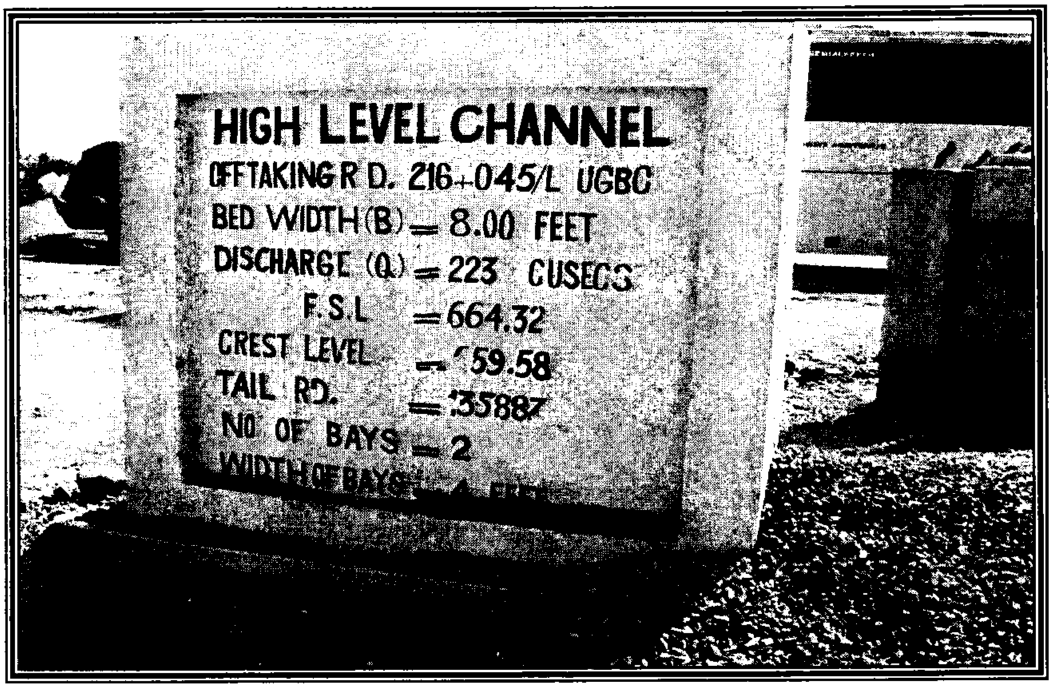


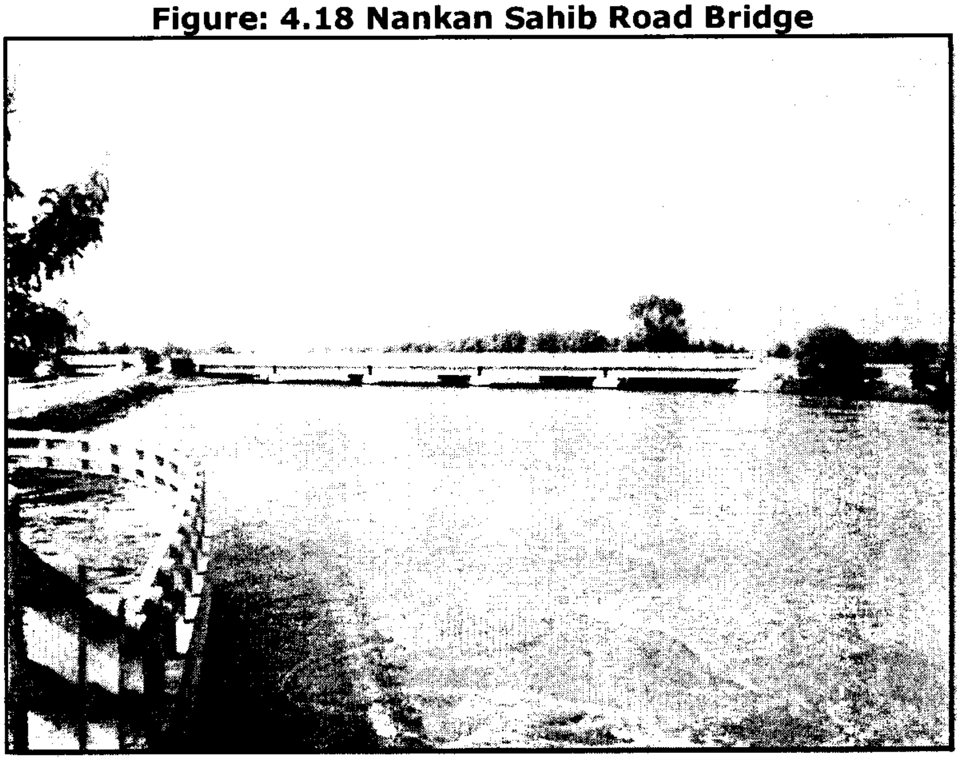
**Figure: 4.17 Technical Data of High Level Channel**




## 4.7 Nankana Sahib Road Bridge at RD 216+500

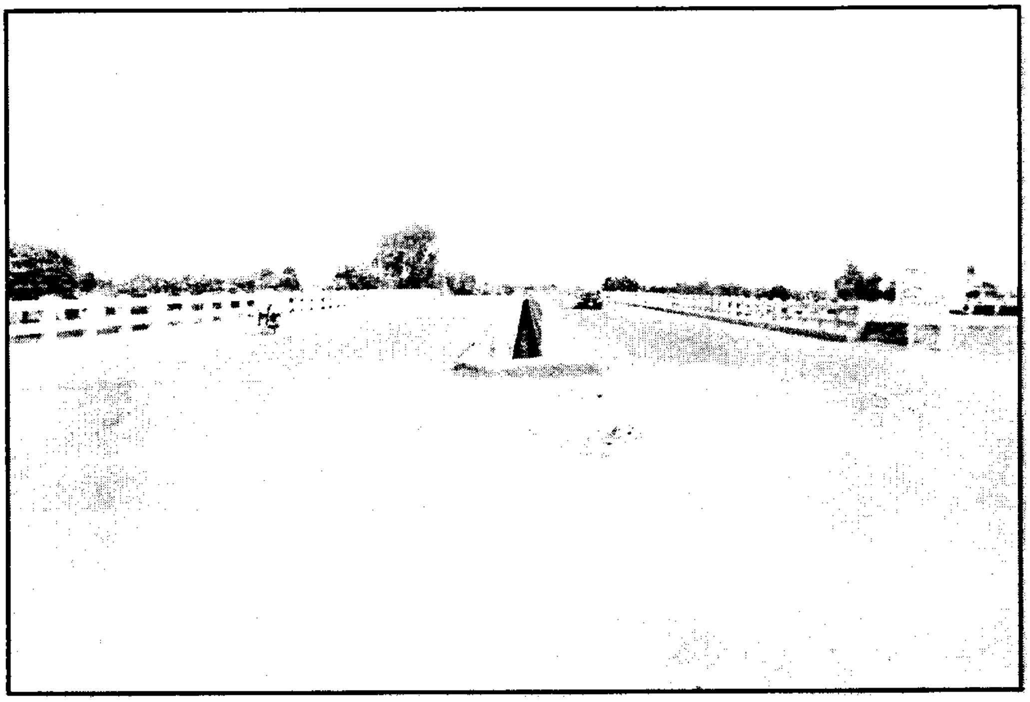
A newly constructed 4 lanes bridge exists at RD 216+500 of Upper Gugera Branch over which road to Nankan Sahib passes.

**Figure: 4.18 Nankan Sahib Road Bridge**



The bridge girders are resting on concrete piles capped with concrete at tops. The bridge has five equal spans.

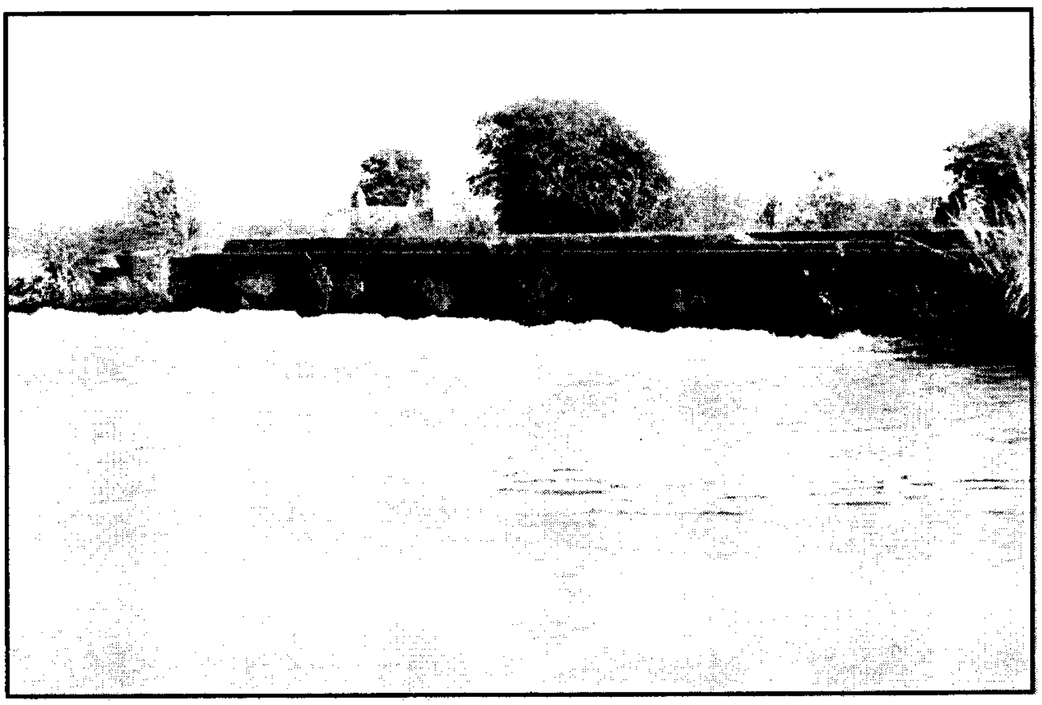
Figure: 4.19 Nankan Sahib Road Bridge



## 4.8 Village Road Bridge at RD 219+000

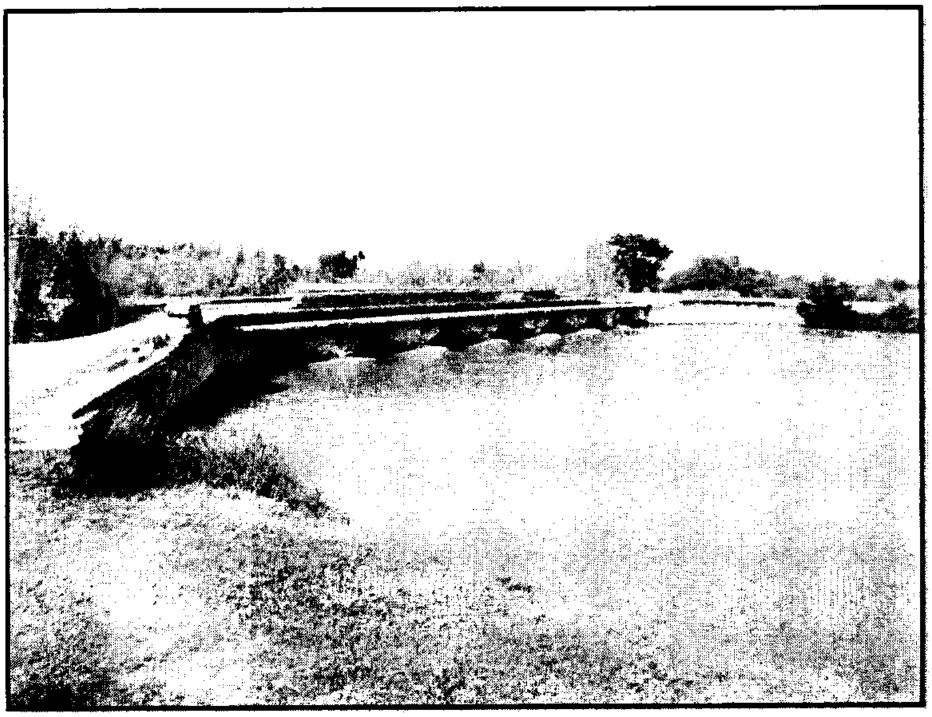
A village road bridge constructed in brick masonry exist at RD 219+000 of Upper Gugera Branch for crossing. Bridge has seven spans.

**Figure: 4.20 Village Road Bridge at RD 219+000 - Downstream View**



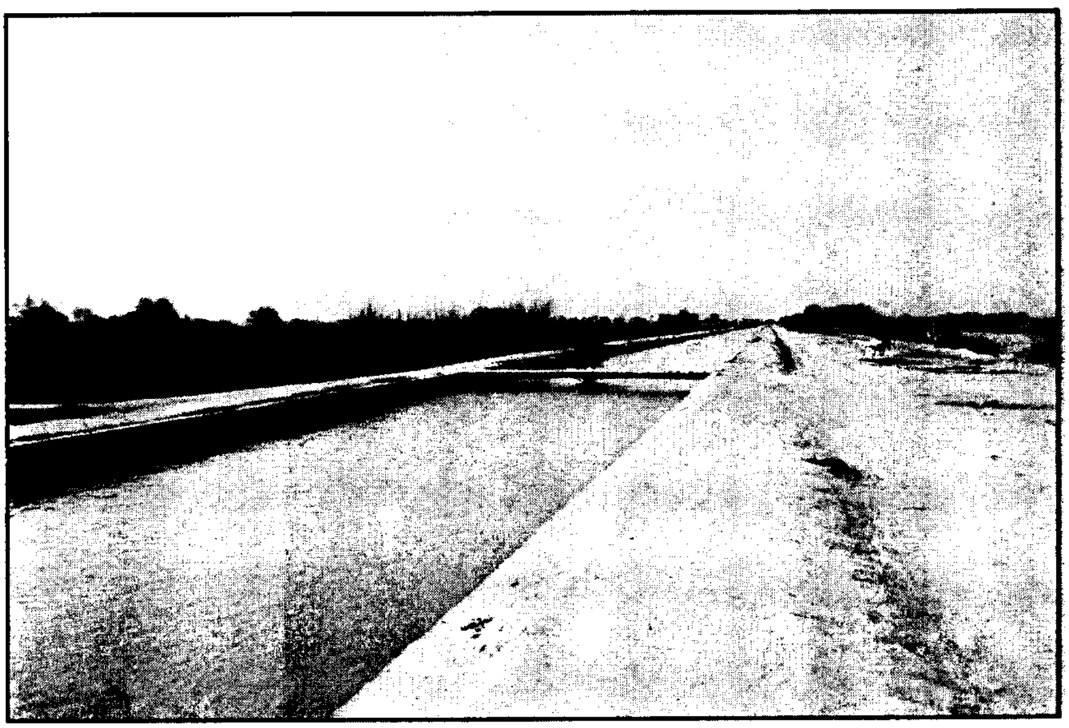
The deck of the bridge is resting over brick masonry arches. A gas pipeline is also crossing the canal along upstream side of the bridge. A small Masjid exists along right bank of the Upper Gugera Branch near village road bridge

**Figure: 4.21 Village Road Bridge at RD 219+000 - Upstream View**



A wooden bridge is constructed along High Level Channel by local population (Residents of Chandra Kot on left bank of UGB) for crossing from left bank to right bank just in line with village road bridge Figure: 4.22.

**Figure: 4.22 Wooden Bridge Over High Level Channel**



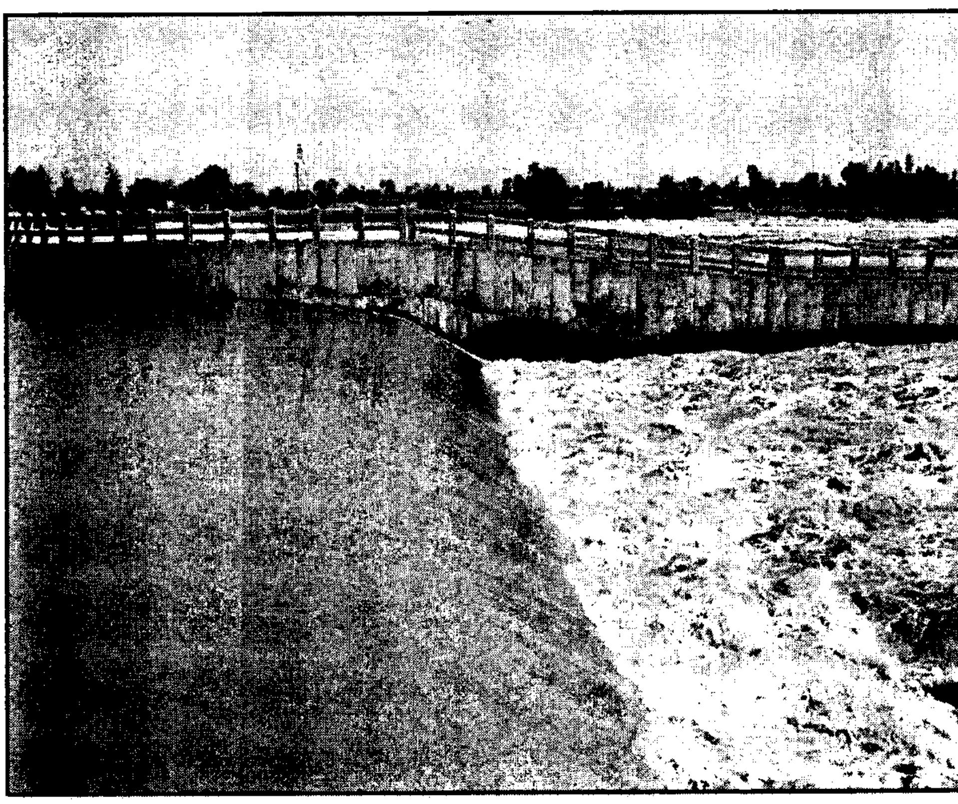
## 4.9 Fall Structure at RD 220+750

The un-gated fall/flume structure at RD 220+750 has a width of 54.87 m. The structure is newly built in place of old structure at RD 220+000. This structure was constructed in the bed of canal by diverting canal flow towards right side.

The basic hydraulic data of RD 220+750 are summarized as:

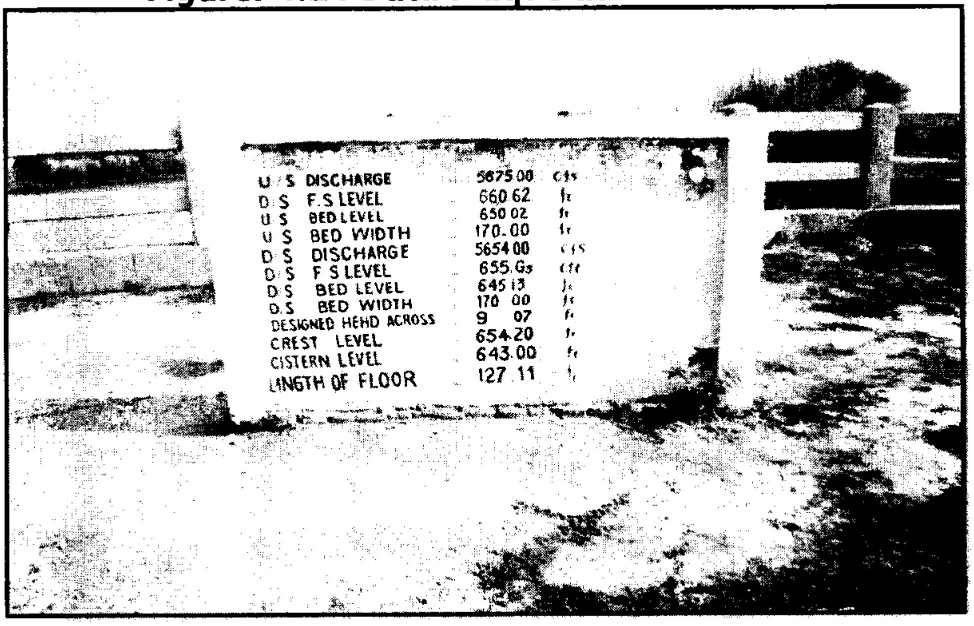
| Description | Unit | Designed |
|---|---|---|
| U/S Bed level | masl | 198.18 |
| U/S FSL | masl | 201.41 |
| D/S Bed level | masl | 196.68 |
| D/S FSL | masl | 199.92 |
| D/S Bed width | m | 54.88 |
| D/S Full supply depth | m | 1.49 |
| D/S Discharge | m³/s | 122.00 |

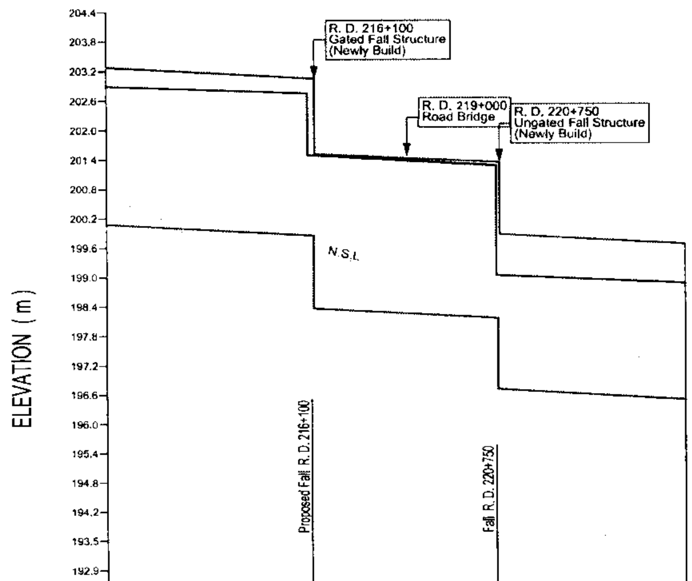
**Figure: 4.23 Fall Structure at RD 220+750 - Downstream View**



There is no bridge over this fall structure. The plague on which canal and fall data is written is constructed on left bank (Figure: 4.24) of the Upper Gugera Branch. Unpaved road exist along both banks from Nankan Sahib Road bridge to RD 220+750. However, on downstream from this fall road only exist along left bank. A head of 1.49 m (4.59 ft) is available at this fall structure.

**Figure: 4.24 Data Plaque at RD 220+750**






**PROPOSED DATA**

| | R.D. 211+000 – 216+100 | R.D. 216+100 – 220+750 | R.D. 220+750 – 226+060 |
|---|---|---|---|
| BANK WIDTH L R (m) | | 7.6 | 7.6 |
| FREE BOARD (m) | | 0.91 | 0.91 |
| F.S. DISCHARGE Cs | | 55.75 | 56.34 |
| W.S. SLOPE IN FEET %o | | 0.13 | 0.34 |
| MANNING S | | 0.025 | 0.205 |
| F. S. DEPTH (m) | | 3.23 | 3.84 |
| BED WIDTH (m) | | 51.83 | 36.11 |

| R. D. (ft) | FULL SUPPLY LEVEL (RL) | BED LEVEL (RL) |
|---|---|---|
| 211000 | 203.20 | 200.08 |
| 212000 | 203.28 | 200.04 |
| 213000 | 203.24 | 200.00 |
| 214000 | 203.20 | 199.96 |
| 215000 | 203.16 | 199.92 |
| | 203.16 | 198.37 |
| | 201.60 | 198.37 |
| 216000 | 201.59 | 198.36 |
| 217000 | 201.55 | 198.32 |
| 218000 | 201.49 | 198.28 |
| 219000 | 201.47 | 198.24 |
| 220000 | 201.43 | 198.20 |
| | 201.46 | 198.17 |
| | 199.91 | 196.68 |
| 221000 | 199.90 | 196.67 |
| 222000 | | |
| 223000 | 199.82 | 196.59 |
| 224000 | 199.77 | 196.54 |
| 225000 | 199.73 | 196.50 |
| 226000 | 199.69 | 196.46 |

**CLIENT:- M/s Gugera Hydro Power Co. (Pvt) Ltd.**

team

Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

**UPPER GUGERA BRANCH**

**FEASIBILITY STUDY REPORT**

| | |
|---|---|
| Design by | **GOGERA CANAL LONGITUDINAL SECTION R.D. 211+000 TO 226+060** |
| Checked by | |
| Approved by | |

| DATED | SCALE | DRAWING No. |
|---|---|---|
| March: 2014 | 1 : 400 | 4-1 |

# SECTION 5

# HYDROLOGY AND SEDIMENT

# CHAPTER- 5

# HYDROLOGY AND SEDIMENT

## 5.1. General

This chapter presents hydrological and sediment studies and comprises of data collection regarding discharge, water level, sediment and their analysis. Meteorological data and its analysis are also presented in this chapter.

The Gugera Branch Canal originates from the Lower Chenab Canal from its RD 140+050. The main areas to which it supplies water are Toba Tek Singh and Faisalabad. Upper Gugera Branch after travelling a distance of about 85.95 km it further bifurcated at RD 280+000 into two canals namely Lower Gugera Branch (LGB) and Burala Branch. The tail of Lower Gugera Branch is at RD 387+566 and Burala Branch is at RD 485+755.

Its purpose is to develop a Hydro Electric Power Project along RD 216+100 of Upper Gogera Branch Canal. The site is located 70 km south of Lahore and 67 Km from Faisalabad.

## 5.2. Meteorological Data and Analysis

### 5.2.1. Data Collection

Metrological data (Temperature, Rainfall, Humidity and Wind Speed) for Faisalabad and Lahore was collected from the office of the Director, Pakistan Metrological Department Lahore for the last 10 years (2004-2013) as no other climatologically station exists in the project vicinity.

### 5.2.2. Data Analysis

Four seasons are being experienced in the project area i.e. winter, spring, summer and autumn. The climate of the project area is generally hot and dry in summer and moderately cold in winter. Summer starts in April and continues until September. July and August are the months of summer monsoon. Winter begins in October and lasts until February. Monsoons affect the area in July & August while March and April are pleasant months.

#### 5.2.2.1. Temperature

Daily maximum and minimum temperature data for Faisalabad and Lahore was collected and presented in Annexure: 5.2, 5.2B, 5.3A and Annexure: 5-3B. The data has been processed for mean monthly, daily maximum and minimum values and presented in Table: 5.2 and Table: 5.3 for Lahore and Table: 5.4 and Table: 5.5 for Faisalabad.

Tables show that the hot months are April, May, June July, August, September and October while November, December, January, February and March are the cold. Based on data for the period 2004 through 2013, the lowest and the highest values of mean monthly maximum temperature are 12.12°C and

45.5°C and 12.36°C and 44.2°C for Faisalabad and Lahore for the month of January and June & May, respectively **(Figure: 5.1)**. The minimum mean monthly temperature varies between 0.42°C and 22.3°C and 4.09°C and 22.46°C for Faisalabad and Lahore, respectively **(Figure: 5.4)**.

Over all the temperature will not affect the construction activity whole the year.

**Figure 5.1: Mean Monthly Maximum (Maxi) Temperature ($C^0$)**

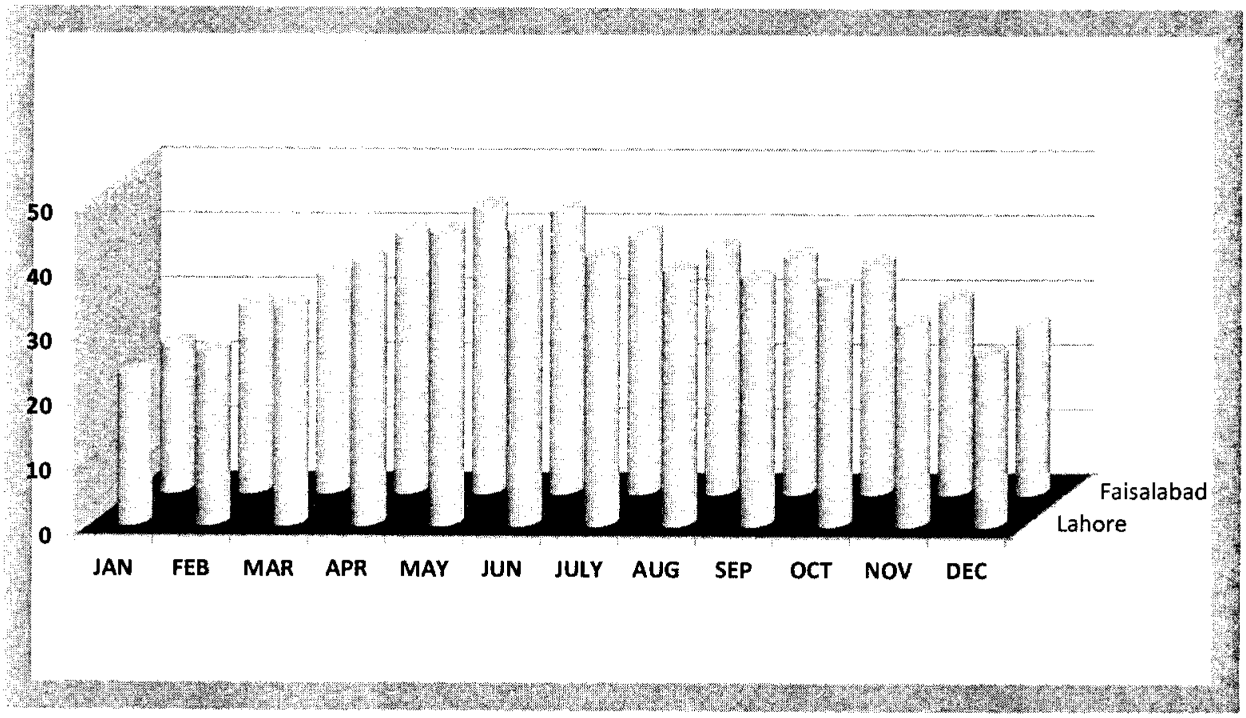



**Figure 5.2: Mean Monthly Maximum (Min) Temperature ($C^0$)**

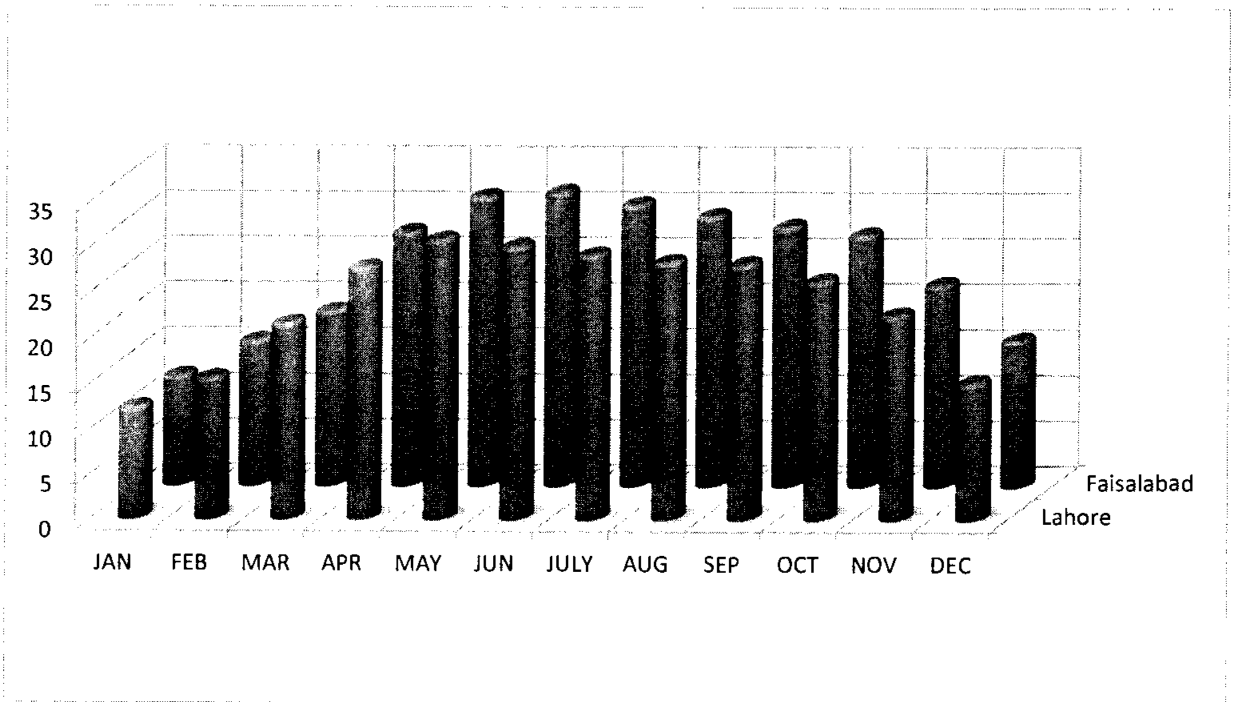


Figure 5.3: Mean Monthly Minimum (Max) Temperature ($C^0$)

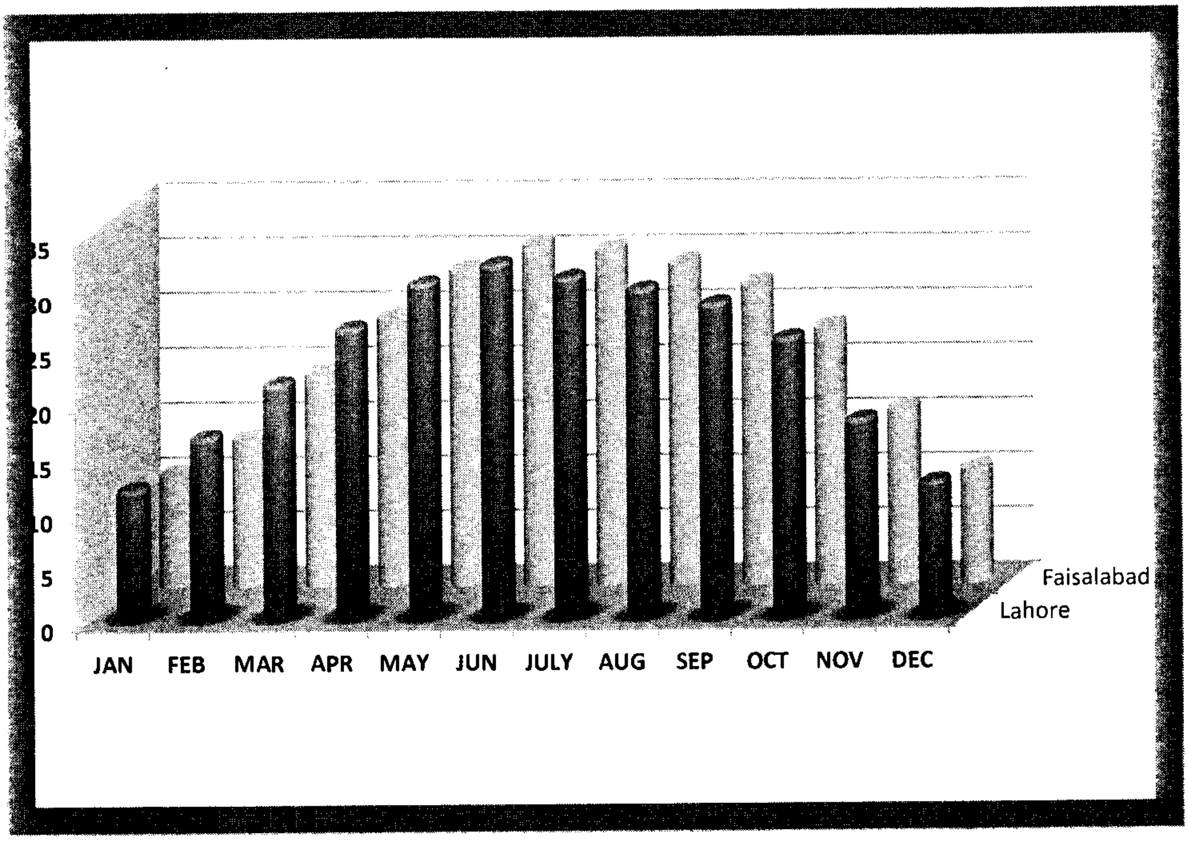
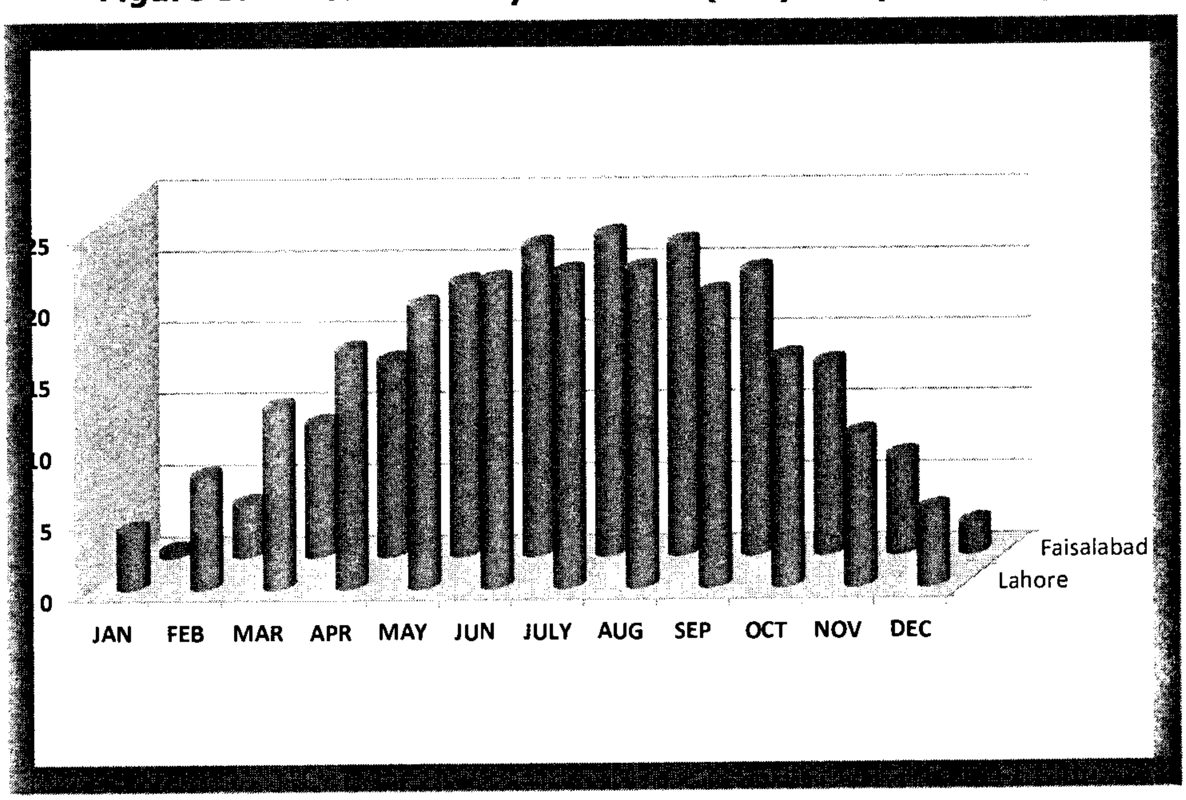



Figure 5.4: Mean Monthly Minimum (Min) Temperature ($C^0$)




From Figure: **5.1 and 5.3** it can be seen that maximum temperature at Faisalabad is the highest while at Lahore shows the minimum. The minimum temperature at Lahore is highest while Faisalabad shows the minimum. The daily maximum temperature for Faisalabad and Lahore is 48°C and 46.5°C, respectively while the daily minimum temperature recorded is -1.8°C and 0.8°C at Faisalabad and Lahore, respectively.

### 5.2.2.2. Rainfall

Daily rainfall data for Faisalabad and Lahore was collected and presented in Annexure: 5.4 and Annexure 5.5, respectively. The data of rainfall has been processed on monthly and annual basis and placed in Table: 5.6 and Table 5.7 for Lahore and Faisalabad, respectively.

Monsoons hit the area in July, August and till first week of September. Heavy rains are expected in these months. Considerable rains are also expected in December and January due to western disturbance. Average monthly rainfall for (2004-2013) is presented in Table: 5.6 and 5.7.

Average annual total rainfall for the period of 2004 through 2013 at Faisalabad and Lahore is 450.9 mm and 482.2 mm, respectively. Most of the rainfall occurs during the summer monsoon period (July to August). November is the month of minimum rainfall and July is the month of maximum rainfall (Figure: 5.3). The maximum annual rainfall recorded so far (2004-2013) is 565 mm and 656.8 mm in the year 2008 at Lahore and Faisalabad, respectively.

**Figure 5.5: Mean Monthly Rainfall (mm)**

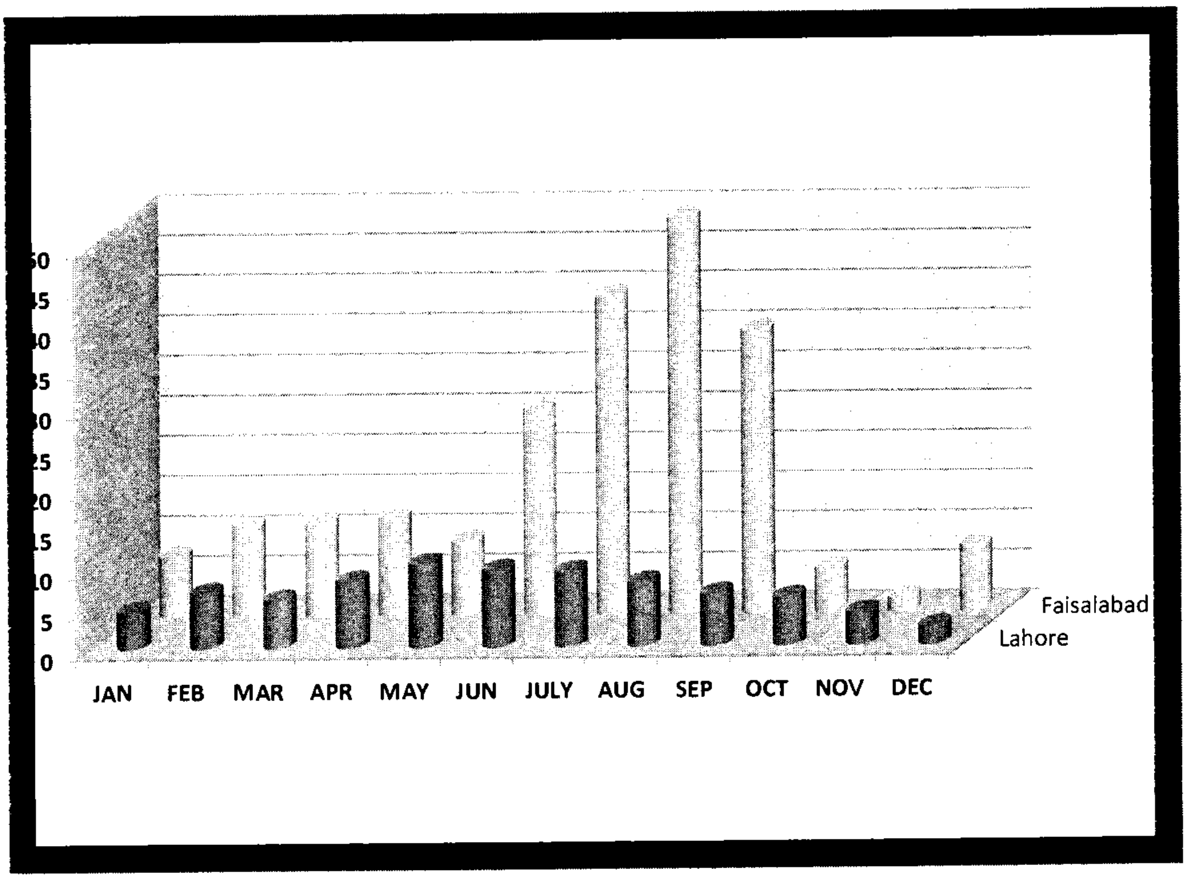
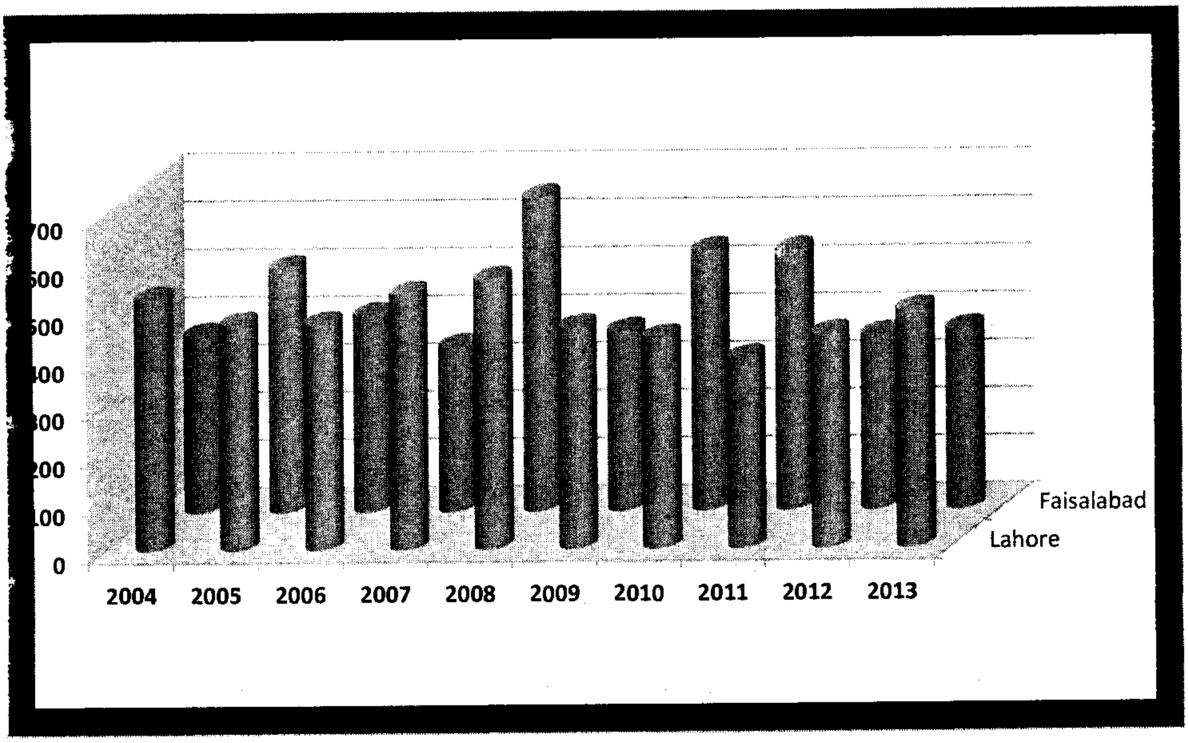


**Figure 5.6: Mean Monthly Rainfall (mm)**




### 5.2.2.3. Humidity

Humidity is measured at 08:00 and 17:00 hours. The collected daily data for Lahore and Faisalabad is presented in Annexure: 5.6, 5.7, 5.8 and 5.9 respectively. Maximum and minimum monthly humidity for Lahore is shown in Table: 5.8 and Table: 5.9, respectively and for Faisalabad is shown in Table 5.10 and Table; 5.11, respectively. Mean monthly maximum and minimum humidity for the period 2004-2013 are compiled in Figure: 5.7 and Figure: 5.8 recorded at 0800 and 1700. The figures indicating variation in humidity ranging from 50% in May to 90% in January.

**Figure 5.7: Mean Monthly Maximum Humidity at 8 AM**

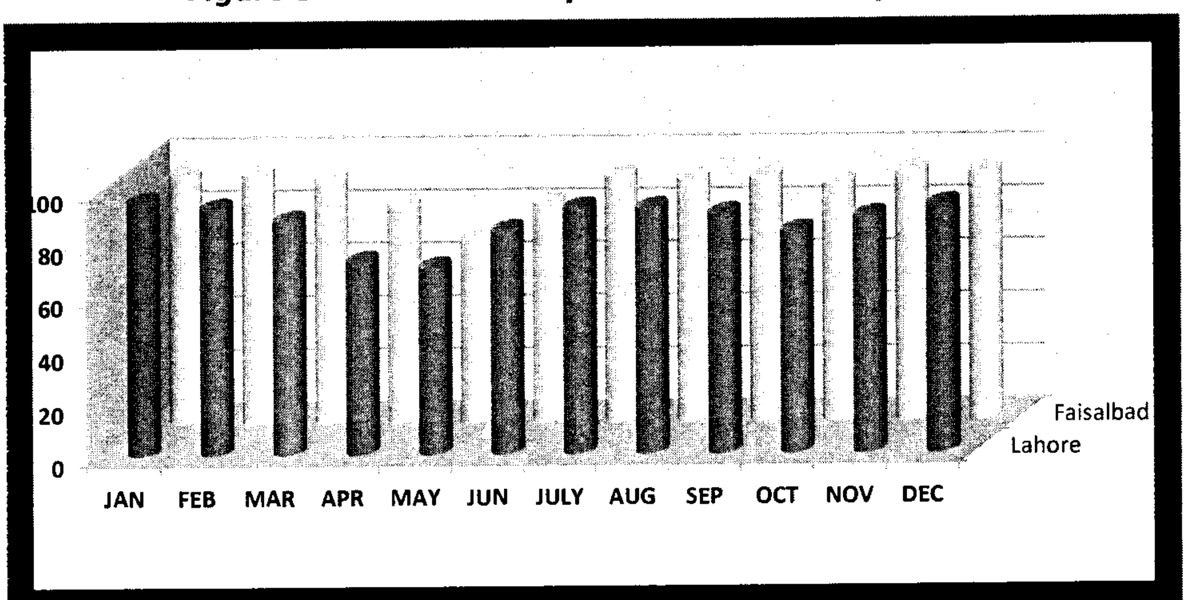
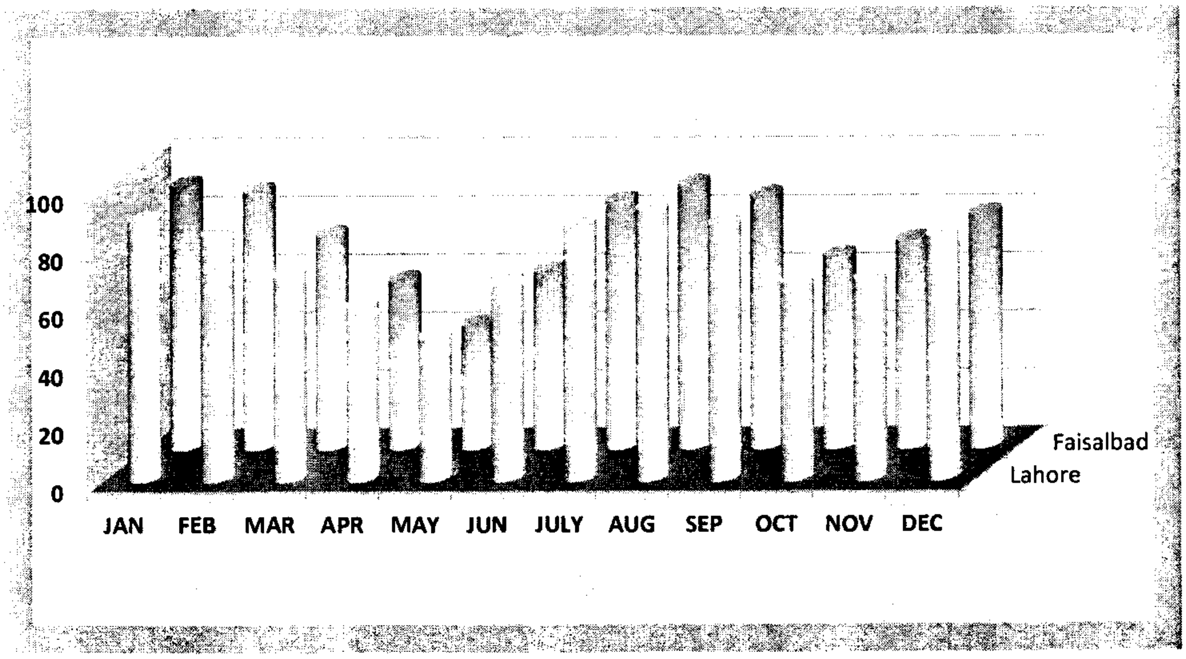


**Figure 5.8: Mean Monthly Minimum Humidity at 5 PM**




### 5.2.2.4. Wind speed

The daily wind speed data recorded at 8 AM and 5 PM for 2004-2013 for Lahore and Faisalabad are Annexure: 5.10 and 5.11 and 5.12 and 5.13, respectively. Average monthly (maximum and minimum) wind speed is calculated at 8 AM and 5 PM and presented in Table: 5.12 and 5.13 for Lahore and Table 5.14 and 5.15 for Faisalabad, respectively. Figure: 5.9 and 5.10 shows the average monthly wind speed measured during the period of 2004 to 2013 at 8 AM and 5PM, respectively.

**Figure 5.9: Mean Monthly Maximum Wind Speed (Knot/hr) at 8 AM**

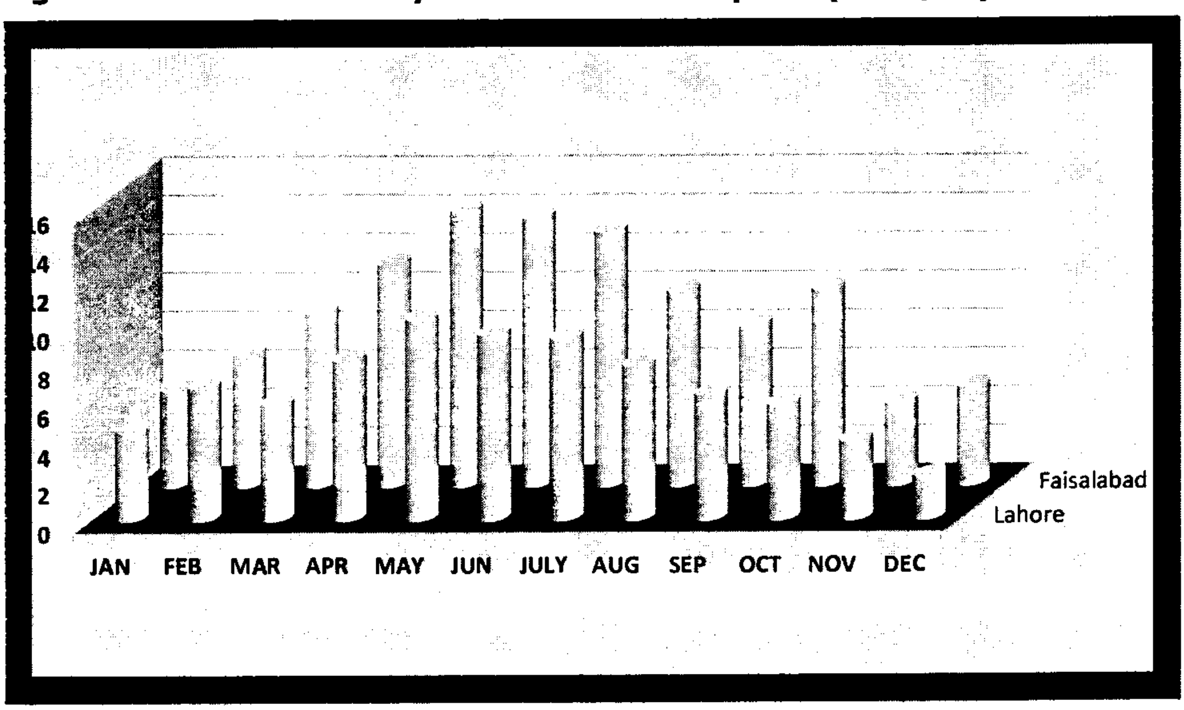
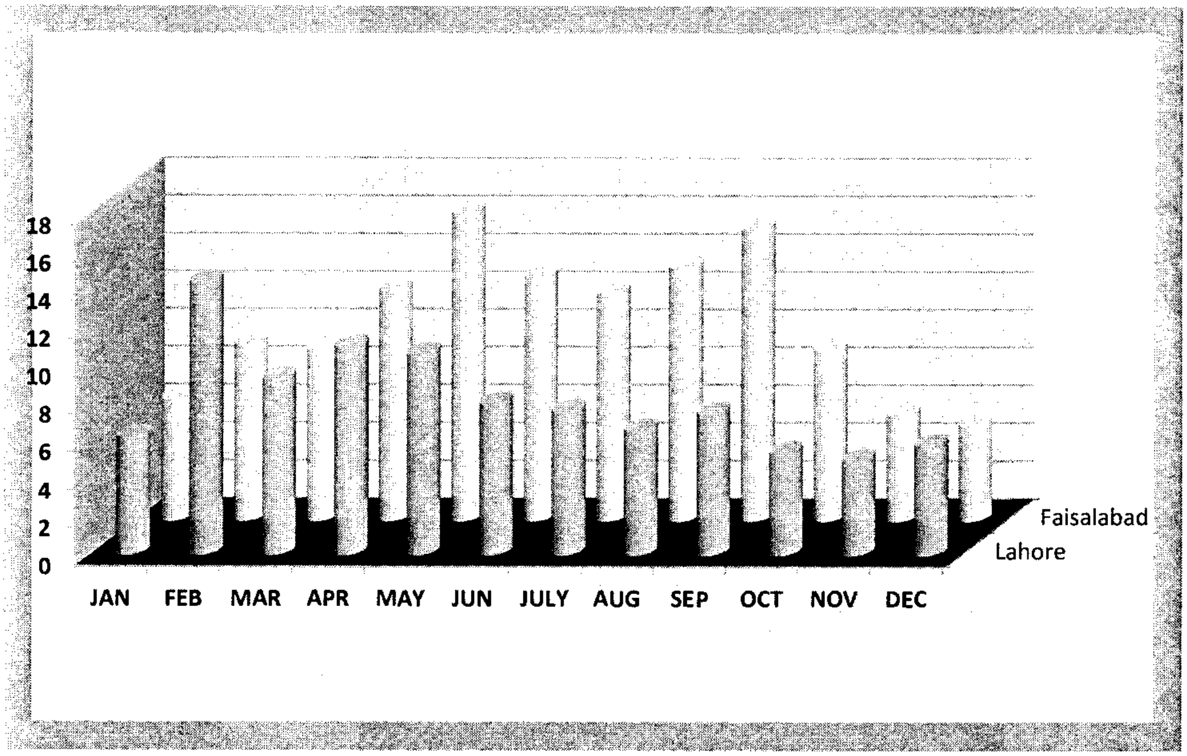


Figure shows that May, June, July and August are the month of maximum wind speed.

**Figure 5.10: Mean Monthly Maximum Wind Speed (Knot/hr) at 5 PM**




## 5.3. Hydrology

### 5.3.1. Data Sources

#### 5.3.1.1. Discharge

The daily discharge data of Upper Gugera Branch Canal at RD 220+750 has been collected from the office of Executive Engineer and Sub-divisional Officer, Irrigation and Power (I&P) Department, Government of Punjab at Lahore and Sheikhupura. The daily historic data was collected from 2008 through 2013 being after remodeling of canal. The collected data was entered in to computer files for further analysis.

#### 5.3.1.2. Water Levels

The gauge data at upstream and downstream is being observed, however, data was not collected because the gauges are not linked with mean sea water level.

### 5.3.2. Flow Data Analysis

The collected data from 2008 to 2014 was processed for 10-daily mean, mean monthly, minimum monthly and maximum monthly. This is presented in Annexure: 5-5. The mean monthly discharge is also presented in Table: 5-8 and Figure: 5.11

| Table: 5-1 Mean Monthly Discharge ($m^3/s$) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Months** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **Mean** |
| **Jan** | 37 | 37 | 39 | 60 | 49 | 53 | **46** |
| **Feb** | 63 | 65 | 51 | 58 | 54 | 25 | **53** |
| **Mar** | 88 | 80 | 80 | 88 | 99 | 105 | **90** |
| **Apr** | 93 | 92 | 90 | 76 | 105 | 108 | **94** |
| **May** | 115 | 120 | 110 | 115 | 86 | 102 | **108** |
| **Jun** | 115 | 121 | 114 | 108 | 103 | 116 | **113** |
| **Jul** | 119 | 119 | 113 | 101 | 110 | 115 | **113** |
| **Aug** | 117 | 118 | 86 | 106 | 108 | 84 | **103** |
| **Sep** | 111 | 108 | 100 | 78 | 108 | 118 | **104** |
| **Oct** | 78 | 86 | 99 | 96 | 90 | 128 | **96** |
| **Nov** | 108 | 93 | 110 | 99 | 97 | 104 | **102** |
| **Dec** | 86 | 87 | 98 | 88 | 98 | 98 | **92** |

From Table:5.1 and Figure: 5.11 it is concluded that the mean minimum flows are available in the month of January while mean maximum are in the month of June and July. It can also be concluded that mean maximum in year of 2008 & 2012 is available in the month of July, in 2009 & 2010 in month of June, in year 2011 in the month of May while in 2013 in the month of October.

**Figure: 5.11 Mean Monthly Discharge ($m^3/s$)**

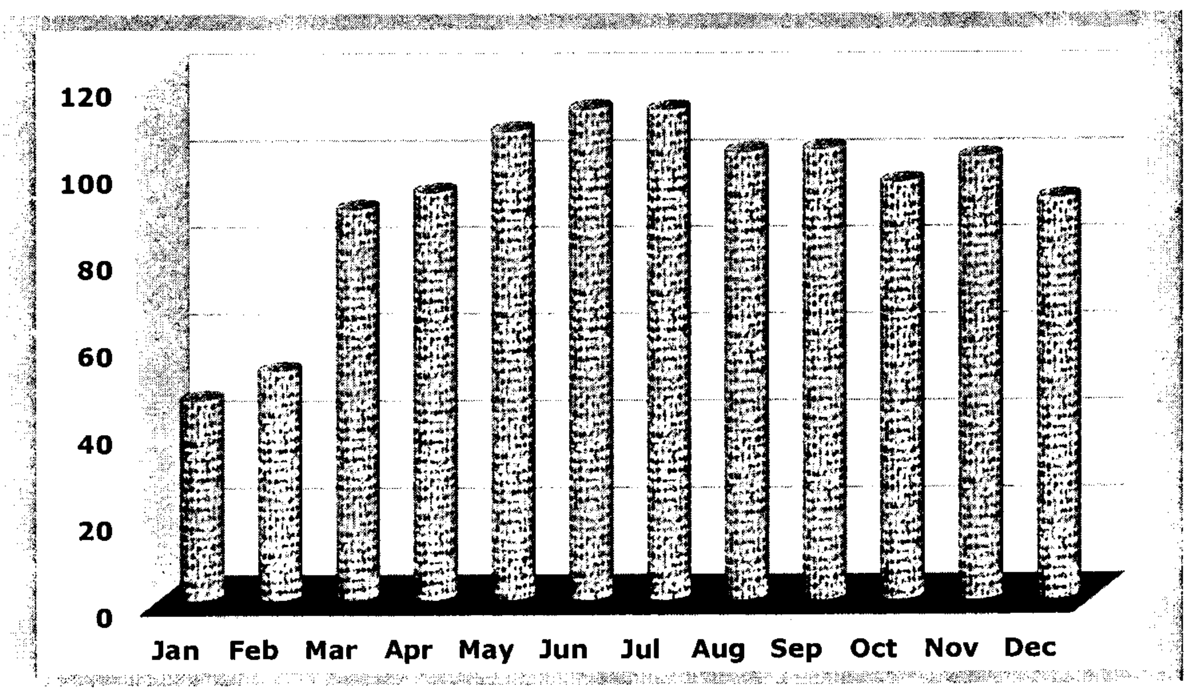
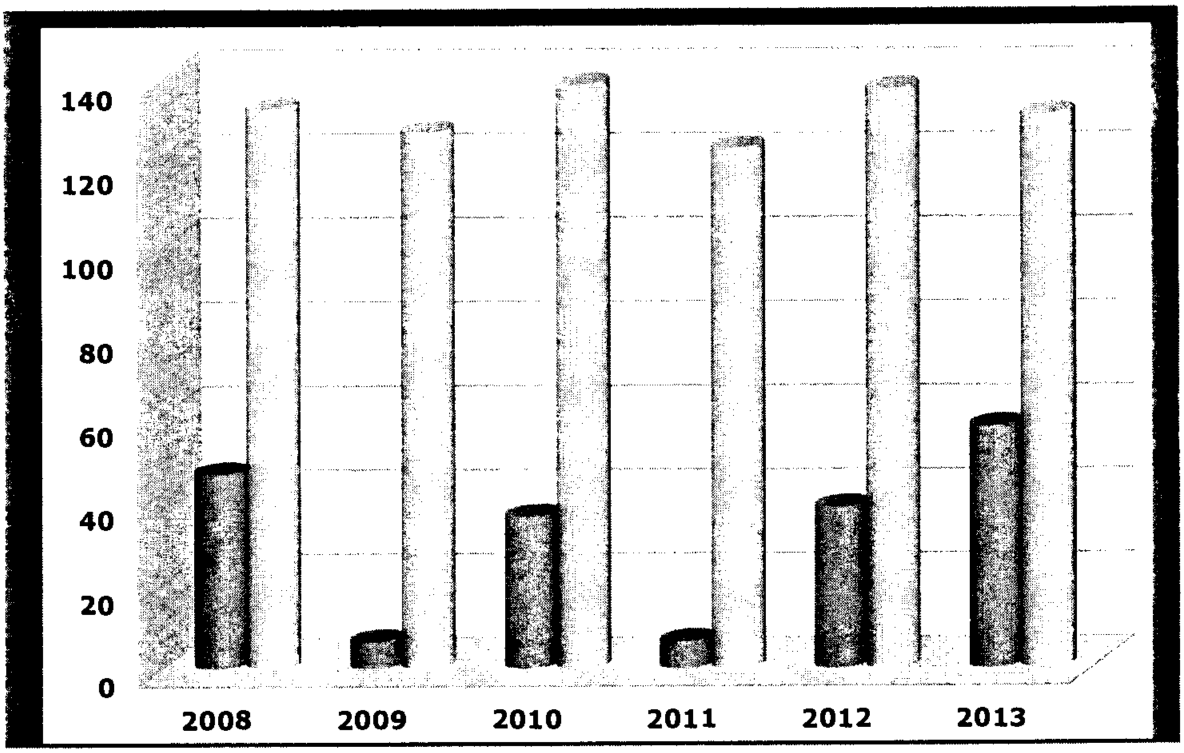


Figure: 5.12 shows the extreme minimum and maximum flows passes in each years. The maximum flows are the year of 2010 while minimum are in the year of 2009.

**Figure: 5.12 Minimum and Maximum Discharge ($m^3/s$)**




### 5.3.2.1. Canal Closure

Mostly the canal remains closed for maintenance purposes for about 20 to 32 days during the months of January and February. The canal closure usually starts from the second week of January till the second week of February; however some abnormal closures have also been noted in different years during the period of record. The detail of canal closure for the periods 2008-2014 is given in Figure: 5.13 below.

**Figure: 5.13 Canal Closure Period**

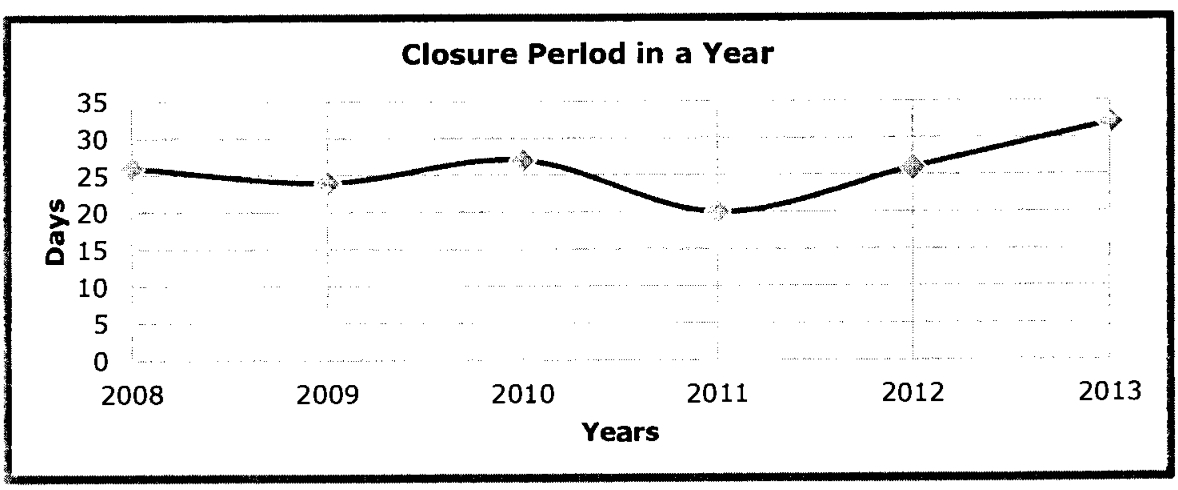
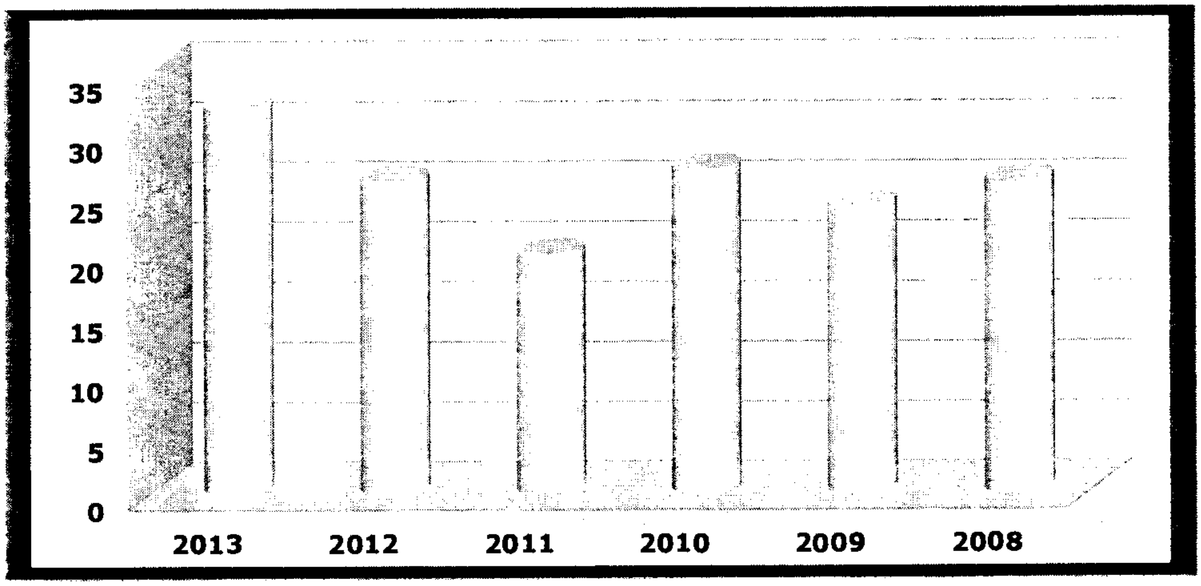



Figure: 5.13 and Figure 5.14 clearly indicates that the canal closure normally ranges from 20-32 days. It is also mentioned that canal remained closed in other months than January and February. The average closure period is 26 days. It is important to note that canal remained closed in other months also it may be due to rain in the canal command area.

**Figure: 5.14 Canal Closure in Every Year**

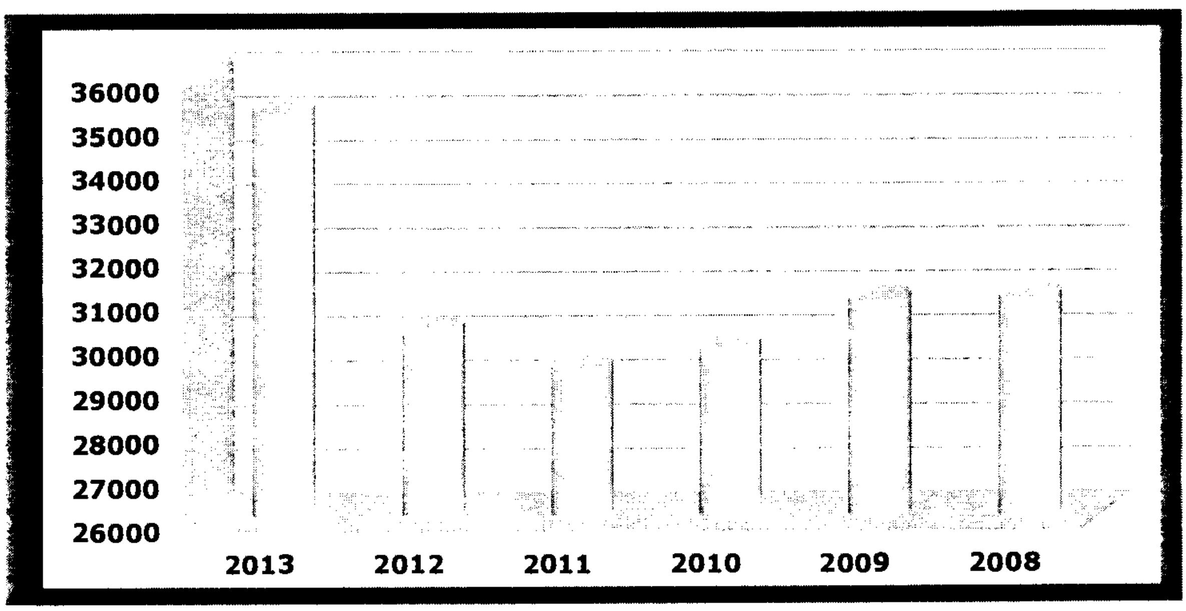



#### 5.3.2.2. Yearly Volume of Flows

The canal flows for the period 2008 through 2014 are also processed for volume of water and presented in Figure: 5.15.

The Figure: 5.15 show that maximum volume of water (35,218 $m^3$) in period 2008-2013 is during 2013 while the minimum volume of water (29,385 $m^3/s$) is during 2011. The average volume of water for the period of 2008-2013 is 30,938 $m^3$.

**Figure: 5.15 Yearly Volume ($m^3$)**



### 5.3.2.3. Availability of Flows During 2008-2013

Flow duration analysis is made on daily basis for each year separately and presented in Figure: 5.16. It can easily be concluded that flow duration curve for year 2013 shows more discharge availability than other years. At the same time it also concluded that canal remained closed more days than other years. The flow availability during the year 2010 is less shows increasing trend during 2009 and 2008.

The flow duration curve for full period starting from 2008 till 2013 on daily basis is also prepared and presented in Figure: 5.17. It shows the following:

- Discharge of 05 $m^3/s$ is available for 91.81% of Time;
- Discharge of 22 $m^3/s$ is available for 91.18% of Time;
- Discharge of 45 $m^3/s$ is available for 90.08% of Time;
- Discharge of 75 $m^3/s$ is available for 82.76% of Time;
- Discharge of 100 $m^3/s$ is available for 56.76% of Time; and
- Discharge of 120 $m^3/s$ is available for 8.11% of Time;

**Figure: 5.16 Flow Duration Curve on Yearly Basis**

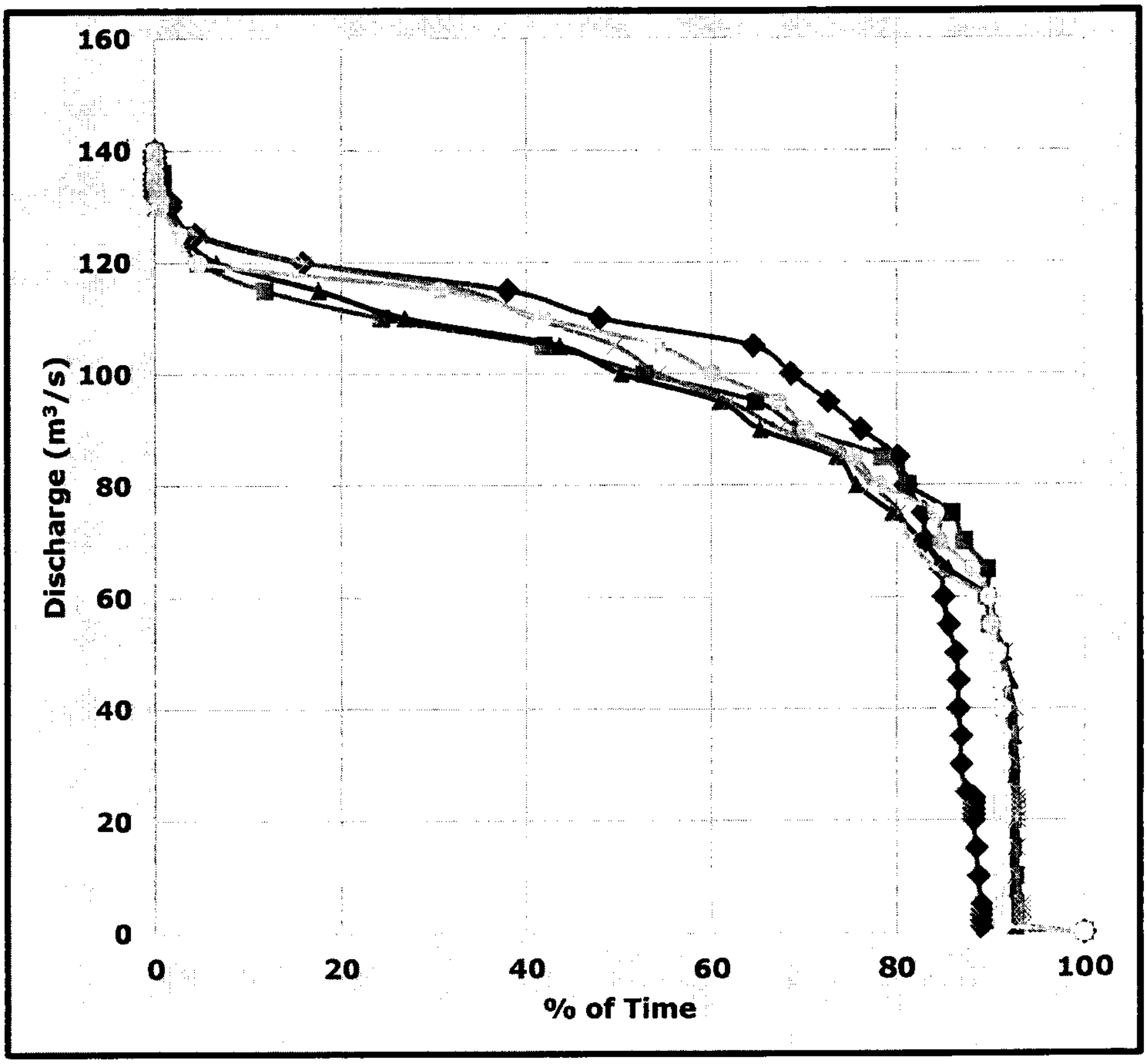


**Figure: 5.17 Flow Duration Curve on Yearly Basis**

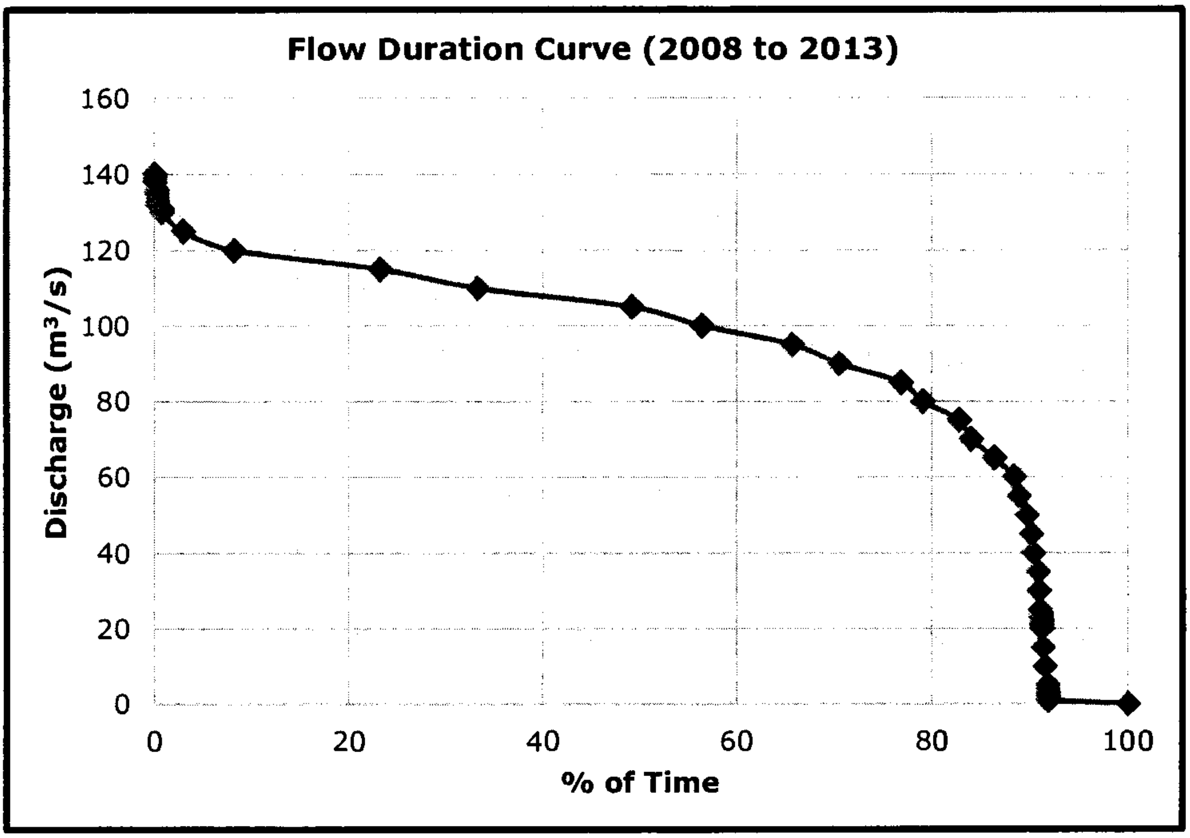
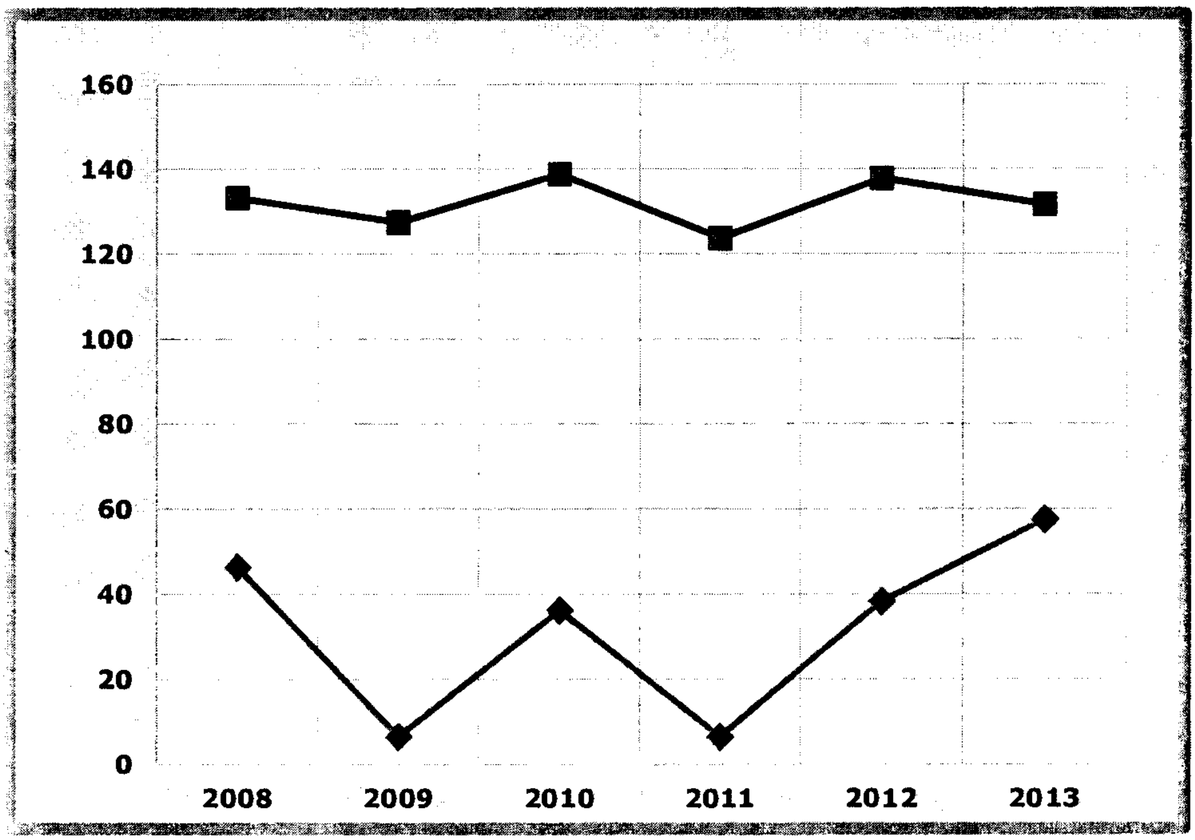



**Figure: 5.18 Minimum and Maximum Discharge in each Year**



## 5.4. Flooding Possibility

Flooding and breach of canal may result in suspension of power generation and flooding of powerhouse facility. As the canal is manmade structure and being regulated at its head, chances of flooding through head regulator are remote or negligible. The only possibility for flooding is the up doab floods or excessive rainfall in the project Area.

Historically the Rechna Doab has been subjected to frequent and severe flood damages in the vicinity of Ravi and Chenab River. The site is almost in the middle reach of Rechna Doab and therefore never subject to flood damages.

Breach of canal may be also remote possibility, therefore suspension of power generation will not be a problem.

## 5.5. Sediment Data

No sediment data is being collected at site. Sediment data at head regulator of Lower Chenab Canal is be recorded especially during flood season. It is important to note that the proposed project site is about 110 km downstream from Lower Chenab Canal Head regulator. Therefore, coarse sediment would not reach to site and will settle in the main Lower Chenab Canal reach. The only suspended sediment will reach the site. As the LCC bifurcate in to two at RD 140+050, therefore suspended sediment reaching at site would be half or even less.

As the low head turbines are slow moving machines, therefore suspended sediment may not be issue during operation.

## 5.6. Conclusions

On the basis of above discussions, the following can be concluded:

- The average canal closure period is 26 days. Therefore to get more benefits of energy it is proposed that closure period be kept up to 20 to 26 days in future.
- The upstream level will be kept constant at designed full supply level. For downstream water level rating curve should be developed during detailed engineering design.
- The enegy potential will be worked out on daily basis for period 2008 to 2013 being less period of record.
- The sediment entering in to canal are smaller in size and hence not considered harmfull to turbines and other parts. However, sediment data should be recorded at site during detailed engineering design in order to give to turnbine manufacturereres at the time of bidding.

# SECTION 6

## PRELIMINARY PROJECT LOCATION AND LAYOUT ALTERNATIVES STUDY

# CHAPTER 6

## PRELIMINARY PROJECT LOCATION AND LAYOUT ALTERNATIVES STUDY

### 6.1 Introduction

It was considered imperative that before we should start topographic survey and geo-technical investigation, a preliminary layout study is must under which all possible option for locating the project should be studied into details and preferred project location should be selected. Further to be more practical, a preliminary level layout study should also be completed under which one or two best alternatives should be scrutinized and selected to start with the topographic survey and hence geo-technical investigation in the form of boreholes drilling and test pitting (if required).

It would have been more economical and preferred option that if hydropower project facility would have been constructed simultaneously when the gated fall structure of Upper Gugera Branch at RD 216+100 have been constructed.

The Sponsor Company has the LOI for site at RD 216+100 and RD 220+750 of the Upper Gugera Branch to conduct the Feasibility Study Report. The head available at RD 216+100 and RD 220+750 is 1.859 m (6.1 ft) and 1.49 m, respectively when Upper Gugera Branch is flowing at its full capacity.

As it is clear that there exist two fall structures 1st at RD 216+100 and 2nd at RD 220+750 where installation of hydropower project could be possible. Therefore, the following possibilities should be explored so that a preferred project location could be brought up;

- Option I: Construction of two Powerhouses – one near each Fall Structure; and
- Option II: Construction of one Powerhouse – Combination of two falls, near Gated Fall at RD 216+100 or Near un-gated Fall at RD 220+750.

### 6.2 Project at Option I

The project location at option I calls for construction of two hydropower projects such as:

- Project Located at or Near RD 216+100
- Project Located at or Near RD 220+750

The construction of two hydropower projects has merits and demerits however, they would not be economical in present energy tariff and technology scenario in the Pakistan. As both the fall structures have available water head less than 3.0 m which is not considered technological viable in present years. Therefore construction of two powerhouses or single powerhouse at any fall is not considered further.

### 6.3 Project at Option II

To make the hydropower project viable technically and economically, it is considered that head available at both structures should be combined by excavation or raising of canal banks so that limit of 2.5 m should be met. Considering combination of falls/heads, the following two options exists;

- Option II.1 Placing the Project Near RD 216+100
- Option II.2 Placing the Project Near RD 220+750

The above options of hydropower project location have merits and de-merits. However, the merits and de-merits are discussed as under in detail.

#### 6.3.1 Project Location Option II.1

Project location under Option II.1 calls for dismantling of existing Fall Structure at RD 220+750 and bed of Upper Gugera Branch between RD 216+100 and RD 220+750 would be excavated at the existing bed slope of Upper Gugera Branch. By doing this head available at two fall structures would be combined at or near RD 216+100. This Option has merits and de-merit over Option II.2 such as:

**Merits**

- By lowering the bed level means that full supply level in the canal would also be lowered.
- Chance of canal breach is reduced as a result of lowering of full supply level.
- No water logging in the surrounding area especially land lying on right bank.
- No water losses in the form of water seepage. Even canal will act as drain in this area.
- In case of any problem at powerhouse, spillway gates will be opened and canal would remain safe from any breach.
- Raising of canal banks is not required as required in case of Option-II-2.

**Demerits**

- Lowering of canal bed means excavation of wet material which can only be done during canal closure by normal machinery, otherwise under water dredger is required which is costly solution.
- Dumping of excavated material near the canal right bank as there is no or little space on left bank. Dumping of excavated material mean requirement of additional land, if land of canal right of way does not available.
- Strengthen of existing bridge foundations by placing stone gabions all around the piers foundation.
- Dismantling of existing bridge at RD 219+000 and fall structure at RD 220+740, mean additional cost and time.

### 6.3.2 Project Location Option II.2

Project location under Option II-2 means that the existing bed and canal embankment of the canal between fall Structure at 216+100 and RD 220+750 should be raised that the head available at RD 216+100 would be brought at RD 220+750. By doing this head available at two fall structures would be combined at or near RD 220+750. This Option has merits and de-merit over Option II-2 such as:

**Merits**

- No need of extra land for dumping of excavated material on canal right bank.
- No need of strengthen of bridges foundations

**Demerits**

- Raising of water level between proposed powerhouse near RD 220+750, require raising of canal banks.
- Raising of bed level in order to achieve proper hydraulic gradient. It would be done by construction of controlled section by bricks and filling of bed by earth between these controlled sections or filling between these could be made by canal flows laden with silt.
- Increase in water losses due to seepage as a result of increased water level.
- Water logging of surrounding area especially the land along canal right bank.
- Chance of canal breach increased due to increased water level.
- Dismantling of fall structure at RD 216+100, RD 219+000 and Raising of Bridge deck at Nankana Sahib Road. Construction of new head regulator for High Level Canal or remodeling of its head regulator under new water level conditions.

### 6.3.3 Preferred Project Location

Considering the merits and demerits written above for Option II.1 and Option II.2, Option II.1 offered more merits and less demerits than Option II.2. Therefore Option II.1 is considered the preferred option for location of proposed project.

It means combination of falls available at RD 216+100 and RD 220+750 be made near RD 216+100 and not near RD 220+750. Therefore, it is preferred option that proposed project should be located as near as possible to the RD 216+100, in order to minimize the canal banks raising and bed raising/lowering.

Therefore, proposed project would be located near or around RD 216+100.

## 6.4 Main Considerations during Project Location and Layout Planning

Before embarking upon studies of layout alternatives, the following important factors that could affect the placing and layout of the power project was studied in details. These factors are:

- Site Topography
- Site Conditions around Preferred Project location
- Subsurface Conditions from Available Report and Documents
- Climatic Conditions
- Hydrological Conditions

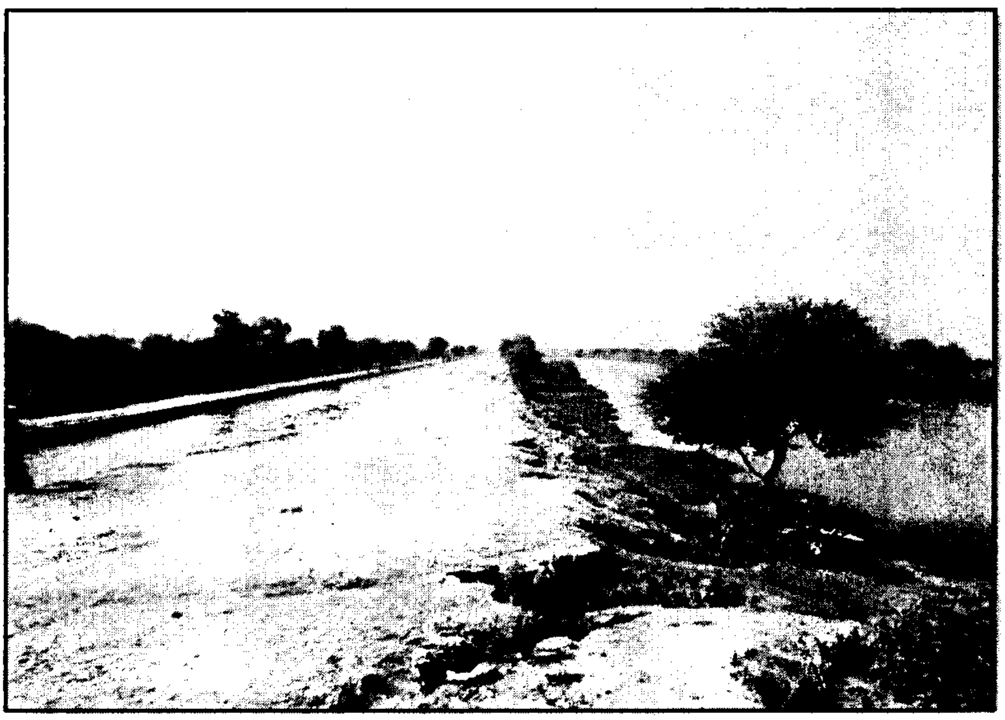
### 6.4.1 Site Topography

The site is relatively level with approximately 1:100 slopes towards south. Generally the ground surface level around the preferred location is level 200.00 m.a.s.l. The full supply level in the canal is generally above the natural ground level (**Drawing No: 6.1**).

### 6.4.2 Site Conditions Around Preferred Project Location

Gugera Branch and High Level canal run parallel from RD 216+100 to their RD 220+750. Fall structures at RD 216+100 and RD 220+750 at Gugera Branch Canal are provided due to change in ground level. The High Level Canal is running along left bank of Gugera Branch as shown in Figure: 6-1. The space between two canal varies from 30 m to 40 m.

**Figure: 6.1 Upper Gugera Branch and High Level Channel**

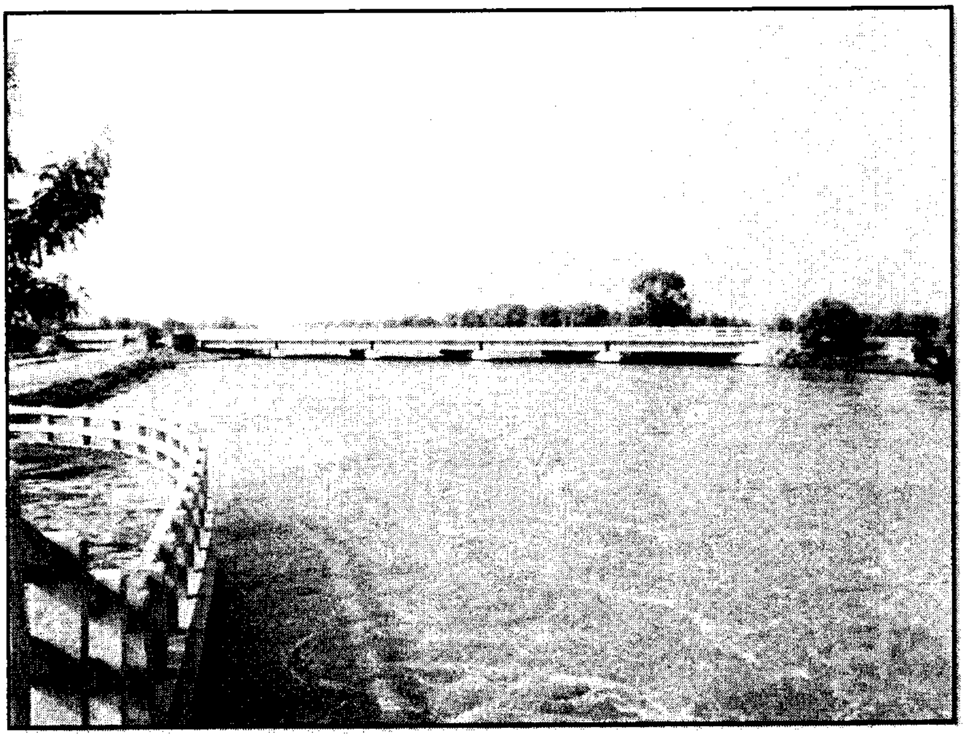


The placing of the powerhouse on left side of Gugera Branch Canal has restriction due to space limitation because High Level Canal is running parallel and width of the bank between two canal is about 30 m. Any excavation in the left bank increases in piping because of full supply level higher in two Canals.

There is no restriction of space on Gugera Branch Canal at right side. The canal bank road is running along its left bank from RD 216+100 to RD 220+750. Land is under agriculture around RD 216+100 and between both RDs.

A newly constructed 4 lanes bridge exists at RD 216+500 of Upper Gugera Branch over which road to Nankan Sahib passes. Locating the proposed powerhouse upstream or downstream of this bridge has merits and demerits. Therefore, while deciding about alternatives layout, the importance of bridge has to be considered.

**Figure: 6.2 Four Lane Newly Constructed Bridge at RD 216+500**



The fall structure at RD 216+100 is newly constructed and is in excellent conditions. It is gated. Gates are being operated manually which can easily be converted in to mechanical operation and can be automatically operated and controlled from powerhouse control room.

### 6.4.3 Sub-Surface Conditions

The subsoil materials along the right and left bank of the Gugera Branch Canal at or near RD 216+100 are typical of the alluvial soils in the region consisting of predominately of fine grained soils ranging from silty clay to sandy clay, sandy silt, fine sand and medium sand. The clayey materials are generally found in upper soil layers. Although the majority of the soil samples were composed of poorly graded sand with silt, medium dense to dense non-plastic.

Generally it is concluded that foundation material are suitable for placing mat foundation which may be the foundation for proposed powerhouse. The SPT values should be more than 20 blows at foundation level.

### 6.4.4 Climate Conditions

The climate of the project area is generally hot and dry in summer and cold in winter. Summer start in April and continues until September. July and August are the months of summer monsoon. Winter begins in October last until February. In summer temperature ranges from 29°C to 44°C, which sometimes shoot to 50°C during May through June. While in winter temperature ranges from 3°C to 20°C.

The average rainfall in the project area was recorded 460 mm. Detail data for rainfall will be collected from the Pakistan Meteorological Department. Most of the rainfall occurs during the monsoon months of July and August amounting to 60% of the total average annual rainfall.

The precipitation record shows that maximum rainfall occurs in the month of August and minimum rainfall during the month of November. There are some rainfalls during December and January also as winter monsoon.

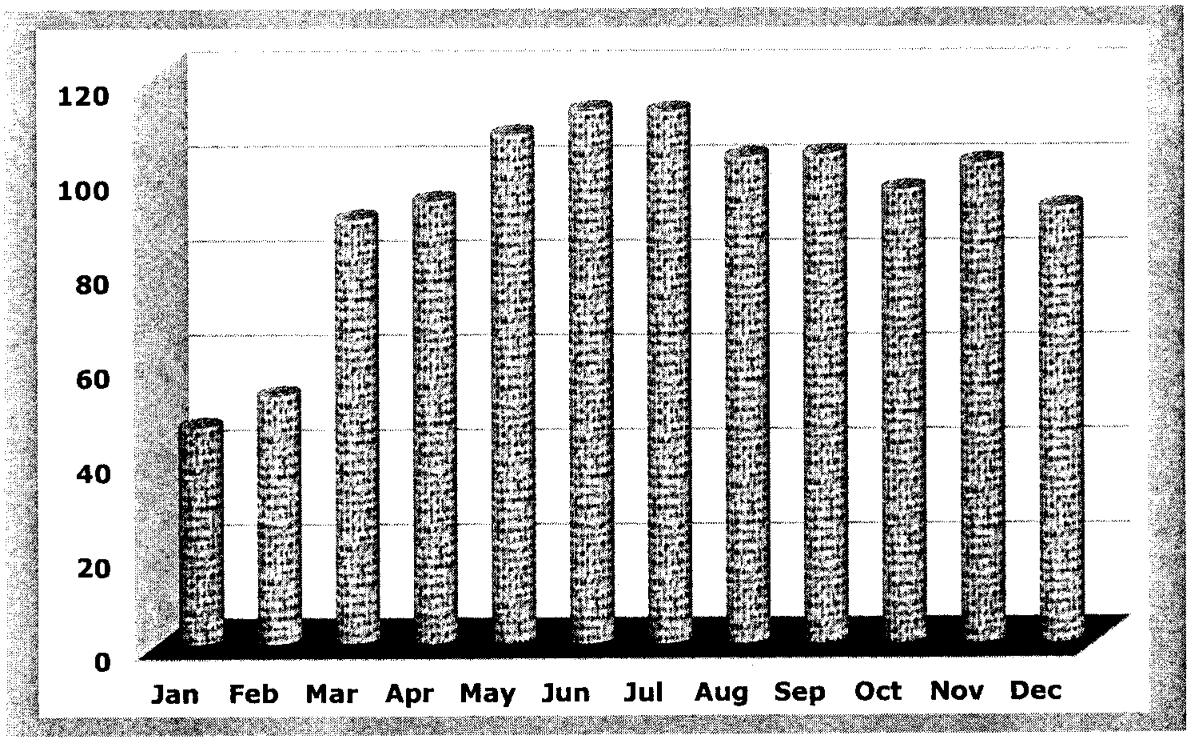
Humidity is measured at 08:00 and 17:00 hours. Average relative humidity ranges from 35% in May to 70% in August.

Average monthly wind speed is calculated by using daily data measured at the Pakistan Meteorological Department. The minimum and maximum values of wind speed are 0.15 knots per hour in November and 4.10 knots per hour in July, respectively.

### 6.4.5 Hydrological Conditions

The Gugera Branch Canal was designed for a capacity of 160 $m^3/s$ (5675 $ft^3/s$) at RD 216+100.

**Figure: 6.2 Average Flow Hydrograph (2008 to 2013)**




## 6.5 Project Operation Criteria and Rules

Hydropower project operating guidelines or rule will be the same as of canal operation till today. However, to maximize the benefit, the following is assumed and has to be considered in future operation of canal after proposed powerhouse is in operation;

- Upstream water level will be kept constant at 203.11 m.a.s.l, which is the Full Supply Level (FSL) in the Gugera Branch Canal at or near Fall structure at RD 216+100. The canal upstream of proposed powerhouse would be filled up to FSL and thereafter downstream release will be made as per canal operation guidelines or rules.
- It is assumed that no discharge is passed through the turbine if the available discharge is less than 30 % of turbine design discharge. The maximum turbine discharge has to be restricted during detailed calculation. However, at this stage it is assumed to pass all flows through the turbines.
- The downstream water level will be derived from discharge rating curve being used for stage and discharge measurement by Irrigation and Power Department at downstream of RD 216+100, if no rating curve is developed till today, then it should be developed during engineering design of the project.
- Canal closure is to be restricted up to the maintenance requirements only. Other closures as foreseen in the historic data should be avoided. Canal should remain in operation as far as possible.

- The powerhouse will be acting as water retaining structure, therefore it is should be designed stable against all loading conditions (Static and dynamic).

## 6.6 Alternative Turbine Types

### 6.6.1 Introduction

The Gugera Branch Canal is operating at maximum design discharge of 122.0 $m^3$/sec at downstream of RD 216+100. The gross head available after combination of both falls is about 3.0 m. The turbines should therefore be designed for optimal operation at net head of 2.8 m which fall in the range of very low head development and high discharge.

The development of a low-head small hydro site is difficult at this times. Low head means low power per unit of flow, and hence a relatively higher cost than for sites with higher heads. Also small power plants suffer from the inverse scale effect, with higher costs relative to larger sites. Hence, all means possible are needed to arrive at an economical development.

Following are the main Kaplan type of turbines that can be installed with varying number of units for this proposed project.

- **"S" Type Turbine**
- **Bevel Gear Turbine**
- **Bulb Type Turbine**
- **Pit Type Turbine**
- **Straflo/Rim Generator Type Turbine**
- **Vertical Axis Turbine**

Each of the above type of turbine has its own merits and demerits in respect of their operational head and discharge range, peak efficiency, maintenance approach and accessibility, civil work, power house depth (i.e. excavation required), and capacity required for lifting of equipment (i.e power house crane capacity).

Keeping in view discharge and head variation, the following two options are recommended for detailed analyses for Gugera Branch Canal Hydropower Project.

- Bevel Gear Turbine
- Pit Type

### 6.6.2 Number and Type of Turbine Units

The proposed site can be studied for the installation of 1, 2, 3, 4, and 5 turbine units. The installation of 5 units was not found suitable due to operational issues. The installation of one unit is also not suitable due to operation reliability and flexibility. The decision regarding number of unit and type of unit is also depend upon maintenance requirement which is not important for proposed site due to canal closure for a month period every year. Considering merits of bevel gear over pit type turbine during installation and cost impact, bevel gear is selected for this project.

## 6.7 Project Layout Alternative Studies

### 6.7.1 Introduction

Keeping in view site conditions & limitation, topography around the RD 216+100, climatic condition and hydrology, the following project layout alternatives were marked during the office studies being more suitable than any other alternative. These alternatives also checked during field visits and finally drawing were prepared on topographic survey conducted during this feasibility study:

- **Layout Alternative: 1** **Powerhouse and New Spillway in Bypass arrangement with long tailrace**
- **Layout Alternative: 2** **Powerhouse and New Spillway in Bypass arrangement.**

Layout alternative defined above, can only be placed along the right side of the existing canal, because, High Level Canal run all along left side of the Gugera Canal between RD 216+100 & RD 220+750.

Therefore, the project can be placed only on right side of existing canal.

### 6.7.2 Layout Alternative: 1 Powerhouse and New Spillway in Bypass arrangement with long tailrace

This layout alternative comprises of placing of powerhouse in bypass canal along right side of existing canal. The proposed bypass canal off-takes from upstream of RD 216+100 and runs parallel till RD 220+750 and joins the existing canal on downstream of RD 220+750. The existing canal from RD 216+100 to RD 220+750 will remain as it and be operating as spill canal in case powerhouse is not operating due to any reason. Further, the gates of existing fall structure at RD 216+100 would be remodeled for automatic operation.

The proposed powerhouse can be placed in the line with existing fall structure at RD 216+100 or on the downstream side of existing bridge/road. Placing of powerhouse on upstream of existing road is considered more suitable due to no additional remodeling works are required at existing bridge. In case powerhouse is placed on downstream of existing road, new bridge would be placed on upstream of powerhouse, which require 1.5 m higher deck level than existing bridge because of higher water level. Due to short distance available between new and old bridge this difference in level cannot be managed without raising of deck of existing bridge.

Placing of powerhouse on upstream of existing road may need some realignment of road due to space limitation between RD 216+100 and existing road and construction of new 4 lane bridge without diversion of existing road. It is proposed that new bridge would be constructed in dry just on downstream side of road. After completion of bridge and road diversion, excavation under the bridge would be started and completed.

This alternative further call for construction and excavation of head and tailrace canal from RD 215+000 to RD 221+100 at the reasonable distance from existing canal, so that excavation for powerhouse be down safely and with less dewatering problems. The excavation of tailrace canal can be performed without canal closure and in parallel to construction of powerhouse. The excavation of canal can be done with conventional excavation equipment (dragline, excavator, etc) and no needs of special equipment like dredger. Excavated material can be placed along both sides of the canal. However, placing of excavated between existing canal and new canal would be done first while extra material would be placed along right side, in order to reduce land acquisition as a whole.

A foot bridge may be required in line with existing bridge at RD 219+100, because local population is using for visiting their land along the right side of the existing canal.

This alternative requires land acquisition along right side for construction of headrace, powerhouse, tailrace and realignment of road to link the new bridge with existing road.

The canal banks upstream of fall structure have to be raised in order to manage the water surges occurred during sudden shutdown of the turbine units, because the existing fall structures is placed at some distance from powerhouse and in case of shutdown flows diversion toward fall structure requires more time than if fall structure is placed alongside of the powerhouse (Alternative: 2).

In this alternative construction work at powerhouse, bridge and tailrace can be started immediately and parallel. Joining of headrace and tailrace with existing canal can be done at any time, however, during canal closure, it would be less costly and simple.

### 6.7.3 Layout Alternative: 2 Powerhouse and New Spillway in Bypass arrangement

This alternative call for construction of powerhouse and spillway in the bypass arrangement along the right side of the existing canal and fall structure at RD 216+100. The bypass canal off-takes from upstream of existing fall structure and joins the existing canal just upstream of existing 4 lanes road bridge along Nankana Sahib Road.

Under this alternative, the existing fall at RD 216+100 would not be used as spillway and would not be remodelled. However, this would not be dismantled in order to save dismantling cost.

Powerhouse would be constructed along right side of the existing canal at save distance from running canal in order to reduce dewatering. Powerhouse may be located upstream of existing fall structure. The headrace may off-take from RD 212+000 and after S-type curve it runs for about 200 m straight before it reach the inlet bay of the powerhouse. The tailrace would start after outlet bay and after travelling about 100 to 150 m in straight alignment, it joins the existing canal through S-type curve.

The existing canal between Nankana Sahib road bridge and RD 220+750 would be excavated to act as tailrace canal. The existing structures at RD 219+100 and RD 220+750 would have to be dismantled. Excavation of existing canal may be done during canal closure being simple and cheap. However, detailed analysis would be done during engineering design for actual requirement of machinery and manpower to complete this work during canal closure period.

This alternative further calls for construction of head regulator of High Level Canal. Using of gates of existing fall structures and head regulator of high level canal in new structures should also be considered during engineering design before starts of construction after proper assessment of their quality and serviceability. However, at this stage new gates would be considered for cost estimation.

This alternative requires less land and also offer good hydraulic conditions because the powerhouse and spillway are placed side by side. Further, piles foundations of the existing road bridge may be protected with placing of stone all around in order to avoid scouring.

The powerhouse and spillway are constructed in one pit which may create some difficulties during construction. There are chances of differential settlement due to different foundation levels and loading conditions, if not properly design and constructed. In addition, flow conditions towards the powerhouse are asymmetrical as the canal bed would be almost double than existing bed width.

## 6.8 Preferred Project Layout Alternative

On the basis of design and drawing prepared for above alternatives, a cost and quantity analyses were made. The cost would include the cost of civil work and environmental work. The cost of E&M equipment were not added being the same for all alternatives. However, cost of gates over the spillway and there remodelling would be included.

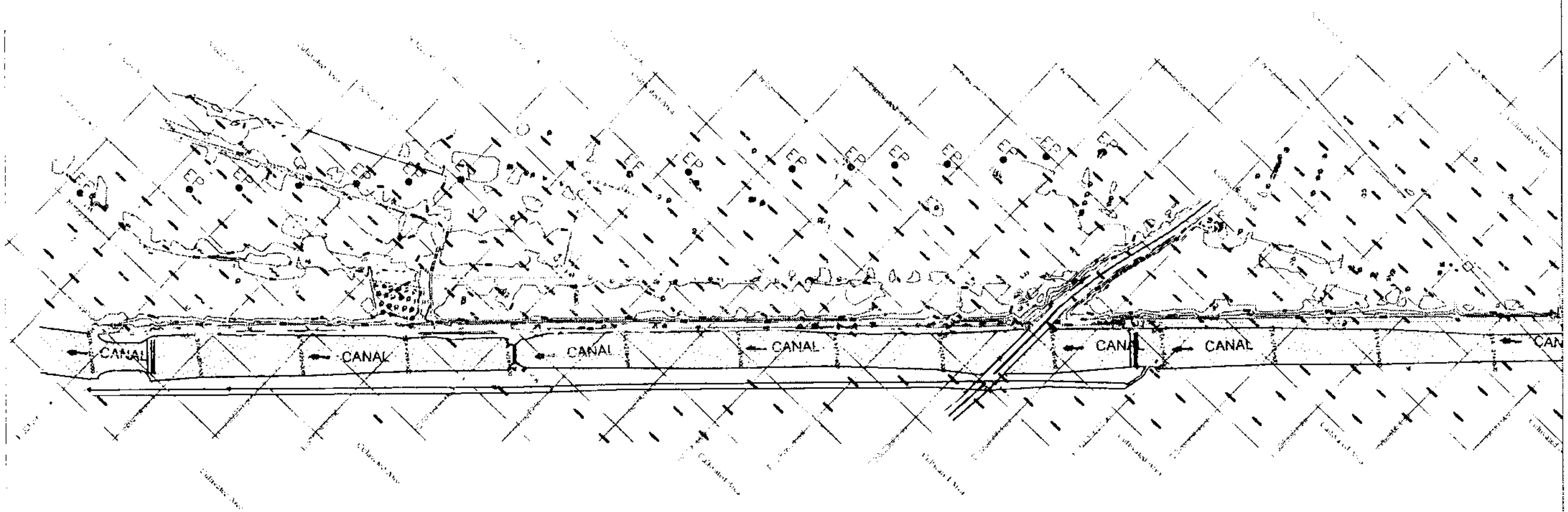
Costs of contingencies, engineering and supervision and transport and erection and testing of E&M would be included. On the basis of economic and financial analysis, the preferred alternative would be selected and design of feasibility level for each structure and component would be performed and presented in **Section: 9**. The drawings of each Alternative is presented in **Drawing No. 6.2 through 6.15**. The quantities and cost for each alternative is present in **Annexure: 6.1 through Annexure: 6.2.**

The unit cost (kWh) analysis is presented in detail in **Annexure: 6.3 through Annexure: 6.4**. The summary of all calculation is presented **Table 6.1** below:

**Table: 6.1 Summary of Cost, Power, Energy and Per Unit Cost**

| | Base Cost (Rs Million) | Power (MW) | Energy (GWh) | Cost/KWh (Rs) |
|---|---|---|---|---|
| Alternative-1 | 1853.20 | 3.6 | 21.12 | 8.81 |
| Alternative-2 | 1398.43 | 3.6 | 21.12 | 13.46 |

The Alternative:2 gives less cost/kWh than Alternative:1 and hence selected as preferred Alternative for further studies under **Section: 9** of this Feasibility Study Report.

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## LEGEND

- BUILDING
- BOUNDARY
- BENCH MARK — B-M 1
- ELECTRIC POLE
- POND
- FENCE
- ROAD
- TRACK
- KM STONE
- HAND PUMP
- TREE 15'
- TREE PALM
- NALA
- SOLLING
- WATER COURSE
- SIGN BOARD
- TS
- MOSQUE
- TUBE WELL — TW
- GATE
- CANAL
- WALL

**NOTES:**

Contour interval 0.5 m

All dimensions are in Meters.

SCALE

**CLIENT:- M/s Gugera Hydro Power Co. (Pvt) Ltd.**

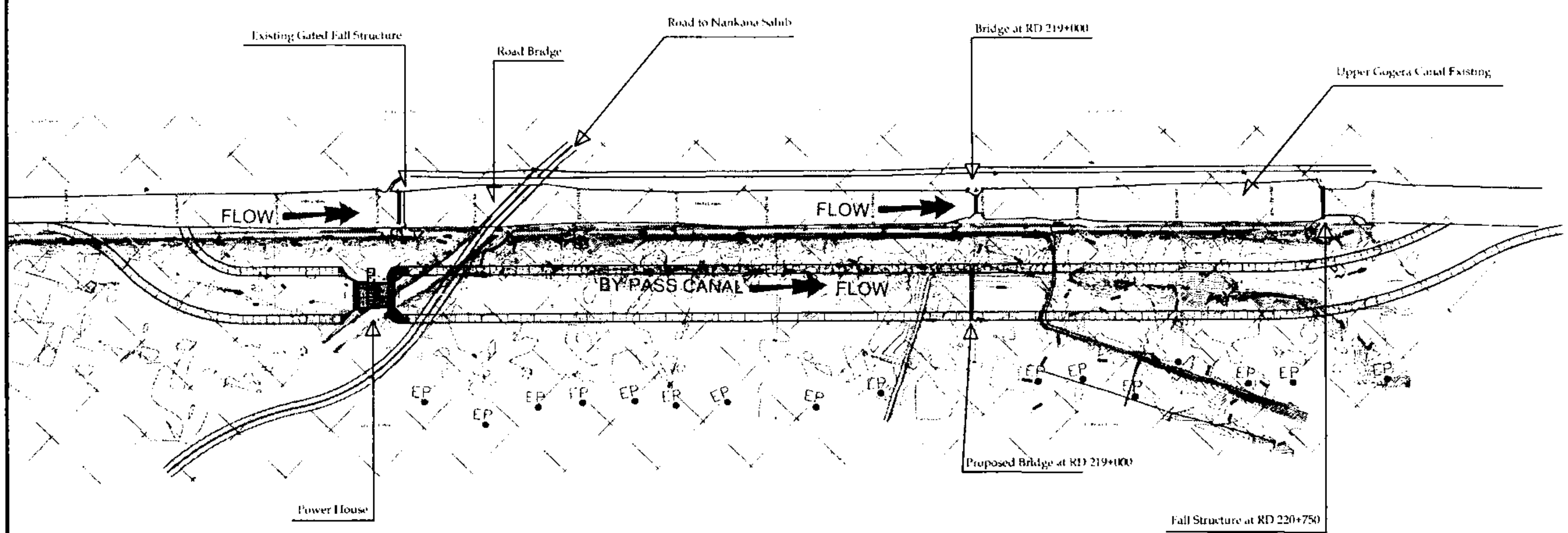
Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

**UPPER GUGERA BRANCH**

**FEASIBILITY STUDY REPORT**

| | |
|---|---|
| Designed by | **SITE TOPOGRAPHY** |
| Checked by | |
| Approved by | |

| DATED | SCALE | DRAWING NO. |
|---|---|---|
| March 2014 | 1 : 1000 | G-1 |




## LEGEND

- BUILDING
- BOUNDARY
- BENCH MARK — B-M 1
- ELECTRIC POLE
- POND
- FENCE
- ROAD
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- TS
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- TUBE WELL
- GATE
- CANAL
- WALL

**NOTES:**

Contour Interval 0.5 m

All dimensions are in Meters.

SCALE

**CLIENT:- M/e Gugera Hydro Power Co. (Pvt) Ltd.**

Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan

**UPPER GUGERA BRANCH**

**FEASIBILITY STUDY REPORT**

| | |
|---|---|
| Designed by | **POWERHOUSE IN BYPASS AND REMODELING OF EXISTING FALL RD 216+100** |
| Checked by | |
| Approved by | |

| DATED | SCALE | DRAWING No. |
|---|---|---|
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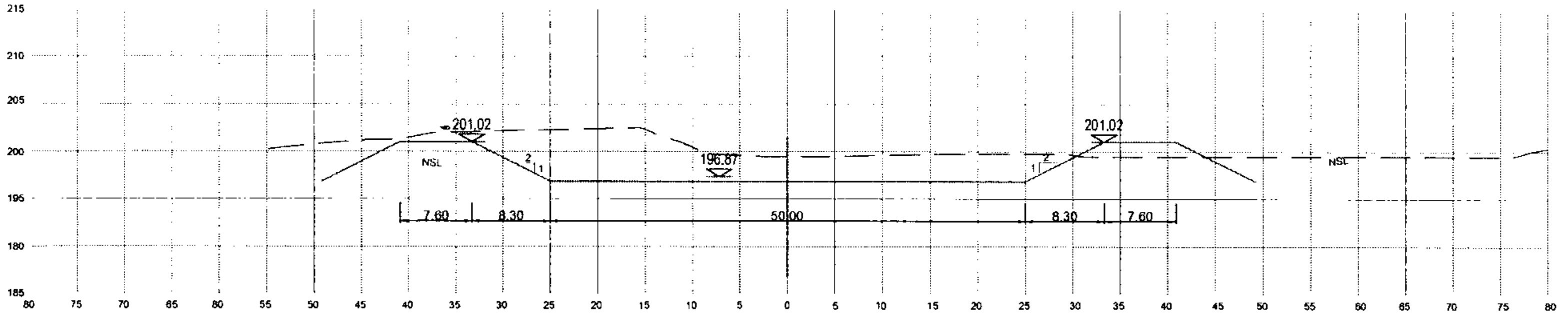
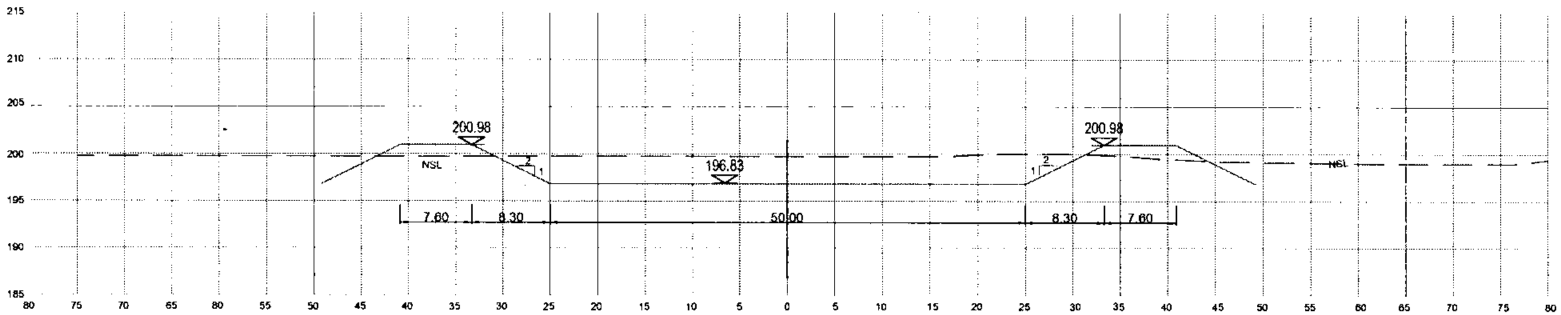
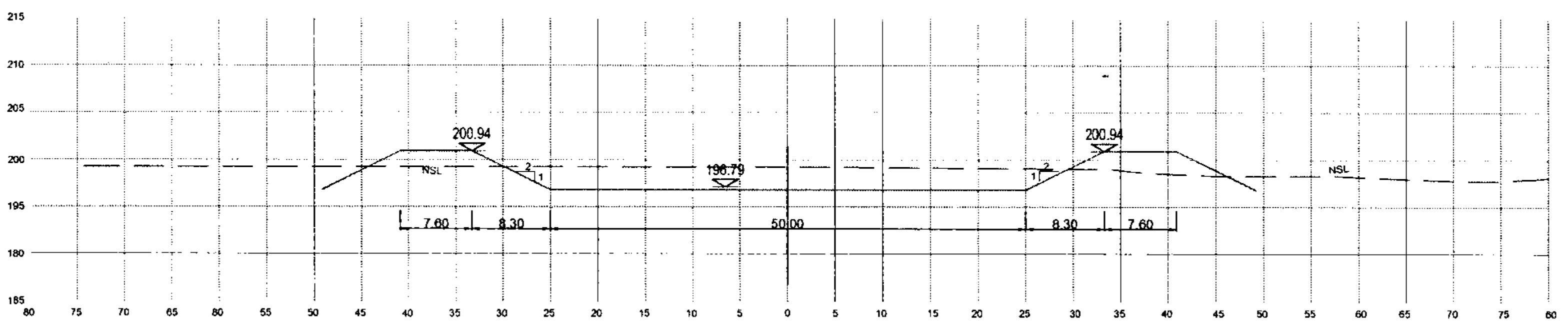



**SECTION 4-4 AT RD 216+000**




**SECTION 5-5 AT RD 217+000**




**SECTION 6-6 AT RD 218+000**

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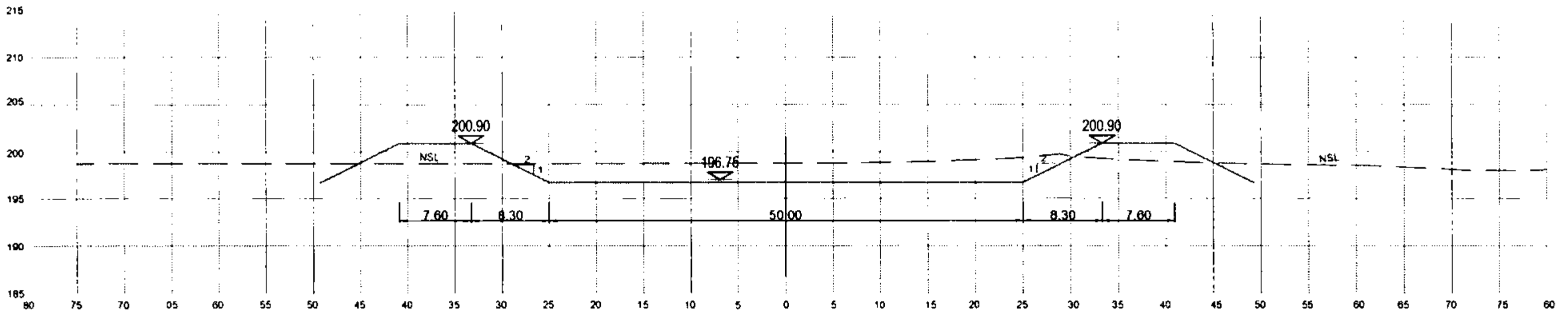
team — Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

**UPPER GUGERA BRANCH**

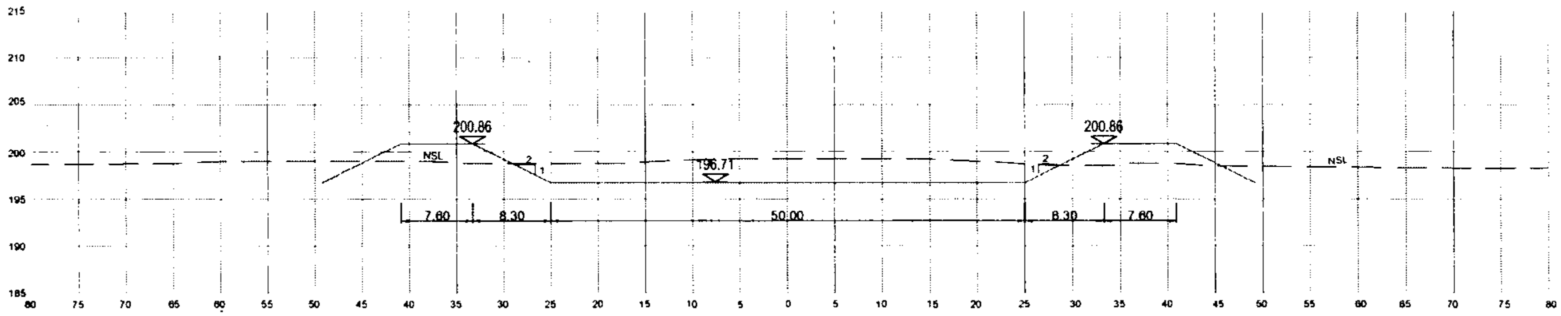
**FEASIBILITY STUDY REPORT**

| | |
|---|---|
| Design by | Alternative-1 TAILRACE CROSS SECTION |
| Checked by | |
| Approved by | Sheet 2 of 3 |

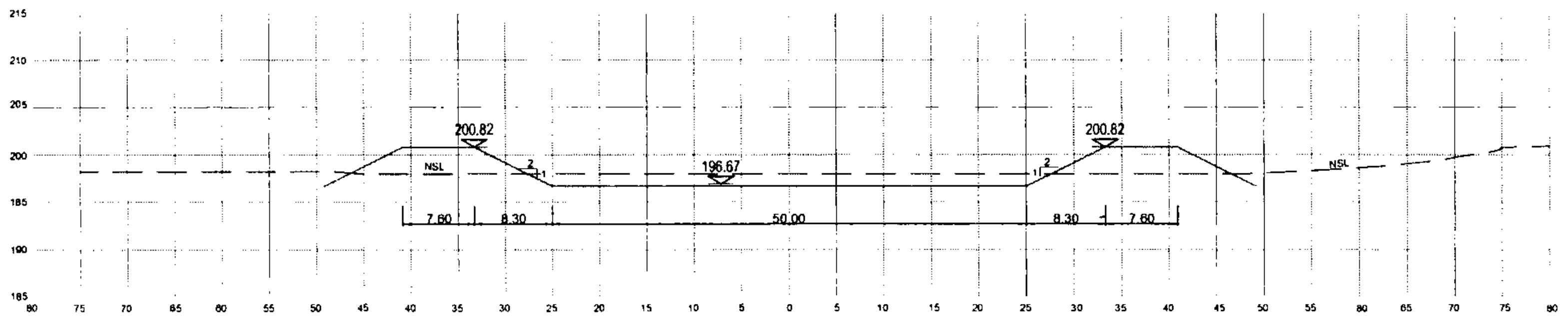
| DATED: | SCALE: | DRAWING No: |
|---|---|---|
| March, 2014 | 1 : 5500 | 6-4 |




**SECTION 7-7 AT RD 219+000**




**SECTION 8-8 AT RD 220+000**




**SECTION 9-9 AT RD 221+000**

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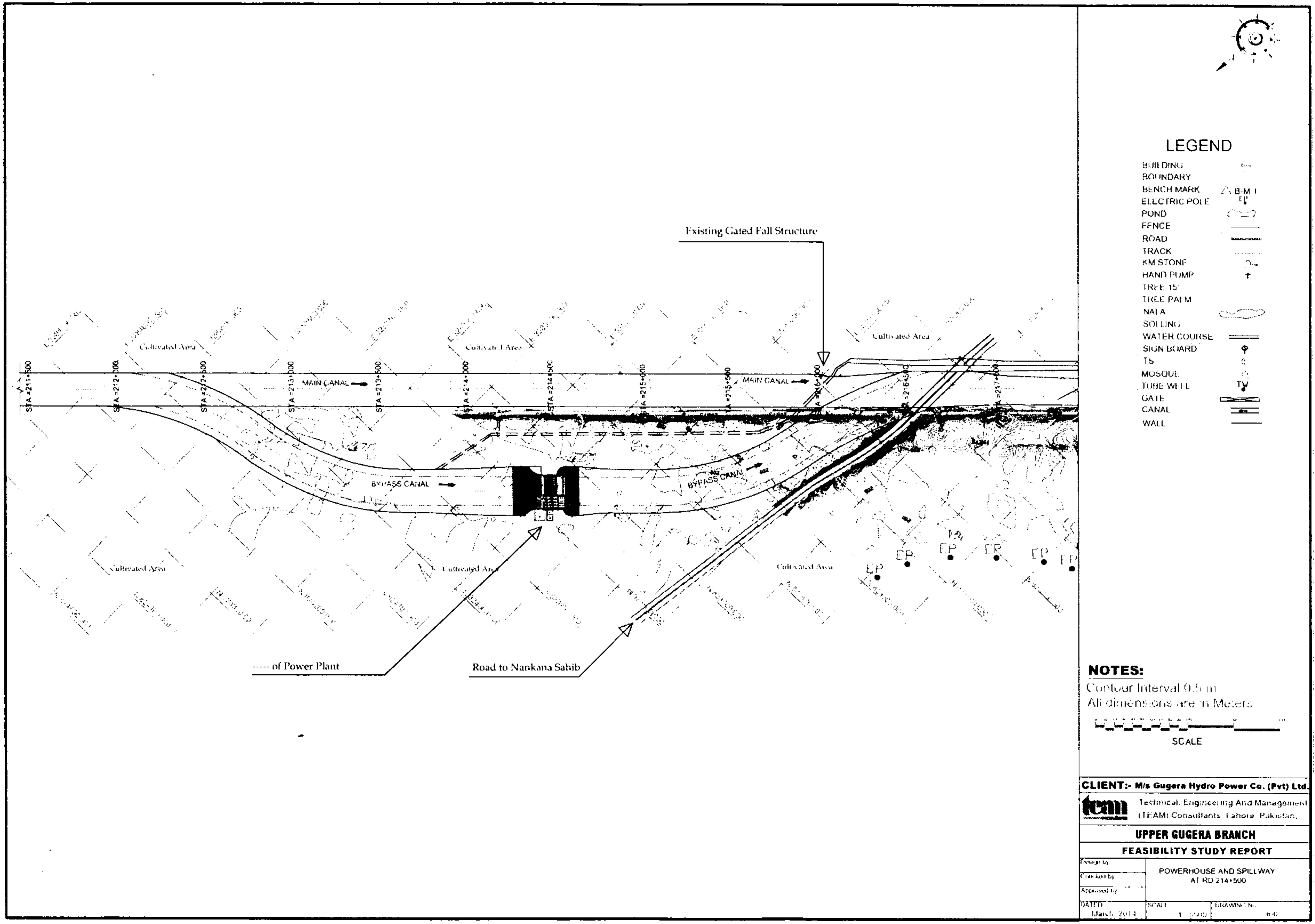
Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

**UPPER GUGERA BRANCH**

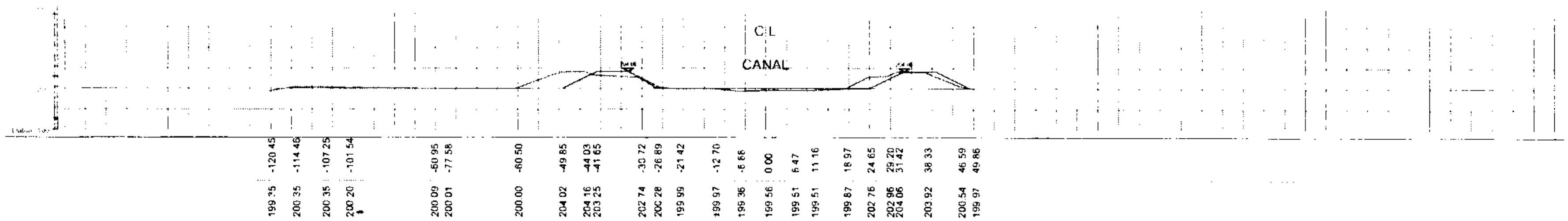
**FEASIBILITY STUDY REPORT**

| | | |
|---|---|---|
| Design by | Alternative-1 TAILRACE CROSS SECTION | |
| Checked by | | |
| Approved by | | Sheet 3 of 3 |
| DATED March 2014 | SCALE 1 : 5500 | DRAWING No. 6-5 |



Existing Gated Fall Structure
Cultivated Area
MAIN CANAL
BYPASS CANAL
STA =211+500
STA =212+000
STA =212+500
STA =213+000
STA =213+500
STA =214+000
STA =214+500
STA =215+000
STA =215+500
EP
----- of Power Plant
Road to Nankana Sahib
LEGEND
BUILDING
BOUNDARY
BENCH MARK
B-M
ELECTRIC POLE
POND
FENCE
ROAD
TRACK
KM STONE
HAND PUMP
TREE
TREE PALM
NALA
SOLING
WATER COURSE
SIGN BOARD
TS
MOSQUE
TUBE WELL
GATE
CANAL
WALL
NOTES:
Contour Interval 0.5 m
All dimensions are in Meters
SCALE
CLIENT:- M/s Gugera Hydro Power Co. (Pvt) Ltd.
team
Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.
UPPER GUGERA BRANCH
FEASIBILITY STUDY REPORT
Design by
Checked by
Approved by
POWERHOUSE AND SPILLWAY AT RD 214+500
DATED
March, 2014
SCALE
DRAWING No.

Station 215+500 (Linear Unit Used Metre )

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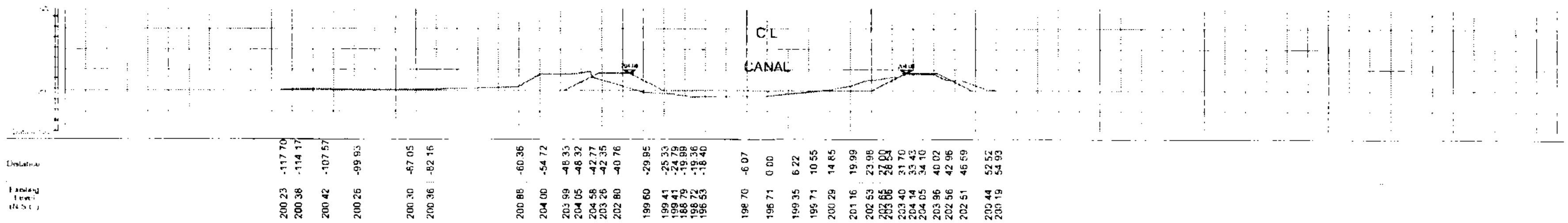


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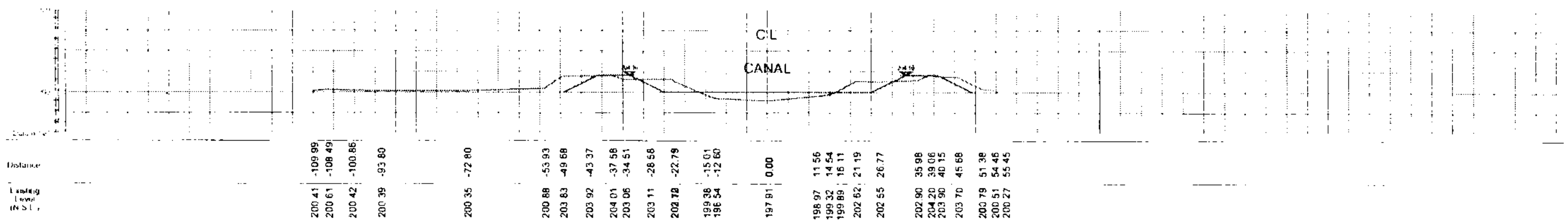


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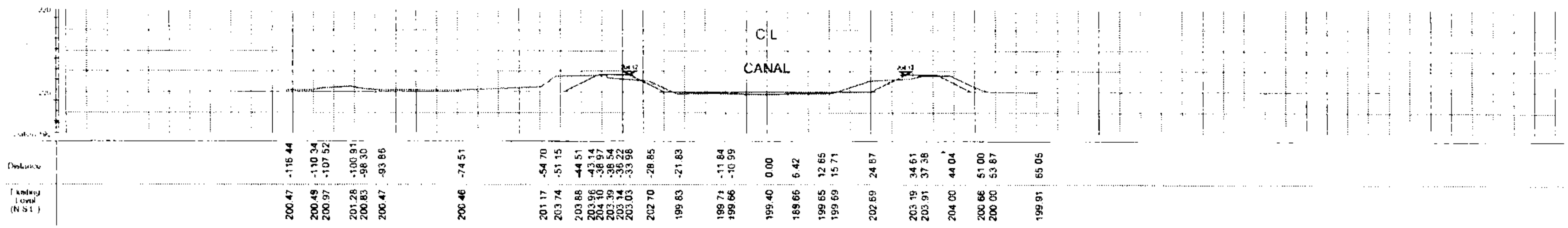


1 All dimensions are in meter.
2 All levels are in meter above sea level. (masl)

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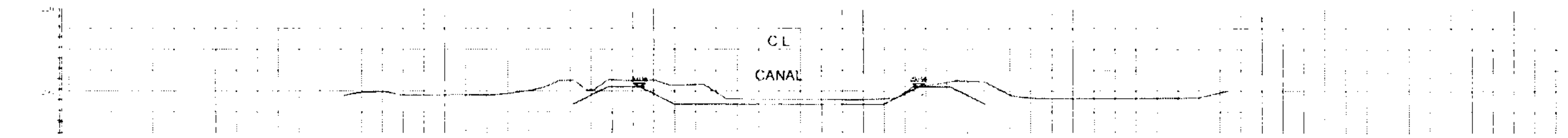
team — Technical, Engineering And Management (TEAM) Consultants. Lahore, Pakistan.

**UPPER GUGERA BRANCH**

**FEASIBILITY STUDY REPORT**

| Design by | **UPPER GUGERA CANAL L-SECTION** SHEET 1 OF 4 | |
|---|---|---|
| Checked by | | |
| Approved by | | |
| DATED March 2014 | SCALE 1 : 1000 | DRAWING No. 6-7 |

Station:217+500 (Linear Unit Used: Metre.)




| Distance | Existing Level (N.S.L.) |
|---|---|
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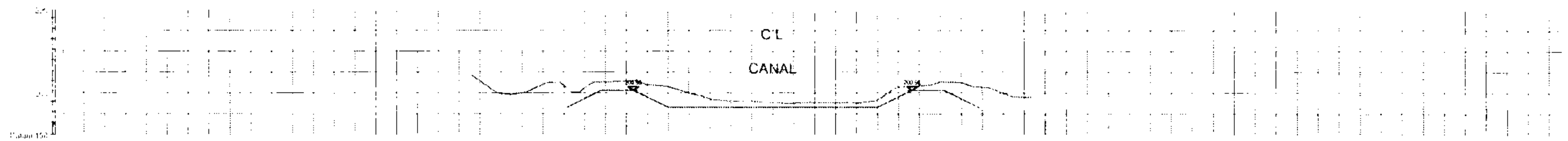
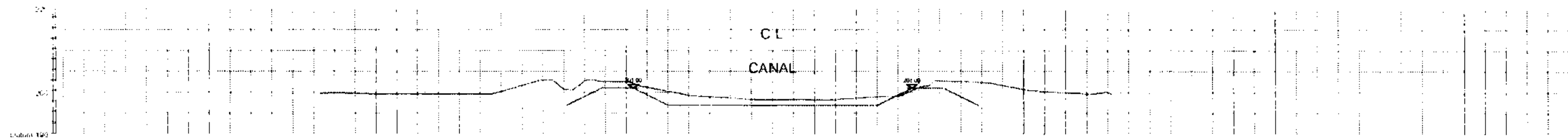
| -100.90 | 199.86 |
| -94.78 | 199.90 |
| -90.37 | 199.06 |
| -79.99 | 199.05 |
| -68.55 | 199.14 |
| -65.53 | 199.33 |
| -59.83 | 200.17 |
| -56.08 | 200.99 |
| -52.78 | 202.50 |
| -52.54 | 202.52 |
| -49.14 | 202.52 |
| -46.11 | 200.29 |
| -44.37 | 200.28 |
| -41.22 | 202.51 |
| -40.39 | 202.76 |
| -38.42 | 202.63 |
| -37.19 | 202.50 |
| -31.36 | 202.48 |
| -30.09 | 202.72 |
| -26.27 | 201.44 |
| -17.99 | 201.59 |
| -12.55 | 198.19 |
| -5.45 | 198.05 |
| 0.00 | 198.05 |
| 9.64 | 198.05 |
| 17.28 | 187.95 |
| 24.41 | 198.12 |
| 28.13 | 198.47 |
| 32.31 | 201.38 |
| 35.60 | 201.43 |
| 42.22 | 202.65 |
| 42.53 | 202.48 |
| 43.15 | 202.39 |
| 48.90 | 202.26 |
| 55.50 | 198.87 |
| 58.53 | 198.52 |
| 61.74 | 198.27 |
| 74.55 | 198.29 |
| 87.97 | 199.28 |
| 99.80 | 198.41 |
| 106.73 | 200.00 |

Station:217+00 (Linear Unit Used: Metre.)



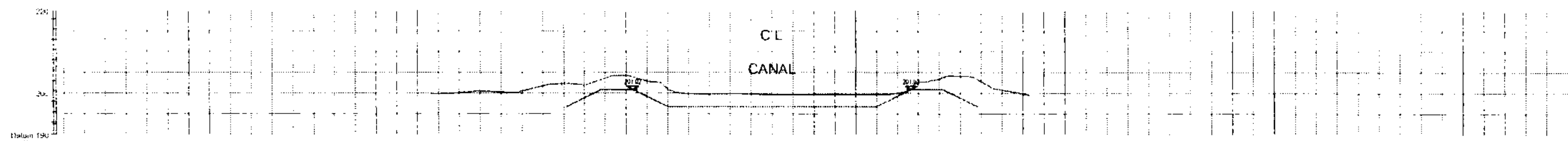

| Distance | Existing Level (N.S.L.) |
|---|---|
| -71.88 | 204.16 |
| -66.10 | 200.16 |
| -62.59 | 199.62 |
| -59.16 | 200.21 |
| -54.15 | 202.54 |
| -51.05 | 202.56 |
| -48.12 | 200.30 |
| -46.26 | 200.26 |
| -43.27 | 202.52 |
| -40.10 | 202.66 |
| -33.45 | 202.85 |
| -32.55 | 203.14 |
| -30.26 | 201.96 |
| -25.41 | 201.65 |
| -14.17 | 198.42 |
| -10.55 | 198.10 |
| -5.65 | 198.10 |
| 0.00 | 197.64 |
| 4.72 | 197.58 |
| 9.20 | 197.79 |
| 15.36 | 197.68 |
| 18.53 | 197.82 |
| 20.26 | 197.65 |
| 24.85 | 198.22 |
| 29.60 | 201.39 |
| 34.53 | 201.75 |
| 37.84 | 201.94 |
| 40.24 | 202.78 |
| 40.98 | 202.68 |
| 45.14 | 202.55 |
| 47.39 | 201.66 |
| 51.79 | 201.29 |
| 57.30 | 199.11 |
| 61.68 | 199.01 |

Station: 216+500 (Linear Unit Used: Metre.)




| Distance | Existing Level (N.S.L.) |
|---|---|
| -107.61 | 199.67 |
| -103.71 | 199.86 |
| -101.02 | 199.72 |
| -93.92 | 199.61 |
| -86.84 | 199.63 |
| -66.16 | 199.56 |
| -54.50 | 202.93 |
| -51.84 | 202.94 |
| -48.97 | 200.65 |
| -46.86 | 200.59 |
| -43.72 | 202.90 |
| -41.96 | 202.95 |
| -40.68 | 202.62 |
| -36.51 | 202.49 |
| -33.45 | 202.58 |
| -31.21 | 201.59 |
| -18.54 | 199.19 |
| -15.00 | 198.95 |
| -7.83 | 198.59 |
| -4.83 | 198.29 |
| 0.00 | 198.20 |
| 3.64 | 198.20 |
| 7.43 | 198.31 |
| 14.14 | 198.18 |
| 18.47 | 198.47 |
| 27.08 | 199.00 |
| 31.49 | 199.14 |
| 36.53 | 201.44 |
| 38.40 | 201.60 |
| 39.74 | 202.84 |
| 41.98 | 202.72 |
| 48.79 | 202.52 |
| 53.41 | 202.13 |
| 82.07 | 200.52 |
| 68.17 | 200.03 |
| 73.61 | 199.79 |
| 76.73 | 199.52 |
| 79.68 | 199.84 |
| 80.48 | 200.23 |
| 81.78 | 199.50 |

Station: 216+00 (Linear Unit Used: Metre.)




| Distance | Existing Level (N.S.L.) |
|---|---|
| -81.79 | 199.90 |
| -76.51 | 199.95 |
| -70.43 | 200.49 |
| -61.30 | 200.15 |
| -53.62 | 202.12 |
| -49.23 | 202.32 |
| -44.61 | 201.99 |
| -38.47 | 204.15 |
| -34.24 | 204.18 |
| -28.68 | 202.81 |
| -26.68 | 202.58 |
| -24.63 | 200.69 |
| -22.15 | 200.04 |
| -16.93 | 199.76 |
| -8.24 | 199.88 |
| 0.00 | 199.63 |
| 12.88 | 199.60 |
| 21.32 | 199.63 |
| 28.00 | 199.62 |
| 32.03 | 200.40 |
| 34.76 | 202.55 |
| 37.06 | 202.20 |
| 38.04 | 203.01 |
| 39.97 | 203.38 |
| 41.72 | 204.13 |
| 46.83 | 204.00 |
| 48.47 | 203.64 |
| 52.86 | 201.10 |
| 58.47 | 200.20 |
| 61.64 | 199.41 |

1. All dimensions are in meter.
2. All levels are in meter above sea level. (masl)

**CLIENT:- M/s Gugera Hydro Power Co. (Pvt) Ltd.**

team consultants — Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

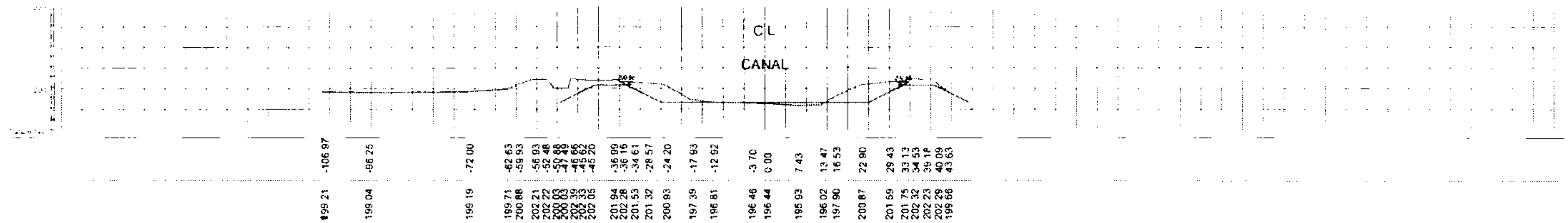
**UPPER GUGERA BRANCH**

**FEASIBILITY STUDY REPORT**

| Design by | **UPPER GUGERA CANAL L-SECTION** |
|---|---|
| Checked by | SHEET 2 OF 4 |
| Approved by | |

| DATED | SCALE | DRAWING No. |
|---|---|---|
| March 2014 | 1 : 1000 | 6.8 |

Station:219+500 (Linear Unit Used: Metre )

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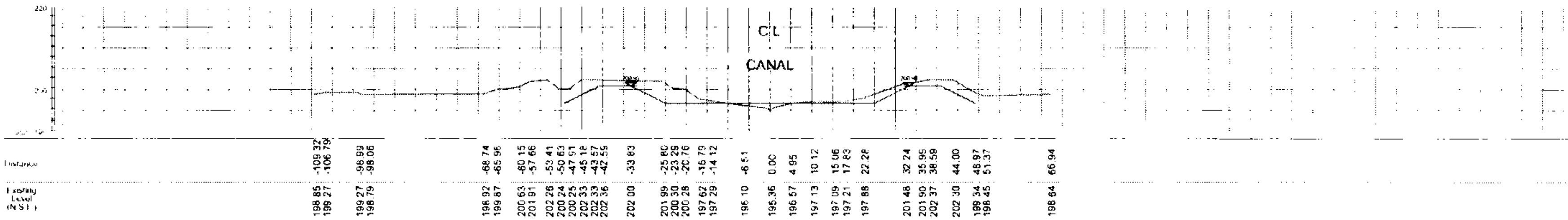


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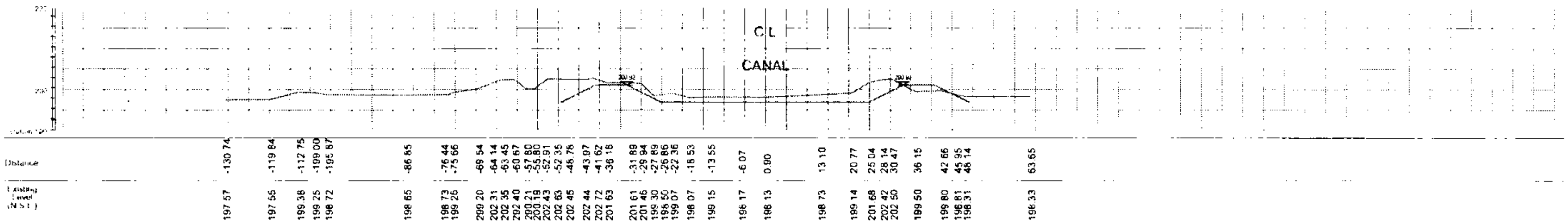


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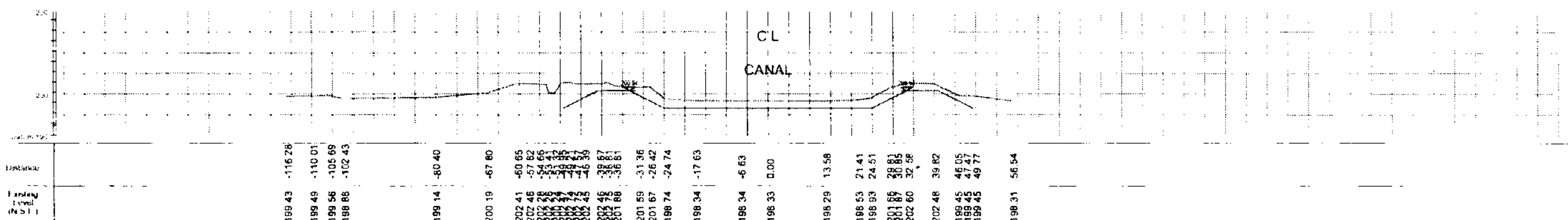



1. All dimensions are in meter.
2. All levels are in meter above sea level (masl)

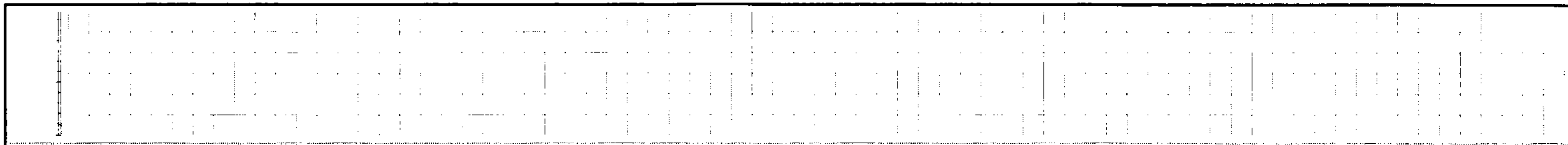
**CLIENT:- M/s Gugera Hydro Power Co. (Pvt) Ltd.**

team consultants — Technical Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

**UPPER GUGERA BRANCH**

**FEASIBILITY STUDY REPORT**

| | |
|---|---|
| Design by | **UPPER GUGERA CANAL L-SECTION** |
| Checked by | SHEET 3 OF 4 |
| Approved by | |
| DATED March 2014 | SCALE 1 1000 / DRAWING No 6.9 |



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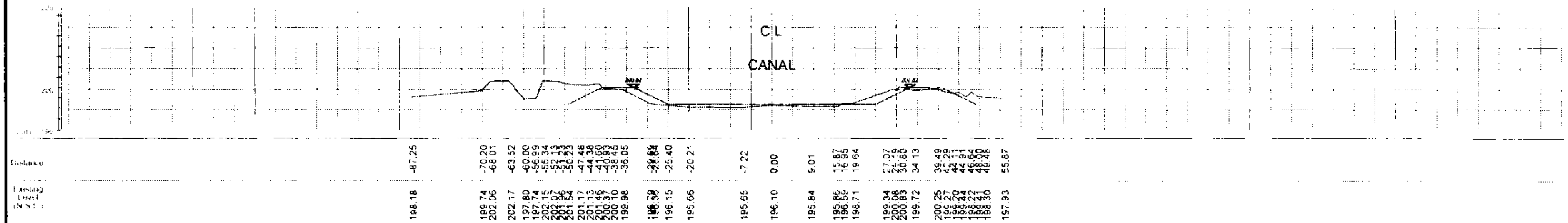


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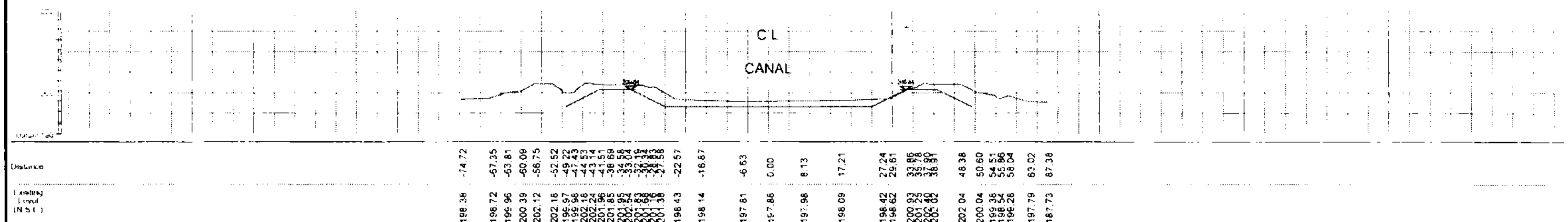


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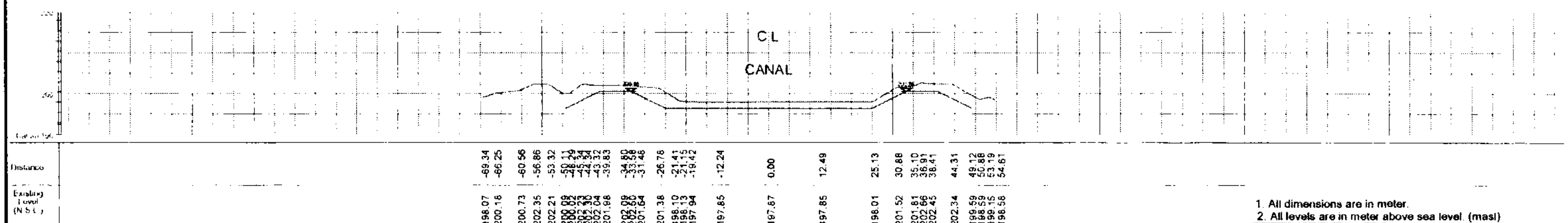



1. All dimensions are in meter.
2. All levels are in meter above sea level. (masl)

**CLIENT:- M/s Gugera Hydro Power Co. (Pvt) Ltd.**

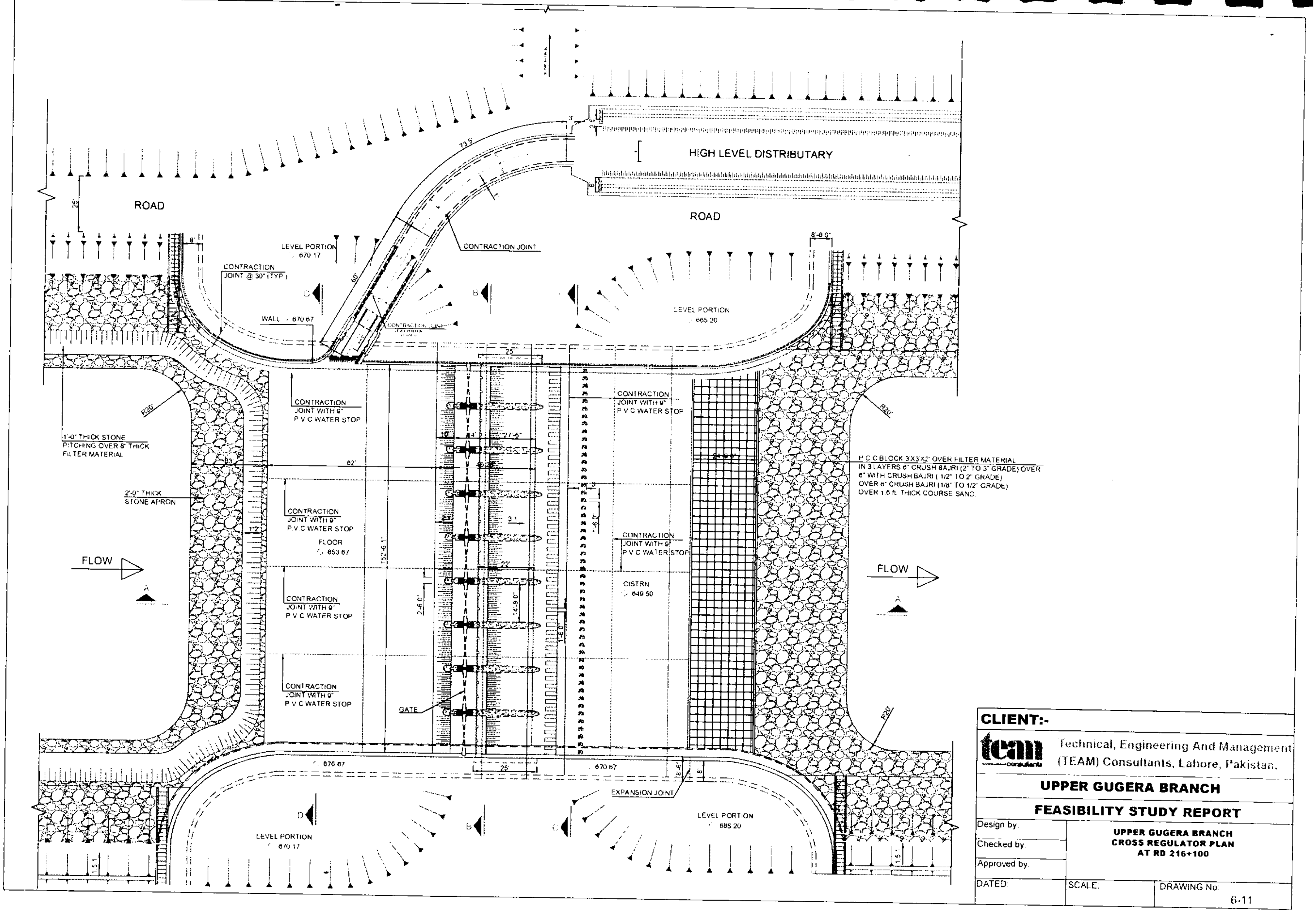
team consultants — Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

**UPPER GUGERA BRANCH**

**FEASIBILITY STUDY REPORT**

| | |
|---|---|
| Design by | **UPPER GUGERA CANAL L-SECTION** |
| Checked by | SHEET 4 OF 4 |
| Approved by | |

| DATED | SCALE | DRAWING No |
|---|---|---|
| March: 2014 | 1 : 1000 | 6-10 |




**CLIENT:-**

team consultants

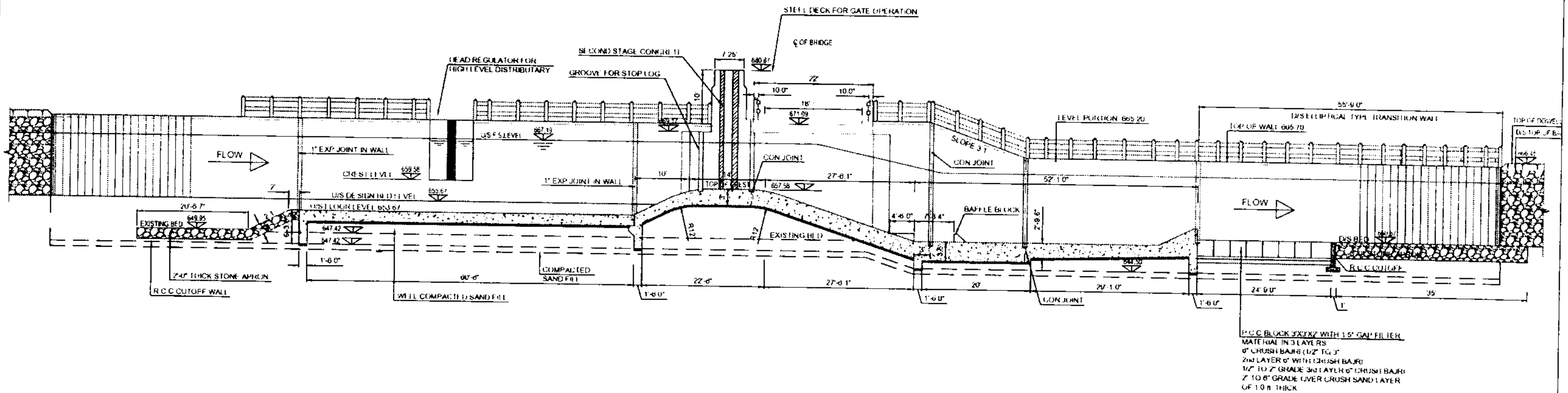
Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

**UPPER GUGERA BRANCH**

**FEASIBILITY STUDY REPORT**

**UPPER GUGERA BRANCH CROSS REGULATOR PLAN AT RD 216+100**

| | |
|---|---|
| Design by. | |
| Checked by. | |
| Approved by. | |
| DATED: | SCALE: |
| DRAWING No. | 6-11 |



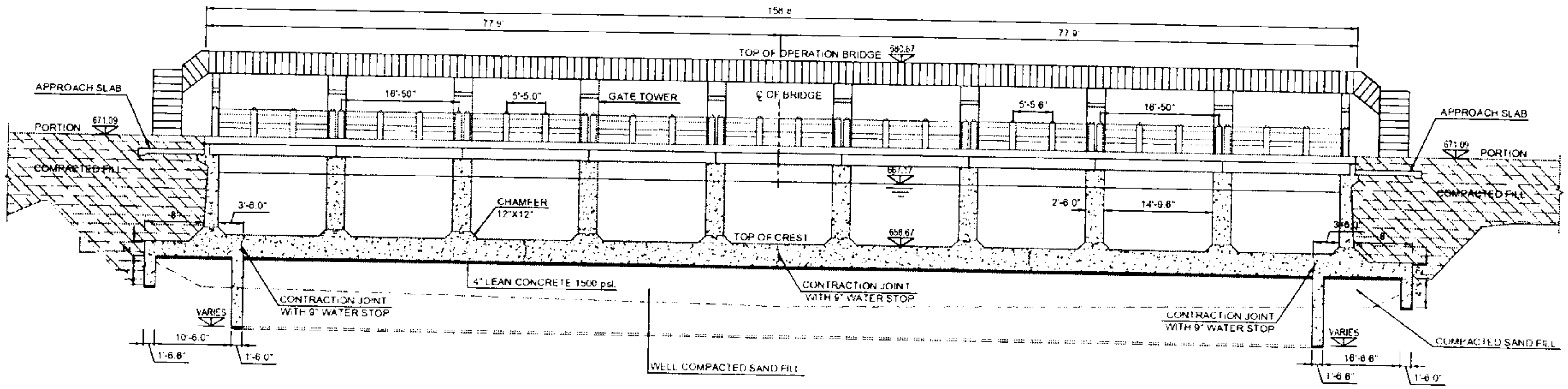

| | |
|---|---|
| **CLIENT:-** | **MANZUR & SONS** |
| team consultants | Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan. |

**UPPER GUGERA BRANCH**

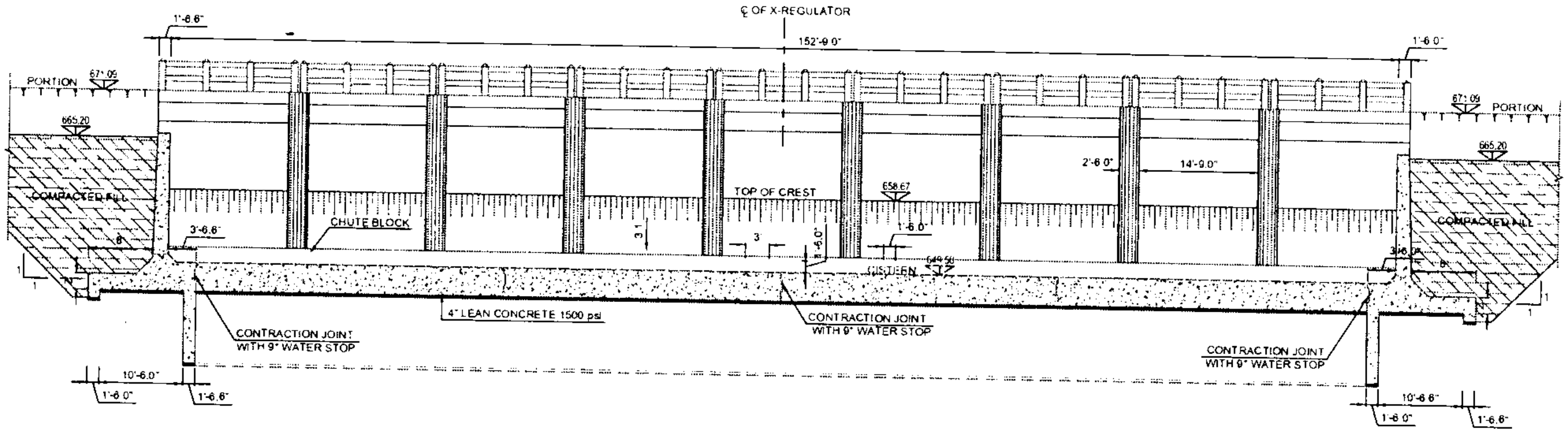
**FEASIBILITY STUDY REPORT**

| | |
|---|---|
| Design by | **UPPER GUGERA BRANCH CROSS REGULATOR AT RD 216+100** |
| Checked by | |
| Approved by | **SECTION A-A** |

| DATED | SCALE | DRAWING No |
|---|---|---|
| March: 2012 | 1/32" = 1'-0" | 6-12 |

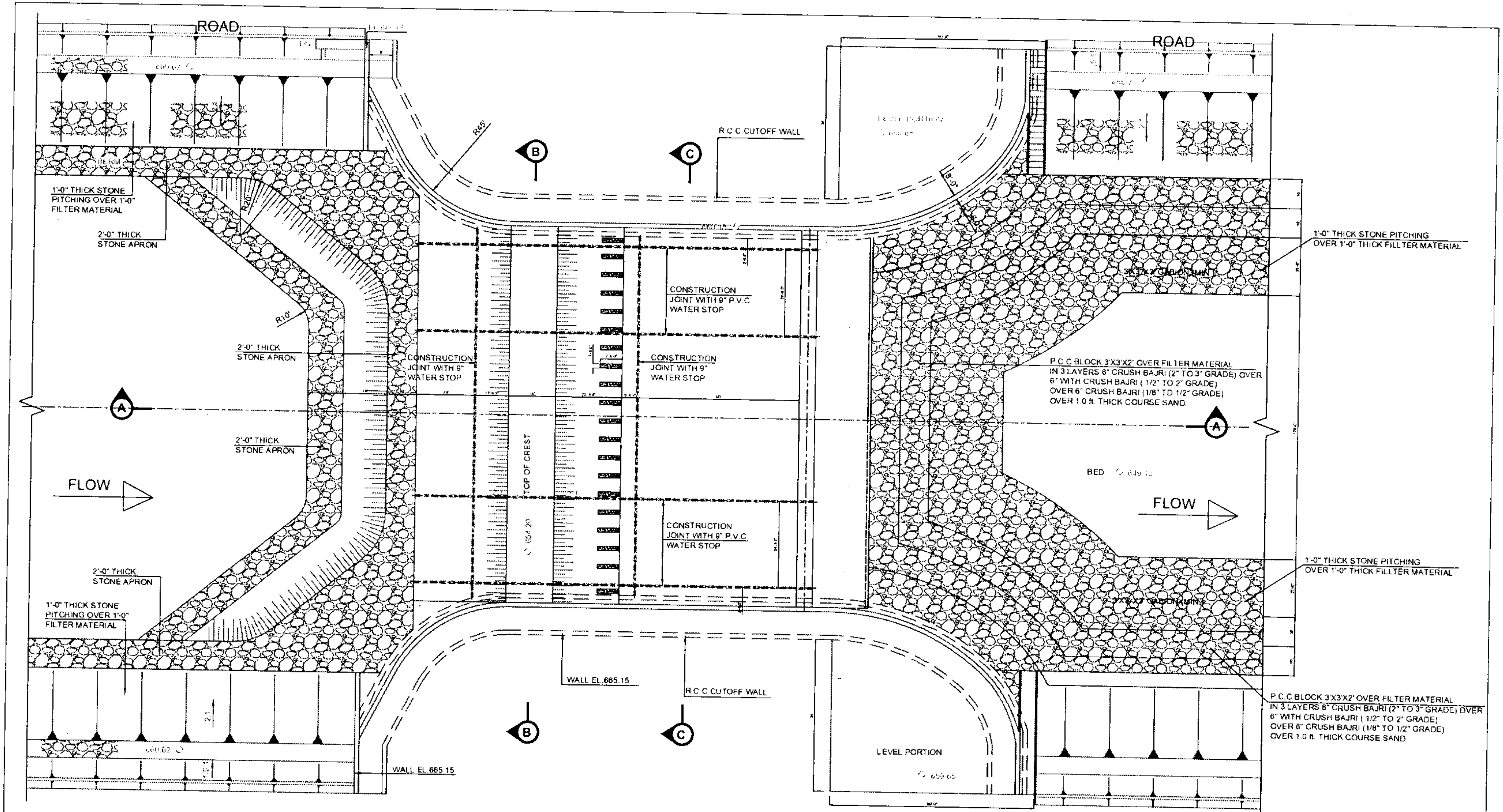



**SECTION B-B**




**SECTION C-C**

| CLIENT:- | | |
|---|---|---|
| team consultants | Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan. | |
| **UPPER GUGERA BRANCH** | | |
| **FEASIBILITY STUDY REPORT** | | |
| Design by | **UPPER GUGERA BRANCH CROSS REGULATOR AT RD 216+100** | |
| Checked by | | |
| Approved by | **SECTION B-B & C-C** | |
| DATED March: 2012 | SCALE: 1/32" = 1'-0" | DRAWING No 6 - 13 |




**CLIENT:-**

Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

**UPPER GUGERA BRANCH**

**FEASIBILITY STUDY REPORT**

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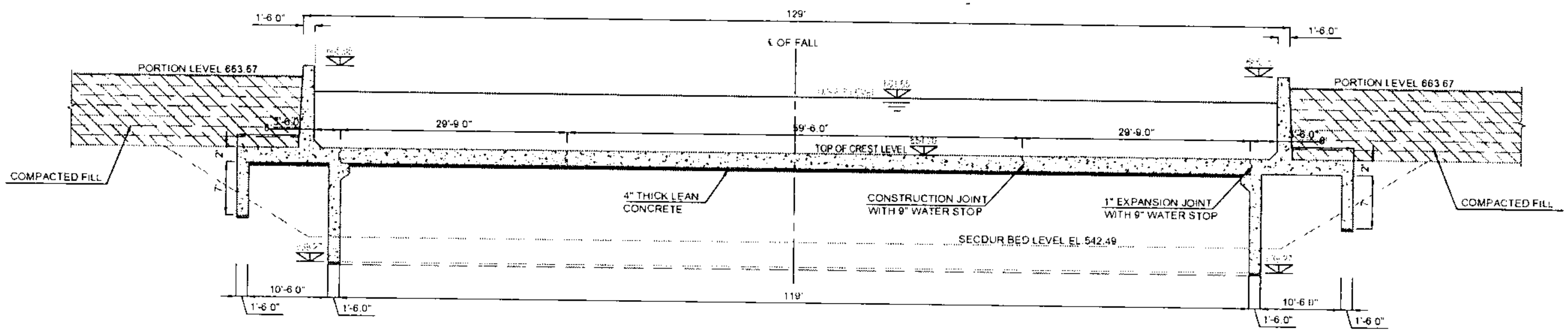
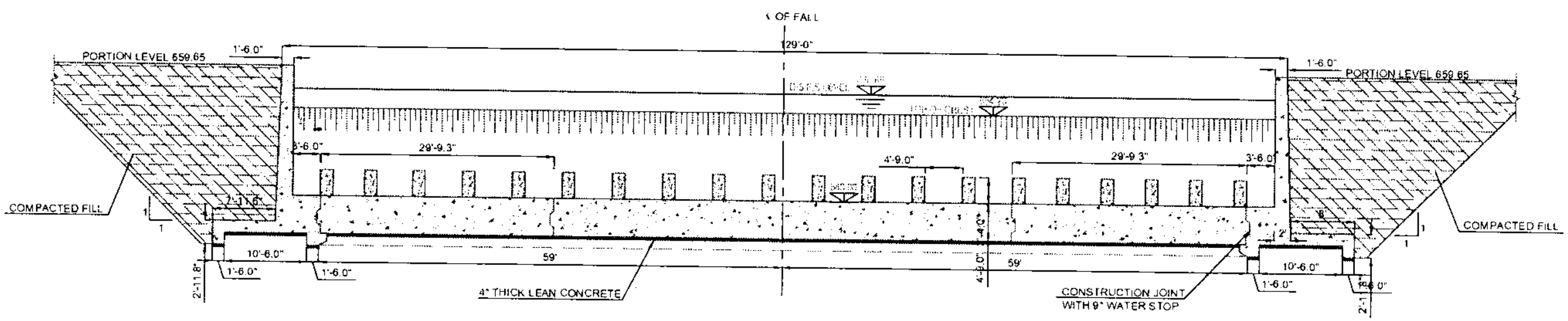
|---|---|
| Design by. | **UPPER GUGERA BRANCH CROSS REGULATOR AT RD 220+750** |
| Checked by. | |
| Approved by. | **DETAIL PLAN** |
| DATED: March: 2014 | SCALE: / DRAWING No: 6-14 |




## SECTION B-B




## SECTION C-C

**CLIENT:-**

Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

**UPPER GUGERA BRANCH**

**FEASIBILITY STUDY REPORT**

| | |
|---|---|
| Design by | **UPPER GUGERA BRANCH CROSS REGULATOR AT RD 220+750** |
| Checked by | |
| Approved by | **SECTION B-B & C-C** |
| DATED: March: 2012 | SCALE | 
| DRAWING No: 6-15 | |

# SECTION 7

# GEOLOGY, GEOTECHNICAL AND CONSTRUCTION MATERIAL

# SECTION 7

# GEOLOGY, GEOTECHNICAL AND CONSTRUCTION MATERIAL

## 7.1. Introduction

This section of the report presents geologic and geotechnical investigations carried out for the feasibility level design of the project and to assess the availability and quality of construction material. Determination of sub soil properties is essential requirement for foundation design of main powerhouse and associated structures. The small modifications can only be made to improve the properties of soil with external aides. These aides are very costly and if used it increases the project cost, therefore, it is preferable to design the foundations as per existing soil properties. The geotechnical investigation carried out through drilling, field testing and laboratory analysis are discussed in this section.

The project area is a part of vast alluvial plain of Chaj Doab in upper Indus basin, which can further be classified into three units namely active flood plain, abandoned flood plain and bar uplands. Main rivers in the area are Chenab and Jhelum. These rivers and their canals are the main source of surface water supplies for irrigated agriculture as well as for recharge of groundwater. The elevation in the area varies from 203 to 204 m above mean sea level. The area has a gentle slope towards south.

The alluvial deposits in the area range in age from pliestocene to recent and are widely distributed. These deposits are composed of clay, silt and sand extending in general to a depth of 300 m and are overlain by recent surfacial coarser deposits along the river channels.

## 7.2. Geologic Setting

The Project area is located in the Rachna Doab formation of the Sub-continent. Geographically, the formation is bounded by Ravi River in the southeast and the Chenab River on the southwest. It covers an area of 28,500 km$^2$ and the width of the widest point is 113 km. The doab covers a length of 403 km starting from confluence of Ravi and Chenab Rivers to the boarder of Jammu and Kashmir

The sub-surface lithology is mainly comprised of fine to medium grained sands, with silt and clay mixed with mudstone along with kankars in some places. Irregularly shaped concretions are generally found associated with relatively fine material in varying quantities. Gravel of small size in cemented sand is occasionally found at various depths.

The geotechnical conditions are favourable for the construction of a powerhouse having raft foundation. The geotechnical parameters have been established through sub soil investigations at the location of purposed structures. However further investigations are proposed at detailed design phase.

The alluvial deposits in the area range in age from pliestocene to recent age and are widely distributed. These deposits are comprised mainly of sand, silt and clay, of fluvial origin extending in general to a depth of 300 meters and presumably overly Precambrian basement rocks. The area where powerhouse has been envisaged is comprised of thick alluvial sub-recent deposits of earthy brown to grey colour clayey silt to silty sand.

## 7.3. Structures and Seismicity

The project area falls in the vast alluvial plain of upper Indus basin consists of sand, silt and clay. No rock outcrop/exposed in the close vicinity of the project area. Tectonic deformation has not been recorded/reported in this area. According to the modified seismic hazard zones map of Pakistan published by Geological Survey - 2006 **(Figure: 7.5)**, the project area is situated in minor to no damage zone where seismic factor is considered to be less than 0.03g. These are generalized values which may be used as a guideline only.

## 7.4. Previous Geo-technical Investigations

During design phase and construction phase of Khanki barrage, Rasul-Qadirabad Link and Khanki Barrage Canal System, a number of geo-technical investigations were carried out. However, Consultants tried to collect from Irrigation Department but could not succeeded.

## 7.5. Present Geotechnical Investigations

### 7.5.1. Introduction

The scope of work to carryout geo-technical investigations was prepared for determination of properties of sub soil stratum. In order to establish foundation design parameters of powerhouse and spillway structure (if applicable) soil properties were worked out.

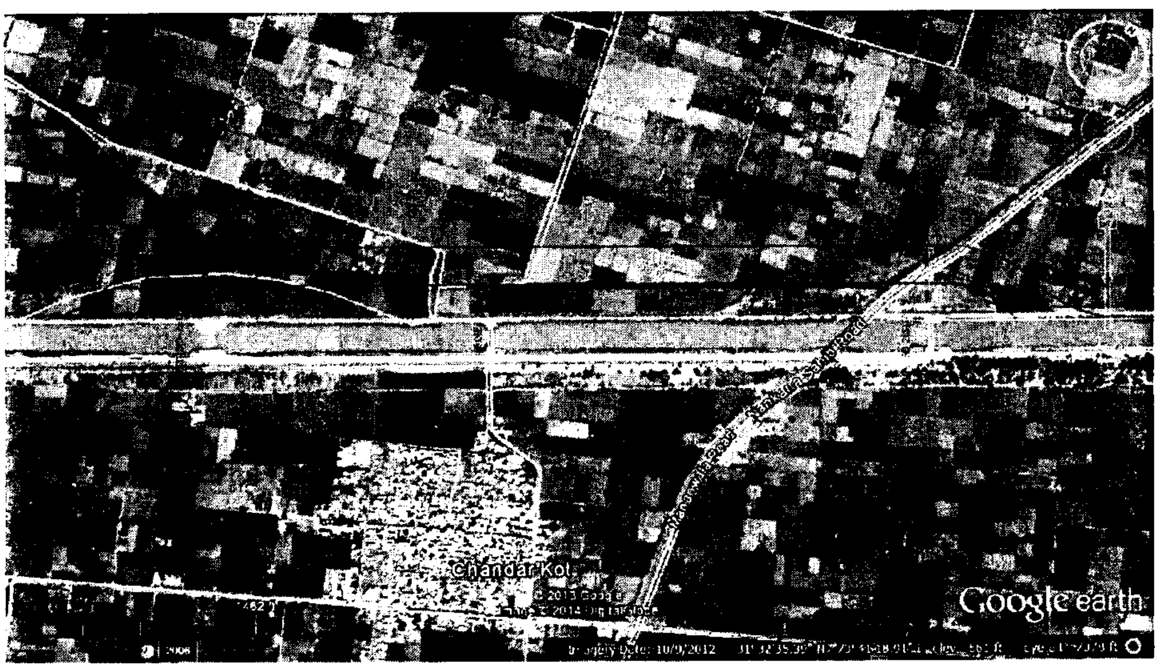



**Figure: 7.1 Location of Borehole near Upper Gugera Branch RD 216+250**

The scope of work consistes of straight rotary drilling of two boreholes on right side of Upper Gugera Canal (UGC) at the proposed powerhouse location to a depth of 40 m each. The locations of borehole are shown in Drawing: 7.1. The geotechnical investigations were executed on proposed powerhouse site located near RD 216+400 Upper Gugera Canal to determine sub-surface conditions and to evaluate the engineering properties of the foundation material. The investigation includes drilling, bore logging, field tests, sampling and laboratory tests. The details of geo-technical investigations are discussed here after. **Figure 7.1** shows location of borehole for field investigations plan for the proposed Construction of 3.6 MW HPP on Upper Gugara Canal at RD 216+000, Nankana road.

### 7.5.2. Rotary Drilling

Rotary drilling method used to perform two number vertical boreholes labelled as BH-01and BH-02 for the assessment of subsoil properties at powerhouse and spillway (if applicable) area of the project. Boreholes were drilled up to the depth of 40 m from natural ground level. The drilling was started on February 01, 2013 and completed on February 06, 2013. Exploratory borings of 150 mm (6 inch) diameter were drilled. All the drilling was completed through overburden material consisting mainly of silt and sand with little clay. Water table was recorded daily in borehole before the start of the drilling. Soil samples through SPT were collected for laboratory tests. The boreholes were lithologically logged and results are presented in Table: 7.1 & 7.2.

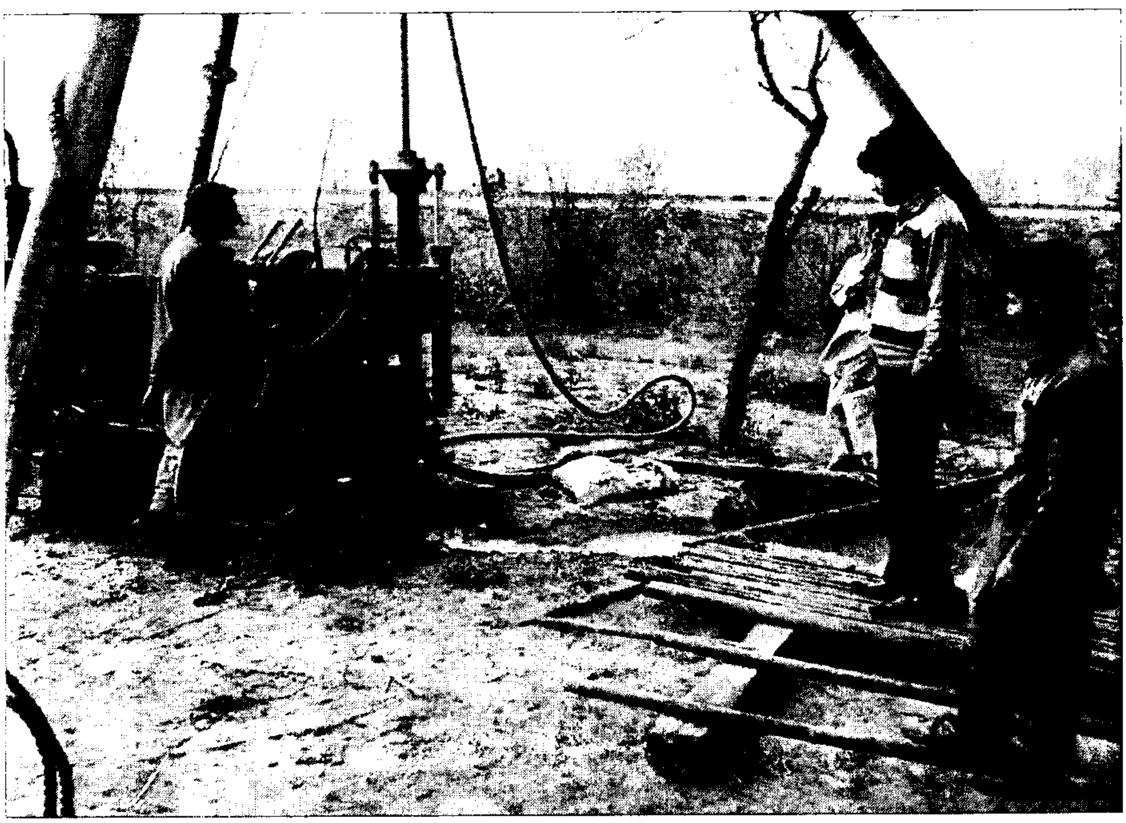


**Figure: 7.2 Drilling in Progress**

### 7.5.3. Field Testing

#### 7.5.3.1 General

Standard penetration tests (SPT) at 1 meter interval and permeability tests in all boreholes at an interval of 5 meter were performed. Total 77 SPTs and 16 permeability tests were performed. Split Spoon Sampler was used for SPT testing and constant head method was employed for permeability tests.

**Figure: 7.3 Standard Penetration Test in Progress**

#### 7.5.3.2 Standard Penetration Tests (SPT)

The objective of this test is to ascertain the resistance afforded to the penetration apparatus in order to obtain an estimate of the in-situ properties. This test gives valuable information regarding the compactness of the soil. In the field, SPT was performed in accordance with ASTM D-1586-84 at one meter interval and presented in Borehole Logs. The N-value of the soil column was recorded and mentioned on filed logs to obtain relative density of granular soils and consistency of the cohesive soils.

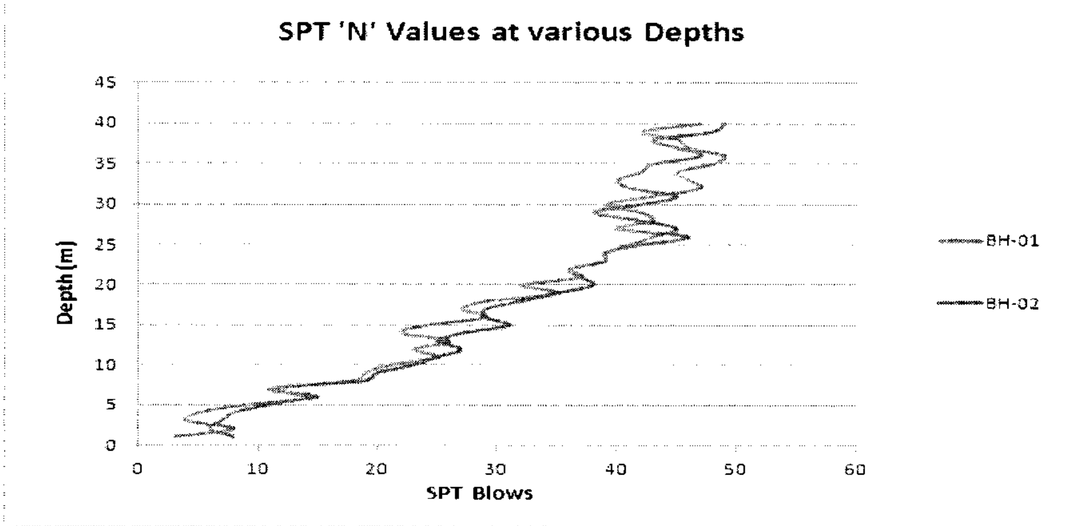



**Figure: 7.4 Standard Penetration Test at Various Depth**

The results of SPT's are presented in Figure: 7.4. It shows that the values varied from 3 to 49 blows. It is gathered from the values that the sub-soil strata in the upper zone is lean clay with loose sand. From Figure 7.4 the subsurface can be divided in to five zones from ground surface to 2 m depth, from 2 to 3 m, from 3 m to 5 m, from 5 m to 40 m and below 40m. It is clear from Figure that SPT values at upper layer are lower than lower layers. The strata between 1 m and 5 m SPT values are between 3 and 9 in BH1 and 8 to 11 in BH2 indicating loose sand. SPT values of strata between 5 m to 40 m are between 10 and 40 because it is composed of dense sand at this level.

#### 7.5.3.3 Ground Water Level

The ground water level was encountered at 8.5 to 9.0 m below natural surface level in both the boreholes. Daily observation of water level in boreholes before the start of drilling reveals somewhat constant water level conditions. Piezometers have been installed in the borehole BH 1 and BH 2 for future monitoring of ground water levels.

#### 7.5.3.4 Permeability of Sub-Soil

During the Geotechnical Investigations at project site two types of permeability tests were performed according to the conditions/behaviours of soil. In over burden or soil, constant head permeability test were performed and presented in Table: 7.3.

During drilling permeability tests (constant head) were performed at each 5 m interval. The permeability of the in-situ soil varies from $3.72 \times 10^{-3}$ to $4.78 \times 10^{-4}$ cm/sec (Borehole Log in Annexure: 7.1). It was observed that the permeability increases as the depth increases in BH-02. However the maximum value of permeability comes out to be $4.78 \times 10^{-3}$ cm/s.

### 7.5.4. Field Sampling

The disturbed samples recovered through SPT spoon sampler were preserved in polythene bags and then placed in plastic containers. All the samples were transported to the Building Standards, Laboratory in Lahore for testing.

Ground water samples from borehole and water samples from canal were also collected and transported to the Building Standard Laboratory Lahore for testing.

### 7.5.5. Laboratory Tests

Various tests were performed at Laboratory as per proposed program to know and evaluate the characteristics of sub-surface soil through some selected samples at different horizons. Brief description of the tests is as follows:

| # | Description of Laboratory Tests | No. of Tests |
|---|---|---|
| 1 | Grain Size Analysis | 27 |
| 2 | Atterberg Limits | 3 |
| 3 | SP Gravity | 10 |
| 4 | Dry Density | 4 |
| 5 | Specific Gravity | 10 |
| 6 | Shear Test& Cohesion Test | 8 |
| 7 | Chemical Analysis of Water Samples – Bore Hole | 3 samples from Canal and 1 sample from each Borehole |

Presented ahead, shows the empirical values for $\phi$, qu, Dr and unit weight of soils based on the SPT.

#### 7.5.5.1 Grain Size Analysis

Grain size analysis has been carried out on selected samples. Grain size analysis curves are placed in Annexure: 7.3 & 7.4 (Volume II of this Report).

#### 7.5.5.2 Atterberg Limits

These tests were performed on cohesive soil samples. The results are shown ahead in Table: 7.1 for Borehole BH1 and Table: 7.2 for Borehole BH2. It is revealed from borehole logs of BH1and BH2 that loose sand layer is encountered at 1 to 5 m depth.

### 7.5.5.3 Chemical Analysis of Water

Water will be required during the construction of the project as well as for mixing and compaction of various materials. Water is also required during project operation for cooling and other purposes. The upper gugera branch canal is readily available source of water for these purposes. The water for mixing concrete needs to be clean and free from deleterious materials i.e. chlorides, magnesium and sulphates etc. which could be injurious to concrete. Six (6) water samples from BH1 and BH2 and three (3) from the canal were collected for the chemical analysis. The results are presented ahead in Table: 7.3.

### 7.5.6. Foundation Condition and Type

The design of the powerhouse shows that foundation level would be 11 m below the natural surface level of 202.50 m.a.s.l. The characteristics of soil in terms of firmness and density have been evaluated through Standard Penetration Test (SPT) carried out at one meter interval for 30 cm penetration. Field investigations have revealed the presence of alluvial deposits up to the final investigated depth of 40.0m.

The sub soil strata consists of clay and sand exists in a very loose to dense condition of compactness. It reveals that the upper zone of clay (5 m) is very lean followed by medium dense to dense sandy silt up to investigated depth. Therefore it is recommended that where SPT blows are less than 10, foundation treatment such as compaction or vibro-compaction is required. Where foundation soil has SPT values more than 15 blows, there is no need of any compaction.

Ground water in bore holes was found at 8.5 to 9 m depth. The overall average K value of the strata is of the order of $10^{-3}$ cm/s and shows medium permeability. For placing the foundation of the power plant, dewatering will be required to lower the ground water table encountered at 8.5 to 9 m depth, which is above the foundation level.

The overall foundation condition as evaluated through these tests reveals that the silty sand at foundation level is in medium state of compactness and medium pervious. Therefore dewatering of powerhouse pit may also be required.

## 7.6. Bearing Capacity

The proposed bottom of the powerhouse is approximately 11 m below the natural surface level. The powerhouse will therefore be founded on fine to medium dense sands where SPT values are between 25 to 30 blows. The angle of internal friction is $25^0$ and generally in this type of materials, shear failure may occur. In evaluating the allowable bearing pressures for structures founded in this material it is recommended that bearing capacity factors may be taken as:

- $N_q = 18.4$
- $N_\varnothing = 22.4$

The angle of internal friction for saturated silt is assumed $28^0$, which give the parameters used and results of settlement analysis.

### 7.7. Settlement

The expected low bearing pressures below the powerhouse foundation should ensure that settlement consideration is unlikely to dictate the size of foundation required. We recommend that settlements may be estimated using an elastic model with the following range of assumed values for Young's modulus:

- Silts/clays Es = 5 to 15 MPa
- Sands Es = 20 to 50 MPa

### 7.8. Earth Pressures

Other important structures include the retaining walls. For their design the following parameters may be used:

Sands and Dry Silts

- Angle of internal friction Ø = $28^0$
- Active earth pressure coefficient k3 = 0.33
- At rest pressure coefficient ko = 0.5

Saturated Silts

- Angle of internal friction Ø = $25^0$
- Active earth pressure coefficient k3 = 0.41
- At rest pressure coefficient ko = 0.57

### 7.9. Liquefaction of Fine Grained Material

Liquefaction of fine grained material is the phenomena where material loses its shear strength upon shaking due to earth quake. The particle size analysis reveals that the fine to medium sands that exist below the powerhouse foundation generally have a grading which lies within the easy or very easy to liquefy range. However, they are generally in a sufficiently dense state (as measured by SPT values between 15 and 40) to ensure that liquefaction is unlikely.It is concluded that liquefaction of the fine sands is unlikely under seismic loads as per the recommendations of the Building Code of Pakistan in the project area.

### 7.10. Earthwork

Excavation within the silts and fine sands will be easy, provided that the site is adequately dewatered. The side slopes of 1:2 are considered appropriate for deep excavations in the fine sands. However, to ensure stability of the slope it will be important to control both surface and subsurface water flow.

The control of all storm water will need to be carefully controlled to prevent erosion and the formation of runnel gullies within the overlying silt layer. The concentration of storm water run-off over the silts must be avoided. Small bunds should be provided at the top of excavations, or the ground sloped away from the excavation pit, to prevent excessive water running down the slopes.

The fine sands and silts will generally be suitable for compacted fill or for the temporary coffer dams.

## 7.11. Dewatering of Excavation Pit with Slurry Trench Wall all around

The permeability tests reveal that surface conditions are medium pervious. Before installation of tube wells excavation pit would be enclosed from four sides by constructing cement/bentonite slurry trench walls in order to seal the excavation pit. Dewatering the site is unlikely to be particularly complex although the expected cost to dewater the site will need to be carefully evaluated during the detailed engineering design stage.

In designing and preparing contract specifications during detailed engineering design for the dewatering scheme, it is important to ensure the following:

- The pumping system is kept operational throughout the excavation and foundation concreting period. Failure of the pumping system would result in saturation of the excavated slopes which would result in massive sloughing;
- Adequate filters are provided around all wells/well points to avoid the migration of fines.

## 7.12. Construction Material

### 7.12.1. Introduction

The major construction materials required for the project include cement, bricks, steel, coarse and fine aggregates etc. The sources of construction materials discussed herein are made on the basis of their use in different completed and ongoing projects, as no specific study has been carried out for this project. However, it is opined that some confirmatory tests should be carried out for each quarry site for approval of designated construction material source during construction stage. Availability of such materials is discussed below.

### 7.12.2. Kirana Hills (Coarse Aggregate)

Kirana hills located about 12 km south of the town of Sargodha are the most widely used and nearest source of aggregate. From the project site, it is about 150 km hauling distance. The formation is predominantly composed of grey slate, red and grey quartzite with minor amount of conglomerates. These meta-sedimentary rocks are inter-layered with andesite, rhyolite and tuff beds. This sequence is intruded by basic igneous rocks of diabasic composition. Besides, the presence of ankerite rock has also been reported by Davies and Crawford (1971). Petro-graphic studies of ankeritic carbonatites show the following analysis.

- Calcium oxide 29.2%
- Ferric Oxide 21.0%
- Silica 17.4%

### 7.12.3. Margalla Hill limestone (Coarse Aggregate)

Another source of coarse aggregate being utilized is Margalla hill limestone located near Taxila and is situated about 365 Km hauling distance from project site. The limestone of this source is grey in colour, weathered surface is pale grey, fine to medium grained, nodular, medium to thick bedded and rarely massive. This source is being widely used in all important projects in Pakistan.

### 7.12.4. Fine Aggregate

The nearest source of fine aggregates (sand) for project is Chenab which is locally available. After testing of locally available sand and its suitability in construction or otherwise then the choice remains to obtain suitable sand from Lawrencepur which is presently being used in important projects in Pakistan.

### 7.12.5. Cement

Cement is available in quantity required for the construction of the project near project site. The Gharibwal Cement Factory is about 140 km from the project site which is producing Ordinary Portland Cement of good quality. Required quantity of cement is not huge which can be catered easily by Gharibwal Cement Factory. Slag cement from Karachi may have to be transported.

### 7.12.6. Steel

Steel may not be available in quantity required for the construction of the project near project site. So steel will have to be procured from the nearest big cities like Lahore or Islamabad.

### 7.12.7. Bricks

The bricks and blocks of all sizes could be procured from local market near to the site.

**Figure: 7.5 Seismic Hazard Zones of Pakistan**

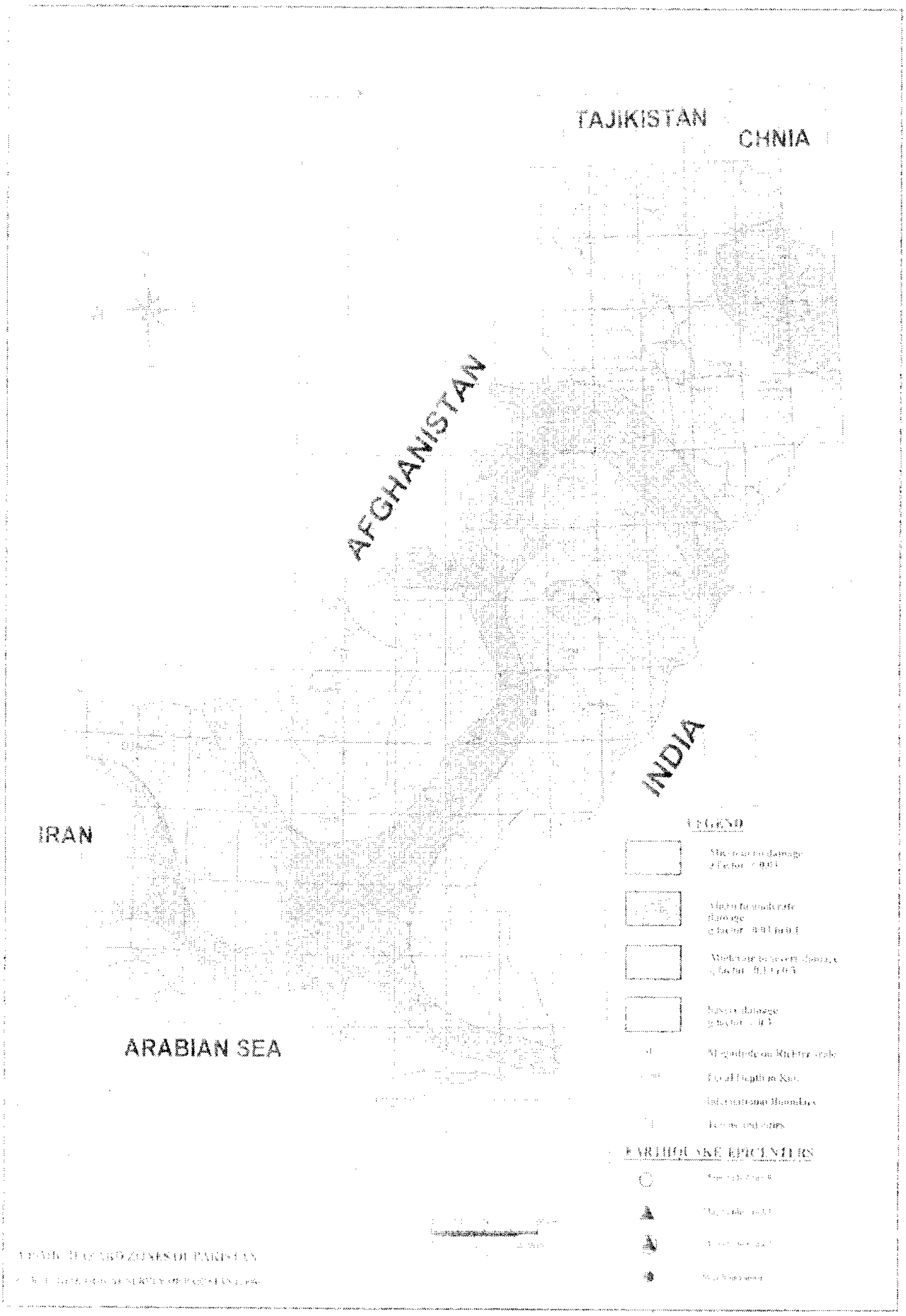
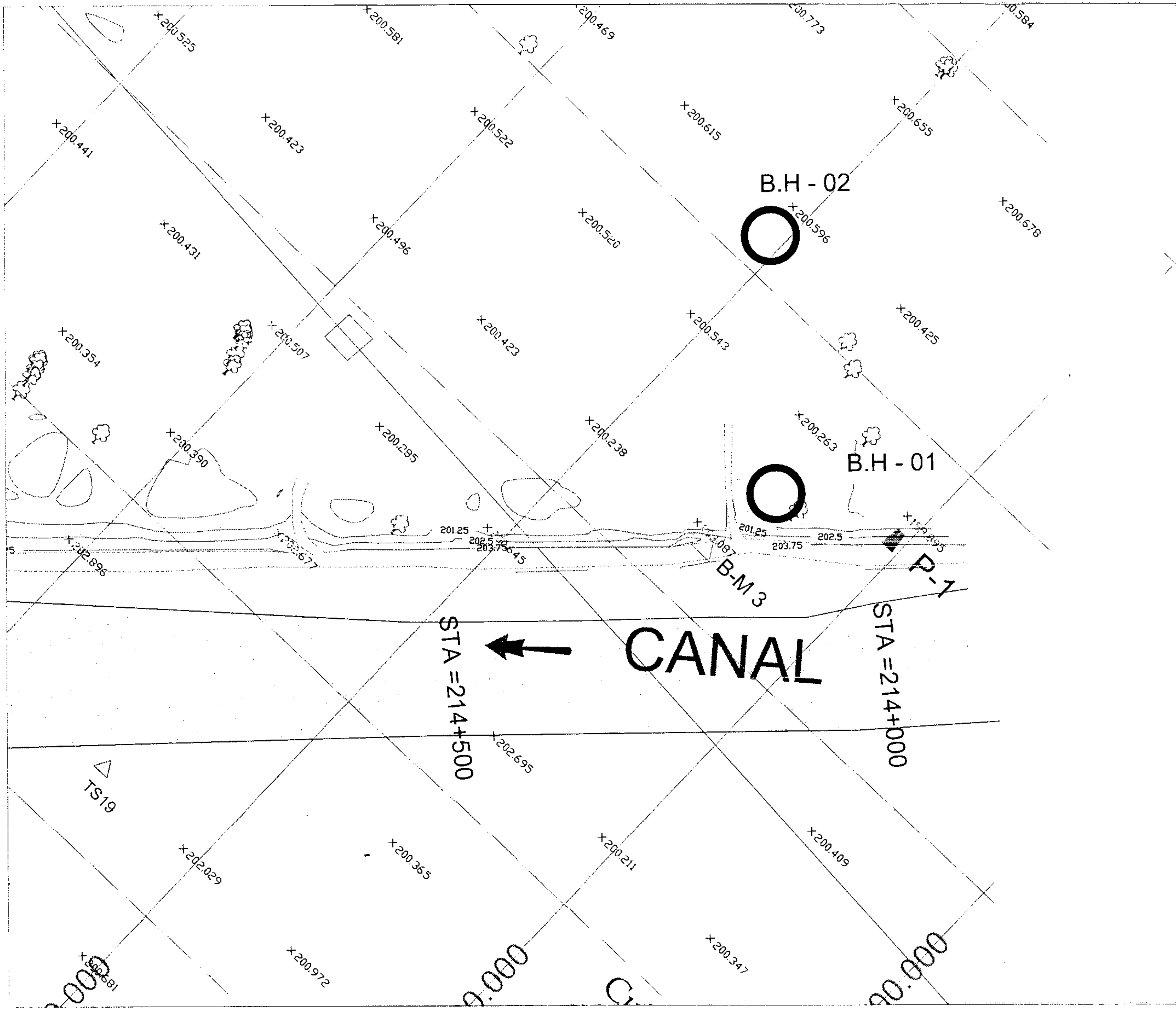


**Table 7.1**
**Summary of Laboratory Test Results**

| Borehole No. | Sample No. | Depth (m) | Grain Size Analysis | | | Atterberg Limits | | | Direct Shear Test | | Specific Gravity | Dry Density | Permeability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gravel (%) | Sand (%) | Fines (%) | Liquid Limit (%) | Plastic Limit (%) | PI (%) | C (kPa) | φ (Degrees) | | g/cm$^3$ | K (cm/sec) |
| BH-1 | SPT-2 | 2.0 | 0 | 94 | 6 | Non-Plastic | | | | | 2.68 | | |
| | SPT-4 | 4.0 | 0 | 5 | 95 | 31 | 18 | 13 | | | 2.69 | | |
| | SPT-6 | 6.0 | 1 | 86 | 13 | | | | | | | | |
| | SPT-8 | 8.0 | 0 | 81 | 19 | | | | | | | | |
| | SPT-10 | 10.0 | 0 | 89 | 11 | | | | | | | 1.68 | 3.72 E-03 |
| | SPT-12 | 12.0 | 0 | 89 | 11 | | | | | | | | |
| | SPT-15 | 15.0 | 1 | 87 | 12 | | | | 1.7 | 25 | 2.67 | | |
| | SPT-18 | 18.0 | 0 | 96 | 4 | | | | 1.1 | 27 | | 1.68 | 3.87 E-03 |
| | UDS-1 | 20.0 | 0 | 80 | 20 | | | | 2.1 | 26 | 2.66 | | |
| | SPT-21 | 22.0 | 0 | 88 | 12 | | | | 2.3 | 25 | 2.65 | | |
| | SPT-23 | 24.0 | 0 | 86 | 14 | | | | | | | | |
| | SPT-28 | 29.0 | 0 | 82 | 18 | | | | | | | | |
| | SPT-32 | 33.0 | 1 | 92 | 7 | | | | | | | | |
| | SPT-39 | 40.0 | 1 | 96 | 3 | | | | | | | | |

**Table 7.2**
**Summary of Laboratory Test**

| Borehole No. | Sample No. | Depth (m) | Grain Size Analysis | | | Atterberg Limits | | | Direct Shear Test | | Specific Gravity | Dry Density | Permeability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gravel (%) | Sand (%) | Fines (%) | Liquid Limit (%) | Plastic Limit (%) | PI (%) | C (kPa) | φ (Degrees) | | g/cm$^3$ | K (cm/sec) |
| BH-2 | SPT-2 | 2.0 | 0 | 7 | 93 | 33 | 17 | 16 | | | 2.67 | | |
| | SPT-4 | 4.0 | 0 | 6 | 94 | 35 | 17 | 18 | | | 2.68 | | |
| | SPT-6 | 6.0 | 0 | 87 | 13 | Non - Plastic | | | | | | | |
| | SPT-8 | 8.0 | 0 | 83 | 17 | | | | | | | | |
| | SPT-10 | 10.0 | 0 | 90 | 10 | | | | | | | | |
| | SPT-12 | 12.0 | 0 | 93 | 7 | | | | | | | 1.68 | 4.78 E-03 |
| | SPT-16 | 16.0 | 0 | 96 | 4 | | | | 2.9 | 23 | 2.65 | | |
| | UDS-1 | 18.0 | 0 | 85 | 15 | | | | 2.7 | 24 | 2.66 | | |
| | SPT-19 | 20.0 | 0 | 93 | 7 | | | | 1.7 | 27 | 2.65 | 1.68 | 4.15 E-03 |
| | SPT-21 | 22.0 | 0 | 73 | 27 | | | | 1.7 | 27 | | | |
| | SPT-24 | 25.0 | 0 | 91 | 9 | | | | | | | | |
| | SPT-29 | 30.0 | 0 | 94 | 6 | | | | | | | | |
| | SPT-39 | 40.0 | 0 | 91 | 9 | | | | | | | | |

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LEGEND

BUILDING
BOUNDARY
BENCH MARK B-M 1
ELECTRIC POLE EP
POND
FENCE
ROAD
TRACK
KM STONE
HAND PUMP
TREE 15'
TREE PALM
NALA
SOLLING
WATER COURSE
SIGN BOARD
TS
MOSQUE
TUBE WELL TW
GATE
CANAL
WALL

**NOTES:**

Contour Interval 0.5 m
All dimensions are in Meters.

SCALE

**CLIENT:- M/s Gugera Hydro Power Co. (Pvt) Ltd.**

team consultants — Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

**UPPER GUGERA BRANCH**

**FEASIBILITY STUDY REPORT**

| | |
|---|---|
| Designed by | **BORE HOLE LOCATION MAP B.H - 1 & B.H - 2** |
| Checked by | |
| Approved by | |

| DATED | SCALE | DRAWING No |
|---|---|---|
| March 2014 | 1 : 1000 | 7-1 |

# SECTION 8

# SEISMIC HAZARD STUDY

# SECTION 8
# SEISMIC HAZARD STUDY

## 8.1. Introduction

Gugera Hydro Electric Power Project site is located in the central part of Punjab plain which is characterized by low to moderate level of seismicity. The collisional zone of the Indian tectonic plate lies about 150-200 km north of project site in the Himalayan Mountains. Several devastating earthquakes have originated from this collisional zone. However, away from collisional zone, low to moderate level of seismicity has been recorded in the stable basement mass.

The seismic hazard evaluation for the project was conducted through the study of regional geological and tectonic information collected from the available literature and maps and collection of historical and instrumental earthquake records. On the basis of this data, the critical tectonic features affecting the project site were identified and seismic hazard evaluation was conducted accordingly.

## 8.2. Geology

The project site is covered with thick alluvial deposits of Quaternary age laid down by Jhelum and Chenab rivers. The geological map of the project area published by the Geological Survey of Pakistan is shown in Figure: 8.1. The Quaternary sediments of the Punjab plain comprise the following:

**Stream Deposits**

Qm - Streambed and meander-belt deposits

Qf - Floodplain deposits

**Deposits of Extinct Streams**

Qmx - Streambed and meander-belt deposits

Qfx - Floodplain deposits (lower terrace)

**Older Terrace Deposits**

Qc - Chung Formation; mostly loess deposits of the upper terrace

Qcm - Loess and floodplain deposits of the middle terrace.

The alluvial deposits are underlain by the basement rocks of the Indian shield, exposed at places in area between Shahkot and Sargodha. Based on borehole data and gravity survey, a Basement High having northwest to southeast trend is marked by Kazmi & Rana (1982), which is shown in Figure: 8.2. The project site lies on the south-eastern side of this Basement High. Based on the contours of depth to basement rocks, the thickness of alluvial deposits at the project site is more than 335 meters (1100 ft.).

## 8.3. Tectonic Setting

The geodynamic framework of northern Pakistan is characterized by the collision and coalescence of Eurasian and Indian continental plates, which were once separated by the oceanic domains, and creation of the Kohistan island arc in the late Cretaceous. The collisional process started in the late Eocene to early Oligocene with the formation of the Himalayan Ranges and this process still continues. Relative to Eurasia, the Indian plate is still moving northwards at a rate of about 4 cm/year. The subduction of the Indian plate beneath the Eurasian plate has resulted in folding and thrusting of the upper crustal layers near the collisional boundary which lead to the formation of high Himalayan Mountains. The thrusting has been depicted from north to south in the shape of MKT (Main Karakoram Thrust), MMT (Main Mantle Thrust), MBT (Main Boundary Thrust) and SRT (Salt Range Thrust). The Salt Range Thrust which is nearest to the project site is just on the other side of river Jhelum.

Quittmeyer et al. (1979) have classified whole of the area of Pakistan into fifteen seismotectonic provinces. Out of these the three distinct provinces which are influencing the project site are:

- Salt Range province;
- Himalayas province; and
- Indus basin province

A brief description of the salient features of these seismotectonic provinces is given below.

### 8.3.1. Salt Range Province

The SaltRange is bounded on the north by Hazaraseismotectonic province, on the south by Punjab plain and extends from the Suleiman range on the west to the Himalayas in the east. General orientation of this range is east-northeast, but prominent southeast trending transverse features offset parts of it. It is composed of folded and faulted thrust sheets and represents thin-skinned internal deformation within the Indian plate resulting from its collision with Eurasia.

Although it is the frontal zone of deformation in this region, the SaltRange is characterized by low level seismic activity, in contrast to other parts of the frontal zone in Pakistan. It has limited known history of moderate or large magnitude earthquakes. Micro-earthquake studies, however, indicate that at low magnitude levels ($M_L < 4$), the entire SaltRange is active, especially along transverse faults at points where it is offset. Cambrian salt deposits may provide an explanation for this aseismic character of the SaltRange. Deformation may result from aseismic slip along a decollement surface mechanically detached by the salt. The micro seismic activity may represent small readjustments within the decollement sheets.

### 8.3.2. Himalayas Province

The Himalayas represent one of the primary compressional features that have resulted from the collision of the Indian plate with Eurasia. This zone of deformation is the result of folding and thrusting associated with the development of large nappe structures and deep crustal shortening. The Himalayas trends in a southeasterly direction just east of the Hazara-Kashmir syntaxis and further east, it has an east-west trend.

Seismicity within this seismotectonic province is characterized as moderate to high level. Most events are associated with the frontal zone of deformation. They are located parallel to and northeast of the surface trace of the main frontal thrust. One great earthquake, the 1905 Kangra earthquake with Ms=7.8 occurred within this zone, probably rupturing a 300 km portion along the main frontal thrust.

In the vicinity of the Hazara-Kashmir syntaxis, the mapped surface trace of the main frontal thrust bends around from a southeast trend to a southwest orientation. The seismically defined fault zone, however, does not follow the mapped surface faults; it appears to continue for an additional about 100 km to the northwest of the Hazara-Kashmir syntaxis.

### 8.3.3. Indus Basin Province

The Indus basin is located within the Indian plate south and southwest of the Himalayas and Salt Range and east of the predominantly northward trending mountain ranges of western part of Pakistan. This feature is a fore deep basin. The seismicity occurring within this zone is generally of low level. Although infrequent, some events have caused considerable damage. Southwest of the Himalayas, the events occur along a discontinuous, but nevertheless, linear trend about 200 km from the main frontal thrusts (e.g. Main Boundary thrust). This same trend parallels the Salt Range, but not at as great a distance. This activity within the Indus basin may be related to the bending of the lithosphere, active basement faults transverse to the fold and thrust belts, and/or development of a new frontal thrust.

Surface faults have not been mapped in the Indus basin; the extensive alluvial cover has buried any structural evidence of faulting. Inferences based on gravity data, however, indicate basement faults may exist in some portions of the IndusBasin.

The Punjab Plain, which is the upper part of the Indus basin, shows low to moderate level of seismicity which is associated with the faulting in the Basement rocks covered by the alluvial deposits. The Basement High, depicted by outcrops of Basement rocks near Sargodha, Chiniot and Shahkot and extending from Sargodha to Faisalabad and further southeast towards Indian border (Figure: 8.2), shows a concentration of earthquakes with magnitude up to 5.5 on the Richter scale. A moderate earthquake originated from the Basement High in Punjab Plain could produce appreciable ground shaking at site due to thick alluvial deposits.

## 8.4. Earthquake Record

The ground motions produced by earthquakes pose a multitude of hazard to structures, either by direct loading of the structures or by initiating a sequence of events that may lead to damage to the structure, or even failures unless this has been catered for in the design.

The available earthquake record for the region in which the project is located can be classified into the following two types:

- Historical Seismicity
- Instrumental Seismicity

### 8.4.1. Historical Seismicity

The historical seismicity data is available in the form of descriptive account of damage due to past earthquakes mostly at the populated places. Since Lahore is the nearest populated place, the effects of the historical earthquakes on this city is available in historical literature. Quittmeyer and Jacob (1979) presented a comprehensive description of historical record from earthquakes in this region. The description of damage caused by past earthquakes in Lahore is given below:

- 24 September, 1827 - Destructive in Lahore region and Fort Kolitaran near city destroyed, about 1000 perished in ruins. A hill shaken down, which fell into river Rowee (Ravi), produced an inundation of 100 coss of land. Maximum intensity 8.9.
- 22 January 1832 - Origin near Lahore, violently felt, people all rushed out of houses. Maximum intensity5.7.
- 4 February 1851 –strongly felt in Lahore, appears to have extended all over Punjab. Intensity at Lahore 5.6.
- 17 February 1851 - Strongly felt in Lahore, Multan. Intensity at Lahore 6.5.
- 29 August 1858 - Sharp shocks felt in Lahore. Intensity at Lahore 6.5.
- 4 December 1865 - Lahore - two smart shocks. Intensity at Lahore 3.5.
- 4 April, 1905 –Kangra earthquake, caused damage to buildings in Lahore.7.8

### 8.4.2. Instrumental Seismicity

In Pakistan and most other parts of the world, the seismic record is too short and incomplete to develop a complete sample that is truly representative of the spatial and temporal distribution of shocks over a large period. Nevertheless, all the available information has been gathered for the period covering the last century, which was used to develop a satisfactory and safe assessment of seismic hazard for the project.

A composite list of earthquakes that occurred in the project region and adjoining areas has been prepared. It is based upon earthquakes reported by International Seismological Center (ISC), United States Geological Survey

(USGS), Tarbela Seismic Observatory (Pakistan) and Pakistan Meteorological Department. This composite list includes events within an area between latitudes 290 to 350 and longitudes 720 to 780 (i.e. more than 300 km radius of the site). This composite earthquake catalogue is presented in Annex: 8.1.

This earthquake list contains 1302 events having different magnitude recorded between 1904 and 2008. In preparing this composite catalogue, more weight was given to the data listed in the ISC catalogue because data within this catalogue tends to be more accurate, being calculated with more data than is used in the other listings, and less likely to contain duplicates. The source catalogues overlap considerably and both automatic and manual procedures that incorporate judgment about source catalogue reliability and priority were used to help eliminate duplicate entries from the combined listing.

The reporting agencies have given a variety of magnitudes viz. Body-wave magnitude (MB), Surface-wave magnitude (MS), Richter/Local magnitude (ML) or Duration-magnitude (MD) etc. All these types of magnitudes were converted into a uniform magnitude-scale i.e. MW (Moment Magnitude) as given in earthquake catalogue. MW represents area source rather than a point source and the same type of magnitude is mostly being used in the seismic hazard analysis.

Conversion from MS and MB to MW was achieved through latest equation suggested by Scordilis (2006):

| | |
|---|---|
| $MW = 0.67\,MS + 2.07$ | for $3.0 < MS < 6.1$ |
| $MW = 0.99\,MS + 0.08$ | for $6.2 < MS < 8.2$ |
| $MW = 0.85\,MB + 1.03$ | for $3.5 < MB < 6.2$ |

For ML, the value of ML was taken equal to MW as suggested by Idriss (1985) and supported by operators of local networks in Pakistan.

The recorded seismicity is plotted in Figure: 8.3. The concentration of seismicity in the north and northeast is associated with Himalayan frontal faults. The Punjab plain shows low to moderate level of seismicity. As seen from Figure: 8.3, there is a concentration of magnitude 4-5 earthquakes associated with Basement High which indicates the presence of buried faults along the Basement High. South of the site, very low earthquake activity is observed.

## 8.5. Seismic Hazard Evaluation

For seismic hazard evaluation both deterministic and probabilistic methods of seismic hazard evaluation were used.

### 8.5.1. Deterministic Procedure

In the deterministic procedure, critical seismogenic sources, like faults, representing a threat to the project are identified and a maximum magnitude assigned to each of these faults. The capability of the faults is ascertained through observation of historical and instrumental seismic data and geological criteria such as rupture length – magnitude relationship or fault movement – magnitude relationship.

The maximum ground motion is then obtained by considering the most severe combination of maximum magnitude and minimum distance to the project site, independently of the return period. The main tectonic features within about 300 km of the project site which could be controlling the earthquake hazard at site are as follows:

- Main Boundary Thrust,
- Salt Range Thrust, and
- Buried Fault associated with Basement Faulting.

Empirical correlations have been developed between maximum potential of a fault and key fault parameters like rupture length, fault area, fault displacement and slip rate. Out of these fault parameters, only fault lengths are known with sufficient accuracy. For the faults around the site, the half length rupture of the fault has been taken and the maximum earthquake magnitude (in moment magnitude Mw scale) of each of the fault was calculated using Wells & Coppersmith (1994) relationship between fault rupture length and magnitude potential. The maximum magnitude for the buried fault in basement rocks is taken equal to the maximum recorded magnitude. The maximum potential magnitudes associated with the above mentioned tectonic features are given in Table: 8.1.

**Table: 8.1 Maximum Potential Magnitudes**

| Tectonic Feature | Fault Rupture Length (km) | Magnitude (Mw) |
|---|---|---|
| Main Boundary Thrust | 200 | 8.0 |
| SaltRange Thrust | 50 | 7.0 |
| Buried Fault | - | 5.5 |

The peak horizontal ground acceleration at the site caused by the earthquake with maximum magnitude occurring at the closest distance to fault was then calculated by using the latest attenuation relationships developed by various researchers from strong motion data from USA and worldwide. These relations were used so, due to absence of enough strong motion data for the south Asian region, no attenuation relation for this region is available. The 50-percentile (median) values of the peak horizontal ground acceleration (PGA) obtained by four attenuation relationships are given in Table: 8.2. For all the faults, thrust rupture mechanism and stiff soil site conditions have been assumed.

**Table : 8.2 Peak Horizontal Ground Accelerations (PGA)**

| Tectonic Feature | Maximum Magnitude (MW) | Closest Distance to Fault (Km) | Peak Horizontal Acceleration (g) Median | | | |
|---|---|---|---|---|---|---|
| | | | Campbell &Bozorgnia (2008) NGA | Idriss (2008) NGA | Boore and Atkinson(2008) | Abrahamson & Silva (2008) |
| Main Boundary Thrust | 8.0 | 250 | 0.03 | 0.03 | 0.02 | 0.04 |
| SaltRange Thrust | 7.0 | 200 | 0.03 | 0.02 | 0.01 | 0.03 |
| BuriedFault | 5.5 | 10 | 0.24 | 0.14 | 0.16 | 0.16 |

### 8.5.2. Probabilistic Procedure

In probabilistic seismic hazard evaluation, the seismic activity of seismic source (line or area) is specified by a recurrence relationship, defining the cumulative number of events per year versus the magnitude. Distribution of earthquake is assumed to be uniform within the source zone and independent of time.

The procedure consists of subdividing the study area into a number of elementary zones (seismic sources) and computing the probability of one or several earthquakes of specified size occurring within each zone during a specified period. For each source, the probability of the earthquake being of a specified magnitude and the attenuation of the resulting ground motion are combined to derive the probabilities associated with the exceedance of different levels of ground motion at the site. The contributions of all sources are then summed up to give the total hazard in terms of probability or annual frequency of occurrence of the ground motion at the project site.

The recorded earthquake data presented earthquake catalogue was used as database for the probabilistic seismic hazard analysis and frequency-magnitude relationship. Due to incompleteness, the data prior to 1960 was not used in the probabilistic analysis.

The distribution of seismicity and faults (Figure: 8.3) is such that it is difficult to associate the observed seismicity with a particular fault. Moreover most of the area is covered by thick alluvial deposits. Therefore a source model based on area source was employed in the probabilistic analysis.

Magnitude-frequency curve was developed for area source of about 300 km radius around the site. The plot of magnitude 'Mw' against cumulative number of earthquake per year 'Nc' was made for the area source (Figure: 8.4) from which recurrence relation was developed in the form of Richter' equation which is, Log Nc = a – bm

Coefficients 'a' and 'b' are derived from least square linear regression of the data up to a minimum or threshold magnitude above which the seismic record is assumed to be complete.

The evaluation of return period of different levels of ground motions was carried using probabilistic method originally developed by Cornell (1968) and later developed by various researchers. The attenuation relationship of Boore et al. (1997) for soil site with VS30=300 m/sec was used in the analysis.This equation was developed for shallow crustal earthquakes in tectonic environment similar to that of the project area. The results of the probabilistic seismic hazard analysis, showing annual frequency of exceedance of horizontal ground acceleration at the project site and also tabulated below:

| Annual Frequency of Exceedance | Return Period (years) | Peak Ground Acceleration (g)* |
|---|---|---|
| 0.01 | 100 | 0.14 |
| 0.005 | 200 | 0.16 |
| 0.002 | 500 | 0.18 |
| 0.001 | 1000 | 0.20 |
| 0.0004 | 2500 | 0.23 |

* PGA for stiff soil condition (VS30=300m/sec)

## 8.6. Seismic Design Parameters

It is a normal practice to use ground motion having 10% probability of exceedance in 50 years (i.e. a return period of about 500 years) for design of building projects. If life hazard or economic loss is a matter of concern, ground motion having high return period is used for the design of the projects. As the project under study does not pose any significant life hazard but only economic loss in case of failure under severe earthquake loading, it should be designed for lower return period.

Keeping in view the results of deterministic and probabilistic hazard, it is recommended that important project components should be designed for peak horizontal ground acceleration of 0.20g having a return period of 1000 years. Other less important structures should be designed for peak horizontal ground acceleration of 0.18g having a return period of 500 years.

## 8.7. Conclusions And Recommendations

The seismic hazard evaluation for Upper Gugera Hydro Electric Project at RD 214+500 was carried out through a study of all the available geological, tectonic and seismicity data of the region in which the project is located.

The project is located in a stable region which is more than 200 km away from the collisional boundary of the Indian and the Eurasian plates.

The Project area is covered with thick alluvial sediments deposits by ancient streams of Indus basin. The Basement rocks underlying alluvial deposits show high elevations and site area lies near the south-eastern side of this Basement High. The thickness of the alluvial deposits is estimated to be about 335 meters (1100 ft.)

The recorded seismicity of the area is depicted mainly by small to moderate earthquake activity in the Punjab Plain. The historical earthquake data shows that large magnitude damaging earthquakes have frequently occurred within 300 km of site in the Himalayan range.
The main active tectonic features affecting the site area are the Main Boundary Thrust, Salt Range thrust and Buried faults beneath Punjab plain. Except Buried faults below Punjab plain, other faults passes at a distance from site area, therefore, are not expected to cause appreciable shaking at the project site.

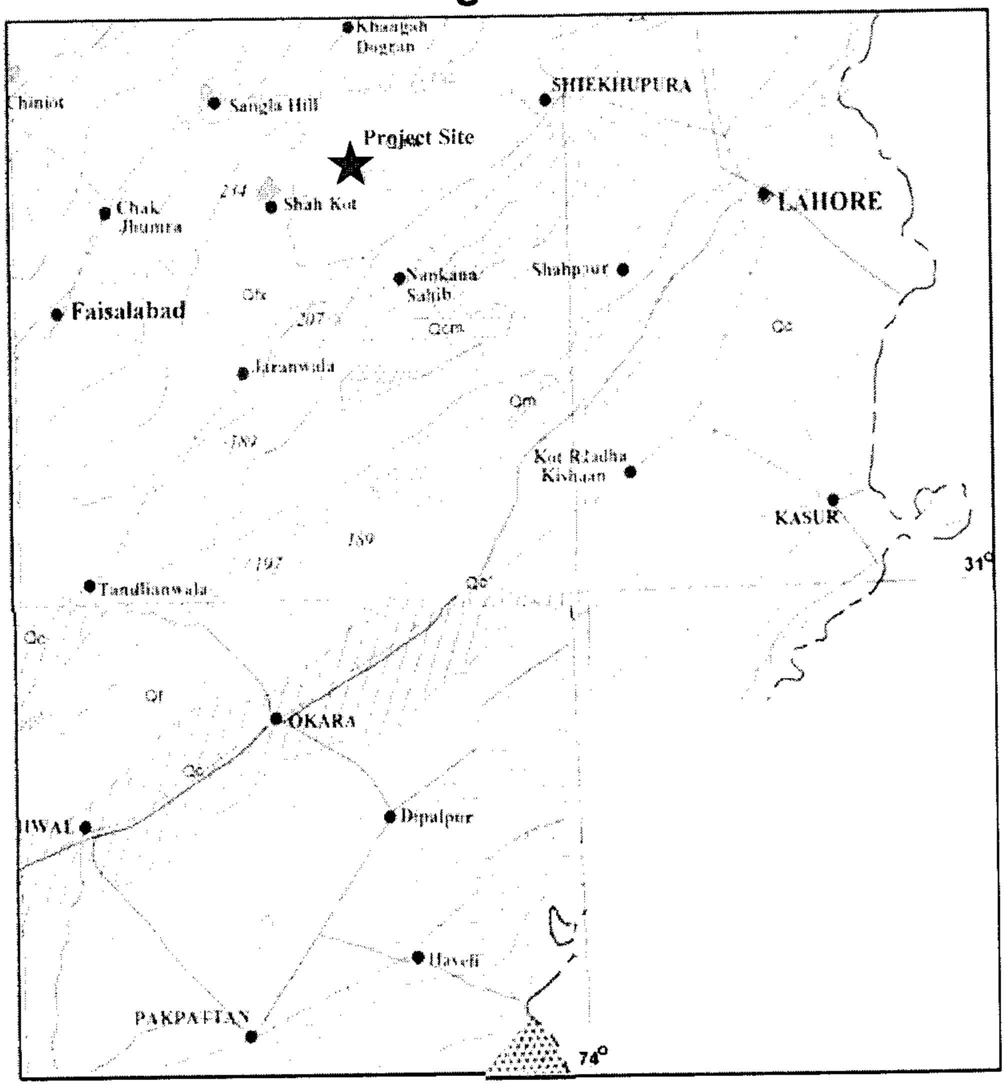
Several small to moderate earthquakes have originated from the Punjab plain which is thought to be caused by small blind thrusts in the Basement rocks, particularly associated with Basement High, as this area shows relatively more seismicity.

The results of probabilistic analysis show that peak horizontal ground acceleration with a return period of about 500 years is 0.18g and with a return period of 1000 year is 0.20g for stiff soil (SD type soil profile) foundation condition. It is recommended that important components of the project should be designed for PGA of 0.20g to avoid economic loss due to earthquake hazard. Other less important structures should be designed to withstand PGA of 0.18g.

## REFERENCES


- Kazmi and Rana 1982, Tectonic Map of Pakistan: Geological Survey of Pakistan, Quetta.
- Quittmeyer, R.C., et al; Seismicity of Pakistan and its relation to surface faults; Geodynamics of Pakistan (1979).
- Quittmeyer, R.C., and Jacob K. H.; Historical and modern seismicity of Pakistan, Afghanistan, northwestern India and Southeastern Iran; Bull. Seismological Society of America, Vol. 69, No. 3 (1979).
- E. M. Scordilis; Empirical global relations converting Ms and mb to moment magnitude, Journal of Seismology (2006).
- Idriss I. M.; Evaluating seismic risk in engineering practice, Proceedings of the 11th International Conference on Soil Mechanics and Foundation Engineering, San Francisco (1985).
- Wells & Coppersmith; New empirical relationship among magnitude, rupture length, rupture width, rupture area, and surface displacement. Bulletin of the Seismological Society of America Vo. 84 (1994).
- Campbell &Bozorgnia; NGA ground motion model for the geometric mean horizontal component of PGA, PGV, PGD and 5% damped linear Elastic response spectra for periods ranging from 0.01 to 10 seconds, Earthquake Spectra, Vol. 24, No.1 (2008).
- Idriss I. M.; An NGA empirical model for estimating the horizontal spectral values generated by shallow crustal earthquakes, Earthquake Spectra, Vol. 24, No.1 (2008).
- Boore, D. M. and Atkinson, G. M.; Ground motion prediction equations for the average horizontal component of PGA, PGV and 5% damped PSA at spectral periods between 0.01s and 10.0 s, Earthquake Spectra, Vol. 24, No.1 (2008).
- Abrahamson, N. and Silva, W.; Summary of the Abrahamson and Silva NGA Ground-motion relations, Earthquake Spectra, Vol. 24, No.1 (2008).
- Cornell, C.A.; Engineering seismic risk analysis, Bull. Seism. Soc .Am.,Vol. 58, No.5 (1968).
- Boore et al; Equations for estimating horizontal response spectra and peak acceleration from western north American earthquakes: A summary of recent work, Seism. Res. Letters, Vol. 68 (1997).

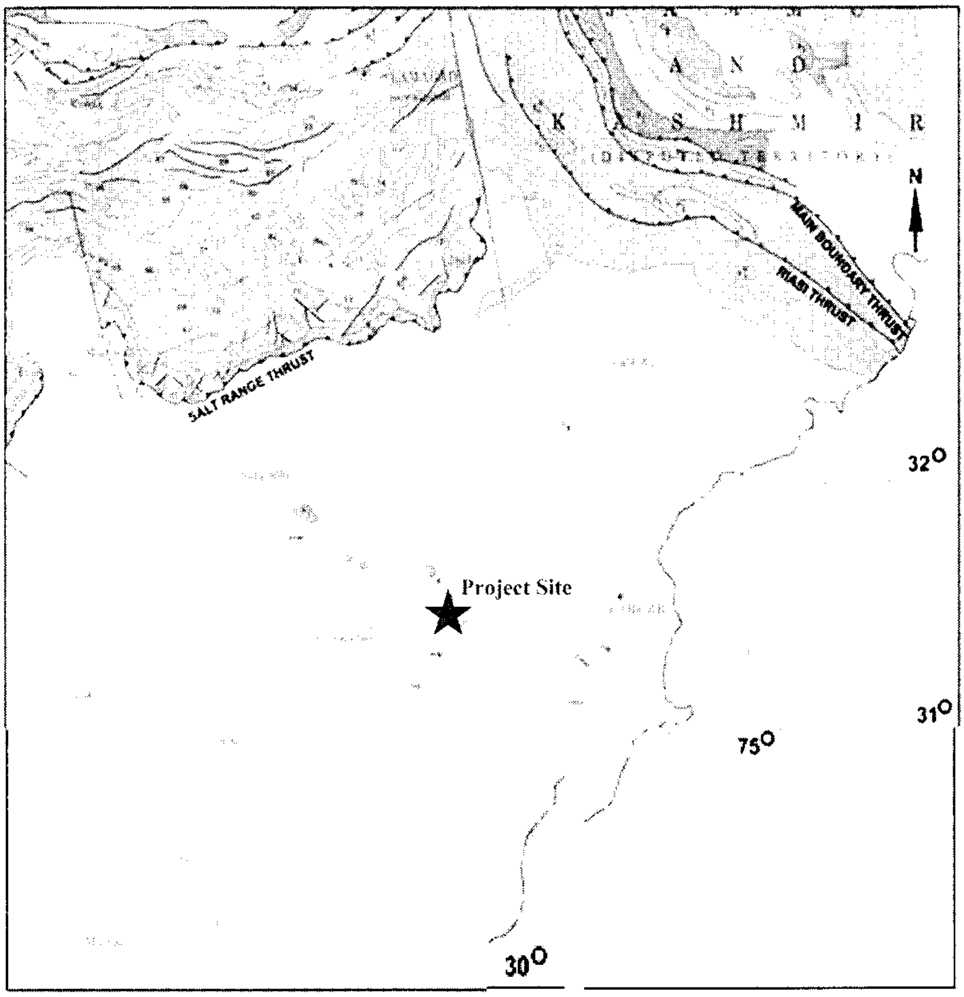
# Figure 8.1




Note: Reproduced from
GSP - Geological Map of Pakistan (1993)

GEOLOGICAL MAP

# Figure 8.2




Note Reproduced from
GSP – Tectonic Map of Pakistan (1984)

**TECTONIC MAP**

## Figure 8.3

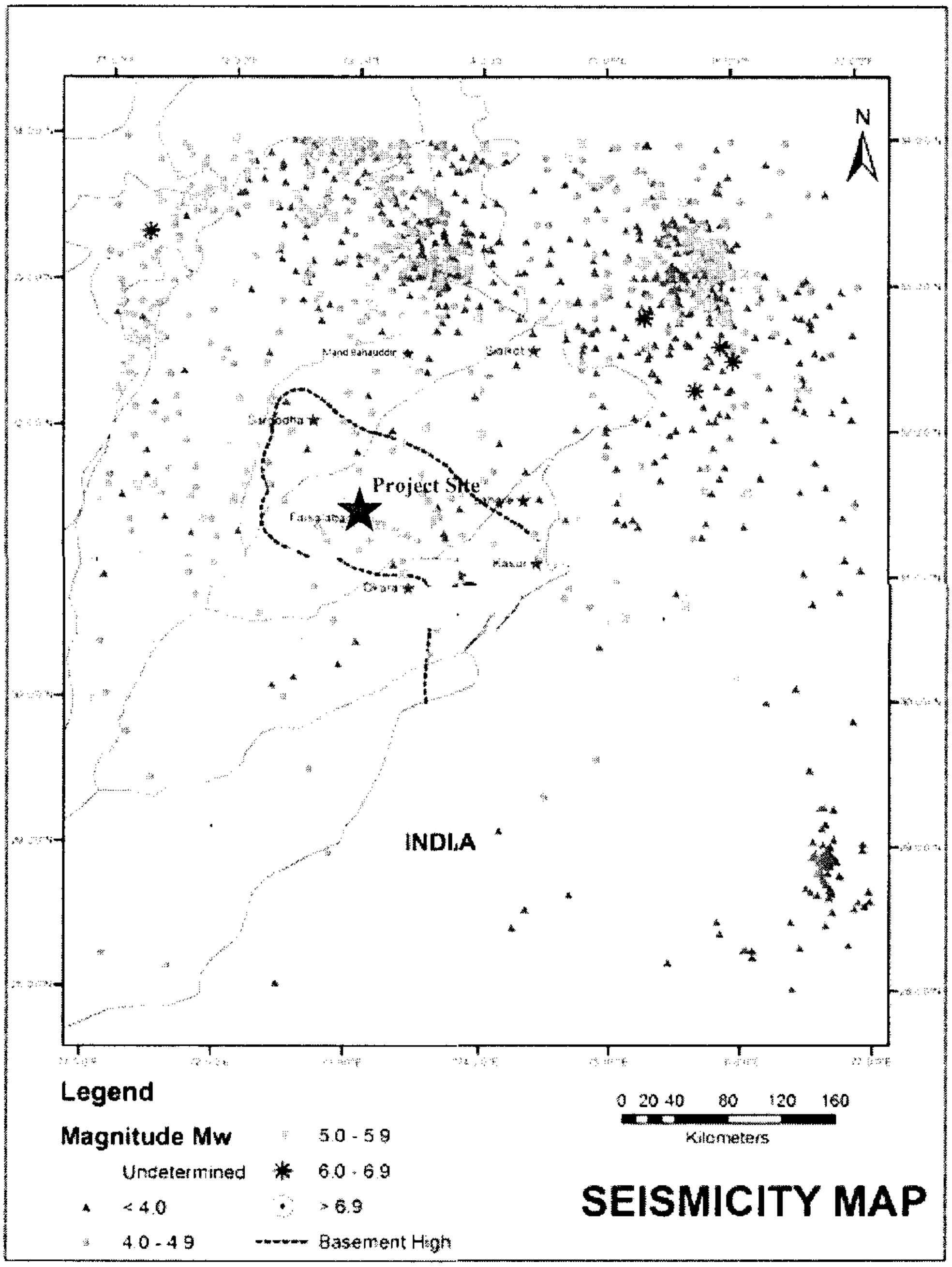

N
Sargodha
Sialkot
Project Site
Kasur
Okara
INDIA
Legend
Magnitude Mw
Undetermined
< 4.0
4.0 - 4.9
5.0 - 5.9
6.0 - 6.9
> 6.9
Basement High
0 20 40 80 120 160
Kilometers
SEISMICITY MAP

**Figure 8.4**

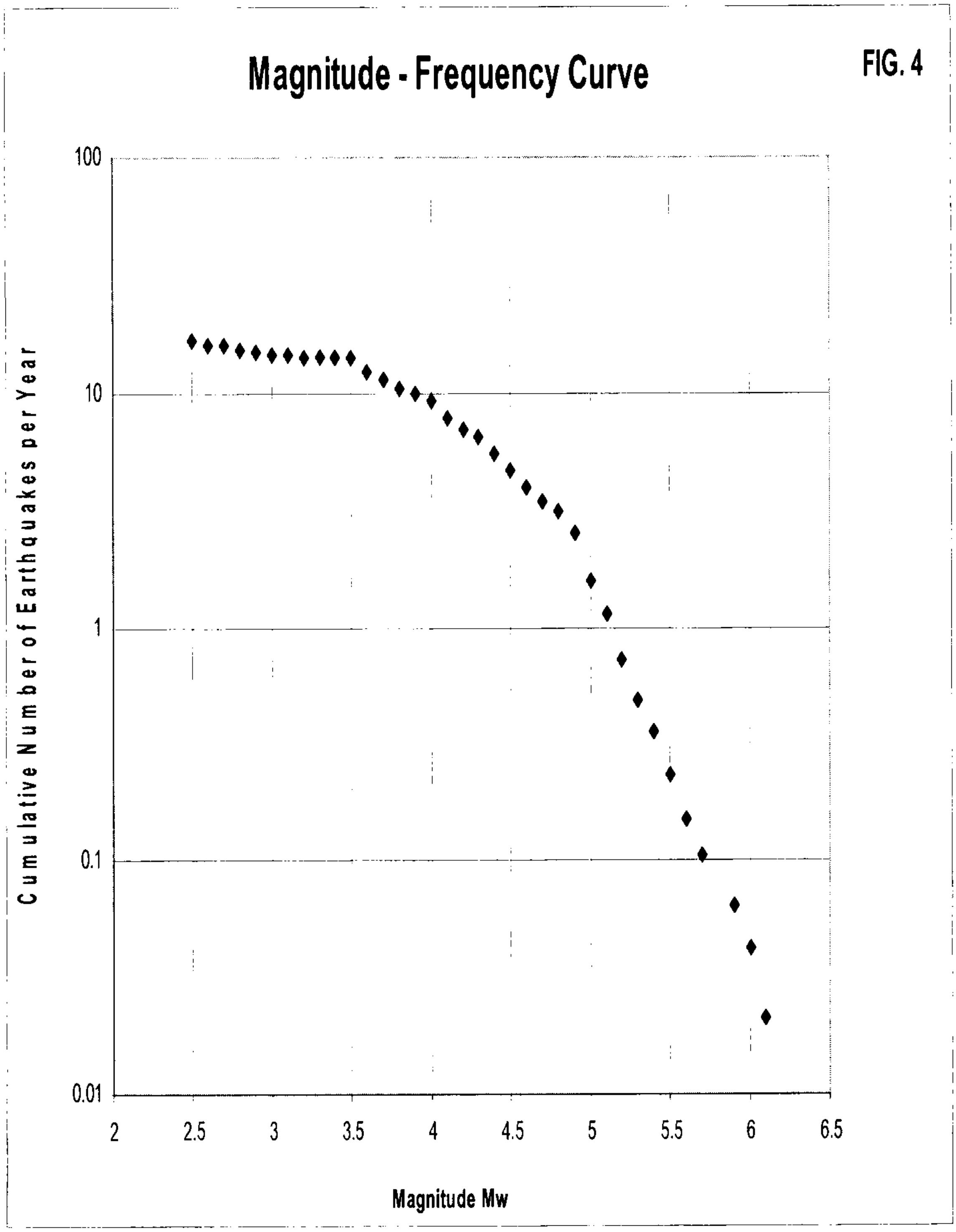
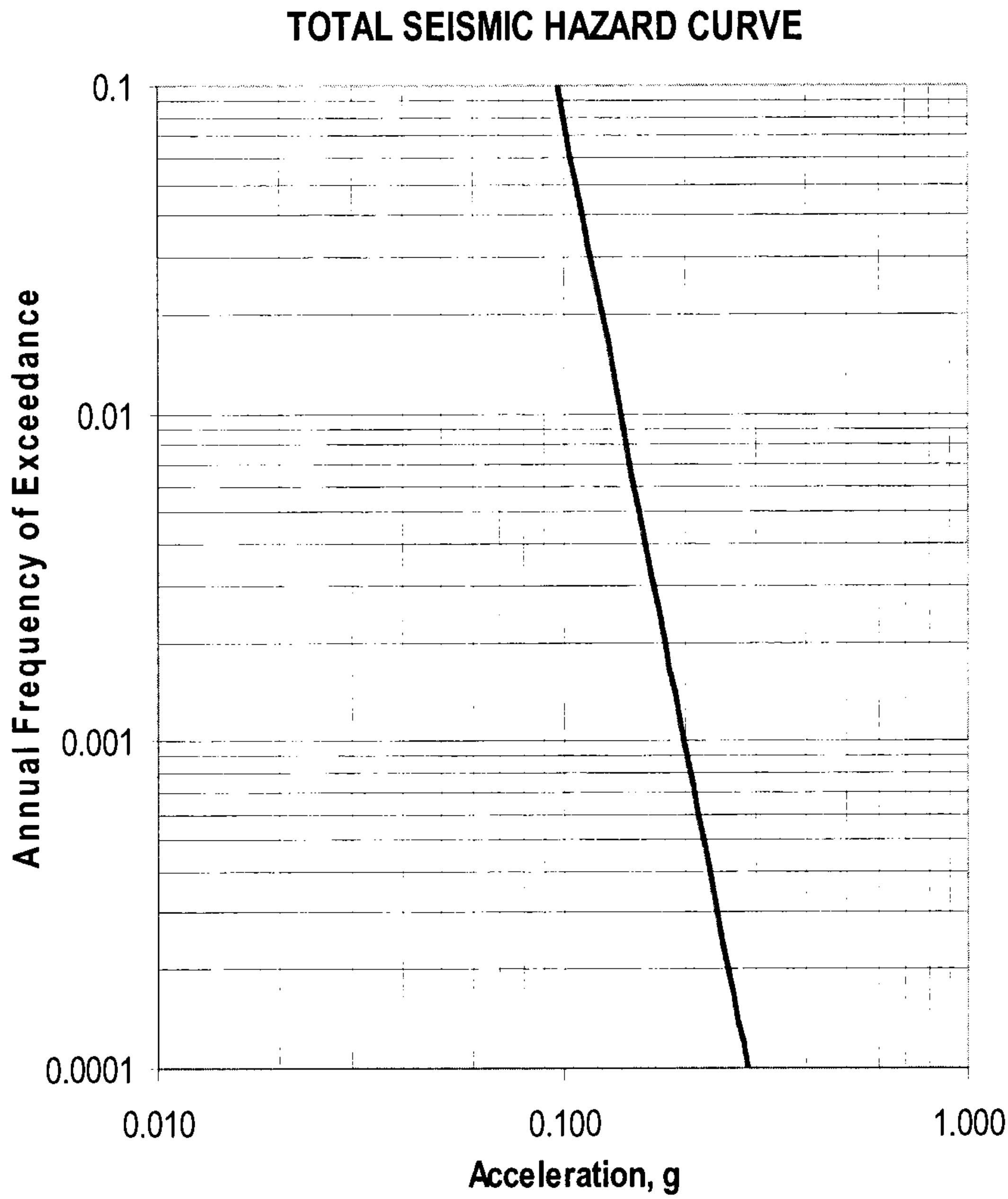
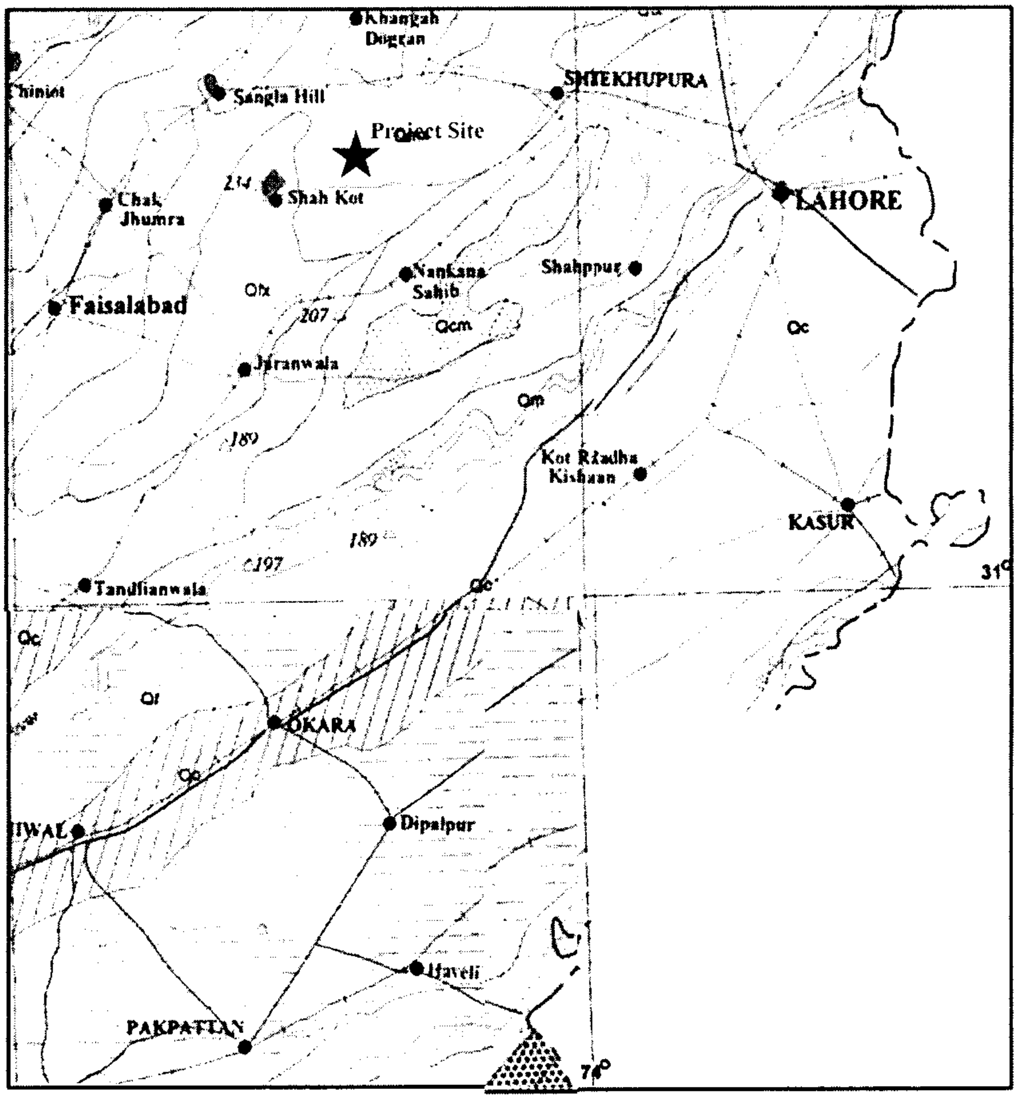

Magnitude - Frequency Curve
FIG. 4
Cumulative Number of Earthquakes per Year
100
10
1
0.1
0.01
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
Magnitude Mw

**Figure 8.5**

FIG. 5



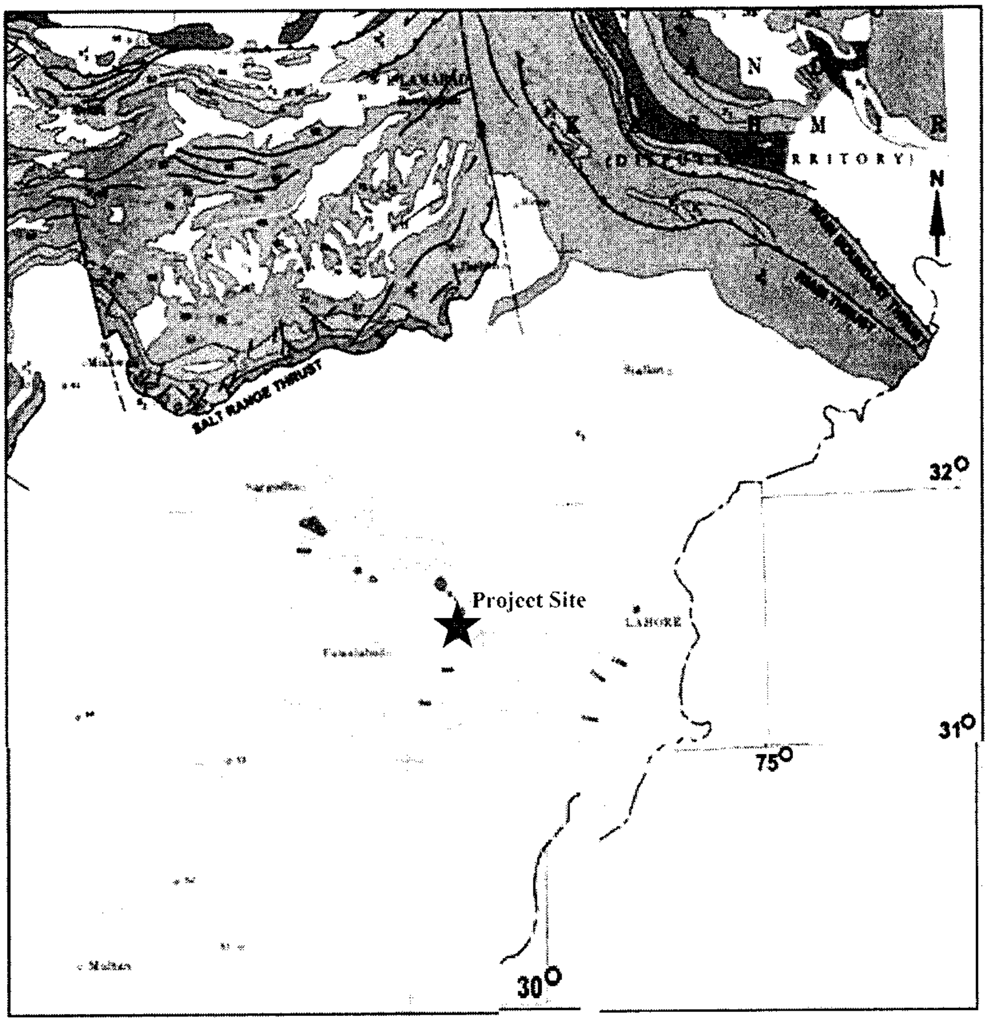
# Figure 8.1




Note: Reproduced from
GSP - Geological Map of Pakistan (1993)

**GEOLOGICAL MAP**

# Figure 8.2




Note Reproduced from
GSP – Tectonic Map of Pakistan (1984)

## TECTONIC MAP

## Figure 8.3

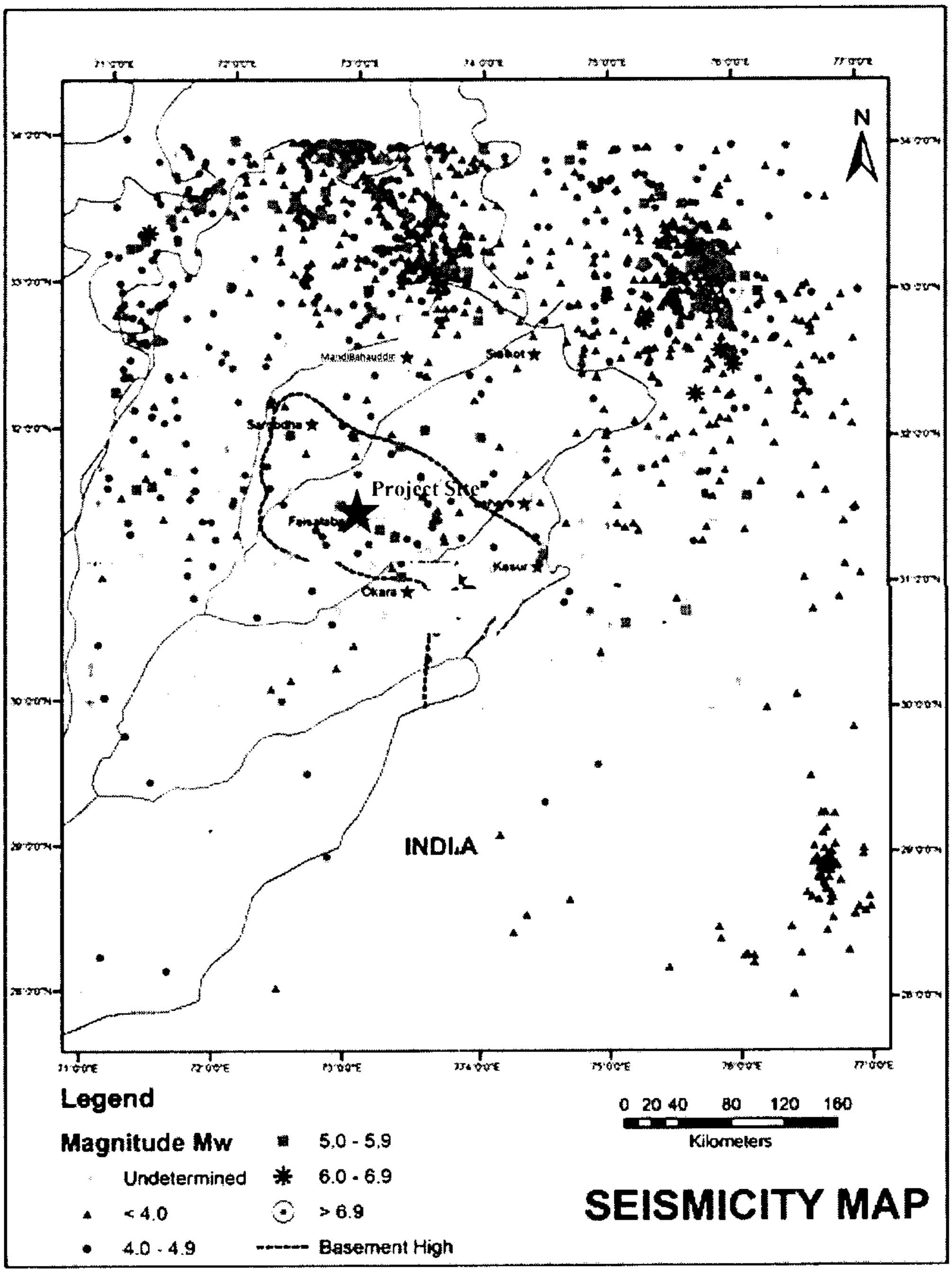

N
Mandi Bahauddin
Sialkot
Sargodha
Project Site
Faisalabad
Lahore
Kasur
Okara
INDIA
Legend
Magnitude Mw
Undetermined
< 4.0
4.0 - 4.9
5.0 - 5.9
6.0 - 6.9
> 6.9
Basement High
0 20 40 80 120 160
Kilometers
SEISMICITY MAP

Figure 8.4

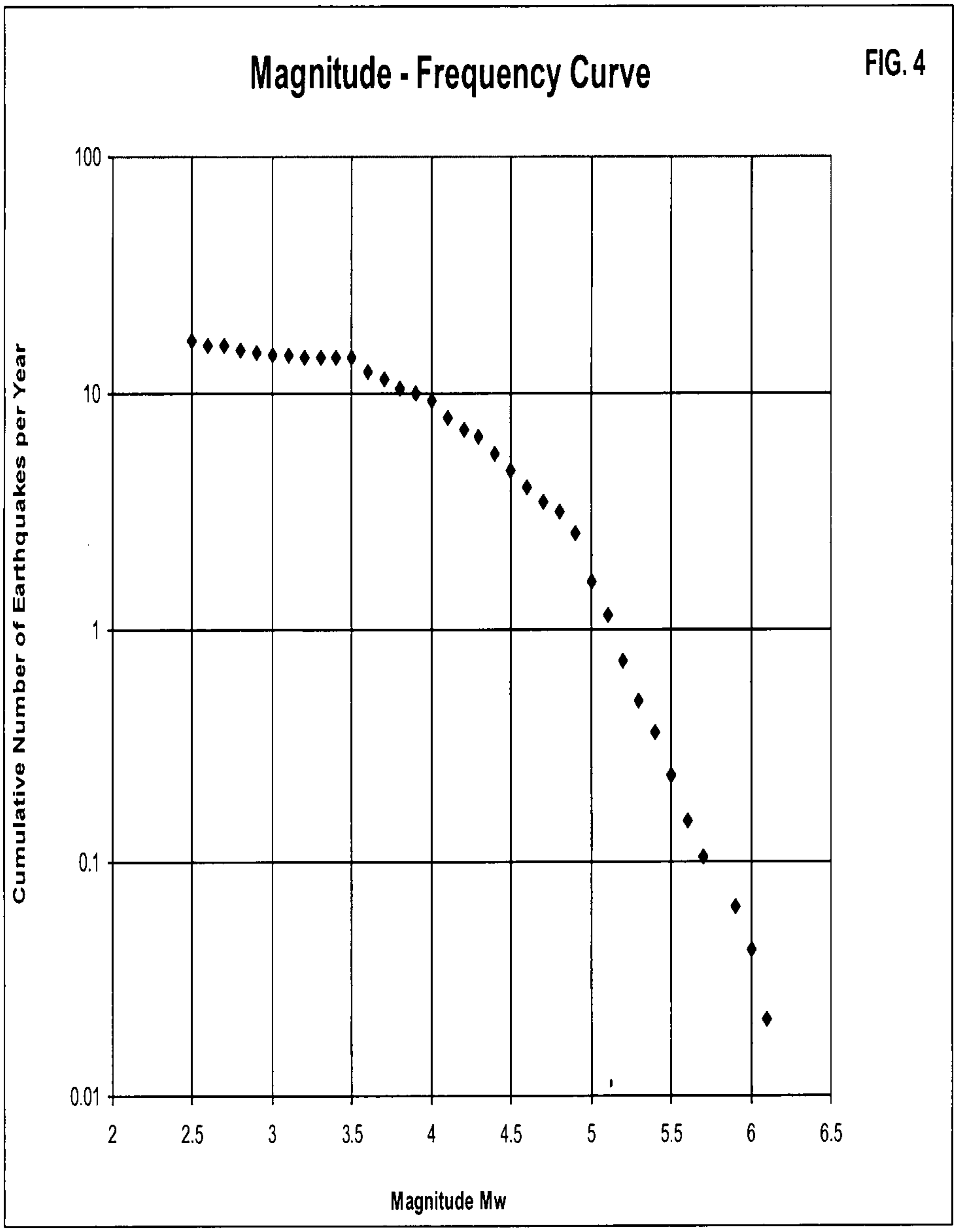
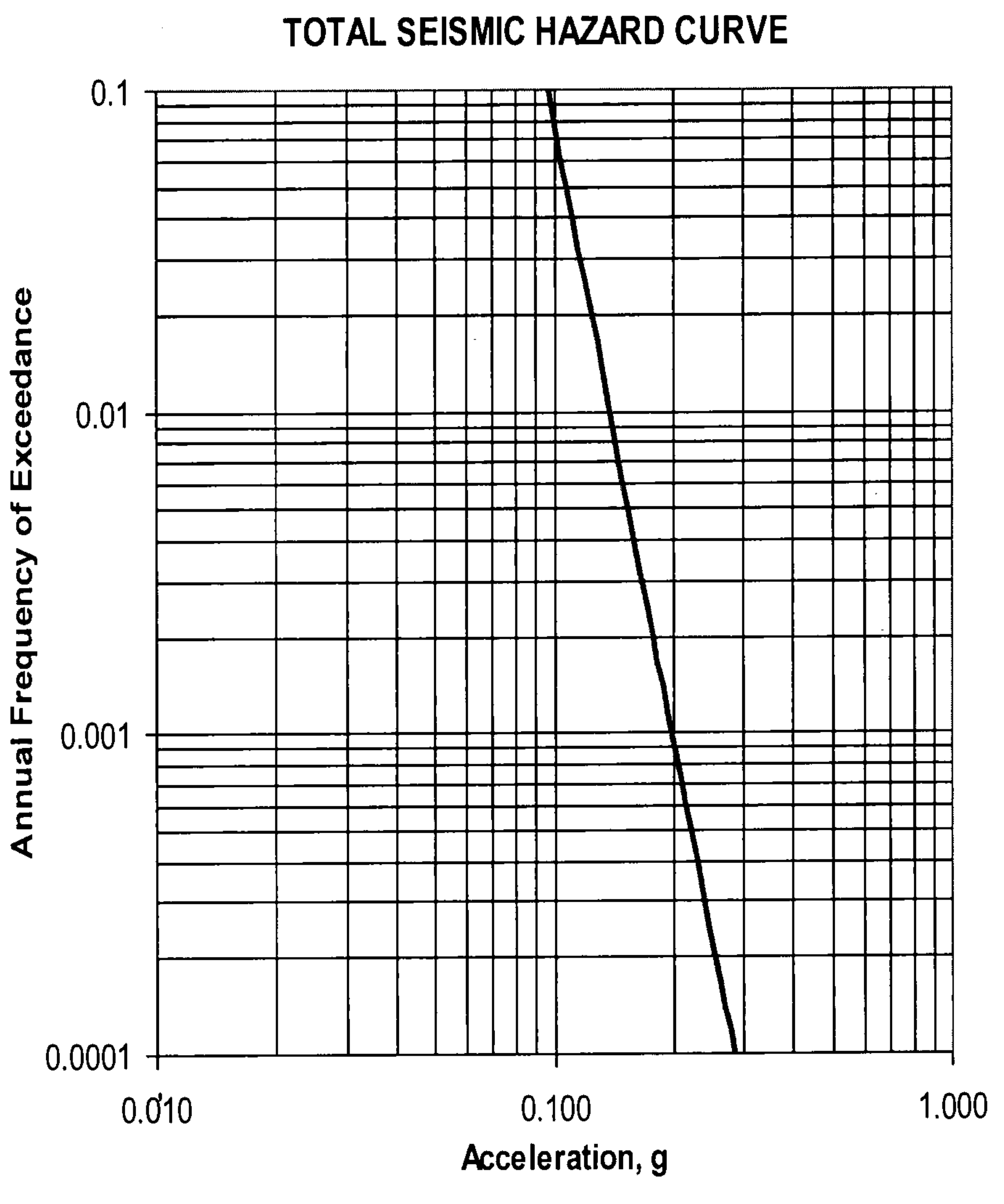

Magnitude - Frequency Curve
FIG. 4
Cumulative Number of Earthquakes per Year
100
10
1
0.1
0.01
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
Magnitude Mw

Figure 8.5

FIG. 5



# SECTION 9

# PROJECT PREFERRED LYOUT DESCRIPTION

# SECTION 9
# PROJECT PREFERRED LAYOUT DESCRIPTION

## 9.1. General

Having completed comprehensive preliminary layout alternative analysis, a preferred layout was concluded. Therefore, in this section only preferred layout alternative resulted under Section 6 would be discussed in details. This section therefore, would cover the layout of the civil structure and mechanical and electrical equipment used for Gugera Hydro Electric Power Project. Further under this section layout components such as headrace, spillway, powerhouse, loading and unloading bay, service bay, inlet structure and outlet bay, tailrace, turbines, generator, governors, transformer, LV/HV installation, switchgear, transmission line and interconnection facilities will be presented. The general layout is presented in Drawing: 9.1. Others details regarding project are presented in Drawing: 9.2 to Drawing: 9.4.

## 9.2. Project Layout

The location and layout of the preferred layout has been selected on the basis of unit cost analysis. The preferred layout is such which offer minimum cost per kWh. Therefore, the project physical arrangement and overall characteristics have been configured for optimum hydropower development of the Gugera Hydro Electric Power Project having head available at RD 216+100 and RD 220+750. The project features have been selected considering foundation conditions, cost and schedule, constructability and environmental issues.

The preferred layout is the powerhouse and spillway placed in the bypass arrangement just upstream of Existing fall at RD 216+100 along its right bank. The spillway is placed along the left bank of powerhouse structures. The powerhouse and spillway are placed at RD 214+500 due to constraint of space on right side of the canal near RD 216+100 because of existence of Nankan Sahib Bridge. There is no need of canal diversion for construction of powerhouse and spillway. Powerhouse/spillway would be constructed under dry condition along right bank. After completion of construction of powerhouse and spillway the canal flows will be diverted toward them after connecting the headrace and tailrace on upstream and downstream of the them.

The part between RD 212+000 and proposed powerhouse is called headrace canal. Its length would be 762 m. The headrace would be constructed new. As already written that powerhouse and spillway are placed at RD 214+500. The tailrace starts from downstream powerhouse transition and link the existing Gugera Branch canal just upstream of the Highway Bridge at same alignment with lowered bed level conditions.

Therefore, the Gugera Hydro Electric Power Project comprises of the following main components:

- Headrace;
- Powerhouse and spillway Intake Bay;

- Powerhouse (Machine hall and Service bay) structure housing three Bevel Gear type turbines and generators with a total installed capacity of 3.6 MW;
- Erection bay on right side of the Powerhouse;
- Gated spillway along left bank of Powerhouse structure;
- Powerhouse Outlet bay;
- Tailrace;
- Access road on left and right bank of upper Gugera Branch Canal;
- Operation and maintenance staff colony and rest house and other civic facilities;
- Turbine and generators;
- Unit transformers and Switchgear, and
- Transmission line and interconnection facilities.

## 9.3. Headrace Canal

The headrace canal starts from the existing Gugera Branch Canal at RD 212+000 to the proposed powerhouse location at RD 214+500 along the right hand side of existing Gugera Canal. The headrace starts at 200.0 m.a.s.l and ends at 199.90 masl before powerhouse inlet bay starts. The length of the headrace is about 762 m. The slopes and bed of headrace are protected by stones laid over geo-textile to protect the fines from movement and in order to run the headrace without major maintenance cost. If geo-textile is not used below the stones then fine under the pitching would be removed by fluctuation due to load rejection and tripping of turbines.

The headrace has been designed by using Manning's formula. The water surface profile and bed slope 1:8333 of the existing canal were kept constant. The water level at the entrance into the headrace is 203.16 masl being the designed Full Supply level of the Existing Canal at RD 216+100. The water level at power house is at 203.16 masl. The canal's designed bed width is 54.88 m with 1.51 m water depth and a bed slope of 1:8333. The n coefficient used is 0.17. A free board of 1.0 m has been provided. Hydraulic data of the headrace is given in Table 9.1.

**Table: 9.1: Main features of Headrace Canal**

| Item | Unit | Size |
|---|---|---|
| Water level at start of headrace | masl | 203.16 |
| Water level at power house location | masl | 203.16 |
| Canal width | m | 54.88 |
| Water Depth | m | 1.51 |
| Bed slope | ‰ | 0.12 |
| Free board | m | 1.00 |
| Embankment slope | | |
| inward | | 1:2 |
| outward | | 1:2 |

The embankments of the canal show a top width of 6 m and are made of compacted earth with 1:2 inward & 1:2 outward slopes. A road of 4.0 m is constructed at the crest of the embankments along right and left bank of the headrace. The embankments and bed of the canal are protected by stones over geo-textile.

## 9.4. Powerhouse Inlet Bays and Retaining Walls

The in-take bay in front of powerhouse and spillway consists of concrete slabs bounded by concrete cantilever retaining walls. Concrete slab in front of powerhouse and spillway with 18.0 m width starts at level 199.90 masl (bed level of headrace canal) and slopes down to a level 192.80 masl (invert level of powerhouse intake). The transition to the slopes of the headrace canal is carried out with circular concrete retaining walls.

Cement slurry trench walls are foreseen underneath the retaining walls and underneath the intake bay to minimize uplift and avoid piping underneath these structures and powerhouse structure.

## 9.5. Power Station Complex

### 9.5.1. General

The general arrangements of powerhouse and bottom outlets are shown in Drawing: 9.1 through Drawing: 9.4.

The turbine units are located at RD 214+500 approximately. The turbine unit and spillway are so placed that it becomes hydraulically more efficient. The spillway is placed along the left hand side of the powerhouse. An access is provided over the powerhouse and spillway to connect the left bank with right bank.

### 9.5.2. Powerhouse Layout

The powerhouse is constructed in the bypass arrangement along right side of the existing Gugera Branch. Cofferdams at upstream and downstream side are provided to protect the foundation excavation and construction areas from entering of ground water or rain water. The cofferdams have to be constructed at starts of construction/excavation and consist of soil excavated from the powerhouse excavation pit. Excavation of powerhouse foundation requires deep well dewatering under protection of cement slurry trench wall all around the powerhouse, spillway and underneath the retaining walls and upstream and downstream concrete floor in order to avoid piping underneath the powerhouse and spillway foundation.

The powerhouse structure includes inlet and outlet bay, machine hall (three (3) unit blocks). The loading bay is provided along right side of the Machine Hall. The substructure and superstructure is constructed of cast-in-place reinforced cement concrete. The roof consists of pre-cast and post tensioned concrete girder with composite metal deck and 20 cm thick cast-in-place lightweight reinforced concrete slab.

The powerhouse yard is located adjacent to service bay. Roll-up door allow easy access of vehicles and semi-trailers required for delivery of major electrical and mechanical equipment. The yard is asphalted with adequate drainage features to accommodate yard drainage. The switchyard and yard are enclosed by fencing and a lockable gate at the road side.

### 9.5.3. Machine Hall

The machine hall extends along the entire unit blocks and loading bay. It houses the turbine and generator and other E&M equipment as generator terminals, AC/DC distribution and oil cooling units. Its floor level is at 198.70 m.a.s.l with a length of about 23 m and a width of 17.2 m. The necessary height is defined by the hoisting requirement and is estimated at being 8.5 m.

The stairs in the control room area connect the floors between 192.53 m.a.s.l and 223.23 m.a.s.l. Mechanical workshop, turbine pits and sumps area are equipped with necessary hoists for handling of equipment. The service area comprises the control room, offices and storage areas, kitchens/lunchroom, locker and washrooms.

The walls are constructed of concrete. Interior walls and concrete ceiling are painted; the floors are sealed by natural concrete or by using ceramic tiles. Doors are standard steel doors with required fire rating. Windows are made of single glasses with pressed steel frames. Insulation is provided where required for energy conservation. All items are selected for durability, cost effective and ease of maintenance.

### 9.5.4. Loading Bay

A separate loading bay is provided on the right hand side of the powerhouse. The loading bay floor level is 200.92 m.a.s.l. At entrance roll-up gate of 7.0 m width is located in the right side wall for vehicle access to machine hall. The loading block is used as platform during erection and maintenance of turbines, generators and other E&M equipment. Additionally, a local workshop is established in service bay.

### 9.5.5. Service Bay

A service bay is located on the right side of the powerhouse. It is multi-storey building for housing control room, conference room, offices, kitchen, bathrooms, workshop and rooms for batteries, etc. Control room is provided at 204.16 m.a.s.l. A stair is provided to link the floors.

### 9.5.6. Spillway

A spillway is located along the left bank of the powerhouse building. The discharging capacity of the spillway is equal to full supply discharge of the Gugera Canal. It will be a gated structures. Radial gates having remote control system would be provided. The control of gates for opening and closing would be done from main control room. It will pass flows during tripping of turbine due to faults in the system or in the unit. A concrete deck bridge would be provided for vehicle traffic. The gates would be radial and operated from elevated deck of steel structure. The gates could be flap gates and would be operated from inside the crest of the spillway. Exact selection of type of gates would be done during detailed design phase by EPC Contractor.

### 9.5.7. Trashracks

Trash racks are installed at the intake at an angle of $78^0$ to facilitate mechanical cleaning and to reduce hydraulic losses. The size of the intake is 4.37 m x 8.32 m. As no intermediate pier is provided, therefore three horizontal steel beams installed behind the trash racks will act as support structures. For cleaning of trash rack a crane for each intake is foreseen or trash racking machine moving on rails.

### 9.5.8. Stop Logs

Stop logs are foreseen at the intake and at the end of the draft tube. Stoplogs are also provided on upstream and downstream of spillway gates. These are required in order to facilitate erection, repair and maintenance of turbines and gates. Placing and removing of stop logs at intake would be by trashrack cleaning machine and at draft tube and bottom outlets are foreseen by mobile crane of suitable capacity. Because there will be only one unit and bottom outlet closed at the same time one complete set of stop logs is provided.

### 9.5.9. Construction Pit

Powerhouse and spillway would be constructed in single excavation pit. A designed dewatering system would be installed for lowering down the groundwater level in order to cast concrete under dry conditions. Dewatering system will remain in operation till the concrete work is finalized. However, cement slurry trench walls all around the powerhouse would be constructed first before start of excavation. Therefore, these cut-off walls have significant effects on reduction of inflow water, ultimately result in less operation and maintenance cost of dewatering.

## 9.6. Spillway Gates

Spillway gates are foreseen on downstream and upstream side of the machine hall for their operation. Gates are radial and operated hydraulically and operation will be controlled from machine hall control room. Size of gate is given in the respective Drawing.

## 9.7. Outlet Bay and Retaining Walls

The outlet bay consists of concrete slabs bounded by concrete cantilever retaining walls. Concrete slab starts at downstream of powerhouse at level 192.63 masl (invert level of draft tube) and sloping up to level 196.91 masl (bed level of tailrace canal). It is hinged to the powerhouse foundation with an expansion joint. The retaining walls also provide transition to the tailrace cross section. The tail-water level is such that the draft tube remains submerged even in minimum tail-water level to avoid cavitations.

## 9.8. Tailrace Canal

The powerhouse and bottom outlets discharge directly into outlet bay which is directly linked with the tailrace canal which is ultimately Gugera Canal. The tailrace canal extends from the powerhouse outlet bays to the existing canal up to RD 221+500. Channel is formed in trapezoidal section, with a bed width and bed slope equal to the existing Gugera Branch Canal. The side slopes are 1:2. The tailrace canal bed is covered with stone over geo-textile having length of about 770 m.

## 9.9. Service Roads and O&M Staff Colony

A 4.50 m wide access road is constructed over the left bank of the Gugera Branch Canal to access the canal and strengthen the existing access to villages. A metalled road along left bank would be provided up to RD 221+500.

Operation and maintenance staff will be stationed in a colony constructed near to the powerhouse. Colony is proposed along the right bank of the headrace canal. It would consist of residential building, community building, masjid, etc, to serve the daily requirement of the operation and maintenance staff.

## 9.10. Electro-mechanical Equipment

### 9.10.1. Layout and design criteria

As already described in Section 6 of this feasibility study report that the Bevel Gear Bulb Turbines will be employed for Gugera Hydro Electric Power Project. The turbine would be designed according to the following specified layout data:

- Total discharge = 142 $m^3/s$
- Assumed net head = 2.8 m

The hydraulic layout bases on numeric calculations and model tests which have been carried out in ANDRITZ HYDRO own hydraulic laboratories. The turbine belongs to the Bevel Gear Bulb Standard Series of ANDRITZ HYDRO or equvalent. This means offering turbines are highly proven machine. ANDRITZ HYDRO have sold approximately over 230 units all over the world.

### 9.10.2. Bevel Gear Bulb Turbines

#### 9.10.2.1. Design Concept

The character of the hydropower plant is stamped by the compact construction of the bevel gear bulb turbine. This convincing design is offering a lot of advantages. Turbine, bevel gear and generator are creating an integral unit thus allowing workshop-testing and easy site installation.

Small dimensions and simple in- and outlet contours are reducing the costs for structural works. The double regulated bevel gear bulb turbine is utilizing the available potential energy with highest possible equipment efficiencies and impressing part load characteristics. By means of the bevel gear the turbine transmits its power output to a high-speed synchronous generator of standard design. This design concept allows the selection of the most advantageous speed from hydraulic point of view.

Generally the turbine is equipped with a controllable gate mechanism which in turn controls the water flow. Closing of the gate mechanism by use of a closing weight is a reliable safety. Concept which allows the deletion of an additional stop valve mean a gate valve, for service inspections simple upstream and downstream stop logs will be sufficient.

The engineering work and manufacture of the turbine, and the mechanical analysis of the materials used, as well as the ability of the components to withstand the specific stresses and strains they are subjected to meet the requirements of the German Industrial Standard Specifications.

#### 9.10.2.2. Technical Description

Bevel gear bulb turbine is executed with a horizontal shaft and turbine housing with round shaped inlet. The statically balanced runner with movable blades is fixed to the turbine shaft by means of pressure oil injection method. The turbine shaft and its roller bearings are supported in the rigid and bucking resistant turbine housing. Runner blades are varied by a servomotor located inside the runner hub. By means of the control head, which is located at the opposite end of the turbine shaft, governing oil is transported inside the hollow turbine shaft to the runner servomotor.

The unit has got an easy accessible wicket gate mechanism and guide vanes with a spring facility preventing possible damage to gate mechanism if material gets stuck between the guide vanes. The two-part discharge ring design allows optimal accessibility to the runner. The bevel gear (crown and pinion wheel) with oil lubricated bearings is integrated in the turbine housing. The helical toothing of the bevel gear in conjunction with a careful bearing arrangement ensures a smooth performance. To ensure a long useful service life of the gears they are made of a high-grade special alloy.

The pinion shaft accommodated in a supporting rib of the turbine casing is the connecting element to the generator, which is arranged outside the turbine casing. The coupling between pinion and generator shaft is executed by means of a flexible rubber-sleeve coupling. The flywheel located on the pinion shaft therefore is the counterpart of the flexible coupling. The arrangement of the roller bearings and the bevel gear inside the turbine bulb contributes to reduce the operating noise, because the water flow circulates around.

#### 9.10.2.3. Governor System

The Bevel Gear Bulb Turbine is designed for an emergency trip of the gate mechanism. This means that whenever one of the criteria for an emergency trip occurs, the gate mechanism is closed rapidly. In response thereto the runner also closes with a delay. As a safeguard for the positive closing of the machine unit, the gate mechanism has been provided with a closing weight. The servo-valves translate the signals received from the Digital Turbine Governor into hydraulic control forces. The servo-valves of the gate and runner control loops translate the electrical control impulses into forces acting directly upon the servomotors for runner pitch and gate position control.

The actual control positions of the gate and runner servomotors are feedback electronically by feedback transmitters. Further on the controls and electrical system elements such as digital turbine governor with control and protection functions, generator controls and level monitoring are included.

## 9.11. TECHNICAL DATA

### 9.11.1. Hydraulic Data

- Max. Head water level = 203.16 m a.s.l.
- Max. Tail water level = 199.92 m a.s.l.
- Head water level at rated discharge = 203.16 m a.s.l
- Tail water level at rated discharge = 192.92 m a.s.l
- Gross head = 3.00 m
- Trash rack losses (Assumption) = 0.05 m
- Outlet losses = 0.14 m
- Net head = 2.8 m

- Discharge ( full load) = 47.0 $m^3/s$
- Power output on turbine shaft = 1.2 MW
- Setting level runner centre line = 194.20 m a.s.l
- Max. possible discharge = 142 $m^3/s$
- Turbine Runner = 2.10 m

### 9.11.2. Powerhouse Intake Criteria

The output and efficiency values as indicated hereinafter presume proper intake flow conditions. For investigation the intake flow conditions and in order to secure proper operation of the units, it is recommended that the following criteria shall apply:

1. The turbine intake as well as the draft tube outlet has to show a sufficient submergence.
2. Flow is free from separations and air sucking vortices.
3. Velocity distribution within $\pm$ 10 percent of the average velocity for at least 80 % of all velocities.
4. Maximum deviation of velocity shall not exceed 20 % of the average velocity locally. Locally limited deviations are accepted whereas criteria 1 must be kept up.
5. The deviation between the left and the right half of the turbine inlet will not exceed 5 %.

### 9.11.3. Power fading through polluted water

Under flood conditions or at periods of increased content of debris (such as leaves, grass algae, etc.), a reduction of power can occur due to pollution of runner blades and guide vanes. The rated power can be regained by means of a so called flush control (controlled off-cam operation in certain intervals, during net parallel operation).

### 9.11.4. Technical Data

**Turbine**

- Turbine speed = 214.3RPM
- Generator speed = 750 RPM
- Runner diameter D1 = 2100 mm
- Intake dimensions (round) diam. = 4.395 mm
- Number of runner blades = 4

**Gear design**

Design and layout of bevel gearing system according to DIN 3991 with following minimum safeties:

- tooth foot strength = $S_F$ > 1.6
- seizing = $S_S$ > 2.2
- pitting = $S_H$ > 1.4 (1.2 with high performance oil "API")
- Application factor = $K_A$ 2.0

## 9.12. TECHNICAL SPECIFICATION

### 9.12.1. Bevel Gear Bulb Turbine

With built-in bevel gearing and roller bearings, comprising mainly:

#### (a) One (1) Number Kaplan runner

One number Kaplan runner with spherically shaped hub and variable pitch runner blades, runner blades resistant to corrosion and cavitations, carried in replaceable bushes, blade bolted to the blade crank ring from outside to facilitate an easy dismantling, surfaces of the blade neatly ground to obtain the proper hydraulic profile (checked by 3D-measuring devices). A good finish with double seals for sealing between the runner hub and the blade disk. Runner servomotor accommodated in the runner hub, with the pitch moving mechanism for varying the runner pitch.

#### (b) One (1) Number Turbine shaft

Turbine shaft would be made of steel, with concentric bore for accommodating the oil feed pipes; on runner side the shaft is designed as a cone for fitting the runner by the pressure oil injection method. The shaft is machined with the required seats for the bevel gearing and for the roller bearings.

#### (c) One (1) Number Turbine shaft seal

Turbine shaft seal would be double sealing system with replaceable endless, special rings, and a replaceable single-part shaft liner made of corrosion-resistant material. It has the following advantages:

- no sealing water necessary (exception: if abrasive water must be considered)
- no mixing of oil and water possible
- Two (2) number hoses leading into separate tanks for supervision of the two radial sealing rings
- Extremely wear-resistant ceramic coating on the waterside (chrome-oxide).

#### (d) One (1) Number Guide bearings

One number guide bearing for supporting the turbine shaft on both the runner side and intake side is provided. It is made as roller bearings, designed to accommodate the radial loads and oil lubricated.

### (e) One (1) Number Thrust bearing

One number thrust bearing is foreseen. It is designed to have a main thrust face and an auxiliary thrust face, arranged on the intake side. It would be made as a roller bearing, designed to accommodate the axial loads, oil lubricated.

### (f) One (1) Number Conical wicket gate mechanism

Conical wicket gate mechanism with external gate operating mechanism would be provided for semi-axial flow and for controlling the discharge flow and for stopping the driving water flow. It comprising of the following:

I. <u>Conical guide vanes</u>

Cast, with shrink-fitted replaceable sleeves made of stainless steel including the required gate operating levers

II. <u>Maintenance-free guide vane bearings</u>

Exchangeable oil-free bushes with a Teflon layer (PTFE). Carried in bronze bushes, which can be removed from outside.

III. <u>Oil-and water-resistant seals</u>

Double sealing system for the guide vane stems. Seals made of rubber.

IV. <u>Gate operating mechanism</u>

For operating the guide vanes with links and link pins. Every second link is spring-loaded. This is a safety facility which prevents possible damage to the guide vanes by debris getting stuck between the guide vanes.

V. <u>Gate operating ring</u>

Made of steel with low-friction bearing arrangement.

VI. <u>Gate servomotor</u>

Operated by governor oil together with the required linkage system for connection to the gate operating ring. Servomotor directly supported on turbine housing.

VII. <u>Closing weight</u>

Directly attached to the gate operating ring.

VIII. <u>Outer ring of gate mechanism</u>

Accommodating the bearings for the guide vanes with connecting flanges for mounting to both the discharge ring and the turbine casing

### (g) One (1) Number Inner Ring of gate mechanism

For accommodation of the inner guide vane bearings, the turbine guide bearing (runner side) and the shaft sealing, with connecting flanges to the turbine inner bulb structure.

**(h) One (1) Number Discharge ring**

Double spherical shaped, made in two parts, with seals and mounting elements.

**(i) One (1) Number Downstream wall ring**

On the downstream side made as a welded steel fabrication embedded in concrete, for holding the discharge ring, with the required anchorage material.

**(j) One (1) Number Turbine casing**

Fabricated in welded steel with round-shaped intake prepared for grouting into concrete. With intake bulb, accommodating the turbine shaft and pinion shaft together with their bearings and the bevel gearing, radically supported by sturdy welded-in hollow ribs, with an intake side cover which, when removed, gives access to the runner feedback system, the oil feed system to the runner servomotor, and the intake side turbine bearings.

**(k) One (1) Number Bevel gear**

Accommodated in the turbine casing. It comprising of the following:

i. <u>One (1) Number Crown wheel</u>

   With palloid toothing system, made of specially alloyed steel, mounted on the turbine shaft by means of mounting elements

ii. <u>One (1) Number Pinion wheel</u>

   With palloid toothing system made of specially alloyed steel, mounted on the pinion shaft. The oil required for lubricating the bevel gearing is injected in between the meshing teeth.

**(l) One (1) Number Pinion shaft**

One number pinion shaft including the required mounting elements of the flywheel.

**(m) One (1) Number Pinion shaft bearing system**

One number pinion shaft bearing system with roller bearings, oil lubricated. The bearings are carried in a hollow rib of the turbine casing.

**(n) One (1) Number Flexible coupling including and one (1) Number flywheel**

One (1) Number Flexible coupling including and one (1) Number flywheel for connecting the pinion shaft with the generator shaft, combined with flywheel arrangement equipment including bolts and sleeves made of oil-resistant and anti-ageing rubber.

**(o) One (1) Number Brake**

One (1) Number Brake for stopping the runner from a speed smaller than 20 % of the nominal speed; the brake opens by oil pressure and closes spring-loaded; brake acting upon the flywheel

**(p) One (1) Runner oil feed system**

One (1) Runner oil feed system arranged on the intake side end of the turbine shaft with oil distribution box for admitting the control oil to the runner servomotor system including runner position feedback system

**(q) One (1) Number Inductive speed sensor**

One (1) Number inductive speed sensor for sensing the turbine speed, installed in generator support

**(r) Two (2) Number Linear transmitters**

Two (2) Number Linear transmitters for measuring the position of the runner blades and gate mechanism

**(s) One (1) Number Set of resistance thermometers**

One (1) Number Set of resistance thermometers for the bearings of the turbine and pinion shaft (Pt 100, double elements)

**(t) One (1) Number Set of pipe work and high pressure hoses**

One (1) Number Set of pipe work and high pressure hoses for the lubrication and governing oil

**(u) One (1) Number Set of Tools**

One (1) Number Set of Tools Standard tools for normal maintenance works

### 9.12.2. Hydraulic Governor and Lubrication unit (HPU)

The oil supply unit provides the governing and lubrication oil for the turbine and comprises mainly:

**(a) One (1) Oil sump tank for governing oil**

In welded steel fabrication, equipped with cleaning covers, breathing and filling-in filter, oil level in indicator and oil level switch (LI, LS), oil temperature indicator and oil temperature switch (TT,TI), 1 oil collecting tray (together with lubrication oil tank)

**(b) One (1) Governor Oil Pump, Variable Flow with AC motor**

(One (1) common motor for governing and lube oil pump)

**(c) One (1) Oil strainer (10µm, double arrangement) incl. 1 PDI and PDS**

**(d) One (1) pressure relieve valve**

**(e) One (1) Control block for the governing oil circuit Consisting of:**

- One (1) non return value in pressure oil pipe
- One (1) servo valve, gate mechanism
- One (1) servo valve, runner blades
- One (1) solenoid valve for emergency trip of gate mechanism
- One (1) opening valve for emergency trip of gate mechanism (cartridge)
- One (1) solenoid valve for the turbine brake
- One (1) pressure indication switch (PIS)
- Measurement connections for service checks

**(f) One (1) Oil sump tank for lubrication oil**

In welded steel fabrication, equipped with cleaning covers, breathing and filling-in filter, oil level indicator and oil level switch (LI, LS), oil temperature indicator and oil temperature switch (TT,TI), sump tank heater with thermostat, 1 oil collecting tray (together with governor oil tank)

**(g) One (1) lubrication oil pump, constant-flow, with AC motor**

(One (1) common motor for governing and lub oil pump

**(h) One (1) oil strainer (10µm, double arrangement) incl. 1 PDI and 1 PDS**

**(i) One (1) pressure relieve valve**

**(j) One (1) pressure indicator (PI) in lubrication supply line**

**(k) One (1) flow indicator switch (FIS) in lubrication supply line**

**(l) One (1) Set of pipes and fittings**

For the internal piping of a the components, material steel galvanized

**(m) One (1) set of pipes and/or high pressure hoses**

For the connection of the oil supply unit to the turbine, material stainless steel for piping

The first filling with oil is included in our scope of supply. The whole unit is readily pre-wired on terminal box.

### 9.12.3. Two (2) circle cooling system

For the supply of cooling water for cooling of generator heat (IC81W), two (2) circle cooling system mainly consisting of;

- One (1) Pump unit containing
- One (1) pump with AC-motors
- One (1) non return valves
- One (1) flow controller
- Two (2) temperature transmitter (TT, indicating supply and return line temperatures)
- One (1) pressure accumulator, safety valve, pressure switch PS, pressure indicator PI unit completely piped and wired
- Two (2) TI in supply and return line
- One (1) plate heat exchanger equipment
- One (1) shut off valve
- One (1) 3 way valve (motor driven)
- One (1) throttling valve (generator bearings)
- One (1) throttling valve (generator cooling)

All above mentioned will be skid mounted

#### 9.12.4. One (1) Set of field pipe material and necessary equipment

One (1) Set of field pipe material and necessary equipment to connect the pump unit to the heat exchanger and the consumers (cooler generator, each distance between unit and consumer < 6m); pipe material normal steel, flexible rubber hoses (for compensation of civil work tolerances) delivered as loose parts.

#### 9.12.5. Synchronous Generator

Revolving-field generator, brushless, with integral exciter.

##### 9.12.5.1. Technical Data

- Type SGA 1C 8T
- Mechanical power (at generator shaft) [kW] 1304
- Nominal Output [kVA] 1108
- Ambient Temperature [°C] 40
- Power factor cos Φ 0.9
- Nominal Voltage [V] 690
- Connection Star
- Voltage regulation accuracy [%] ± 1
- Voltage adjusting range [%] ± 5
- Frequency [Hz] 50
- Insulation class F
- Temperature rise B
- Enclosure IP 44
- Cooling IC 81
- Construction type V 1
- Bearing (life time > 100.000 h) Roller Bearing, grease lubricated
- Radio interference suppression N
- Specification standard VDE 0530, EN 60034
- Finish RAL 3000
- Shaft rotation seen from DE Counter clockwise
- Phase sequence Clockwise
- Cable outlet seen from DE downwards
- Weight of alternator [kg] app. 7,000
- Air flow [$m^3$/s] 1.68

- Moment of inertia [$kgm^2$] 228
- Sound pressure level [dB(A)] 89

#### 9.12.5.2. Accessories

- Anti condensation heater, 230 V
- Current transformer for parallel operation
- Analog Automatic Voltage regulator
- Temperature sensor PT 100 in stator winding, 2 pc. Per phase
- Temperature sensor PT 100 in bearing, 2 pc. Per bearing
- Enlarged terminal box with six winding ends (U-V-W-X-Y-Z) for mounting transformers in the star point.
- Current Transformers at star point 1000/1 A for Protection: 5P 10, 20 VA
- Current Transformers at star point 1000/1 A for Measuring: 0,5FS5, 20 VA
- Current Transformers at line 1000/1 A for Protection: ,5P10, 20 VA
- 3pc. Voltage Transformer 690 : √3 / 100 : √3 / 100/3, 30 VA –cl. 0,5, 60 VA – cl. 1,0
- Potential transformer at star point, 110 V, 5 A (30 sec), P = 800 W
- Cable outlet with undrilled cable gland
- Greasing nipple extended at DE and NDE (beside DE)
- Grease overflow tunnel extended at DE
- Coils support with wedges for protection against forces at over speed
- Shaft end with key for mounting a coupling
- Heat exchanger for fresh water, single tube mounted beside the alternator with emergency doors (IP 11) for 100% load including leakage supervision and 2 pc. Temperature sensors PT 100 (air in- and outlet) and 2 pc. Temperature sensors PT 100 (water in- and outlet)

| | |
|---|---|
| Fresh water temperature: | 0° C to max. 30° C |
| Water flow rate: | appr. 12 $m^3$ /h |
| Water pressure drop: | 0.5 bar |
| Max. water pressure: | 6 bar |

#### 9.12.5.3. One Digital Protection Unit

A multifunctional protection unit for small and medium- sized power plants. Following protection functions are available:

- Stator earth-fault protection (V0>, 50N), 51N (over delta-winding of VT)
- Over voltage protection (U>, 59)

- Under voltage protection (U<, 27)
- Frequency protection (f<, f>, 27)
- Time-over current protection (I>>, 50/51)
- Overload protection (49)
- Unbalance protection (46)
- Differential protection (87)

Power distribution: Feeder coming from auxiliary transformer 220/380 VAC, with:

- Connection terminal block for max 60 A
- Buses for 60 A
- Circuit-breaker 60 A with over current and short-circuit instantaneous trips
- Over voltage protection type Degnblock block 3

  Outlets and contactors for the turbines and their ancillaries

- Power supply for governor and lubrication oil pumps
- Power supply for cooling unit, if any)
- Fused feeder for governor/ lubrication oil heating
- Generator heating

Disconnecting clamps for protection and measurement

#### 9.12.5.4. Generator Voltage Cubicles

These cubicles contain one generator circuit breaker for each unit and one station service feeder. In total there will be two blocks, two blocks containing two generator feeders and one station service feeder each.

One circuit breaker 1000 A Rated current 40 kA Short circuit current

We have following singles foreseen as voltage free using 24 VDC relays:

- Generator circuit breaker close (order)
- Generator circuit breaker open (order)
- Generator circuit breaker is open (feedback)
- Generator circuit breaker is closed (feedback)
- Generator circuit breaker is ready for operation (feedback)
- Generator circuit breaker is not ready (feedback)

The operative condition of the circuit breaker will be shown on the touch screen.

These cubicles shall be arranged along the upstream wall of the powerhouse, on generator elevation, (between unit 1 & 2 and 3). The connection generators to these cubicle shall be done by means of cables, while the connection to the main transformers shall be done by means of cables, arranged vertically up to the transformers.

The station auxiliary transformers, being dry type, low voltage transformer, shall be arranged inside these cubicles.

The overall dimensions of these cubicles will be approx 2400x2200 mm;

#### 9.12.5.5. Water level Measurement

One water level measurement system for one power station consisting of:

- One (1) head water level sensor, arranged 10 m upstream of the power house
- One (1) tail water level sensor, arranged 10 m downstream from the power house
- One (1) level sensor after the trash rake of each turbine
- One (1) central processing unit

#### 9.12.5.6. Installation of Cable System

All electric devices are pre-wired to their terminal boxes. The cabling comprises the installation of the cable system between all components of scope of supply. All material necessary for the installation of the cable system is included.

The cubicles, hydraulic unit, generator and the turbine are grounded and connected to the equipment potential point (connection to earthing bands), connection point to the embedded earthing system provided by civil. Aall installations within the powerhouse shall be connected through cables

#### 9.12.5.7. Earthing System for Powerhouse

The general powerhouse and bottom outlets earthing system shall use hot dip galvanized earthing rods, to be arranged in the dewatering wells during the excavation; these earthing rods shall be galvanically (by welding) connected to a cage created by copper wires, fixed by wires to the re-bars. The cagier wires shall have welded connections at designated location, so to form a 2x2m cage all over the powerhouse and bottom outlets structure; the external earthing will be then connected to these flat copper; the embedded material shall be delivered and installed by civil.

#### 9.12.5.8. Main step up transformers

Three (3) main step up transformers will be arranged and located below the rails of the trashrack cleaning machine. Proper access and outlet of cooling air need to be foreseen.

| | |
|---|---|
| • Type | oil filled suitable for outdoor installation |
| • Capacity: | 3x1.5 MVA |
| • Ratio | 0.69/11 kV |

- Connection: YNd11
- Efficiency approx 99%
- Short circuit voltage drop 6%

### 9.12.5.9. 11 kV Switchgear

This switchgear shall be arranged on the generator floor level. The switchgear shall consist of two main transformer feeders, one line feeder and one cubicle containing the busbar potential transformers.

The overall dimensions of these cubicles shall be 5000x1800x2300 mm

The main transformer feeders are equipped each with:

- One (1) vacuum circuit breaker, 630 A rated current and 25 kA short circuit current
- Two (2)current transformers 200/1/1 A
- One (1) three phase quick earthing switch, manually operated
- Two (2) current transformers 500/1/1 A
- Two (2) single phase potential transformers
- One 3-phase cable XLPE approx 10m to T/L terminal, 11kV/3x395mm2

The busbar measuring cubicle is equipped with:

- Two single phase potential transformers

### 9.12.5.10. Station Service AC Equipment

Consisting of (reference is made to the attached single line diagram LJF.000.02.001):

- Two dry type transformer 0,69/0,38kV, capacity 100kVA (arranged in generator voltage cubicles item 3.5.5)
- Two sub distribution busbars located in the generator voltage cubicles, item 3.5.5)
- One (1) main distribution cubicle with approx. 12 feeders and one incoming feeder from the emergency diesel generator

### 9.12.5.11. Emergency Diesel Generating Set

Emergency Diesel Generating Set consisting of:

- One Diesel Generating Set 100 kVA/380 V
- One Fuel Tank suitable for 3 days operation

### 9.12.5.12. 24V DC System

The 24V DC System consisting of three (3) sub systems, one for each group of units and one for common use each sub system consists of:

- One 24V battery, capacity approx 70 Ah
- One battery charger
- One UPS switch
-

### 9.12.5.13. Powerhouse indoor lighting System

The powerhouse shall be equipped with simple permanent lighting system, which shall be subdivided into a turbine gallery system and a generator level system.

The service luminance shall be less than 100 Lux. For maintenance and other detailed work, when required, a mobile lighting system shall be used.

Outdoor lighting on powerhouse and access road, will be delivered and installed by the civil contractor, however four feeders for the power supply will be foreseen in the low voltage main distribution board.

### 9.12.6. Communication System

A simple communication System will be supplied, consisting of:

- One telephone system suitable for 3 incoming lines and 10 branches
- One port for the incoming internet connection (to allow future remote control)

### 9.12.7. Dewatering and drainage system

Powerhouse dewatering and drainage system consisting of:

- Two (2) centrifugal pumps for dewatering, each 7.5 kW, lifting head 20m
- Two (2) submersible pumps for drainage, each 2.2 kW, lifting head 20m

  (contactors, level control located in AC main cubicle)
- Two (2) level switches with 4 positions
- Four (4) non return valves
- Two (2) shut off valves

Embedded piping to be supplied by civil contractor, with suitable flanges to connect the a/m equipment.

### 9.12.8. Powerhouse Crane

One single girder crane will be installed having a lifting capacity of 10 tons and a span of less then 9m (according to the final width of the powerhouse).

### 9.12.9. Trashracks for turbine intake

One trashrack for each turbine intake will be provided; the overall dimensions are approx 8.5 x5.14m;

The design will follow the European practice of having vertically arranged bars with spacers of 50-70mm. The trashrack will be subdivided in segments approx 500mm, wide, to allow easy removal of the individual segments for maintenance and repair.

The trashrack will be carefully protected against corrosion, following the European practice.

### 9.12.10. Trashrack Cleaning Machine

The TRCM-H500 is designed to guarantee the cleaning ability during water velocity conditions up to 1.5 m/sec without reduction of the intake capacity.

Expected trash:

- Aquatic plants, grass, leaves and weeds
- Tree trunks
- Logs
- Branches
- Plastic bags, civilization trash

#### 9.12.10.1. Technical Main Data

| | |
|---|---|
| Cleaning width of rake | 2.5m |
| Net cleaning (lifting) force | 25kN |
| Lifting speed | 0 – 12 m/min. |
| Lowering speed | 0 – 18 m/min. |
| Travel speed | 0 – 25 m/min. |
| Wheel base | 3.2000 mm |
| Maximum turning range | 270 |
| Turning speed | 0 – 1.2 rpm |
| Installed power | 22 kW |

#### 9.12.10.2. Description of the Machine

The machine is mounted into a mobile support carriage. On this support, next to the TRCM, the hydraulic unit, the control cabinet and an operator's cabin are mounted.

The TRCM-H500 consists of the following main components:

- Upper carriage with turn-able platform carrying the electric cabinet and the hydraulic unit
- Operator's cabin with chair and control system
- Undercarriage including electric motor driven drive wheels
- Main arm with cylinder and stop log lifting device

- Telescopic bend arm with cylinder
- Rake with inter-grated hydraulic-operated counter gripper

#### 9.12.10.3. Rail Tracks

Rail tracks to be installed on top of the intake structure forming the required carriageway for the TRCM-H500 to travel back and forth. Rail track consisting of I-shaped HEM beam and a rectangular steed bars welded on top. The TRCM-H500 is running on the rectangular steel bar and counter rollers are running under the upper flange of the I-beam.Including required clumps and high tensile screws for fixing the I-beams to the civil structure.A total length of 40 m rail tracks is considered.

### 9.12.11. One Set of Stoplogs for the Turbine Intake

**Design Characteristics**

- Temperature range (outdoor) — 10 ~ 45 °C
- Max, humidity — 85%
- Seismic condition — 0.1g (Static)

**Basic Characteristics**

- Type of stop log — Sliding
- Number of complete stop log sets — 1
- Number of stop log elements for intake headwater — 5or 6
- Number of intakes — 4
- Number of embedded parts — 4 sets
- Retaining Level — 222.24 ma.s.l.
- Clear width — 4.86 m
- Height of each stop log element — approx. 2.0 m
- Maximum deflection — 1/750
- Location of seal and facing plate — upstream
- Regular operational condition — balanced water pressure

Simple and, robust design, easy in handling and operationally safe.

The stop log is designed to open and close under normal operational condition.

Emergency closure under flow condition is NOT possible.

Welded design of carbon steed structural parts of a minimum thickness of 10 mm with corrosion protecting coating (primer and finish).

All welds are continuous welds and watertight.

All elements are equipped with one bottom seal and two side seals of EPDM (65 Shore), easily accessible and replaceable.

Including embedded parts, such as bottom seal contact surfaces and seal sliding surfaces as well as steel anchor plates (to be laid in first stage concrete).

The side recesses from bottom to the height of the stop logs set are equipped with sealing surface and guiding. From there to the operating level the stop logs are guided by guiding rails.

The minimum thickness for embedded steel parts is 10 mm.

Including one lifting beam to be operated through the TRCM-H500. Equipped with an automatic device actuated by a counterweight placed close to the center of the beam, for coupling and uncoupling the hooks in or out of the water.

### 9.12.12. Set of Stoplog for the Turbine Outlet

**Design Characteristics**

- Temperature range (outdoor) — 0- 10 ~ oC
- Max. humidity — 85%
- Seismic condition — 0.1g (Static)

**Basic Characteristics**

- Type of stop log — sliding
- Number of complete stop log sets — 1
- Number of stop log elements for turbine outlet — 2 or 3
- Number of turbine outlets — 4
- Number of embedded parts — 4 sets
- Retaining level — 215.50 m asl
- Operation (deck) level — 215.50 m asl
- Clear width — 4.86 m
- Height of each stop log element — approx. 2.4 m
- Maximum deflection — 1/750
- Location of seal and facing plate — upstream
- Regular operational condition — balanced water pressure

Simple and, robust design, easy in handling and operationally safe.

The stop log are designed to open and close under normal operational condition.

Emergency closure under flow condition is NOT possible.

Welded design of carbon steel structural parts of a minimum thickness of 10 mm with corrosion protecting coating (primer and finish).

All welds are continuous welds and watertight.

All elements are equipped with one bottom seal and two side seals of EPDM (65 Shore), easily accessible and replaceable.

Including embedded parts, such as bottom seal contact surfaces and seal sliding surfaces as well as steel anchor plates (to be laid in first stage concrete).

The side recesses from bottom to the height of the stop set are equipped with sealing surfaces and guiding. From there to the operating level the stop logs are guided by guiding rails.

The minimum thickness for embedded steel parts is 10 mm.

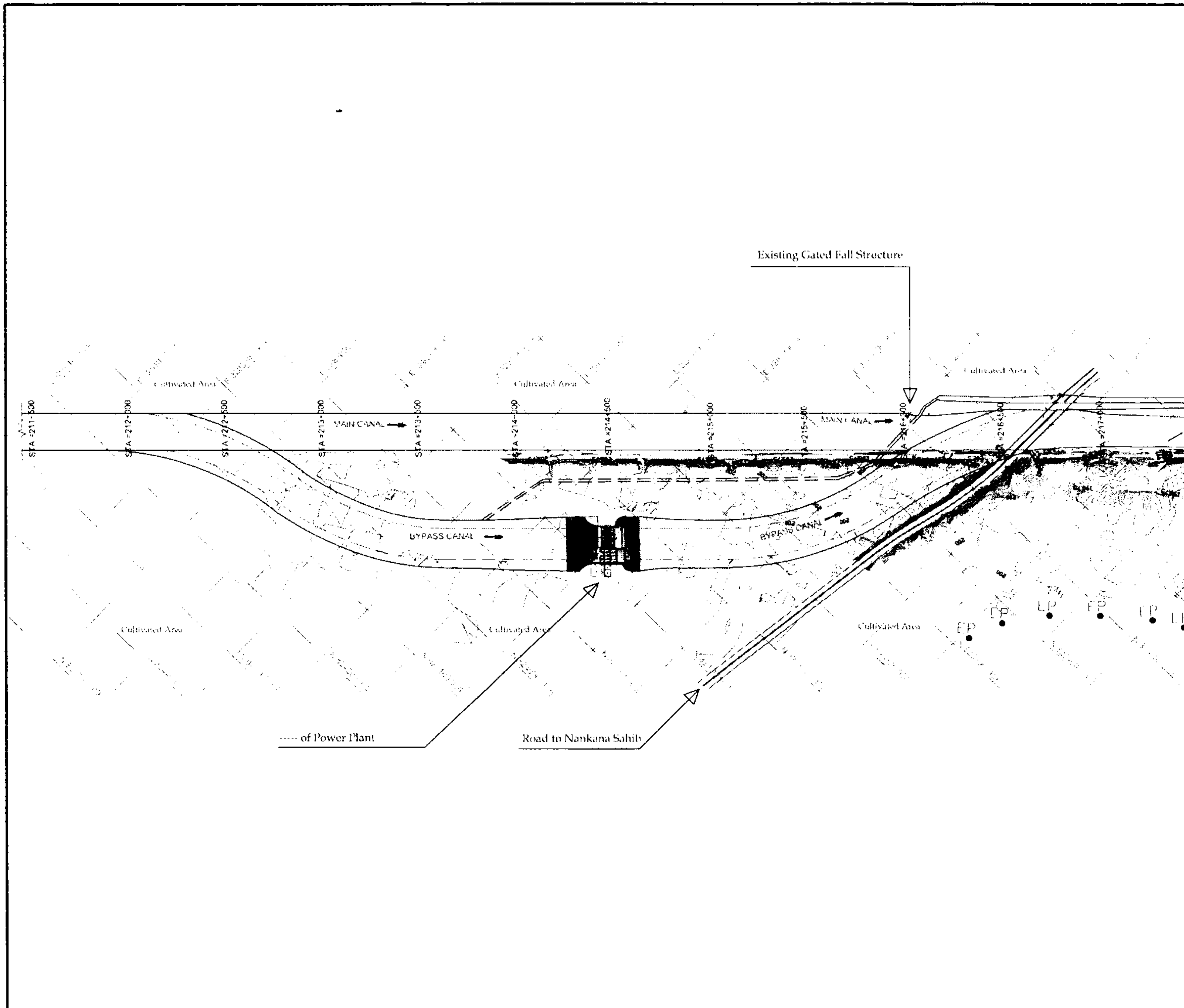
Including one lifting beam to be operated by mobile crane. Equipped with an automatic device actuated by a counterweight placed close to the center of the beam, for coupling and uncoupling the hooks in or out of the water.

### 9.12.13. Power Plant Control System

The power plant control system is located in one cubicle, LUC20. This cubicle shall have one touch panel, the selection of pictures of each individual unit as well as the main control scheme.

It shall include the following equipment:

- Joint control of the units
- I/O for the main equipment
- I/O for the 11 kV Switchgear
- I/O for the station auxiliary system and diesel generator
- Water level Measurement




LEGEND

BUILDING
BOUNDARY
BENCH MARK B-M 1
ELECTRIC POLE
POND
FENCE
ROAD
TRACK
KM STONE
HAND PUMP
TREE
TREE PALM
NALA
SOLLING
WATER COURSE
SIGN BOARD
TS
MOSQUE
TUBE WELL TW
GATE
CANAL
WALL

**NOTES:**

SCALE

**CLIENT:- M/s Gugera Hydro Power Co. (Pvt) Ltd.**

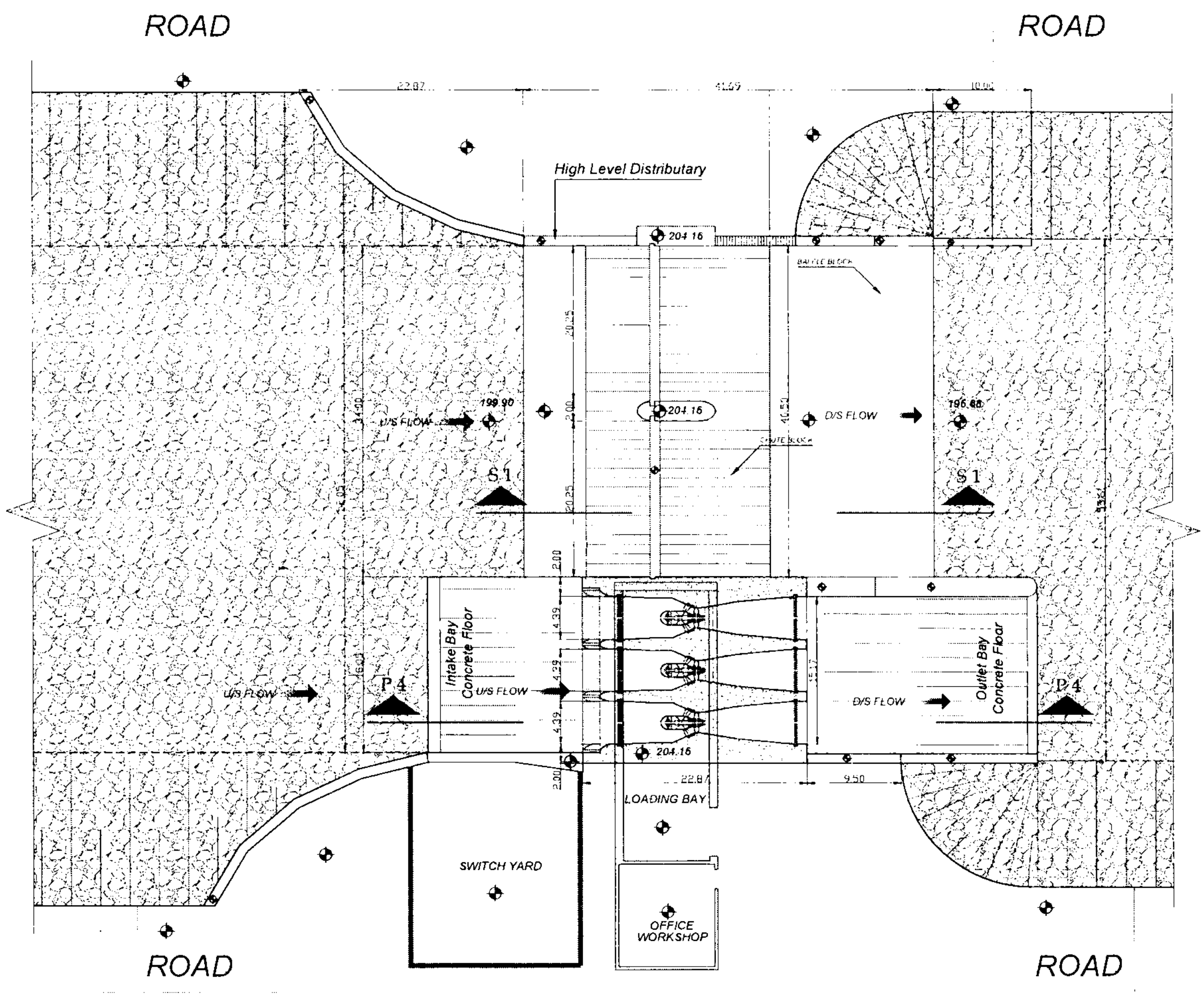
Technical, Engineering And Management (TEAM) Consultants, Lahore Pakistan.

**UPPER GUGERA BRANCH**

**FEASIBILITY STUDY REPORT**

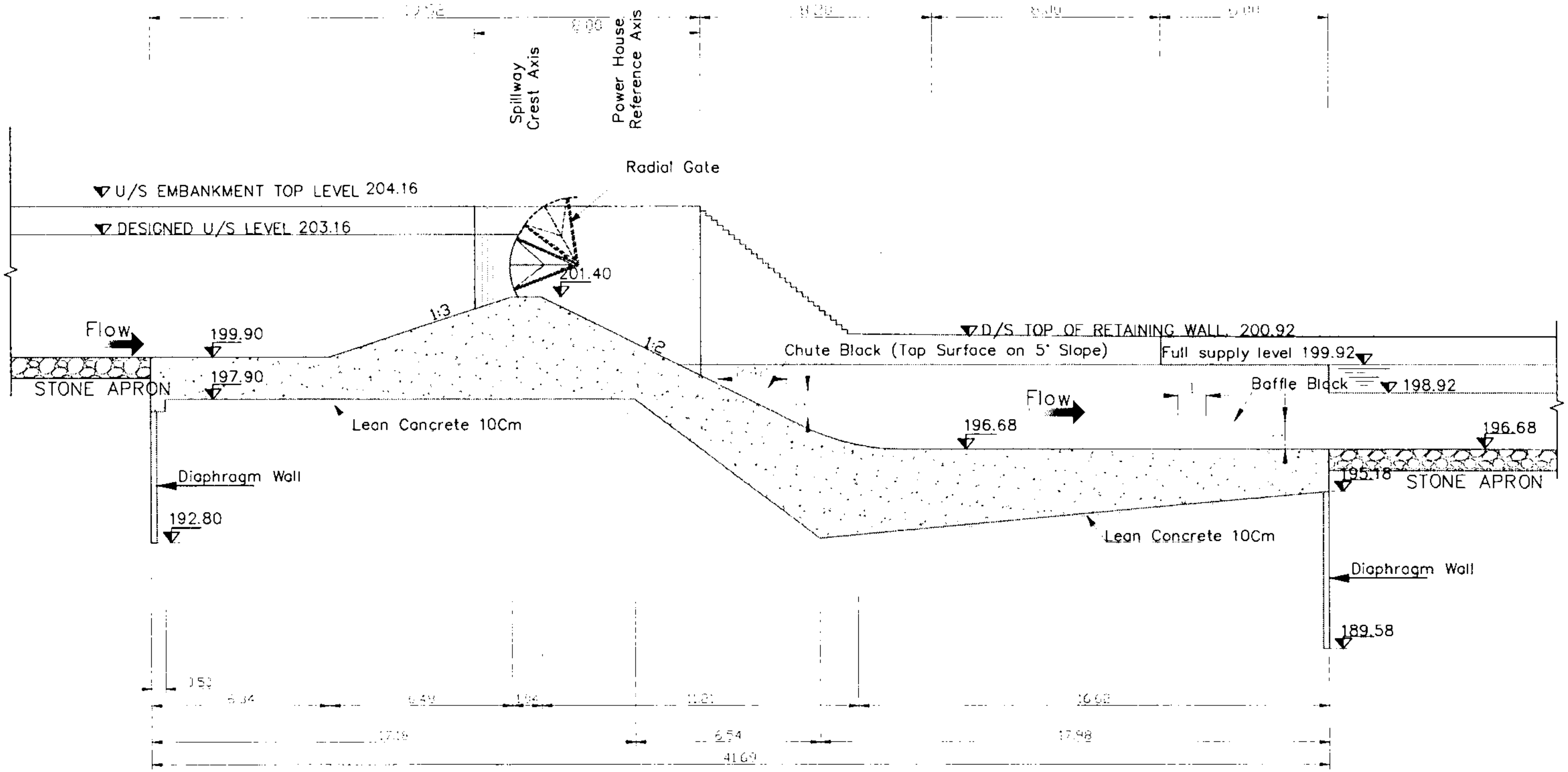
ALTERNATIVE-2
POWERHOUSE AND SPILLWAY
IN BYPASS CANAL

DATED: March 2014




**NOTES:**
All dimensions are in Meters.

| | | |
|---|---|---|
| **CLIENT:- M/s Gugera Hydro Power Co. (Pvt) Ltd.** | | |
| team | Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan. | |
| **UPPER GUGERA BRANCH** | | |
| **FEASIBILITY STUDY REPORT** | | |
| Design by / Checked by / Approved by | **POWER HOUSE AND SPILLWAY PLAN** | |
| DATED March 2014 | SCALE 1:400 | DRAWING No. 9-2 |




Note:-
1. All levels and dimensions are in meters. (masl)
2. Survey Generated by MIA Associates, Lahore.

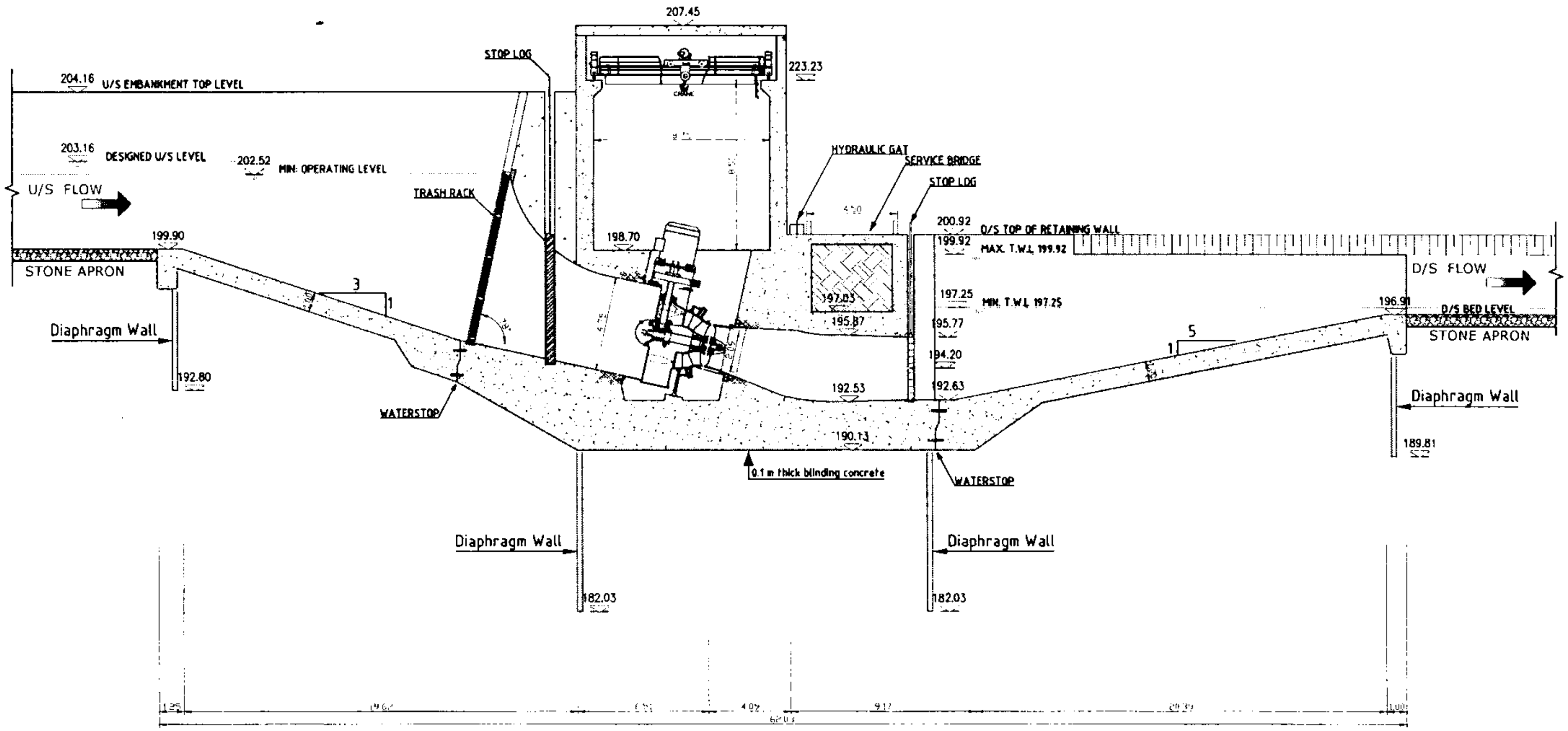
**CLIENT:- PUNJAB HYDROPOWER CO. PRIVATE LIMITED.**

team consultants — Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

**UPPER GOGERA BRANCH**

**FEASIBILITY STUDY REPORT**

| Design by | SPILWAY LONGITUDINAL SECTION S1 - S1 | |
|---|---|---|
| Checked by | | |
| Approved by | | |
| DATED Sept. 2012 | SCALE 1 : 150 | DRAWING No 9-3 |




Note:-
1. All levels and dimensions are in meters. (masl)
2. Survey Generated by MIA Associates, Lahore.

**CLIENT:- PUNJAB HYDROPOWER CO. PRIVATE LIMITED.**

team consultants — Technical, Engineering And Management (TEAM) Consultants, Lahore, Pakistan.

**UPPER GOGERA BRANCH**

**FEASIBILITY STUDY REPORT**

| | |
|---|---|
| Design by | **POWERHOUSE LONGITUDINAL SECTION P 4 - P 4** |
| Checked by | |
| Approved by | |

| DATED | SCALE | DRAWING No |
|---|---|---|
| Sept. 2012 | 1 : 225 | 9-4 |

# SECTION 10

# INITIAL ENVIRONMENTAL EXAMINATION

# SECTION 10

# INITIAL ENVIRONMENTAL EXAMINATION

## 10.1. General

The Gugera Hydro Electric Power Project falls under Category B as per schedules of Pakistan Environmental Assessment Regulations in terms of its anticipated potential impacts. The proponents of the projects that have more adverse environmental impacts are required to submit a complete Environmental Impact Assessment (EIA). Therefore, detailed Environmental Impact Assessment (EIA) is not required for this project and only Initial Environmental Examination (IEE) is required. So IEE has been carried out to fulfil the requirements of the Government of Punjab/Pakistan. Rapid Environmental Assessment Guidelines of the ADB (May 2003) have been used to assist in systematic consideration of all potential impacts.

## 10.2. Project Description

The project is located near RD 214+500 of the Upper Gugera Branch Canal. The Lower Chenab Canal off-takes from Khanki Headwork travel up to RD 140+050 where it bifurcate in to Upper Gugera Branch and Main Line Lower.

Placing of the powerhouse on left side of the Upper Gugera Canal has restriction due to High Level Canal run parallel to Upper Gugera Canal and there is space limitation. On right side of the canal, there is no restriction of space. The canal bank roads are running along right and left banks. Land is under cultivation on right side of the canal between project area.

There are no households exists therefore any settlements will not be affected by the construction of Gugera Canal Hydro Electric Power Project. The land required for powerhouse construction in bypass canal belongs to Punjab Irrigation Department and some land is presently under cultivation and plantation belongs to private land owners. However, this land would be acquired permanently. Consequently, the direct social and land acquisition impacts are small. However, there will be induced social impacts on the people living close to the project areas.

The construction camps for the project would be located on the space available near RD 214+500 of Upper Gugera Canal. The headrace of the project starts at RD 212+000 and powerhouse proposed at RD 214+500. Water after passing through the turbines and bottom outlets falls in the tailrace canal and then to the existing Upper Gugera Canal after lowering of its bed. The main civil structures of the proposed project are as under.

- Headrace
- Power house and spillway
- Tailrace
- O&M Staff Colony

- Contractor Colony and Camps
- Switchyard
- Access Roads

## 10.3. Project Construction Activities

### 10.3.1. Life Cycle Overview

The Gugera Canal Hydro Electric Power Project is a base load plant and will contribute during peak hours also. It will generate electricity throughout the year except during closure period when canal is closed for annual repair and maintenance. The ultimate capacity of the project is 3.6 MW. The construction period of the project is anticipated as 3 years. The design and some preliminary works on infrastructure facilities will be carried out independent of installation of main power plant. The following sections identify the key activities to be completed and facilities to be constructed and operated over the lifetime of this project.

### 10.3.2. Construction Methodology

The construction is planned with the assumption that project will be awarded to a qualified constructor on EPC/Turnkey basis having similar experience in the construction of large hydraulic structures and hydropower schemes and with the experience in the design, manufacture or procurement, transportation, erection, testing and commissioning of hydropower generating equipment.

For all works, conventional construction methods are expected to be applied. Excavations require conventional earth moving equipment only. For concrete works common batching plants, trans-mixtures, pumps, vibrators etc available in local market will be used. Initial activities will include set-up of camps and housing facilities. The majority of the work force will be local, with site laborers and semi-skilled labor available from the project area and skilled labor also coming from the region as well as from other parts of Pakistan. Foreign labor and experts will be employed only for special tasks, especially those associated with installation and testing of major equipment.

### 10.3.3. Land Acquisition

With the help of Power Department of Punjab, the Client will acquire land both on permanent and temporary basis. Permanent land is required for placing the project structures, colony for operation and maintenance staff of the Client and deposition of excavated material from canal bed. Some land will be acquired temporarily on rental basis for some temporary facilities such as stores, workshops etc. The land acquired temporarily will be levelled and topped with fertile soil as per the requirements. The estimated land required will be about 30 Acres.

### 10.3.4. Construction Materials Procurement, Storage and Transportation

Arrangements for procurement / supply of construction materials, their transportation and storage is the responsibility of the EPC contractor engaged for construction. The contractor will make the arrangements for storage of construction materials. The requirement of aggregate (fines, coarse, boulder) for construction of various project structures will be estimated and procured from suitable quarry within or nearest to the project area.

Placement of powerhouse and Spillway is of small quantity therefore single concrete batching plant will be used. Excavated material will also be used as construction material where filling is required.

### 10.3.5. Power Requirements

Power is required for operation of construction equipment, lighting of work areas, colonies, labour camps, de-watering and water supply, etc.

Electric power may be made available from national transmission and grid system or local distribution system. However, considering importance of dewatering and its consequences installation and operation of Diesel Generating (DG) power sets of required capacity is also considered and has to be provided as stand by or alternate arrangement. The strategic positions for operation of DG sets are proposed to be near the Powerhouse structure depending upon the location of ongoing activities.

### 10.3.6. Transportation

Construction materials from quarry sites will be transported to project site by road. Cement and reinforcement would be transported by trucks from factories directly. Power plant equipment and construction equipment will also be transported to site by railway or heavy low bed trailers.

### 10.3.7. Water Requirements

Water is required to meet the potable demands as well as the requirements of project construction activities like concrete preparation and wet drilling during excavation for powerhouse etc. Water can be lifted from the Upper Gugera Branch Canal through pumps. In this case water treatment plant will be necessary to maintain water supply of the standards of World Health Organization (WHO). Ground water is also of good quality and can be used for drinking, construction and operation requirement of the plant. For this purposes a tube wells of required capacity would be installed. Water available from dewatering wells can also be used to fulfil the requirements.

## 10.4. Approach and Methodology

### 10.4.1. Project Screening

A Rapid Environmental Assessment checklist (issued by the ADB in 2003) relating to Hydropower projects containing a list of potential physical, human and biological issues was used for screening of likely environmental and social issues.

### 10.4.2. Baseline Data

Baseline data was collected from offices of Agriculture, Revenue Officer, Forest Department and Wildlife Department of Sheikhupura and Lahore. Technical data presented in different Sections of this report were also consulted and collected. The details of geology, climate, temperatures, water availability and water quality have already been discussed in other Sections of this Feasibility Study Report.

### 10.4.3. Environmental and Social Examination Survey

Scoping sessions for initial environmental and social impact examination (ESIE) were conducted in the project area. Physical features of the project area were thoroughly observed and whole upstream and downstream area was inspected to ascertain the likely physical and biological impacts. It was observed that there is no population exists near headrace channel and power house areas and Tailrace. The survey data collected was interpreted and evaluated by the consultant. On completion of screening, scoping, field survey and baseline data collection, environmental examinations were made and mitigation measures have been recommended for impacts so identified.

## 10.5. Baseline Conditions of the Project Area

### 10.5.1. Physical Resources

#### 10.5.1.1. Topography, Geography, Geology, and Soils

Nankana Sahib is a district in the Punjab province of Pakistan. The district of Nankana Sahib is located about 75 kilometres west of Lahore and about 55 kilometres east of Faisalabad.

The topography of the area is predominantly flat with slope towards the south. The elevation of the project area is around 200 m.a.s.l. For details about geology and soil please refer Section: 7 Geology, Geo-technical and Construction Material of this report.

#### 10.5.1.2. Climate and Hydrology

This district has moderate climate, which is hot in summer and cold in winter. Summer starts from April and continues until September. During peak summer the day temperature rises to 45 °C, but the winter months are very pleasant and the minimum temperature may fall up to 2 °C. The average rain fall in the district is about 50 mm. For details refer Section 6 Hydrology and Sediment of this report.

#### 10.5.1.3. Groundwater and Water Supply

Upper Gugera Canal off take from Lower Chenab Canal and LCC off takes from Khanki Head works located on the River Chenab in District Jhelum, there is a network of distributaries of canals in the district.

Around 60% of the housing units are using municipal water supplies. Majority of the households have the facility of pumping water in their own houses. 30% of households are using hand pumps for potable water. Just 2% households are using potable water taken out of wells.

#### 10.5.1.4. Surface water

Nankana district is bounded by River Chenab on the north-west and River Ravi on the south east. The east and west ends of the district comprise the flood plains of River Chenab and River Ravi, characterized by breaching of looping river channels winding around intricate bars.

#### 10.5.1.5. Air Quality

Air quality in the project area appears good based on observation during the study period. Domestic sources of air pollution, such as emissions from wood and kerosene burning stoves as well as small diesel standby generators in some households, are well dissipated. There are no other industrial pollution sources are present in the vicinity.

The other major source of air pollution is dust arising from traffic and other ground or soil disturbances. Near the access roads along banks of Upper Gugera Canal, when vehicles pass, dust levels increase. The track on canal bank is unpaved but dust levels are elevated when vehicles pass intermittently over these banks.

#### 10.5.1.6. Noise and Vibration

Noise from vehicles and other powered mechanical equipment is intermittent. There are no significant disturbances to the quiet rural setting. Flowing water in the canal especially over the fall structures is source of noise otherwise the area is generally quiet.

### 10.5.2. Ecological Resources

#### 10.5.2.1. Wildlife, Fisheries

Upper Gugera Canal irrigates the district of Sheikhupura and Nanakan sahib, . It was explained by Director, Fisheries Department, Government of Punjab that fish populations in the Chenab River have increasing trends. The main sources of fish in the canals off-taking from the Chenab River are the ponds created by barrages. Fish are entering into canal from Pond and travel down in the canal.

However, they cannot navigate the canal falls as they are too high and without any steps or fish ladders.

As the fish approach a fall, they cannot move further upstream and get trapped. There is therefore a congregation of the fish just below a fall, which is a preferred spot for the fishermen. Since the power project is also utilizing the canal fall, it will have an impact on the fishing. The exact behaviour of the fish after commissioning of the power house, under the modified flow conditions below the tailrace cannot be predicted. Fish and turtles which are forced to pass through the turbines are also almost certain to get killed. The floating dead bodies of these animals (or their parts), in the tail race discharge from the power house, could attract carnivorous birds, like kites, herons, egrets and crows.

It was learnt from the Fisheries Department, that like most other canals, the stretch of the Upper Gugera Canal falling in the Nankana Sahib District is auctioned by the Fisheries Department.

The lower value of the auction amount is due to frequent closures of the canal. This indicates a considerable amount of fishing in the canal. Common fish species of economic importance in the canal include Rohu, Mori, Thela, Singhari and Gulfam.

The economic impact on fishing by the project may have to be worked out with the Fisheries Department.

For saving fish of larger size and turtles from getting killed in the turbines, and to avoid damage to the turbine blades from floating debris like floating logs etc, it is recommended to install trash racks of suitable grid opening at the intakes.

Wolves and jackals are the only wild animals of any importance in the area. The wolves are found occasionally in the low land wastes of Sheikhupura but jackals are found everywhere.

### 10.5.2.2. Terrestrial Habitats, Forests and Protected Species

The project area has Vegetation Cover and Trees, which is sub tropical and semi-arid. It is dominated by rural suburbs and with various productive fields of monocultures that now dominate the agro-ecosystems present in the project area. Common floral species with rooted vegetation are also present near most of the water bodies of the area.

Vegetation of the district has been greatly modified by human intervention of the old open forests of small trees and shrubs. There remain only a few Rakhs or portions of forest which are kept as grazing ground for cattle etc. Among trees the most important are Kikars (Acacia arbica), Shisham or Tahli (Dalbergiasissoo), beri (Zizyphusjajaba), Toot (Morusmarlaccae). Sharin (AlbizziaLebbek), Dharek (Maliaazerdaracb), Phulahi (Acacia modesta) and Nim (Meliaindica), Piple (Ficusreligiosa) and Bogar (Ficusindiea) are planted for shade. The growth in Rakhs is comprised mainly of three species i.e.jand (Prospisspicigera), Karril (Capparisaphylla) and Van or Jal (Salvadoraobeoides), Occasionally Pelu (Acacia loucophhloca) and Farash (Tamarixariculata) are also found. Pilchhi (Tamarixgallio) is found on moist sandy soil along the rivers and is used for wicker work, basket making, etc.

#### 10.5.2.3. Protected areas / National sanctuaries

There are no other protected areas near the project site. However, in Pakistan there are several areas of land devoted to the preservation of biodiversity through the dedication of national parks and wildlife sanctuaries.

### 10.5.3. Economic Development Agriculture, Industries& Tourism

The total area of the district is 2720 square kilometres. The main crops grown in the district are rice, sugarcane, wheat and fodder, etc. The area is well known for producing citrus, guava.

#### 10.5.3.1. Horticulture

The district lies in belt having sub-tropical land of vegetation. A few nurseries have come up but they do not find any market within the district and mostly cater for the needs of Gujrat, Islamabad and Lahore cities.

#### 10.5.3.2. Tourism

In Sheikhupura District there are many places of interest to attract tourists and to promote tourism. There are some archaeological places of significance importance. A number of school students visiting for educational purposes while a reasonable number of tourists are visiting for study and pleasure. Some of them are well known picnic point for the nearby areas. The families are used to spending their weekend for enjoyment.

The other places of interest nearby are Sheikhupura Fort (Qila Sheikhupura), Tomb of Shah Jamal, Hiran Minar which is located about 3 km from Sheikhupura city. Tahir Bagh is in city Sheikhupura. Shrine of Syed Pir Bahar Shah, Syed Waras Ali Shah and Mian Sher Muhammad Sharaqpuri are located in Sheikhupura District. Some sacred places of non Muslims are also situated in this district such as Muqadssa-e-Mariam (Sacred Place for Christian Community)
An old temple (Gurudawara) is located here which is holly place for Sikh community.

#### 10.5.3.3. Transportation

The project site and area is located in the province of Punjab in District Nankana Sahib which is accessible by air, good roads and railway network. A number of airports are operating in Pakistan and receiving International and national flights. AllamaIqbal International Airport Lahore, International Airport Fasialabad, are the nearest airports to the project area and site.
The road distance from these airports are:

i. Lahore to Site via Lahore-Faisalabad dual carriageway = 70 km

ii. Faisalabad to Site via Lahore-Faisalabad dual carriageway = 67 km

Pakistan is also linked with International community via sea and at present three shipping ports are operating.Karachi port and Port Qasim are in or near the port city of Karachi and Port of Gawadar is in Province of Balochistan. These ports are linked with other parts of the country through good network of railway and roads. Karachi the port city is linked with Lahore, Sahiwal, Faisalabad, Gujrat, and Islamabad via Highways, National Highway and Motorway.

The nearest railway is Sheikhupura which lies on the Lahore-Faisalabad Railway line. The nearest railway stations where loading and unloading of heavy equipment is possible are Gujrat, Wazirabad, Sialkot Dryport, Sargodha and Lahore. These stations are along Main Railway track between Lahore and Sarghodha. Lahore is the terminal point on the main track of Lahore-Karachi section.

### 10.5.4. Social and Cultural Resources

#### 10.5.4.1. Population Communities and Employment

According to the 1998 census of Pakistan, the population of the district was 56,383 out of this population 35.45% are urban. Literacy rate of the district is 47.8%. Punjabi is the most spoken language. As emerged from the 1998 census the population of district is predominantly Muslims i.e. 97%. The next higher percentage is of Christians followed by Ahmadis and Scheduled Castes. The proportion of population of Muslims is equal in rural and urban areas. Major tribes/casts: Jat, Gujar, Rajput, Syed, Arain, Mughal. Sub Casts:Gondal, Warraich, Tarar, Ranjha, Cheema, Bajwa, Chattha, Khokhar, Sahi, Sandhu, Ghuman, Virk, Goraya, Bhatti, etc.

The main occupation of women in project rural areas including subproject area of house-keeping which includes attending to the cattle, extracting butter and Ghee from milk, weaving and sewing of family clothes. In addition they generally help their menfolk on farms with the lighter duties like transplanting of seedlings, threshing and winnowing of grains and sometimes they also help in harvesting. Majority of the women prefer independent life as housewives. In city women are housewives or work as professionals like doctors, nurses, teachers etc.

A vibrant population of half a million overseas Pakistani's represent Sheikupura all over the globe particularly in USA, France, Germany, Italy, Spain, Greece and Gulf States. Sheikhupura underwent unprecedented modernization from the year 2000 to 2010, which was, in turn, a result of outstanding business growth witnessed by the city during the decade. Plaza states rapidly emerged with superstores and multinationals owing to a heavy influx of money from other countries. Remittances sent by expatriates have been the lifeline of the city over the years and the city life still owes its prosperity and profundity to these remittances. As a natural result of prosperity, the city doubled its size within the same decade giving a supreme boost to real estate industry.

#### 10.5.4.2. Education and Literacy

The literacy ratio in the district was 47.8% in 1998. The literacy ratio for males is 53.28% against 33.33% for females. The ratio is much higher in urban when compared with rural areas both for male and female.

There are numerous educational institutions in the District imparting education from Mosque/primary school to graduate level which are both for girls and boys. Separate schools and colleges for girls are also available.

### 10.5.5. Health Facilities

There is a district headquarters hospital in Sheikhupura, besides one tehsil headquarters hospital. Over all in district Sheikhupura number of dispensaries, 10 rural health centre, 4 Basic Health Units, etc. are providing health services to the people of Sheikhupura. In the district health facilities forTB, HIV/AIDS are also available. For project and its surrounding villages, hospitals are available in Nankanasahib and Sheikhupura.

### 10.5.6. Culture Heritage Community Structure

There are no official protected heritage sites of historic or religious or archeological importance. The proportion of population of Muslims is equal in rural and urban areas. Major tribes/casts: Jat, Gujar, Rajput, Syed, Arain, Mughal. Sub Casts:Gondal, Warraich, Tarar, Ranjha, Cheema, Bajwa, Chattha, Khokhar, Sahi, Sandhu, Ghuman, Virk, Goraya, Bhatti, etc.

The refugees from India settled in this district also belong largely to these tribes and castes. There are village artisans including Christians, blacksmiths (Lohar), carpenters (Tarkhan), potters (Kumhar)barbers, weavers etc. These mueens are found in all villages and are generally paid in and at the time of each harvest.

The Jat and Gujjar are numerically the strongest tribes and also the most important.

### 10.5.7. Community Involvement

#### 10.5.7.1. Approach to Public Consultation

During feasibility study the objective of the survey was to consult and advise the communities within the project area about project activities and to learn about their concerns. This was undertaken as part of the IEE process during the site visit and social surveys.

The socio economic study showed that about 99% of the households with in the project area were aware of the project. The major sources of information were relatives and friends, while the most important source was surveyors and drillers, geologists and other employees. The public consultation process has commenced in the initial feasibility stages (prior to construction) in order to disclose the project information to the stakeholders and record feedback regarding the proposed project and preferences. Population likely to be impacted is negligible due to the environmentally friendly layout of the proposed hydropower project.

#### 10.5.7.2. Public Consultation Process

The project is located on land owned by Irrigation Department. So no direct affectee was interviewed however, the people inhabited in the nearby village and owners of the cultivated land along the canal site, staff maintaining canal and grazers were interviewed. It is noted that none of the interviewed persons registered any outright opposition to the subproject.

The environmental assessment process under the Pakistan Environmental Protection Act only requires the disclosure to the public after the statutory IEE/IEE has been accepted by the relevant EPA to be in strict adherence to the rules. In this IEE the necessary consultation process was performed as required by the Government.

#### 10.5.7.3. Results of Public Consultation

The consultations identified some potential environmental and social impacts and perceptions of the affected communities. The public consultation in July 2013 resulted in12 responses. The community supports the construction of the power project. Residents in the Chander Kot village, people gathered at site and inhabitants of nearby localities of the project site expect more stable power supply in the area, with lesser complaints of loadshedding, with the provision of power from Gugera Canal Hydro Electric Power Project. Poor people requested for unskilled and semi skilled jobs on priority basis with the contractors during implementation of the project. Land acquisition on permanent and temporarily basis may be involved while resettlement is not involved in this project.

On the basis of the consultations so far, it appears that the project will have no insurmountable environmental and social impacts but the Client will have to make sure that compensation amounts are assessed justifiably and that skilled and unskilled employment should be preferentially given to the affectees or locals of Chander Kot village.

## 10.6. Initial Environmental Examination

### 10.6.1. Environmental Impact Assessment

Under this section, the potential social and environmental impacts likely to occur due to development of Gugera Canal Hydro Electric Power Project are discussed. The project screening in respect of physical, human and biological issues was considered according to the ADB checklist.

### 10.6.2. Land Issues

#### 10.6.2.1. Land Area Under Project

Land area of about 30 Acres will be acquired for various project components.

#### 10.6.2.2. Section of Canal Road likely to be affected

About 1 km section of canal road near powerhouse will be affected due to tailrace canal during construction period. This section of road will be upgraded or an alternate route during construction period of the project should be constructed to allow smooth mobility of the occasional traffic.

#### 10.6.2.3. Power Channel

Gugera Canal Hydro Electric Power Project is located near RD 214+500 of Upper Gugera Brach Canal. The channel banks shall be raised through compacted fill. The excavated material obtained at the powerhouse site could be used in this filling as well as back filling around powerhouse. There will therefore be no significant impacts.

#### 10.6.2.4. Tailrace

The excavated material from tailrace channel will be placed in stock piles along both canal banks. May be more material would be placed along right bank of the canal as right of way of Upper Gugera Canal. The width of the canal is controlled by providing side protection with stones up to 50 m, further downstream, the canal would remain unlined as it is presently.

#### 10.6.2.5. Disposal of Excavated Materials

Excavated material from powerhouse pit and tailrace could be used in back filling of powerhouse, filling of headrace and tailrace banks, etc. The excessive material would be placed in properly designed stock piles and would be protected by tree plantation.

### 10.6.3. Water Issues

#### 10.6.3.1. Water Quantities

The maximum discharge at the Upper Gugera Canal is 122 $m^3/s$ at RD 220+750. There will be no reduction of flows downstream of the proposed powerhouse because powerhouse and spillway are both discharging in the same tailrace channel.

#### 10.6.3.2. Water Quality

The chemical analyses of water samples obtained from the Upper Gugera Canal were carried out at Building Standards Laboratory Lahore.

It was established that there will be no corrosion impact on the turbine impellers. The canal water is good for irrigation use. However, it will need treatment for drinking and other human needs.

### 10.6.4. Climate and Atmosphere

There will be no impact on climate and atmosphere of the area due to construction and operation of the hydropower project, being small in size and will not create any new water bodies.

### 10.6.5. Socio-Economic Impacts

#### 10.6.5.1. Socio-Economic and Induced Impacts due to Economic Spin-Off

As presented in the socio-economic section of this report there will be no impact on houses/settlements of the project area as no household is needed to be displaced. The major impacts of the project, because of land acquisition for the project, camps and work areas are small because construction camps will mainly be located on the common bank between existing and new canals. There will be no loss of private property or loss of any other assets including plantation, loss of livelihood and income directly linked to the above losses and other indirect losses may be insignificant.

In addition, people have showed their support for the construction of the project as the impact on irrigated land, houses and other resources is negligible.

#### 10.6.5.2. Land Required by the Project

The project may require 30 acers of land between RD 212+000 on permanent basis and few acres of land on temporary or rental basis for the placing of construction camps and roads during the construction period.

#### 10.6.5.3. Impacts on Land

The land that is being acquired for the project on permanent basis some of it is belongs to Irrigation Department, Government of Punjab which lies along canal under ROW. The land required on temporary basis would be returned to the owners after levelling and topping by fertile soil stocked separately before the start of bulk excavation.

#### 10.6.5.4. Impacts on Family Income

There will be no impact on family income due to the construction of project. Loss of income from the 15 acres land should be compensated by cash.

### 10.6.6. Economic and Development Benefits

#### 10.6.6.1. Macro-economic Impacts

The project will give rise to a number of economic benefits at both the macro-economic Level and the local level. The key macro-economic benefits that are expected from the project are listed below and discussed in the following subsections:

- Reduced electricity costs and rationing;
- Increase in investment and national income;
- Increase in export revenues;
- Implementation of rural electrification program; and
- Lower energy costs to the consumer.

#### 10.6.6.2. Reduced Costs of Power

Pakistan has the highest unit rate of per kilowatt-hour in the region, which has severely affected its industry and domestic consumers. Especially, the country's lower and middle class cannot afford the existing tariff rates. The high tariff has forced everyone to minimize the consumption of the energy. Sizable amount of the current generating capacity in Pakistan is provided by private power producers, which is being generated from expensive fossil fuels that have to be imported and need foreign exchange. Electricity generation from water is cheap and does not need any expensive imported fuels.

#### 10.6.6.3. Reduced Electricity Rationing and Associated Costs

At the macro-economic level, the major potential benefit is reduced electricity costs, decrease load shedding and improvement in industrial production. Electricity rationing causes a major direct loss to the economy in terms of lost sales, disruption costs and the value of un-served energy to commercial, industrial and domestic users.

#### 10.6.6.4. Increased Investment and National Income

Inadequate power supplies are a major constraint to domestic and foreign inward investment. It is apparent that economic growth has been severely hampered by inadequate and unreliable sources of power in country.

#### 10.6.6.5. Implementation of Rural Electrification Programs

Although major parts of the rural population currently has no access to electricity. These villages needed to be electrified as the government is striving for poverty alleviation. Village electrification will be the first step towards achieving this goal.

### 10.6.7. Local Economic Benefits

The local economic benefits resulting from the project include:

- Employment, and
- Impact on the local economy

#### 10.6.7.1 Employment

Majority of the population of the project area is engaged in agriculture and livestock activates. The majority of prospective employees will be in the unskilled and semi-skilled categories and the need for imported management staff is expected to be relatively low. A large proportion of the workforce will preferably be drawn from the immediate local area.

Training of staff during construction will substantially increase the expertise of the labour force within the area. On completion of the project, employees will be equipped with the knowledge and experience, which will assist them in obtaining further employment in the construction industry.

#### 10.6.7.2 Impact on the Local Economy

During the construction phase, the generation of local employment opportunities will act as a catalyst to stimulate the local economy. Increased incomes in the area will encourage the formation and growth of local businesses, which will result in new indirect employment opportunities. Both processes will alleviate pressure on land resources.

Similarly, the availability of cash from compensation payments will result in opportunities for investment. In combination with programs for assistance and advice, opportunities will arise both to improve agricultural productivity and to develop new businesses.

Studies of the local economy undertaken by the consultants pointed to the seasonal nature of financial problems experienced by a large proportion of the population and the inability of many families to cope with unexpected or unplanned costs. The potential for increasing savings and for investment "new" cash, as result of the project, will help to alleviate these problems. The availability and circulation of money will result in an enduring economic growth.

During the operation phase, the main economic benefits of the project will be those resulting from increase power availability locally. From discussions with local authorities and people in the project area, it is clear that there is considerable potential for development in the retail, construction and industrial sectors in the town. The lack of reliable and economic power supplies is considered a major constraint for development in entire project area.

### 10.6.8. Ecological Impacts

In the Project area, forests and terrestrial plants do not contain any forest trees and there are no protected areas or trees in the project vicinity. Small number of trees of mesquite are likely to be removed for the preparation of land for construction of small power house colony and related facilities. No fish found in the canal is recorded. Impact on ecology on the project area is very minor or of no significance. Some trees found on the bank of the canal upstream of the powerhouse location will have to be removed for raising the canal banks. Buffalos and goats from Chadar Kot village graze or browse these bushes. The growth of bushes and vegetation cover will increase on the canal banks. This will be a positive impact on the flora of the area.

#### 10.6.8.1 Wildlife Habitat

The project area is dominated by cultivated fields. There is a wildlife habitat in the vicinity of the project site, which may not have impacts at large, because a limited labour force would be mobilized due to small size of the project. Effect of noise created by construction machinery would be less than the already existing noise of flowing water over the canal falls.

#### 10.6.8.2 Fish Habitat

The variety of fish in the Upper Gugera Canal is an extension of their greater habitats in the Chenab River. This is probably also true for turtles, otters, eels and some other aquatic mammals, reptiles and other amphibians, about which no information is available.

Fish in the River Chenab enter the canal from its head-regulator and travel as far downstream. However, while coming upstream, they cannot navigate the canal falls as they are too high and without any steps or fish ladders. The falls, therefore define a boundary of their habitat (for upstream movement).

As Gugera Canal Hydro Electric Power Plant is located at RD 214+500 to replace the falls at RD 216+100 and 221+750, the navigation of fish from tailrace to upstream of powerhouse and back may not be possible. As no fish record is available, therefore a complete study should be conducted at detailed engineering design stage and if needed, fish ladder of appropriate size may be provided.

#### 10.6.8.3 Bird Communities

The major impact has already occurred due to construction of the barrage and and fall structures and there will be no significant impact on wild life and bird population.

### 10.6.9 Impacts during Construction and Operation

#### 10.6.9.1. Construction Camps and Work Areas

The powerhouse and areas in proximity of site has ample space at canal banks to accommodate labour camps, residential camps for the contractor's supervisory staff and residential camps for Client and Consultants staff. Local population is using water for domestic use from piped water supply and agriculture use from the nearby canals. In winter, flow in these canals will be low and sometimes not available due to canal closure. Sufficient water for use in the camps will not be available without affecting the riparian use by the local inhabitants. The contractor may be required to get the raw water from canal and treat it for human consumption or install new tube wells for this purpose.

At the peak construction period i.e. May to October, personnel consisting of labour, contractor's supervisory staff, Client Staff and Consultant staff will be required at site. Social conflicts may arise among themselves. A residential colony and camp for senior staff could be constructed separately on right bank. This camp could be used primarily for powerhouse construction and may be utilized by contractor for senior supervisory staff residences as well.

#### 10.6.9.2. Construction Plant and Equipment

A reasonable number of equipment and plant will be required for construction of the powerhouse and tailrace. The number and type of equipment required will largely depend on the construction methodology for each component of work. However, a reasonable number of equipment in shape of dozers, scrapers, cranes and transport vehicles will be required. Careful planning would be needed to develop work area, parking places for the equipment near the powerhouse. Availability of space is not an issue because project is not located in mountainous regions.

#### 10.6.9.3. Storage of Construction Materials

Sufficient land is available at the powerhouse site. Storage for cement, aggregate, fuel and other materials required for construction needs to be developed at the site. Improper storage of materials may cause pollution and hazardous materials may adversely affect the health of workers. The likely impact of some materials is given hereunder:

- Handling for loading and unloading of cement may generate particular pollution. Storage should be in bins or protected sheds and in properly stacked manner. Breaking of cement bags and scattering of cement must be avoided.
- Fuel storage tanks shall be leak proof to avoid soil pollution. Handling of fuel should avoid surface contamination. All carbon-based fuels are carcinogenic. The surface spill over of fuel not only spoils soil but is also carried away with surface water flows. Thus, it may cause damage to existing flora and fauna. Excess spill may cause air pollution and adversely affect the health of site workers.
- Many toxic and hazardous materials are used during construction. These hazardous materials include oils, fuel, paints, gases, cut pieces of plastic cable sheathings etc. Separate stores should be built for toxic materials and their handling, storing and transportation. Strict regulations should be followed and utmost care be exercised in handling of such materials.

#### 10.6.9.4. Communication and Transportation

Existing national highway Fasialabd-Nankana sahib passes through Upper Gugera canal at RD 216+300 and Fasialabd-Nankanasahib linked with motorway at Sheikhupura. In this route, carriage of heavy machinery is possible. The canal road from bridge at RD 261+300 upto the powerhouse site at RD 214+500 has a canal bank road which is a narrow carriage way at present. This stretch has to be upgraded and widened to take the traffic load of construction works. There are few trees along the road upto the proposed powerhouse site. The alignment for upgrading this road should be such as to avoid the cutting of these trees or if it is essential, then compensation to the owners and re-plantation of the trees on other places must be ensured.

#### 10.6.9.5. Use of Hazardous Material

Some of the materials used in construction are toxic and hazardous in nature. Hydrocarbon compounds are toxic to various degrees. All the carbon-based compounds containing chlorine are highly toxic and carcinogenic. Common toxic materials used in the construction are fuels, lubricants, transformer oil, paints and varnishes, chlorine, acids and nitrogen gas etc. The use of toxic materials without necessary safeguards may cause acute and long lasting effects on the workers' health.

#### 10.6.9.6. Water Supply for Construction Camps

Construction camps are proposed on the right bank of Upper Gugera Canal near RD 216+000. Moreover, local people use hand pumps/piped water for domestic use and canal water for agricultural purposes. Use of canal water in camps may create water disputes with the locals. Better option to get raw water by installation of their own tube wells. In no case untreated water, either from streams or Upper Gugera Canal should not be allowed for any consumptive use to avoid spreading of water borne diseases.

#### 10.6.9.7. Solid Wastes

Dumping of solid wastes is a source of diseases, air and soil pollution and spoils the aesthetics of the area. Proper landfill sites should be made and solid wastes should be disposed into the landfill. The landfills should be covered with soil as per standard practice. Waste materials of different types are generated during construction. These materials include pieces of cable, empty containers of toxic materials and used oils and lubricants. All such toxic materials should be disposed of in sealed landfills.

#### 10.6.9.8. Air Quality

Existing air quality of Project area is pollution free. Construction of Upper Gugera Canal hydroelectric project will require a lot of machinery and equipment. These will use fuel and oils that will generate the following air pollutants.

- Particulate from running of construction plants and equipment.
- Particulate pollution from quarrying operations.
- Lead oxide and sulphur dioxide from vehicles.
- Carbon dioxide and nitrogen oxide from operation of equipment and vehicles.

All the above pollutants are injurious to health of the workers and the locals as well. This will be the only serious impact on the health of persons working near the plants and equipment. The plumes of air pollution will dilute by the time they reach the main population centres around the site.

### 10.6.9.9. Noise

Operation of equipment creates maximum noise on construction sites. Construction equipment such as dozers, scrapers, vehicles, aggregate separator plant and concrete mixer produce noise with influence up to 200 meters distance. Excessive noise level cause damage to eardrums, lungs and even affects the nervous system of the workers. The permissible noise level is 85 dß.

### 10.6.9.10. Sewage Effluent from Construction Camps

EPA Act 1997 requires that all the municipal and industrial wastes should be treated for surface discharge to any stream or open land to comply with EPA NEQS standards. The people at construction site where camp sites are proposed, to use canal or any surface flows for drinking and other consumptive use. It is most likely that the sewage effluent will be discharged in the adjoining canals. Even if sewage effluent from the camps is treated in compliance with NEQS standard, it will not remove the coliform and pathogenic bacteria. The use of such water by downstream riparians will transmit many diseases, which are endemic in the area. Therefore, consultant recommends disinfection of the treated sewage effluent before its surface discharge.

### 10.6.9.11. Construction Spoils

Construction spoils depend on the type and nature of the project and also on the construction methodology. Better construction techniques can reduce the production of construction spoils. In case of construction of powerhouse, major construction spoils are in the form of excavated materials, which are not utilized in the works. Another source of spoils is from work areas. Work area spoils may also be toxic and need proper landfill disposal. A small amount of spoil is expected in such cases. Unplanned disposal of surplus spoils may result in negative environmental impacts as stated below:

Sediments from the deposited spoils are likely to impair the water quality of the canal. This will affect the health of the people. The turbidity in the canal will increase during construction period with negative impacts on its flora and fauna.

- Spoils not properly placed affect the aesthetics of the land mass.
- Spoils containing toxic elements will come in contact with people. The health of the people will thus be affected.
- Flora and fauna in the land used for spoils is permanently lost.

In the light of above likely environmental impacts sites for disposal of spoils should be carefully selected to minimize the negative impacts.

#### 10.6.9.12. Insect Vector and Endemic Diseases

Depressions will likely to be formed during construction and they will at times detain surface flow resulting in formation of stagnant ponds. Numerous insects breed in these ponds, which act as vectors for many diseases. They also breed mosquitoes, which are endemic in the area. Development of ponds for prolonged periods should not be allowed on construction sites.

#### 10.6.9.13. Archaeological Sites

Preservation of archaeological and historical heritage is obligatory under the Pakistan Antiquities Act 1975. All the artefacts, monuments, petrography and building of historical importance come under archaeological heritage. Even old mosques, temples, churches and graveyards are covered under this Act. No item of archaeological or historical importance has been found near the powerhouse site or in the areas likely to be used for project works. Therefore, there will be no impact on historical heritage due to construction of the project.

#### 10.6.9.14. Impact on Flora and Fauna

Forest trees do not exist on project work site. Some trees on the banks of Upper Gugera Canal and mesquite bushes are likely to be removed for the preparation of the site for the construction of powerhouse and related facilities. No wild life habitat exists in the project area, so there will be no significant impacts on existing wild life however, it may have a minor impact on migratory birds.

#### 10.6.9.15. Social Conflicts during Construction

The construction camps and construction of operation and maintenance staff colony are proposed to be established near the project site on the right bank of the Upper Gugera Canal. A labour force is expected to come from Chander Kot and Nanakanasahib Town. The population of Chander Kot, the labour coming from other skilled labour will have mix ethnic combinations. Social conflicts may arise within the labour camp and also with the local residents. Appropriate public relations have to be maintained for social cohesion. Furthermore, maximum employment of local labour may have positive effects in resolution of such conflicts.

#### 10.6.9.16. Impacts During Operation Stage

On completion of construction works and during operation of the project some induced impacts are foreseen to emerge as follows.

Chander Kot road will be upgraded and proper access bridge should be provided. For operation of the project, Client will maintain sufficient staff at site. This will encourage commercial activities in the region. Local persons will also be employed for operation of the project. In the overall, the project will therefore have more positive impacts.

### 10.7. Environmental Impact Mitigation

### 10.7.1. Land Related Mitigation

Only 30 acers of land may be required on permanent basis. Some trees and mesquite shrubs on banks likely to be removed which will be compensated by replanting these trees on some other place or if these trees are on private land then it should be compensated to relevant party.

### 10.7.2. Water Related Mitigation

During construction period flows of the canal will not be affected because powerhouse and spillway will be constructed in bypass. The water use and water rights will be affected.

The mean monthly flows during June, July, August and September is 122 $m^3/s$. There is no change in flow pattern and decrease in flow quantity therefore there are no quality related impacts.

### 10.7.3. Air Quality and Noise Mitigation

Continuous sprinkling of water on road where construction equipment and vehicles are operating is necessary to minimize dust particulate pollution during construction. Mixing and concreting plants should be located away from the residential areas to avoid particulate and noise pollution.

Old plants and vehicles produce greater air pollutants and should not be used. Plants and vehicles used for construction should be in good condition. Vehicular emission standards of EPA, NEQS should be complied. Vehicles producing noise greater than permissible noise should be provided mufflers on exhaust systems.

Operators of equipment and vehicles generating noise greater than 85 dß should be provided with ear protection devices. No worker should be exposed to noise level of 85 dß or greater, even with ear protection, for more than 8 hours in a day.

### 10.7.4. Archaeological and Historical Sites Mitigation

No impact on archaeological and historical sites is expected. Hence, no mitigation measures are needed to be included.

### 10.7.5. Mitigation Measures Relating To Fish

The Contractors must be prohibited to use explosives, or electric current, to kill fish in the canal. His workers may also be prohibited to catch fish from the canal by netting or any other method, unless agreed with the Fisheries Department, or their local contractor.

## 10.8. Environmental Monitoring Plan

### 10.8.1. General

The purpose of preparation of Initial Environmental Examination (IEE) Report will not be useful unless the mitigation measures suggested in the Report to offset the adverse impacts are implemented. In most cases the mitigation measured required during construction are incorporated in the tender documents of the contract. The land acquisition and compensation issues will be taken up by the sponsor of the project.

Some negative impacts occur due to direct impact of the execution of the project such as the loss of agricultural land, loss of social cohesion, loss of utility services and loss of biological resources. If there is no monitoring of the environmental implementation plan there will be no mitigation of the negative impacts identified. Therefore, at this feasibility stage general objectives of monitoring plan and negative impacts identified are dealt with in this section.

### 10.8.2. General Objectives of EMP

The general objectives of Environmental Management Plan (EMP) are given hereunder:

- Identify and assess environmental status and trends on a continuous basis.
- Act as an early warning system to identify any sudden or unforeseen environmental deterioration.
- Provide effective environmental surveillance and provide information for continued environmental management.
- Identify effectiveness of the mitigation or benefit enhancement measures.
- Ascertain the nature and extent of impacts, which were uncertain at the time of IEE study and suggest suitable mitigation measures.
- Ensure compliance with the administrative and legal framework.
- Ensure fulfilment of the obligations required under National Environmental Protection Act 1997.

### 10.8.3. Institutional Set Up For Monitoring

A team of specialists should be deputed to carry out monitoring during construction and operation stages. The Client shall be responsible for deputing the team and its administrative control.

### 10.8.4. Monitoring Of Environmental Parameters during Construction

- Ensure that water supplied to residential camps and labour camps is properly treated and complies with WHO drinking water standards.
- Ensure that sewage effluents from the camps is treated and disposed off in compliance of NEQS.
- Ensure that solid wastes from camps are collected and disposed of in landfills.

- Ensure that fuel and lubricants are not spilled and that there is no leakage from the tank to the under soil.
- Ensure that proper care taken in transportation, handling and storage of toxic materials. Moreover, workers handling the toxic materials should be provided with protective devices.
- Empty drums of toxic materials and rejected pieces of cables etc. are disposed of in special landfills or transported outside project area for safe disposal. Empty drums of toxic materials should not in any case be allowed to be used for water storage.
- Ensure that flora and fauna are not destroyed by operation of the facility. In case damage is unavoidable, enlist the vegetation and wildlife damaged, and implement mitigation measures.
- Monitor that no plant or equipment is generating excessive pollutants or noise in excess of 85dB.
- Ensure that proper traffic management is enforced. Traffic should be controlled so that the local users do not suffer due to the heavy traffic movement of the construction works.
- Ensure that surplus excavated material is disposed of on approved disposal sites.

#### 10.8.5. Environmental Monitoring During Operation Stage

Prompt reporting system for all the environmental monitoring activities is required to alert the project executing agencies for timely remedial measures. The following reports are recommended.

- Monthly Monitoring Report
- Accident Report on the same day of occurrence.

## 10.9. Environmental Costs

### 10.9.1. Environmental Costs for Compensation

The environmental costs are minimum as the location of the project is along existing canal. The land that will be used for the powerhouse, headrace channel, spillway, tailrace channel, contractors camps, stores, operators colony, belong to the Irrigation Department. Therefore, nominal amount of Rs 60.00 million will be required for acquisition of 30 acres of land will be needed for construction of the project. This land is being used for agriculture at present by tenants.

However, during the construction of the project and construction of the existing road from RD 216+300 to powerhouse at RD 214+500 alternate route for use of local people will be constructed. The cost of realignment of road and relocation is the major environmental cost which is included in the project cost.

## 10.10. Conclusions

This study was carried out at the planning stage of the project. Primary and secondary data were used to assess the environmental impacts. The potential environmental impacts were assessed in a comprehensive manner. The report has provided a picture of all potential environmental impacts associated with the Project, and recommended suitable mitigation measures. This study recommends that some further follow up studies are undertaken during project processing in order to meet all the Government of Pakistan's requirements.

For saving fish of larger size and turtles from getting killed in the turbines, and to avoid damage to the turbine blades from floating debris like floating logs etc, it is recommended that the project may install trash racks of suitable grid opening at the powerhouse and bottom outlets intake.

There are some further considerations for the planning stages such as obtaining clearance for the project under the Pakistan Environmental Protection Act (1997) but environmental impacts from the construction of Upper Gugera Canal Hydro Electric Power Project will mostly take place during the construction and some during operation stage. There are also some noise impacts and waste management issues for the operational stage that must be addressed in the detailed design of the project.

There are a number of key actions required during the detailed design phase. Prior to construction of the project the Client must receive clearance certification from the EPD and must complete an EMP that will be accepted by the EPD and agreed by the contractor prior to signing the contract. The information provided in this report can form the basis of any further submission to EPD as required in future.

Baseline monitoring activities should be carried out during project detailed design stage to establish the baseline of parameters for checking during the construction stage. The monitoring schedule recommends monitoring on two occasions of the project. The results should be integrated with the contract documentation to establish performance action thresholds, pollution limits and contingency plans for the contractor's performance.

During the commissioning phase noise monitoring should ensure that statutory requirements have been achieved. Monitoring activities during project operation will focus on periodic recording of environmental performance and proposing remedial actions to address any unexpected impacts.

## SUMMARY AND CONCLUSIONS

Construction of Gugera Canal Hydro Electric Power Project is feasible with respect to environmental and socioeconomic point of view. Implementation of the EMP is required and the environmental impacts associated with the project need to be properly addressed during detail design and in the phase of construction.

# SECTION 11

# POWERS AND ENERGY POTENTIAL ESTIMATION

# SECTION 11

# POWERS AND ENERGY POTENTIAL ESTIMATION

## 11.1 Introduction

The only benefits a hydropower project gives are the electric power and energy. Therefore in this section a summary of the power and energy potential estimation for the Gugera Branch Canal Hydro Electric Power Project is presented. Power and energy calculations have been carried out according to the following formulae:

**POWER**

$P = Q \times H \times g \times \eta /1000$

Where

| | | |
|---|---|---|
| P | = | Power (MW) |
| Q | = | Discharge ($m^3/s$) |
| H | = | Available net head (m) |
| g | = | Acceleration due to gravity (9.81 m/sec$^2$) |
| $\eta$ | = | Efficiency coefficient (91.25%) of Turbine, gear, Generator and transformer system |

**ENERGY**

$E = P \times T$

Where

| | | |
|---|---|---|
| E | = | Energy (MWh) |
| P | = | Power (MW) |
| T | = | Time (h) |

## 11.2 Discharge

The available discharge data was processed in details in Section 5 Hydrology and Sediment. The flows availability were processed for the period of 2008 through 2013. It is concluded that the flows availability in Gugera Branch after its remodelling is the right option to use in power and energy estimation

The criterion adopted for the powers estimation is that the minimum discharge to be accepted by a turbine is 40% of its design discharge capacity and for a net of head of 2.8 m at full supply level on upstream and downstream side. Moreover, it is clarified that the design discharge of Upper Gugera Branch Canal is 160.67 cums (5675cs). By considering the present flows; discharge 142 cums has been selected for plant size. Overall Plant efficiency is 91.25% and Plant total output (gross) has been worked-out as 3.6MW.

### 11.3 Head

No data available for upstream water level and downstream of the both fall structures. It is therefore concluded that power and energy estimation would be performed for 2.8 m net head by considering 0.2 m head loss due to trash rack, slots for stop logs and intake transition. It is mentioned that this will be the minimum head and would increase when level on downstream of the fall would be available for all discharges.

### 11.4 Efficiencies

Power and energy estimation have been carried out keeping in view the overall constant efficiencies for turbines, gearing system, generators and transformers such as follows:

- Hydraulic Turbine = 95% } 93.57%
- Gearing system = 98.5% }
- Generators = 98.5%
- Unit Transformers = 99%
- Overall plant efficiency = 91.25%

### 11.5 Head Loss

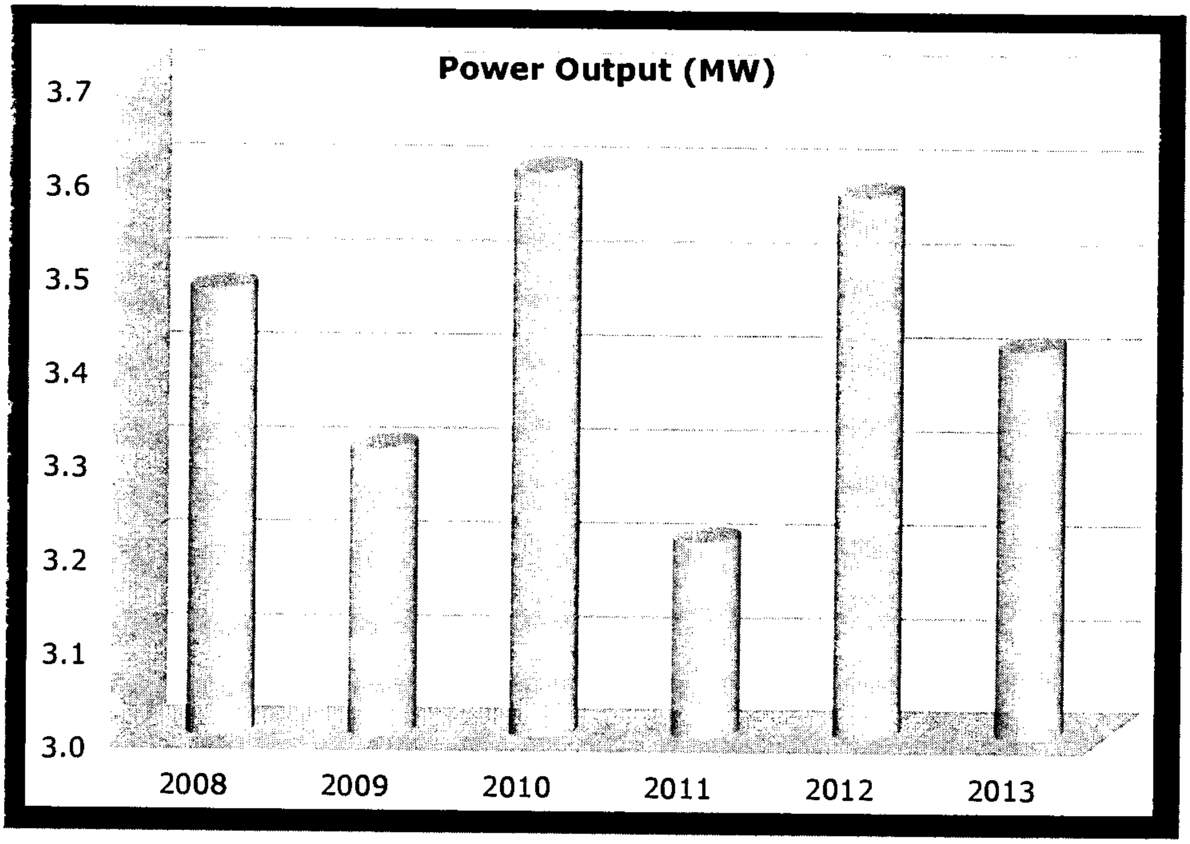
A constant head loss of 0.20 m has been taken for intake transition, stop logs slot, trash rack etc. However, head loss will be investigated during detailed engineering design when a turbine manufacturer has been selected.

### 11.6 Power and Energy Estimation

The power and energy calculations have been performed by using the daily data of discharge for the years 2008 to 2013 and constant net head of 2.8 m. The results are as follows:

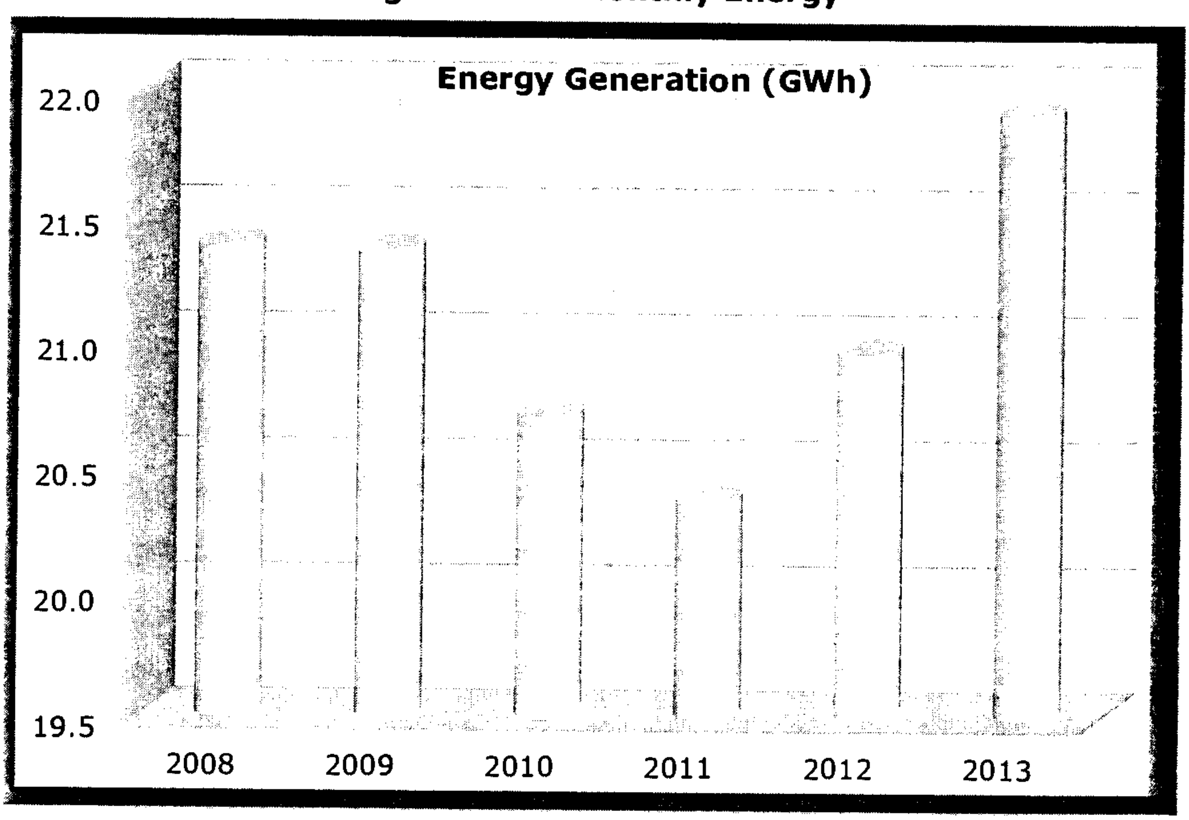
The daily power output (MW) is given in Annex: 11.1 while the maximum power output is graphically presented in Figure: 11.1.

**Figure 11.1: Monthly Maximum Power**




The daily energy (GWh) generation is given in Annex: 11.2 while the yearly energy generation is graphically presented in Figure: 11.2.

**Figure 11.2: Monthly Energy**



## 11.7 Conclusions

Keeping in view, all the above-mentioned facts and results presented in tables, figures and annexes, the following conclusions have been made:

- The average maximum power output during the year 2008-2013 is 3.6 MW.
- The average annual energy generation during the year 2008-2013 is 21.12 GWh.

# SECTION 12

# CONSTRUCTION, TECHNIQUE, PLANNING AND BUDGETING

# SECTION 12

## CONSTRUCTION, TECHNIQUE, PLANNING AND BUDGETING

### 12.1 Introduction

The feasibility level construction planning and budgeting required for implementation of Gugera Hydro Electric Power Project is described in this chapter. Based on the specified construction material and their quantities, type and kind of construction equipment involved, techniques of construction, sequence of construction, procurement and installation activities and their dependence on the flows in Upper Gugera Branch, a 36 month construction (24 months construction and 6 months design) period is anticipated. Assuming July, 2016 construction notice to proceed, the first unit could be on line by August, 2018 and all units on line by December, 2018.

An implementation schedule which includes pre-construction phase and construction phase is presented in **Figure: 12.1**, showing the duration and sequence between the critical tasks and major milestones of the project till commercial operation of the full hydropower project.

The schedule is prepared with the assumption that project will be awarded to a qualified constructor on EPC/Turnkey basis having similar experience in the construction of large hydraulic structures and hydropower powerhouses and with the experience in the design, manufacture or procurement, transportation, erection, testing and commissioning of hydropower generating equipment.

### 12.2 Pre-construction Phase

Pre-construction phase of the project according to time line of the latest Power Policy of the Government of the Punjab revised in 2009 depends upon the following main activities. For further details please refer to **Figure. 12.1**.

#### 12.2.1 Tariff Negotiations

After completion of feasibility study and approval by Punjab Power Development Board, the Sponsor will approach NTDC/CPPA for negotiation of tariff. Time given in the Power Generation Policy is 90 days. But examples show that it never achieved. At the mutually agreed tariff, NTDC will approach NEPRA for tariff determinations and will submit a proposed tariff schedule as a starting point for negotiation. The proposed tariff will be two part tariff, energy sale price and capacity purchase price. The tariff will be based on the total project cost, loan terms and reasonable rate of return on equity. Once the proposed levellized tariff will be determined by NEPRA, Punjab Power Development Board (PPDB) will issue Letter of Support for the project. On issuance of LOS, the Sponsor is required to furnish a bank guarantee as per the Power Policy of the Government of Punjab. NEPRA has a minimum time of 06 months for decision making. Experience indicates that about 06 month time might be necessary for this task. PPDB would issue LOS within 10 days subject that Sponsor submits the performance guarantee within 15 days.

### 12.2.2 Power Purchase Agreement

The power purchase agreement, implementation agreement and water use agreement as security documents will be prepared and signed after the client will get the LOS from PPDB. These documents will be based on model agreement provided for this purpose by PPDB.Parallel to the tariff negotiations, preparation of the PPA can be started. The PPA has to be negotiated between Power Purchaser and the sponsor after determination of tariff by NEPRA.

### 12.2.3 Water Use License (WUL) and Implementation Agreement (IA)

Parallel to the finalization of PPA, the sponsor will negotiate and sign the water use license and Implementation agreement with Irrigation Department of Punjab. Signing of Water Use Agreement with Irrigation Department is very critical activity and has lot of impact on water (fuel) availability, because a number of tributaries and minor are off-taking from Lower Chenab Canal before off-taking point of Upper Gugera Branch and also from Upper Gugera Branch before the proposed site for hydropower project under planning and design. PPDB has provided a time frame of 06 - 09 months for all such process, till Financial Close. It is not clear from Policy how the guarantee extended by GOP will be included in the security documents.

### 12.2.4 Appointment of Implementing Consultants

It is anticipated that appointment of the Implementation Consultant will be started after approval of the feasibility study and parallel to the above mentioned activities. The consultant will be responsible for preparation of tender level design and tender documents, bids evaluation, Award of contract, quality control during construction and contract administration. Hiring of consultants required 06 months under competitive bidding.

### 12.2.5 Appointment of Financial Advisor

For the arrangement of debt part of the financing, the Sponsor Company need appointment of financial advisor well before. Financial advisor will be responsible and assist the Sponsor Company for tariff negotiation and financial close. The minimum duration for financial closing after issuance of LOS is 09 months.

### 12.2.6 Appointment of Legal Consultants

The services of legal consultants are also foreseen to meet the requirement of security documents, being less technical and more legal. Before start of negotiation with respective departments/organizations of security document legal consultants must have been appointed.

### 12.2.7 Land Acquisition

In parallel with the approvals, land acquisition will be commenced and accomplished. The land to be acquired permanently for this project is for the purpose of head race channel, power house complex, tail race channel and the operator colony. Land acquisition is not critical activity to the time schedule and can be performed during the entire pre-construction phase however, if not properly supported by Punjab Government, it may become the bottleneck.

### 12.2.8 Consents

Soon after signing of security documents, the Sponsor Company approaches various department and agencies, including the State Bank of Pakistan, Ministry of Commerce, Ministry of Finance and the Securities and Exchange Commission, Electricity Inspector to obtain their consent and approval. This activity may take 09 months.

### 12.2.9 Initial Environmental Examination

Chapter 10 to this Feasibility Report constitutes the project Initial Environment Examination and is intend for use in meeting the GOP and EPA Punjab requirements in connection with environmental study clearances. Upon tariff determination IEE will be submitted for approval from EPA Punjab. The review and approval process is required 09 months but should be completed before financial close.

### 12.2.10 Tender Document and Tendering

In parallel and correspondence with above activities, the Implementation Consultants will prepare performance specifications and tender documents required for the project delivery contractor, bidding and selection. Filed survey, technical studies, and tender document preparation are the activity just after signing of concession agreement. The intent would be to have tender documents complete and ready for issuance once preliminary financial commitments are obtained and when LOS is issued. During this phase some detailed investigation in the field of geo-technical will be performed. The time requirements are as follows:

- Tender Design 5 months
- Approval by Client and PPDB 1 month
- Bidding Period 3 months
- Evaluation of Proposal 2 months
- Contract Award 2 months
- **Total** **13 months**

### 12.2.11 Award of ( EPC/T ) Contract

The FIDIC Contract conditions of "Engineering, Procurement and Construction" on Turnkey (EPC/T) is a worldwide preferred option for construction of Hydro Electric projects. Tariff adjustment by NEPRA is also based on EPC/T bids. The processing of bidding and selection of the project delivery contractor shall be concluded prior to Financial Close. The selection of the contractor can be on negotiated price or lowest bid price however, the selection must be transparent to satisfy PPDB and Power Purchaser requirement. It is important to mention that contractor qualification, specifications and contract documents must meet lender requirement. Mobilization of the contractor has been planned a critical task within 07 days after the Financial Close.

### 12.2.12 Financial Close

Upon signing of concession documents, the Sponsor would formally apply for loans to different financial institutions. During the period when security documents are being negotiated the Sponsor Company would be consulting with potential lenders to identify interested and eligible entities. The interested lenders would review the Project, carrying out their own due diligence and offer loan terms.

The agreed terms sheets for loans will be submitted to PPDB for approval at least one month advance of the schedule financial close. Upon signing of loan agreement and project delivery contract and after obtaining all consents, the documents will be submitted to PPDB for review and final approval. PPDB will take 45 days to review and confirm the achievement of financial close and will provide the Government guarantee as per the format in the Implementation Agreement. The minimum time from issuance of LOS to financial close is 9 months.

## 12.3 Construction and Procurement

### 12.3.1 Investigations & Detailed Design by Contractor

As the detailed engineering designs, drawings and related investigations is responsibility of EPC/T contractor under the FIDIC conditions about 3 months have been envisaged for critical tasks of additional investigations, working out the plant size and final layout for review and approval by the sponsor and PPDB. Side by side the contractor will move for and construction of civil works and procurement of turbines, Generators and other E & M equipment; the next critical task. Refer to the master program attached.

### 12.3.2 Construction Means and Methodology

For all works, conventional construction methods are expected to be applied. Excavations require conventional earth moving equipment only. For concrete works common batching plants, trans-mixtures, pumps, vibrators etc available in local market will be used. Initial activities will include set-up of camps and housing facilities. The majority of the work force will be local, with site laborers and semi-skilled labor available from the project area and skilled labor also coming from the region as well as from other parts of Pakistan. Foreign labor and experts will be employed for special tasks, especially that associated with installation and testing of major equipment.

### 12.3.3 Site Facilities

Temporary roads are required to the disposal area, as well as temporary and permanent camps. Aggregate processing and concrete batching facilities are to be erected and operated by the contractor. The contractor will be constructing camps, offices and other utilities with sufficient work area. At project completion, the roads to all permanent facilities and relocated public road if any will be upgraded and finished with proper drainage, paving and shoulders.

### 12.3.4 Power Canal

After mobilization of contractor at site and establishing of site camps and facilities, in parallel to excavation of powerhouse construction pit and headrace & tailrace and construction of banks would be undertaken.

The ground water in the headrace and tailrace area is about 8.5 m to 9.0 m below natural surface level. However, near the tailrace join the existing canal downstream of RD 220+750, the ground water is near the natural surface or above the natural surface. The excavation of canal can be done by using standard excavation equipment before excavation surface reach ground water level. The underwater excavation would be done by using dragline or backhoes. The excavated dry material would be placed in layers upon banks on both sides and compacted with slandered compaction equipment. The soil is composed of clay and silt sheep foot roller may also be employed for banks compaction.

The banks and bed of headrace would be protected with stone laid over geo-textile material having proper thickness and hardening against falling weight of stone. The size of stone used in protection would depend upon scour and bouncy forces. Banks of the tailrace would be protected with stone however, bed would be unlined. First 100 m length of tailrace bed would also be protected with stones.

### 12.3.5 Powerhouse

After enclosing the powerhouse construction pit by banks, the construction of powerhouse is a time dense activity program must be carried out to excavate, install dewatering system and treat the foundation. On completion of excavation and foundation treatment, the steel reinforced base concrete will be poured and subsequent concrete works will be completed leaving spaces for second stage concreting which will be placed during installation of embedded part for turbine / draft tubes/gates/stoplogs.

The super structure will be accordingly completed in accordance with the planned sequence. The draft tube liner would be available before start of concreting of draft tubes. However, turbine embedded part will be available for installation during the second stage concreting. The powerhouse substructure and superstructure does not require unusual construction techniques or methods for reinforced concrete construction.

The powerhouse roof will be constructed along with the installation of powerhouse crane system, which can be used for turbines, generators and installation of other E & M equipment. Backfilling around powerhouse will be done upon completion of up and downstream retaining walls.

All these activities related to powerhouse construction will require 24 months.

In equivalent with installation of the turbine and generator, the other electro-mechanical equipment and controls will be installed. Finally, testing and commissioning will be achieved in 4 months as indicated in the master program. The other architectural work, parking and security are completed parallel to testing and commissioning of the plants.

### 12.3.6 Supply of Turbine and Generator Equipment

The procurement, supply, scheduling and transport of the major equipment is the responsibility of the EPC contractor. Procurement of major equipment requires careful planning so that installation can be finished prior to desire commissioning date. The critical activities are the supply of turbines and generators.

The process of procuring and transportation of hydropower turbines and generators of this size takes about 19 months. However, about 12 to 14 months are required for erection/ installation of the above equipment including testing and commissioning. Keeping in view time constraint effort could be made to reduce the time required for procurement and transportation so that powerhouse could be put in to testing within 24 months.

### 12.3.7 Supply of Switch Gear Equipment

In parallel of supply of E&M equipment for powerhouse, transmission line and interconnection equipment will be procured. The installation and testing of transmission facility will require 6 months in addition to switchgear installation. However transmission line will be constructed by Power Purchaser

The installation of switchyard equipment is not a critical task. The size of equipment can easily be procured from the local market. Installation and testing should require not more than 3 months. The civil works for switchyard are small and contractor can handle these easily.

### 12.3.8 Supply of Spillway Motorized System

Manufacture and installation of motorized system may require about 8 months which needs to be started parallel with civil construction.

### 12.3.9 Erection, Testing and Commissioning

Erection, testing and commissioning includes final inspection of construction and equipment, testing of all equipment and facilities, operational tests of electro-mechanical equipment under different load conditions (both dry and wet condition) and safety tests. The activities require about 4 months after finalization of erection of the E&M equipment.

### 12.3.10 Conclusions

Based on the project scope, construction quantities, sequence of activities and their dependence on expected canal closure, the total construction period includes:

- Pre-construction phase: 18 months
- Design 06 months
- Construction phase: 24 months

Total construction time is 48 months. Critical paths are as under

**SEQUENCE OF CRITICAL PATH**

1. Preparation of feasibility study
2. Clearance of feasibility report by PPDB
3. Tariff determination by NEPRA
4. Tariff Approval by PPDB and LOS issuance
5. PPA, IA, WUL and Financial Close.
6. Award of EPC Contract and mobilization
7. Detail design for civil works, plant size and final layout and Construction of Colony and construction camps
8. Manufacturing and Transportation of E & M equipment
9. Construction Civil Works
10. Erection / installation of E & M equipment
11. Testing and Commissioning
12. Handing and Taking Over

Special consideration should be given to the critical tasks related to the canal closure and schedule transportation of the E & M equipment to the site.

## 12.4 Construction Sequence and Budgeting

In order to achieve the completion of construction in schedule time, requirement of budget is highly important. Further budgeting is also important in order to complete economical and financial analysis and found that the project is sound in financial terms.

Keeping in view construction activities and their sequence of execution and required skill and equipment during construction and completion of that activity, budget allocation was made for the procurement of material, labor, machinery, etc. Budget requirement would be made on 6 monthly basis and interest during construction would also be calculated in order to establish that the estimated cost would be returned through sale of energy. Therefore, budgeting is made and presented in **Table: 12-1**.

# GUGERA CANAL HYDRO ELECTRIC POWER PROJECT

## IMPLEMENTATION SCHEDULE

| ID | Description |
|---|---|
| A | Pre Construction [illegible] |
| A-1 | PPDB Issuance of LOI |
| A-2 | **Feasibility Study** |
| | Preparation |
| | Review and Clearance by POE |
| | Approved by PPDB |
| A-3 | **Tariff Determination and Approval** |
| | Tariff, Power Sales Terms & NEPRA Approval |
| | Approval of Tariff by PPDB |
| A-4 | **Appointment of Legal Advisor** |
| | Power Purchase Agreement |
| | implementation Agreement |
| | Water use Agreement |
| A-5 | NOC of EIA from Punjab EPA |
| A-6 | **Consultancy and Tendering** |
| | Appointment of Consultants |
| | Additional Investigation and Surveys |
| | Tender Design and Tender Documents |
| | Tendering and Receiving |
| | Tender Evaluation and Selection |
| | Negotiation and Awards |
| A-7 | **Appointment of Financial Advisor** |
| | Preliminary Financing Plan |
| | Detailed Financing Commitments |
| | Preliminary Financing Commitments |
| | Finalize Financing Documents |
| | Submit Loan Terms to PPDB |
| | PPDB Approval and GOP Guarantees |
| A-8 | Performance Guarantee |
| A-9 | Issuance of IOS by PPDB |
| A-10 | Land Acqusition |
| A-11 | Consents |
| B | Construction [illegible] |
| B-1 | **Notice to Proceed** |
| B-2 | **Design and Investigations** |
| | Site Investigation |
| | Design by EPC Contractor |
| | Mobilization, Site installation and Demobiliration |
| | Construction of O& M Housing Facility |
| | Construction of Access Roads |
| B-3 | **Construction of Diversion Canal** |
| | Excavation |
| | Diversion of Canal |
| B-4 | **Construction of Headrace** |
| | Filling of Embankments |
| | Filling of Canal Bed |
| | Stone Lining in Bed and Slopes |

## GUGERA CANAL HYDRO ELECTRIC POWER PROJECT

### IMPLEMENTATION SCHEDULE

| ID | Description |
|---|---|
| B-5 | **Powerhouse and Spillway/Bottom Oulets** |
| | Excavation |
| | Construction of Diaphargm Wall |
| | Installation of Dewatering System |
| | Running and Maintenance of Dewatering System |
| | 1st Stage Concrete |
| | 2nd Stage Concrete |
| | Installation of Embedded Parts of Turbo-generator Unit-1 |
| | Installation of Embedded Parts of Turbo-generator Unit-2 |
| | Installation of Embedded Parts of Turbo-generator Unit-3 |
| | Installation of Embedded Parts of Turbo-generator Unit-4 |
| | Installation of Embedded Parts of Cranes |
| | Installation of Embedded Parts of Bottom Outlets Gates |
| | Backfilling |
| B-6 | **Construction of Tailrace** |
| | Excavation of Tailrace |
| | Linning of Tailrace |
| B-7 | **Dismentalling of Concrete Fall Structure** |
| B-8 | **Protection of Bridges Foundations** |
| B-9 | **Plugging of Diversion Canal** |
| B-10 | **Filling and Rehabilitation of Diversion Canal Land** |
| B-11 | **Turbo-genetator Unit 1** |
| | Design and Fabrication |
| | Transportation |
| | Installation |
| | Wet testing and Commissioning |
| B-12 | **Turbo-genetator Unit 2** |
| | Design and Fabrication |
| | Transportation |
| | Installation |
| | Wet testing and Commissioning |
| B-13 | **Turbo-genetator Unit 3** |
| | Design and Fabrication |
| | Transportation |
| | Installation |
| | Wet testing and Commissioning |
| B-14 | **Turbo-genetator Unit 4** |
| | Design and Fabrication |
| | Transportation |
| | Installation |
| | Wet testing and Commissioning |
| B-15 | **Swicthyard and Transmission Line** |
| B-16 | **Start of Commercial Operation** |
| B-17 | **Taking over Certificate** |

# SECTION 13

# PROJECT QUANTITIES AND COST

# SECTION 13

## PROJECT QUANTITIES AND COST

### 13.1 Introduction

This chapter describes the basis of cost estimation of the Gugera Hydro Electric Power Project, in Nankana, Punjab Province of Pakistan. The cost estimation is probably one of the critical tasks amongst the other studies required at the feasibility stage. The difficulties stem from numerous factors, some of which are unpredictable such as the rapidly changing market prices of various materials, equipments, inflation, foreign exchange rates, price escalation, etc.

There are several cost estimation methods available which are very effective provided all required information is available. For example, the "unit price" basis is excellent, provided that unit prices of all items are analyzed properly. The estimation of prices of certain items utilizing empirical formulas / equipment cost curves can also be used but again these formulas or curves are time dependent i.e. these remain valid for a certain period of time and cannot be directly used if these are not updated. Another method of cost estimation is to use competitive bid prices from Consultant's data bank of the similar projects. However, it is not always possible to directly use these prices due to several reasons such as the different locations, sizes and type of projects and the time, the competitive bids are received. A combination of the above methods supplemented by engineering judgment and proper rate analysis is the only choice that would result in a realistic cost estimate.

The cost has been estimated for Civil works as well as Electro-mechanical equipment, Transportation, Erection, Testing and Commissioning. Cost of Camps and Temporary facilities, their running and maintenance, Land Acquisition & Resettlement have also been worked out. The possible costs related to Engineering and Administration of the project and physical contingencies have been assessed. Similarly the, IDC, Taxes and Duties and Price Contingencies (Escalation) have also been estimated to arrive at a total project cost. Some other costs which a private developer has to put in also estimated and made part of the project cost estimation.

### 13.2 Quantities Estimation

The civil works quantities such as concrete, steel, excavation, etc. have been estimated based on engineering design drawings consisting of plans and sections of all components of the project, which were prepared based on the topographic survey and data from the geo-technical investigations.

## 13.3 Basis of Cost Estimation

The capital cost of the Gugera Hydro Electric Power Project has been estimated based on the unit rate analysis for civil works, budgetary quotations received from various equipments manufacturers / suppliers and supplemented by Consultants price data bank and lastly by assessment and engineering judgment for other cost components.

All costs presented are for March 2014 without allowances for subsequent cost escalation. The cost estimates are based on the following general assumptions:

- A single contractor will take total responsibility for the project completion including design, construction, equipment procurement, installation, testing and commissioning.
- Prior to tendering the Project Sponsor shall obtain feasibility approval, tariff approval, consents, land acquisition, environmental compensations, financial commitments, detailed engineering design and bidding documents. Completion of all of the above is necessary to reduce risk contingencies that will be otherwise included in the contractor's bid prices.
- The FIDIC contract conditions of "Engineering, Procurement & Construction/ Commissioning" on Turnkey (EPC/T) will be used for construction of Gugera Hydro Electric Power Project. The EPC/Turnkey contract under FIDIC has its own implications with respect to obligations and risks of each party. The rate analysis and project cost has been estimated keeping in view the implications of the EPC/Turnkey contract conditions under FIDIC.

### 13.3.1 Unit Rate Analysis

"Direct cost unit rates" have been analyzed for all major work items, reflecting costs of labour, construction equipments and materials based upon realistic "construction methods" as well as "rates of production". Similarly the quantities have been calculated for all major work items. Costs of minor items have been estimated by using an allowance ranging from 2 to 5% depending upon the degree of take-off details.

### 13.3.2 Indirect General Expenses

The indirect general expenses include the insurances, guarantees, taxes, and contractor's home office over heads, profits and contingencies. All of the indirect costs have been taken into account, for rate analysis.

### 13.3.3 Construction Schedule

A realistic construction schedule indicating the mile stones of the project has been prepared to define the "time related" indirect costs. It is also important to decide the methodology for execution and production of the principal items of the works against the allocated time to the tasks.

### 13.3.4 Bid Factor

"Bid Factor" has been assessed to convert the "direct cost unit rates" into "unit prices" for estimation. In the projects of complex nature like hydropower projects, it may vary from 15% to 60% depending upon the indirect costs. The indirect costs, other than the usual components, also depend upon many factors such as location of the project and geo-political situation of the area, contract conditions and associated risks, the cost for mobilization and administrative personnel, the cost of contractors interest during construction, the type of financing and duration of the project, etc.

## 13.4 Currency Break-Down

Currency Break-down has also been made to assess the local and foreign currency costs, to arranging FEC, to assess the price escalation in both the currencies and overall impact on completion costs of the project due to price adjustments.

## 13.5 Cost Estimate for Civil Works

A detailed cost estimates for the civil works have been prepared on the basis of rate analysis and detailed quantities of principle items of work for each component of the Project. The costs have been estimated for powerhouse and other structures and associated works, which include:

- Preliminary Works include O&M colony, contractor camps and construction yard
- Environment & Resettlement Costs
- Headrace Channel
- Intake Bay
- Dewatering during Construction
- Power House
- Outlet Bay
- Tailrace Channel
- Modification in to Existing Fall Structure to as Spillway

The quantities of excavation, filling and compaction, concrete including formwork, reinforcement and stone pitching and rip-rap, dewatering, etc, based on engineering design made for this feasibility study have been estimated. The unit rates were established as defined above were used for preparation of cost estimate.

## 13.6 Cost Estimation for Electro-mechanical Equipment

The cost has been estimated for all the electromechanical equipments of the Project. As the electromechanical equipments have several sub-components and devices, the cost of major assemblies is only determined which is deemed to include the costs of all related components, devices and sub-systems, although the same are not mentioned explicitly. However, in several cases, the costs of individual component was taken and then the cost of the complete assembly was determined taking into account the installation, wiring and construction details, as applicable. Variable costs of Turbines, Generators, Governing system and other Electro-mechanical equipment from "Euro zone" and "out side the Euro zone" have been considered. Cost of electrical and mechanical equipments is based on the budgetary price from some reputed manufacturers; recent tender price received from various agencies on similar units, consultants data bank and rationalized desk studies.

## 13.7 Transportation and Shipment

For the hydro-mechanical, electrical equipment and hydraulic steel structure an amount of 5% of their net cost has been taken into consideration for transport to Pakistan, transport to the site and insurance.

## 13.8 Erection, Commissioning and Testing

Erection, commissioning and testing of equipments were estimated to amount to about 4% of the cost of mechanical, electrical equipment and hydraulic steel structure.

## 13.9 11 kV Transmission Line

The cost has been estimated for interconnection to the 132 KV Walgan Sohail Grid station, the nearest LESCO grid. Two 11 KV transmission lines each 06 km long have been estimated.

## 13.10 Engineering and Supervision

This includes costs for foreign and local consultants to do further site investigations, the detailed engineering design and preparation of tender documents and supervision of the construction work. The cost of these activities was taken as 4% of the engineering works costs including civil works and E&M equipment, etc.

## 13.11 Administration, Audit and Accounts

A 2% cost of engineering works has been taken into account for administrative, local audit and accounts, bank and other charges. The cost is taken as a local component.

## 13.12 Legal Fees

As defined in pre-construction phase preparation of security document and their negotiation with different organization/department is more legal than engineering. Therefore to cover the cost of the legal an amount of 1.5% of cost of engineering works has been taken into consideration.

## 13.13 Financial Fees

In the Pre-construction phase preparation of financial documents and their negotiation with different organizations will be carried out. Therefore to cover the cost of the financial charges an amount of 1.5% of cost of engineering works has been taken into consideration.

## 13.14 Pre-construction Expenses

Costs and expenditure incurred during pre-construction phase was estimated to count for expenses during issuance of LOI, feasibility study, LOS, financial closing, etc. An amount of 2% of the engineering works is estimated and included in the project base cost. However, at time of tariff submission the actual expenditure would be made part of the base cost.

## 13.15 Import and Other Charges

Customs duty at the rate of 5% on the import of plant and equipment not manufactured locally has been taken as per policy. The cost is taken as local cost.

## 13.16 Project Outflows

Project outflows consist of base cost, price escalation and interest on the barrowed amount (local and foreign). The interest paid during the remaining period also forms part of the cash outflows. Total base cost bifurcated into local and foreign cost components with phasing are represented in Table 13.3.

## 13.17 Project Base and Total Cost

The summary of total cost is presented in **Table: 13.1** while details in **Table: 13.2.**

**Table: 13.1**

**SUMMARY OF COST ESTIMATE**

| Code | Description | Amount (Million Pak. Rs.) | Remarks |
|---|---|---|---|
| **1000** | **Preliminary Works** | 75,717,097 | |
| **1100** | **Environment & Resettlement Costs** | 62,000,000 | |
| **1200** | **Civil Works** | | **657,170,968** |
| 1210 | Headrace Channel | 60,707,050 | |
| 1220 | Construction Pit for Powerhouse and Spillway | 128,954,616 | |
| 1230 | Intake Bay | 52,454,268 | |
| 1240 | Power House | 169,084,580 | |
| 1250 | Outlet Bay | 32,947,233 | |
| 1260 | Tailrace Channel | 149,881,954 | |
| 1270 | Strengthening and Dismantling of Existing Structures | 20,400,000 | |
| 1280 | Hydraulic Steel Structures | 42,741,267 | |
| **1300** | **Electrical and Mechanical Works** | | **381,017,905** |
| 1301 | Hydro-Mechanical Equipment | 265,825,244 | |
| 1310 | Powerhouse Mechanical Equipment | 19,884,956 | |
| 1320 | Powerhouse Electrical Equipment | 33,318,707 | |
| 1330 | Transmission Line | 30,528,804 | |
| **1400** | **Transportation and Erection Charges** | 31,460,194 | |
| | **Sub Total** | **1,175,905,970** | |
| **1500** | **Engineering Cost of EPC** | **47,036,239** | |
| | **Total EPC Cost** | **1,222,942,209** | |
| **1600** | **Client Engineering and Supervision** | **48,917,688** | |
| **1700** | **Independent Engineer** | **24,458,844** | |
| **1800** | **Administration, Audit and Accounts** | **24,458,844** | |
| **1900** | **Legal Advisor Charges** | **18,344,133** | |
| **2000** | **Financial Advisor Charges** | **18,344,133** | |
| **2100** | **Pre-Construction Expenses** | **24,458,844** | |
| **2200** | **Insurance During Construction** | **16,509,720** | |

| | | | |
|---|---|---|---|
| | Sub Total - 15 | 1,398,434,415 | |
| 2300 | Contingencies @ | 000,000 | |
| | TOTAL BASE COST | 1,398,434,415 | 1 US $ = 102 Rs. |
| | TOTAL BASE COST ( 1 US $ = 102 Rs.) | 13,710,141 | |

## Table: 13.2

## SUMMARY OF COST ESTIMATE

| Code | Description | Unit | Rate (Pak. Rs.) | Qty | Total Amount (Pak. Rs.) | Local Amount (Pak. Rs.) | Foreign Amount (Pak. Rs.) |
|---|---|---|---|---|---|---|---|
| 1000 | **Preliminary Works** | | | | | | |
| 1001 | Construction and Maintenance of Camps, Offices and Colony | 10% | 65,717,097 | 1 | 65,717,097 | 52,573,678 | 13,143,419 |
| 1002 | Mobilization and De-Mobilization | L.S. | 10,000,000 | 1 | 10,000,000 | 2,000,000 | 8,000,000 |
| | Total - A | | | | 75,717,097 | 54,573,678 | 21,143,419 |
| 1100 | **Environment & Resettlement Costs** | | | | | | |
| 1101 | Land Acquisition | Acrs | 2,000,000 | 30 | 60,000,000 | 60,000,000 | - |
| 1102 | Resettlement and Compensations etc | L.S. | 2,000,000 | 1 | 2,000,000 | 2,000,000 | - |
| | Total - B | | | | 62,000,000 | 62,000,000 | - |
| 1200 | **Civil Works** | | | | | | |
| 1210 | **Headrace Channel** | | | | | | |
| 1211 | Excavation | $m^3$ | 244.00 | 28,476 | 6,948,144 | 6,600,737 | 347,407 |
| 1212 | Filling including Compaction | $m^3$ | 78.00 | 309,168 | 24,115,104 | 22,909,349 | 1,205,755 |
| 1213 | Stone Pitching in Canal Bed | $m^2$ | 2,058.00 | 5,205 | 10,711,890 | 10,176,296 | 535,594 |
| 1214 | Stone Pitching in Canal Slopes | $m^2$ | 2,498.00 | 6,674 | 16,671,652 | 15,838,069 | 833,583 |
| 1215 | Dismantling of Plug | $m^3$ | 244.00 | 6,800 | 1,659,200 | 1,576,240 | 82,960 |
| | **Section Total** | | | | 60,105,990 | 57,100,691 | 3,005,299 |
| | Other Misc. items @ | 1% | | | 601,060 | 571,007 | 30,053 |
| | **Sub Total - 2** | | | | 60,707,050 | 57,671,698 | 3,035,352 |
| 1220 | **Construction Pit for Powerhouse and Spillway** | | | | | | |
| 1221 | Excavation | $m^3$ | 244.00 | 14,917 | 3,639,748 | 3,457,761 | 181,987 |
| 1222 | Filling including Compaction | $m^3$ | 78.00 | 2,695 | 210,210 | 199,700 | 10,510 |
| 1223 | Dewatering Pumps including Installation | Nos | 283,384.00 | 67 | 18,986,728 | 18,037,392 | 949,336 |
| 1224 | Standby Pumps | Nos | 65,344.00 | 11 | 718,784 | 682,845 | 35,939 |
| 1225 | Operation and Maintenance of Pumps | Hr | 538.00 | 193,536 | 104,122,368 | 98,916,250 | 5,206,118 |
| | **Section Total** | | | | 127,677,838 | 121,293,948 | 6,383,890 |
| | Other Misc. items @ | 1% | | | 1,276,778 | 1,212,939 | 63,839 |
| | **Sub Total - 3** | | | | **128,954,616** | **122,506,887** | **6,447,729** |
| 1230 | **Intake Bay** | | | | | | |
| 1231 | Structural Concrete - Slab | $m^3$ | 14,769.00 | 490 | 7,236,810 | 6,874,970 | 361,840 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1232 | Structural Concrete - Retaining wall | $m^3$ | 12,810.00 | 2,115 | 27,093,150 | 25,738,493 | 1,354,657 |
| 1233 | Lean Concrete Class - D | $m^3$ | 8,410.00 | 36 | 302,760 | 287,622 | 15,138 |
| 1234 | Reinforcing Steel (Grade - 60) | tonne | 119,634.00 | 130 | 15,552,420 | 14,774,799 | 777,621 |
| 1235 | Cut-off-Walls | $m^3$ | 10,805.00 | 139 | 1,501,895 | 1,426,800 | 75,095 |
| 1236 | Filling including Compaction | $m^3$ | 78.00 | 3,178 | 247,884 | 235,490 | 12,394 |
| | **Section Total** | | | | 51,934,919 | 49,338,174 | 2,596,745 |
| | Other Misc. items @ | 1% | | | 519,349 | 493,382 | 25,967 |
| | **Sub Total - 4** | | | | **52,454,268** | **49,831,556** | **2,622,712** |
| **1240** | **Power House with Spillway** | | | | | | |
| 1241 | Structural Concrete Class - A | $m^3$ | 14,769.00 | 654 | 9,658,926 | 9,175,980 | 482,946 |
| 1242 | Mass Concrete Class - B | $m^3$ | 12,810.00 | 4,820 | 98,009,310 | 93,108,845 | 4,900,465 |
| 1243 | Second Stage Concrete | $m^3$ | 14,769.00 | 612 | 9,038,628 | 8,586,697 | 451,931 |
| 1244 | Lean Concrete Class - D | $m^3$ | 8,410.00 | 130 | 1,093,300 | 1,038,635 | 54,665 |
| 1245 | Cut-off-Walls | $m^3$ | 12,236.12 | 759 | 9,287,215 | 8,822,854 | 464,361 |
| 1246 | Reinforcing Steel (Grade - 60) | tonne | 119,634.00 | 243 | 29,071,062 | 27,617,509 | 1,453,553 |
| 1247 | Reinforcing Steel (Grade - 40) | tonne | 91,482.00 | 61 | 5,580,402 | 5,301,382 | 279,020 |
| 1247 | Filling including Compaction | $m^3$ | 78.00 | 9,784 | 763,152 | 724,994 | 38,158 |
| 1248 | Architectural Works | L.S. | 3,267,201 | 1 | 3,267,201 | 3,103,841 | 163,360 |
| | **Section Total** | | | | 165,769,196 | 157,480,737 | 8,288,459 |
| | Other Misc. items @ | 2% | | | 3,315,384 | 3,149,615 | 165,769 |
| | **Sub Total - 5** | | | | 169,084,580 | 160,630,352 | 8,454,228 |
| **1250** | **Outlet Bay** | | | | | | |
| 1251 | Structural Concrete Class - Slab | $m^3$ | 14,769.00 | 733 | 10,825,677 | 10,284,393 | 541,284 |
| 1252 | Structural Concrete Class - Retaining wall | $m^3$ | 12,810.00 | 777 | 9,953,370 | 9,455,702 | 497,668 |
| 1253 | Lean Concrete Class - D | $m^3$ | 8,410.00 | 61 | 513,010 | 487,360 | 25,650 |
| 1254 | Reinforcing Steel (Grade - 60) | tonne | 119,634.00 | 76 | 9,092,184 | 8,637,575 | 454,609 |
| 1254 | Cut-off-Walls | $m^3$ | 10,805.00 | 176 | 1,901,680 | 1,806,596 | 95,084 |
| 1255 | Fillings including Compaction | $m^3$ | 78.00 | 196 | 15,288 | 14,524 | 764 |
| | **Section Total** | | | | 32,301,209 | 30,686,150 | 1,615,059 |
| | Other Misc. items @ | 2% | | | 646,024 | 613,723 | 32,301 |
| | **Sub Total - 7** | | | | **32,947,233** | **31,299,873** | **1,647,360** |
| **1260** | **Tailrace Channel** | | | | | | |
| 1261 | Excavation in canal | $m^3$ | 488.00 | 242,972 | 118,570,336 | 112,641,819 | 5,928,517 |
| | Filling including Compaction | $m^3$ | 82.21 | 10,200 | 838,542 | 796,615 | 41,927 |
| 1262 | Stone Pitching in bed of Canal | $m^2$ | 2,058.00 | 5,200 | 10,701,600 | 10,166,520 | 535,080 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Stone Pitching in Canal Slopes | $m^2$ | 2,498.00 | 6,364 | 15,897,272 | 15,102,408 | 794,864 |
| 1263 | Dismantling of Plug | $m^2$ | 244.00 | 6,800 | 1,659,200 | 1,576,240 | 82,960 |
| | **Section Total** | | | | 147,666,950 | 140,283,602 | 7,383,348 |
| | Other Misc. items @ | 1.5% | | | 2,215,004 | 2,104,254 | 110,750 |
| | **Sub Total - 8** | | | | 149,881,954 | 142,387,856 | 7,494,098 |
| **1270** | **Strengthening and Dismantling of Existing Structures** | | | | | | |
| 1271 | Construction of Bridge at RD 219+000 | LS | 20,000,000 | 1 | 20,000,000 | 19,000,000 | 1,000,000 |
| | **Section Total** | | | | 20,000,000 | 19,000,000 | 1,000,000 |
| | Other Misc. items @ | 2% | | | 400,000 | 380,000 | 20,000 |
| | **Sub Total - 9** | | | | 20,400,000 | 19,380,000 | 1,020,000 |
| **1280** | **Hydraulic Steel Structures** | | | | | | |
| 1281 | Trash Rack at Intake (5.5m x 9.0m) | Nos | 2,895,394 | 3 | 8,686,182 | 7,817,564 | 868,618 |
| 1282 | Trash Rack Cleaner | Nos | 3,860,525 | 1 | 3,860,525 | 3,474,473 | 386,052 |
| 1283 | Stoplog Set for Intake (4.75 m x 6.5 m) | Nos | 3,009,918 | 2 | 6,019,836 | 5,417,852 | 601,984 |
| 1284 | Stoplog Set for Outlet bay (4.75 m x 3.5 m) | Nos | 1,955,419 | 2 | 3,910,838 | 3,519,754 | 391,084 |
| 1285 | Stoplogs Lifting Mechanism | Nos | 1,973,912 | 2 | 3,947,824 | 3,553,042 | 394,782 |
| 1286 | Spillway Gates | Nos | 7,738,999 | 2 | 15,477,998 | 13,930,198 | 1,547,800 |
| | **Section Total** | | | | 41,903,203 | 37,712,883 | 4,190,320 |
| | Other items or Misc. items @ | 2% | | | 838,064 | 754,258 | 83,806 |
| | **Sub Total - 10** | | | | 42,741,267 | 38,467,141 | 4,274,126 |
| | Total Civil Work Cost - C | | | | 657,170,968 | 622,175,363 | 34,995,605 |
| **1290** | **Electrical and Mechanical Works** | | | | | | |
| 1291 | **Hydro-Mechanical Equipment** | | | | | | |
| 1292 | Bevel Gear (1.2 MW each) | Nos | 41,862,332 | 3 | 125,586,996 | - | 125,586,996 |
| 1293 | Generator and Exciter | Nos | 37,675,833 | 3 | 113,027,499 | - | 113,027,499 |
| 1294 | Governor | Nos | 7,849,229 | 3 | 23,547,687 | - | 23,547,687 |
| 1295 | Powerhouse crane (60 Tonne) | Nos | 3,663,062 | 1 | 3,663,062 | - | 3,663,062 |
| | **Sub Total - 11** | | | | 265,825,244 | - | 265,825,244 |
| **1300** | **Powerhouse Mechanical Equipment** | | | | | | |
| 1301 | Cooling System | L.S. | 2,093,083 | 1 | 2,093,083 | 209,308 | 1,883,775 |
| 1302 | Fire Fighting System | L.S. | 523,437 | 1 | 523,437 | 52,344 | 471,093 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1303 | Drainage & Dewatering | L.S. | 3,139,625 | 1 | 3,139,625 | 313,963 | 2,825,662 |
| 1304 | High & Low Pressure Air | L.S. | 3,663,062 | 1 | 3,663,062 | 366,306 | 3,296,756 |
| 1305 | Ventilation & Air Conditioning | L.S. | 2,616,520 | 1 | 2,616,520 | 261,652 | 2,354,868 |
| 1306 | Workshop Equipment | L.S. | 4,186,167 | 1 | 4,186,167 | 418,617 | 3,767,550 |
| 1307 | Water Level Measuring Device | Nos | 523,437 | 1 | 523,437 | 52,344 | 471,093 |
| 1308 | Miscellaneous Mechanical Systems | L.S. | 3,139,625 | 1 | 3,139,625 | 313,963 | 2,825,662 |
| | **Sub Total - 12** | | | | **19,884,956** | **1,988,497** | **17,896,459** |
| **1310** | **Powerhouse Electrical Equipment** | | | | | | |
| 1311 | Unit Transformer | Nos | 2,000,000 | 3 | 6,000,000 | 1,800,000 | 4,200,000 |
| 1312 | Auxiliary Transformer | Nos | 400,000 | 2 | 800,000 | 240,000 | 560,000 |
| 1313 | HT/MV/LV Switch Gears | L.S. | 10,465,417 | 1 | 10,465,417 | 3,139,625 | 7,325,792 |
| 1314 | D.C Supply | L.S. | 4,186,167 | 1 | 4,186,167 | 1,255,850 | 2,930,317 |
| 1315 | Earthing System | L.S. | 2,093,083 | 1 | 2,093,083 | 627,925 | 1,465,158 |
| 1316 | Emergency D.G.Set | Nos | 2,093,083 | 1 | 2,093,083 | 627,925 | 1,465,158 |
| 1317 | Measuring & Protection | L.S. | 5,232,708 | 1 | 5,232,708 | 1,569,812 | 3,662,896 |
| 1318 | Telecommunication Equipment | L.S. | 1,401,707 | 1 | 1,401,707 | 420,512 | 981,195 |
| 1319 | Lighting and Clock | L.S. | 1,046,542 | 1 | 1,046,542 | 313,963 | 732,579 |
| | **Sub Total - 13** | | | | **33,318,707** | **9,995,612** | **23,323,095** |
| **1320** | **Transmission Line** | | | | | | |
| 1321 | 11 Kv Transmission Line (Two Circuits) | KM | 2,544,067 | 12 | 30,528,804 | 27,475,924 | 3,052,880 |
| | **Sub Total -14** | | | | **30,528,804** | **27,475,924** | **3,052,880** |
| | **Sub Total E & M** | | | | 349,557,711 | 39,460,033 | 310,097,678 |
| **1390** | Transportation and Erection Charges @ | 9% | | | 31,460,194 | 3,551,403 | 27,908,791 |
| | Total E & M Work Cost - D | | | | 381,017,905 | 43,011,436 | 338,006,469 |
| **1400** | **Total Cost (Total A+B+C+D)** | | | | **1,175,905,970** | **781,760,477** | **394,145,493** |
| **1500** | **Engineering Cost of EPC** | 4% | | | **47,036,239** | **31,270,419** | **15,765,820** |
| **1600** | **Total EPC Cost** | | | | **1,222,942,209** | **813,030,896** | **409,911,313** |
| **1700** | **Client Engineering and Supervision** | 4% | | | **48,917,688** | **32,521,236** | **16,396,453** |
| **1800** | **Independent Engineer** | 2% | | | **24,458,844** | **16,260,618** | **8,198,226** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1900 | Administration, Audit and Accounts | 2% | | | 24,458,844 | 16,260,618 | 8,198,226 |
| 2000 | Legal Advisor Charges | 1.5% | | | 18,344,133 | 12,195,463 | 6,148,670 |
| 2100 | Financial Advisor Charges | 1.5% | | | 18,344,133 | 12,195,463 | 6,148,670 |
| | Pre-Construction Expenses | 2% | | | 24,458,844 | 16,260,618 | 8,198,226 |
| 2200 | Insurance During Construction | 1.35 % | | | 16,509,720 | 10,975,917 | 5,533,803 |
| | Sub Total - 15 | | | | 1,398,434,415 | 929,700,829 | 468,733,587 |
| | Contingencies @ | 0% | | | - | - | - |
| 2300 | TOTAL BASE COST | Pak. Rs. | | | 1,398,434,415 | 929,700,829 | 468,733,587 |
| | TOTAL BASE COST ( 1 US $ = 102 Rs.) | US $ | | | 13,710,141 | 9,114,714 | 4,595,427 |

# TABLE - 13.3

## UPPER GUGERA CANAL HYDRO ELECTRIC POWER PROJECT

### SUMMARY OF COST ESTIMATE ( YEARWISE BREAK UP )

( Amount in Million Rupees )

| Item | Description | Total Project Cost | | | Year 1 | | | Year 2 | | | Year 3 | | | Year 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Local | Foreign | Total | Local | Foreign | Total | Local | Foreign | Total | Local | Foreign | Total | Local | Foreign | Total |
| A | PRELIMINARY WORKS | 54.574 | 21.143 | 75.717 | 21.830 | 8.457 | 30.287 | 21.830 | 8.457 | 30.287 | 5.457 | 2.114 | 7.572 | 5.457 | 2.114 | 7.572 |
| B | ENVIRONMENT & MITIGATION | 62.000 | 0.000 | 62.000 | 18.600 | 0.000 | 18.600 | 37.200 | 0.000 | 37.200 | 6.200 | 0.000 | 6.200 | 0.000 | 0.000 | 0.000 |
| C | CIVIL WORKS | 622.175 | 34.996 | 657.171 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 248.870 | 13.998 | 262.868 | 373.305 | 20.998 | 394.303 |
| D | HYDRO-MECHANICAL EQUIPMENT | 1.989 | 283.722 | 285.711 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.392 | 198.605 | 199.998 | 0.597 | 85.117 | 85.713 |
| E | ELECTRICAL EQUIPMENT | 37.472 | 26.376 | 63.848 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 26.230 | 18.463 | 44.694 | 11.242 | 7.913 | 19.154 |
| F | TRANSPORTATION & ERECTION CHARGES | 3.551 | 27.909 | 31.460 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.776 | 11.164 | 12.939 | 1.776 | 16.745 | 18.521 |
| G | **SUB TOTAL ( ITEM A TO G )** | **781.761** | **394.146** | **1175.987** | **40.438** | **8.457** | **48.887** | **59.030** | **8.457** | **67.487** | **289.926** | **244.345** | **534.271** | **392.376** | **132.887** | **525.263** |
| H | ENGINEERING COST OF EPC ( 4% OF G ) | 31.270 | 15.766 | 47.036 | 6.254 | 3.153 | 9.407 | 9.381 | 4.730 | 14.111 | 9.381 | 4.730 | 14.111 | 6.254 | 3.153 | 9.407 |
| I | **TOTAL EPC COST** | **813.031** | **409.912** | **1222.943** | **46.684** | **11.610** | **58.294** | **68.411** | **13.187** | **81.598** | **299.307** | **249.075** | **548.381** | **398.630** | **136.040** | **534.670** |
| J | CLIENT ENG. AND SUPERVISION ( 4% OF I ) | 32.521 | 16.396 | 48.918 | 6.504 | 3.279 | 9.784 | 9.756 | 4.919 | 14.675 | 9.756 | 4.919 | 14.675 | 6.504 | 3.279 | 9.784 |
| K | INDEPENDENT ENGINEER ( 2% OF I ) | 16.261 | 8.198 | 24.459 | 1.626 | 0.820 | 2.446 | 6.504 | 3.279 | 9.784 | 6.504 | 3.279 | 9.784 | 1.626 | 0.820 | 2.446 |
| L | ADMIN, AUDIT AND ACCOUNTS ( 2% OF I ) | 16.261 | 8.198 | 24.459 | 3.252 | 1.640 | 4.892 | 4.878 | 2.459 | 7.338 | 4.878 | 2.459 | 7.338 | 3.252 | 1.640 | 4.892 |
| M | LEGAL ADVISOR CHARGES ( 1.5% OF I ) | 12.195 | 6.149 | 18.344 | 3.049 | 1.537 | 4.586 | 4.878 | 2.459 | 7.338 | 3.049 | 1.537 | 4.586 | 1.220 | 0.615 | 1.834 |
| N | FINANCIAL ADVISOR CHARGES ( 1.5% OF I ) | 12.195 | 6.149 | 18.344 | 3.049 | 1.537 | 4.586 | 4.878 | 2.459 | 7.338 | 3.049 | 1.537 | 4.586 | 1.220 | 0.615 | 1.834 |
| O | PRE-CONSTRUCTION EXPENSES ( 2% OF I ) | 16.261 | 8.198 | 24.459 | 16.261 | 8.198 | 24.459 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| P | INSURANCE DURING CONSTRUCTION ( 1.35% OF I ) | 10.976 | 5.534 | 16.510 | 2.744 | 1.383 | 4.127 | 2.744 | 1.383 | 4.127 | 2.744 | 1.383 | 4.127 | 2.744 | 1.383 | 4.127 |
| Q | **SUB TOTAL ( ITEM I TO P )** | **929.781** | **468.734** | **1398.436** | **83.168** | **38.805** | **113.174** | **182.050** | **30.147** | **132.197** | **329.287** | **264.190** | **593.477** | **415.196** | **144.392** | **559.588** |
| R | CONTINGENCIES ( 0% OF Q ) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| S | **BASE COST ( ITEM A TO Q )** | **929.701** | **468.734** | **1398.436** | **83.168** | **38.005** | **113.174** | **102.050** | **30.147** | **132.197** | **329.287** | **264.190** | **593.477** | **415.196** | **144.392** | **559.588** |
| T | CUSTOM DUTIES ( 5% OF D & E ) | 15.505 | 0.000 | 15.505 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 7.752 | 0.000 | 7.752 | 7.752 | 0.000 | 7.752 |
| U | ESCALATION DURING CONSTRUCTION | 155.399 | 24.169 | 179.568 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 69.060 | 14.428 | 83.488 | 86.340 | 9.741 | 96.081 |
| V | INTEREST DURING CONSTRUCTION | 203.595 | 0.000 | 203.595 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 54.829 | 0.000 | 54.829 | 148.766 | 0.000 | 148.766 |
| | **PROJECT COST** | **1304.200** | **492.903** | **1797.104** | **83.168** | **30.005** | **113.174** | **102.050** | **30.147** | **132.197** | **460.928** | **278.618** | **739.546** | **658.054** | **154.133** | **812.187** |

# SECTION 14

# ECONOMIC ANALYSIS

# SECTION -14
# ECONOMIC ANALYSIS

## 14.1 Introduction

Feasibility study attempts to assess the practicability of an idea and suggestions of a project. In economic term practicability of an idea of a project can be assessed through analysis by juxtaposing returns (usually referred as benefits) from its operation against costs to be incurred over its useful life.

In case of hydropower projects, useful life of the civil engineering work has been assumed to be 60 to 80 years and that of electrical and mechanical equipments 30 years. Analysis has therefore been done over a period of 30 years.

## 14.2 Economic Analysis

Economic analysis is a systematic and scientific approach to determine the programme of action by comparing the ex-ante performance with ex-post achievements which essentially entails major socio-economic developments in the area of influence. Economic analysis seeks to ascertain the reward for investment and provides guidelines to establish the feasibility of the project. It is necessary that gains generated should exceed the cost of the goods and services used in its construction and operation. At least these gains must match or yield higher returns from an alternative investment. The primary objective of undertaking economic analysis is thus to determine whether the contribution of a particular project in the shape of added value benefits is adequate enough to justify use of scarce resources needed in the form of project investment costs. The economic justification of investment in a capital intensive project depends on three factors: firstly, there is a need for the project, secondly, where technological options are available, the project represents the most economic choice of option; and thirdly, that investment in the project will produce an acceptable return to the national economy. This process involves the assessment of project benefits and identification of project costs over the economic life of the project.

The economic evaluation of this project has been carried out on the basis of providing an equivalent quantum of generation from the steam plant using furnace oil.

It is further assumed that proposed plant will run in integrated mode with the National Grid.

## 14.3 Shadow Pricing

The economic analysis of the project requires that all costs and benefits must be evaluated at prices within the economy which reflect their real worth. Major inputs into the scheme of economic analysis do not necessarily reflect their true opportunity cost to the economy because of distortions in market prices. Like many other developing countries, the prices of goods and services are distorted by subsidies and taxes in Pakistan too. The rate of foreign exchange has differed from its true opportunity cost. Due to disguised under-employment in agriculture and implications of minimum wage legislation in the industrial sector, the price of labour has generally been higher than its true opportunity cost. Shadow pricing has, therefore, been used to find out true opportunity cost of capital as well as other inputs to determine the economic cost of this project to the national economy.

### 14.3.1 Cost Of Capital

Shadow price of capital is defined as the opportunity cost of funds withdrawn from other uses and is considered equal to marginal cost of capital in the economy of Pakistan. The World Bank has used 10% discount rate for rural electrification projects and 12% by Planning Commission of Pakistan for economic evaluation of public sector projects followed by a study of Havard Advisory Group on opportunity cost of capital. Accordingly, costs and benefits have been discounted @ 12% for the assessment of economic feasibility of the project.

### 14.3.2 Cost Of Labour

In cases where there is significant unemployment and under-employment in a local economy shadow wage rates for labour should be used which are considerably lower than actual wages paid. The objective in economic analysis is to use the opportunity cost as an alternative application. In Pakistan the situation is one of under-employment for unskilled labour rather than full employment since there is labour shortages in rural areas in sowing and harvesting seasons. There is no employment problem for skilled labour as there are sufficient opportunities locally and in nearby oil producing countries.

The project is located in District Nankanasahib of the Punjab province, where during harvesting period of crops, the labour supply is found to be scarce for construction or other economic activities. On the other hand the skilled labour force is not sufficient to meet the local needs of the area as observed in the district and surrounding settlements. Therefore, shadow wage rates of 1.00 and 0.75 for skilled and unskilled labour respectively, have been used for deriving the economic cost (refer Mangla Raising Project, Wapda).

The economic cost of labour has been determined by applying shadow wage factors to the total labour cost which is equivalent to 38% of the local cost of the project with 40% & 60% as skilled and unskilled labour components, respectively.

### 14.3.3 Cost Of Material

Most of the material inputs for the project, i.e., steel, cement etc, are transported to the project site involving high freight expenditures. It is, therefore, assumed that shadow rate for material may be used as 0.92.

The results of shadow conversion factors have been applied to various components of project costs to derive adjusted economic costs.

### 14.3.4 Exchange Rate

Since 1982, the value of the Pakistani Rupee has been worked out with the help of a "managed float" linking it to a basket of currencies. It is recognized that conversion factors are sometimes used even when a currency is floating especially if restrictions exist on currency exchange. Based on the facts it is concluded that conversion factor should not be applied to the exchange rate. Prevailing inter bank exchange rate of 1US$ = Rs102.00 has therefore been applied.

## 14.4 Economic Cost

The economic costs are derived by converting financial cost with adjustments for direct transfer payments like taxes, subsidies and interest (transfer payments) during construction, besides adjustments for distortions in the market prices of traded and untraded goods used in the project works. For this study also economic costs of the project have been derived by removing transfer payments in addition to adjustment of cost of labour and material with appropriate shadow conversion factors. The economic costs of the project thus derived have been used in economic evaluation and given in Tables 14.1 and 14.2.

## 14.5 Derivation Of Thermal Equivalence

The project feasibility has been assessed on the assumption that in the absence of hydelgeneration, an equivalent thermal generation plant would be required to produce equivalent amount of energy per annum. A comparative study has, therefore, been made and costs calculated on the basis of providing an equivalent quantum of generation from the steam plant using furnace oil described as economic benefits.

## 14.6 Operation And Maintenance Cost

The annual operation and maintenance cost excluding establishment cost of a steam electric plant has been assumed as 4% of the estimated capital cost.

## 14.7 Economic Benefits

Economic benefits have been computed based on the equivalent thermal generation costs that would be avoided if the Hydro Electric Power Project is installed. Thus the savings for not installing thermal plant, fuel and operating costs would be benefits, attributable to the project.

**BENEFITS OF EQUIVALENT THERMAL PLANT**

| **DESCRIPTION** | | |
|---|---|---|
| Energy | GWh | 20.80 |
| Plant Factor | % | 84 |
| Cost per KW* | US$ | 1200 |
| O & M Cost | % | 4 |
| Fuel Cost (Financial)/KWh** | Rs. | 15 |

* Based on latest capacity cost of thermal power projects.

** Electricity Marketing Data (Power System Statistics - 38th Issue). Planning Power Department (NTDC), WAPDA.

The economic feasibility of the project is shown in Tables14.1 and 14.2 with & without CDMfor the proposed hydropower project. CDM benefits has been taken as US$ 1.5/ton of $CO_2$ which is very low. The internal economic rates of return (IERR) of the project with & without CDMare 16.11%and16.03%with B.C Ratio of 1.26respectively.

## 14.8 Sensitivity Analysis

Although the project has shown economic viability with higher rates of return than the opportunity cost of capital even then the project is susceptible to different kind of adverse circumstances like cost over-run, delay in construction and decrease in benefits. The economic feasibility of the project has, therefore, been assessed against 10% decrease in benefits, 20% cost overrun, as well as combined impact of both the variations to see if the project remains economically viable. The results show that the project yields economically viable rates of return as shown in Tables 14.3 and 14.4 and summarised below:

| Description | Base Case | 10% decrease in benefits | 20% cost over-run | Combined impact |
|---|---|---|---|---|
| With CDM | 16.11% | 14.11% | 12.79% | 11.14% |
| Without CDM | 16.03% | 14.04% | 12.72% | 11.08% |

## 14.9 Justification Of The Project

The project is economically justifiable in view of supplying low cost hydel power to the local area. The electricity will act as a catalyst for development of basic industry, creation of employment opportunities and uplift of socio-economic conditions, etc. The project has shown economic viability in the form of positive rates of return and also qualifies the sensitivity analysis criteria.

## TABLE - 14.1
## UPPER GUGERA CANAL HYDRO ELECTRIC POWER PROJECT
## ECONOMIC ANALYSIS WITH CDM

MILL.Rs

| YEAR | COSTS | | | EQUIVALENT THERMAL BENEFITS | | | | CDM BENEFITS | TOTAL BENEFITS | NET BENEFIT |
|---|---|---|---|---|---|---|---|---|---|---|
| | CAPITAL | O & M | TOTAL | CAPITAL | O & M | FUEL | TOTAL | | | |
| 1 | 1150.27 | | 1150.27 | 225.16 | | | 225.16 | | 225.16 | -925. |
| 2 | 737.58 | | 737.58 | 121.24 | | | 121.24 | | 121.24 | -616. |
| 3 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.30 | 295.96 | 274. |
| 4 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.30 | 295.96 | 274. |
| 5 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.30 | 295.96 | 274. |
| 6 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.30 | 295.96 | 274. |
| 7 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.30 | 295.96 | 274. |
| 8 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.30 | 295.96 | 274. |
| 9 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.30 | 295.96 | 274. |
| 10 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.30 | 295.96 | 274. |
| 11 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.30 | 295.96 | 274. |
| 12 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.30 | 295.96 | 274. |
| 13 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275. |
| 14 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275. |
| 15 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275. |
| 16 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275. |
| 17 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275. |
| 18 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275. |
| 19 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275. |
| 20 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275. |
| 21 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275. |
| 22 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275. |
| 23 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275 |
| 24 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275 |
| 25 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275 |
| 26 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275 |
| 27 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275 |
| 28 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275 |
| 29 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275 |
| 30 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275 |
| 31 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 275 |
| 32 | -188.79 | 20.98 | -167.81 | | 13.86 | 280.80 | 294.66 | 1.53 | 296.19 | 464 |
| **TOTAL** | **1887.85** | **629.30** | **2328.36** | **346.40** | **415.80** | **8424.00** | **9186.20** | **43.54** | **9229.74** | **6901** |

| | | |
|---|---|---|
| **PW OF BENEFITS @ 12%; MILL.Rs** | **=** | **2198.64** |
| **PW OF COSTS @ 12%; MILL.Rs** | **=** | **1744.70** |
| **NET PRESENT WORTH; MILL.Rs** | **=** | **453.94** |
| **BENEFIT COST RATIO** | **=** | **1.26** |
| **I . E . R . R** | **=** | **16.11%** |

## TABLE - 14.2
## UPPER GUGERA CANAL HYDRO ELECTRIC POWER PROJECT
## ECONOMIC ANALYSIS WITHOUT CDM

MILL.Rs

| YEAR | COSTS | | | EQUIVALENT THERMAL BENEFITS | | | | NET BENEFITS |
|---|---|---|---|---|---|---|---|---|
| | CAPITAL | O & M | TOTAL | CAPITAL | O & M | FUEL | TOTAL | |
| 1 | 1150.27 | | 1150.27 | 225.16 | | | 225.16 | -925.11 |
| 2 | 737.58 | | 737.58 | 121.24 | | | 121.24 | -616.34 |
| 3 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 4 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 5 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 6 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 7 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 8 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 9 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 10 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 11 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 12 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 13 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 14 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 15 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 16 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 17 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 18 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 19 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 20 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 21 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 22 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 23 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 24 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 25 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 26 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 27 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 28 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 29 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 30 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 31 | | 20.98 | 20.98 | | 13.86 | 280.80 | 294.66 | 273.68 |
| 32 | -188.79 | 20.98 | -167.81 | | 13.86 | 280.80 | 294.66 | 462.47 |
| TOTAL | 1887.85 | 629.30 | 2328.36 | 346.40 | 415.80 | 8424.00 | 9186.20 | 6857.84 |

**PW OF BENEFITS @ 12%; MILL.Rs = 2189.86**
**PW OF COSTS @ 12%; MILL.Rs = 1744.70**
**NET PRESENT WORTH; MILL.Rs = 445.16**
**BENEFIT COST RATIO = 1.26**
**I . E . R . R = 16.03%**

**TABLE - 14.3**
**UPPER GUGERA CANAL HYDRO ELECTRIC POWER PROJECT**
**SENSITIVITY ANALYSIS WITH CDM**

MILL.Rs

| YEAR | TOTAL COST | BENEFITS | 10% LESS BENEFITS | NET BENEFITS | 20% COST OVER-RUN | NET BENEFITS | COMBINED IMPACT |
|---|---|---|---|---|---|---|---|
| 1 | 1150.27 | 225.16 | 202.64 | -947.63 | 1380.32 | -1155.16 | -1177.68 |
| 2 | 737.58 | 121.24 | 109.12 | -628.46 | 885.10 | -763.86 | -775.98 |
| 3 | 20.98 | 295.96 | 266.36 | 245.39 | 25.17 | 270.79 | 241.19 |
| 4 | 20.98 | 295.96 | 266.36 | 245.39 | 25.17 | 270.79 | 241.19 |
| 5 | 20.98 | 295.96 | 266.36 | 245.39 | 25.17 | 270.79 | 241.19 |
| 6 | 20.98 | 295.96 | 266.36 | 245.39 | 25.17 | 270.79 | 241.19 |
| 7 | 20.98 | 295.96 | 266.36 | 245.39 | 25.17 | 270.79 | 241.19 |
| 8 | 20.98 | 295.96 | 266.36 | 245.39 | 25.17 | 270.79 | 241.19 |
| 9 | 20.98 | 295.96 | 266.36 | 245.39 | 25.17 | 270.79 | 241.19 |
| 10 | 20.98 | 295.96 | 266.36 | 245.39 | 25.17 | 270.79 | 241.19 |
| 11 | 20.98 | 295.96 | 266.36 | 245.39 | 25.17 | 270.79 | 241.19 |
| 12 | 20.98 | 295.96 | 266.36 | 245.39 | 25.17 | 270.79 | 241.19 |
| 13 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 14 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 15 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 16 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 17 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 18 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 19 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 20 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 21 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 22 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 23 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 24 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 25 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 26 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 27 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 28 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 29 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 30 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 31 | 20.98 | 296.19 | 266.57 | 245.59 | 25.17 | 271.02 | 241.40 |
| 32 | -167.81 | 296.19 | 266.57 | 434.38 | -201.37 | 497.56 | 467.94 |
| **TOTAL** | **2328.36** | **9229.74** | **8306.76** | **5978.40** | **2794.03** | **6435.70** | **5512.73** |

| INTERNAL RATE OF RETURN = | | | | 16.11% | 14.11% | 12.79% | 11.14% |
|---|---|---|---|---|---|---|---|

## TABLE - 14.4
## UPPER GUGERA CANAL HYDRO ELECTRIC POWER PROJECT
## SENSITIVITY ANALYSIS WITHOUT CDM

MILL.Rs

| YEAR | TOTAL COST | BENEFITS | NET BENEFITS | 10% LESS BENEFITS | NET BENEFITS | 20% COST OVER-RUN | NET BENEFITS | COMBINED IMPACT |
|---|---|---|---|---|---|---|---|---|
| 1 | 1150.27 | 225.16 | -925.11 | 202.64 | -947.63 | 1380.32 | -1155.16 | -1177.6 |
| 2 | 737.58 | 121.24 | -616.34 | 109.12 | -628.46 | 885.10 | -763.86 | -775.9 |
| 3 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 4 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 5 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 6 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 7 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 8 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 9 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 10 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 11 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 12 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 13 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 14 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 15 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 16 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 17 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 18 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 19 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 20 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 21 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 22 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 23 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 24 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 25 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 26 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 27 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 28 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 29 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 30 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 31 | 20.98 | 294.66 | 273.68 | 265.19 | 244.22 | 25.17 | 269.49 | 240.0 |
| 32 | -167.81 | 294.66 | 462.47 | 265.19 | 433.00 | -201.37 | 496.03 | 466. |
| **TOTAL** | **2328.36** | **9186.20** | **6857.84** | **8267.58** | **5939.22** | **2794.03** | **6392.17** | **5473.** |

**INTERNAL RATE OF RETURN = 16.03% 14.04% 12.72% 11.08%**

# SECTION 15

# FINANCIAL ANALYSIS

# SECTION- 15

# FINANCIAL ANALYSIS

## 15.1 Introduction

The Financial analysis is undertaken to ascertain the expected returns on investment and assess the financial viability of the project. For a project to be financially viable, it is necessary that gains generated (expected returns) exceed the cost of goods and services used in the form of project investment. At least, these gains must match or yield higher returns as compared to an alternative investment plan.

## 15.2 Financial Analysis

The primary objective of undertaking this kind of analysis is to determine whether the contribution of a particular project in the shape of added value of benefits is adequate enough to justify the use of already scarce resources needed for construction and operation of the project in the form of project investment cost. As financial analysis is basically carried out from the view point of project owner rather than the economy as a whole, it specifically aims to:

- determine the costs and returns of the project under reasonable financing plan
- establish a framework demonstrating the financial viability of the project during financial negotiations for project financing and capital investment
- assess repayment capability of the project

## 15.3 Project Base Cost

The project base cost is a mix of local and foreign currency components. The local currency cost is required for payment of land compensation, construction, tools and supplies, inland transportation, insurance, etc. which, in this case, amounts to about 66.48% of the total base cost including transmission line cost. The foreign cost is required for import of electro-mechanical equipment like generators, turbines, auxiliaries, etc. which, in this case, amounts to about 33.52%of the total base cost. The year-wise phasing (during construction) of the project base cost and its break-up into local and foreign components is presented in Chapter 12 (Bill of Quantities and Cost Estimates).

## 15.4 Financial Cost

The financial cost of the project includes interest during construction (IDC) and custom duties. The power projects are exempted from import duties but are subjected to custom duties @ 5% on import of plant and equipment not manufactured locally (Refer hydel policy 2002). The escalation during construction has also been added @ 6.5% and 2.2% per annum on local and foreign components respectively. The IDC has been charged at the rate of

11.79% both on local and foreign currency components for the purpose of financial analysis only (not for tariff determination). The financial costof the project is estimated as Rs1797.104 million.

### 15.4.1 Unit Costs

Unit cost refers to cost per unit of energy generated or cost per unit of installed capacity. It is a useful parameter as it indicates project financial efficiency at a glance. Cost of generation and installation per unit has been worked out for the project as per WAPDA'spractice. The project generation cost per kWh inclusive of custom duties, escalation and IDC and the cost per MW of installed capacityare shown in Table 15.1 and summarised below:

| Description | Generation Cost / kWh | | Installed Cost /MW(Financial Cost) | | Installed Cost / MW (EPC Cost) | |
|---|---|---|---|---|---|---|
| | Rs | US Cents | M.Rs | M.US$ | M.Rs | M.US$ |
| | 8.62 | 8.45 | 499.20 | 4.89 | 339.71 | 3.33 |

### 15.4.2 Operation And Maintenance Cost

The operation and maintenance costs of the project have been assessed @ 1.5% per annum of the base cost, which amounts to Rs 20.977 million per annum during its 30 years of useful life.

## 15.5 Financial Benefits Analysis

The project will yield both direct and indirect financial benefits. The direct benefits include annual power revenue obtained from sale of electricity generated by the project over its useful life. The indirect benefits will come in the form of savings of foreign exchange for importing an equivalent steam power plant, its annual maintenance cost and cost of fuel to be used for operating the plant. Only the direct benefits of the scheme via power revenues have been used to assess the financial viability of the project.

The proposed project may supply 3.6 MW of power and generate 20.80GWh per annum at its generation bus-bar but shall be able to deliver about 20.38GWhofenergyannualy at NTDC grid. The expected financial benefits throughout the life of the project are estimated as Rs356.42&355.12millionper annum with & without CDM respectively. Only 85% of the CDM benefits are attributed for the first ten years after the operation of the project, as the remaining 15% have to be paid as consultancy charges for the arrangement of CERs and after 10 years of plant operation, full CDM benefits are attributed to the project. CDM benefits are taken @ 1.5$/ton.

Energy from the project is assumed to be available at a constant rate throughout the life of the project. The power benefits from this project will thus be available from sale of power subject to the prevailing demand. Power benefits have been estimated by assuming likely constant sale price of energy and O&M costs. The likely sale price for estimation of power revenues has been obtained by escalating the average energy sale price of Rs8.94 per kWh in 2012-13 @ 10% per annum to Rs17.42 per kWh in the year 2019-20.

To determine the financial viability of the project 98% of gross power benefits have been attributed to generation facility and only 2% auxiliary losses have been assumed. The results of financial analysis are given in Tables15.2 and 15.3, which show that the project yields financial rate of returns of 18.87%and18.80% with and without CDMbenefits respectively,which is greater than the prevailinginterest rates and hence makes the project viable.

## 15.6 Non-Quantifiable Benefits

The importance of availability of electricity from the local hydropower plant needs no emphasis. Locally available hydro electricity would accelerate pace of development through village electrification. This would encourage local development of local industries. The people would also get employment through setting up of industries. The project would also increase the business activity in the area, thereby providing increased employment and investment opportunities and provide incentive to the work force to live near their homes. Availability of reliable electric supply would also provide cleaner and better living conditions to the local residents.

Furthermore, it will help to achieve improvement in health facilities and general standard of living of the local people of the project area and also usher in an era of continuous prosperity as well as economic emancipation through utilization of indigenous resources of land, labour and capital.

## 15.7 Conclusion

The project is socially, economically and financially viable, hence recommended for implementation.

**TABLE - 15.1**
**UPPER GUGERA CANAL HYDRO ELECTRIC POWER PROJECT**
**COST PER kWh AND MW**

| | DESCRIPTION | MILLION Rs. |
|---|---|---|
| 1 | BASE COST | 1398.436 |
| | a) LOCAL | 929.701 |
| | b) F.E.C | 468.734 |
| 2 | ESCALATION ON : | 179.568 |
| | a) LOCAL @ 6.5% | 155.399 |
| | b) FOREIGN @ 2.2% | 24.169 |
| 3 | CUSTOM DUTIES @ 5% | 15.505 |
| 4 | INTEREST DURING CONSTRUCTION | 203.595 |
| | a) LOCAL | 134.597 |
| | b) F.E.C | 68.998 |
| 5 | FINANCIAL COSTS | 1797.104 |
| | * a) LOCAL | 1304.200 |
| | b) F.E.C | 492.903 |
| 6 | AMORTIZATION @ 11.79% FOR 20 YEARS AND LEVELISED OVER 30 YEARS OF FINANCIAL COST | 158.289 |
| 7 | OPER.& MAINT. COST @ 1.5% OF BASE COST | 20.977 |
| 8 | ANNUAL RECURRING COST | 179.265 |
| 9 | ANNUAL ENERGY (GWh) | 20.80 |
| 10 | COST PER kWh - Rs | 8.62 |
| | US Cents | 8.45 |
| 11 | INSTALLED CAPACITY (MW) | 3.60 |
| 12 | INSTALLED COST PER MW - Million Rs | 499.20 |
| | Million US$ | 4.89 |

* Inclusive of total Interest during construction.

## TABLE - 15.2
## UPPER GUGERA CANAL HYDRO ELECTRIC POWER PROJECT
### FINANCIAL ANALYSIS WITH CDM

MILL.Rs

| YEAR | PROJECT COST | O&M | TOTAL COST | ENERGY GWh | ENERGY BENEFITS | CDM BENEFITS | TOTAL BENEFITS | NET BENEFITS |
|---|---|---|---|---|---|---|---|---|
| 1 | 930.09 | | 930.09 | | | | | -930.09 |
| 2 | 663.42 | | 663.42 | | | | | -663.42 |
| 3 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.30 | 356.42 | 335.44 |
| 4 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.30 | 356.42 | 335.44 |
| 5 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.30 | 356.42 | 335.44 |
| 6 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.30 | 356.42 | 335.44 |
| 7 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.30 | 356.42 | 335.44 |
| 8 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.30 | 356.42 | 335.44 |
| 9 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.30 | 356.42 | 335.44 |
| 10 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.30 | 356.42 | 335.44 |
| 11 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.30 | 356.42 | 335.44 |
| 12 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.30 | 356.42 | 335.44 |
| 13 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 14 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 15 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 16 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 17 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 18 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 19 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 20 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 21 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 22 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 23 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 24 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 25 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 26 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 27 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 28 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 29 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 30 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 31 | | 20.98 | 20.98 | 20.80 | 355.12 | 1.53 | 356.65 | 335.67 |
| 32 | -159.35 | 20.98 | -138.37 | 20.80 | 355.12 | 1.53 | 356.65 | 495.02 |
| **TOTAL** | **1593.51** | **629.30** | **2063.45** | **624.00** | **10653.61** | **43.54** | **10697.15** | **8633.70** |

**INTERNAL RATE OF RETURN = 18.87%**

**NOTE:**

1. Auxiliary losses taken as 2%.
2. Revenue attributed to the project @ 98%.
3. Sale price of Rs 17.42 taken for the year 2019- 2020.

## TABLE - 15.3
## UPPER GUGERA CANAL HYDRO ELECTRIC POWER PROJECT
### FINANCIAL ANALYSIS WITHOUT CDM

MILL.Rs

| YEAR | PROJECT COST | O&M | TOTAL COST | ENERGY GWh | ENERGY BENEFITS | NET BENEFITS |
|---|---|---|---|---|---|---|
| 1 | 930.09 | | 930.09 | | | -930.09 |
| 2 | 663.42 | | 663.42 | | | -663.42 |
| 3 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 4 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 5 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 6 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 7 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 8 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 9 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 10 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 11 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 12 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 13 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 14 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 15 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 16 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 17 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 18 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 19 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 20 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 21 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 22 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 23 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 24 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 25 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 26 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 27 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 28 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 29 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 30 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 31 | | 20.98 | 20.98 | 20.80 | 355.12 | 334.14 |
| 32 | -159.35 | 20.98 | -138.37 | 20.80 | 355.12 | 493.49 |
| **TOTAL** | **1593.51** | **629.30** | **2063.45** | **624.00** | **10653.61** | **8590.16** |

**INTERNAL RATE OF RETURN = 18.80%**

**NOTE:**

1. Auxiliary losses taken as 2%.
2. Revenue attributed to the project @ 98%.
3. Sale price of Rs 17.42 taken for the year 2019- 2020.

# SECTION 16

# TARIFF DETERMINATION

# SECTION - 16

# TARIFF DETERMINATION

## 16.1 Tariff Structure

The proposed Reference Tariff is a typical two parts tariff comprising an Energy Purchase Price (EPP) for the energy generated and delivered to the power purchaser and a Capacity Purchase Price (CPP) based on the installed plant capacity. The tariff is based on 18% Return on Equity, as it is considered reasonable for the investor. The cash flows of revenues have been derived from multiplying each element of the capacity tariff by the guaranteed capacity, and each element of the energy tariff by the amount of energy sold over the useful life of the project. The cash flow of cost comprises the equity component of the investment, the repayment of principal as well as interest on loans in local and foreign currencies, variable and fixed operation and maintenance costs, insurance cost, ROEDC and water use charges.

## 16.2 Energy Purchase Price

Energy Purchase Price consists of two components.

### a) Variable O&M Cost

Variable O&M cost caters for the cost of the services of the O&M operators for day to day management of the power plant. It includes the cost of lubricants and other chemicals etc. It also covers cost of maintenance of the plant including replacement of parts as and when required. It has been taken as 25% of O&M Cost which amounts to Rs 0.221/kWh annually comprises on local and foreign components equally.

### b) Water Charges

Water charges are payable to the Government of Punjab on net energy generated by the plant for using the canal water. The charges are payable in pursuance to the Water Use Agreement (WUA), to be executed between the company and the Government of Punjab @ Rs 0.15/kWh. Water charges have been added in the tariff stream as a pass through item.

## 16.3 Capacity Purchase Price

Capacity Purchase Price (CPP) is a fixed monthly payment per kW of the capacityavailable at the plant to meet the fixed cost of the project, provided that plant is available for dispatch as per the standards defined in Power Purchase Agreement (PPA). The CPP comprises of fixed O&M cost, debt repayment, insurance, return on equity, return on equity during construction and withholding tax.

### a) Fixed O&M

Fixed O&M cost component reflects the fixed cost of all the O&M staff including the remuneration to staff and other administrative costs including rent, utilities, environmental monitoring, local taxes and duties, etc. It also includes the management fee and cost of O&M contractor's management to be engaged for operation and maintenance of the plant. It has been worked out @ 75% of O&M Costwhich amounts to Rs 318.475/KW/Month.

**b) Insurance**

The insurance cost is required for insurance policies to maintain the plant as defined in PPA and as required by the lender. The risks to be covered through insurance includemachinery breakdown, natural calamities (like earthquake, etc) and business interruption. It has been taken @ 1.35% of EPC Cost and its tariff is about Rs382.170/KW/Month.

**c) Return on Equity**

Return on equity is meant to provide benefit to the project sponsor on the amount of equity. A hydropower plant carries a higher risk as compared to an equivalent thermal plant due to being capital intensive, longer gestation period, susceptibility to political instability, security problems and cost over-runetc.As such these projects claim higher returns. The risk profile has deteriorated significantly in the current security situation and uncertaintiesprevailingin the country, which warrants higher returns on equity as evidenced in a recent ROE of 17% allowed by NEPRA on some similar projects. The return on investment should be correlated with sponsor's risk to safeguard his interests and to encourage involvement of private investors in these kinds of power sector developments. In view of the aforementioned facts,ROE of 18% has been applied in tariff calculations for the project, which seems to be justifiable. In case this rate is not allowed by NEPRA, the deficiency may be covered by the CDM benefits. The return on equity has been calculated on 20% of project cost while the remaining 80% amount of the project cost has been considered as a foreign loan (debt).

**d) Debt Services**

The debt equity ratio of 80:20 has been applied in the tariff profile of the project. This component is needed to meet the repayment of principal and interest amounts. It matches the loan payment stream. The tenure of debt payment of US$ 11.09 million is assumed as 10 years. For equity of US$ 2.77 million no interest has been calculated but for foreign debt LIBOR for 3 months+450 bps (4.82%)have been used to calculate interest during construction and repayment of loan. The repayment of loan is calculated on quarterly basis but shows annually. The payment of loan starts immediately after commissioning of the project. Interest during construction (US$ 0.60 million) is capitalized to estimate the installments of the repayment.

**e) Withholding Tax**

Withholding tax is another pass through item just like the other taxes and the power purchaser shallbe required to pay the actual amount of withholding tax to the investor, subject to maximum of 7.5% of the 18% return on equity. No corporate tax, general tax, excise duties, levies fee etc. by any Government functionary including local bodies have been considered. Its tariff is about Rs98.603/KW/Month.

### f) Hydrological Risk

Hydrological risk will be borne by the power purchaser in accordance with the Power Policy of theGovernment. The levelised tariff is based on 10% discount rate as provided under Clause 4.3(54) of theHydelPolicy, 2009of the Government of Punjab.

The salient features of tariff assumptions are summarized in Table 16.1.

## 16.4 Reference Tariff

The levelized tariff has been computed over 30 years of useful life of the project, which comes to Rs9.658 per kWh, equivalent to US Cents 9.469 per kWh. The tariff is subject to revision on the basis of firm EPC cost after COD. The summary of reference tariff is shown in Table-16.2. Year-wise tariff profile of the project is presented in**Table-16.3**.

**Table – 16.2**

**Summary of Reference Tariff**

| **Description** | | **Average Year** | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 1-10 | 11-20 | 21-30 | 1-30 |
| **EPP** | | **0.36** | **0.36** | **0.36** | **0.36** | **0.36** |
| | Water Use Charges | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| | Variable O&M | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 |
| **CPP** | | **12.58** | **11.37** | **4.47** | **4.47** | **6.77** |
| | ROE | 2.41 | 2.41 | 2.55 | 2.55 | 2.50 |
| | Debt Service | 8.26 | 7.05 | 0.00 | 0.00 | 2.35 |
| | ROEDC | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 |
| | Insurance | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 |
| | Fixed O&M (Escalable) | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 |
| | Withholding Tax | 0.20 | 0.20 | 0.21 | 0.21 | 0.21 |
| **Total Tariff (Cents/KWh)** | | **12.95** | **11.74** | **4.84** | **4.84** | **7.14** |

**Levelized Tariff (Rs/kWh) = 9.658Cents/kWh =9.469**

## TABLE - 16.1

## UPPER GUGERA CANAL HYDRO ELECTRIC POWER PROJECT

## ASSUMPTIONS OF TARIFF

| Production | |
|---|---|
| Installed Capacity (MW) | 3.60 |
| Auxiliary Power Losses (%) | 0.5 |
| Net Capacity (MW) | 3.582 |
| Gross Generation (GWh) | 20.80 |
| Net Generation (GWh) | 20.71 |
| Plant Factor | 66% |
| Rs/USD | 102.00 |

| Operational Costs/kWh - Cents | |
|---|---|
| Water use charges | 0.15 |
| Operation & Establishment | 25% |
| Maintenance | 75% |
| Project Insurance | 1.35% |

**Amount in Million US$**

| Description | |
|---|---|
| **EPC Cost** | **11.99** |
| Indirect Costs | 1.72 |
| **Base Cost** | **13.71** |
| Custom Duties | 0.15 |
| **Project Cost** | **13.86** |
| Foreign Loan | 11.09 |
| Equity | 2.77 |
| IDC | 0.60 |
| **Total Project investment** | **14.46** |
| Initial % Debt | 80% |
| Initial % Equity | 20% |
| Return on Equity (Annual Dividend) | 18% |
| Discount Rate for Levelized Tariff | 10% |
| Repayment of Equity (Years) | 20 |
| Repayment of foreign loan (Years) | 10 |
| Interest rate of Equity | 0% |
| LIBOR rate for 3 months | 0.32% |
| Basic Points (bps) | 450 |
| Interest rate of foreign loan | 4.82% |
| Credit line Commitment Fee | 0.0% |
| First year of amortization | 2016 |
| First year of Operation | 2016 |
| Last year of Operation | 2045 |

# TABLE - 16.3
## UPPER GUGERA CANAL HYDRO ELECTRIC POWER PROJECT
### REFERENCE TARIFF

| Year | Energy Charges (Rs/kWh) | | | Capacity Charges (Rs/kW/Month) | | | | | | | TOTAL TARIFF (Rs/kWh) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Water Charges | Variable O&M Cost | TOTAL | Fixed O&M Cost | Insurance | Return On Equity | Withholding Tax @7.5% | Debt Repayment | ROEDC | TOTAL | |
| 1 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1178.284 | 98.603 | 4039.060 | 136.419 | 6153.010 | 13.206 |
| 2 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1178.284 | 98.603 | 3906.073 | 136.419 | 6020.024 | 12.929 |
| 3 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1178.284 | 98.603 | 3773.086 | 136.419 | 5887.037 | 12.651 |
| 4 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1178.284 | 98.603 | 3640.100 | 136.419 | 5754.050 | 12.374 |
| 5 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1178.284 | 98.603 | 3507.113 | 136.419 | 5621.063 | 12.097 |
| 6 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1178.284 | 98.603 | 3374.126 | 136.419 | 5488.076 | 11.819 |
| 7 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1178.284 | 98.603 | 3241.139 | 136.419 | 5355.090 | 11.542 |
| 8 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1178.284 | 98.603 | 3108.152 | 136.419 | 5222.103 | 11.264 |
| 9 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1178.284 | 98.603 | 2975.166 | 136.419 | 5089.116 | 10.987 |
| 10 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1178.284 | 98.603 | 2916.984 | 136.419 | 5030.934 | 10.866 |
| 11 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 12 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 13 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 14 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 15 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 16 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 17 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 18 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 19 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 20 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 21 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 22 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 23 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 24 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 25 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 26 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 27 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 28 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 29 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |
| 30 | 0.150 | 0.221 | 0.371 | 318.475 | 382.170 | 1246.068 | 98.603 | 0.000 | 136.419 | 2181.734 | 4.933 |

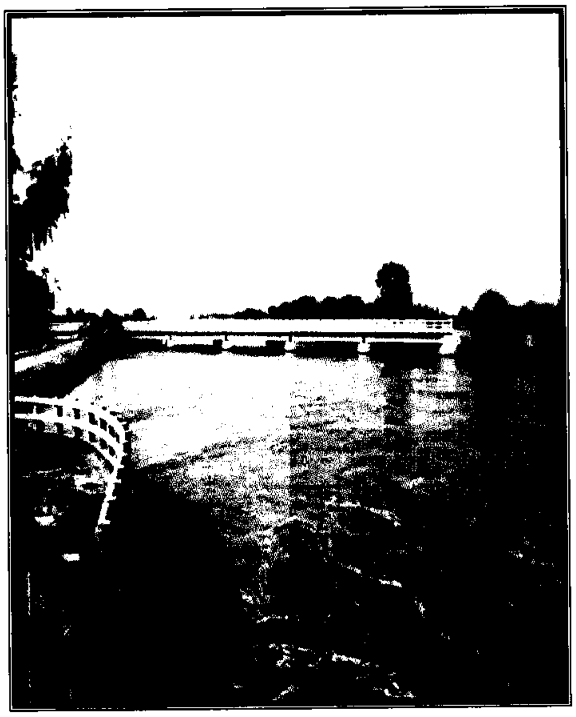
**Levelized Tariff (Rs/kWh) = 9.658**
**Levelized Tariff (Cents/kWh) = 9.469**

M/s GUGERA HYDROPOWER COMPANY

# Gugera Hydro Electric Power Project

(Upper Gugera Branch Canal RD 216+100 to 220+750)

# FEASIBILITY STUDY REPORT



## ANNEXURES (Volume-II)

team consultants

Technical, Engineering and Management (TEAM) Consultants, Pakistan

M/s GUGERA HYDROPOWER COMPANY

# Gugera Hydro Electric Power Project

(Upper Gugera Branch Canal RD 216+100 to 220+750)

# FEASIBILITY STUDY REPORT

## ANNEXURES (Volume-II)

APPROVED FEASIBILITY STUDY
Granted by POEs in their meeting
held on 03-12-2015

MANAGING DIRECTOR
PUNJAB POWER DEVELOPMENT BOARD

team Technical, Engineering and Management (TEAM) Consultants, Pakistan

No. PPDB/ 863 /2016

**PUNJAB POWER DEVELOPMENT BOARD**
**ENERGY DEPARTMENT**

Irrigation Secretariat, Old Anarkali, Lahore
(Ph: 042-99213879 Fax: 99213885)

**Date:** 23 / 06 /2016

**M/s Gugera Hydropower Company**
64-Ahmed Block New Garden Town
Lahore

Subject: **APPROVAL OF FEASIBILITY STUDY REPORT OF 3.6 MW GUGERA HYDROPOWER PROJECT ON UPPER GUGERA BRANCH CANAL AT RD. 216+100 to RD. 220+750, DISTRICT NANKANA**

It is conveyed that pursuant to Section 4.2 (Para 52 & 53) of the Punjab Power Generation Policy-2009 (the "Policy"), a Panel of Experts (POEs), comprising following members, was appointed by PPDB to monitor, review and approve feasibility study report (the "Report") of 3.6 MW Gugera Hydropower Project on Upper Gugera Branch Canal at RD. 2016+100 to RD. 220+750, District Nankana, being developed by your Company:

1. The Managing Director, Punjab Power Development Board (PPDB), Lahore.
2. The Managing Director, Private Power & Infrastructure Board (PPIB), Islamabad
3. Dr. Engineer Javed Yunas Uppal, Chairman EPDC, Lahore
4. The Chief Executive Officer, Lahore Electric Supply Company (LESCO)
5. The Project Director, Punjab Power Management Unit (PPMU), Lahore
6. The Superintending Engineer, LCC (East), Circle Office, Irrigation Department, Faisalabad

2. During the course, POEs held a number of meetings and made certain observations / suggestions paving the way towards ultimate completion of the Report. Accordingly, after thorough review, the POEs during their final meeting held on 03rd December 2015, approved the said feasibility study report subject to approval of Initial Environmental Examination (IEE) Report from Environment Protection Agency (EPA) and approval of Interconnection Study from Lahore Electric Supply Company (LESCO). POE also certified the duly filled Performa (Annex-II) regarding net annual plant factor to apply for NEPRA's Upfront Tariff for Small Hydropower Generation Projects, notified by GoP, Ministry of Water & Power on March 28, 2016. The POEs resolved that:

(i) *POE conditionally approved the feasibility study of 3.6 MW Gugera Hydropower Project, subject to the approval of Initial Environmental Examination (IEE) Report from Govt. of the Punjab, Environment Protection Agency and approval of Interconnection study from NTDC / concerned DISCO. POE further directed the Sponsor to get the said approvals from concerned Authorities and submit the same to PPDB within 15 days of issuance of minutes of POE meeting, since the progress of the Project is already delayed.*

(ii) *POEs certifies only the completion of the Feasibility Study. However, due to nature of data and resultant conclusions, POEs jointly and/or individually will not be responsible for reliability of data contents and conclusions given in the feasibility study.*

3. The Sponsor has submitted the approval of IEE from EPA on 23.04.2016 and approval of Interconnection Study from LESCO on 01.06.2016. Since the conditions of the approval of feasibility study have been fulfilled, the Feasibility study of subject cited Hydropower Project stands approved.

4. In view of the above and relevant stipulations of the Policy, now, your Company is required to approach National Electric Power Regulatory Authority (NEPRA) for grant of Generation License and acceptance of NEPRA's Upfront Tariff for Small Hydropower Generation Projects, notified by GoP, Ministry of Water & Power on March 28, 2016. Thereby, please note that your petition for acceptance of Upfront Tariff along with its terms & conditions. A copy of duly signed & stamped complete set of final feasibility study is being enclosed herewith.

5. PPDB appreciates your efforts towards completion of the Feasibility Study Report and hopes that the same pace and spirit would be kept by your Company for timely development of the project to meet the energy needs of the country.

*Regards,*

**SANIYA AWAIS**
*Managing Director*

**ENCL:** <u>*Complete set of stamped & signed Final Feasibility Study Report*</u>

CC:
1. The Chairman PPDB Board / Additional Chief Secretary, Government of the Punjab, Energy Department, Lahore
2. The Managing Director, Private Power & Infrastructure Board (PPIB), Islamabad
3. The Chief Executive Officer, Lahore Electric Supply Company (LESCO)
4. The Project Director, Punjab Power Management Unit (PPMU), Lahore
5. Dr. Engr. Javed Yunas Uppal, Chairman EPDC, 1-A, Aibak Block, Garden Town Lahore
6. The Superintending Engineer, LCC (East), Circle Office, Irrigation Department, Faisalabad

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## ANNEXURE

# ANNEXURE 2-1

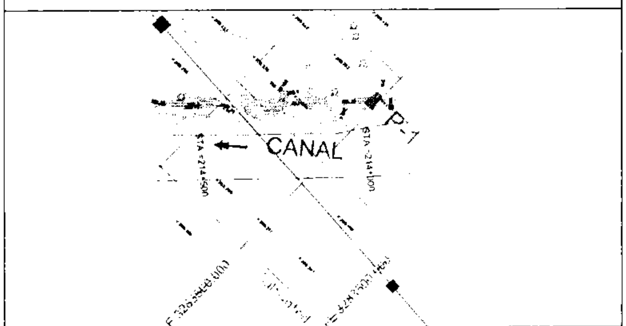
# DESCRIPTION OF PRIMARY SURVEY MARKERS

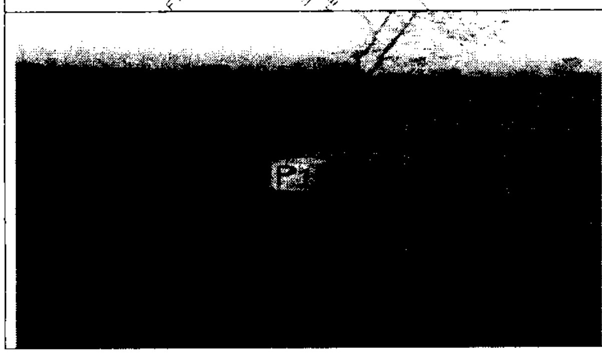
## DISCRIPTION OF BENCH MARK & PILLARS (PRIMARY POINTS)

**P 1**

**E: 3283495.922 N: 823762.947 Z: 204.23**

**Description:**
PVC Pipe 6" Dai embedded and Painted with red colour on the 187 m North East side of Pylon on Track along canal 258 m North West from other Pylon.

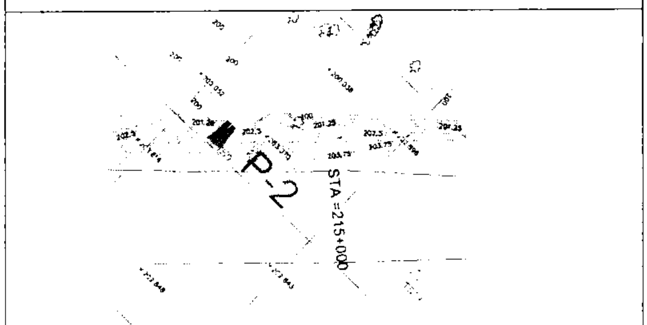


**P-2**

**E: 3283225.135 N: 823502.594 Z: 204.256**

**Description:**
PVC Pipe 6" Dai embedded and Painted with red colour on the 73 m North West side of RD 215+000 on the Track along canal..

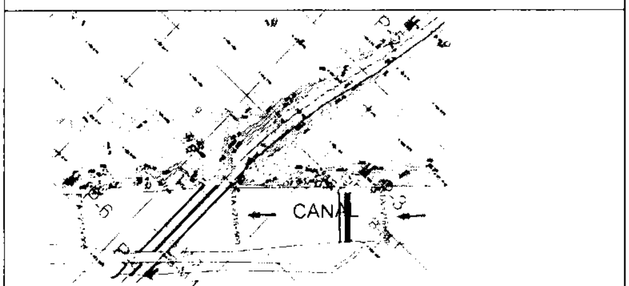


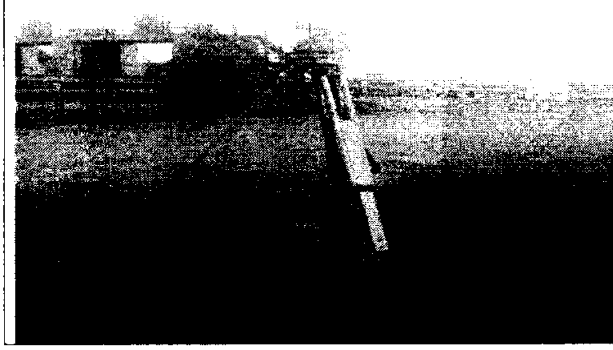

## DISCRIPTION OF SURVEY MARKER/PRIMARY POINTS

**P-3**

**E: 3283040.546 N: 823323.213 Z: 204.542**

**Description:**
PVC Pipe 6" Dai embedded and Painted with red colour on the 25 m North West Bridge and 52 m North West side of Hand Pump Opp. RD No. 216+000 on the Track along canal.

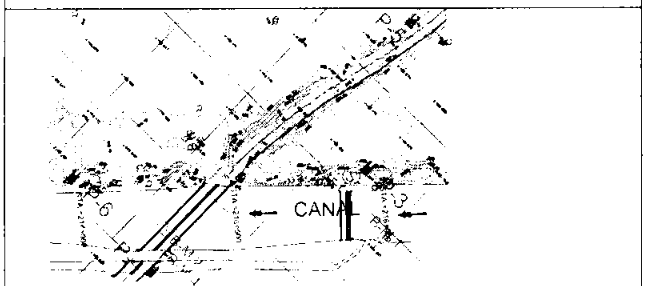


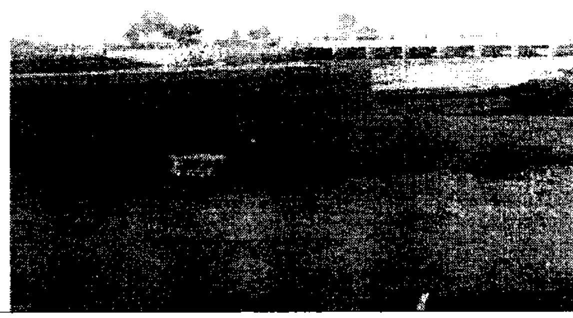


**P-4**

**E: 3282950.697 N: 823097.303 Z: 204.77**

**Description:**
PVC Pipe 6" Dai embedded and Painted with red colour on the small Bridge near large Bridge along canal.



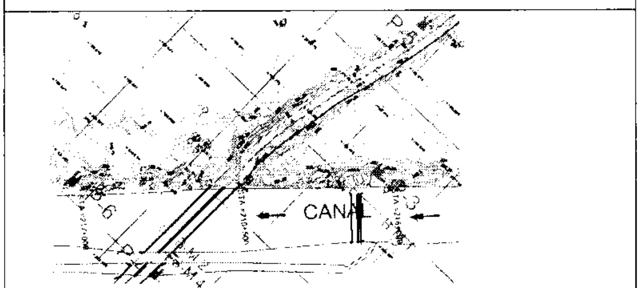


## DISCRIPTION OF SURVEY MARKER/PRIMARY POINTS

**P-5**

**E: 3282972.045 N: 823461.05 Z: 202.146**

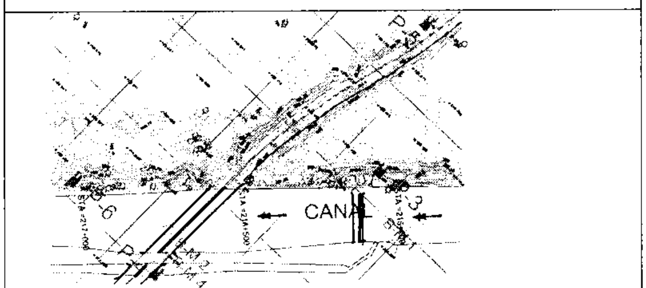
**Description:**
PVC Pipe 6" Dai embedded and Painted with red colour on the 253 m North West from Bridge along Main Road.



**P-6**

**E: 3282827.835 N: 823109.825 Z: 202.981**

**Description:**
PVC Pipe 6" Dai embedded and Painted with red colour on the 139 m West side from Bridge and Opp. RD No. 217+000 on the Track along canal.

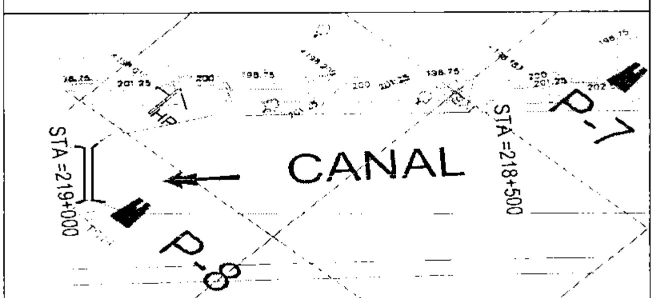


## DISCRIPTION OF SURVEY MARKER/PRIMARY POINTS

### P-7

E: 3282542.087 N: 822843.172 Z: 202.62

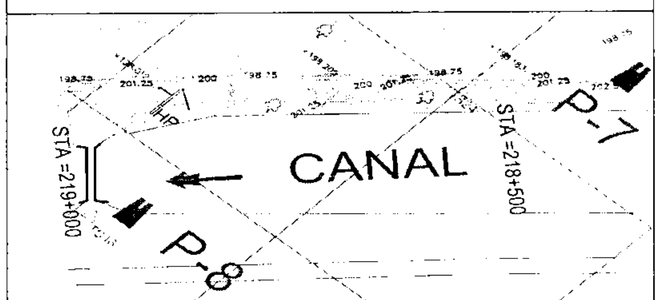
**Description:**
PVC Pipe 6" Dai embedded and Painted with red colour on the 196 m East side from Bridge and also 48 m east from RD No. 218+500 on the Track along canal.




### P-8

E: 3282452.7 N: 822665.5 Z: 202.193

**Description:**
PVC Pipe 6" Dai embedded and Painted with red colour on the 23 m West from RD No. 219+000 and near culvert/Foot bridge south side of canal.



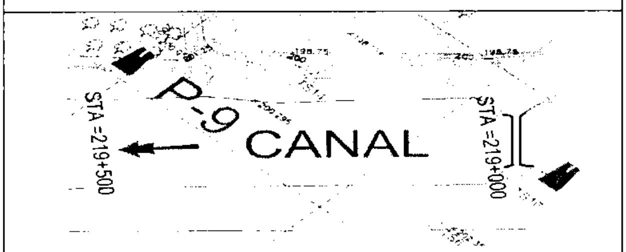


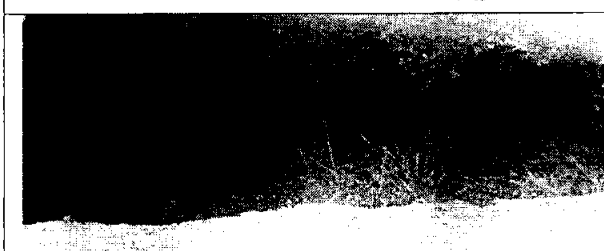
IM-ASSOCIATES
H # 66, Street # 2, Canal Point, Harbanspura, Lahore
Ph: - 042-36132738, Fax: 042-36520145, 0333-4330667, 0333-4804161, 0300-9428204

**P-9**

**E: 3282294.377 N: 822602.076 Z: 202.535**

**Description:**
PVC Pipe 6" Dai embedded and Painted with red colour on the 33 m West from road junction and Opp. RD No. 219+500 on the Track along canal.



**P-10**

**E: 3282050.533 N: 822370.814 Z: 202.237**

**Description:**
PVC Pipe 6" Dai embedded and Painted with red colour on the 36 m west from RD No. 220+500 on the Track along canal.